DESIGN AND IMPLEMENTATION ALGORITHM FOR SIMULATION MODELING FOR EMERGENCY EVACUATION BASED ON IMPROVED FITNESS DEPENDENT OPTIMIZER

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(Artificial Intelligence)

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Dedication

This Thesis is Dedicated To:

My Father's Soul
My Uncle's Soul

My Mother
My Grand Parent
My Lovely Wife, Shiraz

My Dear Sister and Brothers

With My Love and Respect

Danial Abdulkareem Muhammed
10/05/2020

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Abstract

Human lives face jeopardies due to emergency incidents. A sufficient emergency evacuation plan is crucial to avoid adverse consequences, such as injury and death. Hence, various pedestrian evacuation models have been developed, and comprehensive surveys on these models for different applications, simulations, and circumstances have been conducted to offer an operative model. Further, new models have been enhanced to interact with system evacuations in a building in the event of an emergency. Hereafter, it is utilized to design a new intelligent simulation model; Cellular Automata (CA) has been chosen to combine with the idea of fuzzy logic technique, kth nearest neighbors (KNN) algorithm, and some statistical equations to address the final problem. The designed model accurately determines the following; individuals' speeds based on their properties, individuals' emergency behaviors, and their evacuation time during the evacuation process. Moreover, Fitness Dependent optimizer (FDO) is one of the most recently introduced algorithms in 2019. This research presents an improved FDO algorithm (IFDO), which significantly improves the original FDO in solving complex optimization problems. IFDO to improve FDO, it calculates alignment and cohesion and then using both with the pace in FDO in updating its position. Moreover, in determining the weights FDO used weight factor (wf) which was (0) in most cases and (1) in only a few cases. Conversely, IFDO makes the (wf) randomization in [0-1] range. During this research, the IFDO algorithm and its method of converging on the optimal solution are demonstrated. Additionally, the IFDO is tested on a group of 19 classical benchmark test functions, and the results are compared with FDO and three distinguished algorithms: Particle Swarm Optimization (PSO), the genetic algorithm (GA), and the Dragonfly algorithm (DA); furthermore, the IEEE

Congress of Evolutionary Computation Benchmark Test Functions (CECC06, 2019 Competition) [1] were utilized to test performance of the IFDO. FDO and three modern algorithms: (DA), the whale optimization algorithm (WOA), and the salp swarm algorithm (SSA) were selected to be compared with the IFDO results. The IFDO results show improved presentation in most cases and reasonable results in other cases. Finally, the IFDO is applied to real-world applications including our simulation model as confirmation of its possibility.

Table of Contents

List of Tables

Table No	***Title***	***Page No***

List of Figures

Figure No ***Title*** ***Page No***

List of abbreviations	
Abbreviations	**Description**
ABC	Artificial Bee Colony
AMO	Animal Migration Optimization
AMPS	Adaptive Method for the Population Size
APOA	Artificial Plant Optimization Algorithm
CA	Cellular Automata
CEC	Congress on Evolutionary Computation
C.W.A	Collision With Agents
C.W.O	Collision With Obstacles
DA	Dragonfly Algorithm
FDO	Fitness Dependent Optimizer
FW	Fitness Weight
GA	Genetic Algorithm
IFDO	Improved Fitness Dependent Optimizer
IOB	Investigated Occurrences and Behaviours
KNN	k-th Nearest Neighbors
MD	Models
min:sec:ms	Minute:Second:MiliSecond
MT	Models Type
MTH	Methods
O.B.D.E	Occurring Different Behaviors During Evacuation
PNT	Participants
PSO	Particle Swarm Optimization
REF	References
SSA	Slap Swarm Algorithm
SST	Simulation State
WF	Weight Factor
WOA	Whale Optimization Algorithm

Chapter 1: Introduction

1.1 Overview

With the continuous and rapid economic growth and due to speedy growth in population and extreme demand for space, a large number of modern buildings with different structures, duration more evacuation, and dense of residents have been built in developed countries [2, 3]. Thus, it is essential to have an effective evacuation of the ability [4] with the existence of emergencies in such buildings, such as fire, bomb, and violence by terrorist and toxic gas release. Emergency evacuation for these buildings leads to a serious issue for residents, governments, and building designers [3]. Concerning congestion and crushing during the occurrence of an emergency, several events conveyed [5]. Pressure on the people makes an estimate of their behavior during evacuation be very problematic, meanwhile for the same condition they have different responses [6]. The difference in age, gender, society, familiarity, and physical abilities has a great impact on that various response [7]. Nonetheless, the occurring accident is scary, threats human life and makes the people during the crowd follow nearly mutual behavior characteristics. [8-12]. With moving toward the exit door it is apparent that people walk over and push others with the hope to move to safe space [13]. Eventually, such behaviors change the simple evacuation into more serious evacuation and the evacuation proportion would be reduced [14, 15].

Since there is no empirical data from evacuation, only modeling is used for describing rules and situations that appear via communication between evacuees and environments [16]. Therefore, crowd simulation is becoming progressively more essential, useful, and helpful in emergency [17, 18]. There are some models of evacuation simulation, such as BGRAF, Exodus, and

Simulex [19-21]. However, there is a limitation from the perspective of using homogenous people [22]. Few types of research mentioned the effect of agents' speed on evacuation time without considering the heterogeneity of the agents' in biological, physical, and emotional properties. Nonetheless, knowledge about various properties of agents to define a desired speed for the agents may significantly affect the evacuees' behaviors and evacuation proficiency.

1.2 Problem Statement

Some emergency cases will not be controlled easily and will be obstacles in front of the evacuation process because of perplexity, dread and even uncertainty and uneasiness to mass dwellers. Many factors affect evacuation processes such as the surrounding, how they react with each other, and various environmental conditions, that is why many evacuation approaches occur like protective, preventive, rescue and constructive evacuation. The issue of evacuation proceeds to the crowd's movement and it is affected by the physical and social environment, such as the high degree of danger, pressure, and lack of data, which is a mixture of environmental hazards; population demographics and the attendee's conduct. A crowd is gathering of a group of people that has many features, during simulation several potential behaviors are anticipated, and simulation is a way of guessing behaviors through answering for the "what-if" conditions.

Hence, Crowd evacuation is a way to aping the behavior of participants in the same situation, in the last 20 years many types of research have been done, practicing evacuation have been considered to lower the damages; deaths and injuries in emergencies involving pedestrians. The sole purpose of the investigations is to improve a managing emergency that is why many models are enhanced to see how people react in different scenarios in emergencies.

1.3 Objectives

The objectives of this research are ordered as follows:

A- Scheme a novel smart and dependable model to pretend attendees' appearing emergency conducts and evacuation efficacy when an area requires emergency evacuation.

B- Creating an intelligent model for pedestrians crowd emergency evacuation simulation based on the Cellular Automata Model from examining the effect of the combination of different factors such as environments, heterogeneity in agents' speeds, agents' distributions and familiarities, on both of appearing emergency behaviors and evacuation performance.

C- Improving in one of the recently implemented evolutionary algorithms in 2019 which is fitness dependent optimizer (FDO), and then it used to optimize the created pedestrians crowd intelligent model, it is worth to mention that because this is an improvement in the original FDO, it is known as improved fitness dependent optimizer (IFDO).

Thus, the current research sheds light on the pedestrian evacuation specifically and generally. Yet it is a chance for the scholars to gain relevant information with ease and decide about how their forthcoming researches be directed.

1.4 Contributions

The contributions of this research are listed as follows:

1. In this research, an intelligent model for pedestrians crowd emergency evacuation simulation based on the Cellular Automata Model was built and speed of each agent is specified with consideration of human

physical, biological, and emotional factors, and incorporate the varied speed with different factors, such as environment, agents' distributions, and familiarity of the agents to the exit doors to improve agents' emergency behaviors and evacuation efficiency.

2. During this research, a significant modification was done on FDO by introducing IFDO via adding new factors in updating position and also randomization weight factor to better exploration and exploitation. Afterward, the created model was optimized with both of the original FDO and the IFDO to find the best location of the main exit door in the evacuation area to be used by the evacuees to evacuate from the area.

1.5 Thesis Organization

The structure of this research is organized as follows:

Chapter 2 – Literature Review – It focuses on describing crowd evacuation models, identifying existing models, determining implications, features, utilizing in various applications to various problems, and illustrating previous nature-inspired algorithms.

Chapter 3 – **Research Methodologies** – It focuses on methods that are used in this research and discuss them.

Chapter 4 – **Experimentations and Results** – It focuses on performing experiments of written scenarios and real-world problems, and then shows the results through charts and briefed in tables.

Chapter 5 – **Results Discussion** – It focuses on comparing, discussing, and evaluating the output of the experimentations.

Chapter 6 – **conclusion and suggestions** – It focuses on concluding the research appearances and recommendations for further research.

CHAPTER 2: Literature Review and Theoretical Background

This chapter can be divided into forth parts, the first part presents various pedestrians' crowd evacuation models and demonstrates the previous works on the crowd evacuation models, the second part illustrates previous nature-inspired algorithms, the third part presents KNN algorithm, and the forth one shows fuzzy logic techniques.

2.1 Evacuation Models for Crowd

The crowd is performing a bunch of people together [23]. It is the only condition in which reverse could be the alternative of panic rather than being touched [24]. In 1895 presenting La Psychologie des foules by LeBon was the starting of researchers' concern for crowd dynamics [25]. On the other hand, Helbing in 1991 presented a widespread work, which was one of the attempts for such reason to display the motion of pedestrians [26]. Scientists, until 2001, had previously created relating models going for alleviating clog and obstacle wonders dependent on experimental information [27]. Meanwhile, different fields studied crowd dynamics when pedestrians' dynamic was presented [28]. Irregular movement, the effect of congestion and the occurrence of own-arrangement were specified [29]. Numbers of applications were simulated via this crowd evacuation model [28-33]. For displaying crowd evacuation from building various methods developed, such as cellular automata method, social force method, lattice gas method and agent-based method [34-36]. Hence, these methods based on the ability to know the detail of the individuals in the crowd covered via three different models macroscopic model, mesoscopic model and microscopic model [37, 38]. On the other hand, different hybridized methods were developed, such as zone-based, layer-based, and sequentially based [39].

Another method generic framework was presented from the previously mentioned hybridized models [37].

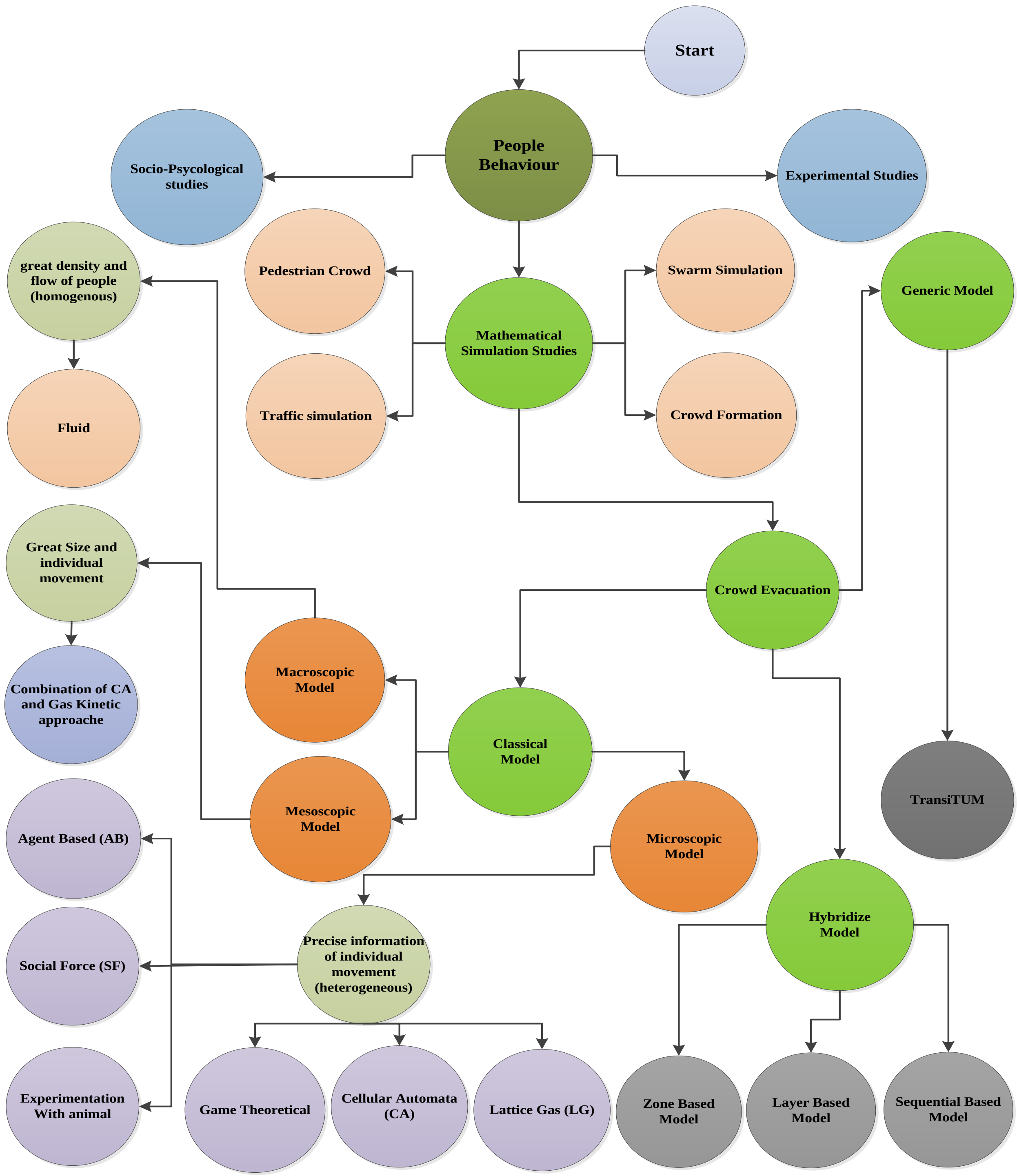

Figure 2. 1 An overview of the developed models for crowd evacuation [40, 41]

Figure 2.1 shows an overview of the developed models for crowd evacuation. The crowd models are categorized into three main models; these are a classical model, a hybridized model, and a generic model. Each model has its approaches to investigating the flow of people and their behaviors during the evacuation process.

2.1.1 Classical Model

The classical model can be divided into three different models; macroscopic, mesoscopic and microscopic. Each model was to design different approaches to know how humans move and behave during movements from one place to another of the specified area. These models are described in the following points:

1- Macroscopic Model:

Macroscopic is one of the classical models and with such a model flow of people is noticed and individual features are neglected due to dealing with the homogenous people. Figure 2.2 illustrates the macroscopic model. In the macroscopic model, the fluid dynamic was designed.

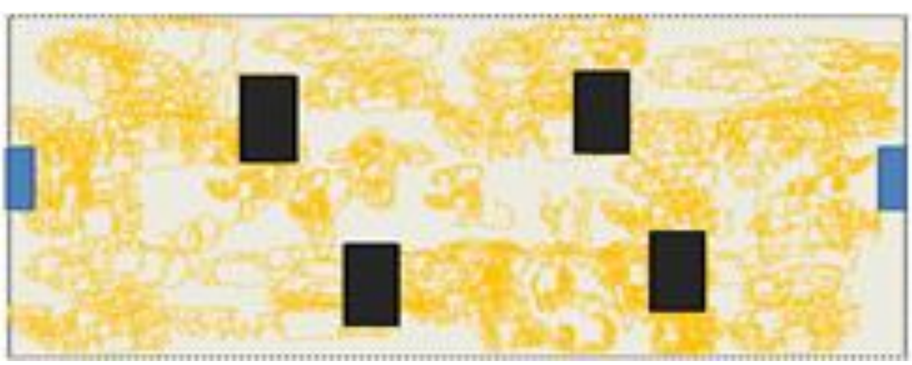

Figure 2. 2 Macroscopic model

In previous decades, fluid-like characteristics had been represented as a pedestrian crowd. There were numbers of connections between fluid and pedestrians, for instance, movement on all sides of the obstructions shows follow "streamlines", so, it was not an unexpected situation, especially, such as the premature models of pedestrians, which is vehicular dynamics took motivation hydrodynamics or gas-kinetic theory [42-45]. Henderson believed that a person on foot flocks acts comparably to gases or fluid [46]. Bradley estimated that the Navier– Stokes conditions administering smooth movement could be utilized to depict movement in groups at high densities [47]. Helbing et al. abridged that at medium and high densities, the movement of a person on foot flocks demonstrated some hitting analogies with the movement of fluid. For example, the impressions of people on foot in snow seem to be like streamlines of liquids or, once more, the surges of walkers through standing groups are practically equivalent to riverbeds [48]. Liquid powerful models portray how thickness and speed change after some time with the utilization of halfway differential conditions [49].

2- Microscopic Model:

There are several old models of which microscopic is one. Within which everything is realized accurately such as full information about individual and individual manners. Nevertheless, it is not perfect in examining the huge number of attendees. Figure 2.3 illustrates the microscopic model, as shown in the figure the area is digitized into number of cells, and each cell maight be occupied with an object as presented with yellow, black, and blue colors or might be empty as presented with white color . Several objects are designed in microscopic such as cellular automata, lattice gas, social force, agent-based, game theory, and experimental approaches. Details about cellular automata and its applications are demonstrated below:

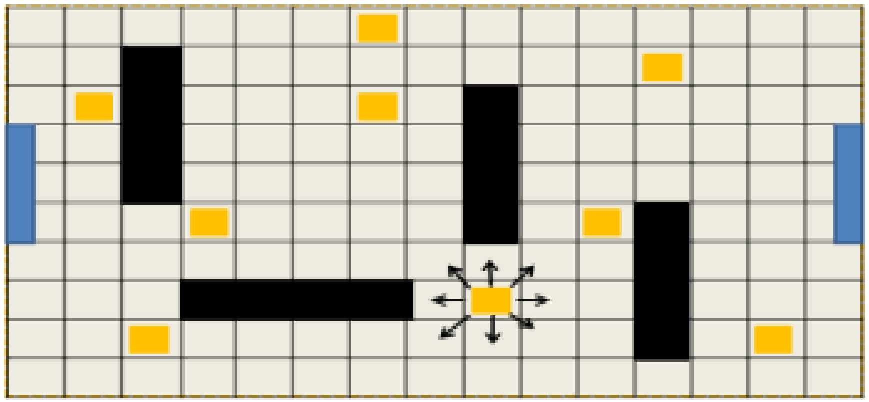

Figure 2. 3 Microscopic model

A. Cellular Automata

The accurate invention of physical methods in which ‘time and space’ are a remote and liable set of dissimilar values being approved inside the corporeal dimensions is called cellular automata. Cell automation includes a normal identical network, which is to some extent perpetual in grade with a different variable at every position (cell). The status of each cellular automation is mostly based on the approximations of the total reasons for all sites. The development of cellular automation in distinct stages, with the speculation of the ‘variable’ at a site undergoing the influence of the reasons at endpoints ‘in its neighborhood on the’ start of the previous procedure. For the area of the site (cell), it is essential to take into account two things: the ‘site’ and the ‘neighboring locales’. The causes at all the sites are to be up to date together at the same time in order, in the light of the speculations of all the causes in their neighborhood at the start of the previous process, and for the distinctive preparation of local instructions in the corporeal abilities. They have been connected and reintroduced for a wide assortment of purposes and alluded to by an assortment of names, including tessellation automata homogeneous structures, cell structures, cellular structures, and iterative arrays. Von Neumann and Ulam were the ones who introduced cell automata first, which they called it cell spaces, like imaginable idealizing of ‘organic’ outlines (Von Neumann, 1963, 1966), which has a unique enthusiasm behind showing ‘natural self-multiplication’. For a variety of reasons, they have been linked and reinstated and referred to by a variety of names such as tessellation automata homogeneous structures, cell structures, cellular structures, and iterative arrays [50]. In the last two decades, cellular automata models have been created to consider an evacuating group of individuals under different circumstances. These models can be categorized into two groups. The first depends on the associations among situations and walkers.

B. Lattice Gas Models

In 1982 by Fredkin and Toffoli and 1983 by Wolfram Lattice gases were promoted, which is a unique instance of cellular automata [51-53]. The individual on the grid of lattice gas models is measured as an active element. Possibility and measurement were considered to help these models to investigate individuals’ crowd characteristics [49]. Individuals are fixed with L × W in this model, one individual is for one location. Based on executing a biased random walk with no back steps, the individuals move to a special direction, and available locations are allowed solely [54].

C. Social Force Model

In 1995, Helbing and Molnar presented that pedestrian movements can comply with ‘social forces’. The movement of the pedestrian is controlled by the accompanying principle impacts, which are first, pedestrian needs to achieve a specific goal. Secondly, pedestrian keeps a specific separation from different people on foot. The third one is that pedestrian additionally keeps a specific separation from the edge of obstructions, for example, dividers. Fourthly, a pedestrian is some of the time is pulled in by different people or objects [55].

D. Agent-Based Model

ABMs are computational models that assemble social structures from the " bottom-up ", by reproducing people with virtual agents and making promise associations out of the task of principles that run connections among operators [56]. Bonabeau maintained the perspective of the following manner. In describing agent, the manner of mutual fear is an occurrence, which is growing due to the generally complex individual-level manner and cooperation among agents. Therefore, the agent-based model (ABM) appeared to be perfectly suited to give significant prudence into the method and prerequisites for fear and overcrowd by incoordination [57]. Nearly a couple of decades, the ABM method has been utilized to contemplate crowd evacuation in different circumstances. ABMs compare to other methods, such as cellular automata, social force, lattice gas or fluid-dynamic models are commonly more computationally costly. Besides, dealing with heterogeneous people is considerably easier due to ABMs' capacity to enable every agent to have distinctive manners [49].

E. Game-Theoretic Models

On the off chance that the intelligent choice procedure of the evacuees is reasonable, a game-theoretic methodology can be embraced to display the choice circumstance [58]. In a game, the evacuees survey the majority of the accessible choices and select the elective that augments their utility. Every evacuee's last utility adjustments will rely upon the activities picked by all evacuees. Game is the determination of a cooperative state via a group of individuals, conceivable approaches of every individual, and the group of all conceivable utility adjustments. For one leave, the competitive behavior of the walkers in crisis departure could be deciphered in a game hypothetical manner [59]. For a few ways out, Lo et al., built up a non-agreeable game hypothesis display for the dynamic leave choice procedure of evacuees. The model inspects how the reasonable communicating conduct of the evacuees will influence the clearing designs. For the leave determination process, a blended procedure is considered as the likelihood of leave decision. The blended methodology Nash Equilibrium for the amusement depicts the balance for the evacuees and the blockage conditions of ways out [58].

F. Approaches Based on Experiments with Animals

The utilization of creatures is another methodology for examining swarm departure. Tests in real departure freeze are troublesome, particularly with people given conceivable moral and even legitimate concerns. The elements of evacuation restriction are not comprehended because reviews have been largely kept to numerical recreations [60].

3- Macroscopic Model:

Mesoscopic is one of the classical models and in these model movements of large size of people are investigated and somehow individual features are specified, Figure 2.4 illustrates the mesoscopic model. In mesoscopic, cellular automata and gas Kinetic approaches are combined. The following describes cellular automata and gas Kinetic approach:

Cellular Automata (CA) with Gas Kinetic methodology made a mesoscopic model, which utilized the motion of individuals’ observation. Besides, this model presents and imitates the great size of the group [61]. CA is a model, which is divided into numbers of grids; every grid has adjacent and different state [5]. Besides, CA to interact with simulating the departure of agents depends on separation, distribution, and utilizes an irregular way. CA thinks about the collecting manner of the agents. A key part of the CA display is more suitable to speak to the pedestrian stream in perspective of its straightness, flexibility, and effectiveness [62]. Figure 2.4 shows the macroscopic model.

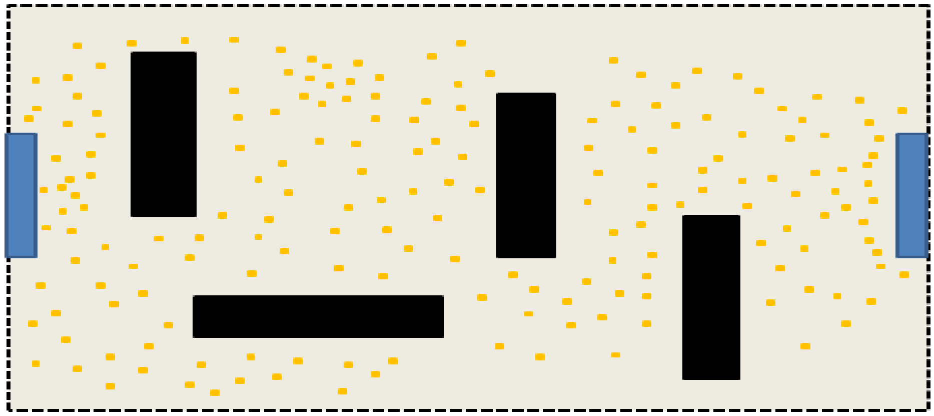

Figure 2. 4 Mesoscopic Model

2.1.2 Hybridized Models

Via using both macro and micro models of the classical models, a model, such as hybridized models designed and it can be divided into three different models; zone-based, layer-based, and sequential based. These models deal with the area of the evacuation and motion of the participants during the evacuation. These models are described in the following points:

1- Zone-Based Model:

In this methodology, the area of simulation is partitioned into numerous zones. In light of user needs, each zone is reproduced either for the microscopic or macroscopic model. Zone imitation under macroscopic procedure gives in the general stream of the group, though zone mimicked with microscopic model offers singular dimension practices perception. Largely, the proposed procedures run the two models all the while on pre-defined zones [63-65].

2- Layer Based Model:

Accepting way of applying both micro and macro methods partly into various layers is another method to deal with mass imitation. These applied methods are used in the whole area of the imitation to determine plane mass movement and additionally motion forms of the agents in the mass. This new method for both distinct layers does the arrangement of the global path, evasion of local obstacle and other wanted manners of the mass [66-68]. Inside this proposed method, the macro method applied to mimic mass motion in accordance set of rules in the first layer and the mass motion manner from this layer goes to the second layer as input. Hereafter, in the second layer micro method is using to mimic motion individuals independently and with rising density protect the cost-effectiveness.

3- Sequential Based Model:

Like layer-based hybrid models, another methodology is a sequential hybrid procedure, which additionally runs both large scale (macro) and small-scale (micro) models for the entire group. It first runs a large-scale model to direct the motion forms of group and after that applies a small-scale model to the same group for watching the individual manners. It executes the two models in a successive way where a synchronization technique is required to exchange the group state between the two modes [69,70].

2.1.3 Generic Model

Due to crowd density, the Simulation of an application nearby requires using most suitable software, the needed dimension of individual manners (corporeal, mental and collective), and execution time. Simulation software projects are reliant on fundamental models that cannot be changed according to end client necessity. Hence, the generic model would be an important need to give the ability to choose models on user selection for detecting different crowd dynamics [71]. The following describes the transit approach:

TransiTUM Model: The latest attempt exhibited to build up a conventional structure for multiscale coupling of walker imitation models for transition zones. Grouping different models, such as mesoscopic and microscopic models need the autonomous of these models. Besides that, essential parameters, such as speed, current location, subsequent goal, max speed and so on could be moved between them via assisting a data file. The displayed model concentrated on autonomous of related models and in this manner can be connected to any mix of mesoscopic and microscopic models. With the assistance of an outer information record, models can openly exchange essential parameters (speed, current location, subsequent goal, max speed and so on) between themselves. It has employed the idea of transit area and relaxation zones to flawlessly move the people from one model to another. Therefore, walkers can enter from any points. Nonetheless, this starter progress in the direction of conventional coupling and multi-point entry to transition zone needs further examination [72].

2.1.4 Literature review on crowd evacuation

In 2006, Zhao et al. offered a two-dimensional cellular automata model to imitate participants leaving through exit dynamics. This study emphasized on two features, way out width and door partition. Hence some convenient aspects appeared, such as the width of the way out ought to be higher than a critical value, and door partition ought to be medium not too large and not too small. Moreover, One way out’s width increment resulted in reducing the flow out for each unit width, nonetheless entire flow out greater than before. Whole way out’s flow out was a cumulative nonlinear function of the way out width.

Furthermore, way out width assessment did not affect on door partition’s best value, and way out design had better be balanced. These aspects improve the efficiency of building design [73].

In 2011, Alizadeh put forward a CA model to examine the procedure of evacuation in a place which was provided with ‘obstructions’ which had various configuration of the place, like places of exit and obstruction, ‘the width of the exit, light’ of the place, psychological status of the evacuee and the dispersal of the people gathered. Its influence was seen in the process of evacuation. A restaurant and a classroom were taken as a case of this model. The way the evacuees distributed, ‘location and with of the door on of the evacuation’ discussed and production of the model was made ready for comparison with some motionless models [74].

In 2012, Tissera et al. exhibited a hybrid simulation model to check behavior patterns in an emergency leaving. Both environmental (EsM) and pedestrian (PsM) sub-models shared inside the hybrid model. Constructing a synthetic location occupied with independent cooperative agents due to the combination of the model with the computational procedure. Authors made sequence investigations; for instance, check the environment to the individuals leaving that were behaviors was available for the ”adjacent door”. After that, check the effect of familiarity of the individuals into the environment, outside motivation to instruct the individuals was utilized to the other conceivable outflow exit. The behavior of people reacting to this improvement is expected to "get out the entryway quicker” [66]. In 2012, Anh et al. showed a hybrid modeling method for evacuation simulation to increase the speed of pedestrians’ movement and worked on the arrangement problem of both micro and macro models. Initial outputs demonstrated that to simulate leaving strategy in road network via the hybrid model more effective than via micro model alone [63].

In 2013, Guo et al. offered an agent-based and fire and pedestrian interaction (FPI) model to investigate the leaving process during an existing emergency. It was thought that the environmental temperature field creates an effect on the probable direction of the movement. Besides, the multi-grid method was applied to define decreasing speed by low transparency in the fire and pedestrian interaction (FPI). Hence, the authors created an extended heterogeneous lattice gas (E-HLG), model. Inside this new model factor of altitude was added to define the height location of lattice locations. Due to the model and experimentations, characteristics of the left in a terrace classroom were studied. Outputs from the extended HLG model were close to the experiments. In addition, leaving controlled due to the altitude factor, and the different decision of choosing evacuation paths and annoying high-temperature field causes to local jamming and clogging [75]. In 2013, Xiong et al. suggested a hybrid model due to utilizing both macroscopic and microscopic models to simulate the crowd in dynamic environments. Movement tendency for the crowd was simulated via the macroscopic model. On the other hand, determining the velocity and moving direction was due to the microscopic model. According to the outputs of the simulation appeared there is a good performance to show the features of crowd movement and humans [76].

In 2014, Guo, Ren-Yong made a model relied on ‘CA with a better separation of the area and advanced speed of walking’ to show going away of people who are walking from a place with one door for exit. Two factors affected the shape of the people gathered during the experiments; ‘the advanced speed of walking and the separation of area’ interval of people at different places and the efficacy of the people who left their houses shown through clocks. Moreover, the connection of ‘width and flow of the exit’ was demonstrated through this archetype [77]. In 2014, Hou et al. applied a modified social force model to simulate the influence of the number and location of the evacuation guides on evacuation dynamics in partial visibility rooms. Inside this model, guiders who are qualified can identify the exit location precisely, and others comply with the guiders' locations and instructions. Experimentations' output reveals for one exit, one or two guiders put a significant impact. Alternatively, for more than one exit position without adequate benefit from the whole exit, the evacuation gets slower. Consequently, it was obvious to increase the effect of guider on making evacuation faster, several exits with the number of evacuation guiders should be equal and guiders properly inside the room centralized of the multi-exits [78].

In 2015, Li and Han proposed a model for simulating pedestrian evacuation relied on widened cellular automata to support various behavioral tendencies in people. Understanding and violence were two of the selected social tendencies to be looked at through this archetype. When examining this simulation, social constraints and pedestrians flow orders were confirmed. The results of the study show that evacuation time does not increase with an individual's knowledge and does not decrease when the individual's condition is noticed as aggressiveness. It is quite obvious that when the individual avoids aggressiveness in his conduct, the best type of evacuation will be recorded [79]. In 2015, Jiang Xueling used cellular automata to show a numerical model. Real-time fire development and group behaviors were measured. For this reason, the evacuation framework and evacuation process mode totally were built. The presented model used to determine the influence of the group and fire distribution on the evacuation. Moreover, capacity of individual tournament was defined. Consequently, the simulation output showed that real time in the fire and group behaviors had a substantial influence on the pedestrian's evacuation. However, in the study it was pointed that all factors could not be measured, due to the lack of empirical data on fire emergency. Hence, only various experimentations were compared via using simulations [80].

In 2016, song et al., created an evacuation scene based on cellular automata and a lattice gas model to simulate behaviors of selfless and selfish for the pedestrians during the evacuation and competitiveness behaviors, meanwhile to present the influence of them on pedestrians' strategies. Furthermore, some experimentation performed on the width of the building exit door and analyzed. Outputs of the simulation tests demonstrated that individuals with self-behavior caused more deficiency and rise evacuation duration. Conversely, sympathy caused to decrease evacuation duration and more collaborators. Finally, an important factor for the duration of the evacuation was the exit door width. When the size was less than six cells of the size of 50 x 50, evacuation time increased, conversely, the time was seriously decreased with increasing the width. However, this would be no noticeable when the door exit width much more increased [81]. Karbovskii et al in 2016 used integration of several modules to present a multi-model agent-based simulation technique. Philosophy of this study has two strategies to direct this integration. Firstly, cooperates of the objects of different models through a shared abstract space. Secondly, persons regularly are organized. Consequently, the agents who work in a common area could be controlled by various agent-based models. Different stories on cinema building evacuation using the general-purpose PULSE simulation environment executed, which is a share out open source solution with MIT license and publicly accessible via GitHub to test this suggested methodology. This study consumes crowd pressure to evaluate the ability of different evolving situations to disturb affect pedestrians in the crowd. Investigation results suggested that stress in crowd started to fluctuate when number of involved agents grew in simulation [82]

In 2017, Han and Liu applied a modified social force model involving an information transmission mechanism to simulate behaviors of walkers, when the majority walkers were unfamiliar with the evacuation location during a disaster. This improved model considers the approach of preventing collision and disappearing information. The difference between this adapted model and the previous model was this altered model defines the way of finding and selecting the correct direction, and the previous model was applied to eliminate the pedestrians collide. The output of the simulation demonstrated that due to information transmission mechanism walkers could determine the right motion direction, although walkers' real behavior could be simulated when an emergency exists. Furthermore, there were different outcomes from the simulation was obtained to enhance the evacuation. Firstly, utilizing all exit door via the occupied extensively reduce time and rise efficiency of the evacuation. Secondly, using exits with more width completely causes the decreasing time of the evacuation and enhancing evacuation efficiency. Thirdly, in the start of evacuation walkers were restricted to select exits with greater width with fewer densities for their evacuation route. Lastly, at the start of the evacuation process essential directing was vital [83].

In 2018, Kontou et al. made a model of crowd evacuation on cellular automata (CA) parallel computing tool to simulate and evaluate manners and different features of pedestrians in the evacuation area; including disables. The simulation process was made in a school where disables existed. A center of education in Xanthi, which contained disable people, was selected for the simulation process. With observing and prevailing earthquake, the school organized security application; the total time of the emptying was noted. Lastly, suggested archetype through the experimental data validated and there was a suitability implication to the particular location [84]. In 2018, Poulos et al.

employed an agent-based evacuation model to simulate the school's staff and nearly 1500 children of an inclusive evacuation process executed for the whole city. This study emphasizes on kindergarten to 12th-grade school and examines the movements of various mediators. This simulation certified via comparing the real event, which shot video of the event, and expected a result from the developed model simulation, errors between the real and expected was the only %7.6. Hence, output said that utilizing a mathematical model in evacuation for adapting logistical issues in an emergency arrangement is fair [85].

Kaserekaa et al in 2018 proposed an intelligent Agent-Based Model, which allowed a modeling and evacuation simulation of persons in a building on emergency, such as, fire. Evaluation of suggested model was built on four factors, such as, the total of people alive (TV), total deaths (TM), average potency of the alive persons (MP), and average time taken to exit (MT). The simulation executed on a building requiring the overall arrangement of Kinshasa supermarkets. Thus, it was appeared thinking again about plan of the supermarket's evacuation during fire occurrence was possible by the authors of the proposed model. Moreover, some evacuee people, fire spreading, speed and other factors could influence the model. This model mentioned the importance of emotion, physical, disability, stress, wind speed, age, and gender that may significantly influence the making decision of people to evacuate. The author hoped to use fuzzy logic to involve these factors inside this model [86].

Table 2. 1 Highlighting previous models and approaches' features, techniques and implications

REF	MTH	MD	PNT	SST	IOB
[73]	CAM	Microscopic	Homogenous	Emergency	Effect of exit dynamics on flux, arching
[74]					Impact of distribution of the evacuees, location, and width of the door on time of the evacuation argued
[66]	Layer-based	Microscopic and macroscopic	Heterogeneous		Clogging and perform goal-directed navigation behavior patterns in an emergency evacuation, environment, familiarity, and external motivation impacts
[63]	Zone-based				Increase speed of pedestrians' movement
[75]	E-HLGM	Microscopic			Altitude factor added caused to control evacuation, choosing evacuation paths, annoying high-temperature field caused to local jamming and clogging
[76]	Sequential-based	microscopic and macroscopic		Normal	Crowd tendency, determine velocity, moving direction
[77]	CAM	Microscopic	Homogenous		The shape of the crowd, duration of the individuals at various positions, the efficiency of the evacuees expressed via two-time indicators, the association between width and flow of the exit
[78]	SFM			Emergency	Effect of Evacuation leaders on the evacuation process
[79]	CAM			Normal	Familiarity and aggressive, evacuation time
[80]	CAM			Emerg ency	Group behaviors, influence of the group and fire distribution on the evacuation, capacity of individual tournament

[81]	LGM and CAM		Heterogeneous		Selfless and selfish for the pedestrians during the evacuation
[82]	ABM				Consumes crowd pressure to evaluate the ability of different evolving situations to disturb affect pedestrians in the crowd
[83]	SFM with the information transmission mechanism		Heterogeneous		Unfamiliar pedestrian behaviors with the evacuation location
[84]	CAM				Disable children, evacuation time
[85]	ABM	Microscopic	Homogeneous	Emergency	Movements of various mediators. Supporting that mathematical model in evacuation for adapting logistical issues in the emergency arrangement is fair
[86]	ABM				Making decision of people to evacuate
My Proposed model	CAM with fuzzy logic, knn, and some statistical equations		Heterogeneous		Emergency behaviours and evacuation time

2.2 Optimization History

Since the computers were developed, the focus was on the aspects of probing unidentified and investigating for the finest solution. Alan Turing in 1945 to infringement Enigma ciphers of Germany within the Second World War utilized search algorithm [87]. Real-life methods advancement and a dramatic rise in the volume of computation caused difficulty in real-life problems. Therefore, issues of fast and proficiently in solving complex problems via old-style methods based on formal logic or mathematical programming were appeared [88]. Many algorithms have been created with a variety of determinations to handle these restraints and optimization problems were one of them. The optimization procedure is getting the best solution in a function due to looking for a parameter. Existing solutions are denoted by entire possible values, which great one is the best solution. Generally, optimization problem solving was the purpose of inventing optimization algorithms [89].

Based on the environment of the algorithms, there is a simple arrangement for optimization algorithms that can separate them into two central groups: deterministic algorithms, and stochastic algorithms. The first group, which is the deterministic algorithms, produces a similar set of answers when similar preliminary starting point uses to begin the iterations due to utilizing inclination for instance hill-climbing with a strict move. Alternatively, the second group, which is the stochastic algorithms regularly, produces various answers with similar preliminary values without utilizing inclination. On the other hand, there is a minor difference in the last values; a similar best solution would meet in a specified accuracy. Stochastic algorithms are categorized into two types: heuristic and metaheuristic [90].

Heuristic algorithms utilize trial and error to look for a solution; in their expectation take a feasible amount of time in achieving a value solution. Likewise, they have a tendency to different approaches in using randomization techniques and local explorations [91]. Additional researches and improvements on heuristic algorithms changed them into metaheuristic algorithms, which these new groups of algorithms have superior performance compared to the heuristics algorithms, therefore prefix of “meta”, which means ``higher'' or ``beyond’’ was linked [92]. Nevertheless, presently these two expressions terms (heuristic and metaheuristic) are indistinguishable to the scientists, though slight dissimilarity exists in their meanings. In recent times, metaheuristic nature-inspired algorithms in solving recent non-linear numerical global optimization difficulties strongly and professionally accomplish. Slightly, entire metaheuristic algorithms attempt to build stability between local exploration and randomization [93].

Lately, existing real-world problems are complicated and considering space, time, and cost, it is unbearable to explore all conceivable solutions. Consequently, to solve such real-world problems, reasonable techniques with low cost, fast is essential. Hence, scientists to know how to deal with their difficulties, they have investigated natural occurrences and animals behaviors, for instance, in what way path selection occur by ants, in what way evasion the enemy and chasing pray occur by a group of birds, flies or fish, and in what way gravity works. Therefore, the name of nature-inspired algorithms was selected for the algorithms enthused with nature [94].

2.2.1 Literature on optimization

There are many nature-inspired algorithms, the University of Michigan from 1960 started to develop such algorithms when Holland and his colleagues published a book in 1960 for their GA and republished it in 1970 and 1983 [95]. Simulated annealing (SA) by Kirkpatrick et al was implemented. The motivation of the SA algorithm was the annealing process of metal [96].

PSO and Ant Colony Optimization (ACO) are two commonly used swarm intelligence, which proposed by Kennedy and Eberhart in 1995 and Dorigo et al., 1996 respectively, PSO enthused from grouping collective behavior of bird in observing for food and ACO enthused from nature of ant, which has ability of holding the previous paths in its mind [97-99]. Authors of the PSO thought these behaviors help the optimization issues; then other algorithms take benefits from the PSO algorithm in defining. In the last two decades, various outstanding intelligence swarms have been suggested, such as Differential Evolution (DE) in

1997 was offered by R. Storn and K. Price, it was a vector-based algorithm and performed better than GA in many applications [100].

In 2005 Artificial Bee Colony (ABC) proposed by Karaboga and Basturk [101, 102]. Xin-She Yang created the Firefly Algorithm (FA) in 2009 [103]; and then, the same year by the same author (CS) was suggested [104]. Moreover, a bat-inspired algorithm was another suggestion by Xin-She in 2010 [105]. Future, artificial plant optimization algorithm (APOA) proposed by Bing-Yu et al., in 2013, it is inspired by the natural plant growing process [106]. Additionally, Li et al., in 2014 offered a newly announced algorithm; Animal Migration Optimization (AMO), which is enthused from swarm migration behavior in animals [107]. Later, Mirjalili A. S. proposed three algorithms; first, DA in 2015 based on food fascination and enemy diversion behaviors, second, WOA in 2016, third, in 2017, Salp Swarm Algorithm (SSA) [108-109]. Novel ABC had been altered with two modified ABC were created by Laizhong et al., in the first variant an adaptive method for the population size (AMPS) was implemented by the authors [110], and authors in the second variant implemented a ranking based adaptive ABC algorithm (ARABC) [111], these variants were for improvement exploitation in the original ABC algorithm. In 2019, Jaza Abdullah and Tarik Rashid developed a Fitness dependent optimizer or FDO algorithm, the FDO algorithm looks at the behaviors of bee swarm during the reproduction and imitates the swarm bee activities. Finding a different proper solution among various possible solutions builds a substantial part of this algorithm [112].

Researchers extensively utilized the above mentioned algorithms in a lot of various areas. However, there is no specific algorithm to achieve the most fitting solution for the entire optimization problems. Some algorithms yield better solutions for some specific problems compared with others. Therefore, chasing adaptation in optimization techniques is an open problem [113].

2.2.2 Fitness Dependent Optimizer (FDO)

The FDO can be divided into the scout bee searching process and the scout bee movement process. In the scout bee searching process, the algorithm makes the scout bees search for a suitable hive (solution) among many potential hives (solutions). Through the scout bee updating process, the algorithm utilizes a random walk and a fitness weight mechanism to move into a new position; accordingly, this section contains two parts.

A. Scout Bees Searching Process

The process of scout bees searching numerous possible hives to obtain a new proper hive means that the main part of this algorithm focuses on that process. In this algorithm, a proper solution is denoted by a scout bee that searches for a new hive. Moreover, meeting optimality means choosing the best hive among numerous hives. Furthermore, when the FDO begins execution, it defines an artificial scout population with random locations in an X_i ($i=1, 2, \ldots n$) space search by means of upper and lower boundaries. Through the execution, the FDO picks the global best solution. Finding a new hive (solution) in this algorithm is represented by a scout bee position. Scouts based on a random walk search in the search space for a more suitable solution as shown in the pseudocode of the single objective FDO see figure 2.5; when the more suitable solution is revealed, the earlier solution is ignored. Nevertheless, if the scout cannot achieve a more suitable solution, then it uses the former solution with the expectation of finding a more suitable solution next time. Finally, in the case of not finding a more appropriate solution with the former solution, the scout will continue with the current solution, which is the best solution at that time.

```
Initialize scout bee population X_{i,t} (i = 1, 2, ..., n)
while iteration (t) limit not reached
    for each artificial scout bee X_{i,t}
        find best artificial scout bee x*_{i,t}
        generate random-walk r in [-1, 1] range
        if(X_{i,t} fitness == 0) (avoid divide by zero)
            fitness weight = 0
        else
            calculate fitness weight. equation (2.2)
        end if
        if (fitness weight = 1 or fitness weight = 0)
            calculate pace_{i,t} using equation (2.3)
        else
            if (random number >= 0)
                calculate pace_{i,t} using equation (2.5)
            else
                calculate pace_{i,t} using equation (2.4)
            end if
        end if
        calculate X_{i,t+1} equation (2.1)
        if(X_{i,t+1} fitness < X_{i,t} fitness)
            move accepted and pace_{i,t} saved
        else
            calculate X_{i,t+1} equation (2.1) with previous pace_{i,t}
            if (X_{i,t+1} fitness < X_{i,t} fitness)
                move accepted and pace_{i,t} saved
            else
                maintain current position (don't move)
            end if
        end if
    end for
end while
```

Figure 2. 5 Pseudocode of SOFDO [112]

B. Scout Bee Movement Process

In this algorithm, the scout, to obtain a better solution, updates its current position by adding pace. The updated artificial scout bee can be calculated according to equation (2.1) as follows:

$$X_{i,t+1} = X_{i,t} + pace \qquad (2.1)$$

where i denotes the current search agent, t denotes the current iteration, X denotes an artificial scout bee (search agent), and pace denotes the movement rate and direction of the artificial scout bee. The pace is typically reliant on the fitness weight fw. Nevertheless, a random mechanism completely relies on the direction of the $pace$.

In FDO, the fitness weight (fw) value is typically utilized to manage the $pace$. The algorithm determines the fitness weight (fw) for every artificial scout using equation (2.2).

$$fw = \left| \frac{x^{*}_{i,t\ fitness}}{x_{i,t\ fitnees}} \right| - wf \qquad (2.2)$$

where $\mathrm{x}^{*}_{\mathrm{i,t\ fitness}}$ denotes the best global solution's fitness function value that has been revealed so far. $xi, t\ fitness$ denotes the current solution's value of the fitness function; wf denotes a weight factor, randomly set between 0 and 1, which is used for controlling the fw.

Later, the algorithm considers some settings for (fw), for instance, if fw = 1 or 0, and $\mathrm{x}_{\mathrm{i,t\ fitnees}}$ = 0, the algorithm sets the pace randomly according to equation (2.3). On the other hand, if fw > 0 and fw < 1, then the algorithm generates a random number in the [-1, 1] range to make the scout search in every direction; when r < 0, pace is calculated according to equation (2.4), and when r >= 1, pace is calculated according to equation (2.5).

$$\left\{\begin{array}{ll} fw = 1\; or\; fw = 0 \text{ or } x_{i,t\,fitness} = 0, \quad pace = x_{i,t} * r & (2.3) \\ fw > 0\; and\; fw < 1 \left\{\begin{array}{ll} \mathrm{r} < 0, \mathrm{pace} = \left(\mathrm{x}_{\mathrm{i,t}} - \mathrm{x}^{*}_{\mathrm{i,t}}\right) * \mathrm{fw} * -1 & (2.4) \\ \mathrm{r} \geq 0, \quad \mathrm{pace} = \left(\mathrm{x}_{\mathrm{i,t}} - \mathrm{x}^{*}_{\mathrm{i,t}}\right) * \mathrm{fw} & (2.5) \end{array}\right\} \end{array}\right\}$$

where r denotes a random number in the range of [-1, 1], xi, t denotes the current solution, and $\mathrm{x}^{*}_{\mathrm{i,t}}$ denotes the global best solution achieved thus far. Among various applications for random numbers, the FDO selects Levy flight because it considers further stable movement via its fair distribution curve [93]. The FDO pace is saved in every iteration for the accepted solution, and then it can be used next time see pseudocode of the single objective FDO in figure 2.5.

2.3 The k Nearest Neighbours Algorithm

This algorithm work with a training set and look at each feature in the training set as a various dimension in an area. Each dimention would have a value of observation, thus there are number of points in the area. Hence, similarity of two points can be measured which is the distance between them. This measurement can be specified via some appropriate metrics such as Euclidean, Manhattan, and others [114]. In the following the equation of euclidian distance is shown:

$$\mathrm{dist}((\mathrm{x}_1, \mathrm{y}_1), (\mathrm{x}_2, \mathrm{y}_2)) = \sqrt{(\mathrm{x}_2 - \mathrm{x}_1)^2 + (\mathrm{y}_2 - \mathrm{y}_1)^2} \qquad (2.4)$$

Where x_2 and y_2 presents the coordinate of the exit door location, and x_1 and y_1 presents the coordinate of the pedestrian's location.

Consequently, the algorithm to select most common class among many classes makes a decision to choose the nearest data points to the new observation [115].

2.4 Fuzzy Logic Technique

In the mid-1960s fuzzy logic was expressed by Lotfi Zadeh, based on previous work in the area of fuzzy set theory. Moreover, Fuzzy logic is an advancement of boolean logic, in which a degree of truth could be indicated for any concept between 0.0 and 1.0. Furthermore, inaccuracies and uncertainties can be treated with the fuzzy logic. Consequently, due to the combination of the fuzzy logic with linguistic variables as shown in figure 2.6, the membership functions were chosen to define fuzzy systems in natural language [116, 117]. The following is the definition of the linguistic variable:

> *Let V be a variable (quality of service, tip amount, etc.), X the range of values of the variable and TV a finite or infinite set of fuzzy sets.*
> *A* ***linguistic variable*** *corresponds to the triplet (V, X, TV).*

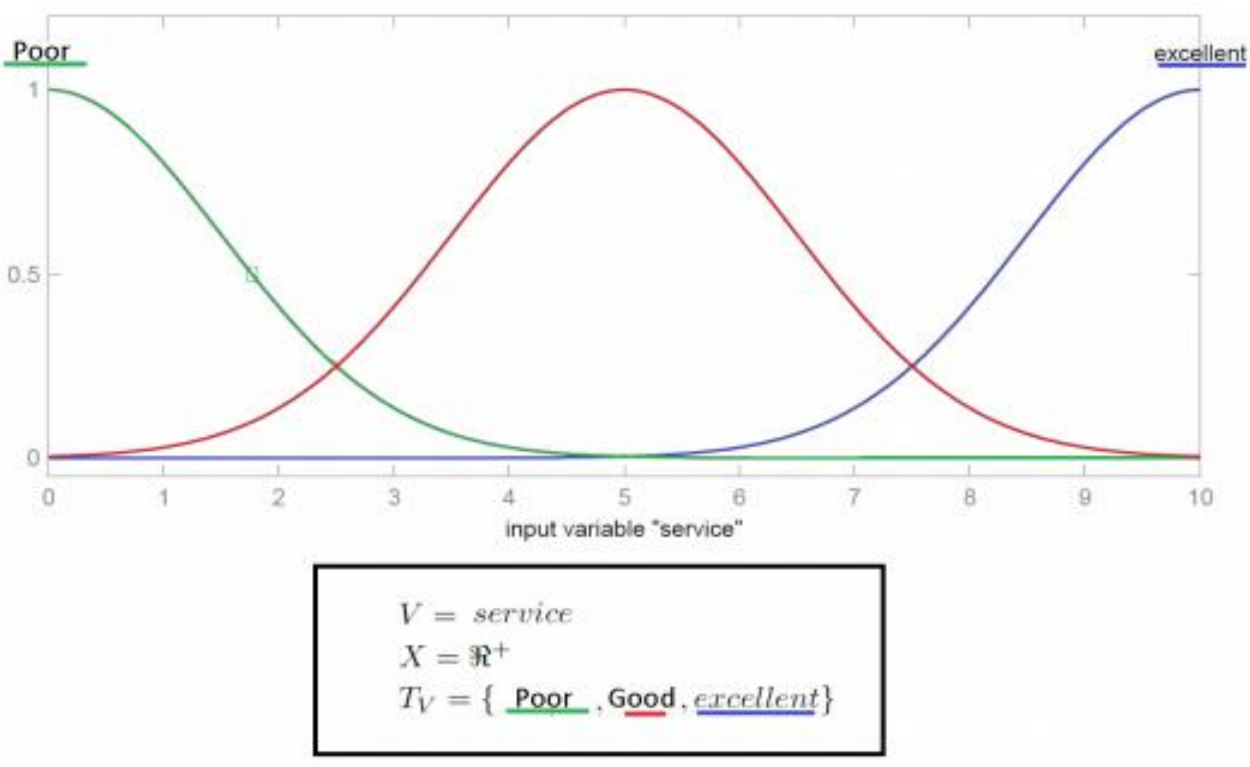

Figure 2. 6 Linguistic variable ‘quality of service’ [116]

Membership function has various forms, such as exponential, sigmoid, gaussian, tangent, hyperbolic, triangular, and trapezoidal can be selected by following the guidance of the expert or by statistical studies. In this study tringuler function, traposidal R-function, and L-function are considered. In the following these functions will be explained [118].

Triangular function: defined by a lower limit a, an upper limit b, and a value m, where a < m < b. Figure 2.7 shows the tringuler function.

$$\mu_A(x) = \begin{cases} 0, & x \leq a \\ \frac{x-a}{m-a}, & a < x \leq m \\ \frac{b-x}{b-m}, & m < x < b \\ 0, & x \geq b \end{cases}$$

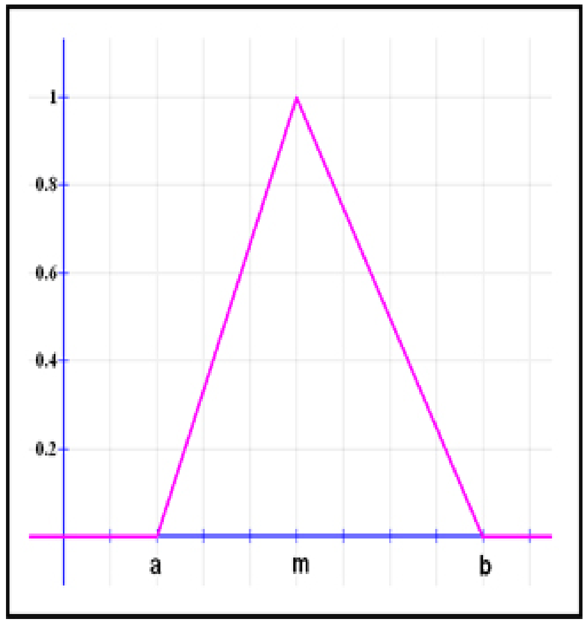

Figure 2. 7 Triangular function [118]

Trapezoidal function: defined by a lower limit a, an upper limit d, a lower support limit b, and an upper support limit c, where a < b < c < d. There are two special cases of a trapezoidal function, which are called R-functions and L-functions. Figure 2.8 shows trapezoidal R-functions with parameters c = d = - ∞ and 2.9 shows trapezoidal L-functions with parameters a = b = + ∞.

$$\mu_A(x) = \begin{cases} 0, & x > d \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 1, & x < c \end{cases}$$

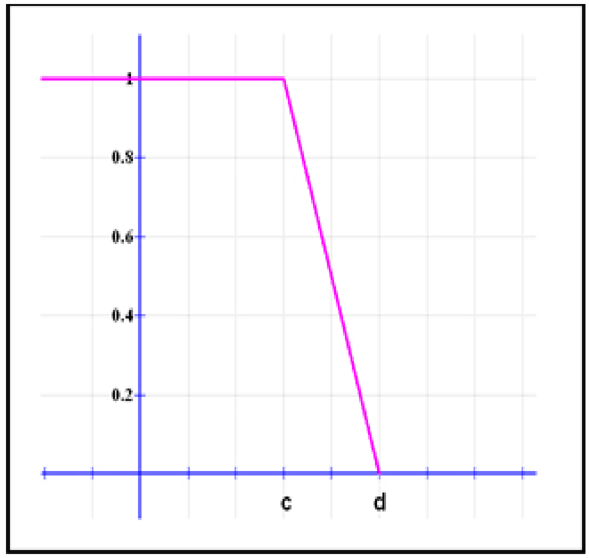

Figure 2. 8 Trapezoidal R-function [118]

$$\mu_A(x) = \begin{cases} 0, & x < a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & x > b \end{cases}$$

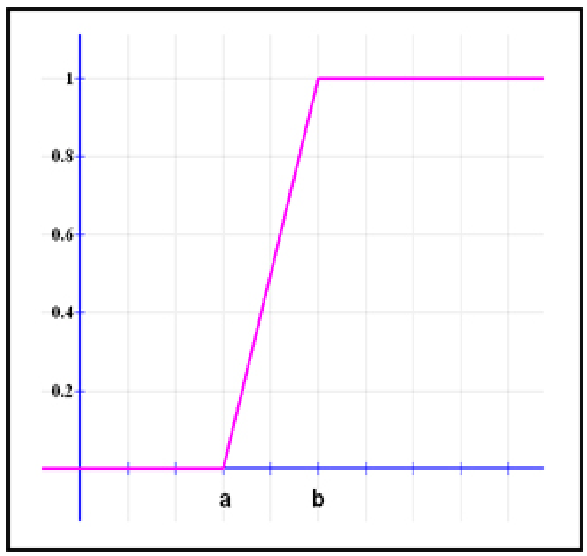

Figure 2. 9 Trapezoidal L-function [118]

CHAPTER 3: Research Methodologies

This chapter can be divided into two parts, the first part discusses the methodology of the created our intelligent crowd simulation model, the second part argues the methodology of improvement in one of the the most recent algorithm (FDO) and implemented (IFDO).

3.1 Methodology of the Intelligent Crowd Simulation Model

In this part the methodology of the created our intelligent crowd simulation model will be discussed in the following subsections:

3.1.1 Data Collection

Various techniques exist to collect data. Notice straight situations of emergency are crucial to get dependable data for various styles of environments, but the altered method was used due to its difficulty. For example, values of the entire parameters were listed via general databases and inside them, few pieces of knowledge for the variety of the agents were provided. Also, the building interior is a significant factor for crowd evacuation and according to Zhang researches were examined the geometry's influence on the crowd, evacuation is insufficient. Furthermore, positions of the obstacles and space size have a great part during evacuation. Consequently, the data of this research was gathered from an interview which that contains several structured questions about physical, biological and emotional properties. In addition to that, a direct questionnaire is used which contains several dichotomous questions of the type of closed-ended questions. To find samples of the interview and questionnaire see Appendix A, and also to find a sample of the used data see Appendix B.

3.1.2 Model Structure

Here the structure of the proposed model is presented and explained. With having an emergency inside a building, all individuals try to move towards the main exit doors to evacuate. Hence, congestion could easily occur as the building style is complex that contains multiple exit doors, obstacles, and people might be not familiar with the architecture of the building or choose the main entrance randomly or follow others to evacuate regardless of choosing the path is safer or shorter. These agents might have some behaviors when they move to evacuate, such as, failing, waiting, helping, jumping, and others as well as they have their properties, which are used for identifying their speed. Emergency, such, as fire, smoke, and others has its role in managing the speed of agents. Consequently, environment components, speed of agents, and behaviors patterns together execute the simulating process of evacuation duration of agents and different behavior of each agent within the evacuation process. Finally, the result of both executed processes could be viewed. Figure 3.1 shows the structure of the presented model which comprises all components that participate in executing the simulation process during an emergency situation. Moreover the figure divided into several linked parts to clarify sequence of performing the simulation procees by our created intelligient model.

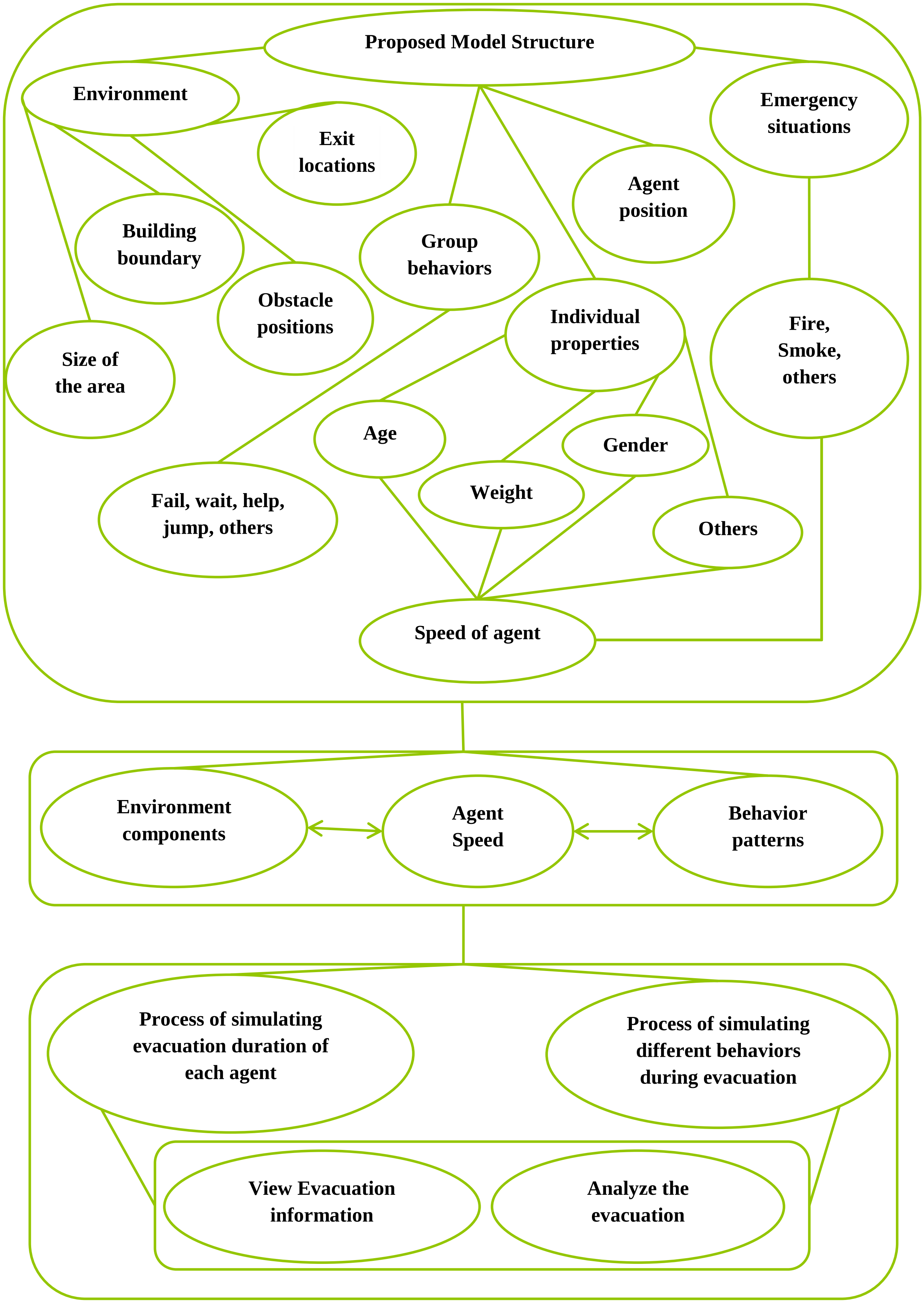

Figure 3. 1 Model Structure

3.1.3 Model Description

Here the developed model is explained and the implementation of the case study’s geometry, agents, and their behaviors and distributions is described. In the next subsection describing the agents’ speed will be clarified. Figure 3.2 shows the design of this model.

In this study, a pedestrian crowd evacuation during emergency-based CA is built. This model is managed for the first floor of the case studies see figure 3.7. This floor is created according to the CA method which belongs to a family of microscopic models, which discrete, continuous, and dynamic are characteristics of that family. Thus, the floor is separated into grids. Each grid is a cell with a size of $0.5*0.5^{m2}$. Typically, cells may get occupied by agents, walls, exit doors or obstacles or may be empty. To separate the area into grids, a two-dimensional array is used with the size of the floor is going to be created. For the case study’s of this research the dimention was (100*100). Moreover, Different agents are implemented, such as males and females with the difference in physical, biological, and emotional properties. These properties are treated via the idea of fuzzy logic technique see figure 3.3 and 3.4. Inside this model, the agents are distributed through the floor of the building either manually or randomly. Furthermore, the emergency is considered as a coefficient, which makes an influence on the agent’s speed rather than visible for the agents during the evacuation. Additionally, it can be said that KNN used to find the nearest exit location by the evacuees to evacuate, for more details see figure 3.5 and 3.6. Figure 3.7 clarifies that there are different components inside our model, such as main walls that close the area and specified with the cyan color, rooms’ wall specified with the pink color, the gray color is used for obstacles and the yellow for agents inside the building, exit doors are specified with the dark blue. Moreover, the figure presents the agent's distribution through the building floor.

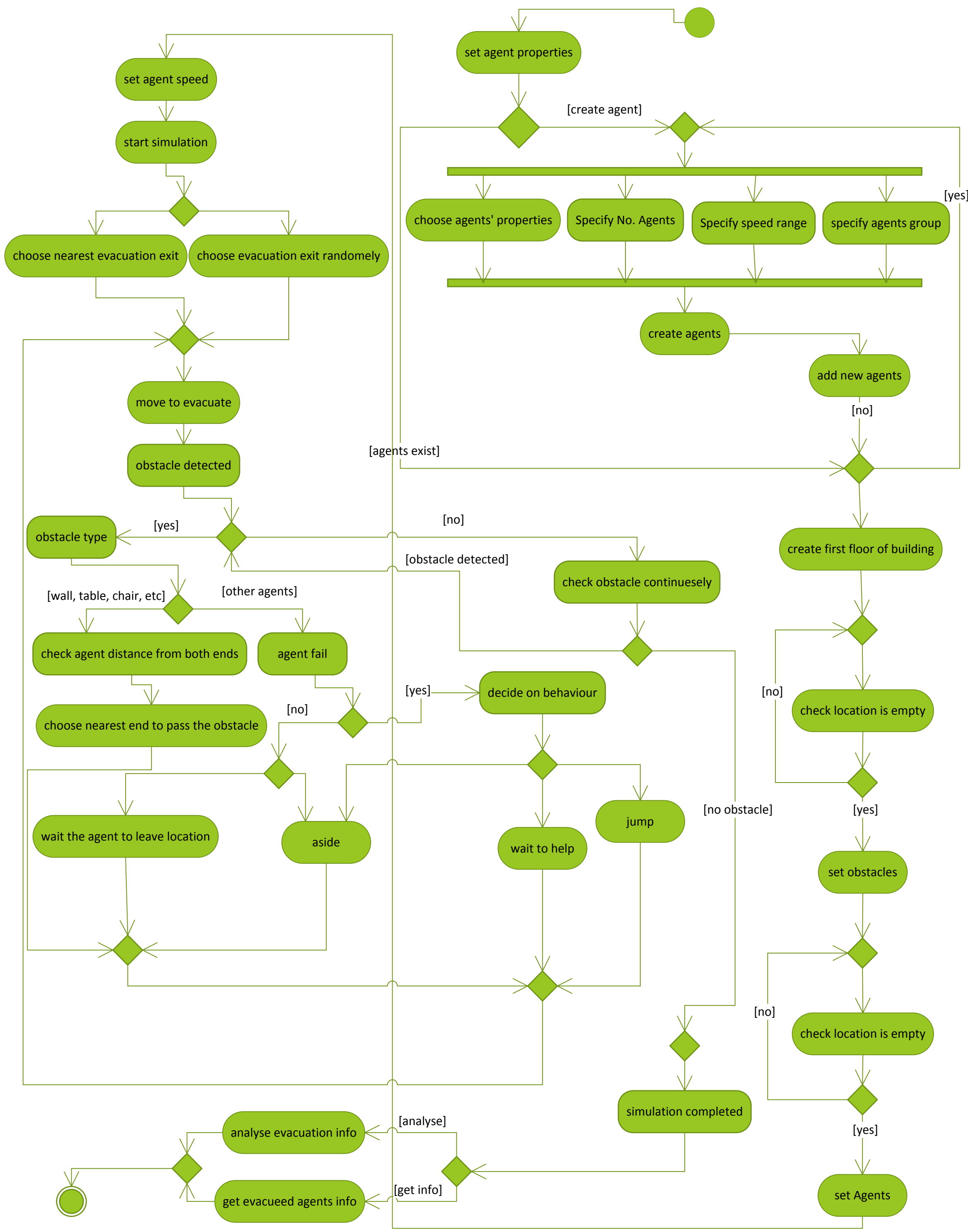

Figure 3. 2 Illustrates the design of this model

```
Determine evacuees individual properties(p = 1, 2, ..., n)

Generate factor gender (gi) for male gi = 1.0, for female gi = 0.5

Generate factor emergency (ei) for normal situation ei
                = 1.0, for emergency situation ei
                = 1.07Generate value of each property (property_value)

Generate fuzzy linguistic variables (age, weight, disease, collaboration,
shock)
Generate membership functions of linguistic variables

Generate degree of truth between [0,1]range

Upper is upper value of the degree of truth

Lower is the lower value of the degree of truth

While iteration (t) limit not reached

    For each individual property of the evacuee
      Find degree of truth value (upper and lower)for each property

      using membership functions (3.11.,3.12, and 3.13)

      Find mv of the interval that property value fall in ...

      ... using equation (3.4)

      If (prop_value < mv)
          Calculate weightedmean using equation (3.2)
      Else

      If(prop_value > mv)

          Calculate weightedmean using equation (3.3)

      Else

          Calculate weightedmean using equation (3.2) or equation (3.3)
          desired speed of the agent saved
      End if
      End if
    End for
End while
Calculate speed using equation (3.5)
```

Figure 3. 3 Pseudocode of used idea of fuzzy logic technique

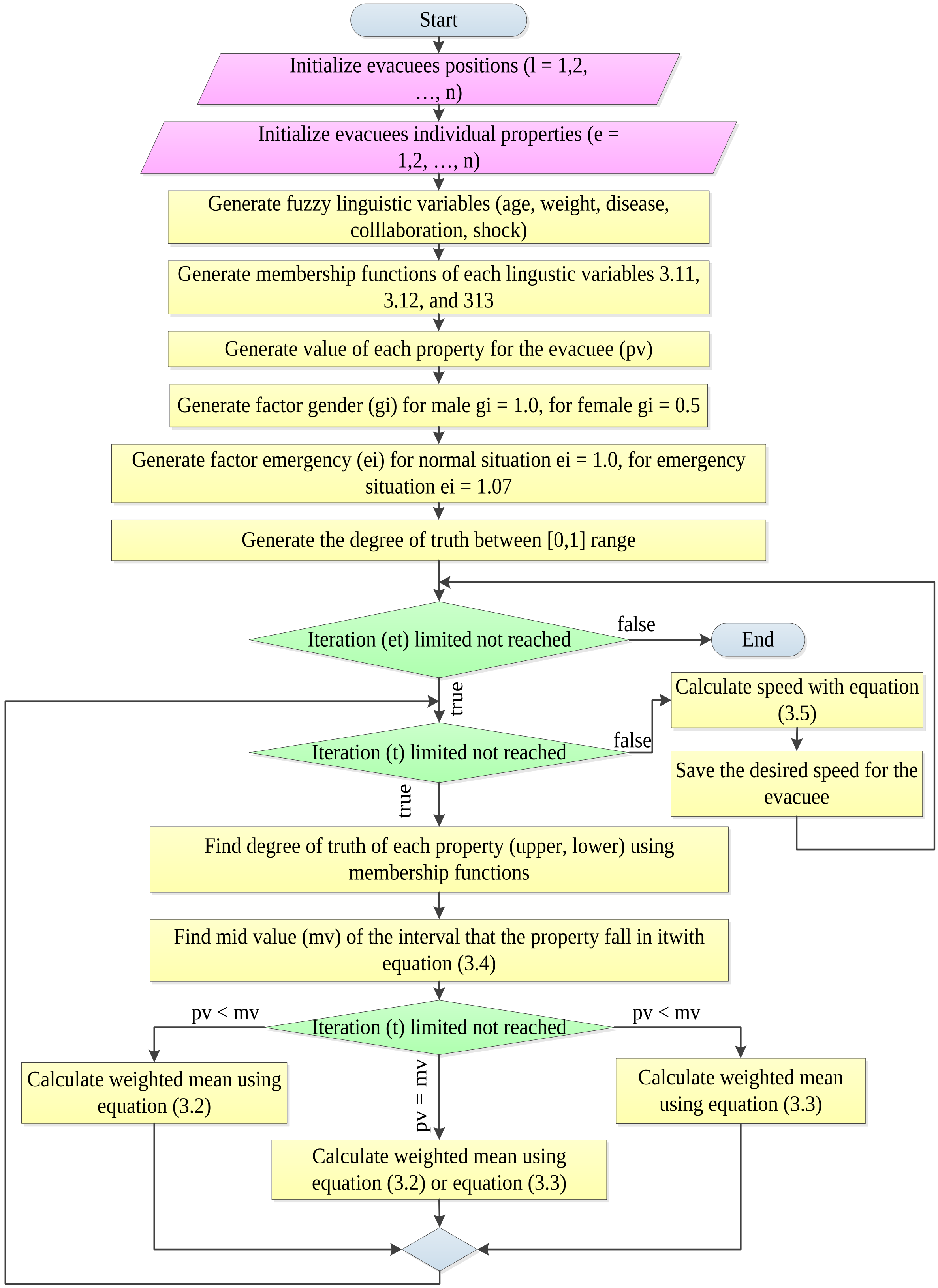

Figure 3. 4 Flowchat of used the idea of fuzzy logic technique

```
Initialize evacuees and exit doors

Organize (E, G, e)

where E: all points of the exit locations G: class of exit doors e: agent

While i = 1 to n do

    Calculate distance (Ei, e)

End while

Calculate set L comprising locations for the k smallest distances d(Ei, e)
```

Figure 3. 5 Pseudocode of KNN to find nearest exit location

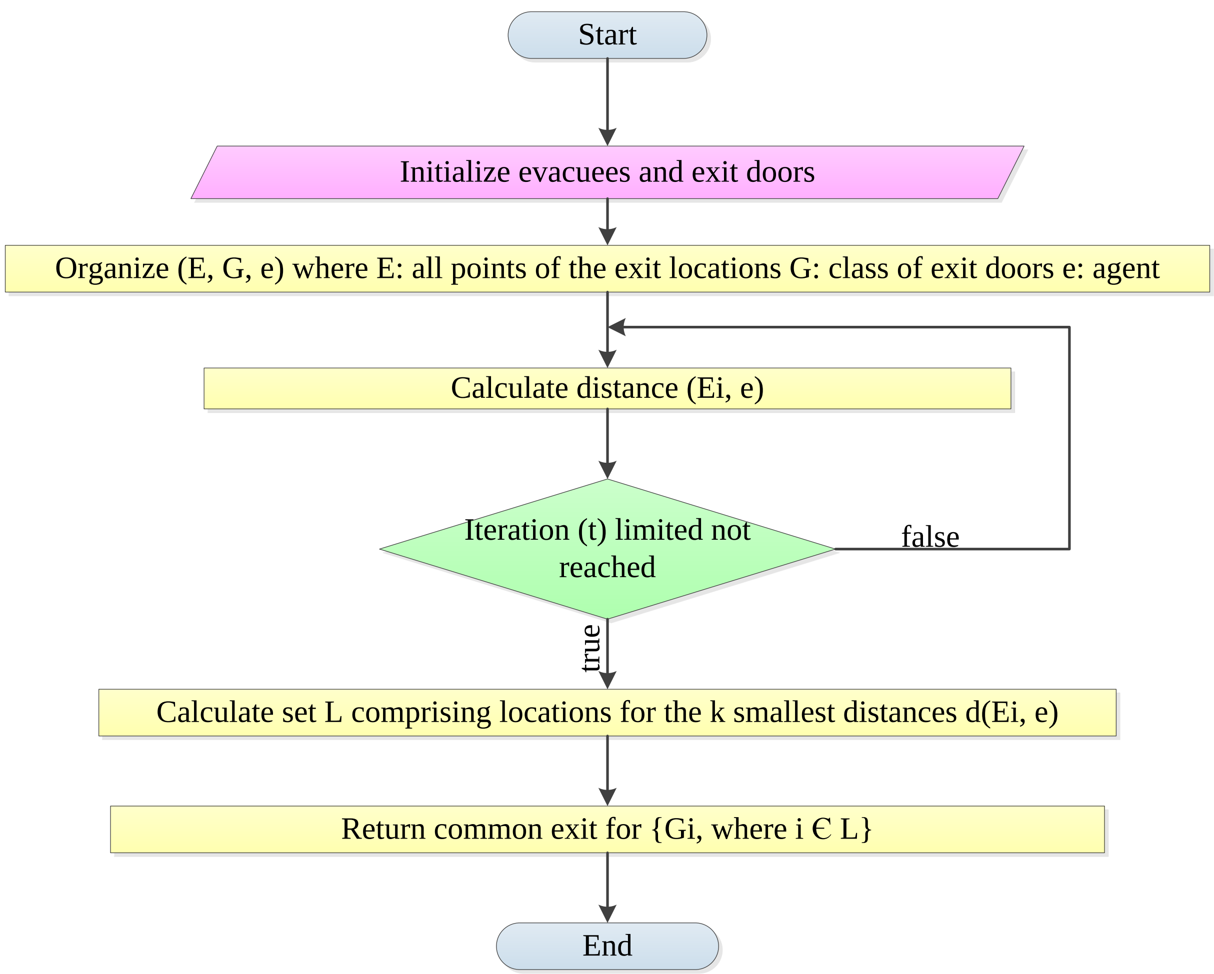

Figure 3. 6 Flowchart of KNN to find nearest exit location

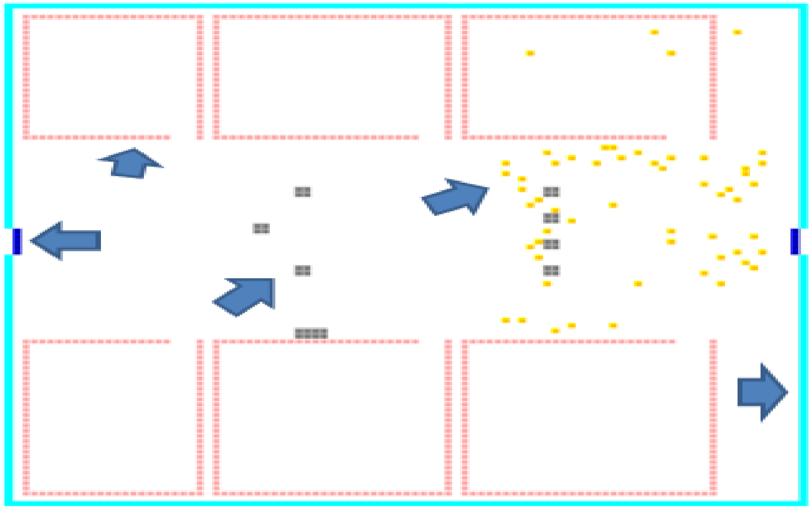

Figure 3. 7 Illustrates the implemented first floor of the case study

Inside this model, the agent can move with 8 directions during the evacuation. Figure 3.8 is the moving directions of the agents.

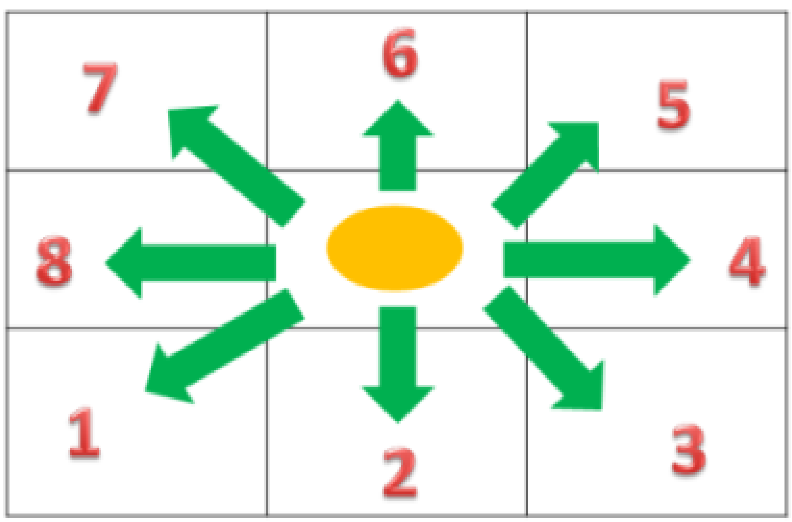

Figure 3. 8 Illustrates the directions of the agent's movement

Inside this framework, agents move with specified speed but when face obstacles or collapse with other mediators and this might cause delay for some while. Upon this case, several behaviors appeared; for example, when an agent faces an obstacle, it checks its distance from both ends of the obstacle. Then, the agent decides to pass the obstacle from the closer end via a method created inside our model sees figure 3.9.

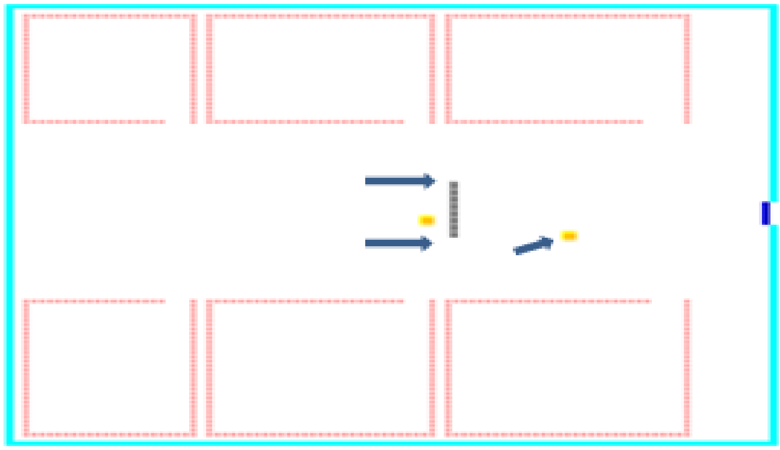

Figure 3. 9 Illustrates the agent behavior when faced obstacle

Moreover, when an agent collapses with another agent, either the agent waits for the other agent to go from the occupied location or the agent passes the other agent and goes to another empty location. When the agent waits for others its color changes into dark green, while the agent passes the others then its color changes into light green (see Figure 3.10).

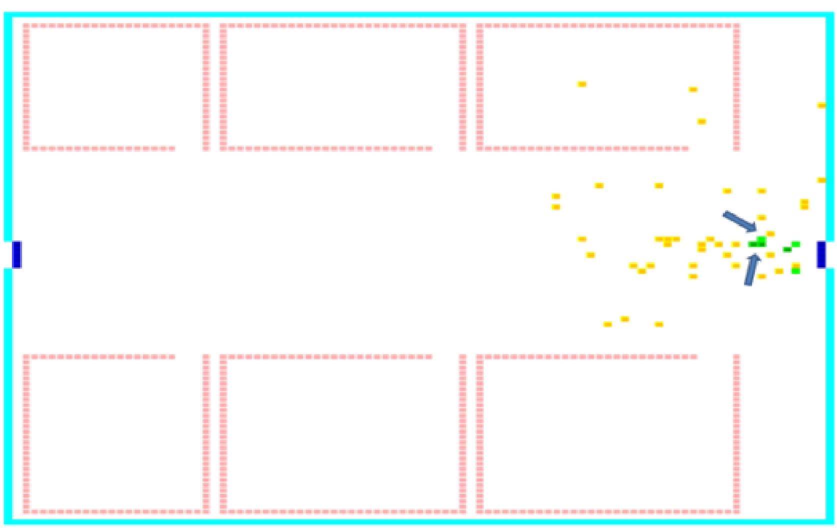

Figure 3. 10 Illustrates the agent behavior when faced other agent

3.1.4 Define Evacuee Speed

Here in this part, the desired speed of each agent as mentioned in the previous subsection is clarified.

As explained in the first subsection in section 1 chapter 3, each agent has its physical, biological, and emotional properties, which are collected via interviews. Thus, in this model, the speed of the agents will be determined from those agent's characteristics. For this specification, this model acquires some benefits from the fuzzy logic technique. The rest of this part explains how this model conducts the desired speed for each agent. To formulate the fuzziness into a distinct measurable parameter, the fuzzy logic idea could be used. Hence, to attain a realistic solution, the fuzzy logic-based model can be accepted. Reality is treated in fuzzy logic, which is a method of a lot of valued logic. From this, our model learns to use the idea of a fuzzy logic technique to analyze the agent's properties and based on that calculates the desired speed of the agent. First, the found properties of the participant are managed as fuzzy linguistic variables to represent the qualities spanning a particular range. For instance, age {adult, very young, young, old, and very old}, weight {very slim, slim, heavy, and very heavy}, disease {very low, low, medium, high, and very high}, shock {very low, low, medium, high, and very high}, and collaboration {very low, low, medium, high, and very high}. Then membership to each range is managed based on triangular, trapezoidal R-functions, and trapezoidal L-functions as showed in chapter 2 figures 2.7, 2.8, and 2.9. Figures, 3.11, 3.12, 3.13 present the membership functions of the age, weight, disease, shock, collaborate respectively.

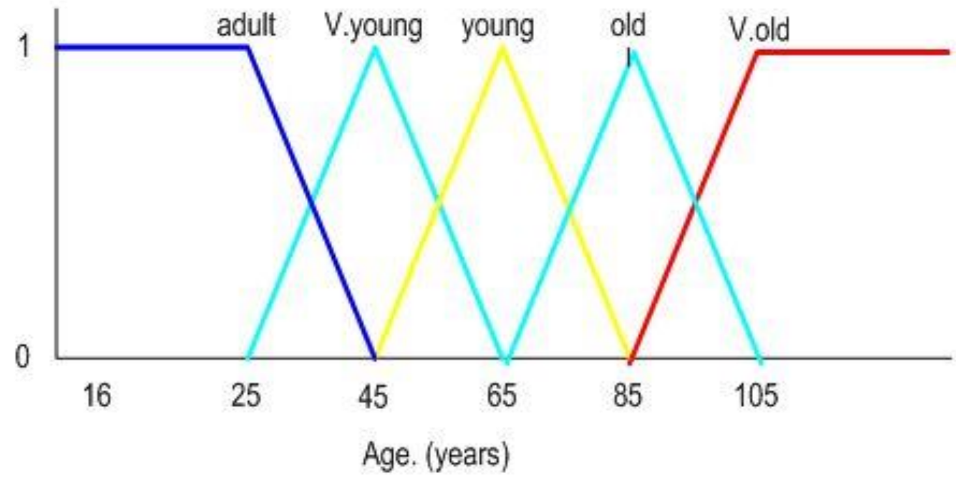

Figure 3. 11 Age membership function

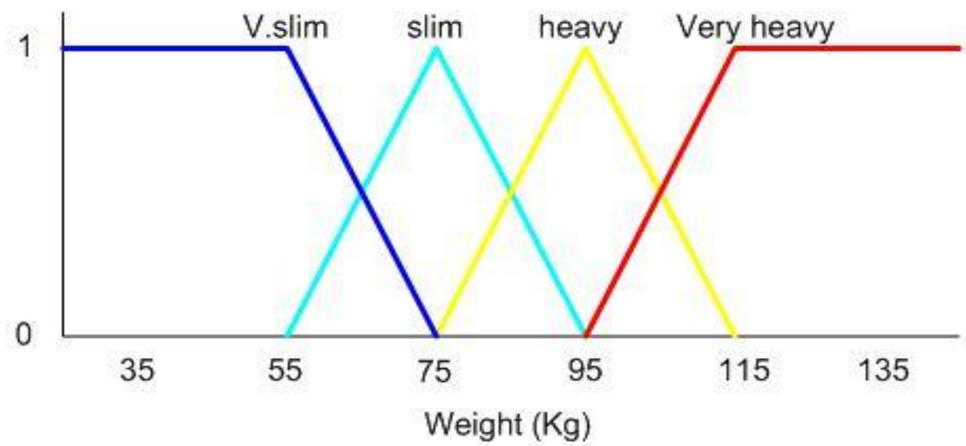

Figure 3. 12 Weight membership function

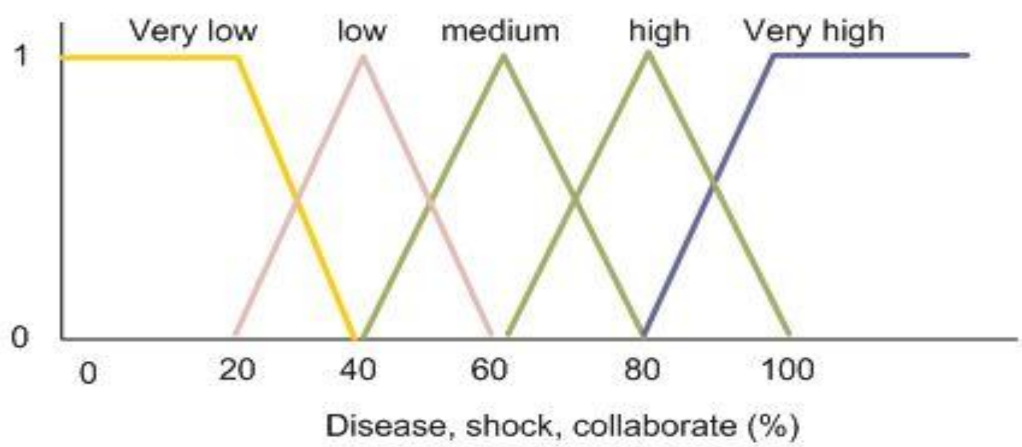

Figure 3. 13 Disease, shock, collaborate membership function

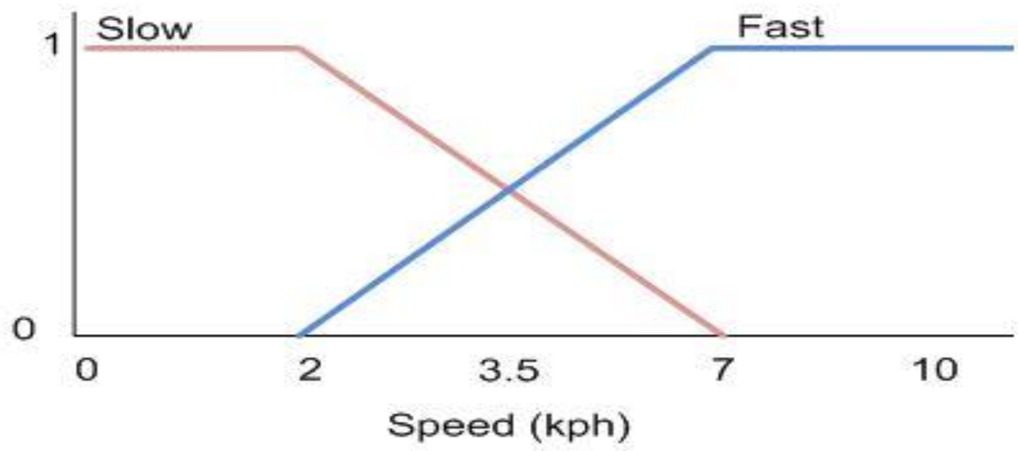

Figure 3. 14 Speed membership function

The degree of each property of agent is determined via the proposed membership functions (See Figures 3.11, 3.12 and 3.13). The speed range for the degrees is managed on the speed membership Figure 3.14. Each property would have two values lower and upper and then these values would be worked on via weighted mean (See Equation 3.1).

$$weightprop = \frac{\sum_{i=1}^{n} w_i * sr_i}{\sum_{i=1}^{n} w_i} \qquad (3.1)$$

wi is the degree of the given property's value and sri is the speed range for the degree. Equation 1 in this research designed in different ways to create heterogeneity within a single class interval (see equation 3.2 and 3.3). In the following example conducting the desired speed is explained:

Let an agent has two properties, such as age and weight properties. First of all, the weight of each property is defined separately via using equations (3.2) and (3.3).

$$weightprop = weighted\ mean = (l * minisr + u * maxisr)/(l + u) \qquad (3.2)$$

$$weightprop = weighted\ mean = (u * minisr + l * maxisr)/(l + u) \qquad (3.3)$$

l and u are lower and upper values of the given property value respectively, $minisr$ is minimum interval speed range and $maxisr$ is maximum interval speed range. To use these equations, the model should find the degree of the given property value. Hence, the created membership functions are used (see Figures 3.11 and 3.12). For instance, for the age property, if an agent is 27 years old, the membership function of age is used (See Figure 3.11). This membership function consists of numbers of class intervals. To find the right class interval, the model checks the intervals and finds the right one (See Figure 3.16). Consequently, the model finds 27 years old comprised of 0.7 adults and 0.3 very young. These two values would be the given property value's upper and lower values respectively. Moreover, the membership function of speed is used (See Figure 3.14) to find the given property value at which speed range is. In this study, the speed range defined between 2k/h and 7k/h. To preserve the logical variation in the property's weight values for different agents within the speed range, this model separates the speed range into several class intervals, for instance, if agent is 27 years old class interval for speed would be 5k/h - 6k/h, while for agent is 49 years old class interval for speed would be 4k/h - 5k/h (See Figure 3.16). The reason for this difference range is related to the logic, which the elder person is slower than younger. Furthermore, we should find the mid-value of the chosen class interval using the Midvalue equation (See Equation 3.4).

$$Midvalue = lv + uv/2 \qquad (3.4)$$

lv is the lower limit and uv is the upper limit of the chosen class. $Midvalue$ separates the class interval into two different parts, the first half of the interval and the second half of the interval (see Figure 3.16). This operation is used to create various weights for the given properties values in both halves of intervals, from this operation the repetition of weight is avoided and heterogeneity in agents' properties weights is formed. Hence, if the given property value is smaller than the mid-value, the model uses equation (3.2) to find the weight of the given value, otherwise, if it is greater than the mid-value, the model uses the equation (3.3). However, if the given value is equal to the mid-value both equations (3.2) and (3.3) give the same weight. The same operations are used for weight property. After that, the mean of the properties' weights is calculated via equation (3.5), which is the mean equation to conduct the desired speed for the agent with the multiplication of g_i and e_i where g_i and e_i are gender and emergency coefficients respectively. Table 3.1 Shows an example of some of the agents desired speed using fuzzy logic technique in finding the degree of truth of the property's value. To see all agents look at appendix C.

$$desiredSpeed = \left(\frac{\sum_{i=1}^{n} w_i}{n}\right) * g_i * e_i \qquad (3.5)$$

Finally, factors of the gender and emergency were counted for the desired speed. From this, the desired speed is affected by those factors, while speeds for male and female is different even both have the same properties. The female speed in our expectation for the simulation was decreased by 0.5, while the male speed remains the same for the simulation. Thus if the speed of males is 5.5 kilometer per hour (kph), it is for female agents decreased to 3.3 kph. Therefore, the created model set g_i factor to 0.5 for female and 1.0 for male. On the other hand, during an emergency, evacuees run as fast as they could. Hence, the speed of the evacuees during an emergency is more than the normal situation, therefore the created model during specifying the desired speed set e_i factor with 1.07 for emergency situation and 1.0 for normal situation. Figure 3.15 illustrates the conducted desired speed in kph for the agents.

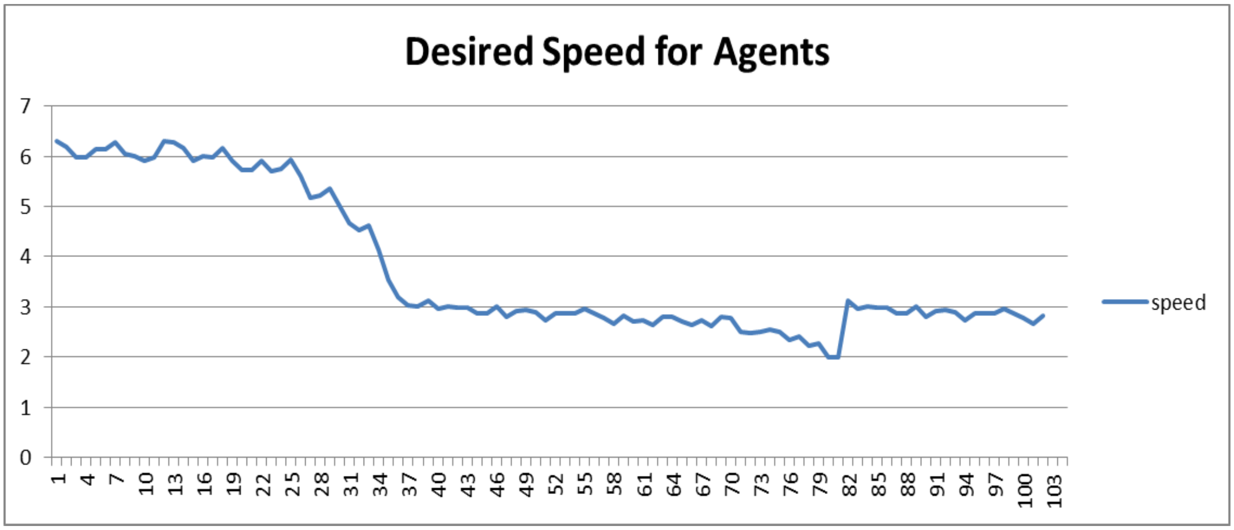

Figure 3. 15 Result of determining the desired speed for agents based their properties

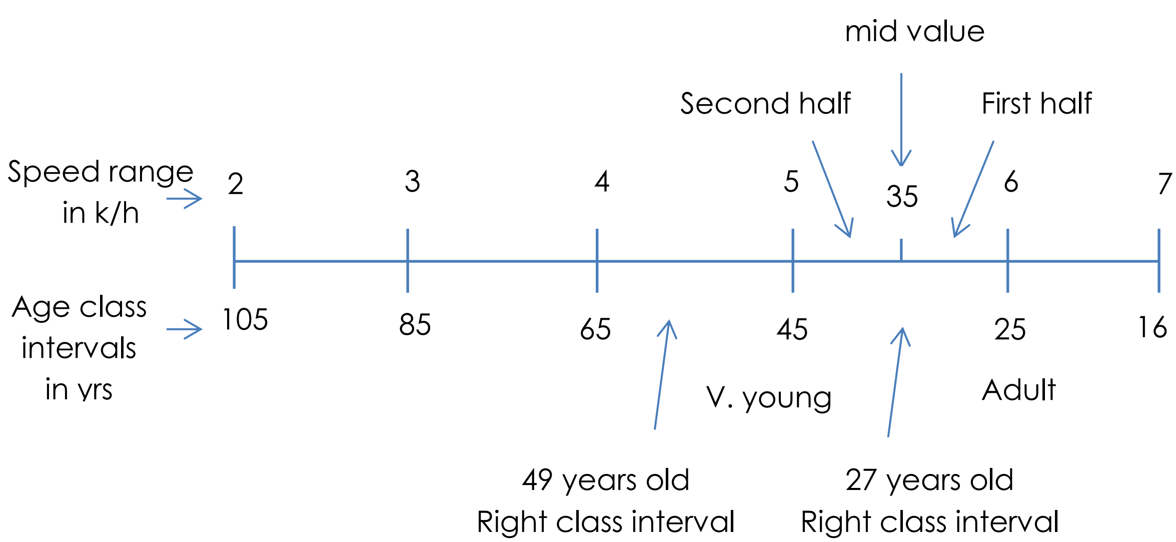

Figure 3 . 16 How weights of agent's properties are identified

Table 3. 1 Defined desired speed for some of the agents based on their properties using fuzzy logic technique

Agent ID	Gender	Age (yrs.)	Weight (kg.)	Disease	Collaboration	Shock	Desired Speed
1	Male	0.75 very young and 0.25 adult	%100 slim	%100 very low	%100 very low	%100 very low	6.17
2	Male	0.75 very young and 0.25 adult	0.75 heavy and 0.25 slim	%100 very low	%100 very low	%100 very low	5.99
3	Male	0.6 adult and 0.4 very young	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	6.01
19	Male	0.55 very young and 0.45 adult	0.7 slim and 0.3 very slim	%100 very low	%100 very low	0.5 low and 0.5 very low	5.93
20	Male	0.85 very young and 0.15 young	0.8 slim and 0.2 heavy	%100 very low	%100 very low	0.7 very low and 0.3 low	5.75
21	Male	0.8 very young and 0.2 adult	0.5 heavy and 0.5 slim	%100 very low	%100 very low	0.7 low and 0.3 very low	5.7
22	Male	%100 adult	0.9 slim and 0.1 heavy	%100 very low	%100 very low	0.65 low and 0.35 very low	5.9
28	Male	0.8 adult and 0.2 very young	0.95 slim and 0.05 very slim	0.95 slim and 0.05 very slim	0.5 low and 0.5 very low	0.9 low and 0.1 medium	5.35
36	Female	%100 adult	0.65 slim and 0.35 heavy	%100 very low	%100 very low	%100 very low	3.13
37	Female	0.65 very young and 0.35 adult	0.9 slim and 0.1 heavy	%100 very low	%100 very low	%100 very low	3.01
41	Female	0.6 very young and 0.4 adult	0.95 slim and 0.05 heavy	%100 very low	%100 very low	0.65 very low and 0.35 low	2.86
65	Female	%100 adult	0.65 very slim and 0.35 slim	%100 very low	0.55 very low and 0.45 low	0.7 medium and 0.3 high	2.77
69	Female	0.65 very young and 0.35 adult	0.6 very slim and 0.4 slim	%100 very low	0.7 low and 0.3 very low	0.9 high and 0.1 medium	2.63
74	Female	0.75 adult and 0.25 very young	0.9 very slim and 0.1 slim	0.85 very low and 0.15 low	0.55 medium and 0.45 low	0.55 high and 0.45 medium	2.54
81	Female	0.6 very young and 0.4 adult	0.95 slim and 0.05 heavy	0.85 very high and 0.15 high	0.6 high and 0.4 very high	0.55 high and 0.45 very high	2.0

3.2 Methodology IFDO Algorithms

This part presents the IFDO algorithm, and discusses the methodology of improvement in the original FDO algorithm and creating the IFDO algorithm.

A. The Improved Fitness Dependent Optimizer (IFDO)

The IFDO is developed from the original FDO, which is an evolutionary optimization algorithm that was proposed by Jaza and Tarik. The idea of this algorithm is essentially based on the generative process and collective decision-making used by bees. The bees search for many possible hives to obtain a new proper hive. Based on the original FDO, our proposed improved fitness-dependent optimizer is introduced as shown in see IFDO flowchart Figure 3. 17, and it includes two phases: the updating of the scout bee position, which is improved by the functionalization of certain parameters, and the randomization of the weight factor (wf) in the [0, 1] range.

B. Updating Scout Bee Position

The IFDO, to create a different way of movement, applies order and cohesion, which are two vital signifiers of group motion; cohesion inside a group defines the distance between members, whereas members' alignment inside a group can be indicated by order when it is measured as divergence. Effective movement and maximization of the benefits of grouping for individual group members rely on better group cohesion and alignment.

In the original FDO, to achieve a more suitable solution, the scout bee adds pace to the current position in searching for new positions, as expressed in equation (2.1). In the IFDO, this equation is improved by adding two parameters, such as alignment and cohesion, to the pseudocode of the IFDO illustrated see Figure 3.18. In the following, the new movement of the artificial scout bee is expressed as:

$$X_{i,t+1} = X_{i,t} + pace + (alignment * {}^{1}/_{cohesion}) \tag{3.6}$$

where i is the current artificial scout bee (search agent), t is the current iteration; the pace is the rate of the movement and the artificial bee direction, X is an artificial bee, and alignment is the pace matching of scouts to that of other scouts in neighborhoods, and cohesion, is the inclination of scouts in the direction of the center of the mass of the neighborhood.

This improvement has been made in the light of scout bee behavior, which is always attracted to better solutions and avoids decreased chances of obtaining better solutions. To calculate the alignment and cohesion behaviors, the scouts' neighbors' search landscape should be determined as shown in the pseudocode see Figure 3.18. In the IFDO, the search landscape of the artificial scout's neighbors is expressed as follows:

$$nl = \frac{lB}{2*PI} \tag{3.7}$$

where nl is the landscape of the neighbors, lB is the landscape boundary, and $2 * PI$ is to separate the landscape boundary into smaller boundary to indicate the landscape of the neighbors (nl). To functionalize these two suggested parameters to update the scout bee position, it should be determined whether the scouts fall into the landscape of the neighbors *(ln),* as shown in the pseudocode see Figure 3.18. The alignment and cohesion can be calculated according to equations (3.8) and (3.9).

$$\left\{ n = X - X_i, \;\; n = nl \; or \; n < nl \; \left\{ \begin{array}{l} alignment_k = \frac{\sum_{k=1}^{N} pace_k}{N} \; (3.8) \\ cohesion_k = \frac{\sum_{k=1}^{N} X_k}{N} - X \; (3.9) \end{array} \right\} \right\}$$

where n represents a scout in the neighbors' landscape and the role of the variable n is signifying which scout participates in determining the alignment and cohesion, X represents the current scout's position, N represents the neighborhood's number, $pace_k$ is the pace matching of scouts to that of other scouts in neighborhoods, and x_k represents the position of the k^{th} neighboring scout.

In the IFDO implementation, there are upper boundaries and lower boundaries for the dimensions of the agents to address weight values that are too large or small. See equations (3.10) and (3.11).

$$\left\{ \begin{array}{ll} \text{wvb} > \text{ub}, \text{wvb} = \text{ub} * \text{nrd} & (3.10) \\ \text{wvb} < \text{lb}, \text{wvb} = \text{lb} * \text{nrd} & (3.11) \end{array} \right\}$$

where wvb is the weight value of a bee, ub is the upper boundary of the weight value of a bee, nrd is the new random double value, and lb is the lower boundary of the weight value of a bee.

The IFDO randomly moves the agents. The agent who remains still for finite time is the global best for this status; therefore, that agent randomly moves, and its movement will not be accepted until the agent obtains a better movement. See equation (2.3).

Because the FDO algorithm is PSO-based, this paper tries to add some PSO principles, such as alignment and cohesion, to improve the FDO algorithm from the perspective of convergence. Moreover, the IFDO has the same mathematical complexity as that of the FDO with a slight change in space complexity. The IFDO has time complexity *O (d*p + COF*p)* for each iteration, where *d* is the dimension of the problem, *p* is the population size, and *COF* is the cost of the objective function. On the other hand, IFDO has space complexity *O (COF*p + p*pace+(alignment*1/cohesion))* for all iterations, where *pace+ (alignment*1/cohesion)* is the best previous pace stored. Hence, for the total number of iterations, the time complexity in the IFDO is comparable. On the other hand, for the progress of iterations, its space complexity will be the same. Space complexity is slightly increased in the IFDO compared to the FDO due to the addition of two additional loops to calculate alignment and cohesion, although this increase is negligible, especially in modern computers, which have a substantial amount of memory space and computational time; this causes the IFDO to have decreased time complexity and better convergence.

C. Randomization Weight Factor

The original FDO uses pace as the degree of movement and the artificial bee direction. The regular fitness weight (fw) value is used to manage the pace. On the other hand, random mechanisms completely determine the pace direction. Hence, the minimization of fw is expressed according to equation (3.7).

The authors of the FDO algorithm stated that the weight factor is used to control the fitness weight and that the value of the weight factor is either 0 or 1; if wf = 0, it is a more stable search, and if wf = 1, it the convergence is high, and the chance of coverage is weak. Nevertheless, the authors mentioned that while the fitness function value entirely depends on the optimization problem, the reverse may also happen. Consequently, in our improved fitness-dependent optimizer, we use a random mechanism to control the fitness weight by generating a weight factor in the [0, 1] range, as shown in the pseudocode of the IFDO see Figure 3.18, to increase the IFDO performance, as is shown from the resulting test in section (4). In our proposed improvement, we change equation (3.7), as shown in equation (3.12).

$$fw = \left| \frac{x^{*}_{i,t\ fitness}}{x_{i,t\ fitnees}} \right| \qquad (3.12)$$

With equation (3.12), we find the fitness weight value and then check if it is less than or equal to the generated weight factor, as shown in the pseudocode of the IFDO see Figure 3.18; if it is, then the weight factor is ignored in controlling the fitness weight. Otherwise, the weight factor participates in controlling the fitness weight according to equation (3.13).

$$fw = fw - wf \qquad (3.13)$$

This is a new way of finding the fitness weight, which is avoided by ignoring wf in most cases, and wf reasonably participates in many cases. In the IFDO, the weight factor is randomly set in every iteration for each scout, and a new wf is generated in the new $[0, wf]$ range when a new, better solution is accepted, as shown in the pseudocode of the IFDO see Figure 3.18. From there, new wf limited in $[0, wf]$ is better while for a new solution the IFDO will be more stable and higher coverage than the previous solution due to decreasing wf for each iteration, as well as, it has more convergence than the setting $wf = 0$.

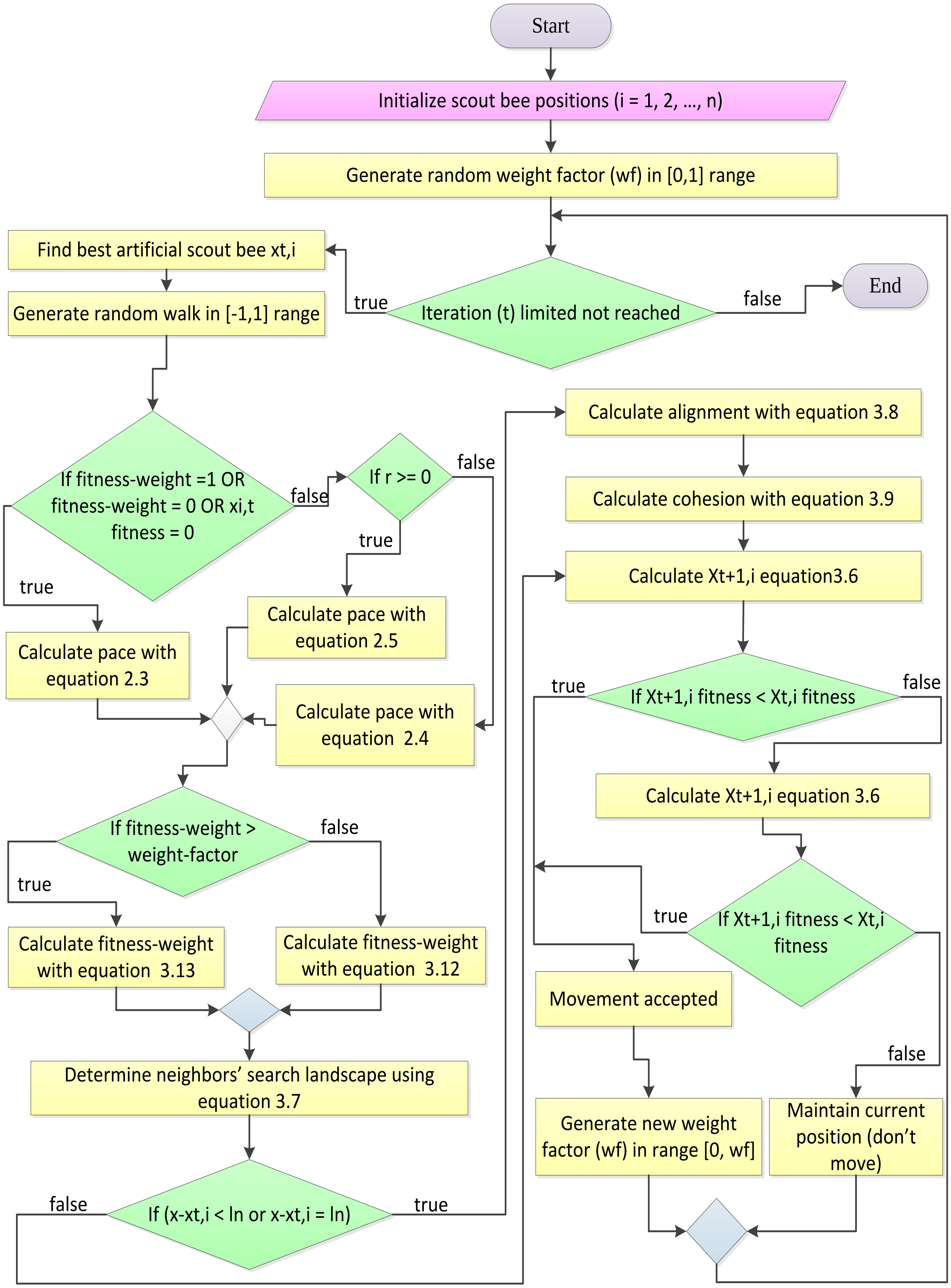

Figure 3. 17 IFDO flowchart

```
Initialize scout bee population X_{t,i} (i = 1, 2, ..., n)
Generate random weight factor (wf) in [0, 1] range
while iteration (t) limit not reached
  for each artificial scout bee X_{t,i}
    find best artificial scout bee x*_{t,i}
    generate random-walk r in [-1, 1] range
    if( X_{t,i} fitness == 0) (avoid divide by zero)
      fitness weight = 0
    else
      calculate fitness weight. equation (3.12)
if(fitness weight > wf)
     calculate fitness weight. Equation (3.13)
     end if
    end if
     determine neighbors search landscape (ln). Equation (3.7)
     if(x(current scout)-x_{t,i}(other scouts) < ln or x-x_{t,i} == ln)
     calculate alignment. Equation (3.8)
     calculate cohesion. Equation (3.9)
     end if
    if (fitness weight = 1 or fitness weight = 0 or X_{t,i} fitness = 0)
      calculate pace using equation (2.3)
    else
       if (random number >= 0)
          calculate pace using equation (2.5)
       else
          calculate pace using equation (2.4)
```

```
        end if
      end if
    calculate X_{t+1,i} equation (3.6)
if( X_{t+1,i} fitness < X_{t,i} fitness)
        move accepted and pace saved
        generate new wf in [0, wf]
else
      calculate X_(t+1,i) equation (3.6) with previous pace
        if (X_(t+1,i)  fitness<X_(t,i)  fitness)
           move accepted and pace  saved
           generate new wf in [0, wf]
        else
            maintain current position (don't move)
        end if
      end if
  end for
end while
```

Figure 3. 18 Pseudocode of the IFDO

CHAPTER 4: Experimentations and Results

This part of the research can be separated into two main parts. Moreover, different experimentations are considered and executed on both parts. After that, results are generated been accordingly. All the experimentations are on a computer with thease attributes: Manufacture: Lenovo Z51, Windows 7 Ultimate 64-bit, intel(R) Core(TM) i7-5500 CPU @ 2.40GHz (4 CPUs), ~ 2.4GHz, memory (8192MB RAM).

4.1 Evacuation Simulation Results of the Polytechnic University's First Floor

This section will present a part of the polytechnic university's presidency's first-floor layout. Moreover, it will analyze the collected data and briefed them inside tables. Furthermore, shows the developed intelligent model's simulation results for various cases.

4.1.1 Building Layout

A case study is used for this research, which is the first floor of the polytechnic university's presidency in Sulaimani city, in the Kurdistan region of Iraq. This part of the university has various employees, students, and visitors with different ages, weight, health, and different reaction or behavior during an emergency case.

4.1.2 Polytechnic University

Polytechnic University is a university in Kurdistan of Iraq. This research considers the first floor of the university's presidency building. Only the area of the part of rooms and hallways is 868 meters width are 31 meters and length 28 meters. This floor comprises six rooms in 252^{m2}, three of them linked and separated with the walls. These three rooms opposed the other linked rooms and between them, there are a large hallway 616^{m2} which contains an enclosed garden in 100^{m2} and inside that garden, there are stairs for the second floor. Moreover, rooms have equal size, which is 7 meters wide and 6 meters in length for each room. This floor has two main exits with a width of 3 meters for each one of them. Data for the employees of this building were collected via interviews and questionnaires. They asked for their age, weight, disease and their reaction during the occurrence of the emergency, for instance, will you be shocked? Alternatively, do you collaborate with other occupants? Genders are also considered. During this collection, 102 persons were involved and used for the analysis. Figure 4.1 illustrates the outline of a part of the first-floor polytechnic university's precedency building.

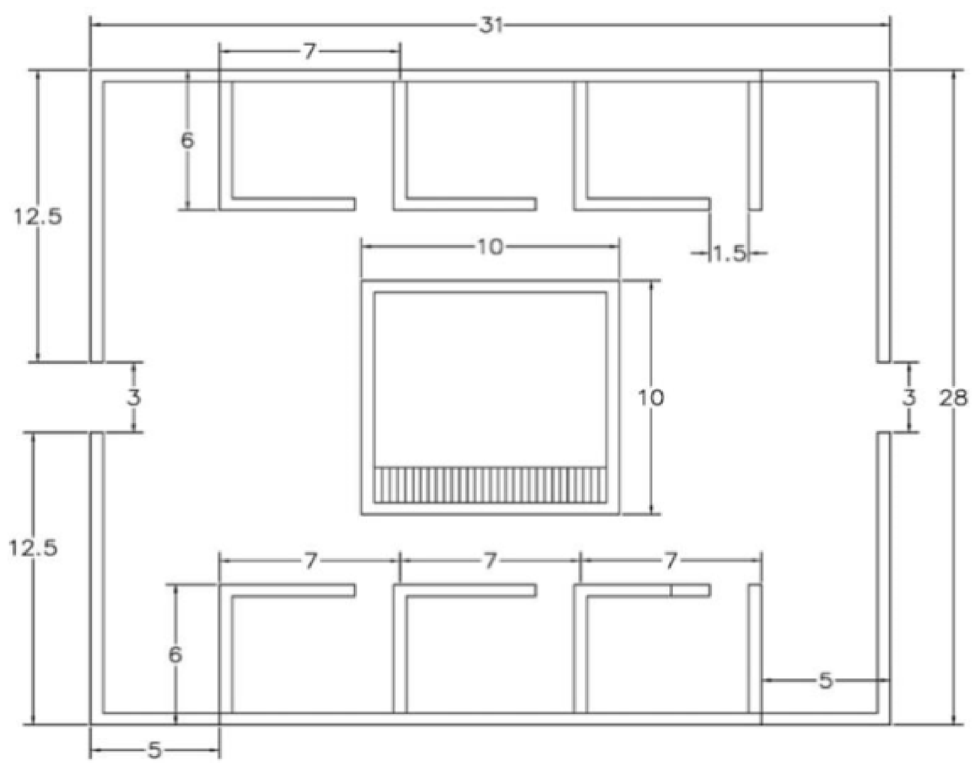

Figure 4. 1 Illustrate the outline of a part of first-floor polytechnic university's precedency building

4.1.3 Analysis of the Collected Data

Here gathered data as a result of interviews and questionnaires will be analyzed.

102 occupants are interviewed and responded to the questionnaire. The data is collected in two main parts. First, is an interview about the occupants' information on physical, biological, and emotional aspects, and the second one is a questionnaire about the behaviors of the occupants that might be occurred during the evacuation process. The results of the 102 participants for the first part and second part were briefed in Tables 4.1 and 4.2.

The first part is interviewing the evacuees and appeared from the 102 participated 61.8 percent is male and 38.2 percent is female. Moreover, the male occupant's age and weight are between 20 to 60 years old and 63 to 110 k/g. On the other hand, female occupants' age and weight are between 19 to 55 years old and 55 to 85 k/g. This interview data is used in defining the desired speed as mentioned in the first subsection in section 1 chapter 3.

According to the found data, 79.37 percent of the male is healthy, 11.11 percent are with low disease conditions and 4.76 percent are with a medium stage disease condition. Moreover, 3.17 and 1.59 with high and very high disease conditions separately. Besides, details information about the shock and collaboration during emergency evacuation are as follows: 71.42 percent and 84.1 percent of them are at normal level correspondingly, while 17.46, 6.34 percent and 4.76, 7.93 percent are in low and medium level respectively. Furthermore, 3.17, 1.58 percent and 1.58, 1.58 percent were in high and very high level correspondingly.

For the females' disease 71.79, 12.82 percent are at very low and low levels respectively. Moreover, 7.69, 5.13, 2.56 are in medium, high, and very high levels consistently. For shock and collaboration aspects 56.41, 64.1 percent are in very low range respectively. 12.82 percent for each low, medium, and high shock levels, while 12.82, 7.69, 10.25 percent are in low, medium, and high collaboration levels correspondingly. Furthermore, 12.82, 5.12 and 10.25, 5.12 are in high and very high levels individually.

The second part is a questionnaire to the same participants, this questionnaire data is used in implementing the agent's behaviors as mentioned in the third subsection in section 1 chapter 3. Thus, similar to the first attempt, from 102 participants, 61.8 percent is male and 38.2 percent is female.

The questionnaire is handed to the participants. Each respondent is allowed to expect one or more than one behavior and from the brief data, it is observed that the result of male occupants for behaviors of wait, aside, jump over, help and wait to fail evacuees were 63.49, 69.84, 30.16, 17.46, 33.33 percent respectively. While the result of the female for behaviors of wait, aside, jumps over, help and wait to fail evacuees were 58.97, 97.44, 10.26, 5.12, 20.51 percent respectively.

Table 4. 1 Interview of 102 occupants' for their physical biological and emotional properties

Gender	Number of participants	Physical and Biological Properties				Emotional Properties	
		Age(yrs.)	Weight(kg)	Levels	Disease	Shock	Collaboration
Male	63	20 – 60	63 – 110	V. Low	50	45	53
				Low	7	11	3
				Medium	3	4	5
				High	2	2	1
				V. High	1	1	1
Female	39	19 – 55	55 – 85	V. Low	28	22	25
				Low	5	5	5
				Medium	3	5	3
				High	2	5	4
				V. High	1	2	2

Table 4. 2 Questionnaire of 102 occupants' for their behaviors during an emergency evacuation

Gender	Number of participants	Behaviors during an emergency evacuation				
		Wait	Aside	Jump over	Help	Wait to fail the person
Male	63	40	44	19	11	21
Female	39	23	38	4	2	8

*In the questionnaire most of the participants were expected more than one behavior during the evacuation.

According to the collected data, 102 different agents' physical, biological, and emotional properties were entered into the model, and because of that, agents were created and their desired speeds were defined. Agents were set randomly through the first floor of the building. Figure 4.2 illustrates the agents' distribution through the first floor.

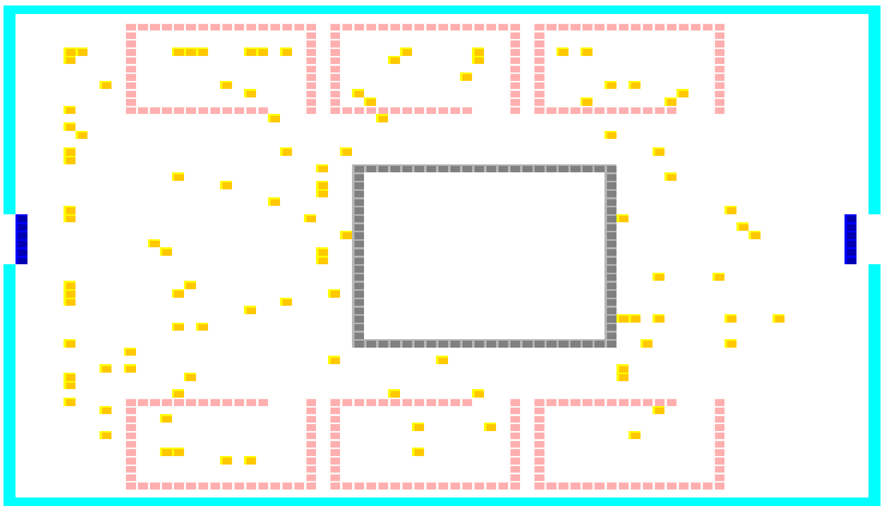

Figure 4. 2 Illustrates 102 agents' distribution through the first floor

These experiments discuss the following cases: 102 agents, 61.8 percent is male and 38.2 percent is female with (1) two main exits, one room door, distributed in the average small and larger area of the floor. (2) Only one main exit door, agents distributed through a small or larger area of the floor and their positions were far or near the exit door. (3) Multiple main exit doors, increase distribution. (4) Two exit room doors and three main exit doors. Familiarity and non-familiarity of the agents for the exits were considered in cases of (1), (3) and (4). Table 4.3 shows the developed intelligent model's simulation results for the mentioned above cases. C.W.A is a collision with agents, C.W.O is the collision with obstacles, and O.B.D.E is occurring different behaviors during evacuation.

Table 4. 3 Experimentations' results from the developed model

Experimentations	**Scenarios**	**Rate of C.W.A (%)**	**Rate of C.W.O (%)**	**O.B.D.E**	**Evacuation time min:sec:ms**
1A	Agents distributed in an average small area of the floor, two main exits, rooms have only one door to go out and agents were no familiar with the exits	56.863	39.235	Aside, wait, fail, jump over	0:59:682
1B	Same as the **1A** but agents were familiar with the exits	21.599	9.804	Aside, wait	0:35:262
1C	Same as the **1A** but agents distributed in a larger area of the floor	57.843	36.275	Aside, wait	0:57:202
2A	only one main exit door was used, agents distributed in a larger area of the floor	58.824	54.902	Aside, wait, help	1:22:155
2B	Same as 2A, but all agents distributed through a very small portion of the floor	97.941	72.549	Aside, wait, wait to fail person, jump over, help, fail	1:47:946
2C	Same as 2A but agents positions were near the exit door	43.137	5.882	Aside, wait	0:21:144
3A	multiple main exit doors and increase agents' distribution area	51.961	38.235	Aside, wait	0:57:100
3B	Same condition **3A**, they are all familiar with the building	20.588	34.314	Aside, wait	0:33:592
4A	two exit room doors, three main exit doors, and agents were no familiar with the exits	39.216	23.529	Aside, wait	0:47:721
4B	Same condition **4A**, agents familiar with the exits	11.765	4.902	Aside, wait	0:21:874

4.2 Evacuation Simulation Results of the Polytechnic Institute's Cafeteria

This section will present a part of the polytechnic institute's first-floor layout. Additionally, it will examine gathered data and briefed them inside tables. Furthermore, shows the developed intelligent model's simulation results for several cases.

4.2.1 Layout of the First Floor

The first-floor layout for our presented framework was the first floor of one of the institutes' in Sulaimaniyah city in the Kurdistan region of Iraq, which was a polytechnic institute. The first floor of this building contains a cafeteria, which different people visit this part of the building such as, Employees, students, visitors, and cafeteria staff with various health, weight, age, and different response or behavior throughout the emergency case. Inside the first floor, 540^{m2} is provided, for the cafeteria with a width of 36 meters and length 15 meters. This area is partitioned into three different subareas; students' area, employees' area, and kitchen and services areas. The area of employees is 10 meters wide and 15 meters length, inside the employees' area there are 6 tables, and one exit doors with 2.5 meters width. The area of students is 17 meters wide and 15 meters length, inside the students' area, there are 8 tables and two exit doors with 2.5 meters width for each. Area of kitchen and services is 9 meters width and 15 meters length; this part contains some components for cooking, refrigerator, and cooler and it has two exit doors with 2 meters width, one is on the students' area and the other one from the back end of the area. Figure 4.3 illustrates the outline of a part of the first-floor polytechnic institute building.

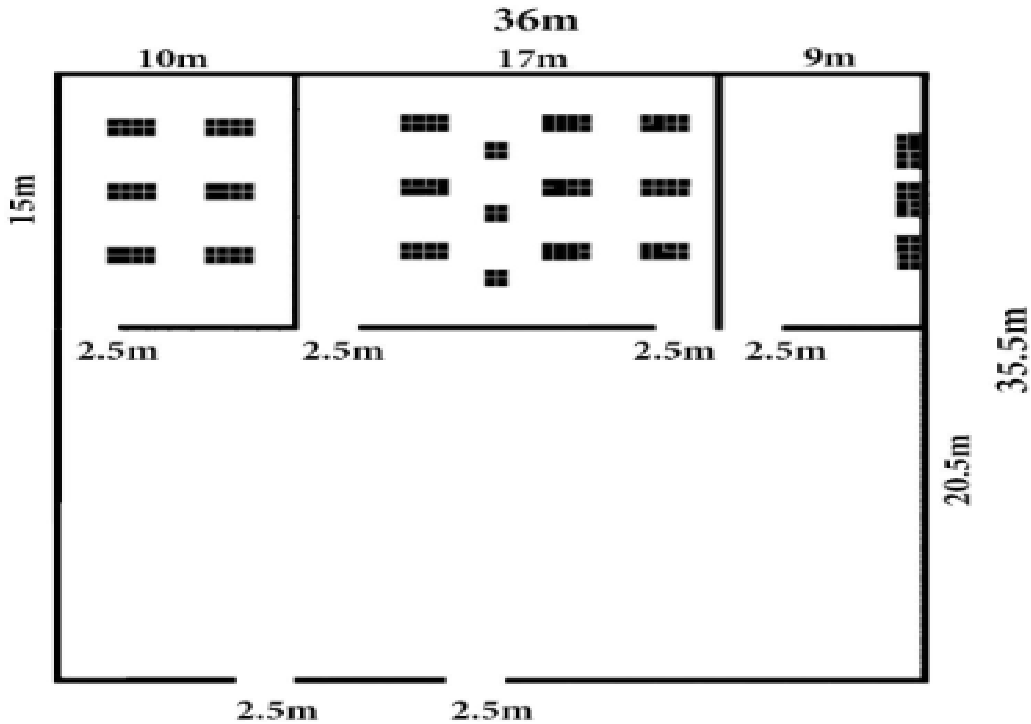

Figure 4. 3 Illustrate the outline of a part of first-floor polytechnic university's precedency building

4.2.2 Gathered Data Specification

The collected data consists of 81 participants 35 males and 46 females. Furthermore, age and weight for the male participants were 18 to 50 years old and 68 to 95 k/g. Age and weight for the female participants were 18 to 43 years old and 57 to 83 k/g. This part of the gathering data utilized in defining the agent's speed while the second part of the collecting data was via the questionnaire was utilized in implementing the agent's behaviors, such as failing, waiting, helping, jumping, and others. Results of the 81 participants for the first part and second part with their analyzing results were briefed in Tables 4.4 and 4.5.

Table 4. 4 Questionnaire of 81 Participants for Their Behaviors during an Emergency Evacuation

Gender	Number of participants	Behaviors during an emergency evacuation				
		Wait	**Aside**	**Jump over**	**Help**	**Wai to fail the person**
Male	35	20 (%57.14)	24 (%68.57)	13 (%37.14)	10 (%28.57)	18 (%51.43)
Female	46	18 (%39.13)	40 (%86.96)	5 (%10.86)	3 (%6.52)	6 (%13.04)

Table 4. 5 Interview of 81 participants' for their physical biological and emotional properties

Gender	Number of participants	Physical and Biological Properties				Emotional Properties	
		Age (yrs.)	**Weight (kg)**	**Levels**	**Disease**	**Shock**	**Collaboration**
Male	35	18 – 50	68 – 95	V. Low	25 (%71.43)	18 (%51.43)	26 (%74.29)
				Low	5 (%14.29)	8 (%22.86)	5 (%14.29)
				Medium	2 (%5.71)	4 (%11.43)	2 (%5.71)
				High	2 (%5.71)	3 (%8.57)	1 (%2.86)
				V. High	1 (%2.86)	2 (%5.71)	1 (%2.86)
Female	46	18 – 43	57 – 83	V. Low	35 (%76.09)	5 (%10.87)	21 (%45.65)
				Low	5 (%10.87)	5 (%10.87)	13 (%28.26)
				Medium	3 (%6.52)	18 (%39.13)	7 (%15.22)
				High	2 (%4.35)	15 (%32.61)	3 (%6.52)
				V. High	1 (%2.17)	3 (%6.52)	2 (%4.35)

In this research work, the model is based on various scenarios, which have been written and executed through various experiments. Concise of experiments' results for the scenarios via the developed intelligent model were briefed inside Table 4.6. For this simulation process, data gathered for 81 individuals. As mentioned in the first subsection in section 1 chapter 3 within the gathering data, individual properties were recorded for each of them. Therefore, these properties were entered into the model, based on these properties individuals were generated and desired speeds were specified for them. These individuals arbitrarily set through the cafeteria. Figure 4.4 illustrates the participants' distribution on the first floor.

The above mentioned scenarios could be briefed in the following points: as mentioned in second subsection of 4.2, 43.21 percent was male and 56.79 percent was female with (1) One main exit for the first floor, two exit doors for students part, only one exit door to each employee part and staff part, and distribution of the individuals in small and large area of the cafeteria. (2) Two main exit doors for the first floor, only one exit door for each of the student part, employee part and staff part, and distribution of the individuals in a small and large area of the cafeteria. (3) Two main exit doors for the first floor, two exit doors for student part, one exit door for employee part and staff part, and distribution of the individuals in a small or large area of the cafeteria. (4) Three main exit doors, two exit or one exit doors for students' part, one exit door for each employee part and staff part, and distribution of the individuals through a large area of the cafeteria. Individuals' familiarity is considered with the points (2), (3) and (4).

Table 4. 6 Experimentations' results from the developed model

No.	Scenarios	Rate of C.W.A (%)	Rate of C.W.O (%)	O.B.D.E	Evacuation time min:sec: ms
No1A	Evacuees distributed in an average small area in the cafeteria, two main exits, each of the employee part, student part, and staff part has one exit door, evacuees were no familiar with the exits	61.728	30.864	Aside, wait	1:0:941
No1B	Same as the No1A but evacuees were familiar with the exits	51.852	65.432	Aside, wait	0:47:261
No1C	Same as the No1A but evacuees distributed in a larger area of the cafeteria	27.16	20.988	Aside, wait, help	0:46:711
No1D	Evacuees distributed in an average small area in the cafeteria, two main exits, two exit doors for students part, and each of the employee part, and staff part has one exit door, evacuees were familiar with the exits.	17.284	33.333	Aside, wait	0:47:130
No2A	Only one main exit door was used, evacuees distributed in a larger area of the cafeteria	32.099	13.58	Aside, wait	0:41:635
No2B	Same as No2A, but all agents distributed through a very small portion of the floor	54.321	20.988	Aside, wait	0:50:682
No2C	Same as No2A but agents positions were near the exit door	49.383	4.938	Aside, wait, help, jump over	0:35:373
No2D	Only one main exit door was used with two exit doors of student part and employees' part and staff part has only one exit door, evacuees distributed in a small area of the cafeteria	44.444	17.284	Aside, wait	0:43:487
No3A	More than two main exit doors and increase evacuees' distribution area	23.457	13.58	Aside, wait	0:41:241
No3B	Same condition No3A, they are all familiar with the exit doors	16.49	16.049	Aside, wait	0:37:976
No4A	Two exit doors for the student part, three main exit doors and evacuees were no familiar with the exits	25.926	7.407	Aside, wait	0:40:51
No4B	Same condition No4A, evacuees familiar with the exits	22.222	7.407	Aside, wait	0:31:307

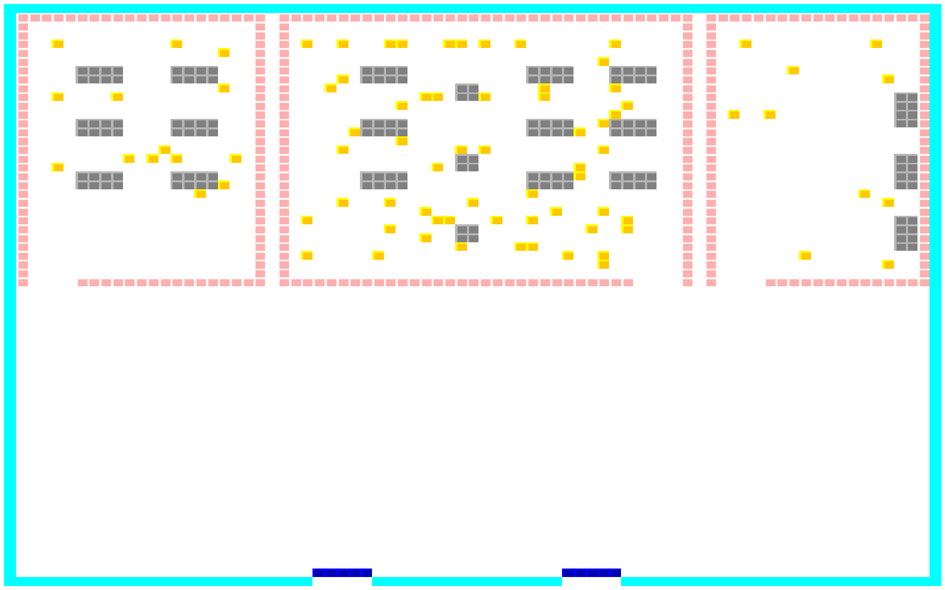

Figure 4. 4 Illustrates the participants' distribution through the cafeteria

4.3 Optimization Results

Improved fitness dependent optimizer's performance is verified using various standard test functions that exist in the literature. Moreover, the performance of the IFDO is evaluated against six the state of art algorithms, such as FDO, DA, GA, PSO, SSA, and WOA. It could be said that result test of (19 classical standard test functions) and the (CEC-C06 tests) for the distinguishable algorithms are taken from the original FDO work [112]. In addition, two real-world applications are optimized via using IFDO; therefore, the section consists of three parts described as follows:

4.3.1 Classical Benchmark Test Functions

The IFDO performance is tested with three groups of test functions [94]. There are various features for the test functions, such as unimodal, multimodal, and composite. To measure the algorithm's specific outcomes, these groups of tests are utilized. The stages of exploitation and convergence to infer a single optimum are verified by unimodal benchmark functions. On the other hand, there are many optimal solutions for the second feature (multimodal test functions); avoidance of local optima and stages of exploration are verified with this feature. It is worth mentioning that among the many optimal solutions, most are local optima, and there is only one global optimum. Avoiding local optimal solutions and moving toward a global optimum solution is essential to an algorithm. Additionally, with the third feature (composite test functions), various search areas can have various forms and large numbers of local optima. Composite test functions are generally moved, amalgamated, biased, and altered adaptations of other test functions. Difficulties that occur in real-world search areas can be identified by this type of standard function see Table 1, 2, and 3 in Appendix F [112].

To determine the average and standard deviation for each algorithm in Table 4.7 based on searching for the optimal solution, the algorithms in Table 4.7 are tested 30 times for 500 iterations and 30 scout bees each with 10 dimensions. Parameter explanations for the DA, PSO, and the GA can be obtained in [119]. Moreover, there is only one parameter for the IFDO and the standard FDO, which is wf. For the FDO, in the test functions in Table 4.7, in only two of the cases (2 and 8) wf is set to 1, and for all other cases, wf is set to 0. In contrast, in our proposed algorithm IFDO, wf is set randomly in the [0, 1] range for all of the cases. However, this range will change when the algorithm detects a more suitable solution; During the test, only the test function TF8 is reduced to -2917375.29380209, and all of the other test functions are reduced to 0.0 (details of the conditions of the test functions can be found in Appendix F in Tables 1, 2 and 3). To confirm that the algorithm does not discriminate in the direction of origin, some degree of shifting is utilized for some of the test functions.

4.3.2 CEC-C06 2019 Benchmark Test Functions

To further evaluate the IFDO, the algorithm was tested on 10 current test function sets of the CEC standard. Professor Suganthan and his colleagues enhanced these test functions for the optimization of a single objective problem [120]. A set of CEC standard test functions are planned to be used in the annual optimization competition “The 100-Digit Challenge”, which is a common name for this set of test functions see Table 4.8, CEC01 to CEC03 are not similar to the test functions CEC04 to CEC10, while CEC01 to CEC03 are not shifted and rotated. However, a feature of scalability is utilized in both CEC01 to CEC03 and CEC04 to CEC10. Regarding the parameters, the CEC benchmark developer provided a set of parameters; the various dimensions for CEC01 to CEC03 are as shown in the Appendix F in Table 4, and a 10-dimensional minimization problem in the [-100, 100] boundary range was set for the functions CEC04 to CEC10.

The CEC global optimum is entirely bound to point 1 to be more appropriate. With the FDO, the three other recent algorithms for optimization, DA, WOA, and SSA, are tested for competitiveness with our proposed IFDO. Various motivations led to choosing these recent algorithms. First, the improved FDO, the original FDO, and the other chosen algorithms are all PSO-based algorithms. Second, in previous works, these algorithms were obviously used. Third, on both real-world problems and benchmark test functions, all of these algorithms have exceptionally good results. Fourth, the authors of these algorithms freely provided the algorithms’ operating methods.

It is worth mentioning that the parameter settings of the chosen algorithms were not changed during the test. The same settings were used for all the opponents, as shown in papers [112] [119] [121] [122]. Readers can access the

MATLAB parameter setting arrangement and their implementations for the algorithms in this reference if desired [123].

Furthermore, the generated random weight factor (wf) in the [0, 1] range is used for all test functions; however, this wf is regenerated in [0,wf] for the next iteration if a better fitness weight (fw) is achieved see the pseudocode in Figure 3.13. To perform the test of IFDO and other competitors' algorithms as presented in Table 4.8, 30 agents with 500 iterations were applied to each algorithm.

Table 4. 7 FDO and chosen algorithms [112] with IFDO Classical Benchmark results

Test Function	IFDO		FDO		DA		PSO		GA	
	AV.	ST.	AV.	ST.	AV.	ST.	AV.	ST.	AV.	ST.
TF1	5.38E-24	2.74E-23	7.47E-21	7.26E-19	2.85E-18	7.16E-18	4.2E-18	1.31E-17	748.5972	324.9262
TF2	0.534345844	1.620259633	9.388E-6	6.90696E-6	1.49E-05	3.76E-05	0.003154	0.009811	5.971358	1.533102
TF3	2.88E-07	6.90E-07	8.5522E-7	4.39552E-6	1.29E-06	2.1E-06	0.001891	0.003311	1949.003	994.2733
TF4	2.60E-04	9.11E-04	6.688E-4	0.0024887	0.000988	0.002776	0.001748	0.002515	21.16304	2.605406
TF5	1.94E+01	3.31E+01	23.50100	59.7883701	7.600558	6.786473	63.45331	80.12726	133307.1	85,007.62
TF6	4.22E+06	8.15E-09	1.422E-18	4.7460E-18	4.17E-16	1.32E-15	4.36E-17	1.38E-16	563.8889	229.6997
TF7	5.68E-01	3.14E-01	0.544401	0.3151575	0.010293	0.004691	0.005973	0.003583	0.166872	0.072571
TF8	-2.92E+06	2.24E+05	-2285207	206684.91	-2857.58	383.6466	-7.1E+11	1.2E+12	-3407.25	164.4776
TF9	1.35E+01	6.66E+00	14.56544	5.202232	16.01883	9.479113	10.44724	7.879807	25.51886	6.66936
TF10	5.18E-15	1.67E-15	3.996E-15	6.3773E-16	0.23103	0.487053	0.280137	0.601817	9.498785	1.271393
TF11	0.525690405	8.90E-02	0.568776	0.1042672	0.193354	0.073495	0.083463	0.035067	7.719959	3.62607
TF12	1.81E+01	2.57E+01	19.83835	26.374228	0.031101	0.098349	8.57E-11	2.71E-10	1858.502	5820.215
TF13	4.10E+09	1.50E-05	10.2783	7.42028	0.002197	0.004633	0.002197	0.004633	68,047.23	87,736.76
TF14	2.68E-07	4.68E-07	3.7870E-7	6.3193E-7	103.742	91.24364	150	135.4006	130.0991	21.32037
TF15	4.03E-16	9.25E-16	0.001502	0.0012431	193.0171	80.6332	188.1951	157.2834	116.0554	19.19351
TF16	9.14E-16	3.61E-16	0.006375	0.0105688	458.2962	165.3724	263.0948	187.1352	383.9184	36.60532
TF17	2.38E+01	1.24E-01	23.82013	0.2149425	596.6629	171.0631	466.5429	180.9493	503.0485	35.79406

TF18	2.24E+02	2.68E-05	222.9682	9.9625E-6	229.9515	184.6095	136.1759	160.0187	118.438	51.00183
TF19	3.15E+01	1.32E-03	22.7801	0.0103584	679.588	199.4014	741.6341	206.7296	544.1018	13.30161

Table 4. 8 Results of the IEEE ECE benchmark 2019 [112]

Test Function	**IFDO**		**FDO**		**DA**		**WOA**		**SSA**	
	AV.	**ST.**	**AV.**	**ST.**	**AV.**	**ST.**	**AV.**	**ST.**	**AV.**	**ST.**
CEC01	2651.198672	13944.10274	4585.27	20707.627	543×108	669×108	411×108	542×108	605×107	475×107
CEC02	4.000002146	1.00E-05	4.0	3.22414E-9	78.0368	87.7888	17.3495	0.0045	18.3434	0.0005
CEC03	13.70240422	4.82E-09	13.7024	1.6490E-11	13.7026	0.0007	13.7024	0.0	13.7025	0.0003
CEC04	31.19516293	12.91586061	34.0837	16.528865	344.3561	414.0982	394.6754	248.5627	41.6936	22.2191
CEC05	1.13187643	0.070551978	2.13924	0.085751	2.5572	0.3245	2.7342	0.2917	2.2084	0.1064
CEC06	12.12714515	0.52079368	12.1332	0.600237	9.8955	1.6404	10.7085	1.0325	6.0798	1.4873
CEC07	115.5677518	10.27465902	120.4858	13.59369	578.9531	329.3983	490.6843	194.8318	410.3964	290.5562
CEC08	4.940001939	0.891043403	6.1021	0.756997	6.8734	0.5015	6.909	0.4269	6.3723	0.5862
CEC09	2.0	3.10E-15	2.0	1.5916E-10	6.0467	2.871	5.9371	1.6566	3.6704	0.2362
CEC10	2.718281828	4.44E-16	2.7182	8.8817E-16	21.2604	0.1715	21.2761	0.1111	21.04	0.078

4.3.3 Quantitative Measurement Metrics

Two quantitative metrics were used for further investigation and detailed observation of IFDO, as shown in Figures 4.5 and 4.6. For each quantitative metric, among the unimodal standard functions TF1 to TF7, the first test function is chosen, among the multimodal standard test functions TF8 to TF13, the second test function is chosen, and among the composite standard functions TF14 to TF19, the third test function is chosen. For each investigation, searching the two-dimensional search space through 150 iterations was performed using 10 search agents.

The first measurement metrics test demonstrates how the search space is covered by the scout bee and presents the course of the convergence. During the test, the positions of the scout bees are logged from the start of the test to the end. Hence, this metric is simply a scout bee search history. At first, the whole area is rapidly discovered by the scout bee, and then, in the direction of optimality, they steadily move. Figure 4.5 presents the first quantitative metrics test. The second measurement metric test illustrates the iteration process that measures the agent's global best convergence. When the number of iterations is increased, xi* (the global best agent) is more precise, and when the scout bee focuses on the exploitation and local search, rapid changes are observed. See figure 4.6.Generally, the IFDO has the ability to successfully explore the search space, justifiably move in the direction of optimalit y and avoid loca l optima.

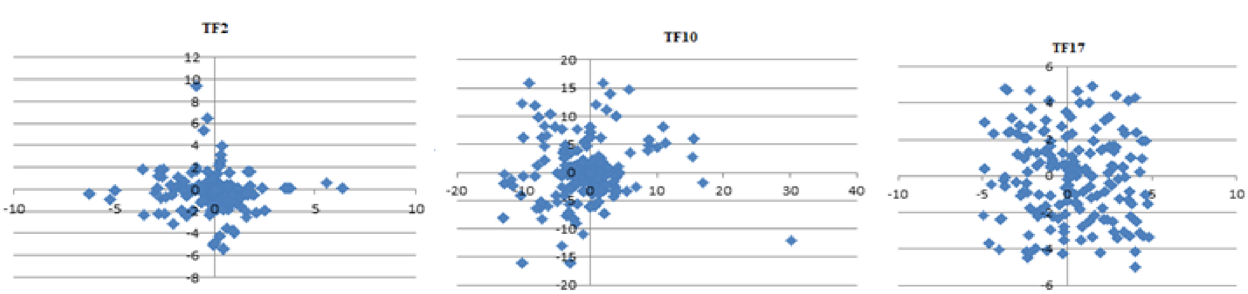

Figure 4. 5 Using unimodal, multimodal, and composite test functions for the IFDO algorithm search history

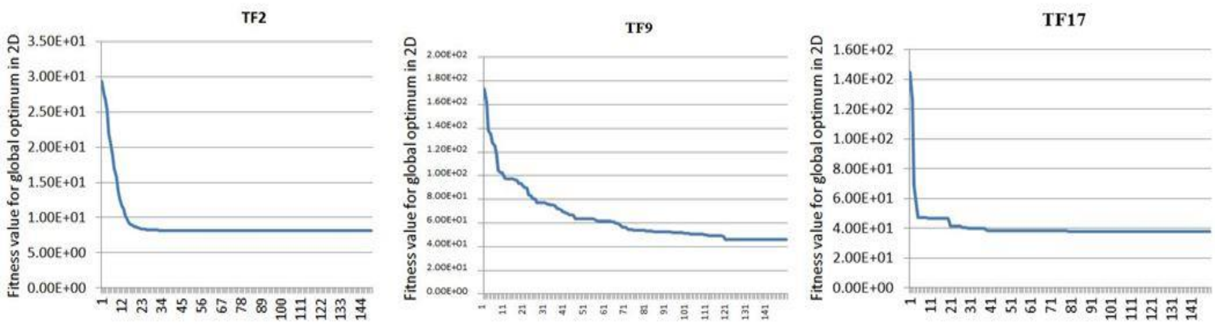

Figure 4. 6 Using unimodal, multimodal, and composite test functions for the IFDO algorithm convergence curve

4.3.4 FDO and IFDO Real World Application

Real-world problems are solved via the IFDO and FDO; in this section, we performed two real-world applications. The first application is the “aperiodic antenna array design,” which was already tried by the original FDO. The second application is the "pedestrian evacuation model", which, to the best of our knowledge, is a new optimization problem that determines the best main door location inside an open area to evacuate people with greater efficiency. The results of the IFDO and FDO are evaluated for both real-world problems:

A- IFDO usage on aperiodic antenna array designs

Developments in radio astronomy and radar methods from the 1960s drew significant attention to aperiodic antenna arrays. Thinned antenna arrays and non-uniform antenna arrays are shown in Figure 4.7. Real-number vectors are needed to express a position in non-uniform arrays to optimize the element position with the intention of achieving the highest sidelobe level (SLL). Additionally, as shown in equation (4.1), a confident boundary position of the element is needed to avoid discordant lobes. Interested readers can consult [124]. The 10 elements of a non-uniform isotropic array are shown in Figure 4.8 and setting the outermost element to have an average element position of $d_{avg} = 0.5\lambda_0$ at position 2.25λ0 is a reason for optimizing the positions of the four elements alone. The limitations of this optimization problem with four dimensions are expressed in equation (4.1) as follows:

$$x_i \in \left|x_i - x_j\right|(0,2.25) > \min\{x_i\}\, 0.25\lambda_0 > 0.125\lambda_0.$$
$$i = 1,2,3,4.\, i \neq j. \qquad (4.1)$$

Nonetheless, there is no element that can be smaller than 0.125λ0 or larger than 2.0λ0. Due to these limitations, each element has a boundary between 0 and 2.25 because the element 2.25λ0 is fixed, and the neighboring elements do not have the ability to be closer than 0.25λ0. Equation (4.2) defines the problem of the fitness function:

$$f = \ max\{20\ log\,|AF(\theta)|\,\} \qquad (4.2)$$

where

$$\mathrm{AF}(\theta) = \sum_{i=1}^{4} \cos[(\cos\theta - \cos\theta_s)2\pi x_i] + \cos[(\cos\theta - \cos\theta_s)2.25 \times 2\pi] \qquad (4.3)$$

For this work is showed in Figure 4.8 regarded that $\theta_s = 90^{\circ}$ [124].

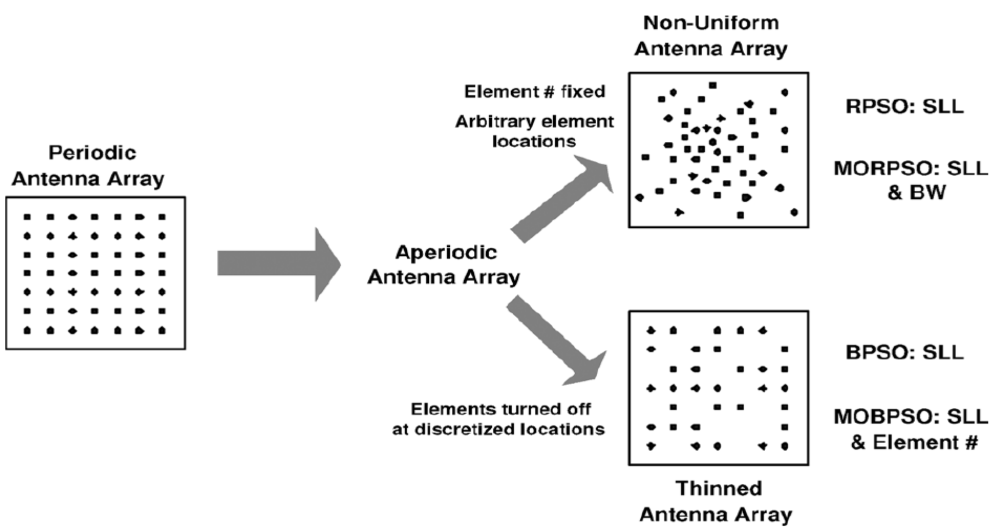

Figure 4. 7 Presents a thinned antenna array and Non-Uniform antenna array [124]

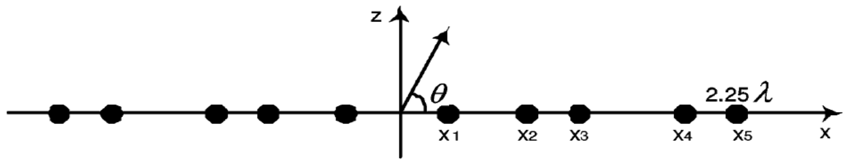

Figure 4. 8 10-elements arrangements in array [124]

Both of the standard FDO and improved FDO were used to optimize the aperiodic antenna array designs in 200 Iteration with 20 artificial scout bees as shown in figure 4.9 and 4.10.

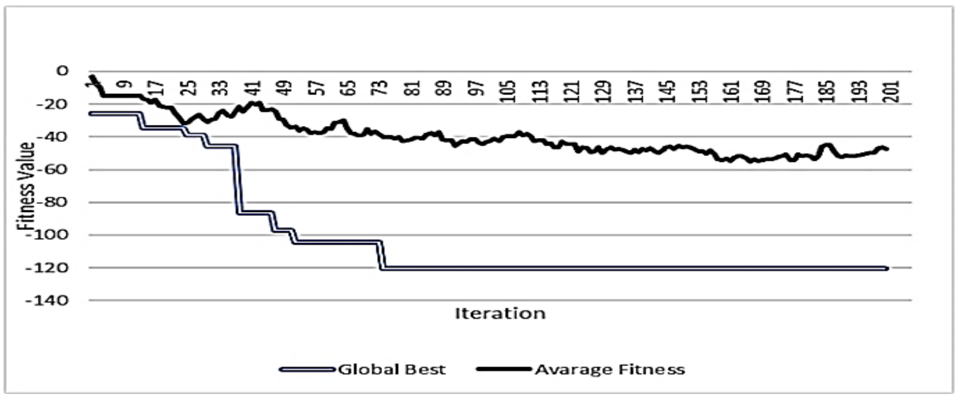

Figure 4. 9 Presents average fitness and global best as a result of optimizing aperiodic antenna array designs in 200 Iteration with 20 artificial scout bees using standard FDO

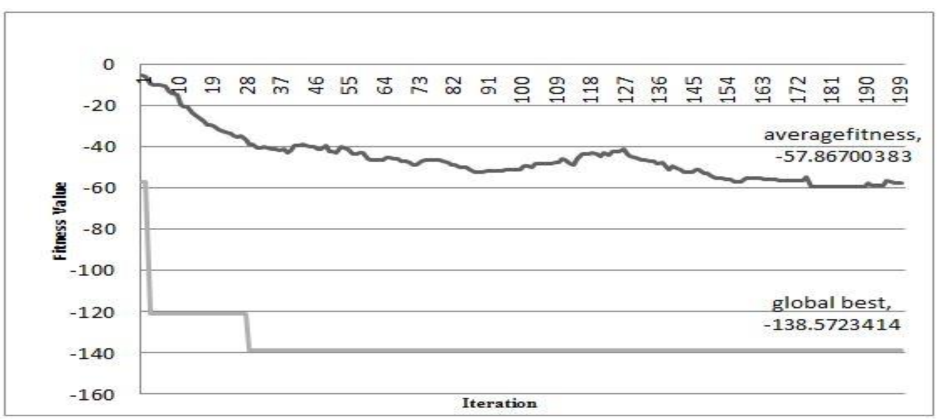

Figure 4. 10 Presents average fitness and global best as a result of optimizing aperiodic antenna array designs in 200 Iterations with 20 artificial scout bees using IFDO

B- IFDO vs FDO practice on our evacuation crowd model

In the last two decades, scenarios involving the evacuation of crowds and pedestrians have been studied in many works to reduce the negative aspects of emergency situations, such as deaths, damages, and injuries [125]. In this part of this paper, we create a simple pedestrian evacuation model based on a cellular automata model see Figure 4.11,

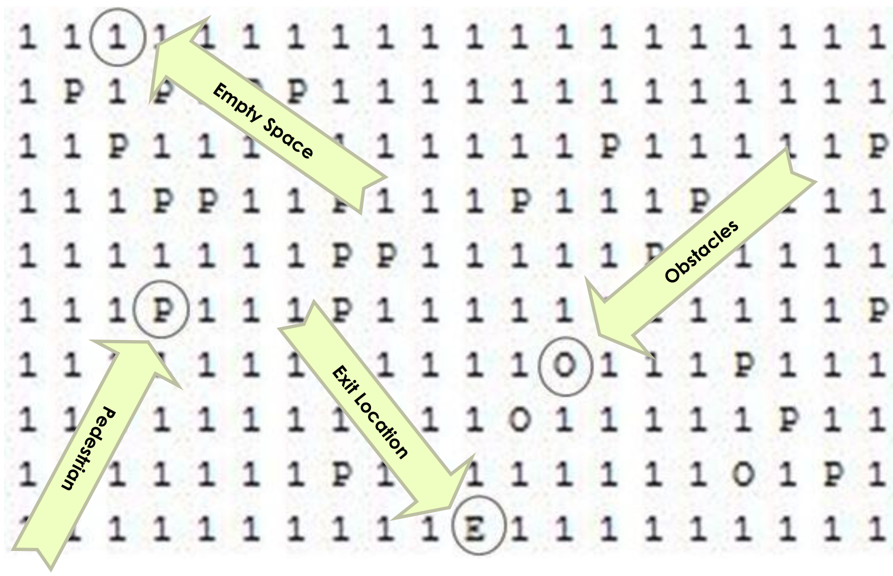

Figure 4. 11 Presents area of the pedestrians' evacuation model

The pedestrians' desired speeds are defined from the methodology of the created intelligent model as mentioned in the fourth subsection in section 1 of chapter 3. Additionally, the evacuation time of each pedestrian is calculated via the pedestrian's desired speed, its distance from the exit door as expressed in equation (4.4), and the average of the evacuation time of the pedestrians is used as average fitness value.

$$\mathrm{evacTime} = (\mathrm{dist}/2) * \mathrm{desiredSpeed} \qquad (4.4)$$

Where dist presents the pedestrian's distance from the door exit locations, which is calculated from the equation of Euclidian distance as showed in chapter

2 equation (2.4), and desiredSpeed presents the pedestrian's speed and its details can be found in the chapter 3 section 1 subsection 4 define evacuee speed.

Both of the standard FDO and improved FDO were used to optimize our evacuation crowd model in 200 Iteration with 20 artificial scout bees as shown in figure 4.12.

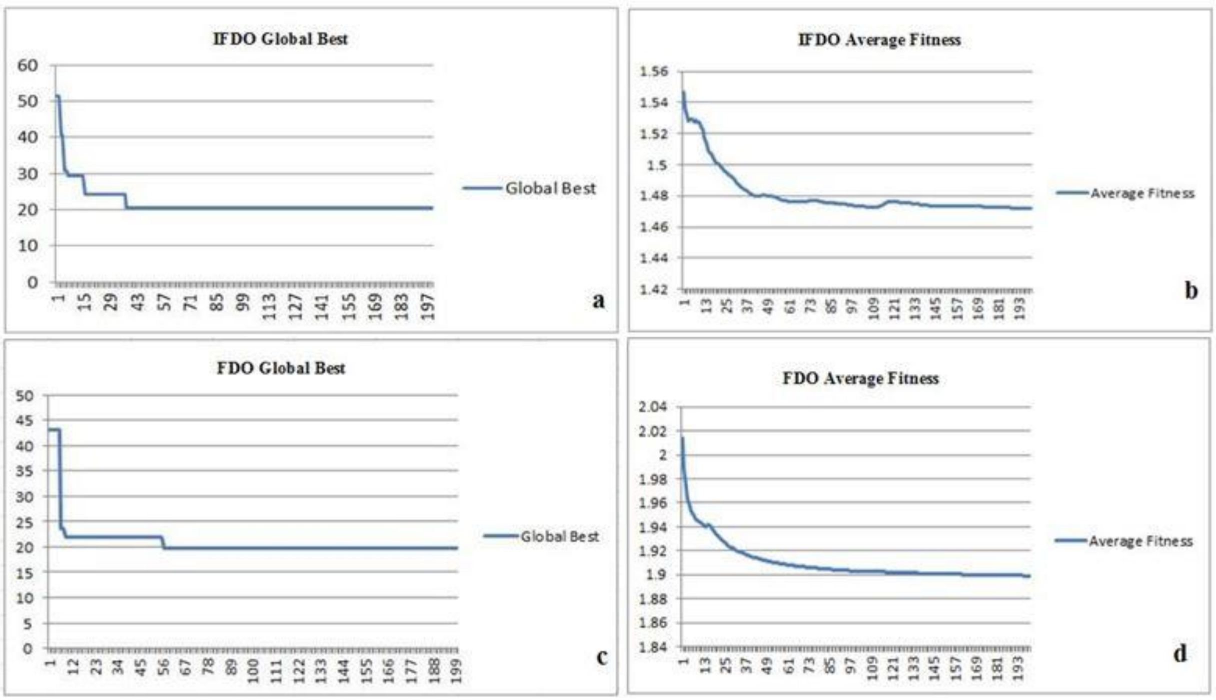

Figure 4. 12 IFDO and FDO global best and average fitness (a) IFDO global best (b) IFDO average fitness (c) FDO global best (d) FDO average fitness

CHAPTER 5: Discussion Results

This part of this research can be divided into three main parts and each part will compare, discuss and evaluate the experimentations' results were mentioned in chapter 4.

5.1 Discussion Results of Simulation of the Polytechnic University's First Floor

In the rest of this section, our model simulation results are discussed. For details of simulation results, look at Appendix D.

From the simulation results, it appeared that defining various desired speeds for the agents would cause to create congestion via the collision of the agents with other agents and obstacles. Moreover, increasing the main exit doors for the floor caused the fluctuation in C.W.A, C.W.O, O.B.D.E and evacuation time. For instance, in experimentation of 1A, 2A and 3A were their distributions nearly the same, but they had different numbers of main exit doors, C.W.A, C.W.O, and O.B.D.E were recorded as 56.863 percent, 39.235 percent, and (aside, wait, fail, jump over) for 1A respectively, 58.824 percent, 54.902 percent, and (aside, wait, help) for 2A respectively, 51.961 percent, 38.235 percent, and (aside, wait) for 3A respectively. Moreover, it was found that with an increasing number of main exit doors C.W.A and C.W.O were decreased and fewer O.B.D.E appeared. Furthermore, agents' evacuation times were decreased and recorded 0:59:682 for 1A, 1:22:155 for 2A and 0:57:100 for 3A, the time managed as a format of min.sec.ms.

Increasing spreading area of agents through the floor had a great impact on appearing various behaviors during the evacuation process, for instance, in experimentation 1A and 1C appeared that behaviors of (aside, wait, fail and jump over) were occurred in 1A and in experimentation 1C (aside and wait) were occurred. The occurrence various behaviors for 1A and 1C appeared due to the difference in the size of the area of agents' distributions. On the other hand, changing in distribution area and decreasing the number of main exit doors into only one main exit as in experimentation of 2A and 2B showed that these two characteristics had a great role in appearing different behaviors during the evacuation. For example, in 2A, C.W.A was fewer compared to C.W.A in 2B, 58.824 percent and 97.941 percent were recorded respectively. Moreover, C.W.O in 2A fewer compares to C.W.O in 2B 54.902 percent and 72.549 percent individually. Furthermore, various emergency behaviors appeared in both, however, appeared behaviors in 2B are much more than in 2A, (Aside, wait, wait to fail person, jump over, help, fail) and (Aside, wait, help) respectively.

Adding another room exit door into the rooms of the floor had a significant influence on minimizing the agent's collision with other agents and obstacles. Moreover, it was reduced evacuation time. Experimentations of 3A and 4A explained that situation. In 3A with one exit room doors and three main exit doors C.W.A and C.W.O were 51.961 percent and 38.235 percent respectively while this rate in 4A with two room exit door and three main exit doors was declined into 39.216 percent and 23.529 percent respectively. However, in both experiments, the same O.B.D.E was recorded. Evacuation time was decreased from 0:57:100 into 0:47:721.

On the other hand, the familiarity of the agents and larger distribution with the increasing number of exit doors had a great effect on improving evacuation time. However, in some cases led to increasing congestion while agents went to the shorter path regardless if there crowd in that exit. For example, in experimentations of 1A with one room exit door, two main exit doors and agents were not familiar with the exits of the floor and 4B with two room exit doors, three main exit doors and agents were familiar with the exits of the floor. The C.W.A and C.W.O in 1A, which were 56.863 percent and 39.235

percent respectively sharply declined into 11.765 and 4.902 respectively in 4B. Moreover, more behaviors were appeared in 1A compares to 4B that were (aside, wait, fail and jump over) and (aside, wait) correspondingly. Furthermore, evacuation performance significantly enhanced while the evacuation time was changed from 0:59:682 into 0:21:874.

5.2 Results Discussion of Simulation of the Polytechnic Institute’s Cafeteria

Inside the developed our new model, it was appeared that increasing number of room exit doors, main exit doors with familiarity of the evacuees to the exit doors and distribution in a larger area of the floor are the key factors to minimize the congestion, collision and appearing agent’s emergency behaviors that directly have a great influence on improving evacuation efficiency. In the remaining of this section, the result of our model simulation is discussed. For details of simulation results, refer to Supplementary File comprises 36 pages is available in the Appendix E.

Obviously specifying heterogeneous speed for the participants creates jamming due to colliding agents with each other and with obstructions. This situation was clearly seen in the simulation results. Furthermore, changing numbers of main exit doors and cafeteria’s distinct parts exit doors create variation in evacuation time and appearing emergency behaviors, such as C.W.A, C.W.O, and O.B.D.E. For example, in experimentation of No1C, No2A, they had different numbers of main exit doors, but they had the same distributions, C.W.A, C.W.O, and O.B.D.E were recorded as 27.66 percent, 33.33 percent, and (aside, wait) for No1C respectively, 45.679 percent, 50.617 percent, and (aside, wait, help) for No2A respectively. Besides, it was found that with adding a number of main exit doors C.W.A and C.W.O were decreased and different O.B.D.E appeared.

Furthermore, agents' evacuation times were reduced and recorded 0:46:74 for No1C, 0:47:805 for No2A, the time managed as a format of min.sec.ms. When participants distributed through a larger area of the cafeteria great effect would be created on the occurring behaviors and also on the evacuation time. For instance, in the experimentation of No1A and No1C behaviors, such as C.W.A, C.W.O, OBOE were 61.78, 30.64, and (aside, wait) for No1A respectively, while these behaviors were 27.859, 20.988, and (aside, wait, help) for No1C respectively. Because of the larger distribution in No1C collision behaviors significantly decreased between participants and participants with obstacles. Besides that, evacuation time considerably improved and recorded as 1:0:941 for No1A and 0:46:711 for No1C. On the other hand, participant familiarity with the exits doors had a great impact on changing the participants' evacuation behaviors and evacuation time, for instance, in the experimentations of No1A vs No1B, No3A vs No3B, and No4A vs no4B behaviors and evacuation time, such as C.W.A and C.W.O changed from 61.728 to 51.852, 65.432 to 30.864, 1:0:941 to 0:47:261 for No1A and No1B respectively, 23.457 to 16.49, 13.58 to 16.49, 0:41:241 to 0:37:976 for No3A and No3B receptively, and 25.926 to 22.222, 7.407 to 7.407, 0:40:51 to 0:31:307, for No4A &No4B respectively.

Furthermore, changing the number of exit doors made a great change in participant's evacuation behaviors and evacuation time, for example, in the experimentation of No3A vs No1A could be clearly noticed. In No1A which had two main exits and participants distributed through a small portion of the cafeteria, the appeared behaviors, such as, C.W.A, C.W.O, and O.B.D.E significantly more occurred than in No3A which had three main exits and participants distributed through larger area of the cafeteria, the result of this experimentation for behaviors, such as, C.W.A, C.W.O, OBDE, and evacuation time was recorded as 61.728, 30.864, (aside, wait), and 1:0:941 for No1A receptively, 23.457, 13.58, (aside, wait), and 0:41:241 for No3A respectively. The result shows appearing behaviors decreased and also evacuation time considerably improved due to an increase in the number of main exits and area of distribution.

From the experimentation result of No1D vs No2D, it appeared that increasing the number of exits is not the only reason to decrease appearing emergency behaviors and improving evacuation efficiency. For example, in the experimentation of No1D, there were two main exit doors, and in the experimentation of No2D, there was only one main exit door. However, the C.W.A is better to be compared to C.W.A in No2D, but C.W.O and evacuation time was better in No2D due to larger distribution.

5.3 Discussion of Optimization Results

In this section results of various traditional benchmark test functions, modern benchmark test functions, and FDO and IFDO tests on real world applications will be discussed and analyzed.

5.3.1 Results Discussion of the Traditional Benchmark Test Functions

The results of the IFDO, FDO, GA, DA, and PSO are illustrated in Table 4.7. The results show that the IFDO in TF5, TF8, TF11, and TF12 was driven better overall in comparison with the selected comparator algorithms. However, the IFDO was worse than the other algorithms in TF6, TF7, and TF13. Moreover, the results of TF7, TF17, and TF18 showed that the IFDO was more comparable to the original FDO, whereas the results of TF10 and TF19 demonstrated that the IFDO outperformed the other competitor algorithms. Additionally, the results of TF1, TF3, TF4, TF9, TF14, TF15, and TF16, which are highlighted in green in Table 4.7, proved that the IFDO surpassed the original FDO, GA, PSO, and DA in all the situations.

5.3.2 Results Discussion of the IEEE ECE Benchmark 2019 Test Functions

The results of the IFDO, FDO, DA, WOA, and SSA are illustrated in Table 4.8. The results show that IFDO in the cases of CEC02, CEC03, CEC09, and CEC10, the IFDO was equal to the original FDO; however, the standard deviation (SD) was changed somewhat. On the other hand, the IFDO surpasses other competitors' algorithms in those cases. In cases CEC04 - CEC08, except for CEC06, the IFDO outperformed all of the opponents; however, in the case of CEC06, the IFDO performed worse than the DA, WOA, and SSA but better than the original FDO. Finally, it is clear that the average IFDO, FDO, and WOA results are equal, whereas the standard deviation of WOA is equal to 0, which means there is no way to promote enhancement because similar results are obtained in all cases.

5.3.3 Results Discussion of the Quantitative Measurement Metrics

From the results noticed that the first measurement metrics test demonstrates how the search space is covered by the scout bee and presents the course of the convergence. During the test, the positions of the scout bees are logged from the start of the test to the end. Hence, this metric is simply a scout bee search history. At first, the whole area is rapidly discovered by the scout bee, and then, in the direction of optimality, they steadily move. Figure 4.5 presents the first quantitative metrics test. The second measurement metric test illustrates the iteration process that measures the agent's global best convergence. When the number of iterations is increased, xi* (the global best agent) is more precise, and when the scout bee focuses on the exploitation and local search, rapid changes are observed. See Figure 4.6.

Generally, the IFDO has the ability to successfully explore the search space, justifiably move in the direction of optimality and avoid local optima.

5.3.4 Results Discussion of the Aperiodic Antenna Array Designs

Based on the limitations stated in equation (4.1), for twenty artificial scout bees within 200 iterations, the original FDO algorithm was utilized to optimize this problem. Moreover, based on equation (4.2), the average fitness value and the global best fitness in each iteration are shown in Figure 4.9. The results indicate that with the element locations {0.713,1.595,0.433,0.130} in iteration 78, the global best solution was achieved.

Likewise, regarding the mentioned restrictions of this problem, similar to the original FDO, this problem was optimized using the IFDO algorithm in 200 iterations for twenty search agents (artificial bees), as shown in Figure 4.10, based on equation (4.2), which contains the average fitness value and the global best fitness in each iteration. The result shows that with element locations {0.701, 1.552, 0.402, 0.130}, the global best solution was achieved in iteration 29. Consequently, from both the IFDO and FDO results, it clearly appears that the IFDO is better for optimizing this problem due to its increasing capability of making better decisions in exploring better hives among the existing potential hives by adding alignment and cohesion when the scout wants to go to a different location in the defined space search; it also avoids unsuitable exploitation in achieving a better solution when, for every achieved better solution, the IFDO generates a new wf to control the fw see the pseudocode in Figure 3.13.

5.3.5 Results Discussion of the FDO and IFDO on Our Evacuation Crowd Model

Both the IFDO and FDO algorithms are applied to this model to achieve the global best solution by finding the best location of the main door through which to evacuate people during the evacuation process. The results showed that the IFDO was more efficient and reached the optimum solution with only 38 iterations with exit point 11, whereas the FDO reached the optimum solution with 57 iterations with exit point 16. Figure 4.12 shows the results of both algorithms.

The reasons behind the IFDO's efficiency are related to the selected parameters, alignment, and cohesion, in updating the position of the artificial scout bees, which makes the algorithm perform better explorations in finding a suitable solution in the landscape. Second, the randomization in defining wf in every iteration for each scout bee when a better solution is achieved makes the algorithm avoid unnecessary exploitations to gain a better solution. Third, the IFDO, as regards covering a reasonable search space, converges sooner to global optimality.

CHAPTER 6: Conclusion and Future Work

6.1 Conclusion

- ✓ An intelligent model built based on analyzing the previous applications of the cellular automata approach which is one of the microscopic model's approaches. Inside this model, cellular automata (CA) employed with a combination of the fuzzy logic idea to define the value of the participant's properties, such as physical, biological, and emotional and then defined values of the participant's properties were used within some statistical equation to define desired speed for that participant. Additionally, the KNN algorithm was applied to find the nearest exit door during the evacuation process.
- ✓ Discusses the impact of the defined desired heterogeneous speed for participants with a combination of participants' behavior, familiarity, environment, and participants' distribution through the distinct parts of the case studies on the appearing emergency behaviors and evocation efficiency. From simulation results appeared different properties of participants caused different speeds for participants. Hence, a collision between participants C.W.A occurred during the evacuation process. Different behaviors, such as C.W.O and O.B.D.E appeared and different evacuation time was recorded for each participant. More experiments presented that environment, such as obstacles, size and number of main and distinct parts of the cafeteria exit doors had a great impact on changing participants' emergency behaviors and evacuation time.
- ✓ An improvement has been done in Fitness Dependent Optimizer from two main points. Firstly, updating the artificial scout bee position, in the IFDO, two additional parameters were added: alignment and cohesion to the

equation of position update in the original FDO. Secondly, change the weight factor (wf) from a stable usage into a random usage in controlling the fitness weight of the fitness the FDO algorithm. IFDO made these changes with the aim of moving the scout bees to optimality with better performance. IFDO to evaluate its performance was tested with 19 test functions single objective benchmark (unimodal, multimodal and composite test functions). Furthermore, benchmarks of 10 modern CEC-C06 were utilized to test IFDO. Results of the IFDO tests with these classical and modern test functions were compared to the FDO and two other distinguished (GA and PSO) algorithms, and other three states of art algorithms (SSA, WOA, and DA). According to the results, IFDO except on some of the cases that had reasonable results compared, the preferred algorithms it surpassed them on most of the other cases.

- ✓ To confirm that IFDO has the ability to address the real life applications, two real world problems were selected; the first one was an existing “Aperiodic Antenna Array Designs” real world problem, and the second one was an evacuation crowd real world problem which this one was created by us. In both of the applications IFDO outperformed the original FDO while in the first mentioned practiced application, FDO needs 78 iterations to discover the global best solution’s optimum solution, whereas IFDO needs only 29 iterations in gaining the global best solution’s optimum solution, also in second mentioned practiced application IFDO exceed the original FDO while IFDO needs only 38 iterations to gain optimum solution of the global best and FDO to achieve the same result needs 57 iterations.

6.2 Future Work

In the future, several suggestions can be concerned into account to improve the proposed algorithms.

- ✓ design and implement fire, thus other features, such as: how the fire spread out through the building according to its environment will be added.
- ✓ The intelligent model analyze and discuss the effect of the fire on the agents' behaviors based on recording numbers of dead, injured or suffocated agents as a result of fire and smoke.
- ✓ enhance the created model to make a simulation for the second floor and above.
- ✓ Use different optimizer algorithms to optimize the created model as a real-world application.
- ✓ Designers and experts can use the results to make a better decision in building an evacuation system

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Publications

1. D. A. Muhammed, S. A. Saeed and T. A. Rashid, "Improved Fitness-Dependent Optimizer Algorithm," in IEEE Access. https://doi: 10.1109/ACCESS.2020.2968064 (Thomson Reuters, IF = 4.098)

2. D. A. Muhammed, S. A. M. Saeed, and T. A. Rashid, “A Simulation Model for Pedestrian Crowd Evacuation Based on Various AI Techniques,” Revue dIntelligence Artificielle, vol. 33, no. 4, pp. 283–292, 2019. https://doi.org/10.18280/ria.330404. (Scopus, Impact per Paper (SNIP): 0.421)

Appendix A

Interview Plan
Before the interview **Objective Interview** **Determining participant physical, biological and emotional properties** **Interviewer: Danial Muhammed and Soran Saed** **Date, location, time** **01-10-2017 to 1-11-2017, precedency building of polytechnic university, 10:00 AM** **Participant (position): Lecturer/Employee/Student/Visitors**
During the Interview
1. What is your position? **2. How old are you?** **3. How many kilos are you? Or What do you weight?** **4. Do you have any disease? If, yes, at which level it is?** **5. Are you shocking during emergency occurrence? If yes, at which level it is?** **6. Are you Collaborating with others during emergency occurrence? If yes, at which level it is?**
After the Interview
Looking at the answers, analyzing them and making them concise inside a table.

Interview plan to collect data about physical, biological and emotional properties of participants

Questionnaire
When you are in the first floor of the presidency of polytechnic university, and it is crowd and an emergency occur which makes you run to find the exit door to go out from the building. What are the appearing behaviours do you expect for your self during the evacuation. Please, tick the following behaviours you expect:
Gender ☐Male ☐ Female
Do you wait on a person in front of you, whenever he/she left the place, you will be continuing from moving? ○ Yes ○ No Do you aside (or pass) the person immediately. ○ Yes ○ No Do you jump over the fallen person, whenever it needs? ○ Yes ○ No Do you help persons? ○ Yes ○ No Do you wait to the fallen persons ○ Yes ○ No

Questionnaire to collect data about behaviours of participants during emergency occurrence

Appendix B

AgentID	Gender	Age(yrs.)	Weight(kg.)	Disease	Collaboration	Shock	Familiarity
1	Male	40	75	1	4	3	Familiar
2	Male	40	90	2	1	8	Familiar
3	Male	33	84	3	12	7	Familiar
4	Male	33	92	6	11	8	Familiar
5	Male	36	84	1	2	1	Familiar
6	Male	22	81	0	2	7	Familiar
7	Male	19	73	6	3	8	Familiar
8	Male	36	90	6	9	1	Familiar
9	Male	47	84	0	9	9	Familiar
10	Male	24	86	9	12	9	Familiar
11	Male	34	84	0	9	8	Familiar
12	Male	30	72	1	8	1	Familiar
13	Male	28	77	3	10	9	Familiar
14	Male	49	71	4	1	2	Familiar
15	Male	34	82	6	10	11	Familiar
16	Male	43	95	2	1	0	Familiar
17	Male	22	84	5	0	11	Familiar
18	Male	36	70	2	0	3	Familiar
19	Male	36	69	3	9	30	Familiar
20	Male	48	79	0	12	26	Familiar
21	Male	41	85	5	5	34	Familiar
22	Male	25	77	9	6	33	Familiar
23	Male	48	80	2	9	28	Familiar
24	Male	19	95	7	12	35	Familiar
25	Male	47	69	1	11	21	Familiar
26	Male	26	70	30	5	47	Familiar
27	Male	34	94	30	26	55	Familiar
28	Male	29	74	30	30	42	Familiar
29	Male	22	87	27	29	54	Familiar
30	Male	27	92	23	27	54	Familiar
31	Male	47	69	50	46	61	Familiar
32	Male	40	80	50	43	74	Familiar
33	Male	23	73	63	47	72	Familiar
34	Male	19	90	73	64	80	Familiar
35	Male	30	81	96	87	92	Familiar
36	Female	23	82	3	6	0	Familiar
37	Female	38	77	13	10	0	Familiar
38	Female	27	75	2	12	16	Familiar
39	Female	23	57	6	2	13	Familiar
40	Female	39	79	12	1	16	Familiar
41	Female	37	76	15	12	27	Familiar
42	Female	35	74	13	12	33	Familiar
43	Female	27	72	13	8	24	Familiar
44	Female	33	67	6	4	32	Familiar
45	Female	24	76	2	13	23	Familiar
46	Female	19	77	8	9	51	Familiar
47	Female	34	57	13	0	46	Familiar
48	Female	23	75	13	1	51	Familiar
49	Female	36	71	4	5	52	Familiar
50	Female	29	73	2	13	50	Familiar
51	Female	36	81	8	12	54	Familiar
52	Female	28	63	11	11	46	Familiar
53	Female	31	67	0	15	41	Familiar
54	Female	38	64	3	11	41	Familiar
55	Female	40	63	12	10	55	Familiar
56	Female	19	65	11	2	41	Familiar
57	Female	24	69	9	27	48	Familiar
58	Female	27	79	12	33	57	Familiar
59	Female	33	69	5	22	54	Familiar
60	Female	30	60	9	36	46	Familiar
61	Female	33	72	11	20	46	Familiar
62	Female	41	75	15	22	57	Familiar
63	Female	22	80	7	34	52	Familiar
64	Female	41	67	5	33	55	Familiar
65	Female	19	62	10	29	66	Familiar
66	Female	19	61	8	22	70	Familiar
67	Female	40	80	8	20	68	Familiar
68	Female	24	62	5	27	74	Familiar
69	Female	38	63	2	34	78	Familiar
70	Female	30	65	9	25	69	Familiar
71	Female	39	82	1	47	69	Familiar
72	Female	37	72	34	56	73	Familiar
73	Female	26	65	30	43	78	Familiar
74	Female	30	57	23	51	71	Familiar
75	Female	24	77	26	49	66	Familiar
76	Female	34	68	37	44	62	Familiar
77	Female	29	59	41	56	74	Familiar
78	Female	20	77	48	67	75	Familiar
79	Female	34	82	45	61	73	Familiar
80	Female	26	72	77	94	94	Familiar
81	Female	37	76	97	88	89	Familiar

A sample of the collected data from the interviewing agents

Appendix C

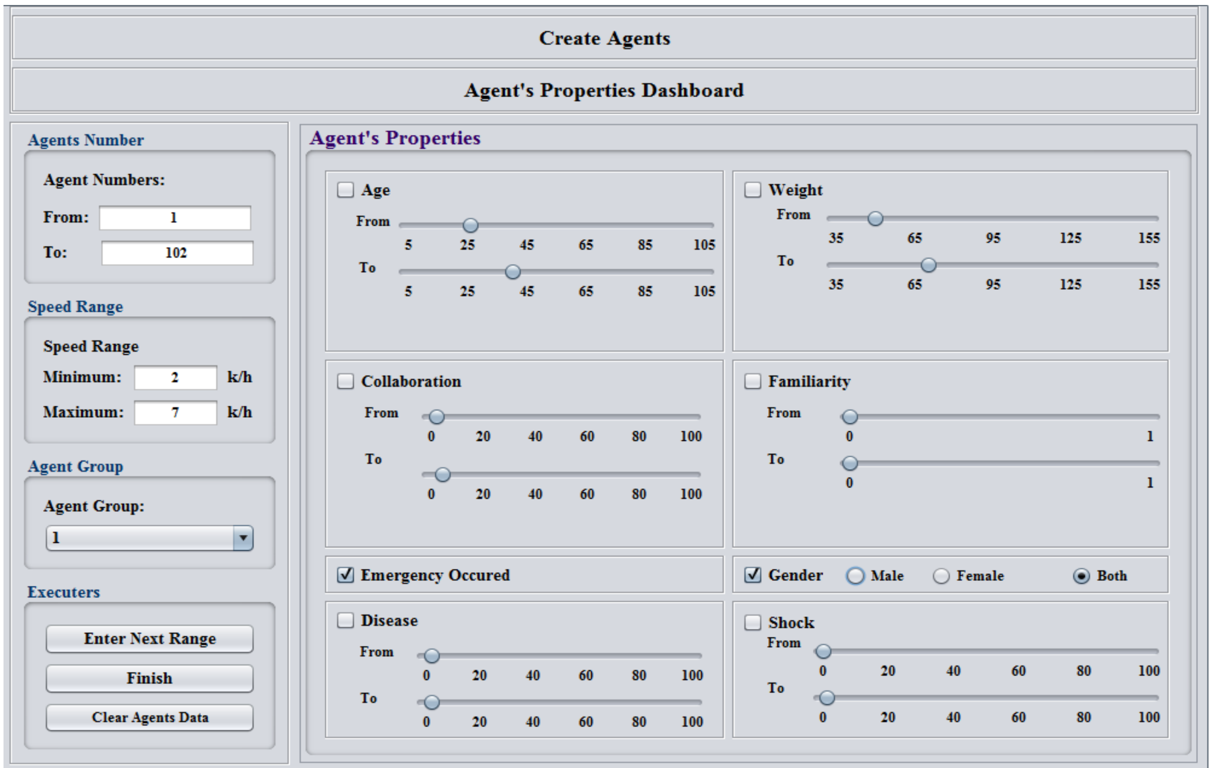
AgentID	Gender	Age(yrs.)	Weight(kg.)	Disease	Collaboration	Shock	Familiarity	Desired Speed
1	Male	0.75 very young and 0.25 adult	%100 slim	%100 very low	%100 very low	%100 very low	Familiar	6.17
2	Male	0.75 very young and 0.25 adult	0.75 heavy and 0.25 slim	%100 very low	%100 very low	%100 very low	Familiar	5.99
3	Male	0.6 adult and 0.4 very young	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.01
4	Male	0.6 adult and 0.4 very young	0.85 heavy and 0.15 slim	%100 very low	%100 very low	%100 very low	Familiar	5.9
5	Male	0.55 very young and 0.45 adult	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.16
6	Male	%100 adult	0.7 slim and 0.3 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.28
7	Male	%100 adult	0.9 slim and 0.1 very slim	%100 very low	%100 very low	%100 very low	Familiar	6.31
8	Male	0.55 very young and 0.45 adult	0.75 heavy and 0.25 slim	%100 very low	%100 very low	%100 very low	Familiar	5.98
9	Male	0.9 very young and 0.1 young	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	Familiar	5.91
10	Male	%100 adult	0.55 heavy and 0.45 slim	%100 very low	%100 very low	%100 very low	Familiar	6
11	Male	0.55 adult and 0.45 very young	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.05
12	Male	0.75 adult and 0.25 very young	0.85 slim and 0.15 very slim	%100 very low	%100 very low	%100 very low	Familiar	6.28
13	Male	0.85 adult and 0.15 very young	0.9 slim and 0.1 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.13
14	Male	0.8 very young and 0.2 young	0.8 slim and 0.2 very slim	%100 very low	%100 very low	%100 very low	Familiar	6.13
15	Male	0.55 adult and 0.45 very young	0.65 slim and 0.35 heavy	%100 very low	%100 very low	%100 very low	Familiar	5.97
16	Male	0.9 very young and 0.1 adult	%100 heavy	%100 very low	%100 very low	%100 very low	Familiar	5.99
17	Male	%100 adult	0.55 slim and 0.45 heavy	%100 very low	%100 very low	%100 very low	Familiar	6.18
18	Male	0.55 very young and 0.45 adult	0.75 slim and 0.25 very slim	%100 very low	%100 very low	%100 very low	Familiar	6.29
19	Male	0.55 very young and 0.45 adult	0.7 slim and 0.3 very slim	%100 very low	%100 very low	0.5 low and 0.5 very low	Familiar	5.93
20	Male	0.85 very young and 0.15 young	0.8 slim and 0.2 heavy	%100 very low	%100 very low	0.7 very low and 0.3 low	Familiar	5.75
21	Male	0.8 very young and 0.2 adult	0.5 heavy and 0.5 slim	%100 very low	%100 very low	0.7 low and 0.3 very low	Familiar	5.7
22	Male	%100 adult	0.9 slim and 0.1 heavy	%100 very low	%100 very low	0.65 low and 0.35 very low	Familiar	5.9
23	Male	0.85 very young and 0.15 young	0.75 slim and 0.25 heavy	%100 very low	%100 very low	0.6 very low and 0.4 low	Familiar	5.73
24	Male	%100 adult	%100 heavy	%100 very low	%100 very low	0.75 low and 0.25 very low	Familiar	5.72
25	Male	0.9 very young and 0.1 young	0.7 slim and 0.3 very slim	%100 very low	%100 very low	0.95 very low and 0.05 low	Familiar	5.91
26	Male	0.95 adult and 0.05 very young	0.75 slim and 0.25 very slim	0.5 low and 0.5 very low	%100 very low	0.65 low and 0.35 medium	Familiar	5.62
27	Male	0.55 adult and 0.45 very young	0.95 heavy and 0.05 slim	0.5 low and 0.5 very low	0.7 very low and 0.3 low	0.75 medium and 0.25 low	Familiar	5.01
28	Male	0.8 adult and 0.2 very young	0.95 slim and 0.05 very slim	0.5 low and 0.5 very low	0.5 low and 0.5 very low	0.9 low and 0.1 medium	Familiar	5.35
29	Male	%100 adult	0.6 heavy and 0.4 slim	0.65 very low and 0.35 low	0.55 very low and 0.45 low	0.7 medium and 0.3 low	Familiar	5.21
30	Male	0.9 adult and 0.1 very young	0.85 heavy and 0.15 slim	0.85 very low and 0.15 low	0.65 very low and 0.35 low	0.7 medium and 0.3 low	Familiar	5.17
31	Male	0.9 very young and 0.1 young	0.7 slim and 0.3 very slim	0.5 medium and 0.5 low	0.7 low and 0.3 medium	0.95 medium and 0.05 high	Familiar	4.67
32	Male	0.75 very young and 0.25 adult	0.75 slim and 0.25 heavy	0.5 medium and 0.5 low	0.85 low and 0.15 medium	0.7 high and 0.3 medium	Familiar	4.53
33	Male	%100 adult	0.9 slim and 0.1 very slim	0.85 medium and 0.15 high	0.65 low and 0.35 medium	0.6 high and 0.4 medium	Familiar	4.62
34	Male	%100 adult	0.75 heavy and 0.25 slim	0.65 high and 0.35 medium	0.8 medium and 0.2 high	%100 high	Familiar	4.14
35	Male	0.75 adult and 0.25 very young	0.7 slim and 0.3 heavy	0.8 very high and 0.2 high	0.65 high and 0.35 very high	0.6 very high and 0.4 high	Familiar	3.54
36	Female	%100 adult	0.65 slim and 0.35 heavy	%100 very low	%100 very low	%100 very low	Familiar	3.13
37	Female	0.65 very young and 0.35 adult	0.9 slim and 0.1 heavy	%100 very low	%100 very low	%100 very low	Familiar	3.01
38	Female	0.9 adult and 0.1 very young	%100 slim	%100 very low	%100 very low	%100 very low	Familiar	3.04
39	Female	%100 adult	0.9 very slim and 0.1 slim	%100 very low	%100 very low	%100 very low	Familiar	3.2
40	Female	0.7 very young and 0.3 adult	0.8 slim and 0.2 heavy	%100 very low	%100 very low	%100 very low	Familiar	2.96
41	Female	0.6 very young and 0.4 adult	0.95 slim and 0.05 heavy	%100 very low	%100 very low	0.65 very low and 0.35 low	Familiar	2.86
42	Female	0.5 very young and 0.5 adult	0.95 slim and 0.05 very slim	%100 very low	%100 very low	0.65 low and 0.35 very low	Familiar	2.86
43	Female	0.9 adult and 0.1 very young	0.85 slim and 0.15 very slim	%100 very low	%100 very low	0.8 very low and 0.2 low	Familiar	2.98
44	Female	0.6 adult and 0.4 very young	0.6 slim and 0.4 very slim	%100 very low	%100 very low	0.6 low and 0.4 very low	Familiar	2.99
45	Female	%100 adult	0.95 slim and 0.05 heavy	%100 very low	%100 very low	0.85 very low and 0.15 low	Familiar	3.01
46	Female	%100 adult	0.9 slim and 0.1 heavy	%100 very low	%100 very low	0.55 medium and 0.45 low	Familiar	2.88
47	Female	0.55 adult and 0.45 very young	0.9 very slim and 0.1 slim	%100 very low	%100 very low	0.7 low and 0.3 medium	Familiar	2.95
48	Female	%100 adult	%100 slim	%100 very low	%100 very low	0.55 medium and 0.45 low	Familiar	2.88
49	Female	0.55 very young and 0.45 adult	0.8 slim and 0.2 very slim	%100 very low	%100 very low	0.6 medium and 0.4 low	Familiar	2.86
50	Female	0.8 adult and 0.2 very young	0.9 slim and 0.1 very slim	%100 very low	%100 very low	0.5 medium and 0.5 low	Familiar	2.86
51	Female	0.55 very young and 0.45 adult	0.7 slim and 0.3 heavy	%100 very low	%100 very low	0.7 medium and 0.3 low	Familiar	2.74
52	Female	0.85 adult and 0.15 very young	0.6 very slim and 0.4 slim	%100 very low	%100 very low	0.7 low and 0.3 medium	Familiar	2.9
53	Female	0.7 adult and 0.3 very young	0.6 slim and 0.4 very slim	%100 very low	%100 very low	0.95 low and 0.05 medium	Familiar	2.93
54	Female	0.65 very young and 0.35 adult	0.55 very slim and 0.45 slim	%100 very low	%100 very low	0.95 low and 0.05 medium	Familiar	2.92
55	Female	0.75 very young and 0.25 adult	0.6 very slim and 0.4 slim	%100 very low	%100 very low	0.75 medium and 0.25 low	Familiar	2.8
56	Female	%100 adult	0.5 slim and 0.5 very slim	%100 very low	%100 very low	0.95 low and 0.05 medium	Familiar	3.01
57	Female	%100 adult	0.7 slim and 0.3 very slim	%100 very low	0.65 very low and 0.35 low	0.6 low and 0.4 medium	Familiar	2.82
58	Female	0.9 adult and 0.1 very young	0.8 slim and 0.2 heavy	%100 very low	0.65 low and 0.35 very low	0.85 medium and 0.15 low	Familiar	2.66
59	Female	0.6 adult and 0.4 very young	0.7 slim and 0.3 very slim	%100 very low	0.9 very low and 0.1 low	0.7 medium and 0.3 low	Familiar	2.78
60	Female	0.75 adult and 0.25 very young	0.75 very slim and 0.25 slim	%100 very low	0.8 low and 0.2 very low	0.7 low and 0.3 medium	Familiar	2.8
61	Female	0.6 adult and 0.4 very young	0.85 slim and 0.15 very slim	%100 very low	%100 very low	0.7 low and 0.3 medium	Familiar	2.79
62	Female	0.8 very young and 0.2 adult	%100 slim	%100 very low	0.9 very low and 0.1 low	0.85 medium and 0.15 low	Familiar	2.65
63	Female	%100 adult	0.75 slim and 0.25 heavy	%100 very low	0.7 low and 0.3 very low	0.6 medium and 0.4 low	Familiar	2.72
64	Female	0.8 very young and 0.2 adult	0.6 slim and 0.4 very slim	%100 very low	0.65 low and 0.35 very low	0.75 medium and 0.25 low	Familiar	2.7
65	Female	%100 adult	0.65 very slim and 0.35 slim	%100 very low	0.55 very low and 0.45 low	0.7 medium and 0.3 high	Familiar	2.77
66	Female	%100 adult	0.7 very slim and 0.3 slim	%100 very low	0.9 very low and 0.1 low	0.5 high and 0.5 medium	Familiar	2.8
67	Female	0.75 very young and 0.25 adult	0.75 slim and 0.25 heavy	%100 very low	%100 very low	0.6 medium and 0.4 high	Familiar	2.62
68	Female	%100 adult	0.65 very slim and 0.35 slim	%100 very low	0.65 very low and 0.35 low	0.7 high and 0.3 medium	Familiar	2.74
69	Female	0.65 very young and 0.35 adult	0.6 very slim and 0.4 slim	%100 very low	0.7 low and 0.3 very low	0.9 high and 0.1 medium	Familiar	2.63
70	Female	0.75 adult and 0.25 very young	0.5 slim and 0.5 very slim	%100 very low	0.75 very low and 0.25 low	0.55 medium and 0.45 high	Familiar	2.71
71	Female	0.7 very young and 0.3 adult	0.65 slim and 0.35 heavy	%100 very low	0.65 low and 0.35 medium	0.55 medium and 0.45 high	Familiar	2.51
72	Female	0.6 very young and 0.4 adult	0.85 slim and 0.15 very slim	0.7 low and 0.3 very low	0.8 medium and 0.2 low	0.65 high and 0.35 medium	Familiar	2.34
73	Female	0.95 adult and 0.05 very young	0.5 slim and 0.5 very slim	0.5 low and 0.5 very low	0.85 low and 0.15 medium	0.9 high and 0.1 medium	Familiar	2.49
74	Female	0.75 adult and 0.25 very young	0.9 very slim and 0.1 slim	0.85 very low and 0.15 low	0.55 medium and 0.45 low	0.55 high and 0.45 medium	Familiar	2.54
75	Female	%100 adult	0.9 slim and 0.1 heavy	0.7 very low and 0.3 low	0.55 low and 0.45 medium	0.7 medium and 0.3 high	Familiar	2.49
76	Female	0.55 adult and 0.45 very young	0.65 slim and 0.35 very slim	0.85 low and 0.15 very low	0.8 low and 0.2 medium	0.9 medium and 0.1 high	Familiar	2.47
77	Female	0.8 adult and 0.2 very young	0.8 very slim and 0.2 slim	0.95 low and 0.05 medium	0.8 medium and 0.2 low	0.7 high and 0.3 medium	Familiar	2.41
78	Female	%100 adult	0.9 slim and 0.1 heavy	0.6 low and 0.4 medium	0.65 medium and 0.35 high	0.75 high and 0.25 medium	Familiar	2.26
79	Female	0.55 adult and 0.45 very young	0.65 slim and 0.35 heavy	0.75 low and 0.25 medium	0.95 medium and 0.05 high	0.65 high and 0.35 medium	Familiar	2.22
80	Female	0.95 adult and 0.05 very young	0.85 slim and 0.15 very slim	0.85 high and 0.15 medium	0.7 very high and 0.3 high	0.7 very high and 0.3 high	Familiar	2
81	Female	0.6 very young and 0.4 adult	0.95 slim and 0.05 heavy	0.85 very high and 0.15 high	0.6 high and 0.4 very high	0.55 high and 0.45 very high	Familiar	2

Defined desired speed for the agents based on their properties using fuzzy logic technique

Appendix D

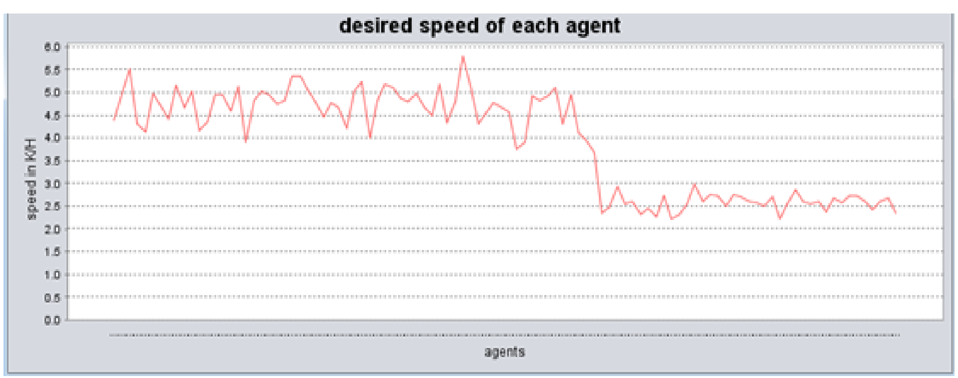
Experimentation and results:

Determine the agents' properties via the model to participate in defining the agents' desired speeds:



Choosing agents properties and defining agents' desired speed

After choosing the agents properties, to get the weight of each properties in determining the speed of the agent, the model works on properties according to the idea of fuzzy logic technique due to designing member function for each property.



Result of defined 102 agents' desired speeds in kph

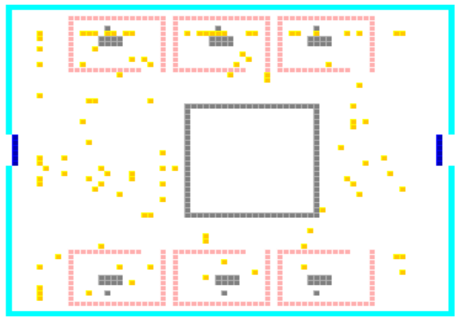
Appendix D

Experimentations and Results

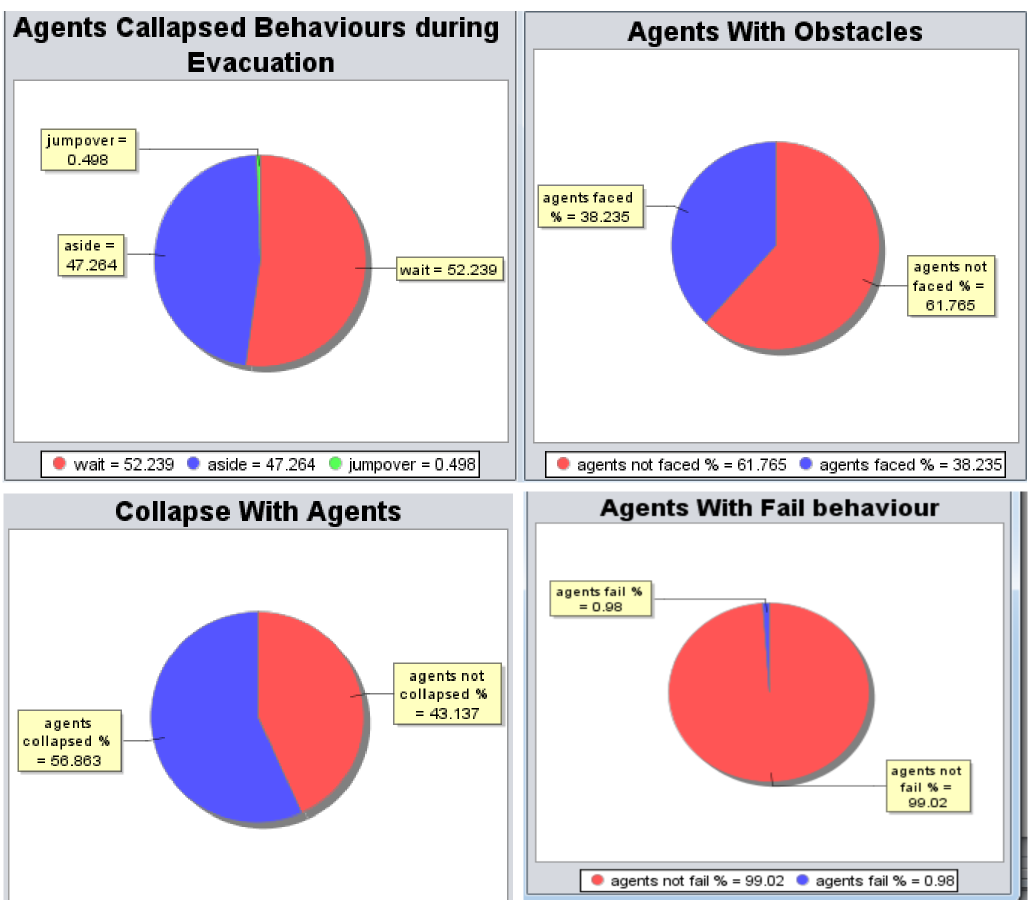
Note: defined speed use in all experimentations

First Experimentation:

A) 102 agents with two main exits, no familiar, in a small distribution(y=65,x=60) through the floor, rooms has only one door to go out



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	36 , 24	1st right	7	5 times	4.3776	28.5	0:35:222
2	34 , 22	1st right	11	6 times	4.9896	32.5	0:32:466
3	34 , 10	1st left	no obstacle	no collapse	5.508	2.5	0:4:420
4	32 , 63	1st left	1	7 times	4.32	32.0	0:31:2
5	32 , 59	1st right	no obstacle	no collapse	4.1184	7.5	0:9:270
6	32 , 18	1st right	11	9 times	4.968	34.0	0:37:869
7	32 , 10	1st left	no obstacle	no collapse	4.7232	2.0	0:3:246
8	31 , 29	1st left	no obstacle	no collapse	4.4064	11.5	0:10:345
9	31 , 10	1st right	12	9 times	5.148	39.0	0:38:401
10	30 , 68	1st left	1	4 times	4.6584	34.5	0:29:324
11	30 , 20	1st left	no obstacle	no collapse	5.0184	7.0	0:5:859
12	29 , 69	1st right	no obstacle	no collapse	4.1472	2.5	0:3:965
13	29 , 11	1st left	no obstacle	no collapse	4.3632	3.0	0:3:410
14	28 , 26	1st left	no obstacle	no collapse	4.9608	10.0	0:7:891
15	27 , 32	1st left	no obstacle	1 time	4.9464	13.0	0:10:603
16	26 , 69	1st left	1	5 times	4.5792	36.5	0:30:194
17	26 , 68	1st left	1	5 times	5.1192	36.0	0:27:15
18	26 , 58	1st right	no obstacle	no collapse	3.888	8.0	0:9:177
19	26 , 33	1st left	no obstacle	no collapse	4.8312	13.5	0:10:856
20	26 , 30	1st left	no obstacle	no collapse	5.0184	12.0	0:8:393
21	25 , 10	1st left	no obstacle	no collapse	4.9392	3.0	0:3:165
22	24 , 68	1st left	1	6 times	4.752	35.5	0:28:380
23	24 , 58	1st left	1	4 times	4.8096	26.0	0:22:125
24	24 , 14	1st right	11	10 times	5.3712	36.0	0:36:41
25	23 , 47	1st left	no obstacle	2 times	5.3496	20.0	0:14:320
26	23 , 10	1st left	no obstacle	no collapse	5.0472	5.0	0:5:24
27	22 , 65	1st right	no obstacle	no collapse	4.8024	4.5	0:5:284
28	22 , 64	1st right	no obstacle	1 time	4.4712	5.5	0:7:277
29	22 , 54	1st left	no obstacle	5 times	4.7808	23.5	0:21:736
30	22 , 52	1st left	no obstacle	4 times	4.6728	22.5	0:20:440
31	22 , 51	1st left	no obstacle	4 times	4.2192	22.5	0:22:738
32	22 , 23	1st left	no obstacle	no collapse	5.0184	8.5	0:7:82
33	21 , 47	1st right	no obstacle	1 time	5.22	13.0	0:10:692
34	21 , 44	1st right	no obstacle	2 times	4.0104	14.5	0:17:802
35	20 , 51	1st right	no obstacle	no collapse	4.8168	11.0	0:9:689
36	20 , 22	1st left	no obstacle	no collapse	5.1768	8.0	0:6:205
37	19 , 52	1st left	no obstacle	3 times	5.0976	22.5	0:16:915
38	19 , 21	1st right	6	3 times	4.8672	29.5	0:27:900

Results of evacuation simulation and specifying evacuation time for each agent

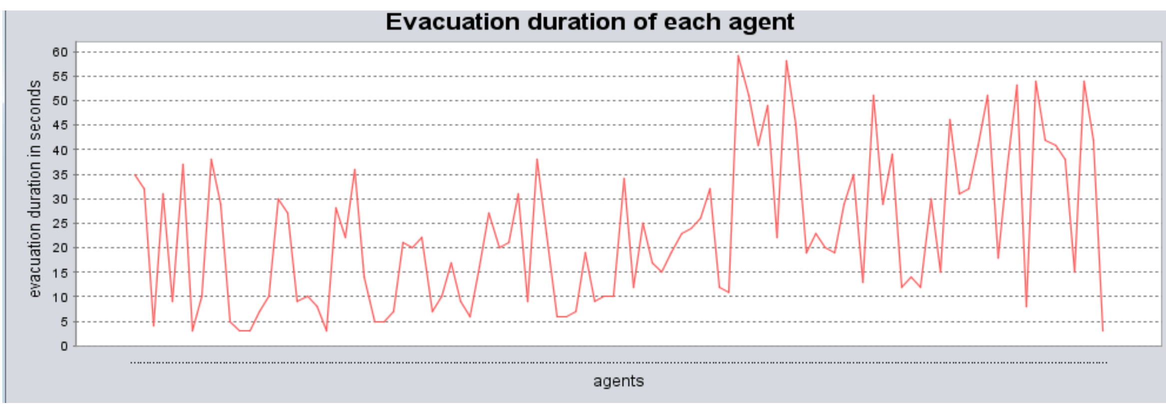
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	18 , 55	1st left	no obstacle	3 times	4.788	24.0	0:20:624
40	18 , 33	1st right	no obstacle	4 times	4.9824	20.0	0:21:178
41	18 , 10	1st right	7	2 times	4.7016	35.5	0:31:901
42	16 , 59	1st right	no obstacle	no collapse	4.4784	7.0	0:9:741
43	16 , 13	1st right	11	10 times	5.1696	36.0	0:38:716
44	15 , 34	1st right	6	1 time	4.3416	19.0	0:23:289
45	14 , 10	1st left	no obstacle	no collapse	4.788	8.5	0:6:743
46	13 , 54	1st right	1	no collapse	5.7816	9.5	0:6:796
47	12 , 59	1st right	no obstacle	no collapse	5.1912	9.0	0:7:359
48	12 , 45	1st left	no obstacle	no collapse	4.32	21.5	0:19:110
49	10 , 66	1st right	no obstacle	no collapse	4.5288	10.0	0:9:380
50	10 , 61	1st right	no obstacle	no collapse	4.7808	10.5	0:10:107
51	10 , 57	1st right	no obstacle	no collapse	4.68	10.0	0:10:870
52	10 , 56	1st left	no obstacle	8 times	4.572	32.0	0:34:537
53	10 , 55	1st right	no obstacle	no collapse	3.7512	10.5	0:12:353
54	10 , 44	1st left	no obstacle	3 times	3.888	22.0	0:25:62
55	10 , 40	1st left	no obstacle	1 time	4.9176	22.5	0:17:630
56	10 , 39	1st right	no obstacle	1 time	4.8312	18.5	0:15:910
57	10 , 38	1st left	no obstacle	2 times	4.9176	24.0	0:19:650
58	10 , 37	1st left	no obstacle	6 times	5.0904	24.0	0:23:358
59	10 , 36	1st right	1	3 times	4.3128	22.0	0:24:967
60	10 , 25	1st right	no obstacle	4 times	4.9392	26.0	0:26:795
61	10 , 20	1st right	no obstacle	3 times	4.0968	27.5	0:32:466
62	10 , 13	1st left	no obstacle	no collapse	3.9528	12.0	0:12:200
63	10 , 10	1st left	no obstacle	no collapse	3.6792	10.5	0:11:4
64	62 , 10	1st right	17	1 time	2.3472	40.5	0:59:682
65	61 , 51	1st left	2	3 times	2.4624	34.5	0:51:891
66	60 , 66	1st left	no obstacle	4 times	2.9304	28.5	0:41:634
67	60 , 52	1st left	1	3 times	2.5416	33.0	0:49:340
68	59 , 19	1st left	no obstacle	no collapse	2.6064	14.5	0:22:255
69	58 , 11	1st right	15	2 times	2.3184	38.5	0:58:245
70	57 , 17	1st right	3	2 times	2.448	27.5	0:45:273
71	57 , 10	1st left	no obstacle	no collapse	2.2824	13.0	0:19:248
72	56 , 44	1st right	no obstacle	no collapse	2.7432	16.0	0:23:82
73	56 , 10	1st left	no obstacle	no collapse	2.2176	14.0	0:20:284
74	55 , 10	1st left	no obstacle	no collapse	2.3112	13.5	0:19:576
75	53 , 51	1st right	8	no collapse	2.5488	15.5	0:29:967
76	53 , 24	1st right	1	2 times	2.9808	24.0	0:35:222

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	61 , 51	1st left	2	3 times	2.4624	34.5	0:51:891
66	60 , 66	1st left	no obstacle	4 times	2.9304	28.5	0:41:634
67	60 , 52	1st left	1	3 times	2.5416	33.0	0:49:340
68	59 , 19	1st left	no obstacle	no collapse	2.6064	14.5	0:22:255
69	58 , 11	1st right	15	2 times	2.3184	38.5	0:58:245
70	57 , 17	1st right	3	2 times	2.448	27.5	0:45:273
71	57 , 10	1st left	no obstacle	no collapse	2.2824	13.0	0:19:248
72	56 , 44	1st right	no obstacle	no collapse	2.7432	16.0	0:23:82
73	56 , 10	1st left	no obstacle	no collapse	2.2176	14.0	0:20:284
74	55 , 10	1st left	no obstacle	no collapse	2.3112	13.5	0:19:576
75	53 , 51	1st right	8	no collapse	2.5488	15.5	0:29:967
76	53 , 24	1st right	1	2 times	2.9808	24.0	0:35:222
77	53 , 10	1st left	no obstacle	no collapse	2.5992	10.0	0:13:723
78	52 , 10	1st right	11	2 times	2.7504	37.0	0:51:623
79	51 , 48	1st left	no obstacle	2 times	2.7432	20.5	0:29:685
80	50 , 26	1st right	2	2 times	2.5128	25.0	0:39:129
81	49 , 61	1st right	no obstacle	no collapse	2.7576	8.0	0:12:531
82	49 , 28	1st left	no obstacle	no collapse	2.7	11.0	0:14:731
83	49 , 21	1st left	no obstacle	no collapse	2.6064	9.5	0:12:990
84	48 , 49	1st left	no obstacle	3 times	2.5776	21.0	0:30:715
85	48 , 27	1st left	no obstacle	no collapse	2.5128	10.5	0:15:20
86	48 , 17	1st right	11	1 time	2.6928	34.0	0:46:955
87	47 , 36	1st right	no obstacle	2 times	2.2176	19.0	0:31:167
88	47 , 29	1st right	1	1 time	2.5488	22.5	0:32:594
89	47 , 24	1st right	7	3 times	2.8584	28.0	0:41:179
90	47 , 10	1st right	9	1 time	2.5992	36.5	0:51:229
91	46 , 33	1st left	no obstacle	no collapse	2.5632	13.5	0:18:500
92	46 , 29	1st right	3	3 times	2.5992	23.5	0:37:627
93	45 , 10	1st right	10	no collapse	2.3832	37.0	0:53:281
94	44 , 18	1st left	no obstacle	no collapse	2.6784	6.5	0:8:770
95	44 , 10	1st right	11	2 times	2.5776	37.0	0:54:262
96	40 , 69	1st left	1	4 times	2.7432	35.5	0:42:450
97	40 , 63	1st left	1	5 times	2.7432	33.0	0:41:287
98	39 , 57	1st left	1	2 times	2.5992	28.5	0:38:187
99	39 , 28	1st left	no obstacle	no collapse	2.4192	11.0	0:15:974
100	39 , 10	1st right	8	3 times	2.6064	36.0	0:54:182
101	37 , 21	1st right	8	1 time	2.6784	31.0	0:42:910
102	37 , 10	1st left	no obstacle	no collapse	2.3472	2.0	0:3:930

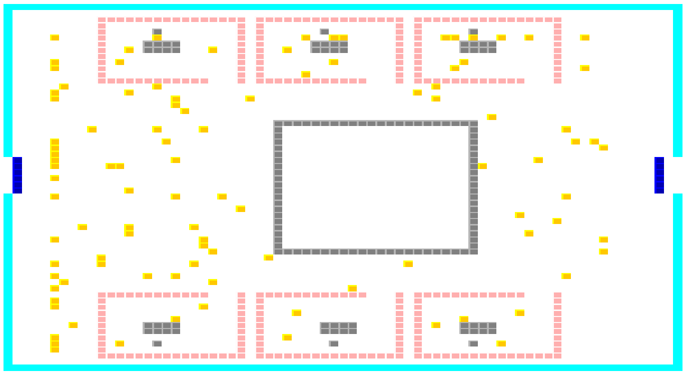
Results of evacuation simulation and specifying evacuation time for each agent



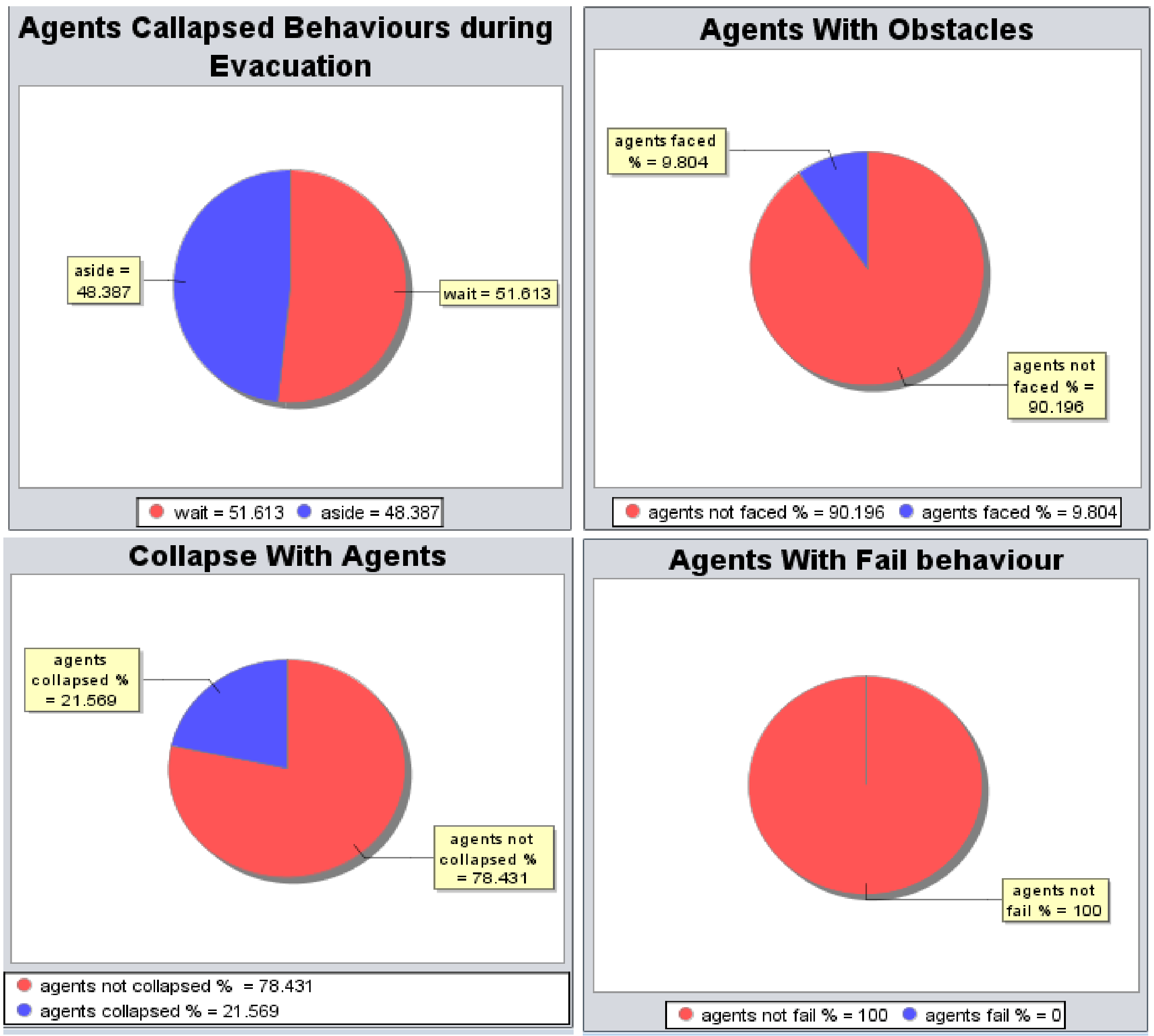
Evacuation time of 102 agents in line graph for first experimentation scenario A

B) 102 agents with two main exits, familiar, in a small distribution(y=65,x=60) through the floor, rooms has only one door to go out

Appendix D



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	41 , 13	1st left	no obstacle	no collapse	4.3776	3.5	0:4:55
2	40 , 64	1st right	no obstacle	no collapse	4.9896	5.0	0:5:449
3	39 , 60	1st right	no obstacle	no collapse	5.508	7.0	0:5:237
4	38 , 30	1st left	no obstacle	5 times	4.32	12.0	0:14:91
5	36 , 65	1st right	no obstacle	1 time	4.1184	4.5	0:7:640
6	36 , 28	1st left	no obstacle	3 times	4.968	11.0	0:10:462
7	36 , 23	1st left	no obstacle	no collapse	4.7232	8.5	0:7:207
8	36 , 10	1st left	no obstacle	no collapse	4.4064	2.0	0:3:257
9	35 , 18	1st left	no obstacle	no collapse	5.148	6.0	0:4:480
10	33 , 10	1st left	no obstacle	no collapse	4.6584	2.0	0:3:181
11	31 , 56	1st right	no obstacle	no collapse	5.0184	9.0	0:7:582
12	31 , 17	1st left	no obstacle	no collapse	4.1472	5.5	0:5:859
13	31 , 16	1st left	no obstacle	no collapse	4.3632	5.0	0:5:643
14	31 , 10	1st left	no obstacle	no collapse	4.9608	2.0	0:2:389
15	30 , 62	1st right	no obstacle	no collapse	4.9464	6.0	0:6:139
16	30 , 23	1st left	no obstacle	no collapse	4.5792	8.5	0:8:359
17	30 , 10	1st left	no obstacle	no collapse	5.1192	2.0	0:1:949
18	29 , 10	1st left	no obstacle	no collapse	3.888	2.0	0:2:643
19	28 , 69	1st right	no obstacle	no collapse	4.8312	2.5	0:2:826
20	28 , 10	1st left	no obstacle	no collapse	5.0184	2.0	0:2:360
21	27 , 68	1st right	no obstacle	1 time	4.9392	3.0	0:4:253
22	27 , 66	1st right	no obstacle	1 time	4.752	4.0	0:5:554
23	27 , 22	1st left	no obstacle	1 time	4.8096	8.0	0:7:347
24	27 , 10	1st left	no obstacle	no collapse	5.3712	2.0	0:2:119
25	25 , 65	1st right	no obstacle	no collapse	5.3496	4.5	0:4:322
26	25 , 26	1st left	no obstacle	1 time	5.0472	10.0	0:8:557
27	25 , 21	1st left	no obstacle	1 time	4.8024	7.5	0:6:640
28	25 , 14	1st left	no obstacle	no collapse	4.4712	4.0	0:4:99
29	23 , 57	1st right	no obstacle	no collapse	4.7808	8.5	0:7:904
30	22 , 24	1st left	no obstacle	no collapse	4.6728	9.0	0:8:427
31	21 , 23	1st left	no obstacle	1 time	4.2192	8.5	0:9:543
32	20 , 51	1st right	no obstacle	no collapse	5.0184	11.0	0:8:815
33	20 , 31	1st left	no obstacle	2 times	5.22	12.5	0:10:2
34	20 , 23	1st left	no obstacle	1 time	4.0104	8.5	0:9:345
35	20 , 10	1st left	no obstacle	no collapse	4.8168	5.5	0:5:177
36	19 , 49	1st right	no obstacle	1 time	5.1768	12.0	0:10:572
37	19 , 18	1st left	no obstacle	no collapse	5.0976	6.0	0:4:631
38	19 , 10	1st left	no obstacle	no collapse	4.8672	6.0	0:6:380

Results of evacuation simulation and specifying evacuation time for each agent

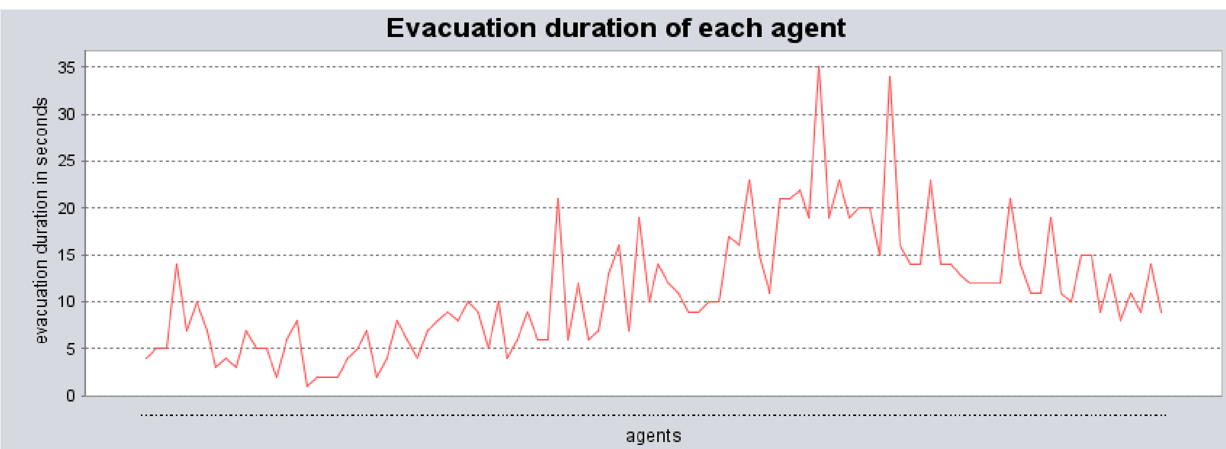
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	18 , 51	1st right	no obstacle	no collapse	4.788	11.5	0:9:830
40	18 , 21	1st left	no obstacle	no collapse	4.9824	7.5	0:6:900
41	18 , 11	1st left	no obstacle	no collapse	4.7016	7.0	0:6:174
42	16 , 37	1st left	4	no collapse	4.4784	22.5	0:21:622
43	15 , 67	1st right	no obstacle	no collapse	5.1696	7.5	0:6:326
44	15 , 53	1st right	4	no collapse	4.3416	10.0	0:12:447
45	15 , 10	1st left	no obstacle	no collapse	4.788	8.0	0:6:926
46	14 , 54	1st right	3	no collapse	5.7816	9.5	0:7:151
47	14 , 40	1st left	no obstacle	no collapse	5.1912	19.5	0:13:744
48	14 , 17	1st left	5	no collapse	4.32	14.5	0:16:280
49	14 , 10	1st left	no obstacle	no collapse	4.5288	8.5	0:7:974
50	12 , 35	1st left	2	no collapse	4.7808	23.0	0:19:364
51	12 , 27	1st left	no obstacle	no collapse	4.68	13.0	0:10:929
52	12 , 18	1st left	3	1 time	4.572	15.5	0:14:852
53	10 , 67	1st right	no obstacle	no collapse	3.7512	10.0	0:12:806
54	10 , 61	1st right	no obstacle	no collapse	3.888	10.5	0:11:586
55	10 , 58	1st right	no obstacle	no collapse	4.9176	10.5	0:9:84
56	10 , 55	1st right	no obstacle	no collapse	4.8312	11.0	0:9:857
57	10 , 53	1st right	no obstacle	no collapse	4.9176	12.0	0:10:661
58	10 , 52	1st right	no obstacle	1 time	5.0904	11.5	0:10:311
59	10 , 41	1st right	no obstacle	no collapse	4.3128	18.0	0:17:276
60	10 , 40	1st left	no obstacle	no collapse	4.9392	21.5	0:16:684
61	10 , 37	1st left	no obstacle	1 time	4.0968	23.5	0:23:811
62	10 , 21	1st left	no obstacle	no collapse	3.9528	14.0	0:15:86
63	10 , 10	1st left	no obstacle	no collapse	3.6792	10.5	0:11:952
64	61 , 10	1st left	no obstacle	no collapse	2.3472	14.5	0:21:636
65	60 , 58	1st right	no obstacle	no collapse	2.4624	12.5	0:21:351
66	60 , 17	1st left	no obstacle	no collapse	2.9304	16.0	0:22:927
67	60 , 10	1st left	no obstacle	no collapse	2.5416	13.5	0:19:126
68	59 , 35	1st left	1	1 time	2.6064	23.0	0:35:262
69	59 , 10	1st left	no obstacle	no collapse	2.3184	13.5	0:19:426
70	57 , 51	1st right	3	no collapse	2.448	13.0	0:23:685
71	57 , 12	1st left	no obstacle	no collapse	2.2824	12.5	0:19:69
72	56 , 54	1st right	2	no collapse	2.7432	11.5	0:20:274
73	56 , 23	1st left	no obstacle	no collapse	2.2176	13.0	0:20:842
74	55 , 60	1st right	no obstacle	no collapse	2.3112	9.0	0:15:872
75	55 , 36	1st left	3	no collapse	2.5488	22.0	0:34:574
76	54 , 26	1st left	no obstacle	no collapse	2.9808	11.0	0:16:502

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	60 , 58	1st right	no obstacle	no collapse	2.4624	12.5	0:21:351
66	60 , 17	1st left	no obstacle	no collapse	2.9304	16.0	0:22:927
67	60 , 10	1st left	no obstacle	no collapse	2.5416	13.5	0:19:126
68	59 , 35	1st left	1	1 time	2.6064	23.0	0:35:262
69	59 , 10	1st left	no obstacle	no collapse	2.3184	13.5	0:19:426
70	57 , 51	1st right	3	no collapse	2.448	13.0	0:23:685
71	57 , 12	1st left	no obstacle	no collapse	2.2824	12.5	0:19:69
72	56 , 54	1st right	2	no collapse	2.7432	11.5	0:20:274
73	56 , 23	1st left	no obstacle	no collapse	2.2176	13.0	0:20:842
74	55 , 60	1st right	no obstacle	no collapse	2.3112	9.0	0:15:872
75	55 , 36	1st left	3	no collapse	2.5488	22.0	0:34:574
76	54 , 26	1st left	no obstacle	no collapse	2.9808	11.0	0:16:502
77	54 , 10	1st left	no obstacle	no collapse	2.5992	10.0	0:14:943
78	53 , 10	1st left	no obstacle	no collapse	2.7504	10.5	0:14:550
79	51 , 42	1st right	no obstacle	1 time	2.7432	15.5	0:23:172
80	51 , 10	1st left	no obstacle	no collapse	2.5128	9.5	0:14:202
81	50 , 27	1st left	no obstacle	no collapse	2.7576	10.5	0:14:739
82	50 , 11	1st left	no obstacle	no collapse	2.7	9.5	0:13:425
83	49 , 65	1st right	no obstacle	no collapse	2.6064	7.5	0:12:991
84	49 , 23	1st left	no obstacle	no collapse	2.5776	8.5	0:12:218
85	49 , 20	1st left	no obstacle	no collapse	2.5128	9.0	0:12:486
86	49 , 10	1st left	no obstacle	no collapse	2.6928	8.5	0:12:310
87	47 , 48	1st right	no obstacle	1 time	2.2176	12.5	0:21:567
88	47 , 25	1st left	no obstacle	1 time	2.5488	9.5	0:14:521
89	47 , 15	1st left	no obstacle	no collapse	2.8584	8.0	0:11:166
90	47 , 10	1st left	no obstacle	no collapse	2.5992	7.5	0:11:200
91	46 , 33	1st left	no obstacle	no collapse	2.5632	13.5	0:19:269
92	46 , 15	1st left	no obstacle	no collapse	2.5992	7.5	0:11:196
93	45 , 69	1st right	no obstacle	no collapse	2.3832	5.5	0:10:835
94	45 , 27	1st left	no obstacle	2 times	2.6784	10.5	0:15:628
95	44 , 26	1st left	no obstacle	2 times	2.5776	10.0	0:15:86
96	43 , 69	1st right	no obstacle	no collapse	2.7432	4.5	0:9:369
97	43 , 26	1st left	no obstacle	no collapse	2.7432	10.0	0:13:719
98	43 , 10	1st left	no obstacle	no collapse	2.5992	5.5	0:8:460
99	42 , 61	1st right	no obstacle	no collapse	2.4192	6.5	0:11:323
100	42 , 18	1st left	no obstacle	no collapse	2.6064	6.0	0:9:566
101	41 , 25	1st left	no obstacle	1 time	2.6784	9.5	0:14:305
102	41 , 18	1st left	no obstacle	no collapse	2.3472	6.0	0:9:282

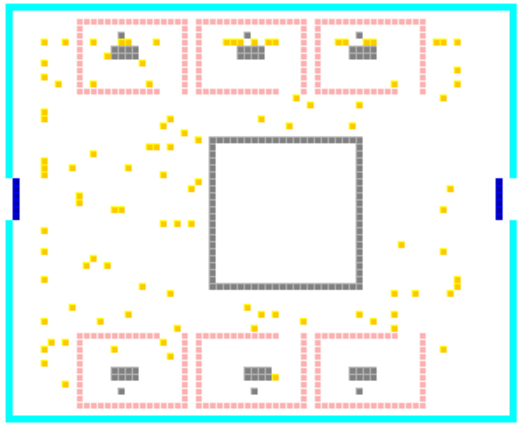
Results of evacuation simulation and specifying evacuation time for each agent



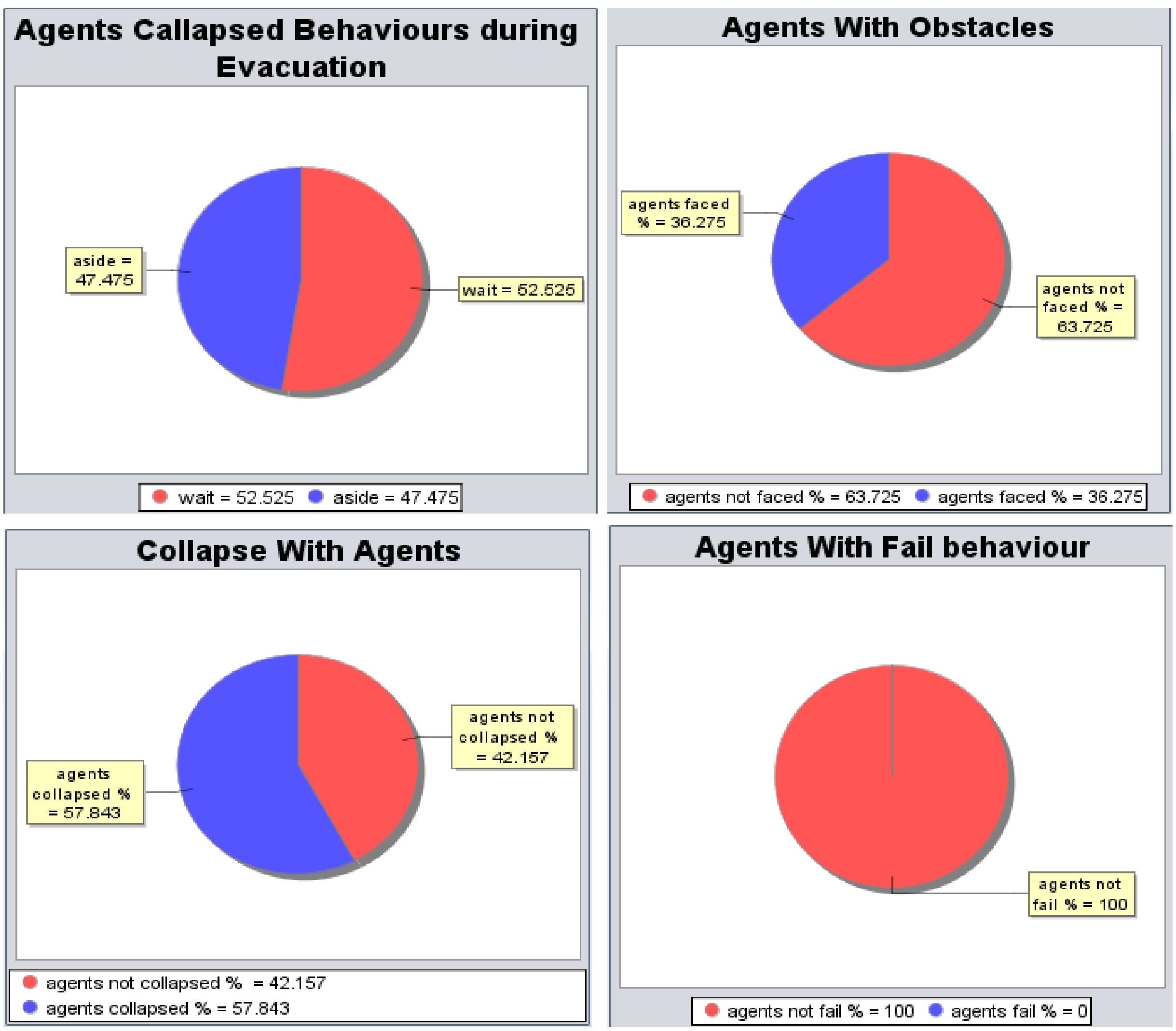
Evacuation time of 102 agents in line graph for first experimentation scenario B

Appendix D

C) With in a larger range (70*60) of distribution



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	37 , 13	1st left	no obstacle	no collapse	4.3776	4.0	0:4:482
2	37 , 10	1st right	10	6 times	4.9896	37.0	0:35:768
3	36 , 25	1st right	10	4 times	5.508	29.5	0:24:657
4	36 , 10	1st left	no obstacle	no collapse	4.32	4.0	0:4:474
5	35 , 19	1st right	9	3 times	4.1184	32.0	0:37:196
6	35 , 10	1st left	no obstacle	no collapse	4.968	2.0	0:2:494
7	34 , 20	1st left	no obstacle	no collapse	4.7232	7.0	0:7:107
8	33 , 59	1st left	1	3 times	4.4064	29.5	0:24:225
9	33 , 11	1st right	10	13 times	5.148	37.5	0:45:721
10	32 , 69	1st right	no obstacle	no collapse	4.6584	2.5	0:3:956
11	32 , 10	1st right	11	3 times	5.0184	37.0	0:32:991
12	31 , 61	1st left	1	5 times	4.1472	31.0	0:29:354
13	31 , 29	1st left	no obstacle	2 times	4.3632	11.5	0:12:111
14	31 , 20	1st right	10	4 times	4.9608	32.0	0:32:436
15	31 , 10	1st left	no obstacle	no collapse	4.9464	2.0	0:4:90
16	30 , 33	1st left	no obstacle	2 times	4.5792	13.5	0:12:878
17	30 , 16	1st left	no obstacle	1 time	5.1192	5.0	0:4:936
18	29 , 67	1st left	1	9 times	3.888	35.5	0:36:325
19	28 , 63	1st left	1	5 times	4.8312	31.5	0:26:371
20	28 , 30	1st left	no obstacle	1 time	5.0184	12.0	0:9:292
21	28 , 21	1st left	no obstacle	no collapse	4.9392	7.5	0:6:476
22	28 , 16	1st left	no obstacle	no collapse	4.752	5.0	0:5:120
23	27 , 56	1st left	1	3 times	4.8096	26.0	0:20:411
24	26 , 67	1st right	no obstacle	no collapse	5.3712	3.5	0:3:318
25	25 , 62	1st right	no obstacle	no collapse	5.3496	6.0	0:5:456
26	25 , 29	1st right	5	5 times	5.0472	25.0	0:28:136
27	24 , 68	1st left	1	7 times	4.8024	34.5	0:32:642
28	24 , 12	1st right	11	5 times	4.4712	37.5	0:38:250
29	23 , 64	1st right	no obstacle	no collapse	4.7808	5.0	0:5:759
30	23 , 31	1st right	1	5 times	4.6728	22.0	0:28:641
31	22 , 54	1st left	no obstacle	3 times	4.2192	24.0	0:25:928
32	22 , 19	1st right	11	3 times	5.0184	33.0	0:30:610
33	22 , 12	1st right	11	2 times	5.22	36.5	0:27:753
34	22 , 10	1st left	no obstacle	no collapse	4.0104	4.5	0:5:372
35	21 , 45	1st right	no obstacle	1 time	4.8168	14.0	0:12:651
36	20 , 58	1st right	no obstacle	no collapse	5.1768	8.0	0:6:934
37	18 , 61	1st left	no obstacle	5 times	5.0976	27.5	0:22:939
38	18 , 45	1st left	no obstacle	no collapse	4.8672	19.0	0:14:69

Results of evacuation simulation and specifying evacuation time for each agent

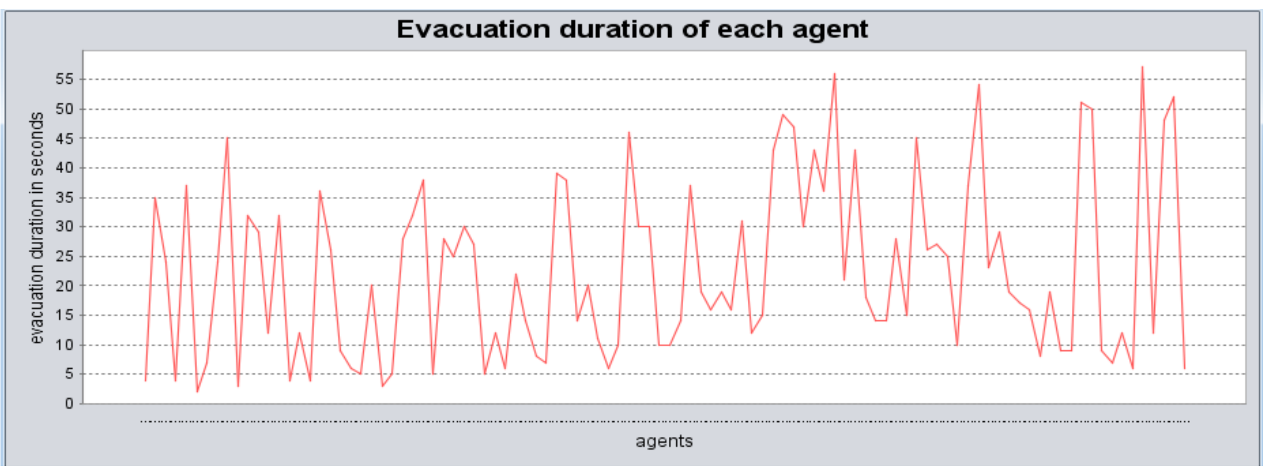
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
38	18 , 45	1st left	no obstacle	no collapse	4.8672	19.0	0:14:69
39	18 , 29	1st left	no obstacle	no collapse	4.788	11.5	0:8:903
40	18 , 15	1st left	no obstacle	no collapse	4.9824	7.5	0:7:48
41	16 , 12	1st right	11	6 times	4.7016	36.5	0:39:500
42	15 , 10	1st right	8	5 times	4.4784	36.0	0:38:598
43	13 , 36	1st right	3	1 time	5.1696	18.5	0:14:983
44	12 , 42	1st right	no obstacle	2 times	4.3416	16.5	0:20:128
45	12 , 24	1st left	no obstacle	no collapse	4.788	14.0	0:11:979
46	12 , 10	1st left	no obstacle	no collapse	5.7816	10.0	0:6:933
47	11 , 27	1st left	no obstacle	1 time	5.1912	13.5	0:10:867
48	11 , 10	1st right	11	9 times	4.32	38.0	0:46:354
49	10 , 69	1st left	no obstacle	3 times	4.5288	30.5	0:30:392
50	10 , 67	1st left	no obstacle	4 times	4.7808	29.0	0:30:474
51	10 , 58	1st right	no obstacle	no collapse	4.68	10.0	0:10:643
52	10 , 56	1st right	no obstacle	no collapse	4.572	10.0	0:10:6
53	10 , 54	1st right	no obstacle	no collapse	3.7512	10.5	0:14:615
54	10 , 51	1st left	2	3 times	3.888	34.5	0:37:559
55	10 , 44	1st right	no obstacle	2 times	4.9176	18.5	0:19:425
56	10 , 41	1st right	no obstacle	1 time	4.8312	18.5	0:16:214
57	10 , 38	1st left	no obstacle	1 time	4.9176	23.0	0:19:78
58	10 , 35	1st right	1	1 time	5.0904	21.0	0:16:134
59	10 , 27	1st right	1	4 times	4.3128	28.0	0:31:853
60	10 , 23	1st left	no obstacle	1 time	4.9392	15.0	0:12:912
61	10 , 21	1st left	no obstacle	no collapse	4.0968	14.0	0:15:143
62	10 , 12	1st right	17	4 times	3.9528	39.5	0:43:216
63	10 , 10	1st right	15	6 times	3.6792	40.5	0:49:900
64	59 , 59	1st left	no obstacle	2 times	2.3472	30.0	0:47:529
65	59 , 44	1st left	no obstacle	no collapse	2.4624	21.0	0:30:941
66	57 , 52	1st left	2	3 times	2.9304	30.5	0:43:714
67	56 , 38	1st left	1	2 times	2.5416	20.5	0:36:114
68	55 , 13	1st right	14	1 time	2.6064	38.0	0:56:76
69	54 , 24	1st left	no obstacle	no collapse	2.3184	14.0	0:21:280
70	53 , 23	1st right	2	4 times	2.448	24.5	0:43:927
71	53 , 10	1st left	no obstacle	no collapse	2.2824	12.5	0:18:217
72	51 , 60	1st right	no obstacle	no collapse	2.7432	9.0	0:14:512
73	51 , 59	1st right	no obstacle	no collapse	2.2176	8.5	0:14:807
74	51 , 45	1st left	no obstacle	1 time	2.3112	19.0	0:28:779
75	51 , 27	1st left	no obstacle	no collapse	2.5488	10.5	0:15:77

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	59 , 44	1st left	no obstacle	no collapse	2.4624	21.0	0:30:941
66	57 , 52	1st left	2	3 times	2.9304	30.5	0:43:714
67	56 , 38	1st left	1	2 times	2.5416	20.5	0:36:114
68	55 , 13	1st right	14	1 time	2.6064	38.0	0:56:76
69	54 , 24	1st left	no obstacle	no collapse	2.3184	14.0	0:21:280
70	53 , 23	1st right	2	4 times	2.448	24.5	0:43:927
71	53 , 10	1st left	no obstacle	no collapse	2.2824	12.5	0:18:217
72	51 , 60	1st right	no obstacle	no collapse	2.7432	9.0	0:14:512
73	51 , 59	1st right	no obstacle	no collapse	2.2176	8.5	0:14:807
74	51 , 45	1st left	no obstacle	1 time	2.3112	19.0	0:28:779
75	51 , 27	1st left	no obstacle	no collapse	2.5488	10.5	0:15:77
76	50 , 17	1st right	11	2 times	2.9808	33.5	0:45:194
77	49 , 44	1st left	no obstacle	no collapse	2.5992	18.5	0:26:220
78	49 , 41	1st right	no obstacle	3 times	2.7504	16.0	0:27:980
79	49 , 39	1st right	no obstacle	1 time	2.7432	17.0	0:25:481
80	49 , 17	1st left	no obstacle	no collapse	2.5128	7.5	0:10:822
81	48 , 55	1st left	no obstacle	4 times	2.7576	24.5	0:37:405
82	48 , 10	1st right	13	1 time	2.7	40.0	0:54:941
83	47 , 41	1st left	no obstacle	no collapse	2.6064	17.0	0:23:674
84	46 , 49	1st left	no obstacle	no collapse	2.5776	21.0	0:29:187
85	46 , 34	1st left	no obstacle	no collapse	2.5128	14.0	0:19:683
86	46 , 31	1st left	no obstacle	1 time	2.6928	12.5	0:17:888
87	46 , 28	1st left	no obstacle	no collapse	2.2176	11.0	0:16:574
88	46 , 14	1st left	no obstacle	no collapse	2.5488	6.0	0:8:739
89	45 , 33	1st left	no obstacle	1 time	2.8584	13.5	0:19:999
90	44 , 62	1st right	no obstacle	no collapse	2.5992	6.0	0:9:725
91	44 , 19	1st left	no obstacle	no collapse	2.5632	6.5	0:9:851
92	44 , 10	1st right	7	2 times	2.5992	35.5	0:51:257
93	43 , 68	1st left	1	7 times	2.3832	35.5	0:50:99
94	42 , 13	1st left	no obstacle	no collapse	2.6784	6.5	0:9:94
95	40 , 65	1st right	no obstacle	no collapse	2.5776	4.5	0:7:544
96	40 , 57	1st right	no obstacle	no collapse	2.7432	8.5	0:12:250
97	40 , 14	1st left	no obstacle	no collapse	2.7432	4.0	0:6:477
98	40 , 10	1st right	12	1 time	2.5992	40.0	0:57:202
99	39 , 59	1st right	no obstacle	no collapse	2.4192	7.5	0:12:46
100	39 , 27	1st right	12	5 times	2.6064	30.0	0:48:615
101	39 , 10	1st right	9	3 times	2.6784	36.5	0:52:928
102	38 , 68	1st right	no obstacle	no collapse	2.3472	3.0	0:6:23

Results of evacuation simulation and specifying evacuation time for each agent

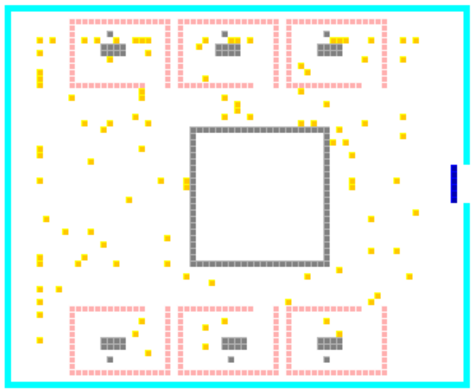


Evacuation time of 102 agents in line graph for first experimentation scenario C

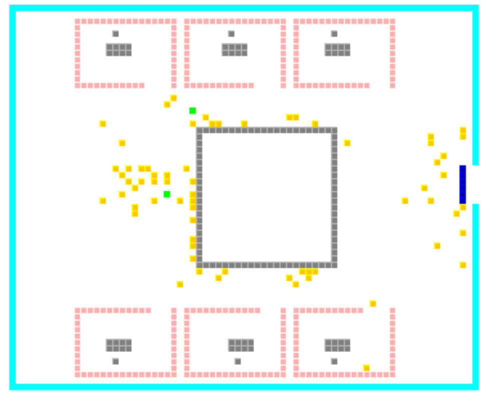
Appendix D

Second:

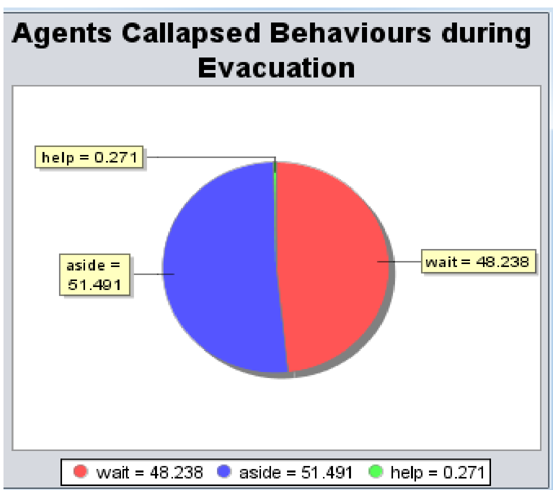
A) With only one main exit

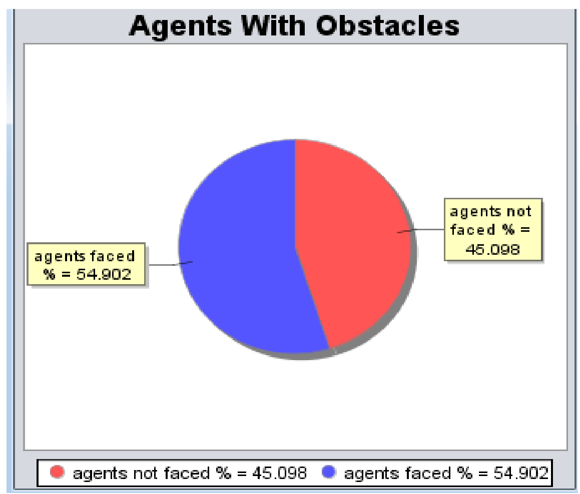


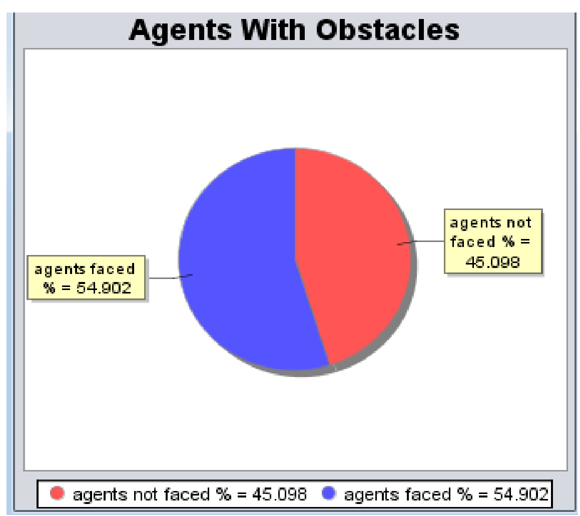
First floor created and agents distributed through the floor



agents during evacuation process







Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	37 , 22	1st right	7	6 times	4.3776	29.5	0:48:315
2	37 , 10	1st right	6	11 times	4.9896	35.0	0:59:637
3	36 , 68	1st right	no obstacle	no collapse	5.508	3.0	0:5:127
4	36 , 17	1st right	9	7 times	4.32	33.5	0:54:873
5	34 , 12	1st right	10	7 times	4.1184	39.5	1:1:594
6	33 , 63	1st right	no obstacle	1 time	4.968	5.5	0:10:678
7	33 , 14	1st right	9	6 times	4.7232	35.5	0:52:350
8	33 , 10	1st right	7	7 times	4.4064	36.5	0:56:788
9	32 , 14	1st right	8	9 times	5.148	34.0	0:48:615
10	31 , 26	1st right	9	10 times	4.6584	29.0	0:52:116
11	31 , 10	1st right	7	9 times	5.0184	38.5	0:58:23
12	30 , 64	1st right	no obstacle	no collapse	4.1472	5.0	0:11:662
13	30 , 62	1st right	no obstacle	no collapse	4.3632	6.0	0:14:764
14	30 , 24	1st right	11	3 times	4.9608	31.0	0:43:187
15	30 , 17	1st right	10	8 times	4.9464	34.0	0:54:57
16	30 , 14	1st right	11	5 times	4.5792	35.5	0:56:7
17	30 , 10	1st right	8	11 times	5.1192	37.0	0:60:759
18	29 , 21	1st right	11	7 times	3.888	31.5	0:57:513
19	29 , 10	1st right	11	19 times	4.8312	40.0	1:8:131
20	28 , 60	1st right	no obstacle	no collapse	5.0184	7.0	0:15:217
21	27 , 68	1st right	no obstacle	no collapse	4.9392	3.0	0:5:267
22	26 , 10	1st right	8	17 times	4.752	38.0	1:10:40
23	25 , 60	1st right	no obstacle	no collapse	4.8096	7.0	0:12:536
24	25 , 57	1st right	no obstacle	2 times	5.3712	8.5	0:16:405
25	24 , 59	1st right	no obstacle	no collapse	5.3496	7.5	0:14:763
26	24 , 14	1st right	10	8 times	5.0472	35.5	0:53:518
27	24 , 10	1st right	14	9 times	4.8024	41.5	0:60:343
28	23 , 20	1st right	10	4 times	4.4712	32.5	0:51:183
29	23 , 13	1st right	13	9 times	4.7808	38.5	0:59:968
30	23 , 10	1st right	12	11 times	4.6728	39.5	1:4:34
31	22 , 29	1st right	2	1 time	4.2192	23.5	0:34:230
32	22 , 11	1st right	8	5 times	5.0184	36.0	0:45:834
33	22 , 10	1st right	7	6 times	5.22	35.5	0:44:167
34	21 , 26	1st right	4	no collapse	4.0104	26.0	0:39:445
35	21 , 11	1st right	10	5 times	4.8168	37.5	0:50:301
36	21 , 10	1st right	9	9 times	5.1768	37.5	0:53:863
37	19 , 65	1st right	no obstacle	no collapse	5.0976	5.5	0:11:961
38	19 , 23	1st right	3	5 times	4.8672	27.0	0:42:470

Results of evacuation simulation and specifying evacuation time for each agent

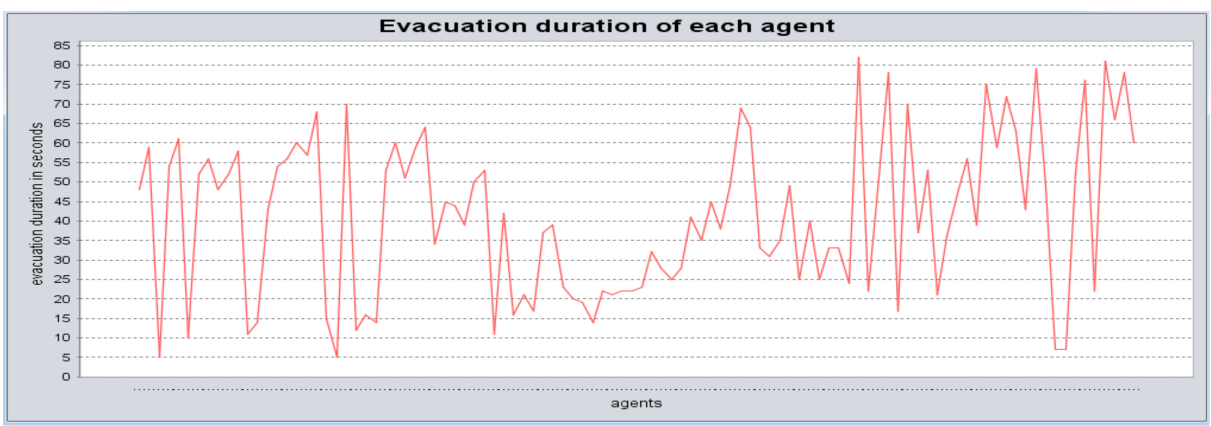
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	18 , 53	1st right	no obstacle	no collapse	4.788	10.5	0:16:788
40	18 , 45	1st right	no obstacle	no collapse	4.9824	14.0	0:21:651
41	16 , 60	1st right	no obstacle	no collapse	4.7016	7.0	0:17:26
42	16 , 24	1st right	1	2 times	4.4784	24.0	0:37:58
43	16 , 21	1st right	3	7 times	5.1696	25.5	0:39:328
44	14 , 69	1st right	no obstacle	no collapse	4.3416	8.0	0:23:421
45	14 , 55	1st right	2	no collapse	4.788	9.0	0:20:922
46	10 , 69	1st right	no obstacle	no collapse	5.7816	10.0	0:19:525
47	10 , 66	1st right	no obstacle	no collapse	5.1912	10.0	0:14:233
48	10 , 61	1st right	no obstacle	no collapse	4.32	10.5	0:22:148
49	10 , 60	1st right	no obstacle	no collapse	4.5288	10.0	0:21:650
50	10 , 59	1st right	no obstacle	no collapse	4.7808	10.0	0:22:576
51	10 , 58	1st right	no obstacle	no collapse	4.68	10.0	0:22:486
52	10 , 54	1st right	no obstacle	no collapse	4.572	11.5	0:23:329
53	10 , 43	1st right	no obstacle	no collapse	3.7512	18.5	0:32:44
54	10 , 41	1st right	no obstacle	no collapse	3.888	18.5	0:28:549
55	10 , 40	1st right	no obstacle	no collapse	4.9176	17.5	0:25:18
56	10 , 35	1st right	1	no collapse	4.8312	21.0	0:28:35
57	10 , 23	1st right	no obstacle	5 times	4.9176	26.5	0:41:849
58	10 , 22	1st right	no obstacle	5 times	5.0904	27.0	0:35:708
59	10 , 21	1st right	no obstacle	5 times	4.3128	27.0	0:45:402
60	10 , 19	1st right	no obstacle	4 times	4.9392	28.5	0:38:187
61	10 , 18	1st right	1	5 times	4.0968	31.0	0:49:820
62	10 , 13	1st right	19	7 times	3.9528	42.0	1:9:68
63	10 , 10	1st right	12	7 times	3.6792	39.5	1:4:709
64	59 , 58	1st right	1	no collapse	2.3472	13.5	0:33:666
65	59 , 56	1st right	no obstacle	no collapse	2.4624	10.5	0:31:737
66	59 , 43	1st right	no obstacle	1 time	2.9304	18.5	0:35:97
67	59 , 26	1st right	no obstacle	1 time	2.5416	26.0	0:49:599
68	58 , 68	1st right	no obstacle	no collapse	2.6064	12.5	0:25:582
69	57 , 43	1st right	no obstacle	no collapse	2.3184	16.5	0:40:457
70	56 , 61	1st right	no obstacle	no collapse	2.448	12.0	0:25:323
71	55 , 44	1st right	no obstacle	no collapse	2.2824	15.5	0:33:477
72	55 , 39	1st right	1	no collapse	2.7432	16.5	0:33:39
73	52 , 66	1st right	no obstacle	no collapse	2.2176	10.5	0:24:313
74	52 , 62	1st right	1	no collapse	2.3112	47.5	1:22:155
75	51 , 66	1st right	no obstacle	no collapse	2.5488	10.5	0:22:448
76	51 , 28	1st right	no obstacle	6 times	2.9808	22.5	0:48:94

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	59 , 56	1st right	no obstacle	no collapse	2.4624	10.5	0:31:737
66	59 , 43	1st right	no obstacle	1 time	2.9304	18.5	0:35:97
67	59 , 26	1st right	no obstacle	1 time	2.5416	26.0	0:49:599
68	58 , 68	1st right	no obstacle	no collapse	2.6064	12.5	0:25:582
69	57 , 43	1st right	no obstacle	no collapse	2.3184	16.5	0:40:457
70	56 , 61	1st right	no obstacle	no collapse	2.448	12.0	0:25:323
71	55 , 44	1st right	no obstacle	no collapse	2.2824	15.5	0:33:477
72	55 , 39	1st right	1	no collapse	2.7432	16.5	0:33:39
73	52 , 66	1st right	no obstacle	no collapse	2.2176	10.5	0:24:313
74	52 , 62	1st right	1	no collapse	2.3112	47.5	1:22:155
75	51 , 66	1st right	no obstacle	no collapse	2.5488	10.5	0:22:448
76	51 , 28	1st right	no obstacle	6 times	2.9808	22.5	0:48:94
77	51 , 10	1st right	11	9 times	2.5992	38.5	1:18:717
78	50 , 64	1st right	no obstacle	no collapse	2.7504	7.0	0:17:395
79	50 , 10	1st right	7	6 times	2.7432	36.0	1:10:528
80	48 , 38	1st right	no obstacle	2 times	2.5128	17.5	0:37:694
81	48 , 24	1st right	5	4 times	2.7576	27.5	0:53:0
82	47 , 58	1st right	no obstacle	no collapse	2.7	8.0	0:21:454
83	47 , 37	1st right	no obstacle	2 times	2.6064	18.5	0:36:526
84	47 , 26	1st right	5	1 time	2.5776	26.0	0:47:71
85	47 , 24	1st right	6	5 times	2.5128	29.0	0:56:830
86	46 , 41	1st right	no obstacle	5 times	2.6928	16.0	0:39:878
87	46 , 10	1st right	11	6 times	2.2176	37.5	1:15:62
88	45 , 26	1st right	7	3 times	2.5488	27.5	0:59:75
89	45 , 10	1st right	10	7 times	2.8584	39.0	1:12:302
90	43 , 10	1st right	11	1 time	2.5992	37.0	1:3:603
91	42 , 33	1st right	4	no collapse	2.5632	22.0	0:43:895
92	42 , 10	1st right	8	8 times	2.5992	37.5	1:19:737
93	41 , 27	1st right	10	no collapse	2.3832	28.0	0:49:132
94	40 , 69	1st right	no obstacle	no collapse	2.6784	2.5	0:7:19
95	40 , 67	1st right	no obstacle	no collapse	2.5776	3.5	0:7:658
96	40 , 25	1st right	11	no collapse	2.7432	29.5	0:52:48
97	40 , 10	1st right	10	9 times	2.7432	39.5	1:16:167
98	39 , 58	1st right	no obstacle	1 time	2.5992	8.0	0:22:521
99	39 , 10	1st right	8	13 times	2.4192	38.5	1:21:455
100	38 , 14	1st right	7	4 times	2.6064	34.5	1:6:761
101	38 , 10	1st right	14	8 times	2.6784	43.5	1:18:357
102	37 , 29	1st right	11	3 times	2.3472	28.5	1:0:151

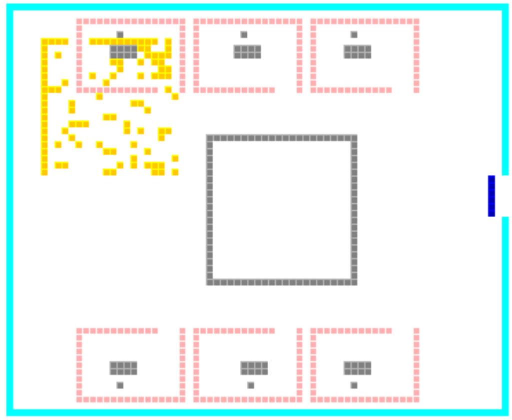
Results of evacuation simulation and specifying evacuation time for each agent



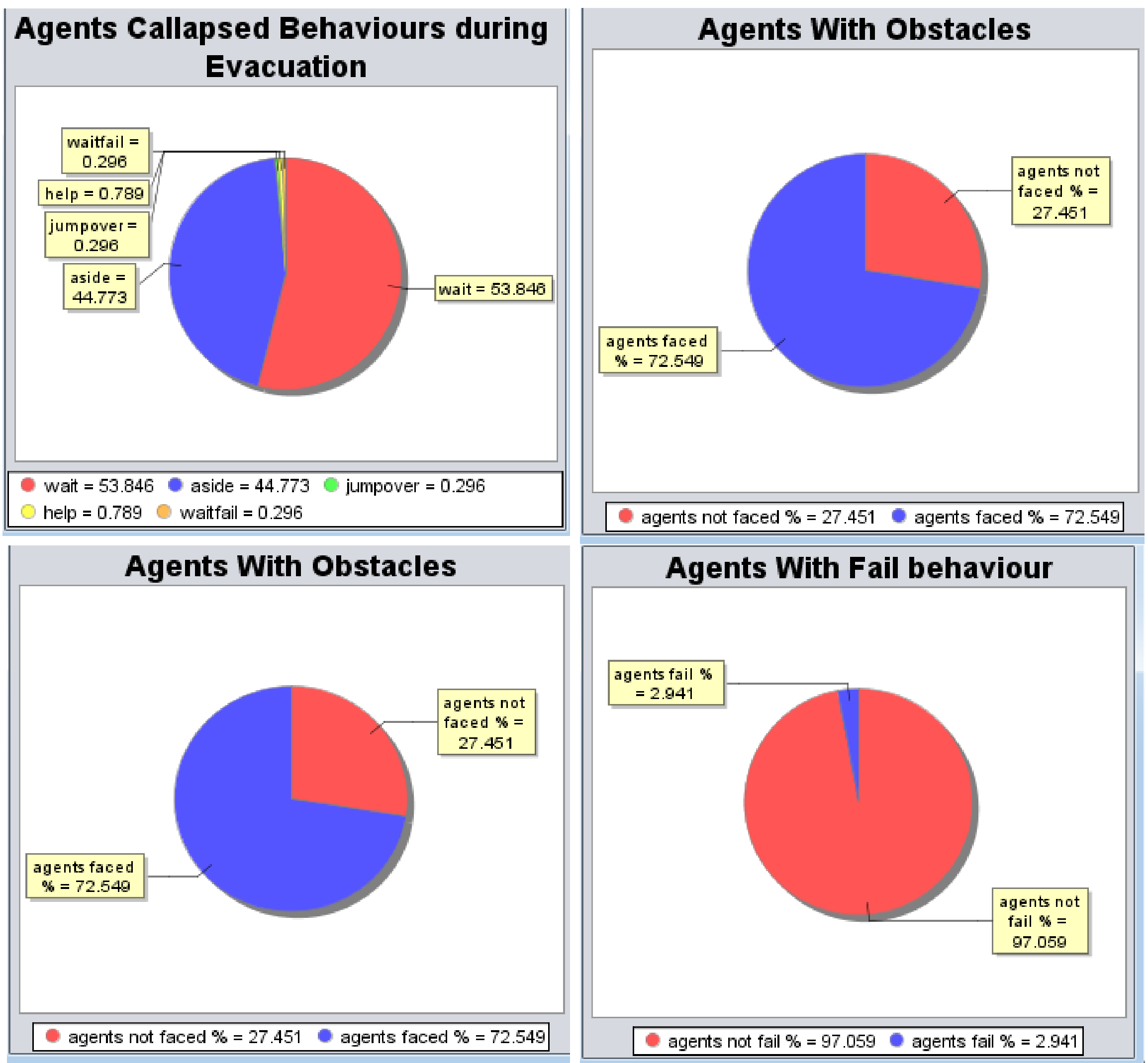
Evacuation time of 102 agents in line graph for second experimentation scenario A

Appendix D

B) All agents distributed through a small part of the floor



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	22 , 10	1st right	9	9 times	4.3776	36.5	1:20:265
2	21 , 20	1st right	12	14 times	4.9896	36.5	1:31:428
3	21 , 19	1st right	10	15 times	5.508	33.5	1:28:601
4	21 , 10	1st right	10	13 times	4.32	37.5	1:25:370
5	20 , 25	1st right	5	10 times	4.1184	27.0	1:1:728
6	20 , 14	1st right	8	19 times	4.968	34.0	1:37:993
7	20 , 10	1st right	12	9 times	4.7232	40.5	1:11:458
8	19 , 24	1st right	3	6 times	4.4064	27.0	0:57:431
9	19 , 23	1st right	2	11 times	5.148	26.5	1:13:642
10	19 , 14	1st right	9	11 times	4.6584	37.0	1:23:648
11	19 , 10	1st right	9	12 times	5.0184	36.5	1:18:963
12	18 , 29	1st right	no obstacle	no collapse	4.1472	22.0	0:21:554
13	18 , 18	1st right	6	7 times	4.3632	31.5	1:2:410
14	18 , 10	1st right	10	11 times	4.9608	38.5	1:26:8
15	17 , 28	1st right	no obstacle	2 times	4.9464	23.5	0:25:329
16	17 , 12	1st right	8	13 times	4.5792	36.0	1:34:260
17	17 , 11	1st right	8	12 times	5.1192	35.5	1:17:912
18	17 , 10	1st right	10	9 times	3.888	38.0	1:24:343
19	16 , 19	1st right	4	15 times	4.8312	27.0	1:30:751
20	16 , 13	1st right	8	12 times	5.0184	34.5	1:26:68
21	16 , 10	1st right	8	7 times	4.9392	36.5	1:9:918
22	15 , 28	1st right	no obstacle	6 times	4.752	24.0	0:40:655
23	15 , 27	1st right	3	8 times	4.8096	28.0	1:8:28
24	15 , 26	1st right	no obstacle	7 times	5.3712	24.5	0:51:559
25	15 , 24	1st right	no obstacle	2 times	5.3496	24.0	0:22:305
26	15 , 20	1st right	3	5 times	5.0472	26.0	0:38:883
27	15 , 17	1st right	5	12 times	4.8024	28.0	1:22:753
28	15 , 10	1st right	8	13 times	4.4712	39.0	1:22:572
29	14 , 28	1st right	no obstacle	9 times	4.7808	25.0	1:1:691
30	14 , 27	1st right	no obstacle	15 times	4.6728	26.0	1:27:699
31	14 , 21	1st right	no obstacle	3 times	4.2192	25.0	0:33:42
32	14 , 10	1st right	8	17 times	5.0184	36.5	1:30:347
33	13 , 27	1st right	1	8 times	5.22	26.5	0:55:750
34	13 , 26	1st right	no obstacle	11 times	4.0104	26.0	1:16:653
35	13 , 24	1st right	no obstacle	4 times	4.8168	25.5	0:39:98
36	13 , 21	1st right	no obstacle	5 times	5.1768	25.5	0:33:401
37	13 , 20	1st right	no obstacle	4 times	5.0976	26.5	0:35:548
38	13 , 10	1st right	13	15 times	4.8672	42.0	1:33:514

Results of evacuation simulation and specifying evacuation time for each agent

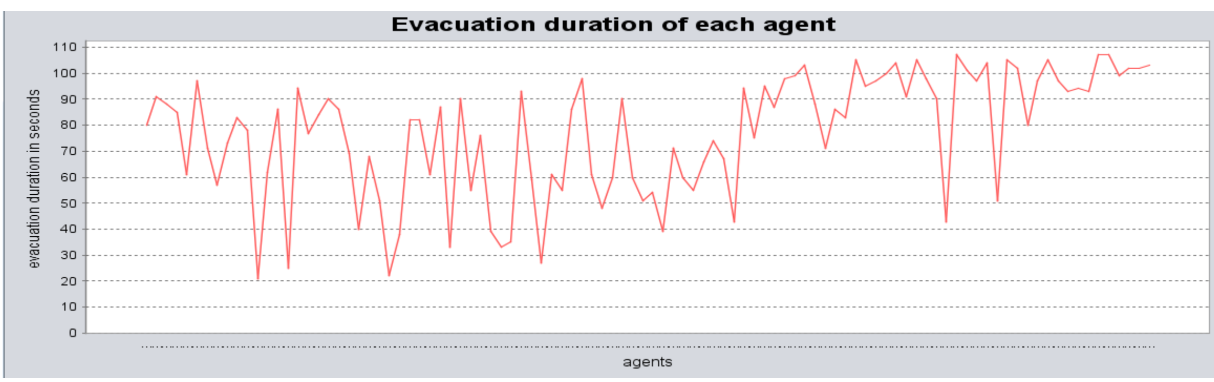
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	12 , 28	1st right	no obstacle	9 times	4.788	26.0	0:59:638
40	12 , 27	1st right	no obstacle	2 times	4.9824	26.0	0:27:205
41	12 , 26	1st right	no obstacle	7 times	4.7016	25.5	1:1:910
42	12 , 25	1st right	no obstacle	6 times	4.4784	25.5	0:55:531
43	12 , 12	1st right	9	13 times	5.1696	36.5	1:26:796
44	12 , 10	1st right	7	17 times	4.3416	36.5	1:38:567
45	11 , 28	1st right	no obstacle	7 times	4.788	26.0	1:1:642
46	11 , 25	1st right	no obstacle	8 times	5.7816	26.0	0:48:193
47	11 , 24	1st right	no obstacle	9 times	5.1912	27.0	1:0:735
48	11 , 10	1st right	10	11 times	4.32	40.5	1:30:827
49	10 , 28	1st right	no obstacle	9 times	4.5288	27.0	0:60:858
50	10 , 26	1st right	no obstacle	6 times	4.7808	27.0	0:51:920
51	10 , 25	1st right	no obstacle	8 times	4.68	25.5	0:54:304
52	10 , 24	1st right	no obstacle	4 times	4.572	28.0	0:39:50
53	10 , 23	1st right	no obstacle	9 times	3.7512	27.0	1:11:882
54	10 , 22	1st right	no obstacle	7 times	3.888	27.5	1:0:235
55	10 , 21	1st right	no obstacle	8 times	4.9176	27.0	0:55:252
56	10 , 20	1st right	no obstacle	10 times	4.8312	29.0	1:6:235
57	10 , 19	1st right	1	11 times	4.9176	28.5	1:14:927
58	10 , 18	1st right	no obstacle	11 times	5.0904	29.5	1:7:906
59	10 , 17	1st right	2	4 times	4.3128	28.5	0:43:126
60	10 , 13	1st right	11	16 times	4.9392	36.5	1:34:69
61	10 , 12	1st right	15	7 times	4.0968	42.5	1:15:303
62	10 , 11	1st right	15	12 times	3.9528	39.0	1:35:919
64	29 , 29	1st right	9	8 times	2.3472	29.0	1:27:394
65	29 , 27	1st right	8	13 times	2.4624	28.0	1:38:262
66	29 , 26	1st right	13	13 times	2.9304	33.0	1:39:814
67	29 , 20	1st right	10	12 times	2.5416	32.0	1:43:533
69	29 , 10	1st right	10	7 times	2.3184	37.0	1:28:870
70	28 , 27	1st right	9	6 times	2.448	28.5	1:11:406
71	28 , 26	1st right	7	9 times	2.2824	28.0	1:26:942
72	28 , 25	1st right	7	10 times	2.7432	28.5	1:23:91
73	28 , 23	1st right	9	15 times	2.2176	30.0	1:45:92
74	28 , 21	1st right	6	12 times	2.3112	30.0	1:35:586
75	28 , 13	1st right	9	12 times	2.5488	35.0	1:37:604
76	28 , 12	1st right	6	15 times	2.9808	34.0	1:40:799
77	28 , 10	1st right	11	12 times	2.5992	38.5	1:44:725
78	27 , 29	1st right	6	12 times	2.7504	27.5	1:31:34

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
64	29 , 29	1st right	9	8 times	2.3472	29.0	1:27:394
65	29 , 27	1st right	8	13 times	2.4624	28.0	1:38:262
66	29 , 26	1st right	13	13 times	2.9304	33.0	1:39:814
67	29 , 20	1st right	10	12 times	2.5416	32.0	1:43:533
69	29 , 10	1st right	10	7 times	2.3184	37.0	1:28:870
70	28 , 27	1st right	9	6 times	2.448	28.5	1:11:406
71	28 , 26	1st right	7	9 times	2.2824	28.0	1:26:942
72	28 , 25	1st right	7	10 times	2.7432	28.5	1:23:91
73	28 , 23	1st right	9	15 times	2.2176	30.0	1:45:92
74	28 , 21	1st right	6	12 times	2.3112	30.0	1:35:586
75	28 , 13	1st right	9	12 times	2.5488	35.0	1:37:604
76	28 , 12	1st right	6	15 times	2.9808	34.0	1:40:799
77	28 , 10	1st right	11	12 times	2.5992	38.5	1:44:725
78	27 , 29	1st right	6	12 times	2.7504	27.5	1:31:34
79	27 , 23	1st right	8	14 times	2.7432	31.0	1:45:742
80	27 , 10	1st right	7	12 times	2.5128	34.5	1:38:54
81	26 , 25	1st right	11	9 times	2.7576	33.0	1:30:555
82	26 , 20	1st right	11	no collapse	2.7	32.0	0:43:780
83	26 , 19	1st right	10	15 times	2.6064	33.5	1:47:946
84	26 , 10	1st right	11	13 times	2.5776	39.0	1:41:725
85	25 , 23	1st right	7	12 times	2.5128	30.5	1:37:51
86	25 , 18	1st right	8	15 times	2.6928	33.0	1:44:300
87	25 , 15	1st right	11	no collapse	2.2176	34.5	0:51:73
88	25 , 12	1st right	11	14 times	2.5488	38.0	1:45:878
89	25 , 10	1st right	9	12 times	2.8584	37.0	1:42:55
90	24 , 27	1st right	7	7 times	2.5992	29.0	1:20:135
91	24 , 14	1st right	8	13 times	2.5632	34.5	1:37:268
92	24 , 10	1st right	11	13 times	2.5992	38.0	1:45:2
93	23 , 28	1st right	7	11 times	2.3832	30.0	1:37:322
94	23 , 27	1st right	9	10 times	2.6784	32.0	1:33:11
95	23 , 24	1st right	7	13 times	2.5776	29.0	1:34:27
96	23 , 22	1st right	8	10 times	2.7432	30.5	1:33:927
97	23 , 13	1st right	11	17 times	2.7432	37.5	1:47:363
98	23 , 10	1st right	7	15 times	2.5992	36.0	1:47:172
99	22 , 22	1st right	9	14 times	2.4192	32.5	1:39:467
100	22 , 16	1st right	7	13 times	2.6064	33.0	1:42:994
101	22 , 15	1st right	8	15 times	2.6784	35.0	1:42:542
102	22 , 14	1st right	8	13 times	2.3472	34.5	1:43:347

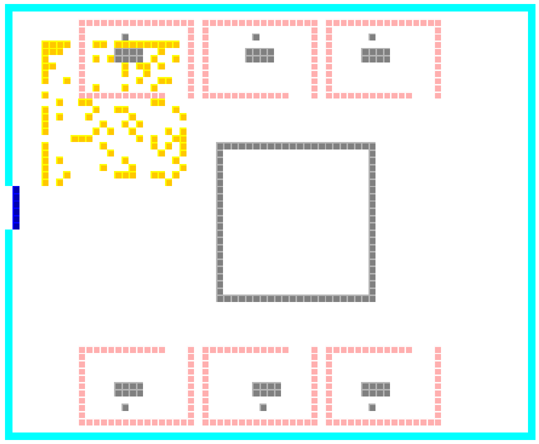
Results of evacuation simulation and specifying evacuation time for each agent



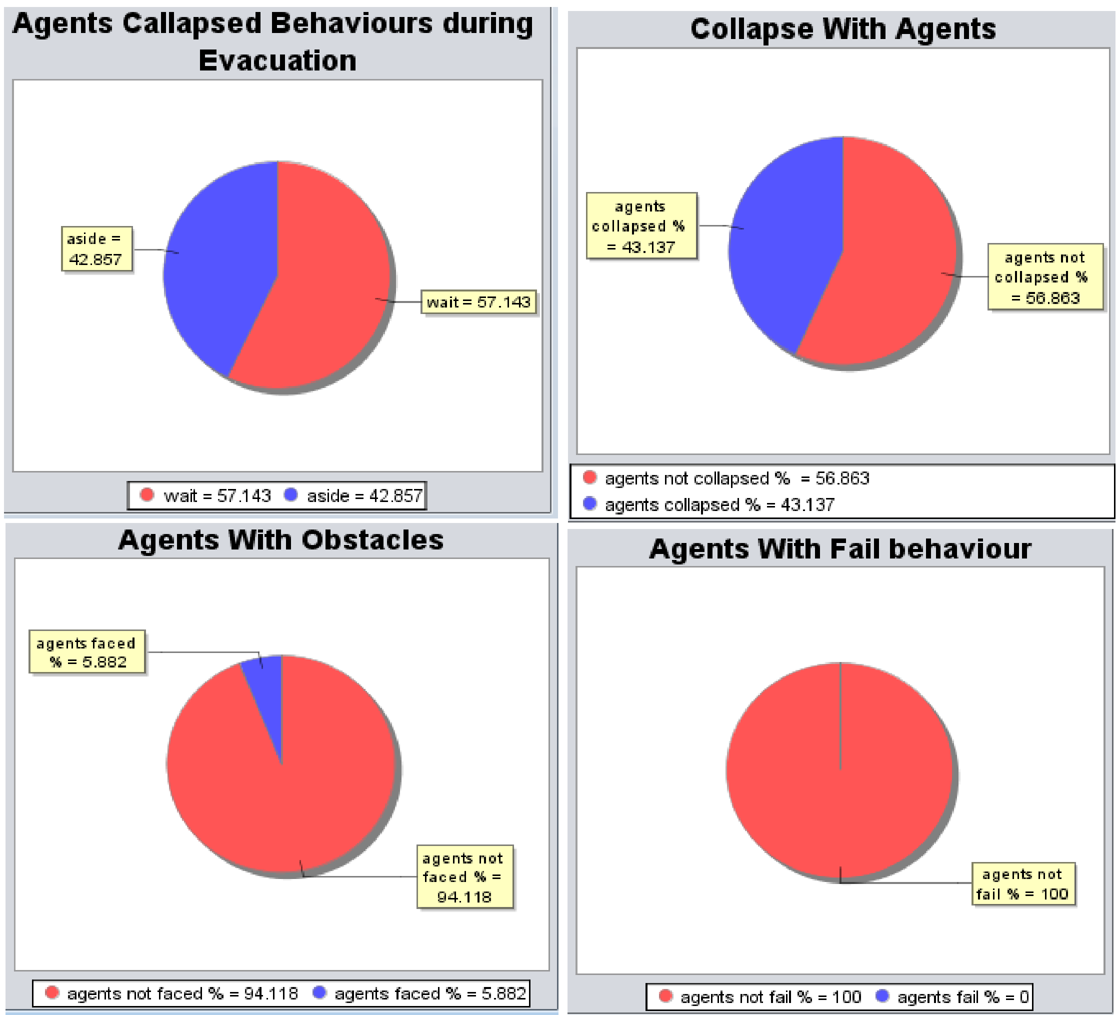
Evacuation time of 102 agents in line graph for second experimentation scenario B

Appendix D

C) Agents near the exit door



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	22 , 12	1st left	no obstacle	1 time	4.3776	6.0	0:7:59
2	22 , 10	1st left	no obstacle	no collapse	4.9896	5.0	0:5:547
3	21 , 29	1st left	no obstacle	1 time	5.508	11.5	0:9:873
4	21 , 25	1st left	no obstacle	2 times	4.32	9.5	0:12:257
5	21 , 24	1st left	no obstacle	no collapse	4.1184	9.0	0:10:574
6	21 , 23	1st left	no obstacle	no collapse	4.968	8.5	0:8:128
7	21 , 22	1st left	no obstacle	1 time	4.7232	8.0	0:9:573
8	21 , 19	1st left	no obstacle	no collapse	4.4064	7.0	0:7:293
9	21 , 13	1st left	no obstacle	1 time	5.148	6.5	0:5:176
10	21 , 12	1st left	no obstacle	no collapse	4.6584	6.0	0:6:398
11	21 , 10	1st left	no obstacle	no collapse	5.0184	5.5	0:6:55
12	20 , 29	1st left	no obstacle	2 times	4.1472	11.5	0:16:639
13	20 , 21	1st left	no obstacle	no collapse	4.3632	7.5	0:9:104
14	20 , 16	1st left	no obstacle	no collapse	4.9608	6.5	0:6:228
15	20 , 10	1st left	no obstacle	no collapse	4.9464	6.5	0:6:365
16	19 , 29	1st left	no obstacle	1 time	4.5792	11.5	0:11:871
17	19 , 27	1st left	no obstacle	1 time	5.1192	10.5	0:10:79
18	19 , 18	1st left	no obstacle	no collapse	3.888	8.0	0:10:207
19	19 , 13	1st left	no obstacle	no collapse	4.8312	8.5	0:9:750
20	19 , 12	1st left	no obstacle	no collapse	5.0184	8.0	0:9:692
21	19 , 10	1st left	no obstacle	no collapse	4.9392	7.0	0:6:632
22	18 , 27	1st left	no obstacle	1 time	4.752	10.5	0:10:986
23	18 , 24	1st left	no obstacle	no collapse	4.8096	9.5	0:9:634
24	18 , 21	1st left	no obstacle	no collapse	5.3712	8.0	0:5:653
25	18 , 17	1st left	no obstacle	no collapse	5.3496	9.5	0:9:141
26	18 , 15	1st left	no obstacle	no collapse	5.0472	8.0	0:6:884
27	18 , 11	1st left	no obstacle	no collapse	4.8024	7.5	0:9:770
28	18 , 10	1st left	no obstacle	no collapse	4.4712	7.5	0:8:173
29	17 , 11	1st left	no obstacle	no collapse	4.7808	8.5	0:10:109
30	17 , 10	1st left	no obstacle	no collapse	4.6728	8.0	0:9:662
31	16 , 28	1st left	no obstacle	2 times	4.2192	11.5	0:16:573
32	16 , 25	1st left	no obstacle	no collapse	5.0184	10.5	0:10:877
33	16 , 21	1st left	3	2 times	5.22	16.0	0:14:883
34	16 , 10	1st left	no obstacle	no collapse	4.0104	9.0	0:11:157
35	15 , 20	1st left	3	2 times	4.8168	15.0	0:19:796
36	15 , 18	1st left	5	no collapse	5.1768	15.0	0:14:106
37	15 , 13	1st left	no obstacle	no collapse	5.0976	8.5	0:8:412
38	15 , 10	1st left	no obstacle	no collapse	4.8672	9.5	0:10:749

Results of evacuation simulation and specifying evacuation time for each agent

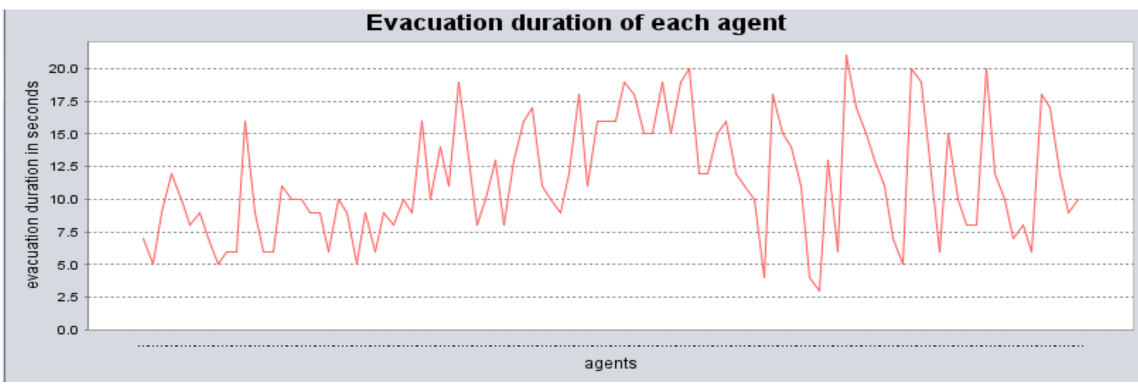
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	14 , 28	1st left	no obstacle	1 time	4.788	12.5	0:13:401
40	14 , 10	1st left	no obstacle	no collapse	4.9824	9.5	0:8:702
41	13 , 24	1st left	no obstacle	2 times	4.7016	12.5	0:13:187
42	13 , 18	1st left	3	no collapse	4.4784	14.5	0:16:688
43	13 , 17	1st left	3	2 times	5.1696	17.5	0:17:663
44	13 , 10	1st left	no obstacle	no collapse	4.3416	10.0	0:11:389
45	12 , 12	1st left	no obstacle	no collapse	4.788	10.5	0:10:951
46	12 , 10	1st left	no obstacle	no collapse	5.7816	10.5	0:9:227
47	11 , 27	1st left	no obstacle	1 time	5.1912	13.5	0:12:49
48	11 , 24	1st left	no obstacle	2 times	4.32	13.5	0:18:457
49	11 , 10	1st left	no obstacle	no collapse	4.5288	11.5	0:11:713
50	10 , 28	1st left	no obstacle	3 times	4.7808	14.5	0:16:258
51	10 , 27	1st left	no obstacle	1 time	4.68	14.0	0:16:886
52	10 , 26	1st left	no obstacle	3 times	4.572	14.0	0:16:953
53	10 , 24	1st left	no obstacle	2 times	3.7512	15.5	0:19:582
54	10 , 23	1st left	no obstacle	1 time	3.888	15.5	0:18:340
55	10 , 22	1st left	no obstacle	1 time	4.9176	15.0	0:15:149
56	10 , 21	1st left	no obstacle	1 time	4.8312	17.0	0:15:377
57	10 , 20	1st left	no obstacle	3 times	4.9176	16.0	0:19:524
58	10 , 19	1st left	no obstacle	3 times	5.0904	16.5	0:15:931
59	10 , 18	1st left	1	2 times	4.3128	17.5	0:19:615
60	10 , 17	1st left	no obstacle	4 times	4.9392	17.5	0:20:61
61	10 , 13	1st left	no obstacle	no collapse	4.0968	11.0	0:12:655
62	10 , 12	1st left	no obstacle	no collapse	3.9528	12.5	0:12:683
63	10 , 10	1st left	no obstacle	no collapse	3.6792	12.5	0:15:11
64	29 , 27	1st left	no obstacle	no collapse	2.3472	10.5	0:16:819
65	29 , 20	1st left	no obstacle	no collapse	2.4624	7.0	0:12:655
66	29 , 19	1st left	no obstacle	2 times	2.9304	6.5	0:11:973
67	29 , 18	1st left	no obstacle	no collapse	2.5416	6.0	0:10:398
68	29 , 10	1st left	no obstacle	1 time	2.6064	2.0	0:4:552
69	28 , 29	1st left	no obstacle	1 time	2.3184	11.5	0:18:208
70	28 , 25	1st left	no obstacle	no collapse	2.448	9.5	0:15:561
71	28 , 21	1st left	no obstacle	2 times	2.2824	7.5	0:14:627
72	28 , 19	1st left	no obstacle	1 time	2.7432	6.5	0:11:283
73	28 , 11	1st left	no obstacle	no collapse	2.2176	2.5	0:4:837
74	28 , 10	1st left	no obstacle	no collapse	2.3112	2.0	0:3:663
75	27 , 23	1st left	no obstacle	1 time	2.5488	8.5	0:13:542
76	27 , 10	1st left	no obstacle	no collapse	2.9808	2.5	0:6:247

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	29 , 20	1st left	no obstacle	no collapse	2.4624	7.0	0:12:655
66	29 , 19	1st left	no obstacle	2 times	2.9304	6.5	0:11:973
67	29 , 18	1st left	no obstacle	no collapse	2.5416	6.0	0:10:398
68	29 , 10	1st left	no obstacle	1 time	2.6064	2.0	0:4:552
69	28 , 29	1st left	no obstacle	1 time	2.3184	11.5	0:18:208
70	28 , 25	1st left	no obstacle	no collapse	2.448	9.5	0:15:561
71	28 , 21	1st left	no obstacle	2 times	2.2824	7.5	0:14:627
72	28 , 19	1st left	no obstacle	1 time	2.7432	6.5	0:11:283
73	28 , 11	1st left	no obstacle	no collapse	2.2176	2.5	0:4:837
74	28 , 10	1st left	no obstacle	no collapse	2.3112	2.0	0:3:663
75	27 , 23	1st left	no obstacle	1 time	2.5488	8.5	0:13:542
76	27 , 10	1st left	no obstacle	no collapse	2.9808	2.5	0:6:247
77	26 , 29	1st left	no obstacle	3 times	2.5992	11.5	0:21:144
78	26 , 28	1st left	no obstacle	2 times	2.7504	11.0	0:17:5
79	26 , 27	1st left	no obstacle	1 time	2.7432	10.5	0:15:50
80	26 , 24	1st left	no obstacle	no collapse	2.5128	9.0	0:13:878
81	26 , 20	1st left	no obstacle	1 time	2.7576	7.0	0:11:567
82	26 , 15	1st left	no obstacle	no collapse	2.7	4.5	0:7:584
83	26 , 10	1st left	no obstacle	no collapse	2.6064	3.5	0:5:333
84	25 , 28	1st left	no obstacle	3 times	2.5776	11.0	0:20:539
85	25 , 27	1st left	no obstacle	2 times	2.5128	10.5	0:19:378
86	25 , 23	1st left	no obstacle	1 time	2.6928	8.5	0:13:453
87	25 , 10	1st left	no obstacle	no collapse	2.2176	4.0	0:6:523
88	24 , 26	1st left	no obstacle	no collapse	2.5488	10.0	0:15:209
89	24 , 16	1st left	no obstacle	no collapse	2.8584	6.0	0:10:263
90	24 , 13	1st left	no obstacle	no collapse	2.5992	4.5	0:8:600
91	24 , 10	1st left	no obstacle	no collapse	2.5632	4.0	0:8:14
92	23 , 26	1st left	no obstacle	4 times	2.5992	10.0	0:20:922
93	23 , 20	1st left	no obstacle	no collapse	2.3832	7.5	0:12:512
94	23 , 18	1st left	no obstacle	no collapse	2.6784	6.0	0:10:430
95	23 , 15	1st left	no obstacle	no collapse	2.5776	5.0	0:7:718
96	23 , 12	1st left	no obstacle	no collapse	2.7432	5.5	0:8:44
97	23 , 10	1st left	no obstacle	no collapse	2.7432	5.0	0:6:816
98	22 , 28	1st left	no obstacle	2 times	2.5992	11.0	0:18:998
99	22 , 27	1st left	no obstacle	1 time	2.4192	10.5	0:17:129
100	22 , 23	1st left	no obstacle	no collapse	2.6064	8.5	0:12:869
101	22 , 18	1st left	no obstacle	no collapse	2.6784	6.0	0:9:553
102	22 , 16	1st left	no obstacle	no collapse	2.3472	7.0	0:10:849

Results of evacuation simulation and specifying evacuation time for each agent

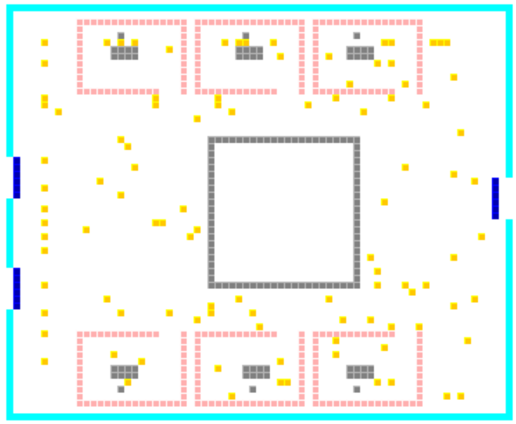


Evacuation time of 102 agents in line graph for second experimentation scenario C

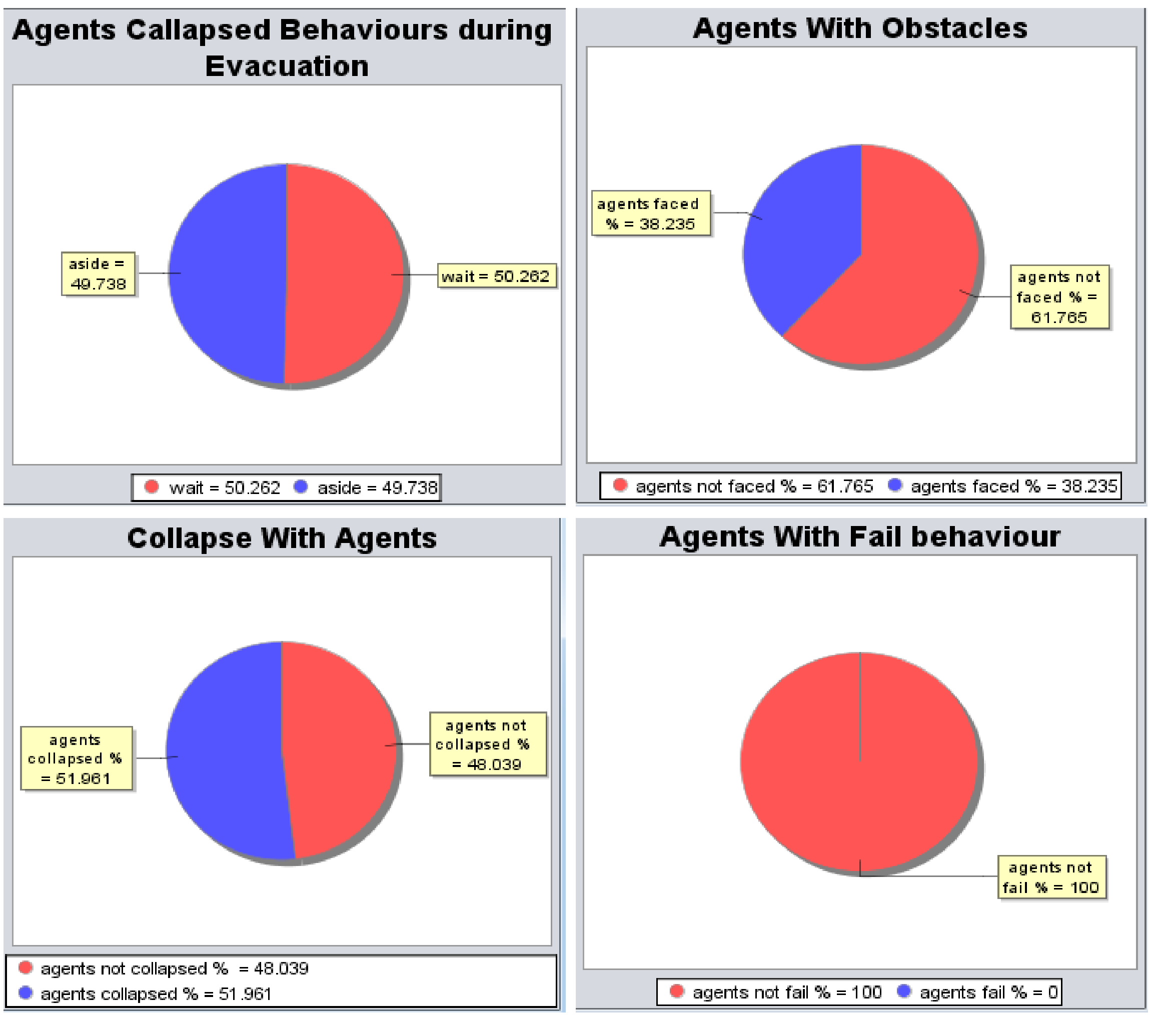
Appendix D

Third:

A) Multiple exit and increase distribution range from 70*60 into 74*63



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	38 , 19	1st left	no obstacle	no collapse	4.3776	6.5	0:7:149
2	38 , 12	2nd left	no obstacle	no collapse	4.9896	4.0	0:5:34
3	37 , 26	2nd left	no obstacle	no collapse	5.508	10.0	0:7:724
4	37 , 19	1st right	9	3 times	4.32	33.0	0:33:685
5	37 , 18	1st left	no obstacle	no collapse	4.1184	6.0	0:6:392
6	36 , 10	1st left	no obstacle	no collapse	4.968	2.0	0:2:551
7	34 , 10	2nd left	no obstacle	no collapse	4.7232	5.5	0:6:795
8	33 , 70	1st left	1	3 times	4.4064	35.0	0:29:70
9	31 , 64	2nd left	1	8 times	5.148	33.0	0:26:704
10	31 , 58	2nd left	1	7 times	4.6584	29.5	0:23:311
11	31 , 19	1st right	11	2 times	5.0184	32.5	0:26:524
12	30 , 68	1st right	no obstacle	no collapse	4.1472	3.0	0:5:237
13	30 , 27	2nd left	no obstacle	no collapse	4.3632	10.5	0:9:900
14	30 , 18	1st right	11	3 times	4.9608	33.5	0:29:619
15	29 , 58	1st right	no obstacle	no collapse	4.9464	8.0	0:7:940
16	29 , 57	2nd left	1	4 times	4.5792	28.0	0:22:70
17	27 , 10	1st left	no obstacle	no collapse	5.1192	2.5	0:4:410
18	26 , 30	1st right	5	5 times	3.888	24.5	0:33:867
19	25 , 61	1st left	1	6 times	4.8312	29.5	0:26:759
20	25 , 31	1st right	3	5 times	5.0184	23.0	0:24:974
21	25 , 22	1st left	no obstacle	1 time	4.9392	8.0	0:8:180
22	24 , 57	2nd left	1	6 times	4.752	25.5	0:25:425
23	23 , 34	1st right	no obstacle	4 times	4.8096	19.5	0:21:942
24	23 , 24	1st right	8	5 times	5.3712	29.0	0:26:850
25	22 , 63	1st right	no obstacle	no collapse	5.3496	5.5	0:5:330
26	22 , 40	1st right	no obstacle	4 times	5.0472	16.5	0:17:599
27	22 , 11	1st right	9	4 times	4.8024	37.0	0:33:761
28	21 , 28	2nd left	no obstacle	no collapse	4.4712	11.5	0:10:168
29	21 , 19	1st left	no obstacle	no collapse	4.7808	7.0	0:6:211
30	20 , 59	1st right	no obstacle	no collapse	4.6728	7.5	0:7:560
31	19 , 62	2nd left	1	5 times	4.2192	27.5	0:29:883
32	19 , 12	1st left	no obstacle	no collapse	5.0184	7.0	0:6:895
33	18 , 66	2nd left	1	9 times	5.22	31.0	0:25:207
34	18 , 57	2nd left	no obstacle	3 times	4.0104	25.0	0:27:682
35	18 , 47	2nd left	no obstacle	1 time	4.8168	20.0	0:15:607
36	17 , 28	1st left	no obstacle	no collapse	5.1768	11.5	0:8:560
37	16 , 54	1st left	5	5 times	5.0976	30.0	0:26:382
38	16 , 13	2nd left	no obstacle	no collapse	4.8672	12.5	0:11:976

Results of evacuation simulation and specifying evacuation time for each agent

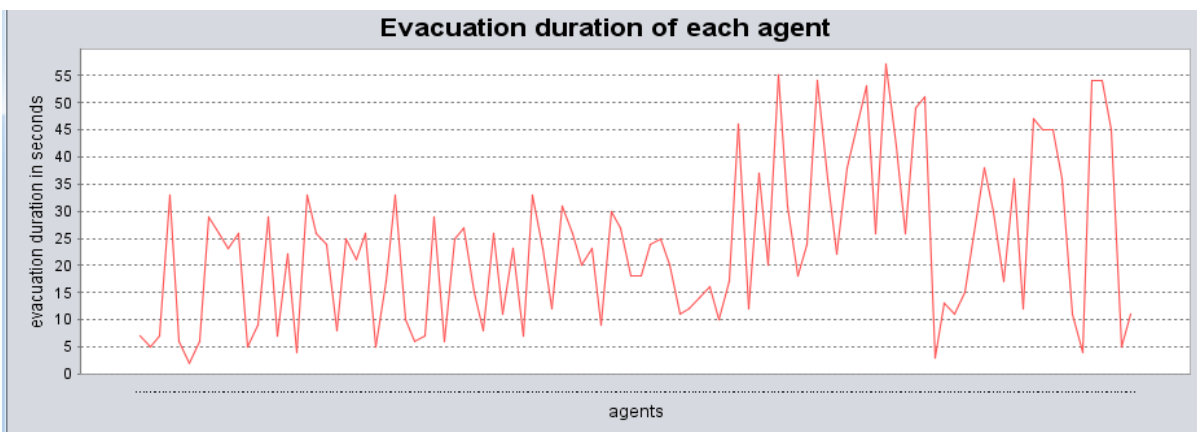
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	15 , 62	1st left	no obstacle	2 times	4.788	28.5	0:23:402
40	13 , 10	1st left	no obstacle	no collapse	4.9824	9.0	0:7:335
41	12 , 10	1st right	13	3 times	4.7016	38.0	0:33:177
42	11 , 36	1st right	3	2 times	4.4784	21.0	0:23:32
43	11 , 18	1st left	1	no collapse	5.1696	18.0	0:12:692
44	10 , 73	1st left	1	2 times	4.3416	34.0	0:31:328
45	10 , 70	1st left	no obstacle	3 times	4.788	31.0	0:26:158
46	10 , 69	2nd left	no obstacle	7 times	5.7816	30.5	0:20:913
47	10 , 61	2nd left	no obstacle	6 times	5.1912	31.5	0:23:826
48	10 , 58	1st right	no obstacle	no collapse	4.32	10.0	0:9:801
49	10 , 57	1st left	1	5 times	4.5288	32.0	0:30:30
50	10 , 54	2nd left	no obstacle	4 times	4.7808	32.0	0:27:910
51	10 , 43	1st left	no obstacle	no collapse	4.68	23.0	0:18:532
52	10 , 42	2nd left	no obstacle	no collapse	4.572	22.5	0:18:634
53	10 , 41	2nd left	no obstacle	1 time	3.7512	23.5	0:24:509
54	10 , 36	2nd left	no obstacle	2 times	3.888	24.0	0:25:680
55	10 , 34	1st left	no obstacle	2 times	4.9176	25.5	0:20:594
56	10 , 28	1st left	no obstacle	no collapse	4.8312	14.5	0:11:741
57	10 , 27	2nd left	no obstacle	no collapse	4.9176	17.0	0:12:814
58	10 , 26	2nd left	no obstacle	no collapse	5.0904	20.5	0:14:372
59	10 , 24	2nd left	no obstacle	no collapse	4.3128	18.0	0:16:410
60	10 , 22	1st left	no obstacle	no collapse	4.9392	13.5	0:10:602
61	10 , 21	2nd left	no obstacle	no collapse	4.0968	18.0	0:17:43
62	10 , 13	1st right	19	5 times	3.9528	41.5	0:46:433
63	10 , 10	1st left	no obstacle	no collapse	3.6792	11.0	0:12:318
64	61 , 38	1st left	no obstacle	2 times	2.3472	22.5	0:37:452
65	61 , 12	1st left	no obstacle	no collapse	2.4624	14.5	0:20:437
66	60 , 12	1st right	17	4 times	2.9304	39.5	0:55:79
67	59 , 41	2nd left	no obstacle	no collapse	2.5416	21.0	0:31:419
68	59 , 12	1st left	no obstacle	no collapse	2.6064	13.5	0:18:765
69	58 , 19	2nd left	1	no collapse	2.3184	15.0	0:24:773
70	57 , 73	1st left	no obstacle	no collapse	2.448	40.0	0:54:674
71	57 , 34	1st left	3	no collapse	2.2824	22.5	0:36:600
72	56 , 44	1st right	no obstacle	no collapse	2.7432	16.0	0:22:718
73	55 , 27	1st right	no obstacle	1 time	2.2176	24.0	0:38:708
74	54 , 66	2nd left	1	3 times	2.3112	29.5	0:45:898
75	54 , 13	1st right	12	2 times	2.5488	37.0	0:53:167
76	53 , 18	2nd left	7	2 times	2.9808	16.5	0:26:648

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	61 , 12	1st left	no obstacle	no collapse	2.4624	14.5	0:20:437
66	60 , 12	1st right	17	4 times	2.9304	39.5	0:55:79
67	59 , 41	2nd left	no obstacle	no collapse	2.5416	21.0	0:31:419
68	59 , 12	1st left	no obstacle	no collapse	2.6064	13.5	0:18:765
69	58 , 19	2nd left	1	no collapse	2.3184	15.0	0:24:773
70	57 , 73	1st left	no obstacle	no collapse	2.448	40.0	0:54:674
71	57 , 34	1st left	3	no collapse	2.2824	22.5	0:36:600
72	56 , 44	1st right	no obstacle	no collapse	2.7432	16.0	0:22:718
73	55 , 27	1st right	no obstacle	1 time	2.2176	24.0	0:38:708
74	54 , 66	2nd left	1	3 times	2.3112	29.5	0:45:898
75	54 , 13	1st right	12	2 times	2.5488	37.0	0:53:167
76	53 , 18	2nd left	7	2 times	2.9808	16.5	0:26:648
77	51 , 10	1st right	7	6 times	2.5992	36.5	0:57:100
78	50 , 70	1st left	1	3 times	2.7504	36.5	0:42:632
79	50 , 39	1st right	no obstacle	2 times	2.7432	17.5	0:26:876
80	50 , 16	1st right	11	1 time	2.5128	35.0	0:49:603
81	50 , 14	1st right	10	4 times	2.7576	35.5	0:51:511
82	50 , 10	2nd left	no obstacle	no collapse	2.7	2.5	0:3:635
83	48 , 25	2nd left	no obstacle	no collapse	2.6064	9.5	0:13:470
84	47 , 60	1st right	no obstacle	no collapse	2.5776	7.0	0:11:71
85	47 , 54	1st right	no obstacle	no collapse	2.5128	10.0	0:15:173
86	47 , 46	1st left	no obstacle	no collapse	2.6928	19.5	0:26:464
87	46 , 53	2nd left	no obstacle	4 times	2.2176	23.0	0:38:149
88	46 , 51	2nd left	no obstacle	no collapse	2.5488	22.5	0:30:881
89	46 , 49	1st right	no obstacle	no collapse	2.8584	12.0	0:17:231
90	46 , 30	1st right	1	4 times	2.5992	22.0	0:36:79
91	46 , 23	2nd left	no obstacle	no collapse	2.5632	8.5	0:12:588
92	46 , 16	1st right	10	1 time	2.5992	34.0	0:47:320
93	43 , 72	2nd left	no obstacle	no collapse	2.3832	33.0	0:45:569
94	43 , 71	1st left	1	5 times	2.6784	35.0	0:45:833
95	43 , 33	1st right	3	3 times	2.5776	21.5	0:36:45
96	43 , 23	1st left	no obstacle	no collapse	2.7432	8.5	0:11:820
97	43 , 10	2nd left	no obstacle	no collapse	2.7432	2.0	0:4:636
98	41 , 12	1st right	7	4 times	2.5992	35.5	0:54:46
99	41 , 10	1st right	11	1 time	2.4192	37.0	0:54:132
100	40 , 17	1st right	7	2 times	2.6064	32.0	0:45:946
101	39 , 68	1st right	no obstacle	no collapse	2.6784	3.0	0:5:572
102	39 , 21	2nd left	no obstacle	no collapse	2.3472	7.5	0:11:897

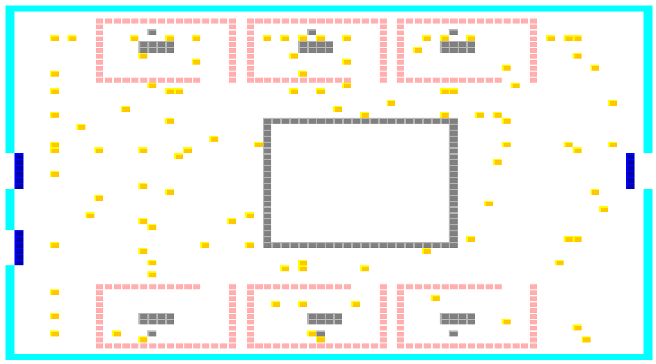
Results of evacuation simulation and specifying evacuation time for each agent



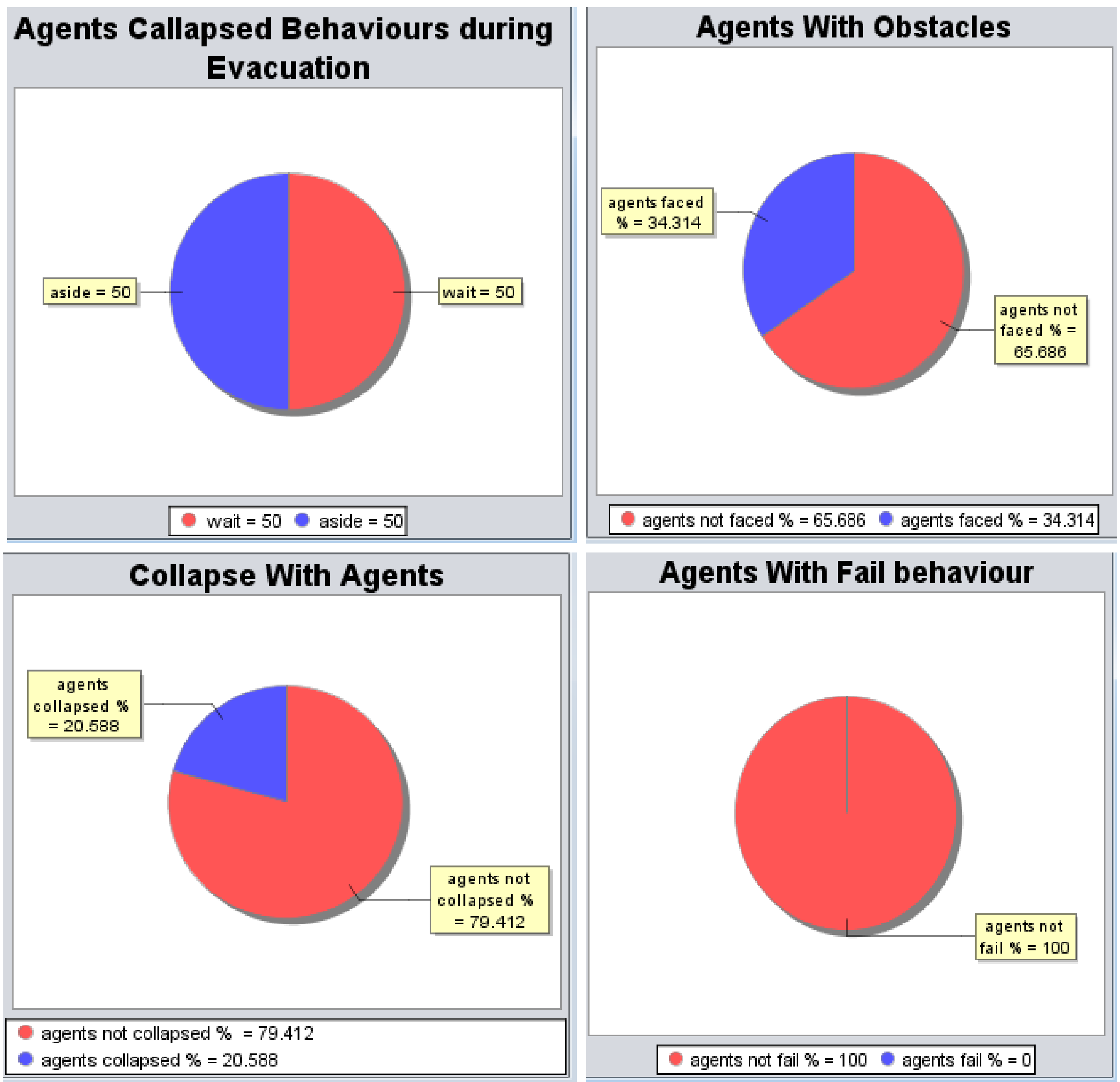
Evacuation time of 102 agents in line graph for third experimentation scenario A

Appendix D

B) Same condition number 3A, but this time they are all familiar with the building



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	32 , 21	1st left	no obstacle	no collapse	4.3776	7.5	0:8:375
2	32 , 13	1st left	no obstacle	no collapse	4.9896	3.5	0:4:284
3	30 , 56	1st right	no obstacle	2 times	5.508	9.0	0:10:534
4	30 , 14	1st left	no obstacle	no collapse	4.32	4.0	0:5:57
5	29 , 57	1st right	no obstacle	3 times	4.1184	8.5	0:13:367
6	29 , 20	1st left	no obstacle	no collapse	4.968	7.0	0:7:317
7	29 , 13	1st left	no obstacle	no collapse	4.7232	3.5	0:4:774
8	27 , 58	1st right	no obstacle	1 time	4.4064	8.0	0:10:558
9	27 , 25	1st left	no obstacle	no collapse	5.148	9.5	0:8:704
10	27 , 17	1st left	no obstacle	no collapse	4.6584	5.5	0:5:549
11	27 , 16	1st left	no obstacle	no collapse	5.0184	5.0	0:5:318
12	27 , 15	1st left	no obstacle	1 time	4.1472	4.5	0:6:36
13	26 , 10	1st left	no obstacle	no collapse	4.3632	2.5	0:4:61
14	24 , 57	1st right	no obstacle	no collapse	4.9608	8.5	0:8:207
15	24 , 31	1st left	no obstacle	2 times	4.9464	12.5	0:12:257
16	24 , 27	1st left	no obstacle	no collapse	4.5792	10.5	0:10:293
17	24 , 10	1st left	no obstacle	no collapse	5.1192	3.5	0:3:699
18	23 , 54	1st right	no obstacle	no collapse	3.888	9.5	0:12:303
19	23 , 10	1st left	no obstacle	no collapse	4.8312	4.0	0:4:367
20	22 , 50	1st right	no obstacle	4 times	5.0184	11.5	0:14:790
21	22 , 28	1st left	no obstacle	no collapse	4.9392	11.0	0:9:338
22	21 , 28	1st left	no obstacle	2 times	4.752	11.0	0:11:111
23	21 , 19	1st left	no obstacle	no collapse	4.8096	6.5	0:7:132
24	20 , 43	1st right	no obstacle	1 time	5.3712	15.0	0:13:209
25	20 , 37	1st left	no obstacle	1 time	5.3496	15.5	0:11:874
26	20 , 21	1st left	no obstacle	no collapse	5.0472	7.5	0:6:860
27	20 , 10	1st left	no obstacle	no collapse	4.8024	5.5	0:5:787
28	18 , 37	1st left	no obstacle	2 times	4.4712	15.5	0:17:302
29	18 , 10	1st left	no obstacle	no collapse	4.7808	6.5	0:7:253
30	17 , 73	1st right	no obstacle	no collapse	4.6728	6.5	0:7:577
31	17 , 62	1st right	no obstacle	no collapse	4.2192	7.0	0:9:286
32	16 , 37	1st left	3	no collapse	5.0184	22.5	0:19:819
33	16 , 35	1st left	3	3 times	5.22	22.5	0:20:395
34	16 , 21	1st left	3	1 time	4.0104	12.5	0:16:821
35	16 , 19	1st left	5	2 times	4.8168	13.5	0:15:858
36	16 , 13	1st left	no obstacle	no collapse	5.1768	8.0	0:7:696
37	16 , 10	1st left	no obstacle	no collapse	5.0976	7.5	0:7:37
38	15 , 55	1st right	2	1 time	4.8672	9.0	0:10:866

Results of evacuation simulation and specifying evacuation time for each agent

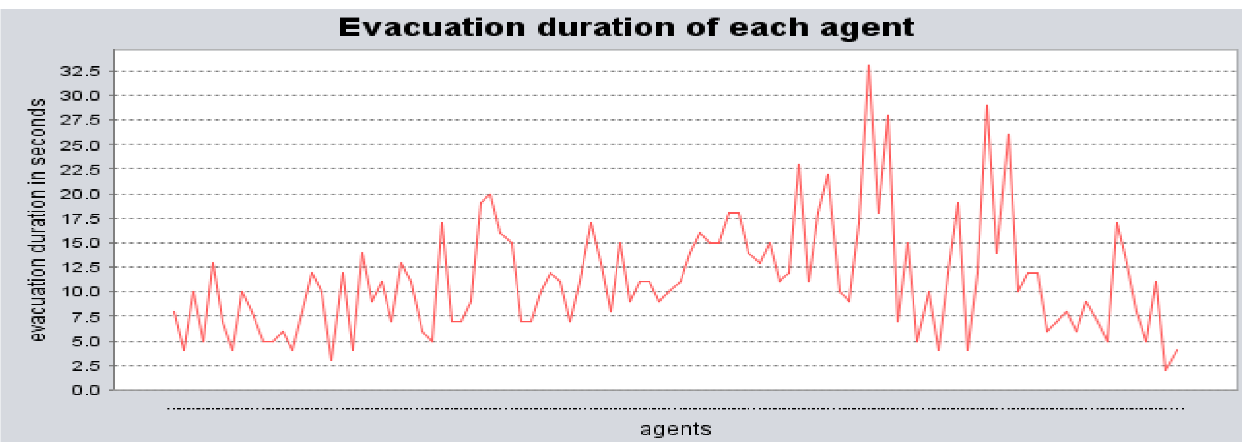
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	15 , 53	1st right	4	no collapse	4.788	10.0	0:12:730
40	15 , 52	1st right	5	no collapse	4.9824	11.0	0:11:994
41	15 , 10	1st left	no obstacle	no collapse	4.7016	8.0	0:7:876
42	14 , 56	1st right	no obstacle	1 time	4.4784	8.5	0:11:174
43	14 , 39	1st left	1	2 times	5.1696	21.0	0:17:863
44	14 , 24	1st left	no obstacle	no collapse	4.3416	12.5	0:13:222
45	14 , 10	1st left	no obstacle	no collapse	4.788	8.5	0:8:630
46	13 , 34	1st left	3	2 times	5.7816	23.5	0:15:750
47	12 , 59	1st right	no obstacle	no collapse	5.1912	9.5	0:9:11
48	10 , 69	1st right	no obstacle	no collapse	4.32	10.0	0:11:642
49	10 , 67	1st right	no obstacle	no collapse	4.5288	10.0	0:11:751
50	10 , 60	1st right	no obstacle	no collapse	4.7808	10.0	0:9:584
51	10 , 55	1st right	no obstacle	no collapse	4.68	10.5	0:10:771
52	10 , 54	1st right	no obstacle	no collapse	4.572	11.5	0:11:564
53	10 , 52	1st right	no obstacle	no collapse	3.7512	11.5	0:14:207
54	10 , 51	1st right	1	no collapse	3.888	13.5	0:16:10
55	10 , 45	1st right	no obstacle	no collapse	4.9176	18.0	0:15:126
56	10 , 44	1st right	no obstacle	no collapse	4.8312	18.5	0:15:836
57	10 , 40	1st left	no obstacle	1 time	4.9176	22.0	0:18:241
58	10 , 35	1st left	1	no collapse	5.0904	25.5	0:18:849
59	10 , 28	1st left	no obstacle	no collapse	4.3128	14.5	0:14:507
60	10 , 25	1st left	no obstacle	1 time	4.9392	14.0	0:13:85
61	10 , 23	1st left	no obstacle	no collapse	4.0968	14.0	0:15:361
62	10 , 11	1st left	no obstacle	no collapse	3.9528	10.5	0:11:666
63	10 , 10	1st left	no obstacle	no collapse	3.6792	10.5	0:12:922
64	62 , 73	1st right	no obstacle	no collapse	2.3472	13.5	0:23:544
65	61 , 10	2nd left	no obstacle	no collapse	2.4624	7.0	0:11:716
66	60 , 71	1st right	no obstacle	no collapse	2.9304	12.5	0:18:515
67	60 , 51	1st right	no obstacle	no collapse	2.5416	13.0	0:22:479
68	60 , 10	2nd left	no obstacle	no collapse	2.6064	6.5	0:10:670
69	59 , 10	2nd left	no obstacle	no collapse	2.3184	6.0	0:9:751
70	56 , 58	1st right	no obstacle	no collapse	2.448	9.5	0:17:824
71	56 , 42	2nd left	no obstacle	no collapse	2.2824	21.0	0:33:592
72	56 , 27	2nd left	no obstacle	no collapse	2.7432	11.5	0:18:207
73	55 , 17	2nd left	6	no collapse	2.2176	14.5	0:28:353
74	55 , 10	2nd left	no obstacle	no collapse	2.3112	4.0	0:7:452
75	54 , 70	1st right	no obstacle	no collapse	2.5488	9.0	0:15:314
76	53 , 10	2nd left	no obstacle	no collapse	2.9808	3.0	0:5:138

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	61 , 10	2nd left	no obstacle	no collapse	2.4624	7.0	0:11:716
66	60 , 71	1st right	no obstacle	no collapse	2.9304	12.5	0:18:515
67	60 , 51	1st right	no obstacle	no collapse	2.5416	13.0	0:22:479
68	60 , 10	2nd left	no obstacle	no collapse	2.6064	6.5	0:10:670
69	59 , 10	2nd left	no obstacle	no collapse	2.3184	6.0	0:9:751
70	56 , 58	1st right	no obstacle	no collapse	2.448	9.5	0:17:824
71	56 , 42	2nd left	no obstacle	no collapse	2.2824	21.0	0:33:592
72	56 , 27	2nd left	no obstacle	no collapse	2.7432	11.5	0:18:207
73	55 , 17	2nd left	6	no collapse	2.2176	14.5	0:28:353
74	55 , 10	2nd left	no obstacle	no collapse	2.3112	4.0	0:7:452
75	54 , 70	1st right	no obstacle	no collapse	2.5488	9.0	0:15:314
76	53 , 10	2nd left	no obstacle	no collapse	2.9808	3.0	0:5:138
77	51 , 18	2nd left	no obstacle	no collapse	2.5992	6.0	0:10:229
78	51 , 10	2nd left	no obstacle	no collapse	2.7504	2.0	0:4:366
79	50 , 70	1st right	no obstacle	no collapse	2.7432	7.0	0:12:856
80	50 , 32	2nd left	no obstacle	no collapse	2.5128	13.0	0:19:720
81	50 , 10	2nd left	no obstacle	no collapse	2.7576	2.0	0:4:398
82	49 , 61	1st right	no obstacle	no collapse	2.7	6.5	0:12:88
83	49 , 46	2nd left	no obstacle	3 times	2.6064	20.0	0:29:48
84	49 , 24	2nd left	no obstacle	no collapse	2.5776	9.0	0:14:489
85	48 , 43	2nd left	no obstacle	no collapse	2.5128	18.5	0:26:325
86	46 , 65	1st right	no obstacle	no collapse	2.6928	5.0	0:10:12
87	46 , 60	1st right	no obstacle	no collapse	2.2176	7.0	0:12:766
88	45 , 62	1st right	no obstacle	1 time	2.5488	6.0	0:12:363
89	45 , 13	2nd left	no obstacle	no collapse	2.8584	3.5	0:6:752
90	44 , 15	2nd left	no obstacle	no collapse	2.5992	4.5	0:7:919
91	42 , 71	1st right	no obstacle	no collapse	2.5632	3.0	0:8:164
92	41 , 70	1st right	no obstacle	no collapse	2.5992	2.5	0:6:774
93	39 , 64	1st right	no obstacle	no collapse	2.3832	5.0	0:9:634
94	39 , 15	2nd left	no obstacle	no collapse	2.6784	4.5	0:7:696
95	39 , 10	2nd left	no obstacle	no collapse	2.5776	2.5	0:5:880
96	38 , 29	1st left	no obstacle	no collapse	2.7432	11.5	0:17:126
97	37 , 24	1st left	no obstacle	no collapse	2.7432	9.0	0:13:571
98	37 , 16	1st left	no obstacle	no collapse	2.5992	5.0	0:8:497
99	37 , 13	1st left	no obstacle	no collapse	2.4192	3.5	0:5:635
100	34 , 63	1st right	no obstacle	1 time	2.6064	5.5	0:11:99
101	33 , 72	1st right	no obstacle	no collapse	2.6784	1.0	0:2:908
102	33 , 10	1st left	no obstacle	no collapse	2.3472	2.0	0:4:196

Results of evacuation simulation and specifying evacuation time for each agent

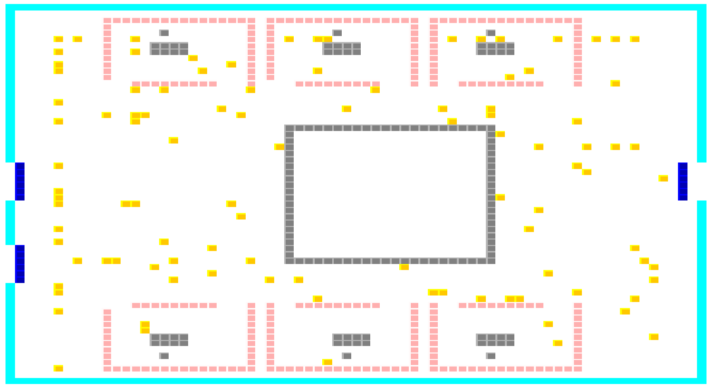


Evacuation time of 102 agents in line graph third experimentation scenario B

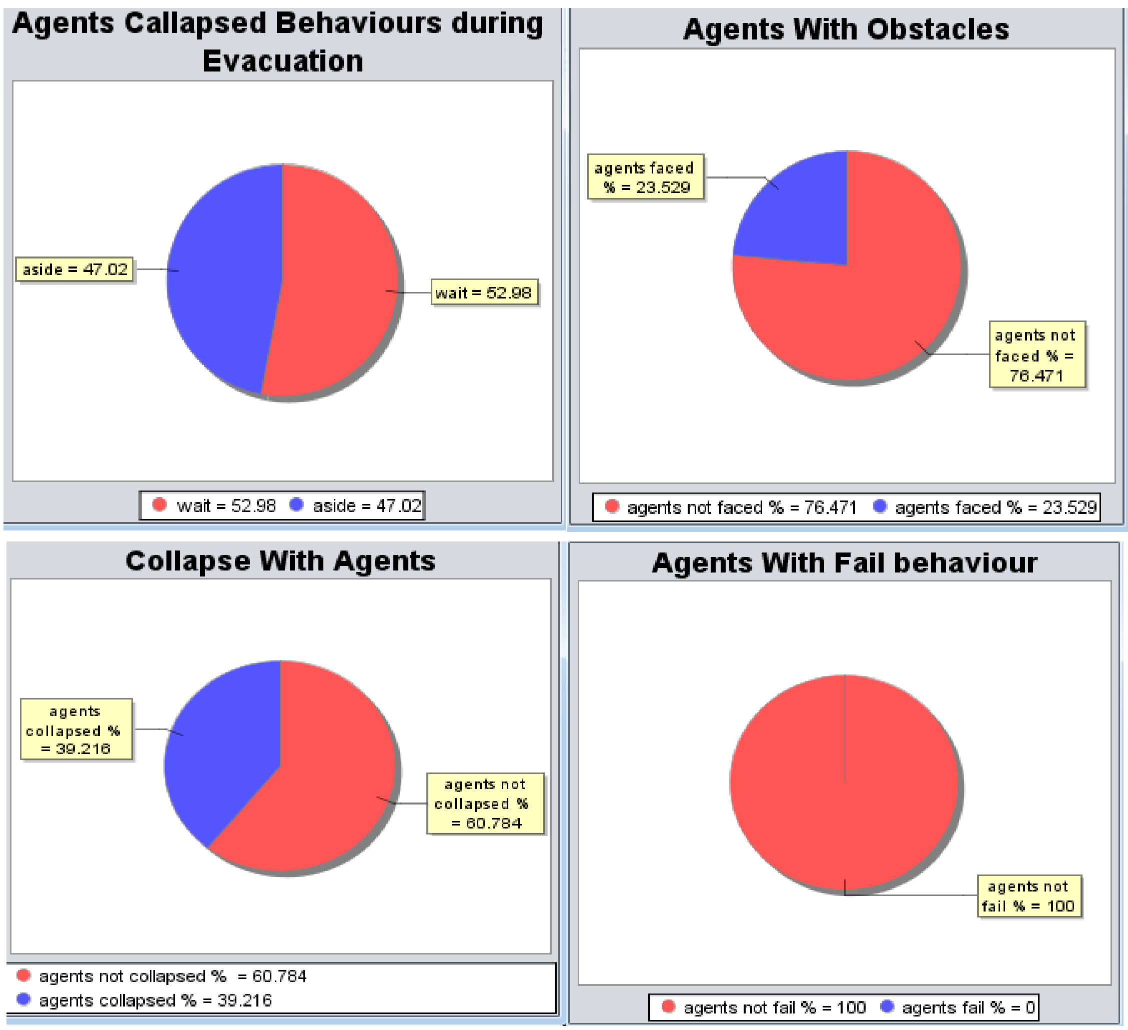
Appendix D

Fourth:

A) 102 agents + no familiar, two exit room and three main exit doors



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	40 , 10	2nd left	no obstacle	no collapse	4.3776	3.5	0:4:984
2	38 , 29	1st left	no obstacle	no collapse	4.9896	11.5	0:8:707
3	37 , 60	2nd left	1	1 time	5.508	30.0	0:15:649
4	36 , 28	1st right	9	7 times	4.32	27.5	0:34:74
5	36 , 18	2nd left	no obstacle	no collapse	4.1184	6.0	0:6:478
6	36 , 17	1st left	no obstacle	no collapse	4.968	5.5	0:5:161
7	36 , 10	1st left	no obstacle	no collapse	4.7232	2.5	0:2:718
8	35 , 56	1st right	no obstacle	no collapse	4.4064	9.0	0:9:396
9	35 , 10	2nd left	no obstacle	no collapse	5.148	5.0	0:4:161
10	34 , 10	2nd left	no obstacle	no collapse	4.6584	6.0	0:7:52
11	32 , 73	1st left	1	12 times	5.0184	39.0	0:31:552
12	31 , 65	1st right	no obstacle	no collapse	4.1472	4.5	0:5:708
13	30 , 64	1st right	no obstacle	no collapse	4.3632	5.0	0:5:885
14	30 , 10	1st left	no obstacle	no collapse	4.9608	3.0	0:3:309
15	27 , 70	1st left	1	8 times	4.9464	36.0	0:27:193
16	27 , 68	1st left	1	6 times	4.5792	35.5	0:29:343
17	27 , 65	1st right	no obstacle	no collapse	5.1192	4.5	0:4:597
18	27 , 60	1st right	no obstacle	no collapse	3.888	7.0	0:8:272
19	27 , 33	1st right	4	4 times	4.8312	22.5	0:23:65
20	26 , 22	1st right	8	7 times	5.0184	30.0	0:31:455
21	25 , 56	1st right	no obstacle	no collapse	4.9392	9.0	0:7:629
22	23 , 64	2nd left	1	3 times	4.752	31.5	0:25:692
23	23 , 51	1st right	no obstacle	1 time	4.8096	11.0	0:10:602
24	23 , 18	1st left	no obstacle	no collapse	5.3712	6.5	0:4:767
25	23 , 10	1st left	no obstacle	no collapse	5.3496	4.0	0:3:820
26	22 , 55	2nd left	no obstacle	no collapse	5.0472	24.0	0:16:705
27	22 , 29	1st right	2	3 times	4.8024	23.5	0:21:621
28	22 , 19	1st left	no obstacle	no collapse	4.4712	6.5	0:6:518
29	22 , 18	2nd left	no obstacle	no collapse	4.7808	11.0	0:9:331
30	22 , 15	1st right	8	3 times	4.6728	34.5	0:32:582
31	21 , 55	2nd left	no obstacle	4 times	4.2192	24.0	0:24:953
32	21 , 50	2nd left	no obstacle	3 times	5.0184	22.0	0:16:321
33	21 , 40	1st right	no obstacle	4 times	5.22	16.5	0:16:59
34	21 , 27	1st right	3	4 times	4.0104	25.0	0:31:457
35	20 , 10	2nd left	no obstacle	no collapse	4.8168	13.0	0:11:840
36	18 , 43	2nd left	no obstacle	1 time	5.1768	18.5	0:12:636
37	18 , 30	2nd left	no obstacle	no collapse	5.0976	14.5	0:10:351
38	18 , 21	2nd left	no obstacle	no collapse	4.8672	15.0	0:11:753

Results of evacuation simulation and specifying evacuation time for each agent

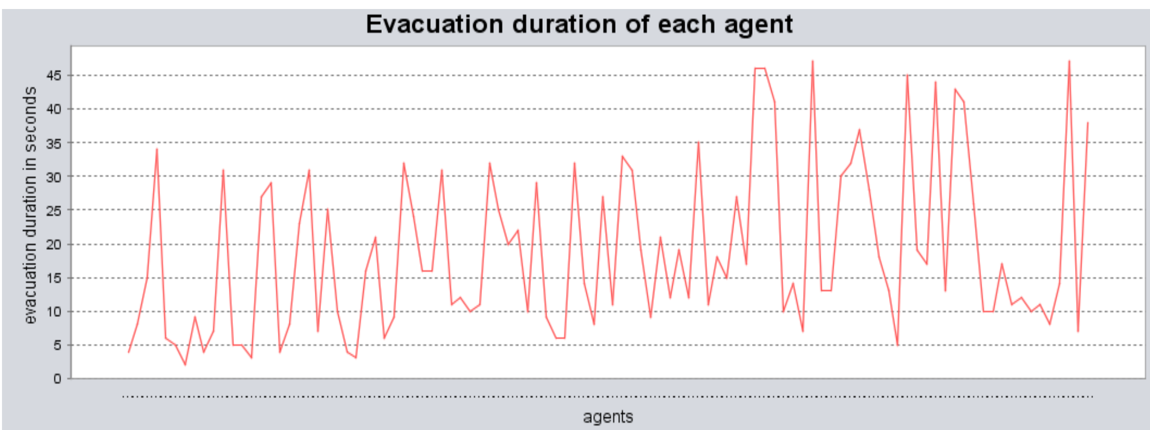
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	18 , 18	1st right	7	5 times	4.788	31.5	0:32:47
40	17 , 68	1st left	1	5 times	4.9824	32.5	0:25:257
41	16 , 57	2nd left	no obstacle	2 times	4.7016	24.5	0:20:606
42	15 , 59	1st left	no obstacle	no collapse	4.4784	25.5	0:22:107
43	15 , 37	2nd left	no obstacle	no collapse	5.1696	16.0	0:10:553
44	15 , 25	1st right	no obstacle	6 times	4.3416	24.0	0:29:480
45	15 , 10	1st left	no obstacle	no collapse	4.788	10.0	0:9:198
46	14 , 28	1st left	no obstacle	no collapse	5.7816	12.5	0:6:886
47	14 , 10	1st left	no obstacle	no collapse	5.1912	8.5	0:6:299
48	13 , 24	1st right	no obstacle	7 times	4.32	24.5	0:32:973
49	12 , 18	2nd left	no obstacle	no collapse	4.5288	16.5	0:14:806
50	12 , 10	1st left	no obstacle	no collapse	4.7808	9.5	0:8:336
51	10 , 70	1st left	no obstacle	9 times	4.68	31.0	0:27:772
52	10 , 68	1st right	no obstacle	no collapse	4.572	10.0	0:11:806
53	10 , 66	1st left	no obstacle	3 times	3.7512	28.5	0:33:88
54	10 , 62	1st left	no obstacle	1 time	3.888	31.0	0:31:838
55	10 , 56	2nd left	no obstacle	3 times	4.9176	24.0	0:19:72
56	10 , 54	1st right	1	no collapse	4.8312	10.5	0:9:538
57	10 , 51	1st left	no obstacle	4 times	4.9176	26.0	0:21:134
58	10 , 38	2nd left	no obstacle	no collapse	5.0904	18.0	0:12:819
59	10 , 37	1st right	2	2 times	4.3128	18.5	0:19:869
60	10 , 34	1st left	no obstacle	no collapse	4.9392	17.5	0:12:972
61	10 , 18	1st right	1	6 times	4.0968	27.5	0:35:450
62	10 , 12	1st left	no obstacle	no collapse	3.9528	11.5	0:11:953
63	10 , 10	2nd left	no obstacle	no collapse	3.6792	17.0	0:18:748
64	62 , 10	2nd left	no obstacle	no collapse	2.3472	10.5	0:15:740
65	61 , 38	1st right	3	no collapse	2.4624	18.0	0:27:995
66	58 , 62	1st right	no obstacle	no collapse	2.9304	11.5	0:17:85
67	57 , 72	1st left	no obstacle	2 times	2.5416	32.5	0:46:218
68	56 , 19	1st right	5	3 times	2.6064	29.0	0:46:102
69	55 , 61	2nd left	no obstacle	no collapse	2.3184	27.5	0:41:197
70	55 , 19	2nd left	no obstacle	no collapse	2.448	7.0	0:10:351
71	53 , 69	1st right	no obstacle	no collapse	2.2824	8.5	0:14:257
72	53 , 10	2nd left	no obstacle	no collapse	2.7432	5.5	0:7:991
73	51 , 70	1st left	1	2 times	2.2176	35.5	0:47:721
74	51 , 58	1st right	no obstacle	no collapse	2.3112	8.0	0:13:549
75	51 , 57	1st right	no obstacle	no collapse	2.5488	9.0	0:13:915
76	51 , 54	1st left	no obstacle	1 time	2.9808	23.5	0:30:670

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	61 , 38	1st right	3	no collapse	2.4624	18.0	0:27:995
66	58 , 62	1st right	no obstacle	no collapse	2.9304	11.5	0:17:85
67	57 , 72	1st left	no obstacle	2 times	2.5416	32.5	0:46:218
68	56 , 19	1st right	5	3 times	2.6064	29.0	0:46:102
69	55 , 61	2nd left	no obstacle	no collapse	2.3184	27.5	0:41:197
70	55 , 19	2nd left	no obstacle	no collapse	2.448	7.0	0:10:351
71	53 , 69	1st right	no obstacle	no collapse	2.2824	8.5	0:14:257
72	53 , 10	2nd left	no obstacle	no collapse	2.7432	5.5	0:7:991
73	51 , 70	1st left	1	2 times	2.2176	35.5	0:47:721
74	51 , 58	1st right	no obstacle	no collapse	2.3112	8.0	0:13:549
75	51 , 57	1st right	no obstacle	no collapse	2.5488	9.0	0:13:915
76	51 , 54	1st left	no obstacle	1 time	2.9808	23.5	0:30:670
77	51 , 37	1st right	no obstacle	4 times	2.5992	18.0	0:32:908
78	50 , 64	2nd left	no obstacle	no collapse	2.7504	29.0	0:37:641
79	50 , 50	1st left	no obstacle	1 time	2.7432	21.5	0:28:694
80	50 , 49	1st right	no obstacle	no collapse	2.5128	12.5	0:18:797
81	50 , 10	1st left	no obstacle	no collapse	2.7576	10.0	0:13:863
82	49 , 10	2nd left	no obstacle	no collapse	2.7	2.5	0:5:112
83	48 , 72	1st left	1	2 times	2.6064	37.0	0:45:319
84	48 , 35	1st left	no obstacle	no collapse	2.5776	14.5	0:19:753
85	48 , 32	2nd left	no obstacle	no collapse	2.5128	13.0	0:17:887
86	48 , 22	1st right	7	3 times	2.6928	29.5	0:44:613
87	47 , 61	1st right	no obstacle	no collapse	2.2176	7.5	0:13:698
88	47 , 26	1st right	5	4 times	2.5488	26.0	0:43:571
89	46 , 72	2nd left	no obstacle	no collapse	2.8584	33.0	0:41:805
90	46 , 46	1st left	no obstacle	no collapse	2.5992	20.0	0:26:550
91	46 , 20	1st left	no obstacle	no collapse	2.5632	7.5	0:10:893
92	45 , 71	1st right	no obstacle	no collapse	2.5992	6.5	0:10:867
93	45 , 30	1st left	no obstacle	no collapse	2.3832	12.0	0:17:432
94	45 , 22	1st left	no obstacle	no collapse	2.6784	8.0	0:11:199
95	45 , 16	1st left	no obstacle	1 time	2.5776	7.5	0:12:577
96	45 , 15	1st left	no obstacle	no collapse	2.7432	7.5	0:10:85
97	45 , 12	1st left	no obstacle	no collapse	2.7432	8.5	0:11:542
98	43 , 70	1st right	no obstacle	no collapse	2.5992	4.5	0:8:432
99	43 , 26	2nd left	no obstacle	no collapse	2.4192	10.0	0:14:683
100	42 , 21	1st right	11	3 times	2.6064	32.0	0:47:519
101	42 , 10	1st left	no obstacle	no collapse	2.6784	5.5	0:7:446
102	40 , 59	2nd left	1	1 time	2.3472	28.0	0:38:756

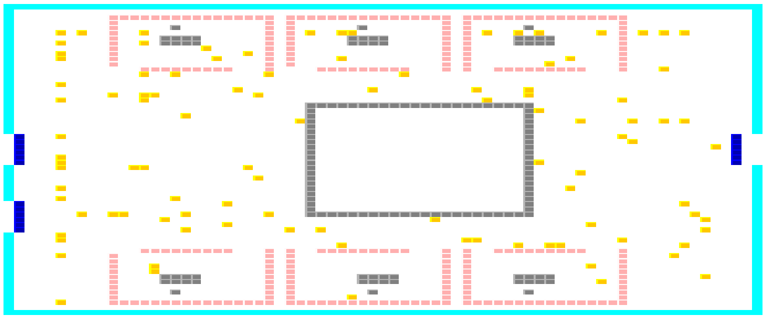
Results of evacuation simulation and specifying evacuation time for each agent



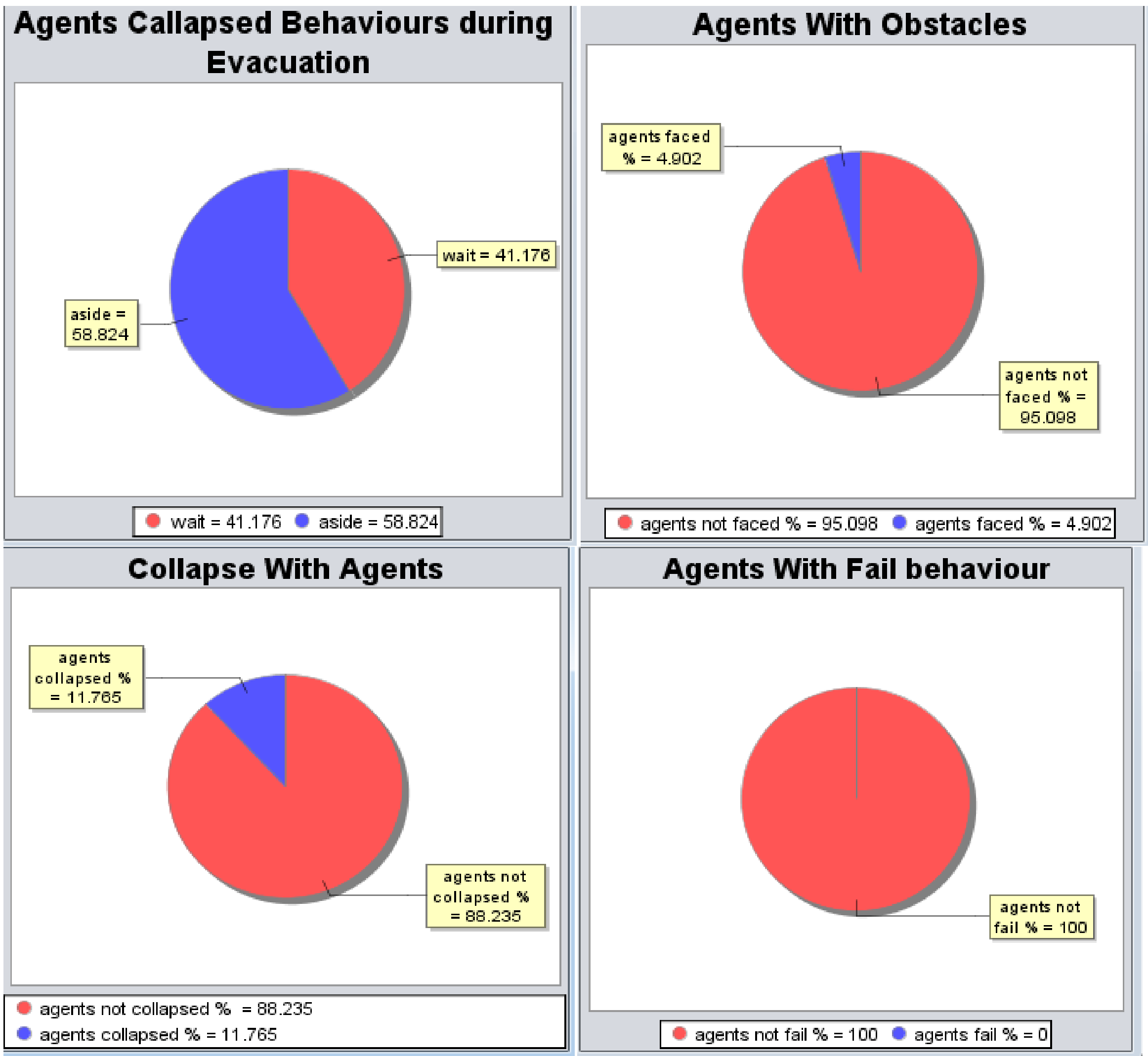
Evacuation time of 102 agents in line graph fourth experimentation scenario A

Appendix D

B) 102 agents + familiar with the exits, two exit room and three main exit doors



First floor created and agents distributed through the floor



Analyzing emergency behaviors appeared during evacuation process

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	38 , 10	1st left	no obstacle	no collapse	4.3776	2.0	0:1:828
2	37 , 60	1st right	no obstacle	no collapse	4.9896	7.0	0:6:99
3	37 , 10	1st left	no obstacle	no collapse	5.508	2.0	0:1:255
4	36 , 26	1st left	no obstacle	no collapse	4.32	10.0	0:9:764
5	36 , 10	1st left	no obstacle	no collapse	4.1184	2.0	0:2:190
6	35 , 56	1st right	no obstacle	no collapse	4.968	9.0	0:7:535
7	34 , 15	1st left	no obstacle	no collapse	4.7232	4.5	0:4:195
8	32 , 72	1st right	no obstacle	no collapse	4.4064	1.0	0:1:623
9	32 , 12	1st left	no obstacle	no collapse	5.148	3.0	0:2:310
10	31 , 58	1st right	no obstacle	no collapse	4.6584	8.0	0:7:213
11	30 , 14	1st left	no obstacle	1 time	5.0184	4.0	0:3:594
12	30 , 12	1st left	no obstacle	no collapse	4.1472	3.0	0:3:366
13	28 , 60	1st right	no obstacle	no collapse	4.3632	7.0	0:7:477
14	27 , 69	1st right	no obstacle	no collapse	4.9608	2.5	0:2:517
15	27 , 64	1st right	no obstacle	no collapse	4.9464	5.0	0:4:482
16	26 , 71	1st right	no obstacle	no collapse	4.5792	2.0	0:2:687
17	26 , 20	1st left	no obstacle	1 time	5.1192	7.0	0:5:727
18	25 , 69	1st right	no obstacle	no collapse	3.888	2.5	0:4:125
19	25 , 10	1st left	no obstacle	no collapse	4.8312	3.0	0:3:906
20	23 , 65	1st right	no obstacle	no collapse	5.0184	4.5	0:4:392
21	23 , 19	1st left	no obstacle	no collapse	4.9392	6.5	0:5:244
22	23 , 10	1st left	no obstacle	no collapse	4.752	4.0	0:3:17
23	22 , 42	1st right	no obstacle	no collapse	4.8096	15.5	0:13:449
24	21 , 64	1st right	no obstacle	no collapse	5.3712	5.0	0:4:436
25	21 , 10	1st left	no obstacle	no collapse	5.3496	5.0	0:4:119
26	20 , 53	1st right	no obstacle	no collapse	5.0472	10.5	0:8:922
27	20 , 46	1st right	no obstacle	no collapse	4.8024	13.5	0:11:316
28	20 , 41	1st right	no obstacle	2 times	4.4712	16.0	0:16:642
29	19 , 39	1st left	no obstacle	no collapse	4.7808	16.0	0:12:479
30	19 , 23	1st left	no obstacle	no collapse	4.6728	8.5	0:7:395
31	18 , 62	1st right	no obstacle	no collapse	4.2192	6.0	0:6:404
32	18 , 36	1st left	no obstacle	no collapse	5.0184	15.0	0:10:595
33	18 , 16	1st left	no obstacle	no collapse	5.22	6.5	0:4:811
34	17 , 16	1st left	no obstacle	no collapse	4.0104	7.0	0:6:338
35	16 , 10	1st left	no obstacle	no collapse	4.8168	7.5	0:6:0
36	15 , 44	1st right	no obstacle	no collapse	5.1768	16.5	0:11:750
37	14 , 73	1st right	no obstacle	no collapse	5.0976	8.0	0:6:672
38	14 , 39	1st left	no obstacle	no collapse	4.8672	16.0	0:12:174

Results of evacuation simulation and specifying evacuation time for each agent

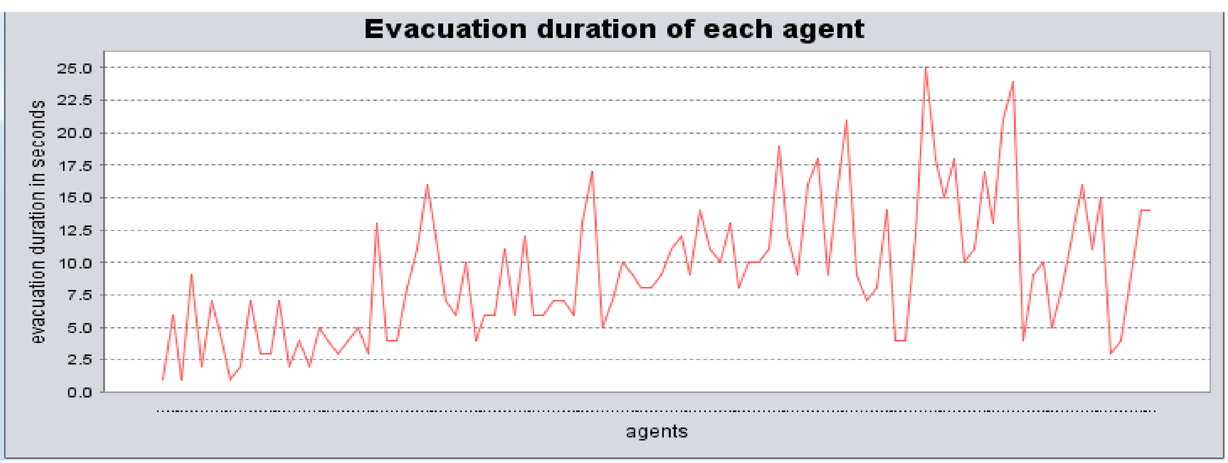
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	14 , 24	1st left	no obstacle	no collapse	4.788	8.5	0:6:952
40	14 , 22	1st left	no obstacle	no collapse	4.9824	8.5	0:6:786
41	14 , 12	1st left	no obstacle	no collapse	4.7016	8.5	0:7:886
42	14 , 10	1st left	no obstacle	no collapse	4.4784	8.5	0:7:886
43	13 , 23	1st left	no obstacle	no collapse	5.1696	9.0	0:6:638
44	12 , 51	1st right	no obstacle	1 time	4.3416	14.5	0:13:777
45	12 , 44	1st right	no obstacle	2 times	4.788	17.5	0:17:137
46	12 , 12	1st left	no obstacle	no collapse	5.7816	9.5	0:5:358
47	11 , 26	1st left	no obstacle	no collapse	5.1912	9.5	0:7:44
48	10 , 73	1st right	no obstacle	no collapse	4.32	10.0	0:10:440
49	10 , 72	1st right	no obstacle	no collapse	4.5288	10.0	0:9:595
50	10 , 67	1st right	no obstacle	no collapse	4.7808	10.0	0:8:922
51	10 , 62	1st right	no obstacle	no collapse	4.68	10.0	0:8:20
52	10 , 61	1st right	no obstacle	no collapse	4.572	10.5	0:9:168
53	10 , 59	1st right	2	no collapse	3.7512	9.5	0:11:646
54	10 , 57	1st right	3	no collapse	3.888	11.0	0:12:667
55	10 , 55	1st right	2	no collapse	4.9176	11.0	0:9:328
56	10 , 41	1st right	3	1 time	4.8312	17.5	0:14:974
57	10 , 38	1st left	no obstacle	no collapse	4.9176	15.0	0:11:749
58	10 , 37	1st left	no obstacle	no collapse	5.0904	14.5	0:10:725
59	10 , 35	1st left	no obstacle	1 time	4.3128	13.5	0:13:209
60	10 , 25	1st left	no obstacle	no collapse	4.9392	11.5	0:8:676
61	10 , 18	1st left	no obstacle	no collapse	4.0968	10.0	0:10:165
62	10 , 13	1st left	no obstacle	no collapse	3.9528	10.5	0:10:299
63	10 , 10	1st left	no obstacle	no collapse	3.6792	10.5	0:11:108
64	59 , 27	2nd left	no obstacle	no collapse	2.3472	13.0	0:19:569
65	59 , 17	2nd left	no obstacle	no collapse	2.4624	8.0	0:12:542
66	59 , 11	2nd left	no obstacle	no collapse	2.9304	7.0	0:9:733
67	58 , 72	1st right	no obstacle	no collapse	2.5416	11.0	0:16:996
68	58 , 68	1st right	no obstacle	no collapse	2.6064	12.0	0:18:184
69	58 , 10	2nd left	no obstacle	no collapse	2.3184	6.0	0:9:681
70	57 , 62	1st right	no obstacle	no collapse	2.448	10.0	0:16:80
71	57 , 51	1st right	1	no collapse	2.2824	14.0	0:21:874
72	57 , 11	2nd left	no obstacle	no collapse	2.7432	6.0	0:9:680
73	57 , 10	2nd left	no obstacle	no collapse	2.2176	5.0	0:7:425
74	56 , 10	2nd left	no obstacle	no collapse	2.3112	5.5	0:8:260
75	55 , 71	1st right	no obstacle	no collapse	2.5488	9.5	0:14:636
76	53 , 12	2nd left	no obstacle	no collapse	2.9808	3.5	0:4:685

Results of evacuation simulation and specifying evacuation time for each agent

Appendix D

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
65	59 , 17	2nd left	no obstacle	no collapse	2.4624	8.0	0:12:542
66	59 , 11	2nd left	no obstacle	no collapse	2.9304	7.0	0:9:733
67	58 , 72	1st right	no obstacle	no collapse	2.5416	11.0	0:16:996
68	58 , 68	1st right	no obstacle	no collapse	2.6064	12.0	0:18:184
69	58 , 10	2nd left	no obstacle	no collapse	2.3184	6.0	0:9:681
70	57 , 62	1st right	no obstacle	no collapse	2.448	10.0	0:16:80
71	57 , 51	1st right	1	no collapse	2.2824	14.0	0:21:874
72	57 , 11	2nd left	no obstacle	no collapse	2.7432	6.0	0:9:680
73	57 , 10	2nd left	no obstacle	no collapse	2.2176	5.0	0:7:425
74	56 , 10	2nd left	no obstacle	no collapse	2.3112	5.5	0:8:260
75	55 , 71	1st right	no obstacle	no collapse	2.5488	9.5	0:14:636
76	53 , 12	2nd left	no obstacle	no collapse	2.9808	3.5	0:4:685
77	52 , 10	2nd left	no obstacle	no collapse	2.5992	2.5	0:4:361
78	51 , 65	1st right	no obstacle	no collapse	2.7504	8.0	0:12:851
79	51 , 44	2nd left	no obstacle	2 times	2.7432	19.0	0:25:511
80	51 , 32	2nd left	no obstacle	no collapse	2.5128	13.0	0:18:425
81	50 , 52	1st right	no obstacle	no collapse	2.7576	11.0	0:15:500
82	50 , 49	1st right	no obstacle	1 time	2.7	12.0	0:18:961
83	49 , 63	1st right	no obstacle	no collapse	2.6064	6.5	0:10:899
84	49 , 61	1st right	no obstacle	no collapse	2.5776	7.0	0:11:862
85	49 , 49	1st right	no obstacle	no collapse	2.5128	12.0	0:17:764
86	49 , 26	2nd left	no obstacle	no collapse	2.6928	10.0	0:13:622
87	48 , 49	1st right	no obstacle	2 times	2.2176	12.0	0:21:224
88	48 , 43	2nd left	no obstacle	no collapse	2.5488	18.5	0:24:922
89	48 , 10	2nd left	no obstacle	no collapse	2.8584	2.0	0:4:436
90	46 , 66	1st right	no obstacle	no collapse	2.5992	5.0	0:9:424
91	46 , 61	1st right	no obstacle	no collapse	2.5632	6.5	0:10:478
92	46 , 13	2nd left	no obstacle	no collapse	2.5992	3.5	0:5:618
93	45 , 17	2nd left	no obstacle	no collapse	2.3832	5.5	0:8:98
94	44 , 58	1st right	no obstacle	no collapse	2.6784	8.0	0:12:577
95	44 , 30	2nd left	no obstacle	no collapse	2.5776	12.0	0:16:880
96	43 , 59	1st right	no obstacle	no collapse	2.7432	7.5	0:11:442
97	43 , 30	2nd left	no obstacle	no collapse	2.7432	12.0	0:15:944
98	43 , 10	2nd left	no obstacle	no collapse	2.5992	2.0	0:3:522
99	42 , 10	2nd left	no obstacle	no collapse	2.4192	2.0	0:4:97
100	41 , 63	1st right	no obstacle	no collapse	2.6064	5.5	0:9:246
101	38 , 27	1st left	no obstacle	2 times	2.6784	10.5	0:14:909
102	38 , 24	1st left	no obstacle	1 time	2.3472	9.0	0:14:24

Results of evacuation simulation and specifying evacuation time for each agent

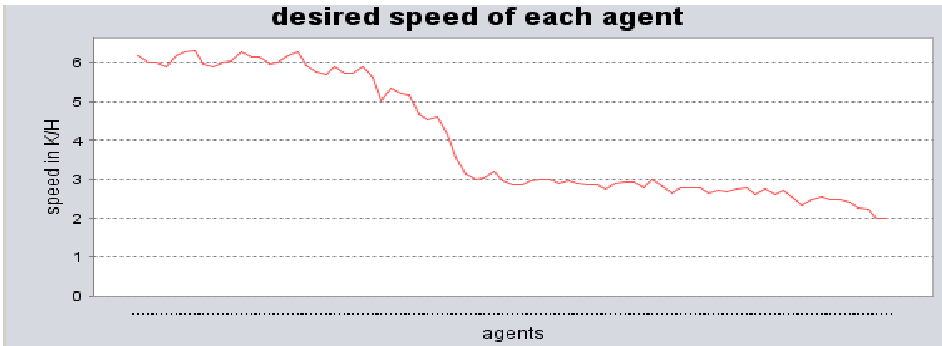


Evacuation time of 102 agents in line graph fourth experimentation scenario B

Appendix E

This simulation is conducted via this model; this model simulated a cafeteria, which comprises three distinct parts, such as the employee part, student part, and staff part. Employees' part, students' part, and staff part for this simulation contain a number of participants, which were 14, 57, and 10 participants respectively.

All participants' specified speed is based on their properties as explained in subsections 4.5 of the submitted main manuscript.

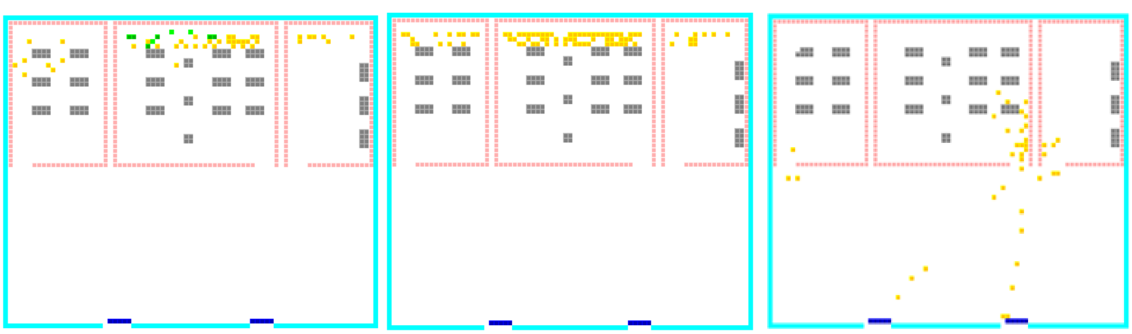


Defined the desired speed of 81 participants via the developed model

Scenario #No1A:

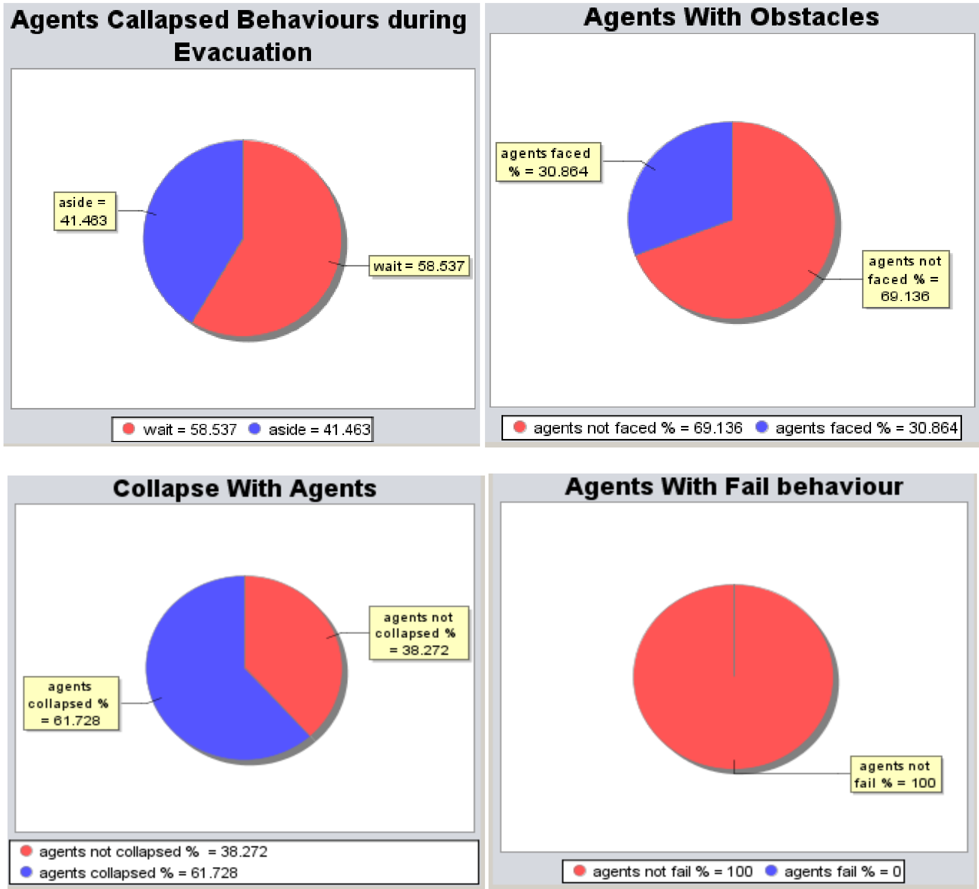
Evacuees distributed in an average small area in the cafeteria, two main exits, each of the employee part, student part, and staff part has one exit door, evacuees were no familiar with the exits.

- Participant distributions:
    - emp_X(16, 33), emp_Y(8, 12) ,
    - student_X(37, 68), student_Y(8, 12),
    - staff_X(75, 89), staff_Y(8, 12)



First floor created and participants distributed through the floor

Appendix E



Analyzing emergency behaviors appeared during the evacuation process

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	10 , 45	1st buttom	no obstacle	1 time	6.1704	32.5	0:11:567
2	10 , 44	1st buttom	no obstacle	no collapse	5.9904	31.0	0:11:160
3	10 , 43	1st buttom	no obstacle	1 time	6.012	36.0	0:14:104
4	10 , 42	1st buttom	no obstacle	1 time	5.8968	34.5	0:15:18
5	10 , 41	1st buttom	no obstacle	1 time	6.1632	31.5	0:11:297
6	10 , 40	1st buttom	no obstacle	2 times	6.2784	32.5	0:11:628
7	10 , 39	2nd buttom	no obstacle	3 times	6.3072	33.0	0:12:828
8	10 , 32	1st buttom	no obstacle	3 times	5.9832	40.0	0:18:159
9	10 , 31	1st buttom	no obstacle	2 times	5.9112	41.0	0:18:246
10	10 , 30	1st buttom	no obstacle	4 times	5.9976	40.5	0:17:649
11	10 , 29	1st buttom	no obstacle	1 time	6.048	39.0	0:14:686
12	10 , 25	2nd buttom	no obstacle	no collapse	6.2784	32.5	0:8:833
13	10 , 23	1st buttom	no obstacle	2 times	6.1272	40.0	0:16:136
14	10 , 22	2nd buttom	no obstacle	1 time	6.1272	32.0	0:10:520
15	10 , 21	1st buttom	no obstacle	no collapse	5.9688	38.5	0:13:633
16	10 , 20	1st buttom	no obstacle	2 times	5.9904	39.5	0:16:587
17	10 , 19	1st buttom	1	no collapse	6.1776	38.0	0:11:373
18	10 , 17	2nd buttom	no obstacle	no collapse	6.2928	30.0	0:8:482
19	10 , 52	1st buttom	no obstacle	2 times	5.9328	33.5	0:14:788
20	10 , 51	1st buttom	1	2 times	5.7528	36.5	0:17:36
21	10 , 50	1st buttom	1	1 time	5.7024	36.0	0:17:62
22	10 , 49	2nd buttom	1	1 time	5.8968	32.5	0:14:344
23	10 , 48	2nd buttom	no obstacle	no collapse	5.7312	32.5	0:14:51
24	10 , 47	2nd buttom	1	2 times	5.7168	33.0	0:16:701
25	10 , 46	1st buttom	no obstacle	2 times	5.9112	32.5	0:15:681
26	10 , 53	2nd buttom	1	3 times	5.6232	37.5	0:20:47
27	10 , 57	1st buttom	no obstacle	no collapse	5.0112	30.5	0:19:367
28	10 , 56	1st buttom	no obstacle	2 times	5.3496	33.0	0:20:463
29	10 , 55	2nd buttom	no obstacle	no collapse	5.2128	33.0	0:18:761
30	10 , 54	2nd buttom	no obstacle	no collapse	5.1696	35.5	0:19:749
31	10 , 58	1st buttom	1	1 time	4.6728	31.5	0:23:993
32	10 , 59	2nd buttom	no obstacle	1 time	4.5288	34.0	0:27:292
33	10 , 60	1st buttom	1	1 time	4.6224	33.0	0:25:404
34	10 , 61	2nd buttom	1	1 time	4.14	33.0	0:28:979
35	10 , 62	1st buttom	no obstacle	2 times	3.5424	32.0	0:35:650
36	10 , 66	1st buttom	1	no collapse	3.132	30.5	0:35:142
37	10 , 65	2nd buttom	1	no collapse	3.0096	32.5	0:36:807
38	10 , 64	1st buttom	1	no collapse	3.0384	31.5	0:37:13

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

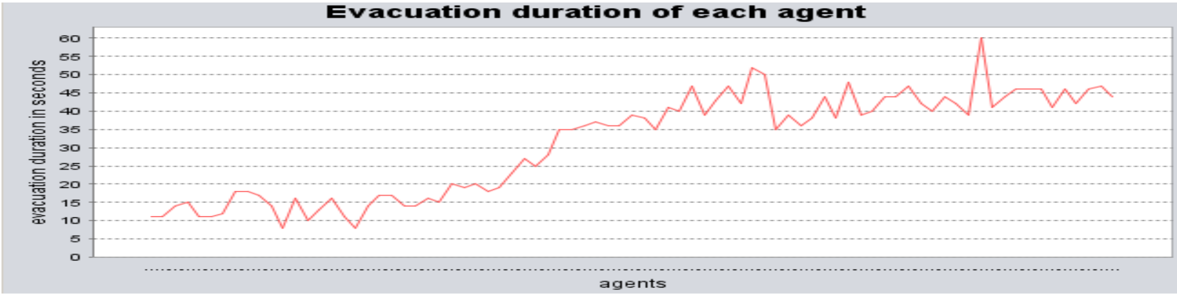
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	10 , 63	1st buttom	1	1 time	3.1968	32.0	0:36:687
40	10 , 67	1st buttom	1	no collapse	2.9592	30.5	0:36:787
41	10 , 81	1st buttom	no obstacle	1 time	2.8584	33.0	0:39:421
42	10 , 79	1st buttom	no obstacle	2 times	2.8584	32.0	0:38:492
43	10 , 77	1st buttom	no obstacle	no collapse	2.9808	31.0	0:35:993
44	10 , 76	2nd buttom	no obstacle	no collapse	2.988	34.5	0:41:85
45	10 , 75	2nd buttom	no obstacle	no collapse	3.0096	33.5	0:40:26
46	11 , 43	1st buttom	1	2 times	2.88	35.0	0:47:28
47	11 , 42	2nd buttom	no obstacle	no collapse	2.952	32.5	0:39:425
48	11 , 41	1st buttom	1	1 time	2.88	34.0	0:43:646
49	11 , 40	2nd buttom	1	2 times	2.8584	36.0	0:47:372
50	11 , 39	2nd buttom	no obstacle	no collapse	2.8584	35.0	0:42:961
51	11 , 26	1st buttom	no obstacle	2 times	2.7432	39.0	0:52:398
52	11 , 20	1st buttom	no obstacle	2 times	2.9016	39.0	0:50:537
53	11 , 18	2nd buttom	no obstacle	no collapse	2.9304	29.5	0:35:467
54	10 , 88	1st buttom	no obstacle	no collapse	2.9232	34.0	0:39:285
55	10 , 87	1st buttom	no obstacle	no collapse	2.8008	31.0	0:36:156
56	10 , 82	2nd buttom	no obstacle	no collapse	3.0096	33.0	0:38:708
57	11 , 47	2nd buttom	no obstacle	1 time	2.8224	34.0	0:44:892
58	11 , 46	2nd buttom	no obstacle	no collapse	2.6568	30.0	0:38:200
59	11 , 44	2nd buttom	1	1 time	2.7792	37.0	0:48:344
60	11 , 52	1st buttom	1	no collapse	2.8008	31.0	0:39:517
61	11 , 51	2nd buttom	1	no collapse	2.7864	32.5	0:40:114
62	11 , 50	2nd buttom	1	no collapse	2.6496	34.5	0:44:129
63	11 , 49	2nd buttom	no obstacle	1 time	2.7216	33.0	0:44:518
64	11 , 48	2nd buttom	no obstacle	1 time	2.7	36.0	0:47:328
65	11 , 58	2nd buttom	no obstacle	2 times	2.772	33.5	0:42:654
66	11 , 57	1st buttom	no obstacle	1 time	2.8008	32.5	0:40:58
67	11 , 56	1st buttom	1	2 times	2.6208	32.0	0:44:945
68	11 , 55	1st buttom	no obstacle	1 time	2.7432	32.0	0:42:62
69	11 , 54	2nd buttom	no obstacle	no collapse	2.628	31.0	0:39:28
70	11 , 53	2nd buttom	1	2 times	2.7072	30.5	1:0:941
71	11 , 59	2nd buttom	no obstacle	no collapse	2.5128	31.5	0:41:251
72	11 , 64	1st buttom	no obstacle	1 time	2.34	31.5	0:44:718
73	11 , 63	2nd buttom	1	2 times	2.4912	34.5	0:46:902
74	11 , 62	1st buttom	1	2 times	2.5416	34.5	0:46:882
75	11 , 61	2nd buttom	no obstacle	2 times	2.4912	33.0	0:46:131
76	11 , 60	2nd buttom	no obstacle	1 time	2.4696	32.0	0:41:987

Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	10 , 76	2nd buttom	no obstacle	no collapse	2.988	34.5	0:41:85
45	10 , 75	2nd buttom	no obstacle	no collapse	3.0096	33.5	0:40:26
46	11 , 43	1st buttom	1	2 times	2.88	35.0	0:47:28
47	11 , 42	2nd buttom	no obstacle	no collapse	2.952	32.5	0:39:425
48	11 , 41	1st buttom	1	1 time	2.88	34.0	0:43:646
49	11 , 40	2nd buttom	1	2 times	2.8584	36.0	0:47:372
50	11 , 39	2nd buttom	no obstacle	no collapse	2.8584	35.0	0:42:961
51	11 , 26	1st buttom	no obstacle	2 times	2.7432	39.0	0:52:398
52	11 , 20	1st buttom	no obstacle	2 times	2.9016	39.0	0:50:537
53	11 , 18	2nd buttom	no obstacle	no collapse	2.9304	29.5	0:35:467
54	10 , 88	1st buttom	no obstacle	no collapse	2.9232	34.0	0:39:285
55	10 , 87	1st buttom	no obstacle	no collapse	2.8008	31.0	0:36:156
56	10 , 82	2nd buttom	no obstacle	no collapse	3.0096	33.0	0:38:708
57	11 , 47	2nd buttom	no obstacle	1 time	2.8224	34.0	0:44:892
58	11 , 46	2nd buttom	no obstacle	no collapse	2.6568	30.0	0:38:200
59	11 , 44	2nd buttom	1	1 time	2.7792	37.0	0:48:344
60	11 , 52	1st buttom	1	no collapse	2.8008	31.0	0:39:517
61	11 , 51	2nd buttom	1	no collapse	2.7864	32.5	0:40:114
62	11 , 50	2nd buttom	1	no collapse	2.6496	34.5	0:44:129
63	11 , 49	2nd buttom	no obstacle	1 time	2.7216	33.0	0:44:518
64	11 , 48	2nd buttom	no obstacle	1 time	2.7	36.0	0:47:328
65	11 , 58	2nd buttom	no obstacle	2 times	2.772	33.5	0:42:654
66	11 , 57	1st buttom	no obstacle	1 time	2.8008	32.5	0:40:58
67	11 , 56	1st buttom	1	2 times	2.6208	32.0	0:44:945
68	11 , 55	1st buttom	no obstacle	1 time	2.7432	32.0	0:42:62
69	11 , 54	2nd buttom	no obstacle	no collapse	2.628	31.0	0:39:28
70	11 , 53	2nd buttom	1	2 times	2.7072	30.5	1:0:941
71	11 , 59	2nd buttom	no obstacle	no collapse	2.5128	31.5	0:41:251
72	11 , 64	1st buttom	no obstacle	1 time	2.34	31.5	0:44:718
73	11 , 63	2nd buttom	1	2 times	2.4912	34.5	0:46:902
74	11 , 62	1st buttom	1	2 times	2.5416	34.5	0:46:882
75	11 , 61	2nd buttom	no obstacle	2 times	2.4912	33.0	0:46:131
76	11 , 60	2nd buttom	no obstacle	1 time	2.4696	32.0	0:41:987
77	11 , 65	2nd buttom	no obstacle	2 times	2.412	33.0	0:46:217
78	11 , 67	1st buttom	1	no collapse	2.2608	31.0	0:42:291
79	11 , 66	2nd buttom	no obstacle	2 times	2.2176	32.5	0:46:490
80	11 , 75	2nd buttom	no obstacle	no collapse	2.0016	32.0	0:47:85
81	11 , 76	1st buttom	no obstacle	no collapse	2.0016	30.5	0:44:363

Results of evacuation simulation and specifying evacuation time for each s participant

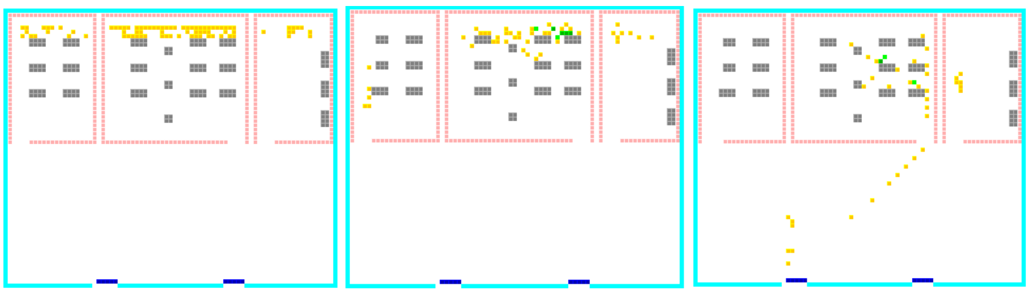
Appendix E



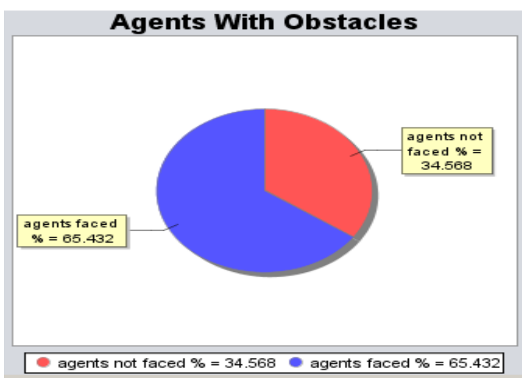
Evacuation time of 81 participants in the line graph for scenario #No1A

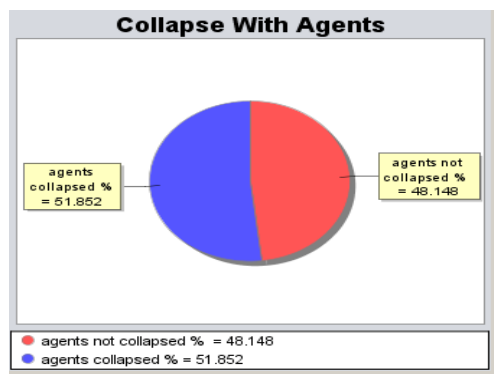
Scenario #No1B:

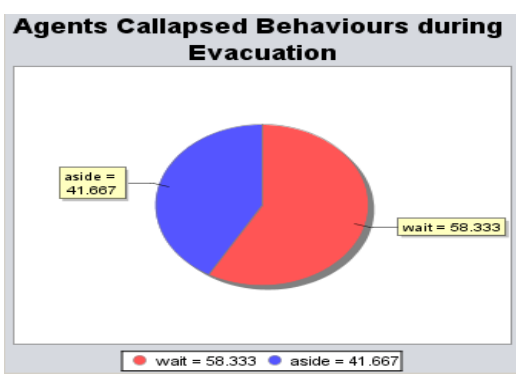
Same as the #No1A but evacuees were familiar with the exits

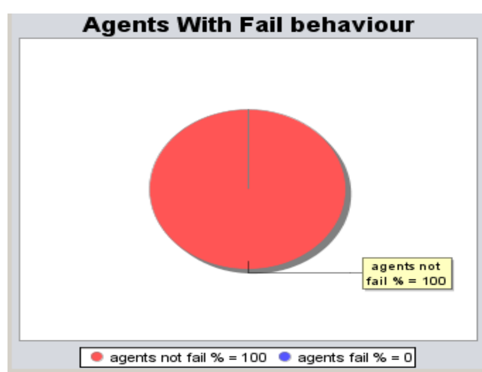


The first floor created and participants distributed through the floor









Appendix E

Analyzing emergency behaviors appeared during the evacuation process

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	10 , 60	1st buttom	1	2 times	3.1968	34.0	0:39:606
40	10 , 64	1st buttom	1	no collapse	2.9592	32.0	0:36:523
41	10 , 77	1st buttom	no obstacle	no collapse	2.8584	31.0	0:36:683
42	10 , 75	1st buttom	no obstacle	no collapse	2.8584	31.0	0:36:790
43	10 , 67	1st buttom	1	no collapse	2.9808	31.0	0:35:755
44	10 , 66	1st buttom	1	no collapse	2.988	31.5	0:35:561
45	10 , 65	1st buttom	1	3 times	3.0096	33.0	0:40:2
46	11 , 44	2nd buttom	2	3 times	2.88	36.5	0:47:630
47	11 , 43	2nd buttom	3	2 times	2.952	38.5	0:48:352
48	11 , 42	2nd buttom	no obstacle	no collapse	2.88	31.5	0:38:320
49	11 , 41	2nd buttom	1	1 time	2.8584	36.5	0:46:570
50	11 , 40	2nd buttom	no obstacle	no collapse	2.8584	30.0	0:36:246
51	11 , 39	2nd buttom	no obstacle	no collapse	2.7432	31.5	0:39:640
52	10 , 88	1st buttom	no obstacle	no collapse	2.9016	32.0	0:36:348
53	10 , 85	1st buttom	no obstacle	no collapse	2.9304	31.5	0:35:535
54	10 , 83	1st buttom	no obstacle	1 time	2.9232	32.5	0:37:265
55	10 , 81	1st buttom	no obstacle	no collapse	2.8008	30.5	0:35:441
56	10 , 80	1st buttom	no obstacle	1 time	3.0096	32.5	0:36:276
57	11 , 47	2nd buttom	1	2 times	2.8224	34.0	0:43:757
58	11 , 46	2nd buttom	no obstacle	no collapse	2.6568	30.0	0:37:810
59	11 , 45	2nd buttom	2	1 time	2.7792	35.0	0:45:632
60	11 , 52	2nd buttom	1	2 times	2.8008	32.5	0:41:576
61	11 , 51	2nd buttom	1	no collapse	2.7864	33.0	0:40:560
62	11 , 50	2nd buttom	1	1 time	2.6496	32.5	0:42:901
63	11 , 49	2nd buttom	1	2 times	2.7216	33.5	0:43:518
64	11 , 48	2nd buttom	1	2 times	2.7	34.5	0:44:464
65	11 , 58	1st buttom	1	no collapse	2.772	32.0	0:39:376
66	11 , 57	1st buttom	1	2 times	2.8008	32.5	0:42:452
67	11 , 56	1st buttom	1	3 times	2.6208	33.5	0:45:889
68	11 , 55	1st buttom	1	no collapse	2.7432	33.5	0:41:595
69	11 , 54	1st buttom	1	1 time	2.628	31.0	0:39:303
70	11 , 53	1st buttom	1	1 time	2.7072	31.5	0:40:707
71	11 , 59	1st buttom	1	no collapse	2.5128	31.5	0:40:735
72	11 , 65	1st buttom	1	2 times	2.34	31.5	0:43:838
73	11 , 64	1st buttom	1	2 times	2.4912	32.5	0:43:804
74	11 , 63	1st buttom	1	1 time	2.5416	32.0	0:41:966
75	11 , 62	1st buttom	2	2 times	2.4912	34.5	0:47:261
76	11 , 61	1st buttom	1	1 time	2.4696	31.5	0:40:678

Results of evacuation simulation and specifying evacuation time for each s participant

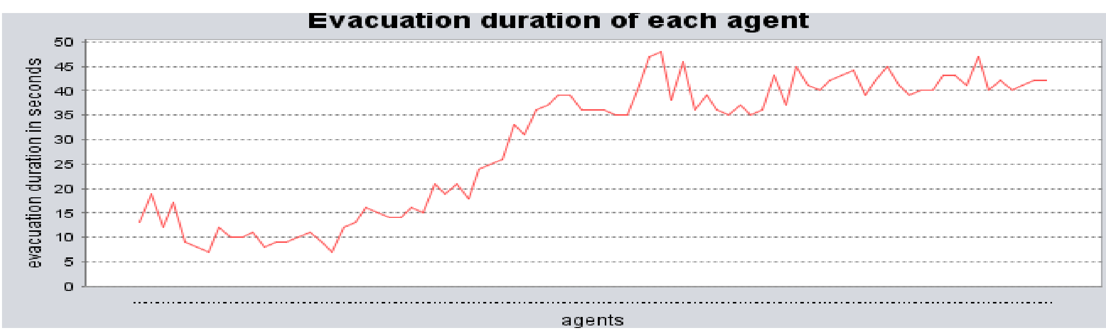
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	10 , 66	1st buttom	1	no collapse	2.988	31.5	0:35:561
45	10 , 65	1st buttom	1	3 times	3.0096	33.0	0:40:2
46	11 , 44	2nd buttom	2	3 times	2.88	36.5	0:47:630
47	11 , 43	2nd buttom	3	2 times	2.952	38.5	0:48:352
48	11 , 42	2nd buttom	no obstacle	no collapse	2.88	31.5	0:38:320
49	11 , 41	2nd buttom	1	1 time	2.8584	36.5	0:46:570
50	11 , 40	2nd buttom	no obstacle	no collapse	2.8584	30.0	0:36:246
51	11 , 39	2nd buttom	no obstacle	no collapse	2.7432	31.5	0:39:640
52	10 , 88	1st buttom	no obstacle	no collapse	2.9016	32.0	0:36:348
53	10 , 85	1st buttom	no obstacle	no collapse	2.9304	31.5	0:35:535
54	10 , 83	1st buttom	no obstacle	1 time	2.9232	32.5	0:37:265
55	10 , 81	1st buttom	no obstacle	no collapse	2.8008	30.5	0:35:441
56	10 , 80	1st buttom	no obstacle	1 time	3.0096	32.5	0:36:276
57	11 , 47	2nd buttom	1	2 times	2.8224	34.0	0:43:757
58	11 , 46	2nd buttom	no obstacle	no collapse	2.6568	30.0	0:37:810
59	11 , 45	2nd buttom	2	1 time	2.7792	35.0	0:45:632
60	11 , 52	2nd buttom	1	2 times	2.8008	32.5	0:41:576
61	11 , 51	2nd buttom	1	no collapse	2.7864	33.0	0:40:560
62	11 , 50	2nd buttom	1	1 time	2.6496	32.5	0:42:901
63	11 , 49	2nd buttom	1	2 times	2.7216	33.5	0:43:518
64	11 , 48	2nd buttom	1	2 times	2.7	34.5	0:44:464
65	11 , 58	1st buttom	1	no collapse	2.772	32.0	0:39:376
66	11 , 57	1st buttom	1	2 times	2.8008	32.5	0:42:452
67	11 , 56	1st buttom	1	3 times	2.6208	33.5	0:45:889
68	11 , 55	1st buttom	1	no collapse	2.7432	33.5	0:41:595
69	11 , 54	1st buttom	1	1 time	2.628	31.0	0:39:303
70	11 , 53	1st buttom	1	1 time	2.7072	31.5	0:40:707
71	11 , 59	1st buttom	1	no collapse	2.5128	31.5	0:40:735
72	11 , 65	1st buttom	1	2 times	2.34	31.5	0:43:838
73	11 , 64	1st buttom	1	2 times	2.4912	32.5	0:43:804
74	11 , 63	1st buttom	1	1 time	2.5416	32.0	0:41:966
75	11 , 62	1st buttom	2	2 times	2.4912	34.5	0:47:261
76	11 , 61	1st buttom	1	1 time	2.4696	31.5	0:40:678
77	11 , 66	1st buttom	1	1 time	2.412	32.0	0:42:348
78	11 , 75	1st buttom	no obstacle	no collapse	2.2608	30.0	0:40:926
79	11 , 67	1st buttom	1	no collapse	2.2176	30.5	0:41:641
80	11 , 77	1st buttom	no obstacle	no collapse	2.0016	30.0	0:42:842
81	11 , 78	1st buttom	no obstacle	no collapse	2.0016	31.0	0:42:796

Appendix E

Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	10 , 42	2nd buttom	1	3 times	6.1704	35.5	0:13:516
2	10 , 41	2nd buttom	3	5 times	5.9904	39.0	0:19:148
3	10 , 40	2nd buttom	no obstacle	1 time	6.012	32.5	0:12:46
4	10 , 39	2nd buttom	1	3 times	5.8968	38.0	0:17:261
5	10 , 32	2nd buttom	no obstacle	no collapse	6.1632	30.0	0:9:52
6	10 , 31	2nd buttom	no obstacle	no collapse	6.2784	30.5	0:8:52
7	10 , 30	2nd buttom	no obstacle	no collapse	6.3072	30.5	0:7:621
8	10 , 29	2nd buttom	no obstacle	1 time	5.9832	32.0	0:12:77
9	10 , 28	2nd buttom	no obstacle	no collapse	5.9112	30.5	0:10:776
10	10 , 27	2nd buttom	no obstacle	no collapse	5.9976	32.0	0:10:756
11	10 , 26	2nd buttom	no obstacle	1 time	6.048	31.5	0:11:681
12	10 , 25	2nd buttom	no obstacle	1 time	6.2784	30.5	0:8:419
13	10 , 24	2nd buttom	no obstacle	no collapse	6.1272	30.5	0:9:145
14	10 , 23	2nd buttom	no obstacle	no collapse	6.1272	32.0	0:9:512
15	10 , 21	2nd buttom	no obstacle	no collapse	5.9688	30.5	0:10:286
16	10 , 20	2nd buttom	no obstacle	1 time	5.9904	31.5	0:11:953
17	10 , 19	2nd buttom	1	no collapse	6.1776	31.0	0:9:29
18	10 , 17	2nd buttom	no obstacle	no collapse	6.2928	30.0	0:7:755
19	10 , 49	2nd buttom	1	1 time	5.9328	32.5	0:12:931
20	10 , 48	2nd buttom	1	no collapse	5.7528	33.5	0:13:344
21	10 , 47	2nd buttom	1	1 time	5.7024	36.0	0:16:89
22	10 , 46	2nd buttom	1	2 times	5.8968	34.5	0:15:146
23	10 , 45	2nd buttom	1	no collapse	5.7312	35.0	0:14:179
24	10 , 44	2nd buttom	1	no collapse	5.7168	35.5	0:14:691
25	10 , 43	2nd buttom	1	3 times	5.9112	35.0	0:16:816
26	10 , 50	2nd buttom	1	1 time	5.6232	33.0	0:15:870
27	10 , 54	1st buttom	1	1 time	5.0112	33.5	0:21:470
28	10 , 53	1st buttom	1	1 time	5.3496	34.5	0:19:292
29	10 , 52	2nd buttom	1	3 times	5.2128	34.0	0:21:350
30	10 , 51	2nd buttom	1	no collapse	5.1696	32.5	0:18:129
31	10 , 55	1st buttom	1	1 time	4.6728	33.5	0:24:813
32	10 , 56	1st buttom	1	no collapse	4.5288	35.5	0:25:952
33	10 , 57	1st buttom	1	1 time	4.6224	35.0	0:26:176
34	10 , 58	1st buttom	3	2 times	4.14	38.0	0:33:201
35	10 , 59	1st buttom	1	no collapse	3.5424	31.5	0:31:464
36	10 , 63	1st buttom	1	no collapse	3.132	33.0	0:36:706
37	10 , 62	1st buttom	1	no collapse	3.0096	33.5	0:37:673
38	10 , 61	1st buttom	1	no collapse	3.0384	34.5	0:39:159

Results of evacuation simulation and specifying evacuation time for each s participant



Evacuation time of 81 participants in the line graph for scenario #No1B

Scenario #No1C:

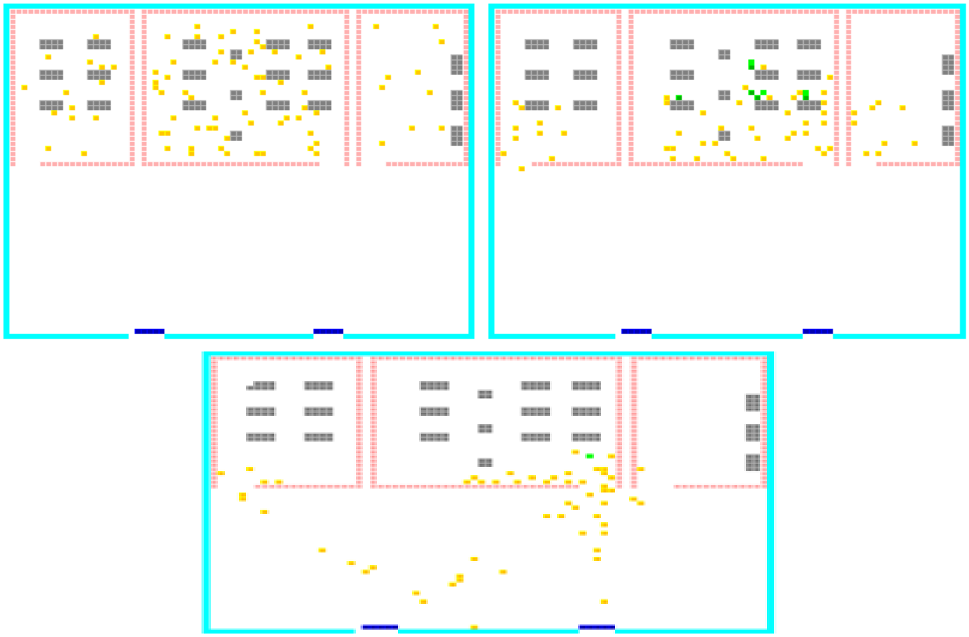
Same as the #No1A but evacuees distributed in a larger area of the floor

Participant distributions:

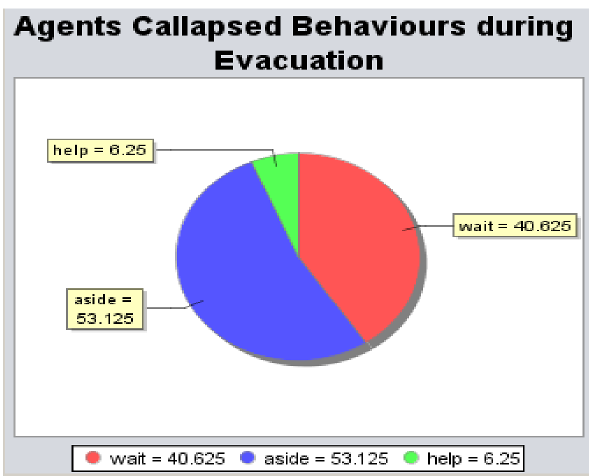
- emp_X(16, 33), emp_Y(8, 35) ,
- student_X(37, 68), student_Y(8, 35),

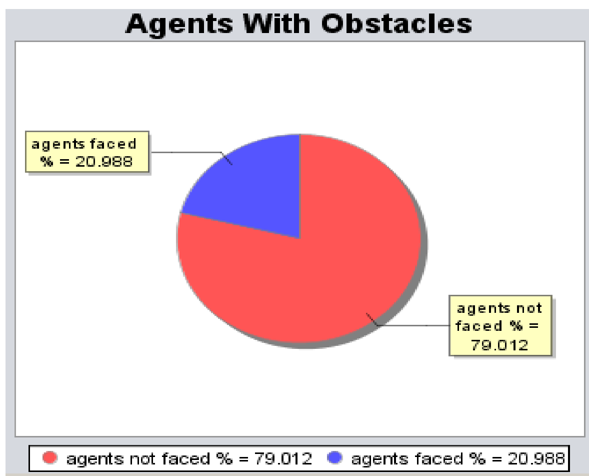
Appendix E

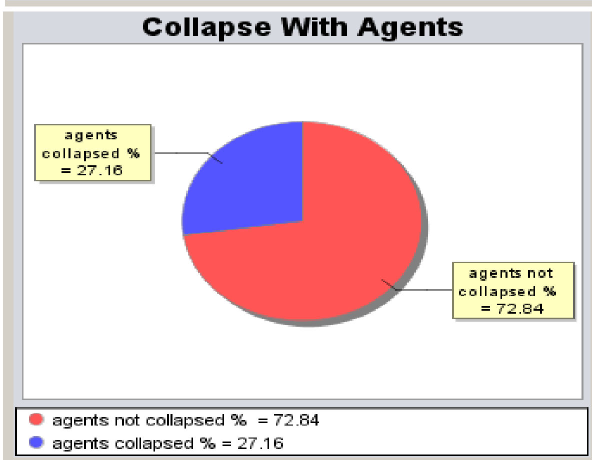
- staff_X(7**5**, 89), staff_Y(8, 35)



The first floor created and participants distributed through the floor







Appendix E

Analyzing emergency behaviors appeared during the evacuation process

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	15 , 49	1st buttom	no obstacle	no collapse	6.1704	28.5	0:8:720
2	15 , 33	2nd buttom	no obstacle	1 time	5.9904	28.5	0:10:576
3	15 , 29	2nd buttom	1	no collapse	6.012	30.0	0:10:189
4	14 , 82	2nd buttom	no obstacle	no collapse	5.8968	30.5	0:11:76
5	14 , 40	2nd buttom	no obstacle	no collapse	6.1632	30.0	0:8:999
6	12 , 64	2nd buttom	1	no collapse	6.2784	31.5	0:8:367
7	12 , 50	2nd buttom	no obstacle	3 times	6.3072	33.5	0:11:800
8	12 , 47	1st buttom	2	1 time	5.9832	34.5	0:13:681
9	12 , 21	1st buttom	no obstacle	no collapse	5.9112	36.0	0:13:95
10	11 , 60	1st buttom	1	no collapse	5.9976	31.0	0:10:480
11	11 , 51	2nd buttom	no obstacle	1 time	6.048	33.0	0:12:47
12	11 , 50	2nd buttom	1	1 time	6.2784	32.0	0:9:463
13	11 , 42	1st buttom	no obstacle	1 time	6.1272	32.0	0:10:553
14	10 , 55	2nd buttom	1	no collapse	6.1272	34.5	0:10:358
15	10 , 42	1st buttom	no obstacle	2 times	5.9688	31.5	0:13:728
16	10 , 39	2nd buttom	1	1 time	5.9904	35.5	0:13:604
17	10 , 18	1st buttom	no obstacle	no collapse	6.1776	37.5	0:11:31
18	10 , 17	1st buttom	no obstacle	1 time	6.2928	38.5	0:11:449
19	16 , 68	2nd buttom	no obstacle	no collapse	5.9328	28.0	0:9:829
20	16 , 55	2nd buttom	1	2 times	5.7528	31.0	0:15:14
21	16 , 49	1st buttom	no obstacle	no collapse	5.7024	28.0	0:12:189
22	16 , 32	1st buttom	no obstacle	3 times	5.8968	39.5	0:17:927
23	15 , 60	1st buttom	1	no collapse	5.7312	30.0	0:12:652
24	15 , 56	1st buttom	1	no collapse	5.7168	29.5	0:12:368
25	15 , 55	1st buttom	1	2 times	5.9112	29.5	0:13:754
26	17 , 40	1st buttom	1	no collapse	5.6232	30.0	0:13:981
27	17 , 75	1st buttom	no obstacle	no collapse	5.0112	27.0	0:16:221
28	17 , 65	1st buttom	1	no collapse	5.3496	28.0	0:14:239
29	17 , 60	2nd buttom	1	no collapse	5.2128	28.0	0:15:338
30	17 , 50	1st buttom	1	1 time	5.1696	28.0	0:18:159
31	18 , 61	2nd buttom	1	no collapse	4.6728	28.0	0:19:407
32	19 , 26	1st buttom	no obstacle	1 time	4.5288	35.0	0:26:633
33	19 , 41	1st buttom	no obstacle	no collapse	4.6224	28.5	0:21:632
34	20 , 52	2nd buttom	no obstacle	1 time	4.14	29.0	0:26:19
35	21 , 54	2nd buttom	no obstacle	1 time	3.5424	26.5	0:28:242
36	22 , 52	2nd buttom	no obstacle	no collapse	3.132	26.5	0:29:911
37	22 , 20	2nd buttom	no obstacle	no collapse	3.0096	24.5	0:27:626
38	21 , 83	1st buttom	no obstacle	no collapse	3.0384	25.5	0:27:214

Results of evacuation simulation and specifying evacuation time for each s participant

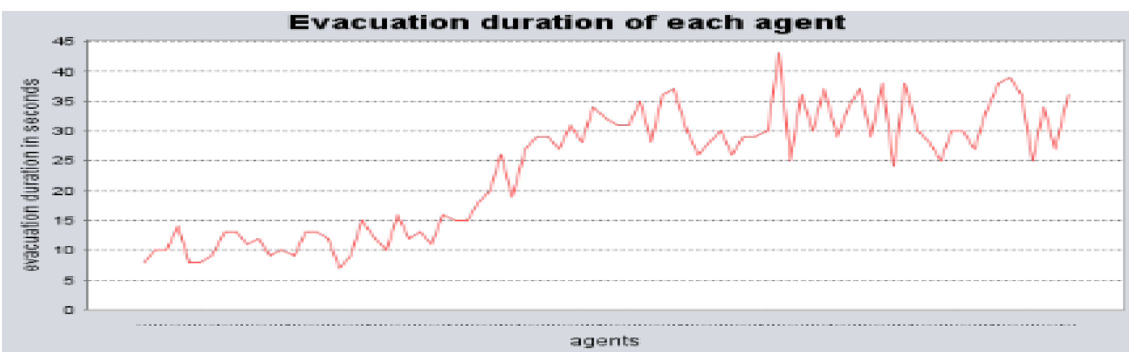
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	21 , 68	2nd buttom	no obstacle	1 time	3.1968	24.5	0:28:349
40	22 , 62	1st buttom	no obstacle	no collapse	2.9592	25.5	0:29:417
41	24 , 66	1st buttom	no obstacle	no collapse	2.8584	23.5	0:28:134
42	24 , 50	1st buttom	no obstacle	no collapse	2.8584	26.0	0:31:308
43	24 , 44	1st buttom	no obstacle	no collapse	2.9808	28.0	0:33:311
44	24 , 39	1st buttom	no obstacle	1 time	2.988	32.5	0:39:325
45	22 , 68	1st buttom	no obstacle	no collapse	3.0096	24.0	0:28:184
46	28 , 40	1st buttom	no obstacle	no collapse	2.88	31.5	0:36:492
47	27 , 85	1st buttom	no obstacle	no collapse	2.952	22.5	0:25:15
48	27 , 76	2nd buttom	no obstacle	no collapse	2.88	24.5	0:30:124
49	27 , 68	1st buttom	no obstacle	no collapse	2.8584	23.0	0:26:895
50	27 , 55	1st buttom	no obstacle	no collapse	2.8584	24.5	0:28:484
51	27 , 48	2nd buttom	no obstacle	1 time	2.7432	27.5	0:36:948
52	26 , 18	2nd buttom	no obstacle	no collapse	2.9016	22.0	0:26:861
53	25 , 83	2nd buttom	no obstacle	no collapse	2.9304	26.0	0:29:749
54	25 , 81	1st buttom	no obstacle	no collapse	2.9232	24.0	0:26:599
55	25 , 79	2nd buttom	no obstacle	no collapse	2.8008	25.0	0:30:372
56	25 , 32	1st buttom	1	3 times	3.0096	34.0	0:43:271
57	28 , 68	1st buttom	no obstacle	no collapse	2.8224	21.5	0:25:742
58	28 , 54	1st buttom	no obstacle	no collapse	2.6568	23.5	0:30:230
59	28 , 51	2nd buttom	no obstacle	no collapse	2.7792	25.5	0:30:258
60	30 , 39	1st buttom	no obstacle	no collapse	2.8008	31.5	0:37:460
61	30 , 33	2nd buttom	no obstacle	no collapse	2.7864	20.5	0:29:522
62	29 , 55	2nd buttom	no obstacle	no collapse	2.6496	26.5	0:33:525
63	29 , 17	1st buttom	no obstacle	1 time	2.7216	29.0	0:37:503
64	28 , 80	2nd buttom	no obstacle	no collapse	2.7	24.5	0:29:589
65	32 , 41	1st buttom	no obstacle	no collapse	2.772	32.0	0:38:551
66	32 , 21	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:24:698
67	31 , 43	1st buttom	no obstacle	no collapse	2.6208	31.0	0:38:316
68	30 , 75	2nd buttom	no obstacle	2 times	2.7432	23.5	0:30:425
69	30 , 63	2nd buttom	no obstacle	no collapse	2.628	20.5	0:25:517
70	30 , 61	2nd buttom	no obstacle	no collapse	2.7072	21.0	0:25:786
71	32 , 42	2nd buttom	no obstacle	no collapse	2.5128	29.5	0:37:872
72	34 , 47	2nd buttom	no obstacle	no collapse	2.34	28.0	0:36:539
73	33 , 51	2nd buttom	no obstacle	no collapse	2.4912	25.0	0:32:185
74	33 , 50	2nd buttom	no obstacle	no collapse	2.5416	27.5	0:35:547
75	32 , 60	2nd buttom	no obstacle	no collapse	2.4912	21.5	0:27:371
76	32 , 50	2nd buttom	no obstacle	no collapse	2.4696	26.5	0:33:584

Appendix E

Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	24 , 39	1st buttom	no obstacle	1 time	2.988	32.5	0:39:325
45	22 , 68	1st buttom	no obstacle	no collapse	3.0096	24.0	0:28:184
46	28 , 40	1st buttom	no obstacle	no collapse	2.88	31.5	0:36:492
47	27 , 85	1st buttom	no obstacle	no collapse	2.952	22.5	0:25:15
48	27 , 76	2nd buttom	no obstacle	no collapse	2.88	24.5	0:30:124
49	27 , 68	1st buttom	no obstacle	no collapse	2.8584	23.0	0:26:895
50	27 , 55	1st buttom	no obstacle	no collapse	2.8584	24.5	0:28:484
51	27 , 48	2nd buttom	no obstacle	1 time	2.7432	27.5	0:36:948
52	26 , 18	2nd buttom	no obstacle	no collapse	2.9016	22.0	0:26:861
53	25 , 83	2nd buttom	no obstacle	no collapse	2.9304	26.0	0:29:749
54	25 , 81	1st buttom	no obstacle	no collapse	2.9232	24.0	0:26:599
55	25 , 79	2nd buttom	no obstacle	no collapse	2.8008	25.0	0:30:372
56	25 , 32	1st buttom	1	3 times	3.0096	34.0	0:43:271
57	28 , 68	1st buttom	no obstacle	no collapse	2.8224	21.5	0:25:742
58	28 , 54	1st buttom	no obstacle	no collapse	2.6568	23.5	0:30:230
59	28 , 51	2nd buttom	no obstacle	no collapse	2.7792	25.5	0:30:258
60	30 , 39	1st buttom	no obstacle	no collapse	2.8008	31.5	0:37:460
61	30 , 33	2nd buttom	no obstacle	no collapse	2.7864	20.5	0:29:522
62	29 , 55	2nd buttom	no obstacle	no collapse	2.6496	26.5	0:33:525
63	29 , 17	1st buttom	no obstacle	1 time	2.7216	29.0	0:37:503
64	28 , 80	2nd buttom	no obstacle	no collapse	2.7	24.5	0:29:589
65	32 , 41	1st buttom	no obstacle	no collapse	2.772	32.0	0:38:551
66	32 , 21	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:24:698
67	31 , 43	1st buttom	no obstacle	no collapse	2.6208	31.0	0:38:316
68	30 , 75	2nd buttom	no obstacle	2 times	2.7432	23.5	0:30:425
69	30 , 63	2nd buttom	no obstacle	no collapse	2.628	20.5	0:25:517
70	30 , 61	2nd buttom	no obstacle	no collapse	2.7072	21.0	0:25:786
71	32 , 42	2nd buttom	no obstacle	no collapse	2.5128	29.5	0:37:872
72	34 , 47	2nd buttom	no obstacle	no collapse	2.34	28.0	0:36:539
73	33 , 51	2nd buttom	no obstacle	no collapse	2.4912	25.0	0:32:185
74	33 , 50	2nd buttom	no obstacle	no collapse	2.5416	27.5	0:35:547
75	32 , 60	2nd buttom	no obstacle	no collapse	2.4912	21.5	0:27:371
76	32 , 50	2nd buttom	no obstacle	no collapse	2.4696	26.5	0:33:584
77	34 , 53	1st buttom	no obstacle	no collapse	2.412	24.0	0:32:39
78	34 , 66	2nd buttom	no obstacle	no collapse	2.2608	19.0	0:25:681
79	34 , 54	1st buttom	no obstacle	no collapse	2.2176	25.0	0:34:413
80	34 , 67	2nd buttom	no obstacle	no collapse	2.0016	19.5	0:27:121
81	35 , 33	1st buttom	no obstacle	no collapse	2.0016	26.0	0:46:711

Results of evacuation simulation and specifying evacuation time for each s participant

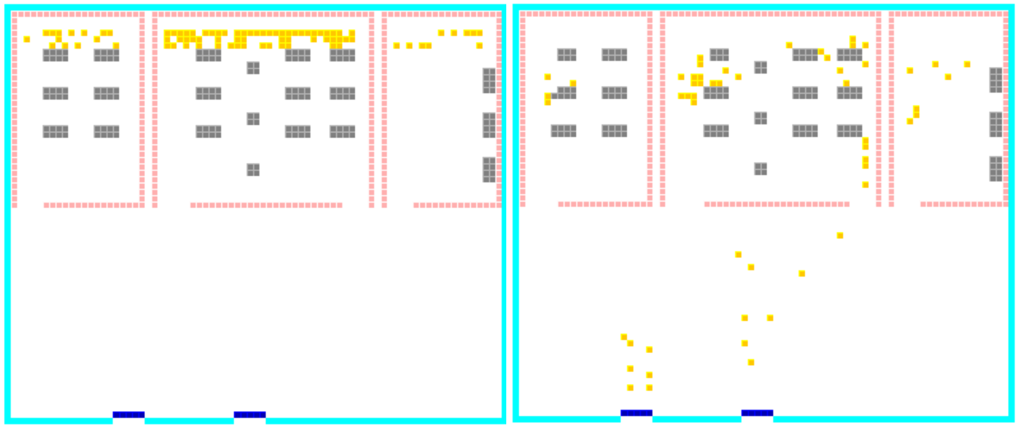


Evacuation time of 81 participants in the line graph for scenario #NoC

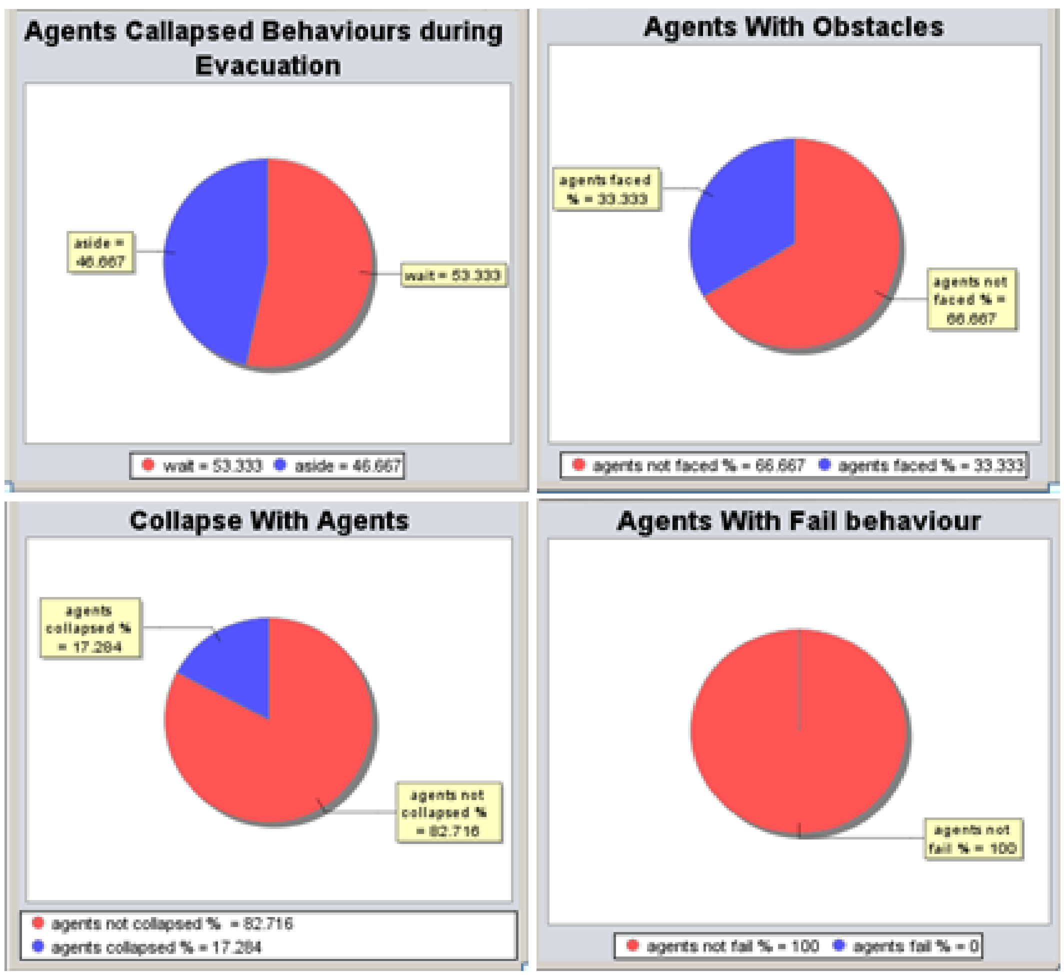
Scenario #No1D:

Evacuees distributed in an average small area in the cafeteria, two main exits, two exit doors for students part, and each of the employee part, and staff part has one exit door, evacuees were familiar with the exits.

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	10 , 49	2nd buttom	no obstacle	2 times	6.1704	31.0	0:11:214
2	10 , 48	2nd buttom	no obstacle	no collapse	5.9904	31.5	0:11:574
3	10 , 47	2nd buttom	no obstacle	no collapse	6.012	30.0	0:10:975
4	10 , 46	2nd buttom	no obstacle	no collapse	5.8968	29.5	0:11:772
5	10 , 45	2nd buttom	no obstacle	no collapse	6.1632	30.5	0:9:895
6	10 , 44	2nd buttom	no obstacle	no collapse	6.2784	30.0	0:8:631
7	10 , 43	2nd buttom	no obstacle	no collapse	6.3072	30.5	0:8:901
8	10 , 42	1st buttom	no obstacle	no collapse	5.9832	31.0	0:11:242
9	10 , 41	1st buttom	no obstacle	no collapse	5.9112	31.0	0:11:930
10	10 , 40	1st buttom	no obstacle	no collapse	5.9976	30.5	0:10:955
11	10 , 39	1st buttom	no obstacle	no collapse	6.048	30.5	0:10:406
12	10 , 30	1st buttom	no obstacle	no collapse	6.2784	30.5	0:8:998
13	10 , 29	1st buttom	no obstacle	no collapse	6.1272	31.0	0:10:316
14	10 , 27	1st buttom	no obstacle	no collapse	6.1272	32.5	0:10:728
15	10 , 26	1st buttom	no obstacle	4 times	5.9688	32.5	0:14:788
16	10 , 25	1st buttom	no obstacle	no collapse	5.9904	32.0	0:11:533
17	10 , 22	1st buttom	no obstacle	no collapse	6.1776	31.0	0:9:832
18	10 , 17	1st buttom	no obstacle	no collapse	6.2928	30.0	0:8:513
18	10 , 17	1st buttom	no obstacle	no collapse	6.2928	30.0	0:8:737
19	10 , 58	2nd buttom	1	no collapse	5.9328	31.0	0:12:53
20	10 , 57	2nd buttom	1	no collapse	5.7528	32.5	0:13:746
21	10 , 56	2nd buttom	1	1 time	5.7024	32.0	0:15:236
22	10 , 55	2nd buttom	1	no collapse	5.8968	33.0	0:12:999
23	10 , 54	2nd buttom	no obstacle	no collapse	5.7312	30.5	0:13:525
24	10 , 52	2nd buttom	no obstacle	1 time	5.7168	33.5	0:15:112
25	10 , 51	2nd buttom	no obstacle	no collapse	5.9112	32.0	0:12:459
26	10 , 59	2nd buttom	1	no collapse	5.6232	34.5	0:15:848
27	10 , 63	2nd buttom	1	no collapse	5.0112	33.0	0:20:658
28	10 , 62	2nd buttom	1	1 time	5.3496	33.0	0:19:467
29	10 , 61	2nd buttom	1	2 times	5.2128	33.5	0:21:412
30	10 , 60	2nd buttom	1	1 time	5.1696	33.5	0:21:119
31	10 , 64	2nd buttom	1	1 time	4.6728	32.0	0:24:332
32	10 , 65	2nd buttom	1	no collapse	4.5288	32.5	0:24:173
33	10 , 66	2nd buttom	1	no collapse	4.6224	31.5	0:22:981
34	10 , 67	2nd buttom	1	no collapse	4.14	31.5	0:27:202
35	10 , 68	2nd buttom	no obstacle	no collapse	3.5424	30.5	0:31:631
36	10 , 82	2nd buttom	no obstacle	no collapse	3.132	33.0	0:36:419
37	10 , 80	2nd buttom	no obstacle	no collapse	3.0096	32.0	0:36:546

Results of evacuation simulation and specifying evacuation time for each s participant

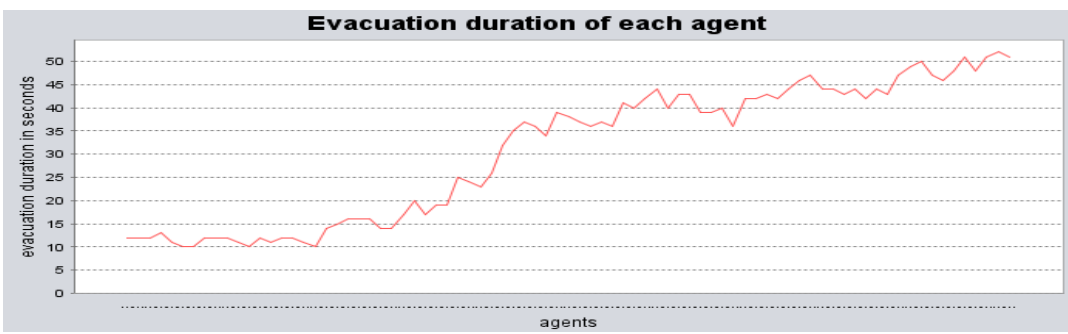
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	10 , 75	2nd buttom	no obstacle	no collapse	3.1968	30.5	0:34:186
40	10 , 86	2nd buttom	no obstacle	no collapse	2.9592	31.5	0:36:370
41	11 , 29	1st buttom	no obstacle	no collapse	2.8584	29.0	0:37:427
42	11 , 26	1st buttom	1	no collapse	2.8584	32.5	0:40:473
43	11 , 23	1st buttom	no obstacle	no collapse	2.9808	29.0	0:35:531
44	11 , 20	1st buttom	no obstacle	no collapse	2.988	29.5	0:35:48
45	10 , 88	2nd buttom	no obstacle	no collapse	3.0096	32.0	0:36:573
46	11 , 62	2nd buttom	1	no collapse	2.88	33.0	0:40:404
47	11 , 61	2nd buttom	1	3 times	2.952	33.0	0:43:933
48	11 , 58	2nd buttom	1	no collapse	2.88	31.5	0:39:642
49	11 , 56	2nd buttom	1	no collapse	2.8584	33.5	0:41:136
50	11 , 51	2nd buttom	no obstacle	no collapse	2.8584	29.0	0:36:522
51	11 , 49	2nd buttom	no obstacle	no collapse	2.7432	31.5	0:40:435
52	11 , 48	2nd buttom	no obstacle	1 time	2.9016	31.0	0:38:645
53	11 , 47	2nd buttom	no obstacle	1 time	2.9304	30.5	0:38:376
54	11 , 42	2nd buttom	no obstacle	no collapse	2.9232	29.5	0:36:413
55	11 , 41	1st buttom	no obstacle	no collapse	2.8008	30.0	0:36:455
56	11 , 39	1st buttom	no obstacle	no collapse	3.0096	30.0	0:35:67
57	11 , 66	2nd buttom	1	no collapse	2.8224	31.0	0:39:140
58	11 , 65	2nd buttom	1	no collapse	2.6568	32.0	0:41:108
59	11 , 64	2nd buttom	1	1 time	2.7792	32.0	0:42:24
60	12 , 33	1st buttom	no obstacle	no collapse	2.8008	31.0	0:41:3
61	12 , 22	1st buttom	no obstacle	no collapse	2.7864	30.5	0:39:329
62	12 , 19	1st buttom	1	1 time	2.6496	31.0	0:42:483
63	11 , 83	2nd buttom	no obstacle	no collapse	2.7216	31.0	0:38:861
64	11 , 67	2nd buttom	1	1 time	2.7	31.5	0:41:689
65	12 , 48	2nd buttom	no obstacle	1 time	2.772	32.5	0:43:914
66	12 , 46	2nd buttom	no obstacle	2 times	2.8008	31.0	0:42:424
67	12 , 45	2nd buttom	no obstacle	no collapse	2.6208	30.0	0:41:44
68	12 , 41	1st buttom	no obstacle	no collapse	2.7432	29.5	0:37:872
69	12 , 40	1st buttom	no obstacle	no collapse	2.628	29.5	0:38:780
70	12 , 39	1st buttom	no obstacle	no collapse	2.7072	30.0	0:38:620
71	12 , 49	2nd buttom	1	no collapse	2.5128	31.5	0:43:570
72	12 , 64	2nd buttom	1	1 time	2.34	31.5	0:46:799
73	12 , 63	2nd buttom	1	2 times	2.4912	32.5	0:47:130
74	12 , 56	2nd buttom	2	no collapse	2.5416	33.5	0:45:656
75	12 , 54	2nd buttom	no obstacle	no collapse	2.4912	31.0	0:43:435
76	12 , 51	2nd buttom	no obstacle	no collapse	2.4696	30.5	0:43:27

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	11 , 20	1st buttom	no obstacle	no collapse	2.988	29.5	0:35:48
45	10 , 88	2nd buttom	no obstacle	no collapse	3.0096	32.0	0:36:573
46	11 , 62	2nd buttom	1	no collapse	2.88	33.0	0:40:404
47	11 , 61	2nd buttom	1	3 times	2.952	33.0	0:43:933
48	11 , 58	2nd buttom	1	no collapse	2.88	31.5	0:39:642
49	11 , 56	2nd buttom	1	no collapse	2.8584	33.5	0:41:136
50	11 , 51	2nd buttom	no obstacle	no collapse	2.8584	29.0	0:36:522
51	11 , 49	2nd buttom	no obstacle	no collapse	2.7432	31.5	0:40:435
52	11 , 48	2nd buttom	no obstacle	1 time	2.9016	31.0	0:38:645
53	11 , 47	2nd buttom	no obstacle	1 time	2.9304	30.5	0:38:376
54	11 , 42	2nd buttom	no obstacle	no collapse	2.9232	29.5	0:36:413
55	11 , 41	1st buttom	no obstacle	no collapse	2.8008	30.0	0:36:455
56	11 , 39	1st buttom	no obstacle	no collapse	3.0096	30.0	0:35:67
57	11 , 66	2nd buttom	1	no collapse	2.8224	31.0	0:39:140
58	11 , 65	2nd buttom	1	no collapse	2.6568	32.0	0:41:108
59	11 , 64	2nd buttom	1	1 time	2.7792	32.0	0:42:24
60	12 , 33	1st buttom	no obstacle	no collapse	2.8008	31.0	0:41:3
61	12 , 22	1st buttom	no obstacle	no collapse	2.7864	30.5	0:39:329
62	12 , 19	1st buttom	1	1 time	2.6496	31.0	0:42:483
63	11 , 83	2nd buttom	no obstacle	no collapse	2.7216	31.0	0:38:861
64	11 , 67	2nd buttom	1	1 time	2.7	31.5	0:41:689
65	12 , 48	2nd buttom	no obstacle	1 time	2.772	32.5	0:43:914
66	12 , 46	2nd buttom	no obstacle	2 times	2.8008	31.0	0:42:424
67	12 , 45	2nd buttom	no obstacle	no collapse	2.6208	30.0	0:41:44
68	12 , 41	1st buttom	no obstacle	no collapse	2.7432	29.5	0:37:872
69	12 , 40	1st buttom	no obstacle	no collapse	2.628	29.5	0:38:780
70	12 , 39	1st buttom	no obstacle	no collapse	2.7072	30.0	0:38:620
71	12 , 49	2nd buttom	1	no collapse	2.5128	31.5	0:43:570
72	12 , 64	2nd buttom	1	1 time	2.34	31.5	0:46:799
73	12 , 63	2nd buttom	1	2 times	2.4912	32.5	0:47:130
74	12 , 56	2nd buttom	2	no collapse	2.5416	33.5	0:45:656
75	12 , 54	2nd buttom	no obstacle	no collapse	2.4912	31.0	0:43:435
76	12 , 51	2nd buttom	no obstacle	no collapse	2.4696	30.5	0:43:27
77	12 , 65	2nd buttom	1	1 time	2.412	32.0	0:46:341
78	12 , 78	2nd buttom	no obstacle	no collapse	2.2608	29.5	0:42:292
79	12 , 68	2nd buttom	no obstacle	no collapse	2.2176	30.0	0:44:740
80	12 , 79	2nd buttom	no obstacle	no collapse	2.0016	30.5	0:46:43
81	12 , 84	2nd buttom	no obstacle	no collapse	2.0016	30.0	0:45:350

Results of evacuation simulation and specifying evacuation time for each s participant



Evacuation time of 81 participants in the line graph for scenario #No1D

Scenario #No2A:

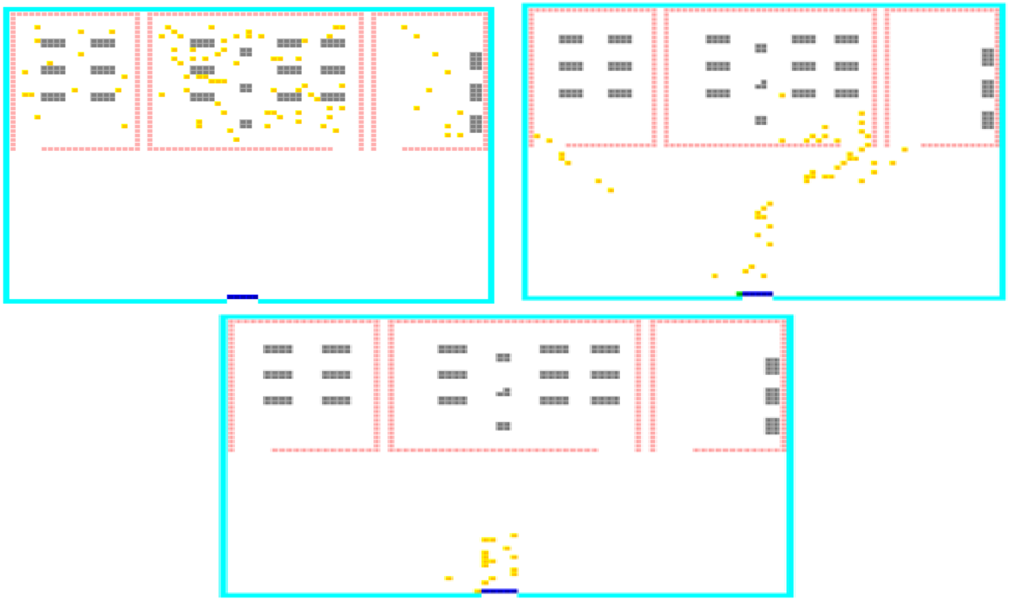
Only one main exit door was used, evacuees distributed in a larger area of the floor

Participant distributions:

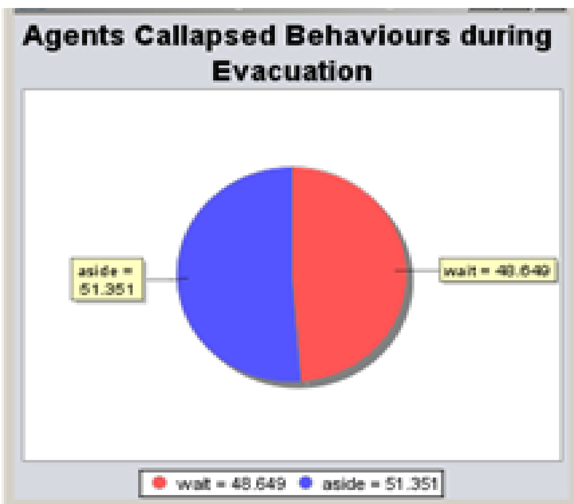
- emp_X(16, 33), emp_Y(8, 20) ,
- student_X(37, 68), student_Y(8, 20),

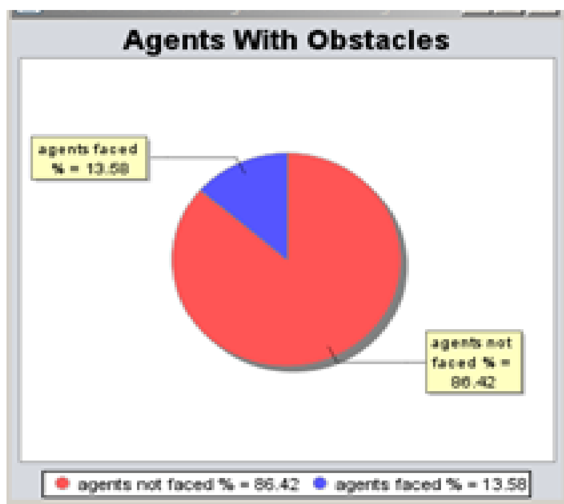
Appendix E

- staff_X(7**5**, 89), staff_Y(8, 20)



The first floor created and participants distributed through the floor





Appendix E

Analyzing emergency behaviors appeared during the evacuation process

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	15 , 25	2nd buttom	no obstacle	1 time	6.1704	28.0	0:9:824
2	14 , 77	2nd buttom	1	no collapse	5.9904	29.0	0:9:788
3	13 , 62	2nd buttom	1	no collapse	6.012	32.0	0:11:24
4	12 , 65	2nd buttom	no obstacle	no collapse	5.8968	30.0	0:11:148
5	12 , 53	2nd buttom	no obstacle	no collapse	6.1632	30.0	0:8:905
6	12 , 46	2nd buttom	no obstacle	no collapse	6.2784	29.5	0:8:12
7	12 , 41	2nd buttom	no obstacle	no collapse	6.3072	29.0	0:7:593
8	10 , 75	2nd buttom	no obstacle	no collapse	5.9832	30.5	0:10:429
9	10 , 67	2nd buttom	1	no collapse	5.9112	32.0	0:11:468
10	10 , 56	2nd buttom	1	1 time	5.9976	32.5	0:12:489
11	10 , 47	2nd buttom	no obstacle	no collapse	6.048	30.5	0:10:144
12	10 , 46	2nd buttom	no obstacle	1 time	6.2784	34.0	0:10:456
13	10 , 45	2nd buttom	no obstacle	no collapse	6.1272	31.5	0:9:456
14	10 , 44	2nd buttom	no obstacle	no collapse	6.1272	31.0	0:9:359
15	10 , 43	2nd buttom	no obstacle	no collapse	5.9688	30.5	0:10:493
16	10 , 40	2nd buttom	no obstacle	no collapse	5.9904	30.0	0:10:556
17	10 , 31	2nd buttom	no obstacle	2 times	6.1776	30.5	0:11:391
18	10 , 19	2nd buttom	1	no collapse	6.2928	30.5	0:8:244
19	17 , 48	2nd buttom	1	2 times	5.9328	30.5	0:13:301
20	17 , 28	2nd buttom	no obstacle	no collapse	5.7528	28.0	0:11:297
21	16 , 75	2nd buttom	no obstacle	no collapse	5.7024	27.5	0:11:442
22	16 , 56	2nd buttom	no obstacle	2 times	5.8968	30.5	0:12:227
23	16 , 46	2nd buttom	1	1 time	5.7312	31.5	0:14:83
24	16 , 44	2nd buttom	no obstacle	no collapse	5.7168	29.5	0:12:630
25	16 , 24	2nd buttom	no obstacle	2 times	5.9112	28.5	0:12:306
26	17 , 53	2nd buttom	1	1 time	5.6232	30.0	0:13:893
27	18 , 55	2nd buttom	1	no collapse	5.0112	30.5	0:18:812
28	18 , 52	2nd buttom	no obstacle	no collapse	5.3496	27.0	0:14:174
29	18 , 27	2nd buttom	no obstacle	2 times	5.2128	28.5	0:17:90
30	18 , 23	2nd buttom	no obstacle	4 times	5.1696	29.0	0:19:766
31	18 , 61	2nd buttom	no obstacle	no collapse	4.6728	26.5	0:18:716
32	18 , 67	2nd buttom	1	no collapse	4.5288	27.5	0:20:246
33	18 , 80	2nd buttom	no obstacle	no collapse	4.6224	28.0	0:19:152
34	19 , 50	2nd buttom	no obstacle	1 time	4.14	28.0	0:24:378
35	19 , 55	2nd buttom	no obstacle	no collapse	3.5424	28.0	0:28:597
36	21 , 55	2nd buttom	no obstacle	1 time	3.132	25.5	0:30:340
37	21 , 32	2nd buttom	no obstacle	1 time	3.0096	25.0	0:30:418
38	20 , 17	2nd buttom	no obstacle	1 time	3.0384	25.5	0:31:201

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

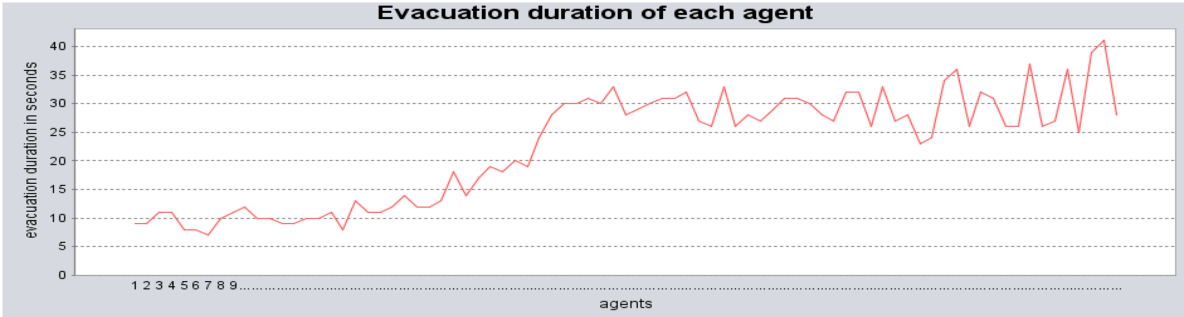
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	19 , 57	2nd buttom	no obstacle	no collapse	3.1968	27.0	0:30:197
40	22 , 53	2nd buttom	1	no collapse	2.9592	28.5	0:33:675
41	23 , 55	2nd buttom	no obstacle	no collapse	2.8584	24.0	0:28:537
42	23 , 47	2nd buttom	no obstacle	no collapse	2.8584	24.5	0:29:771
43	23 , 39	2nd buttom	no obstacle	1 time	2.9808	24.5	0:30:863
44	22 , 62	2nd buttom	no obstacle	no collapse	2.988	27.0	0:31:704
45	22 , 60	2nd buttom	no obstacle	1 time	3.0096	25.0	0:31:34
46	27 , 31	2nd buttom	no obstacle	2 times	2.88	23.0	0:32:814
47	27 , 19	2nd buttom	no obstacle	1 time	2.952	21.5	0:27:332
48	26 , 80	2nd buttom	no obstacle	no collapse	2.88	23.5	0:26:570
49	26 , 49	2nd buttom	no obstacle	no collapse	2.8584	28.5	0:33:359
50	26 , 48	2nd buttom	1	no collapse	2.8584	22.5	0:26:778
51	26 , 41	2nd buttom	no obstacle	no collapse	2.7432	22.5	0:28:666
52	26 , 40	2nd buttom	no obstacle	no collapse	2.9016	22.0	0:27:27
53	25 , 43	2nd buttom	no obstacle	no collapse	2.9304	25.5	0:29:798
54	24 , 41	2nd buttom	no obstacle	1 time	2.9232	24.5	0:31:60
55	23 , 64	2nd buttom	no obstacle	1 time	2.8008	25.0	0:31:765
56	23 , 56	2nd buttom	no obstacle	no collapse	3.0096	26.0	0:30:434
57	28 , 20	2nd buttom	no obstacle	1 time	2.8224	22.0	0:28:233
58	27 , 42	2nd buttom	no obstacle	no collapse	2.6568	21.5	0:27:926
59	27 , 33	2nd buttom	no obstacle	1 time	2.7792	24.0	0:32:938
60	29 , 60	2nd buttom	no obstacle	no collapse	2.8008	21.5	0:32:865
61	28 , 77	2nd buttom	no obstacle	no collapse	2.7864	21.5	0:26:29
62	28 , 48	2nd buttom	no obstacle	no collapse	2.6496	27.0	0:33:784
63	28 , 44	2nd buttom	no obstacle	no collapse	2.7216	22.0	0:27:97
64	28 , 40	2nd buttom	no obstacle	no collapse	2.7	22.0	0:28:483
65	32 , 43	2nd buttom	no obstacle	no collapse	2.772	19.5	0:23:780
66	31 , 67	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:24:877
67	31 , 59	2nd buttom	no obstacle	no collapse	2.6208	20.5	0:34:779
68	31 , 45	2nd buttom	no obstacle	no collapse	2.7432	29.5	0:36:183
69	30 , 85	2nd buttom	no obstacle	1 time	2.628	21.5	0:26:901
70	30 , 55	2nd buttom	no obstacle	no collapse	2.7072	23.0	0:32:626
71	32 , 55	2nd buttom	no obstacle	no collapse	2.5128	24.5	0:31:389
72	33 , 67	2nd buttom	no obstacle	no collapse	2.34	19.5	0:26:90
73	33 , 61	2nd buttom	no obstacle	no collapse	2.4912	20.5	0:26:409
74	33 , 43	2nd buttom	no obstacle	no collapse	2.5416	29.5	0:37:866
75	32 , 82	2nd buttom	no obstacle	no collapse	2.4912	20.5	0:26:494
76	32 , 76	2nd buttom	no obstacle	2 times	2.4696	20.5	0:27:995

Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	22 , 62	2nd buttom	no obstacle	no collapse	2.988	27.0	0:31:704
45	22 , 60	2nd buttom	no obstacle	1 time	3.0096	25.0	0:31:34
46	27 , 31	2nd buttom	no obstacle	2 times	2.88	23.0	0:32:814
47	27 , 19	2nd buttom	no obstacle	1 time	2.952	21.5	0:27:332
48	26 , 80	2nd buttom	no obstacle	no collapse	2.88	23.5	0:26:570
49	26 , 49	2nd buttom	no obstacle	no collapse	2.8584	28.5	0:33:359
50	26 , 48	2nd buttom	1	no collapse	2.8584	22.5	0:26:778
51	26 , 41	2nd buttom	no obstacle	no collapse	2.7432	22.5	0:28:666
52	26 , 40	2nd buttom	no obstacle	no collapse	2.9016	22.0	0:27:27
53	25 , 43	2nd buttom	no obstacle	no collapse	2.9304	25.5	0:29:798
54	24 , 41	2nd buttom	no obstacle	1 time	2.9232	24.5	0:31:60
55	23 , 64	2nd buttom	no obstacle	1 time	2.8008	25.0	0:31:765
56	23 , 56	2nd buttom	no obstacle	no collapse	3.0096	26.0	0:30:434
57	28 , 20	2nd buttom	no obstacle	1 time	2.8224	22.0	0:28:233
58	27 , 42	2nd buttom	no obstacle	no collapse	2.6568	21.5	0:27:926
59	27 , 33	2nd buttom	no obstacle	1 time	2.7792	24.0	0:32:938
60	29 , 60	2nd buttom	no obstacle	no collapse	2.8008	21.5	0:32:865
61	28 , 77	2nd buttom	no obstacle	no collapse	2.7864	21.5	0:26:29
62	28 , 48	2nd buttom	no obstacle	no collapse	2.6496	27.0	0:33:784
63	28 , 44	2nd buttom	no obstacle	no collapse	2.7216	22.0	0:27:97
64	28 , 40	2nd buttom	no obstacle	no collapse	2.7	22.0	0:28:483
65	32 , 43	2nd buttom	no obstacle	no collapse	2.772	19.5	0:23:780
66	31 , 67	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:24:877
67	31 , 59	2nd buttom	no obstacle	no collapse	2.6208	20.5	0:34:779
68	31 , 45	2nd buttom	no obstacle	no collapse	2.7432	29.5	0:36:183
69	30 , 85	2nd buttom	no obstacle	1 time	2.628	21.5	0:26:901
70	30 , 55	2nd buttom	no obstacle	no collapse	2.7072	23.0	0:32:626
71	32 , 55	2nd buttom	no obstacle	no collapse	2.5128	24.5	0:31:389
72	33 , 67	2nd buttom	no obstacle	no collapse	2.34	19.5	0:26:90
73	33 , 61	2nd buttom	no obstacle	no collapse	2.4912	20.5	0:26:409
74	33 , 43	2nd buttom	no obstacle	no collapse	2.5416	29.5	0:37:866
75	32 , 82	2nd buttom	no obstacle	no collapse	2.4912	20.5	0:26:494
76	32 , 76	2nd buttom	no obstacle	2 times	2.4696	20.5	0:27:995
77	34 , 31	2nd buttom	no obstacle	2 times	2.412	20.0	0:36:320
78	34 , 78	2nd buttom	no obstacle	no collapse	2.2608	19.0	0:25:54
79	34 , 43	2nd buttom	no obstacle	no collapse	2.2176	29.0	0:39:857
80	35 , 63	2nd buttom	no obstacle	no collapse	2.0016	18.0	0:41:635
81	35 , 65	2nd buttom	no obstacle	no collapse	2.0016	20.0	0:28:577

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E



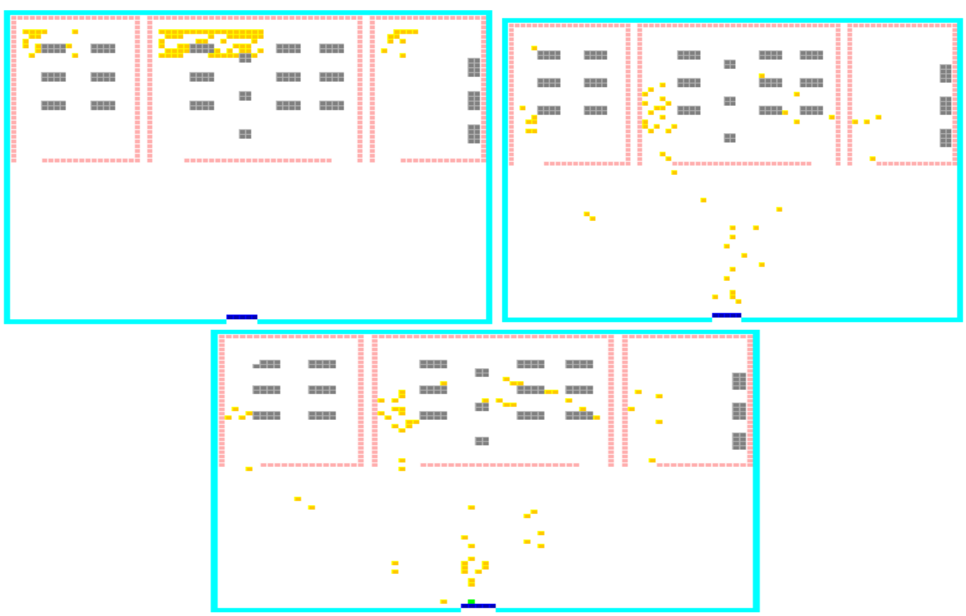
Evacuation time of 81 participants in the line graph for scenario #No2A

Scenario #No2B:

Same as #No2A, but all agents distributed through a very small portion of the floor

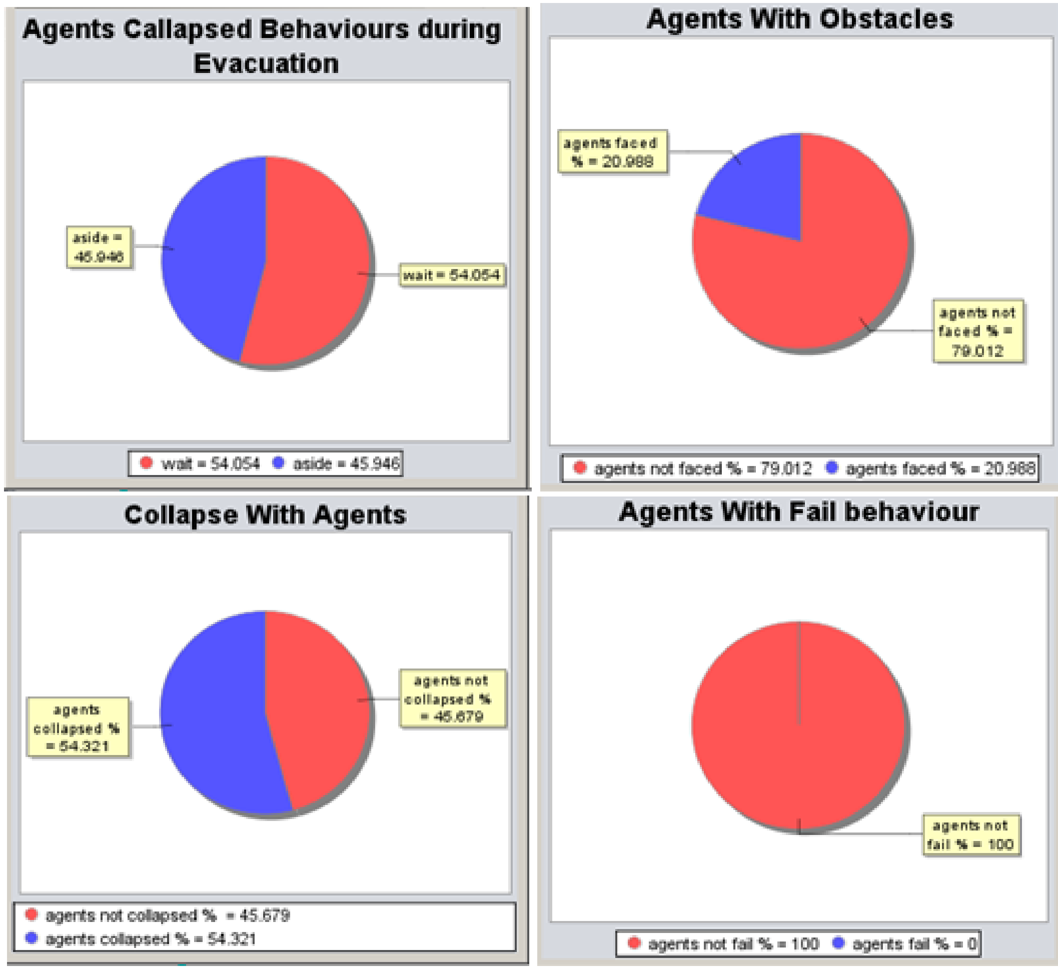
Participant distributions:

- emp_X(16, 25), emp_Y(8, 15) ,
- student_X(37, 55), student_Y(8, 15),
- staff_X(74, 80), staff_Y(8, 15)



The first floor created and participants distributed through the floor

Appendix E



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	10 , 51	2nd buttom	no obstacle	1 time	6.1704	33.5	0:13:814
2	10 , 50	2nd buttom	no obstacle	1 time	5.9904	33.5	0:15:112
3	10 , 49	2nd buttom	no obstacle	1 time	6.012	33.0	0:14:246
4	10 , 48	2nd buttom	no obstacle	no collapse	5.8968	30.5	0:14:205
5	10 , 47	2nd buttom	no obstacle	2 times	6.1632	34.0	0:13:876
6	10 , 46	2nd buttom	no obstacle	no collapse	6.2784	32.5	0:10:997
7	10 , 45	2nd buttom	no obstacle	1 time	6.3072	32.0	0:11:377
8	10 , 44	2nd buttom	no obstacle	no collapse	5.9832	30.5	0:13:620
9	10 , 43	2nd buttom	no obstacle	1 time	5.9112	31.5	0:15:84
10	10 , 42	2nd buttom	no obstacle	no collapse	5.9976	30.0	0:14:10
11	10 , 41	2nd buttom	no obstacle	no collapse	6.048	30.0	0:13:322
12	10 , 40	2nd buttom	no obstacle	no collapse	6.2784	30.0	0:10:658
13	10 , 24	2nd buttom	no obstacle	2 times	6.1272	34.0	0:15:260
14	10 , 23	2nd buttom	no obstacle	no collapse	6.1272	30.0	0:11:270
15	10 , 22	2nd buttom	no obstacle	3 times	5.9688	31.5	0:16:630
16	10 , 20	2nd buttom	no obstacle	4 times	5.9904	32.0	0:15:991
17	10 , 18	2nd buttom	no obstacle	3 times	6.1776	29.5	0:11:991
18	10 , 17	2nd buttom	no obstacle	3 times	6.2928	32.0	0:13:407
19	10 , 78	2nd buttom	no obstacle	no collapse	5.9328	31.5	0:14:312
20	10 , 77	2nd buttom	1	no collapse	5.7528	31.5	0:15:513
21	10 , 75	2nd buttom	no obstacle	no collapse	5.7024	31.0	0:15:966
22	10 , 55	2nd buttom	1	1 time	5.8968	31.5	0:15:42
23	10 , 54	2nd buttom	no obstacle	1 time	5.7312	33.5	0:17:96
24	10 , 53	2nd buttom	no obstacle	no collapse	5.7168	32.5	0:16:736
25	10 , 52	2nd buttom	1	1 time	5.9112	34.0	0:16:503
26	10 , 79	2nd buttom	no obstacle	no collapse	5.6232	30.5	0:15:632
27	11 , 25	2nd buttom	no obstacle	1 time	5.0112	31.5	0:21:935
28	11 , 23	2nd buttom	no obstacle	2 times	5.3496	31.0	0:20:706
29	11 , 22	2nd buttom	no obstacle	no collapse	5.2128	29.0	0:18:996
30	11 , 18	2nd buttom	no obstacle	no collapse	5.1696	30.0	0:19:723
31	11 , 39	2nd buttom	no obstacle	no collapse	4.6728	29.5	0:23:445
32	11 , 40	2nd buttom	no obstacle	no collapse	4.5288	31.0	0:24:872
33	11 , 44	2nd buttom	no obstacle	no collapse	4.6224	31.0	0:23:901
34	11 , 45	2nd buttom	no obstacle	3 times	4.14	33.5	0:34:621
35	11 , 46	2nd buttom	3	3 times	3.5424	38.0	0:44:691
36	11 , 50	2nd buttom	no obstacle	1 time	3.132	32.0	0:38:502
37	11 , 49	2nd buttom	no obstacle	1 time	3.0096	33.0	0:40:951
38	11 , 48	2nd buttom	1	3 times	3.0384	35.0	0:44:34

Results of evacuation simulation and specifying evacuation time for each s participant

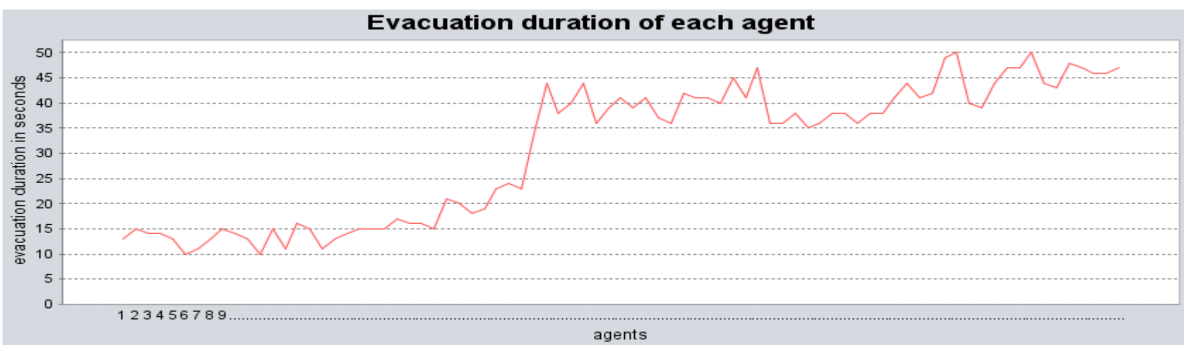
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	11 , 47	2nd buttom	no obstacle	1 time	3.1968	30.5	0:36:835
40	11 , 52	2nd buttom	no obstacle	1 time	2.9592	31.0	0:39:359
41	12 , 25	2nd buttom	no obstacle	1 time	2.8584	31.0	0:41:614
42	12 , 22	2nd buttom	no obstacle	2 times	2.8584	30.0	0:39:57
43	12 , 21	2nd buttom	no obstacle	3 times	2.9808	31.0	0:41:437
44	11 , 76	2nd buttom	no obstacle	no collapse	2.988	31.0	0:37:567
45	11 , 53	2nd buttom	no obstacle	no collapse	3.0096	30.0	0:36:281
46	12 , 55	2nd buttom	1	no collapse	2.88	34.0	0:42:935
47	12 , 52	2nd buttom	1	3 times	2.952	32.0	0:41:813
48	12 , 51	2nd buttom	1	1 time	2.88	33.0	0:41:978
49	12 , 50	2nd buttom	no obstacle	1 time	2.8584	31.0	0:40:959
50	12 , 49	2nd buttom	1	2 times	2.8584	33.5	0:45:522
51	12 , 46	2nd buttom	no obstacle	1 time	2.7432	30.5	0:41:97
52	12 , 45	2nd buttom	1	2 times	2.9016	36.0	0:47:314
53	12 , 43	2nd buttom	no obstacle	no collapse	2.9304	29.5	0:36:198
54	12 , 42	2nd buttom	no obstacle	no collapse	2.9232	29.0	0:36:609
55	12 , 41	2nd buttom	no obstacle	no collapse	2.8008	30.5	0:38:627
56	12 , 39	2nd buttom	no obstacle	no collapse	3.0096	29.0	0:35:547
57	13 , 43	2nd buttom	no obstacle	no collapse	2.8224	29.0	0:36:752
58	13 , 42	2nd buttom	no obstacle	no collapse	2.6568	28.5	0:38:165
59	13 , 39	2nd buttom	no obstacle	no collapse	2.7792	29.0	0:38:397
60	14 , 40	2nd buttom	no obstacle	no collapse	2.8008	28.0	0:36:743
61	13 , 77	2nd buttom	1	no collapse	2.7864	30.5	0:38:900
62	13 , 75	2nd buttom	no obstacle	no collapse	2.6496	29.5	0:38:348
63	13 , 55	2nd buttom	no obstacle	1 time	2.7216	31.0	0:41:893
64	13 , 54	2nd buttom	1	2 times	2.7	33.5	0:44:173
65	14 , 78	2nd buttom	no obstacle	1 time	2.772	30.5	0:41:81
66	14 , 52	2nd buttom	no obstacle	no collapse	2.8008	31.0	0:42:474
67	14 , 51	2nd buttom	1	2 times	2.6208	34.0	0:49:184
68	14 , 49	2nd buttom	2	3 times	2.7432	36.0	0:50:682
69	14 , 42	2nd buttom	no obstacle	1 time	2.628	28.5	0:40:758
70	14 , 41	2nd buttom	no obstacle	no collapse	2.7072	29.0	0:39:914
71	15 , 22	2nd buttom	no obstacle	2 times	2.5128	28.5	0:44:565
72	15 , 48	2nd buttom	no obstacle	1 time	2.34	29.5	0:47:329
73	15 , 47	2nd buttom	no obstacle	1 time	2.4912	31.5	0:47:500
74	15 , 45	2nd buttom	2	1 time	2.5416	34.0	0:50:593
75	15 , 40	2nd buttom	no obstacle	no collapse	2.4912	29.5	0:44:610
76	15 , 39	2nd buttom	no obstacle	1 time	2.4696	28.5	0:43:683

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	11 , 76	2nd buttom	no obstacle	no collapse	2.988	31.0	0:37:567
45	11 , 53	2nd buttom	no obstacle	no collapse	3.0096	30.0	0:36:281
46	12 , 55	2nd buttom	1	no collapse	2.88	34.0	0:42:935
47	12 , 52	2nd buttom	1	3 times	2.952	32.0	0:41:813
48	12 , 51	2nd buttom	1	1 time	2.88	33.0	0:41:978
49	12 , 50	2nd buttom	no obstacle	1 time	2.8584	31.0	0:40:959
50	12 , 49	2nd buttom	1	2 times	2.8584	33.5	0:45:522
51	12 , 46	2nd buttom	no obstacle	1 time	2.7432	30.5	0:41:97
52	12 , 45	2nd buttom	1	2 times	2.9016	36.0	0:47:314
53	12 , 43	2nd buttom	no obstacle	no collapse	2.9304	29.5	0:36:198
54	12 , 42	2nd buttom	no obstacle	no collapse	2.9232	29.0	0:36:609
55	12 , 41	2nd buttom	no obstacle	no collapse	2.8008	30.5	0:38:627
56	12 , 39	2nd buttom	no obstacle	no collapse	3.0096	29.0	0:35:547
57	13 , 43	2nd buttom	no obstacle	no collapse	2.8224	29.0	0:36:752
58	13 , 42	2nd buttom	no obstacle	no collapse	2.6568	28.5	0:38:165
59	13 , 39	2nd buttom	no obstacle	no collapse	2.7792	29.0	0:38:397
60	14 , 40	2nd buttom	no obstacle	no collapse	2.8008	28.0	0:36:743
61	13 , 77	2nd buttom	1	no collapse	2.7864	30.5	0:38:900
62	13 , 75	2nd buttom	no obstacle	no collapse	2.6496	29.5	0:38:348
63	13 , 55	2nd buttom	no obstacle	1 time	2.7216	31.0	0:41:893
64	13 , 54	2nd buttom	1	2 times	2.7	33.5	0:44:173
65	14 , 78	2nd buttom	no obstacle	1 time	2.772	30.5	0:41:81
66	14 , 52	2nd buttom	no obstacle	no collapse	2.8008	31.0	0:42:474
67	14 , 51	2nd buttom	1	2 times	2.6208	34.0	0:49:184
68	14 , 49	2nd buttom	2	3 times	2.7432	36.0	0:50:682
69	14 , 42	2nd buttom	no obstacle	1 time	2.628	28.5	0:40:758
70	14 , 41	2nd buttom	no obstacle	no collapse	2.7072	29.0	0:39:914
71	15 , 22	2nd buttom	no obstacle	2 times	2.5128	28.5	0:44:565
72	15 , 48	2nd buttom	no obstacle	1 time	2.34	29.5	0:47:329
73	15 , 47	2nd buttom	no obstacle	1 time	2.4912	31.5	0:47:500
74	15 , 45	2nd buttom	2	1 time	2.5416	34.0	0:50:593
75	15 , 40	2nd buttom	no obstacle	no collapse	2.4912	29.5	0:44:610
76	15 , 39	2nd buttom	no obstacle	1 time	2.4696	28.5	0:43:683
77	15 , 49	2nd buttom	1	1 time	2.412	31.0	0:48:661
78	15 , 54	2nd buttom	1	no collapse	2.2608	30.0	0:47:887
79	15 , 50	2nd buttom	no obstacle	no collapse	2.2176	29.5	0:46:365
80	15 , 77	2nd buttom	1	no collapse	2.0016	29.0	0:46:725
81	15 , 80	2nd buttom	no obstacle	no collapse	2.0016	29.0	0:47:116

Results of evacuation simulation and specifying evacuation time for each s participant

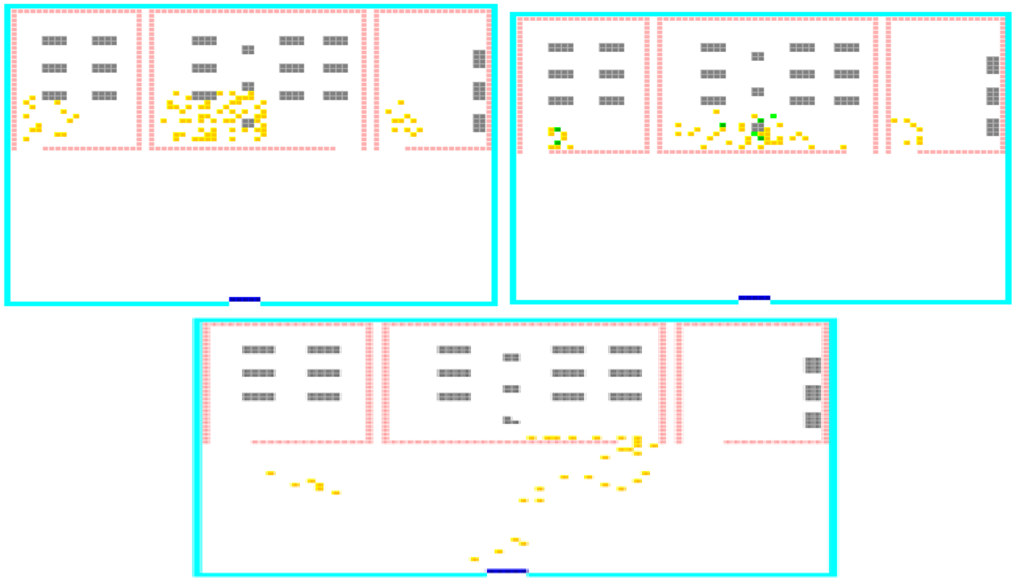


Evacuation time of 81 participants in the line graph for scenario #No2B

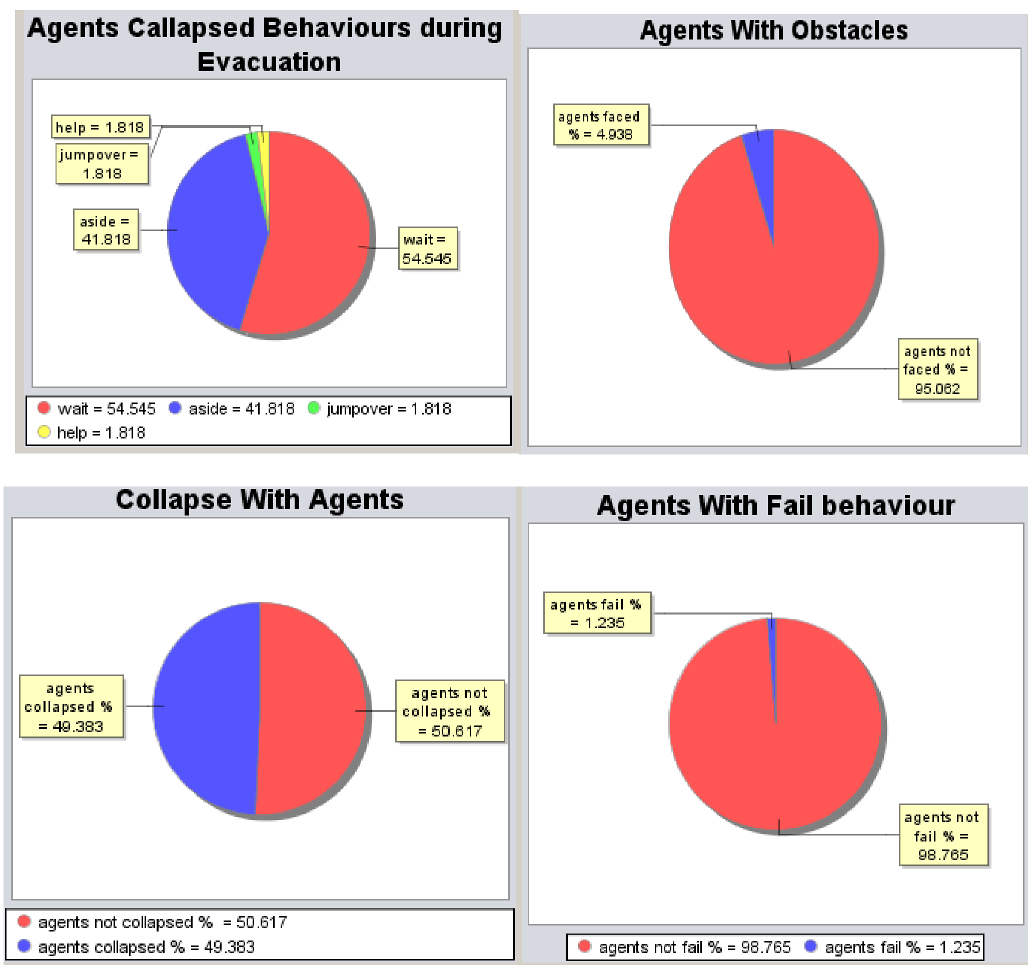
Scenario #No2C:

Same as #No2A but agents positions were near the exit door

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	31 , 44	2nd buttom	no obstacle	no collapse	6.1704	20.5	0:6:595
2	31 , 39	2nd buttom	no obstacle	no collapse	5.9904	19.5	0:7:307
3	31 , 24	2nd buttom	no obstacle	2 times	6.012	22.0	0:9:445
4	31 , 21	2nd buttom	no obstacle	1 time	5.8968	21.0	0:9:703
5	31 , 20	2nd buttom	no obstacle	2 times	6.1632	22.5	0:8:427
6	31 , 17	2nd buttom	no obstacle	2 times	6.2784	21.0	0:9:67
7	30 , 77	2nd buttom	1	no collapse	6.3072	21.0	0:6:44
8	30 , 76	2nd buttom	no obstacle	no collapse	5.9832	20.5	0:7:176
9	30 , 55	2nd buttom	no obstacle	no collapse	5.9112	24.5	0:9:17
10	30 , 54	2nd buttom	no obstacle	no collapse	5.9976	24.0	0:8:144
11	30 , 53	2nd buttom	no obstacle	1 time	6.048	23.5	0:8:463
12	30 , 52	2nd buttom	no obstacle	1 time	6.2784	23.5	0:7:152
13	30 , 51	2nd buttom	no obstacle	1 time	6.1272	24.5	0:8:793
14	30 , 46	2nd buttom	no obstacle	no collapse	6.1272	21.0	0:6:825
15	30 , 43	2nd buttom	no obstacle	1 time	5.9688	30.5	0:11:650
16	30 , 41	2nd buttom	no obstacle	no collapse	5.9904	20.5	0:7:573
17	30 , 40	2nd buttom	no obstacle	no collapse	6.1776	20.5	0:6:782
18	30 , 21	2nd buttom	no obstacle	no collapse	6.2928	20.5	0:5:705
19	31 , 55	2nd buttom	1	1 time	5.9328	23.0	0:10:736
20	31 , 51	2nd buttom	no obstacle	3 times	5.7528	24.0	0:12:572
21	31 , 50	2nd buttom	no obstacle	2 times	5.7024	22.5	0:11:817
22	31 , 48	2nd buttom	no obstacle	1 time	5.8968	21.5	0:8:707
23	31 , 47	2nd buttom	no obstacle	1 time	5.7312	23.5	0:10:111
24	31 , 46	2nd buttom	1	2 times	5.7168	30.0	0:14:801
25	31 , 45	2nd buttom	no obstacle	1 time	5.9112	20.5	0:8:294
26	32 , 21	2nd buttom	no obstacle	2 times	5.6232	21.0	0:11:710
27	32 , 46	2nd buttom	no obstacle	1 time	5.0112	29.5	0:18:293
28	32 , 43	2nd buttom	no obstacle	no collapse	5.3496	31.0	0:16:22
29	32 , 40	2nd buttom	no obstacle	no collapse	5.2128	19.5	0:11:427
30	32 , 39	2nd buttom	no obstacle	2 times	5.1696	21.0	0:14:546
31	32 , 47	2nd buttom	no obstacle	no collapse	4.6728	28.0	0:19:352
32	32 , 50	2nd buttom	1	1 time	4.5288	26.5	0:19:864
33	32 , 54	2nd buttom	1	no collapse	4.6224	20.5	0:18:437
34	32 , 76	2nd buttom	no obstacle	no collapse	4.14	19.5	0:15:977
35	32 , 80	2nd buttom	no obstacle	no collapse	3.5424	20.0	0:18:740
36	33 , 41	2nd buttom	no obstacle	1 time	3.132	19.5	0:23:253
37	33 , 40	2nd buttom	no obstacle	1 time	3.0096	20.0	0:24:626
38	33 , 19	2nd buttom	no obstacle	no collapse	3.0384	18.5	0:21:23

Results of evacuation simulation and specifying evacuation time for each s participant

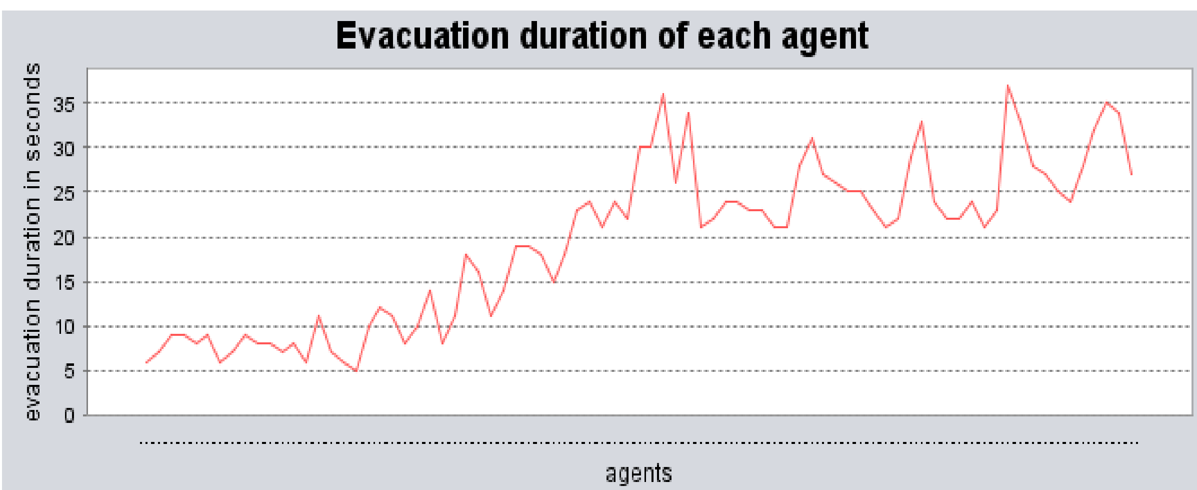
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	33 , 17	2nd buttom	no obstacle	2 times	3.1968	20.0	0:24:791
40	33 , 42	2nd buttom	no obstacle	no collapse	2.9592	19.0	0:22:64
41	33 , 51	2nd buttom	1	1 time	2.8584	25.5	0:30:785
42	33 , 50	2nd buttom	no obstacle	no collapse	2.8584	26.5	0:30:235
43	33 , 49	2nd buttom	1	1 time	2.9808	30.5	0:36:946
44	33 , 47	2nd buttom	no obstacle	2 times	2.988	20.5	0:26:188
45	33 , 43	2nd buttom	no obstacle	1 time	3.0096	30.0	0:34:549
46	34 , 42	2nd buttom	no obstacle	no collapse	2.88	18.5	0:21:862
47	34 , 41	2nd buttom	no obstacle	no collapse	2.952	18.5	0:22:309
48	34 , 39	2nd buttom	no obstacle	1 time	2.88	19.5	0:24:910
49	34 , 24	2nd buttom	no obstacle	no collapse	2.8584	20.5	0:24:952
50	34 , 20	2nd buttom	no obstacle	no collapse	2.8584	20.0	0:23:887
51	34 , 18	2nd buttom	no obstacle	no collapse	2.7432	19.5	0:23:990
52	33 , 79	2nd buttom	no obstacle	no collapse	2.9016	20.0	0:21:630
53	33 , 76	2nd buttom	no obstacle	no collapse	2.9304	19.5	0:21:519
54	33 , 55	2nd buttom	no obstacle	no collapse	2.9232	20.0	0:28:435
55	33 , 54	2nd buttom	no obstacle	1 time	2.8008	26.0	0:31:949
56	33 , 52	2nd buttom	no obstacle	no collapse	3.0096	25.0	0:27:926
57	34 , 50	2nd buttom	no obstacle	1 time	2.8224	20.5	0:26:667
58	34 , 47	2nd buttom	no obstacle	1 time	2.6568	20.0	0:25:933
59	34 , 43	2nd buttom	no obstacle	1 time	2.7792	20.5	0:25:358
60	34 , 80	2nd buttom	no obstacle	no collapse	2.8008	20.0	0:23:244
61	34 , 79	2nd buttom	no obstacle	no collapse	2.7864	19.0	0:21:386
62	34 , 76	2nd buttom	no obstacle	no collapse	2.6496	19.0	0:22:438
63	34 , 55	2nd buttom	no obstacle	1 time	2.7216	24.5	0:29:616
64	34 , 51	2nd buttom	no obstacle	1 time	2.7	27.5	0:33:908
65	35 , 41	2nd buttom	no obstacle	1 time	2.772	18.5	0:24:549
66	35 , 40	2nd buttom	no obstacle	no collapse	2.8008	17.5	0:22:87
67	35 , 39	2nd buttom	no obstacle	no collapse	2.6208	17.5	0:22:51
68	35 , 22	2nd buttom	no obstacle	no collapse	2.7432	19.0	0:24:986
69	35 , 20	2nd buttom	no obstacle	no collapse	2.628	17.0	0:21:578
70	35 , 19	2nd buttom	no obstacle	1 time	2.7072	17.5	0:23:688
71	35 , 43	2nd buttom	no obstacle	no collapse	2.5128	29.5	0:37:491
72	35 , 50	2nd buttom	no obstacle	no collapse	2.34	26.0	0:33:912
73	35 , 49	2nd buttom	no obstacle	no collapse	2.4912	18.5	0:28:407
74	35 , 48	2nd buttom	no obstacle	no collapse	2.5416	18.0	0:27:339
75	35 , 46	2nd buttom	no obstacle	1 time	2.4912	19.0	0:25:598
76	35 , 44	2nd buttom	no obstacle	1 time	2.4696	18.5	0:24:119

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	33 , 47	2nd buttom	no obstacle	2 times	2.988	20.5	0:26:188
45	33 , 43	2nd buttom	no obstacle	1 time	3.0096	30.0	0:34:549
46	34 , 42	2nd buttom	no obstacle	no collapse	2.88	18.5	0:21:862
47	34 , 41	2nd buttom	no obstacle	no collapse	2.952	18.5	0:22:309
48	34 , 39	2nd buttom	no obstacle	1 time	2.88	19.5	0:24:910
49	34 , 24	2nd buttom	no obstacle	no collapse	2.8584	20.5	0:24:952
50	34 , 20	2nd buttom	no obstacle	no collapse	2.8584	20.0	0:23:887
51	34 , 18	2nd buttom	no obstacle	no collapse	2.7432	19.5	0:23:990
52	33 , 79	2nd buttom	no obstacle	no collapse	2.9016	20.0	0:21:630
53	33 , 76	2nd buttom	no obstacle	no collapse	2.9304	19.5	0:21:519
54	33 , 55	2nd buttom	no obstacle	no collapse	2.9232	20.0	0:28:435
55	33 , 54	2nd buttom	no obstacle	1 time	2.8008	26.0	0:31:949
56	33 , 52	2nd buttom	no obstacle	no collapse	3.0096	25.0	0:27:926
57	34 , 50	2nd buttom	no obstacle	1 time	2.8224	20.5	0:26:667
58	34 , 47	2nd buttom	no obstacle	1 time	2.6568	20.0	0:25:933
59	34 , 43	2nd buttom	no obstacle	1 time	2.7792	20.5	0:25:358
60	34 , 80	2nd buttom	no obstacle	no collapse	2.8008	20.0	0:23:244
61	34 , 79	2nd buttom	no obstacle	no collapse	2.7864	19.0	0:21:386
62	34 , 76	2nd buttom	no obstacle	no collapse	2.6496	19.0	0:22:438
63	34 , 55	2nd buttom	no obstacle	1 time	2.7216	24.5	0:29:616
64	34 , 51	2nd buttom	no obstacle	1 time	2.7	27.5	0:33:908
65	35 , 41	2nd buttom	no obstacle	1 time	2.772	18.5	0:24:549
66	35 , 40	2nd buttom	no obstacle	no collapse	2.8008	17.5	0:22:87
67	35 , 39	2nd buttom	no obstacle	no collapse	2.6208	17.5	0:22:51
68	35 , 22	2nd buttom	no obstacle	no collapse	2.7432	19.0	0:24:986
69	35 , 20	2nd buttom	no obstacle	no collapse	2.628	17.0	0:21:578
70	35 , 19	2nd buttom	no obstacle	1 time	2.7072	17.5	0:23:688
71	35 , 43	2nd buttom	no obstacle	no collapse	2.5128	29.5	0:37:491
72	35 , 50	2nd buttom	no obstacle	no collapse	2.34	26.0	0:33:912
73	35 , 49	2nd buttom	no obstacle	no collapse	2.4912	18.5	0:28:407
74	35 , 48	2nd buttom	no obstacle	no collapse	2.5416	18.0	0:27:339
75	35 , 46	2nd buttom	no obstacle	1 time	2.4912	19.0	0:25:598
76	35 , 44	2nd buttom	no obstacle	1 time	2.4696	18.5	0:24:119
77	35 , 51	2nd buttom	no obstacle	1 time	2.412	19.5	0:28:735
78	35 , 54	2nd buttom	no obstacle	no collapse	2.2608	24.5	0:32:399
79	35 , 53	2nd buttom	no obstacle	no collapse	2.2176	27.0	0:35:373
80	35 , 55	2nd buttom	no obstacle	no collapse	2.0016	18.0	0:34:787
81	35 , 79	2nd buttom	no obstacle	1 time	2.0016	20.5	0:27:983

Results of evacuation simulation and specifying evacuation time for each s participant

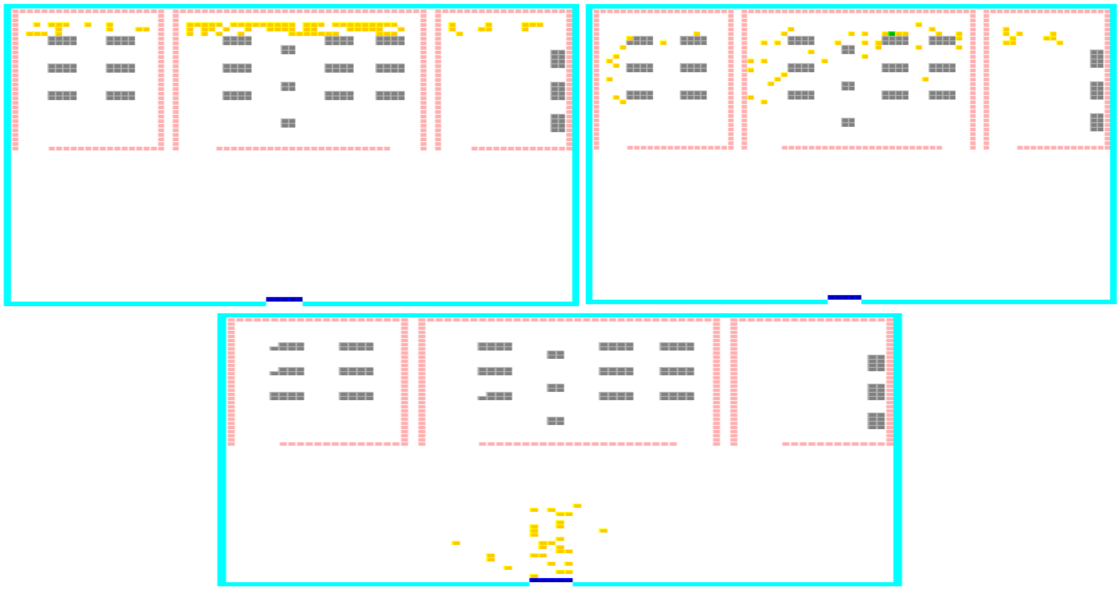


Evacuation time of 81 participants in the line graph for scenario #No2C

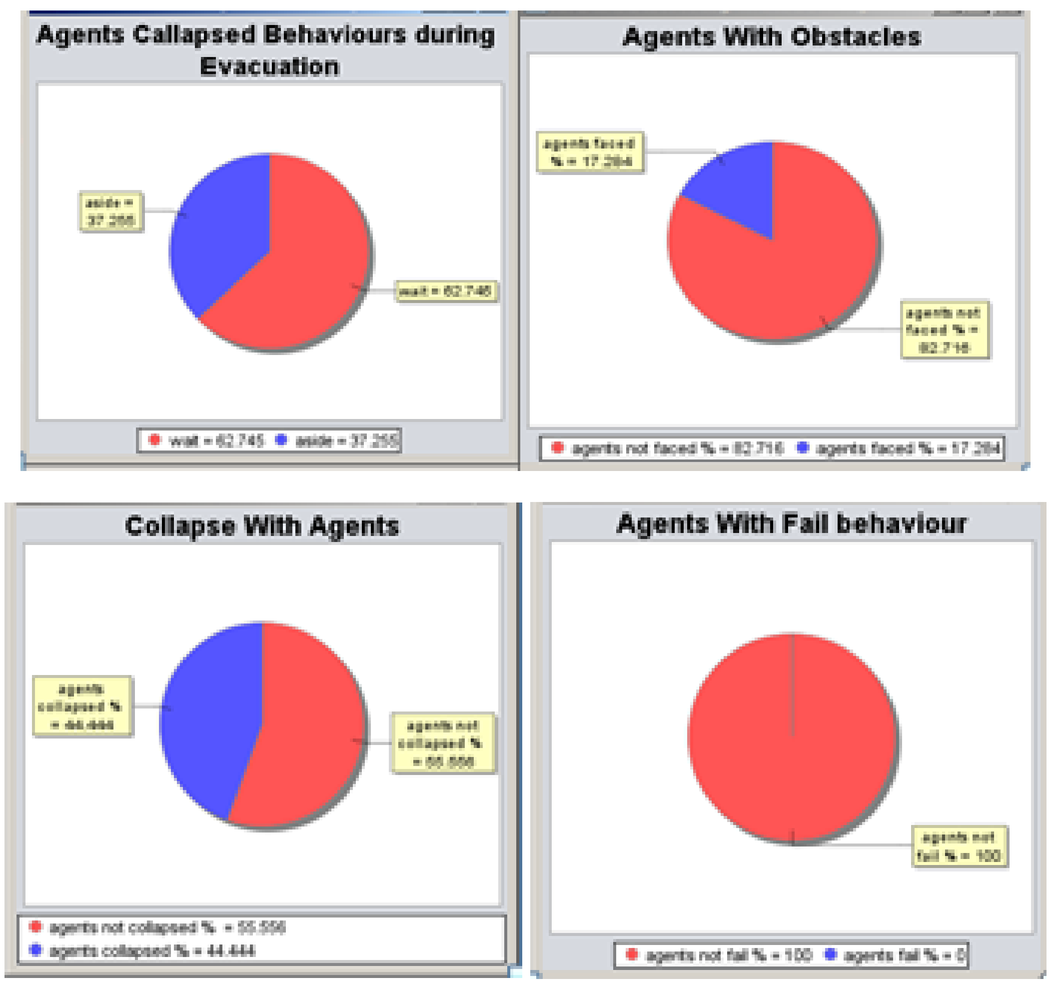
Scenario #No2D:

Only one main exit door was used with two exit doors of student part and employees' part and staff part has only one exit door, evacuees distributed in a small area of the cafeteria

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	10 , 51	2nd buttom	no obstacle	3 times	6.1704	33.5	0:10:209
2	10 , 50	2nd buttom	no obstacle	2 times	5.9904	32.0	0:11:512
3	10 , 49	2nd buttom	no obstacle	1 time	6.012	31.5	0:10:373
4	10 , 48	2nd buttom	no obstacle	no collapse	5.8968	32.0	0:11:206
5	10 , 47	2nd buttom	no obstacle	no collapse	6.1632	30.0	0:8:439
6	10 , 46	2nd buttom	1	no collapse	6.2784	33.5	0:8:543
7	10 , 45	2nd buttom	1	1 time	6.3072	34.5	0:9:409
8	10 , 43	2nd buttom	no obstacle	1 time	5.9832	31.0	0:10:732
9	10 , 42	2nd buttom	1	no collapse	5.9112	30.5	0:10:700
10	10 , 41	2nd buttom	no obstacle	no collapse	5.9976	30.0	0:9:839
11	10 , 40	2nd buttom	no obstacle	no collapse	6.048	30.0	0:9:433
12	10 , 39	2nd buttom	no obstacle	no collapse	6.2784	30.0	0:7:862
13	10 , 28	2nd buttom	1	1 time	6.1272	33.0	0:9:767
14	10 , 25	2nd buttom	no obstacle	1 time	6.1272	32.0	0:9:359
15	10 , 22	2nd buttom	no obstacle	2 times	5.9688	32.5	0:13:348
16	10 , 21	2nd buttom	no obstacle	1 time	5.9904	31.0	0:10:669
17	10 , 20	2nd buttom	no obstacle	2 times	6.1776	30.5	0:10:264
18	10 , 18	2nd buttom	no obstacle	no collapse	6.2928	29.5	0:7:702
19	10 , 60	2nd buttom	no obstacle	1 time	5.9328	34.0	0:13:204
20	10 , 59	2nd buttom	no obstacle	1 time	5.7528	33.5	0:14:677
21	10 , 57	2nd buttom	no obstacle	no collapse	5.7024	32.5	0:13:233
22	10 , 56	2nd buttom	no obstacle	no collapse	5.8968	32.5	0:11:455
23	10 , 55	2nd buttom	no obstacle	no collapse	5.7312	32.5	0:12:810
24	10 , 53	2nd buttom	no obstacle	2 times	5.7168	35.0	0:14:388
25	10 , 52	2nd buttom	no obstacle	1 time	5.9112	33.0	0:11:972
26	10 , 61	2nd buttom	1	1 time	5.6232	33.0	0:15:112
27	10 , 65	2nd buttom	no obstacle	1 time	5.0112	32.5	0:19:863
28	10 , 64	2nd buttom	1	4 times	5.3496	35.5	0:19:950
29	10 , 63	2nd buttom	no obstacle	1 time	5.2128	31.5	0:17:428
30	10 , 62	2nd buttom	1	2 times	5.1696	33.0	0:19:843
31	10 , 66	2nd buttom	no obstacle	no collapse	4.6728	30.0	0:19:977
32	10 , 67	2nd buttom	1	no collapse	4.5288	31.5	0:22:82
33	10 , 75	2nd buttom	no obstacle	no collapse	4.6224	31.0	0:21:29
34	10 , 80	2nd buttom	no obstacle	no collapse	4.14	31.0	0:24:15
35	10 , 85	2nd buttom	no obstacle	no collapse	3.5424	31.0	0:29:131
36	11 , 28	2nd buttom	no obstacle	no collapse	3.132	30.5	0:33:829
37	11 , 21	2nd buttom	no obstacle	no collapse	3.0096	28.5	0:32:820
38	10 , 87	2nd buttom	no obstacle	no collapse	3.0384	31.0	0:32:960

Results of evacuation simulation and specifying evacuation time for each s participant

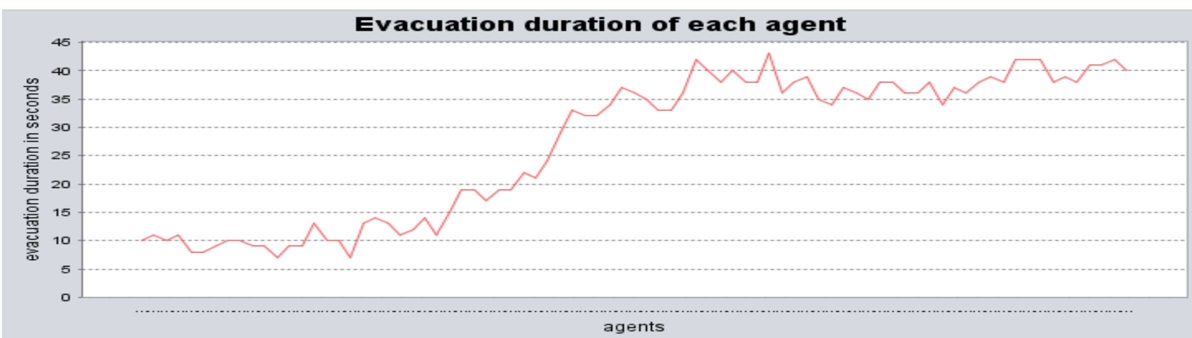
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	10 , 86	2nd buttom	no obstacle	1 time	3.1968	33.5	0:34:855
40	11 , 32	2nd buttom	no obstacle	no collapse	2.9592	32.0	0:37:269
41	11 , 44	2nd buttom	no obstacle	no collapse	2.8584	31.0	0:36:895
42	11 , 42	2nd buttom	no obstacle	no collapse	2.8584	30.0	0:35:395
43	11 , 41	2nd buttom	no obstacle	no collapse	2.9808	29.5	0:33:758
44	11 , 39	2nd buttom	no obstacle	no collapse	2.988	29.5	0:33:646
45	11 , 33	2nd buttom	no obstacle	1 time	3.0096	31.0	0:36:712
46	11 , 64	2nd buttom	no obstacle	1 time	2.88	35.0	0:42:427
47	11 , 63	2nd buttom	1	1 time	2.952	34.5	0:40:932
48	11 , 62	2nd buttom	no obstacle	no collapse	2.88	32.5	0:38:946
49	11 , 61	2nd buttom	no obstacle	3 times	2.8584	32.5	0:40:844
50	11 , 56	2nd buttom	no obstacle	1 time	2.8584	32.0	0:38:350
51	11 , 55	2nd buttom	no obstacle	no collapse	2.7432	32.0	0:38:729
52	11 , 53	2nd buttom	1	1 time	2.9016	36.0	0:43:487
53	11 , 52	2nd buttom	no obstacle	1 time	2.9304	30.5	0:36:323
54	11 , 51	2nd buttom	1	2 times	2.9232	32.0	0:38:573
55	11 , 50	2nd buttom	no obstacle	2 times	2.8008	32.0	0:39:795
56	11 , 47	2nd buttom	no obstacle	no collapse	3.0096	31.0	0:35:346
57	11 , 75	2nd buttom	no obstacle	no collapse	2.8224	30.0	0:34:874
58	11 , 68	2nd buttom	no obstacle	1 time	2.6568	30.5	0:37:579
59	11 , 65	2nd buttom	no obstacle	no collapse	2.7792	31.5	0:36:255
60	12 , 18	2nd buttom	no obstacle	no collapse	2.8008	29.5	0:35:87
61	12 , 17	2nd buttom	no obstacle	1 time	2.7864	29.5	0:38:618
62	11 , 85	2nd buttom	no obstacle	no collapse	2.6496	32.5	0:38:250
63	11 , 80	2nd buttom	no obstacle	no collapse	2.7216	31.5	0:36:247
64	11 , 79	2nd buttom	no obstacle	no collapse	2.7	31.5	0:36:531
65	12 , 46	2nd buttom	no obstacle	1 time	2.772	31.0	0:38:155
66	12 , 43	2nd buttom	no obstacle	no collapse	2.8008	29.5	0:34:567
67	12 , 41	2nd buttom	no obstacle	no collapse	2.6208	30.0	0:37:505
68	12 , 39	2nd buttom	no obstacle	no collapse	2.7432	29.5	0:36:768
69	12 , 21	2nd buttom	no obstacle	1 time	2.628	30.5	0:38:540
70	12 , 19	2nd buttom	1	2 times	2.7072	29.5	0:39:515
71	12 , 53	2nd buttom	no obstacle	no collapse	2.5128	30.0	0:38:554
72	12 , 58	2nd buttom	1	1 time	2.34	32.0	0:42:853
73	12 , 57	2nd buttom	no obstacle	no collapse	2.4912	32.5	0:42:969
74	12 , 56	2nd buttom	no obstacle	1 time	2.5416	32.5	0:42:799
75	12 , 55	2nd buttom	no obstacle	no collapse	2.4912	30.0	0:38:301
76	12 , 54	2nd buttom	no obstacle	no collapse	2.4696	30.0	0:39:252

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	11 , 39	2nd buttom	no obstacle	no collapse	2.988	29.5	0:33:646
45	11 , 33	2nd buttom	no obstacle	1 time	3.0096	31.0	0:36:712
46	11 , 64	2nd buttom	no obstacle	1 time	2.88	35.0	0:42:427
47	11 , 63	2nd buttom	1	1 time	2.952	34.5	0:40:932
48	11 , 62	2nd buttom	no obstacle	no collapse	2.88	32.5	0:38:946
49	11 , 61	2nd buttom	no obstacle	3 times	2.8584	32.5	0:40:844
50	11 , 56	2nd buttom	no obstacle	1 time	2.8584	32.0	0:38:350
51	11 , 55	2nd buttom	no obstacle	no collapse	2.7432	32.0	0:38:729
52	11 , 53	2nd buttom	1	1 time	2.9016	36.0	0:43:487
53	11 , 52	2nd buttom	no obstacle	1 time	2.9304	30.5	0:36:323
54	11 , 51	2nd buttom	1	2 times	2.9232	32.0	0:38:573
55	11 , 50	2nd buttom	no obstacle	2 times	2.8008	32.0	0:39:795
56	11 , 47	2nd buttom	no obstacle	no collapse	3.0096	31.0	0:35:346
57	11 , 75	2nd buttom	no obstacle	no collapse	2.8224	30.0	0:34:874
58	11 , 68	2nd buttom	no obstacle	1 time	2.6568	30.5	0:37:579
59	11 , 65	2nd buttom	no obstacle	no collapse	2.7792	31.5	0:36:255
60	12 , 18	2nd buttom	no obstacle	no collapse	2.8008	29.5	0:35:87
61	12 , 17	2nd buttom	no obstacle	1 time	2.7864	29.5	0:38:618
62	11 , 85	2nd buttom	no obstacle	no collapse	2.6496	32.5	0:38:250
63	11 , 80	2nd buttom	no obstacle	no collapse	2.7216	31.5	0:36:247
64	11 , 79	2nd buttom	no obstacle	no collapse	2.7	31.5	0:36:531
65	12 , 46	2nd buttom	no obstacle	1 time	2.772	31.0	0:38:155
66	12 , 43	2nd buttom	no obstacle	no collapse	2.8008	29.5	0:34:567
67	12 , 41	2nd buttom	no obstacle	no collapse	2.6208	30.0	0:37:505
68	12 , 39	2nd buttom	no obstacle	no collapse	2.7432	29.5	0:36:768
69	12 , 21	2nd buttom	no obstacle	1 time	2.628	30.5	0:38:540
70	12 , 19	2nd buttom	1	2 times	2.7072	29.5	0:39:515
71	12 , 53	2nd buttom	no obstacle	no collapse	2.5128	30.0	0:38:554
72	12 , 58	2nd buttom	1	1 time	2.34	32.0	0:42:853
73	12 , 57	2nd buttom	no obstacle	no collapse	2.4912	32.5	0:42:969
74	12 , 56	2nd buttom	no obstacle	1 time	2.5416	32.5	0:42:799
75	12 , 55	2nd buttom	no obstacle	no collapse	2.4912	30.0	0:38:301
76	12 , 54	2nd buttom	no obstacle	no collapse	2.4696	30.0	0:39:252
77	12 , 59	2nd buttom	no obstacle	no collapse	2.412	29.5	0:38:874
78	12 , 66	2nd buttom	no obstacle	no collapse	2.2608	30.5	0:41:289
79	12 , 65	2nd buttom	no obstacle	no collapse	2.2176	29.0	0:41:110
80	12 , 67	2nd buttom	1	no collapse	2.0016	30.5	0:42:493
81	12 , 76	2nd buttom	no obstacle	no collapse	2.0016	29.5	0:40:796

Results of evacuation simulation and specifying evacuation time for each s participant



Evacuation time of 81 participants in line graph for scenario #No2D

Scenario #No3A:

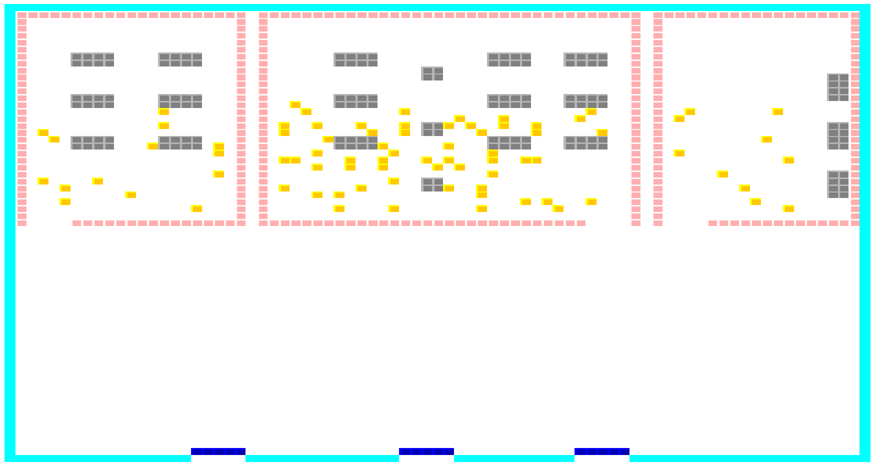
More than two main exit doors and increase evacuees' distribution area

Paricipant distributions:

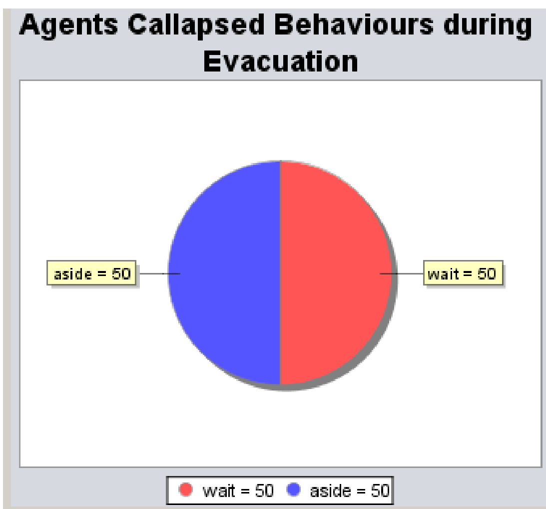
- emp_X(16, 33), emp_Y(20, 35) ,
- student_X(37, 68), student_Y(20, 35),

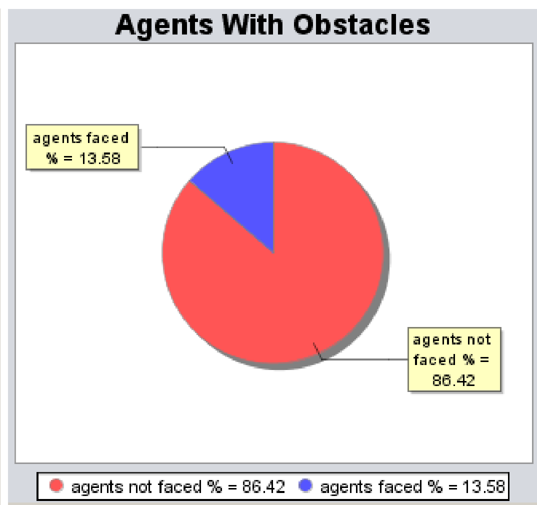
Appendix E

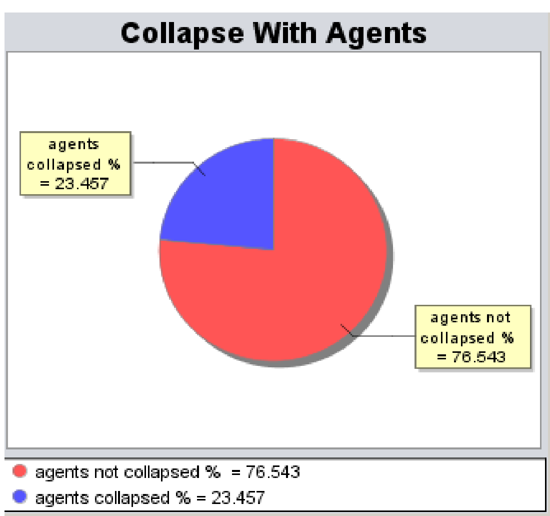
- staff_X(75, 87), staff_Y(20, 35)

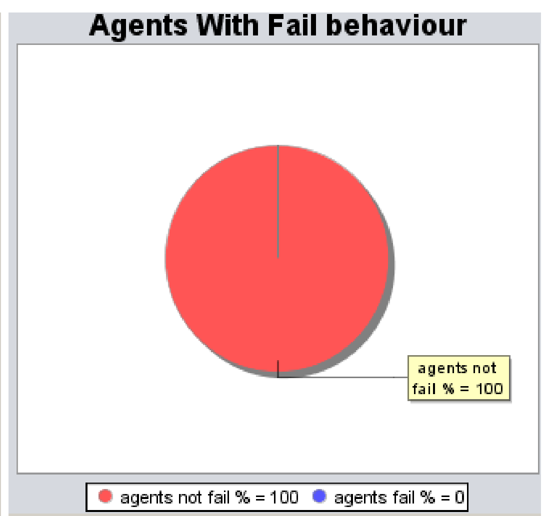


The first floor created and participants distributed through the floor









Appendix E

Analyzing emergency behaviors appeared during the evacuation process

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	23 , 56	3rd buttom	no obstacle	2 times	6.1704	26.0	0:9:829
2	23 , 54	3rd buttom	1	no collapse	5.9904	28.0	0:9:554
3	23 , 50	3rd buttom	2	1 time	6.012	28.5	0:11:354
4	23 , 46	1st buttom	no obstacle	1 time	5.8968	27.0	0:11:445
5	23 , 42	2nd buttom	no obstacle	1 time	6.1632	28.5	0:9:917
6	23 , 39	3rd buttom	no obstacle	no collapse	6.2784	31.0	0:8:429
7	23 , 28	2nd buttom	no obstacle	no collapse	6.3072	23.5	0:6:249
8	22 , 75	1st buttom	no obstacle	no collapse	5.9832	29.5	0:10:458
9	22 , 66	1st buttom	1	no collapse	5.9112	25.5	0:9:607
10	22 , 59	3rd buttom	1	no collapse	5.9976	28.5	0:9:574
11	22 , 55	1st buttom	no obstacle	no collapse	6.048	25.5	0:8:524
12	21 , 84	1st buttom	no obstacle	no collapse	6.2784	30.0	0:7:733
13	21 , 76	2nd buttom	no obstacle	no collapse	6.1272	25.0	0:7:660
14	21 , 67	3rd buttom	1	no collapse	6.1272	25.0	0:7:984
15	21 , 50	1st buttom	no obstacle	no collapse	5.9688	28.5	0:10:313
16	21 , 41	2nd buttom	no obstacle	1 time	5.9904	29.5	0:11:742
17	21 , 28	3rd buttom	no obstacle	5 times	6.1776	34.0	0:14:711
18	20 , 40	2nd buttom	no obstacle	no collapse	6.2928	30.5	0:8:111
19	24 , 57	2nd buttom	no obstacle	no collapse	5.9328	24.5	0:8:832
20	24 , 50	3rd buttom	no obstacle	no collapse	5.7528	25.5	0:10:551
21	24 , 47	3rd buttom	no obstacle	no collapse	5.7024	27.0	0:11:653
22	24 , 39	2nd buttom	no obstacle	no collapse	5.8968	31.5	0:11:502
23	24 , 17	2nd buttom	no obstacle	2 times	5.7312	23.5	0:11:864
24	23 , 62	1st buttom	1	no collapse	5.7168	28.0	0:12:47
25	23 , 59	3rd buttom	no obstacle	no collapse	5.9112	23.0	0:8:789
26	24 , 62	3rd buttom	2	2 times	5.6232	28.5	0:14:256
27	25 , 83	2nd buttom	no obstacle	no collapse	5.0112	24.0	0:13:805
28	25 , 43	1st buttom	2	2 times	5.3496	36.5	0:30:553
29	25 , 18	1st buttom	no obstacle	no collapse	5.2128	22.5	0:12:842
30	24 , 68	1st buttom	no obstacle	no collapse	5.1696	26.0	0:15:95
31	26 , 27	1st buttom	no obstacle	no collapse	4.6728	23.0	0:16:276
32	26 , 33	1st buttom	no obstacle	no collapse	4.5288	22.5	0:18:255
33	26 , 48	3rd buttom	no obstacle	1 time	4.6224	27.5	0:20:830
34	26 , 54	1st buttom	no obstacle	no collapse	4.14	25.5	0:22:263
35	27 , 33	1st buttom	no obstacle	no collapse	3.5424	22.5	0:24:934
36	27 , 75	2nd buttom	no obstacle	no collapse	3.132	23.0	0:25:483
37	27 , 58	1st buttom	no obstacle	no collapse	3.0096	23.5	0:28:15
38	27 , 49	1st buttom	no obstacle	no collapse	3.0384	27.0	0:32:401

Results of evacuation simulation and specifying evacuation time for each s participant

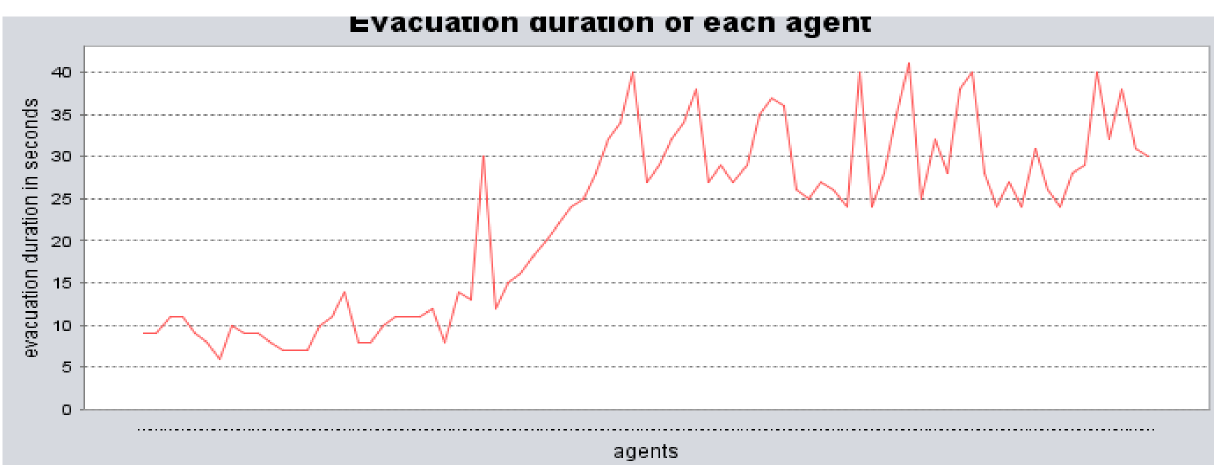
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	27 , 42	2nd buttom	no obstacle	1 time	3.1968	30.5	0:34:540
40	28 , 39	1st buttom	no obstacle	no collapse	2.9592	33.5	0:40:69
41	28 , 54	3rd buttom	no obstacle	no collapse	2.8584	23.5	0:27:773
42	28 , 52	3rd buttom	no obstacle	no collapse	2.8584	25.0	0:29:651
43	28 , 48	2nd buttom	no obstacle	no collapse	2.9808	27.5	0:32:209
44	28 , 45	1st buttom	no obstacle	1 time	2.988	29.5	0:34:324
45	28 , 40	1st buttom	no obstacle	1 time	3.0096	32.5	0:38:849
46	30 , 58	1st buttom	no obstacle	no collapse	2.88	22.0	0:27:340
47	30 , 33	1st buttom	no obstacle	no collapse	2.952	21.0	0:29:513
48	29 , 55	1st buttom	no obstacle	no collapse	2.88	23.5	0:27:734
49	29 , 53	2nd buttom	no obstacle	1 time	2.8584	24.5	0:29:564
50	29 , 48	1st buttom	1	no collapse	2.8584	28.0	0:35:64
51	29 , 45	1st buttom	no obstacle	no collapse	2.7432	29.5	0:37:215
52	29 , 42	2nd buttom	no obstacle	1 time	2.9016	30.0	0:36:376
53	28 , 85	3rd buttom	no obstacle	no collapse	2.9304	22.5	0:26:76
54	28 , 62	3rd buttom	no obstacle	no collapse	2.9232	21.5	0:25:317
55	28 , 61	1st buttom	no obstacle	no collapse	2.8008	22.5	0:27:600
56	28 , 58	2nd buttom	no obstacle	no collapse	3.0096	23.0	0:26:512
57	31 , 22	1st buttom	no obstacle	no collapse	2.8224	20.5	0:24:446
58	31 , 17	3rd buttom	no obstacle	4 times	2.6568	27.0	0:40:937
59	30 , 79	2nd buttom	no obstacle	no collapse	2.7792	21.0	0:24:18
60	32 , 54	2nd buttom	no obstacle	no collapse	2.8008	24.0	0:28:872
61	32 , 46	3rd buttom	no obstacle	no collapse	2.7864	29.0	0:35:12
62	32 , 39	1st buttom	no obstacle	no collapse	2.6496	32.0	0:41:241
63	32 , 19	1st buttom	1	no collapse	2.7216	20.0	0:25:653
64	31 , 49	2nd buttom	no obstacle	no collapse	2.7	26.0	0:32:83
65	33 , 57	3rd buttom	no obstacle	no collapse	2.772	23.5	0:28:395
66	33 , 44	1st buttom	no obstacle	1 time	2.8008	30.0	0:38:751
67	33 , 42	2nd buttom	no obstacle	no collapse	2.6208	32.0	0:40:162
68	33 , 25	1st buttom	no obstacle	1 time	2.7432	20.0	0:28:134
69	32 , 81	2nd buttom	no obstacle	no collapse	2.628	21.0	0:24:950
70	32 , 57	3rd buttom	no obstacle	no collapse	2.7072	22.5	0:27:716
71	34 , 19	1st buttom	1	no collapse	2.5128	18.5	0:24:912
72	35 , 31	1st buttom	no obstacle	no collapse	2.34	18.0	0:31:176
73	34 , 82	3rd buttom	no obstacle	no collapse	2.4912	19.0	0:26:293
74	34 , 67	2nd buttom	no obstacle	no collapse	2.5416	19.0	0:24:91
75	34 , 63	1st buttom	no obstacle	no collapse	2.4912	21.0	0:28:347
76	34 , 61	1st buttom	no obstacle	no collapse	2.4696	21.5	0:29:208

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

AgentID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	28 , 45	1st buttom	no obstacle	1 time	2.988	29.5	0:34:324
45	28 , 40	1st buttom	no obstacle	1 time	3.0096	32.5	0:38:849
46	30 , 58	1st buttom	no obstacle	no collapse	2.88	22.0	0:27:340
47	30 , 33	1st buttom	no obstacle	no collapse	2.952	21.0	0:29:513
48	29 , 55	1st buttom	no obstacle	no collapse	2.88	23.5	0:27:734
49	29 , 53	2nd buttom	no obstacle	1 time	2.8584	24.5	0:29:564
50	29 , 48	1st buttom	1	no collapse	2.8584	28.0	0:35:84
51	29 , 45	1st buttom	no obstacle	no collapse	2.7432	29.5	0:37:215
52	29 , 42	2nd buttom	no obstacle	1 time	2.9016	30.0	0:36:376
53	28 , 85	3rd buttom	no obstacle	no collapse	2.9304	22.5	0:26:76
54	28 , 62	3rd buttom	no obstacle	no collapse	2.9232	21.5	0:25:317
55	28 , 61	1st buttom	no obstacle	no collapse	2.8008	22.5	0:27:600
56	28 , 58	2nd buttom	no obstacle	no collapse	3.0096	23.0	0:26:512
57	31 , 22	1st buttom	no obstacle	no collapse	2.8224	20.5	0:24:446
58	31 , 17	3rd buttom	no obstacle	4 times	2.6568	27.0	0:40:937
59	30 , 79	2nd buttom	no obstacle	no collapse	2.7792	21.0	0:24:18
60	32 , 54	2nd buttom	no obstacle	no collapse	2.8008	24.0	0:28:872
61	32 , 46	3rd buttom	no obstacle	no collapse	2.7864	29.0	0:35:12
62	32 , 39	1st buttom	no obstacle	no collapse	2.6496	32.0	0:41:241
63	32 , 19	1st buttom	1	no collapse	2.7216	20.0	0:25:653
64	31 , 49	2nd buttom	no obstacle	no collapse	2.7	26.0	0:32:83
65	33 , 57	3rd buttom	no obstacle	no collapse	2.772	23.5	0:28:395
66	33 , 44	1st buttom	no obstacle	1 time	2.8008	30.0	0:38:751
67	33 , 42	2nd buttom	no obstacle	no collapse	2.6208	32.0	0:40:162
68	33 , 25	1st buttom	no obstacle	1 time	2.7432	20.0	0:28:134
69	32 , 81	2nd buttom	no obstacle	no collapse	2.628	21.0	0:24:950
70	32 , 57	3rd buttom	no obstacle	no collapse	2.7072	22.5	0:27:716
71	34 , 19	1st buttom	1	no collapse	2.5128	18.5	0:24:912
72	35 , 31	1st buttom	no obstacle	no collapse	2.34	18.0	0:31:176
73	34 , 82	3rd buttom	no obstacle	no collapse	2.4912	19.0	0:26:293
74	34 , 67	2nd buttom	no obstacle	no collapse	2.5416	19.0	0:24:91
75	34 , 63	1st buttom	no obstacle	no collapse	2.4912	21.0	0:28:347
76	34 , 61	1st buttom	no obstacle	no collapse	2.4696	21.5	0:29:208
77	35 , 44	2nd buttom	no obstacle	no collapse	2.412	31.0	0:40:724
78	35 , 57	2nd buttom	no obstacle	1 time	2.2608	23.5	0:32:241
79	35 , 49	1st buttom	no obstacle	no collapse	2.2176	27.0	0:38:212
80	35 , 64	1st buttom	no obstacle	no collapse	2.0016	21.5	0:31:941
81	35 , 85	3rd buttom	no obstacle	no collapse	2.0016	19.0	0:30:404

Results of evacuation simulation and specifying evacuation time for each s participant

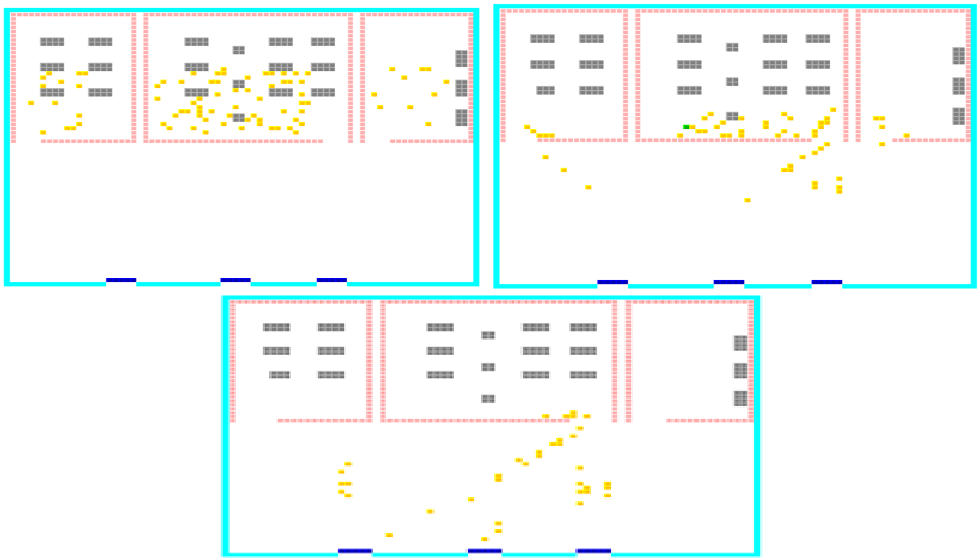


Evacuation time of 81 participants in the line graph for scenario #No3A

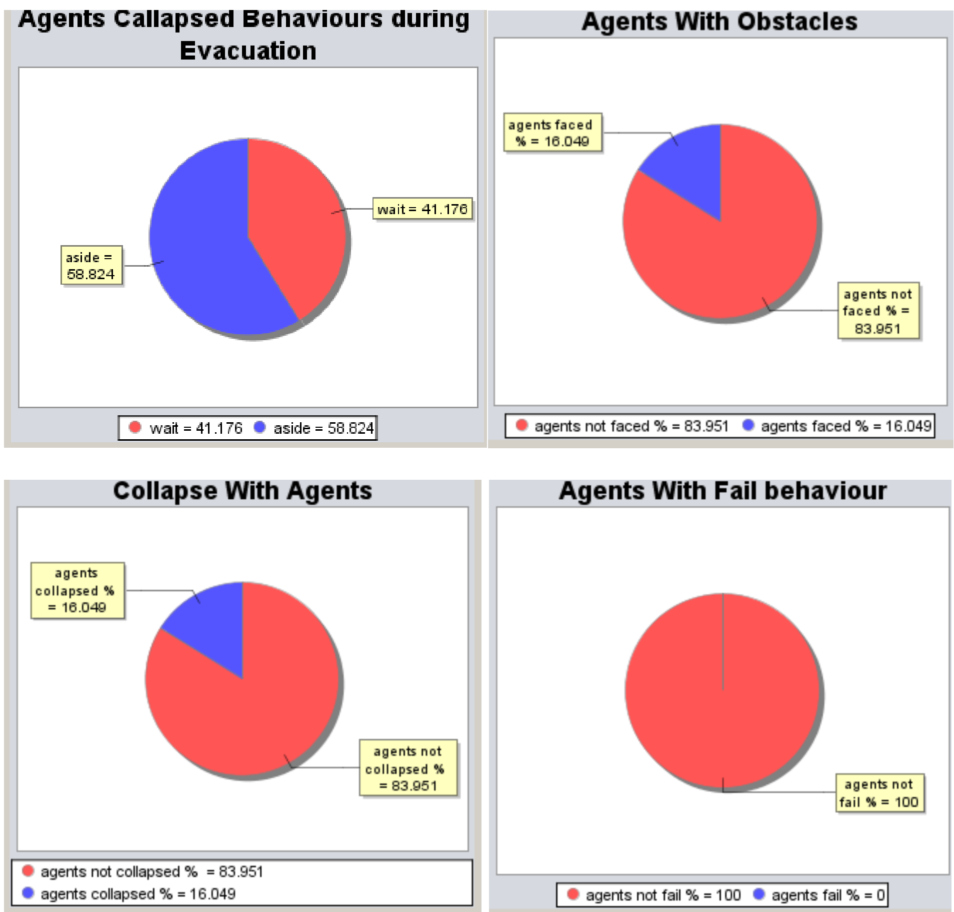
Scenario #No3B

Same condition #No3A, they are all familiar with the exit doors

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	24 , 45	2nd buttom	no obstacle	2 times	6.1704	26.5	0:10:778
2	24 , 22	1st buttom	no obstacle	no collapse	5.9904	23.5	0:8:840
3	23 , 59	2nd buttom	1	2 times	6.012	30.0	0:12:20
4	23 , 44	2nd buttom	no obstacle	no collapse	5.8968	29.0	0:10:960
5	23 , 39	1st buttom	no obstacle	1 time	6.1632	32.5	0:10:647
6	22 , 85	3rd buttom	no obstacle	no collapse	6.2784	25.0	0:6:861
7	22 , 60	2nd buttom	1	no collapse	6.3072	28.0	0:7:850
8	22 , 56	2nd buttom	no obstacle	1 time	5.9832	27.0	0:10:896
9	22 , 52	2nd buttom	no obstacle	1 time	5.9112	25.0	0:10:455
10	22 , 49	2nd buttom	1	1 time	5.9976	26.5	0:11:591
11	22 , 40	1st buttom	no obstacle	2 times	6.048	31.5	0:11:753
12	21 , 67	3rd buttom	1	no collapse	6.2784	25.5	0:7:232
13	21 , 65	3rd buttom	1	no collapse	6.1272	25.5	0:8:89
14	21 , 63	3rd buttom	1	no collapse	6.1272	26.0	0:8:543
15	21 , 49	2nd buttom	no obstacle	no collapse	5.9688	27.0	0:9:764
16	21 , 30	1st buttom	no obstacle	no collapse	5.9904	26.0	0:9:386
17	20 , 55	2nd buttom	1	no collapse	6.1776	27.0	0:8:481
18	20 , 42	1st buttom	no obstacle	no collapse	6.2928	31.0	0:8:433
19	25 , 50	2nd buttom	no obstacle	no collapse	5.9328	25.5	0:9:581
20	25 , 43	2nd buttom	1	1 time	5.7528	29.5	0:13:901
21	25 , 39	1st buttom	no obstacle	no collapse	5.7024	32.0	0:13:757
22	24 , 87	3rd buttom	no obstacle	no collapse	5.8968	24.0	0:8:888
23	24 , 51	2nd buttom	1	no collapse	5.7312	26.0	0:11:129
24	24 , 48	2nd buttom	no obstacle	1 time	5.7168	28.0	0:12:350
25	24 , 47	2nd buttom	no obstacle	1 time	5.9112	28.0	0:11:546
26	25 , 51	2nd buttom	no obstacle	no collapse	5.6232	26.0	0:11:717
27	25 , 75	3rd buttom	no obstacle	no collapse	5.0112	23.0	0:14:353
28	25 , 64	3rd buttom	2	no collapse	5.3496	26.5	0:13:913
29	25 , 62	3rd buttom	2	1 time	5.2128	29.0	0:16:618
30	25 , 55	2nd buttom	no obstacle	2 times	5.1696	25.5	0:15:892
31	26 , 19	1st buttom	1	no collapse	4.6728	22.5	0:16:161
32	26 , 50	2nd buttom	no obstacle	no collapse	4.5288	26.0	0:19:431
33	26 , 64	3rd buttom	1	1 time	4.6224	24.0	0:18:647
34	27 , 42	2nd buttom	no obstacle	no collapse	4.14	30.0	0:25:533
35	27 , 58	2nd buttom	no obstacle	no collapse	3.5424	22.0	0:22:387
36	28 , 63	3rd buttom	no obstacle	no collapse	3.132	22.0	0:25:8
37	28 , 62	3rd buttom	no obstacle	no collapse	3.0096	23.5	0:27:194
38	28 , 52	2nd buttom	no obstacle	no collapse	3.0384	25.5	0:29:385

Results of evacuation simulation and specifying evacuation time for each s participant

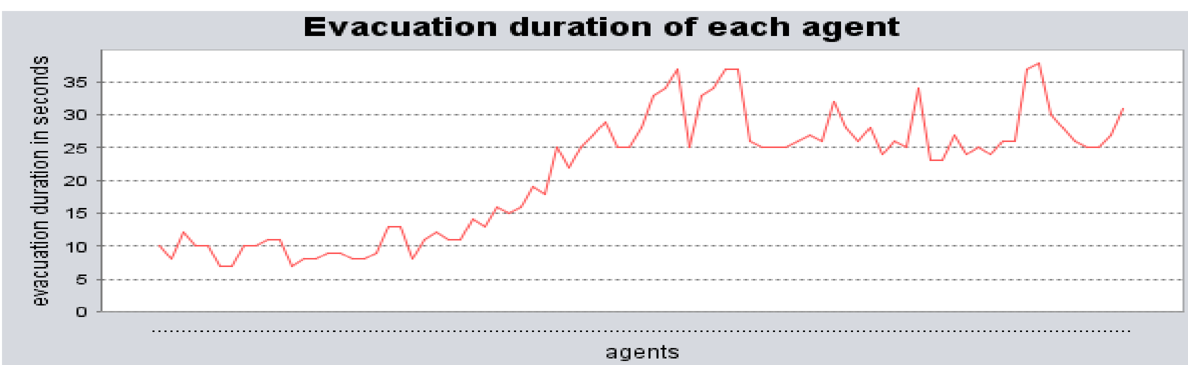
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	29 , 39	1st buttom	no obstacle	no collapse	2.988	32.0	0:37:292
45	29 , 23	1st buttom	no obstacle	no collapse	3.0096	22.0	0:25:697
46	30 , 47	2nd buttom	no obstacle	no collapse	2.88	27.5	0:33:352
47	30 , 46	2nd buttom	no obstacle	no collapse	2.952	29.5	0:34:652
48	30 , 42	1st buttom	no obstacle	no collapse	2.88	29.5	0:37:11
49	30 , 40	1st buttom	no obstacle	no collapse	2.8584	31.5	0:37:976
50	30 , 26	1st buttom	no obstacle	no collapse	2.8584	21.5	0:26:161
51	30 , 21	1st buttom	no obstacle	no collapse	2.7432	20.5	0:25:643
52	29 , 75	3rd buttom	no obstacle	no collapse	2.9016	21.5	0:25:712
53	29 , 66	3rd buttom	no obstacle	no collapse	2.9304	21.5	0:25:400
54	29 , 64	3rd buttom	no obstacle	no collapse	2.8232	22.0	0:26:111
55	29 , 59	2nd buttom	no obstacle	no collapse	2.8806	22.5	0:27:445
56	29 , 57	2nd buttom	no obstacle	no collapse	3.0096	22.5	0:26:111
57	31 , 48	2nd buttom	no obstacle	no collapse	2.8224	26.5	0:32:620
58	31 , 30	1st buttom	no obstacle	no collapse	2.6568	22.5	0:29:748
59	31 , 17	1st buttom	no obstacle	no collapse	2.7792	20.0	0:26:237
60	33 , 57	2nd buttom	no obstacle	no collapse	2.8008	23.0	0:28:578
61	32 , 54	3rd buttom	no obstacle	no collapse	2.7864	19.5	0:24:691
62	31 , 84	3rd buttom	no obstacle	no collapse	2.6496	21.0	0:26:363
63	31 , 86	3rd buttom	no obstacle	no collapse	2.7216	20.5	0:25:759
64	31 , 51	2nd buttom	1	no collapse	2.7	26.5	0:34:154
65	34 , 22	1st buttom	no obstacle	no collapse	2.772	18.5	0:23:533
66	34 , 20	1st buttom	no obstacle	no collapse	2.8008	18.5	0:23:617
67	33 , 86	3rd buttom	no obstacle	no collapse	2.6208	19.5	0:27:338
68	33 , 68	3rd buttom	no obstacle	no collapse	2.7432	19.0	0:24:332
69	33 , 63	3rd buttom	no obstacle	no collapse	2.628	19.5	0:25:464
70	33 , 62	3rd buttom	no obstacle	no collapse	2.7072	19.5	0:24:850
71	34 , 25	1st buttom	no obstacle	no collapse	2.5128	18.5	0:26:821
72	34 , 77	3rd buttom	no obstacle	no collapse	2.34	18.5	0:26:197
73	34 , 46	2nd buttom	no obstacle	no collapse	2.4912	29.0	0:37:307
74	34 , 44	2nd buttom	no obstacle	no collapse	2.5416	29.0	0:38:60
75	34 , 31	1st buttom	no obstacle	no collapse	2.4912	18.5	0:30:732
76	34 , 28	1st buttom	no obstacle	no collapse	2.4696	18.5	0:28:915
77	35 , 17	1st buttom	no obstacle	no collapse	2.412	18.0	0:26:145
78	35 , 80	3rd buttom	no obstacle	no collapse	2.2608	18.5	0:25:679
79	35 , 86	3rd buttom	no obstacle	no collapse	2.2176	18.0	0:25:651
80	35 , 81	3rd buttom	no obstacle	no collapse	2.0016	18.0	0:27:598
81	35 , 87	3rd buttom	no obstacle	no collapse	2.0016	18.5	0:31:895

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	27 . 61	3rd buttom	no obstacle	no collapse	3.1968	23.0	0:25:813
40	29 . 66	3rd buttom	no obstacle	no collapse	2.8582	21.5	0:25:259
41	29 . 54	2nd buttom	no obstacle	no collapse	2.8584	23.5	0:28:159
42	29 . 48	2nd buttom	1	no collapse	2.8584	27.5	0:33:970
43	29 . 42	2nd buttom	no obstacle	no collapse	2.8808	29.5	0:34:532
44	29 . 38	1st buttom	no obstacle	no collapse	2.988	32.0	0:37:292
45	29 . 23	1st buttom	no obstacle	no collapse	3.0096	22.0	0:25:997
46	30 . 47	2nd buttom	no obstacle	no collapse	2.88	27.5	0:33:352
47	30 . 46	2nd buttom	no obstacle	no collapse	2.952	29.5	0:34:852
48	30 . 42	1st buttom	no obstacle	no collapse	2.88	29.5	0:37:11
49	30 . 40	1st buttom	no obstacle	no collapse	2.8584	31.5	0:37:976
50	30 . 28	1st buttom	no obstacle	no collapse	2.8584	21.5	0:26:161
51	30 . 21	1st buttom	no obstacle	no collapse	2.7432	20.5	0:25:643
52	29 . 75	3rd buttom	no obstacle	no collapse	2.9016	21.5	0:25:712
53	29 . 66	3rd buttom	no obstacle	no collapse	2.9304	21.5	0:25:400
54	29 . 64	3rd buttom	no obstacle	no collapse	2.9232	22.0	0:26:111
55	29 . 59	2nd buttom	no obstacle	no collapse	2.8088	22.5	0:27:445
56	29 . 57	2nd buttom	no obstacle	no collapse	3.0096	22.5	0:26:111
57	31 . 48	2nd buttom	no obstacle	no collapse	2.8224	26.5	0:32:820
58	31 . 38	1st buttom	no obstacle	no collapse	2.6568	22.5	0:28:749
59	31 . 17	1st buttom	no obstacle	no collapse	2.7792	20.0	0:26:237
60	33 . 67	2nd buttom	no obstacle	no collapse	2.8008	23.0	0:28:579
61	32 . 64	3rd buttom	no obstacle	no collapse	2.7864	18.5	0:24:691
62	31 . 84	3rd buttom	no obstacle	no collapse	2.6496	21.0	0:26:363
63	31 . 66	3rd buttom	no obstacle	no collapse	2.7216	20.5	0:25:759
64	31 . 51	2nd buttom	1	no collapse	2.7	26.5	0:34:154
65	34 . 22	1st buttom	no obstacle	no collapse	2.772	18.5	0:23:533
66	34 . 20	1st buttom	no obstacle	no collapse	2.8008	18.5	0:23:517
67	33 . 86	3rd buttom	no obstacle	no collapse	2.5288	18.5	0:27:338
68	33 . 68	3rd buttom	no obstacle	no collapse	2.7432	19.0	0:24:332
69	33 . 63	3rd buttom	no obstacle	no collapse	2.628	19.5	0:25:464
70	33 . 62	3rd buttom	no obstacle	no collapse	2.7072	18.5	0:24:850
71	34 . 25	1st buttom	no obstacle	no collapse	2.5128	18.5	0:26:821
72	34 . 77	3rd buttom	no obstacle	no collapse	2.34	18.5	0:26:197
73	34 . 46	2nd buttom	no obstacle	no collapse	2.4912	28.0	0:37:307
74	34 . 44	2nd buttom	no obstacle	no collapse	2.5416	29.0	0:38:60
75	34 . 31	1st buttom	no obstacle	no collapse	2.4912	18.5	0:30:732
76	34 . 28	1st buttom	no obstacle	no collapse	2.4696	18.5	0:28:915

Results of evacuation simulation and specifying evacuation time for each s participant

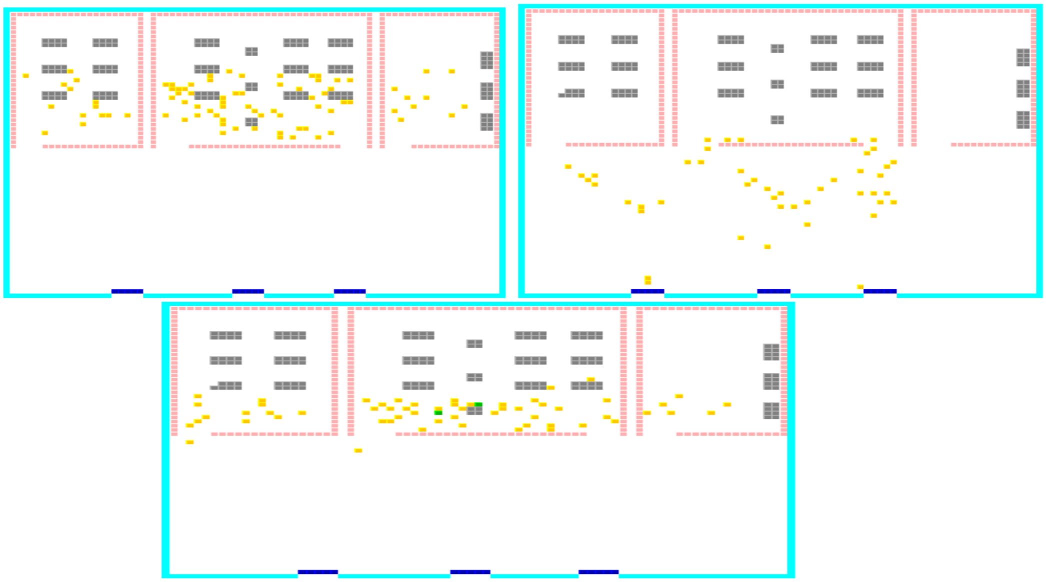


Evacuation time of 81 participants in the line graph for scenario #No3B

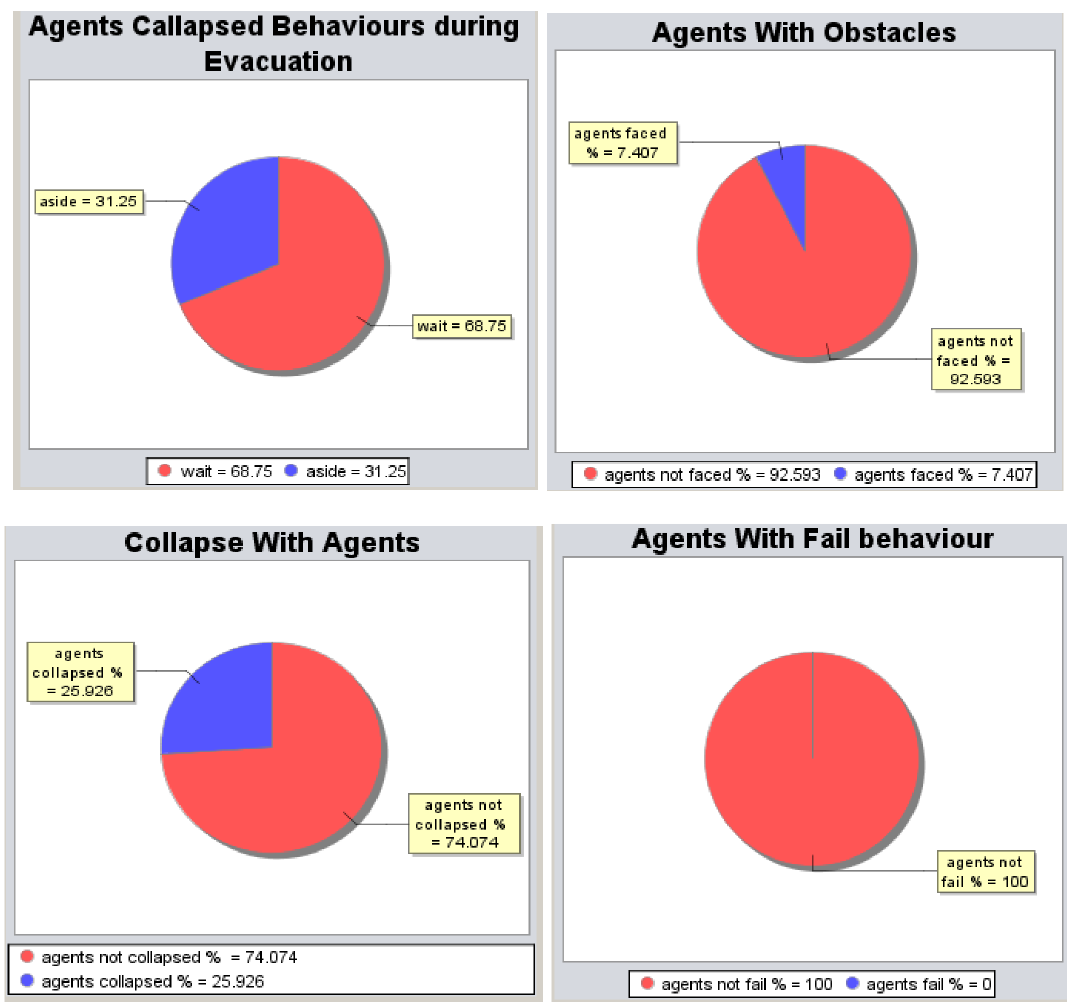
Scenario #No4A:

Two exit doors for the student part, three main exit doors and evacuees were no familiar with the exits

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	23 , 40	2nd buttom	no obstacle	no collapse	6.1704	23.5	0:7:158
2	23 , 39	2nd buttom	no obstacle	no collapse	5.9904	24.0	0:8:473
3	23 , 23	3rd buttom	no obstacle	7 times	6.012	31.0	0:15:481
4	22 , 68	2nd buttom	no obstacle	no collapse	5.8968	24.5	0:9:82
5	22 , 66	1st buttom	1	1 time	6.1632	28.0	0:9:419
6	22 , 63	3rd buttom	no obstacle	1 time	6.2784	26.5	0:8:289
7	22 , 46	1st buttom	no obstacle	no collapse	6.3072	25.0	0:6:175
8	22 , 25	2nd buttom	no obstacle	1 time	5.9832	24.5	0:9:400
9	21 , 63	1st buttom	no obstacle	1 time	5.9112	26.5	0:10:698
10	21 , 62	2nd buttom	1	no collapse	5.9976	26.5	0:8:978
11	21 , 57	1st buttom	1	no collapse	6.048	26.5	0:8:612
12	21 , 51	3rd buttom	no obstacle	1 time	6.2784	26.5	0:8:103
13	21 , 46	2nd buttom	no obstacle	no collapse	6.1272	30.0	0:9:130
14	21 , 17	1st buttom	no obstacle	no collapse	6.1272	24.5	0:7:793
15	20 , 84	3rd buttom	no obstacle	no collapse	5.9688	26.5	0:9:30
16	20 , 80	3rd buttom	no obstacle	no collapse	5.9904	26.0	0:9:52
17	20 , 49	2nd buttom	no obstacle	no collapse	6.1776	25.5	0:7:511
18	20 , 24	2nd buttom	1	no collapse	6.2928	25.5	0:6:661
19	24 , 60	3rd buttom	no obstacle	no collapse	5.9328	23.0	0:8:498
20	24 , 42	2nd buttom	no obstacle	no collapse	5.7528	23.0	0:9:550
21	24 , 41	3rd buttom	no obstacle	no collapse	5.7024	23.5	0:10:536
22	24 , 40	1st buttom	no obstacle	no collapse	5.8968	23.5	0:9:105
23	24 , 24	1st buttom	no obstacle	1 time	5.7312	25.5	0:10:853
24	23 , 57	2nd buttom	no obstacle	1 time	5.7168	24.5	0:11:352
25	23 , 43	3rd buttom	no obstacle	no collapse	5.9112	29.0	0:10:922
26	24 , 65	1st buttom	no obstacle	1 time	5.6232	27.0	0:13:384
27	25 , 50	1st buttom	no obstacle	1 time	5.0112	26.0	0:16:304
28	25 , 43	2nd buttom	no obstacle	1 time	5.3496	23.5	0:12:442
29	25 , 41	2nd buttom	no obstacle	no collapse	5.2128	22.5	0:12:657
30	24 , 75	3rd buttom	no obstacle	no collapse	5.1696	23.5	0:12:865
31	25 , 51	3rd buttom	no obstacle	1 time	4.6728	24.5	0:18:525
32	25 , 64	1st buttom	2	no collapse	4.5288	26.5	0:19:984
33	26 , 40	2nd buttom	no obstacle	no collapse	4.6224	22.0	0:16:196
34	26 , 48	3rd buttom	1	no collapse	4.14	23.0	0:19:210
35	26 , 62	1st buttom	1	no collapse	3.5424	23.0	0:26:794
36	27 , 42	3rd buttom	no obstacle	no collapse	3.132	22.0	0:25:414
37	27 , 28	1st buttom	no obstacle	no collapse	3.0096	22.0	0:24:983
38	26 , 80	3rd buttom	no obstacle	no collapse	3.0384	23.5	0:25:306

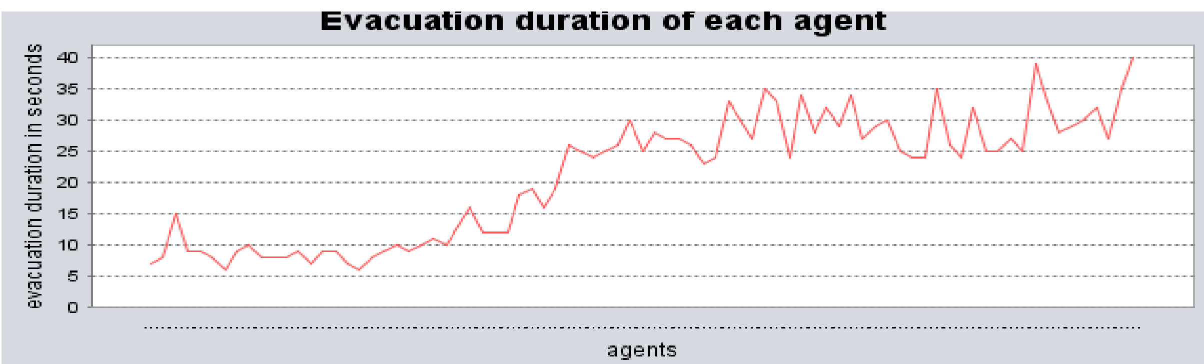
Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	26 , 77	2nd buttom	no obstacle	no collapse	3.1968	24.0	0:26:101
40	27 , 48	1st buttom	no obstacle	no collapse	2.9592	26.5	0:30:995
41	28 , 44	2nd buttom	no obstacle	no collapse	2.8584	21.5	0:25:353
42	28 , 28	1st buttom	no obstacle	no collapse	2.8584	22.5	0:28:871
43	28 , 21	1st buttom	no obstacle	1 time	2.9808	22.5	0:27:10
44	27 , 68	1st buttom	no obstacle	1 time	2.988	23.5	0:27:607
45	27 , 67	2nd buttom	no obstacle	no collapse	3.0096	23.0	0:26:118
46	30 , 26	1st buttom	no obstacle	no collapse	2.88	20.5	0:23:887
47	29 , 75	3rd buttom	no obstacle	no collapse	2.952	21.0	0:24:17
48	29 , 65	1st buttom	no obstacle	no collapse	2.88	21.5	0:33:53
49	29 , 56	1st buttom	no obstacle	no collapse	2.8584	25.0	0:30:644
50	29 , 53	3rd buttom	no obstacle	no collapse	2.8584	21.5	0:27:23
51	29 , 46	1st buttom	no obstacle	1 time	2.7432	27.5	0:35:472
52	28 , 86	1st buttom	no obstacle	1 time	2.9016	28.0	0:33:329
53	28 , 78	3rd buttom	no obstacle	no collapse	2.9304	22.0	0:24:434
54	28 , 63	3rd buttom	no obstacle	1 time	2.9232	22.5	0:34:908
55	28 , 52	3rd buttom	no obstacle	no collapse	2.8008	23.0	0:28:572
56	28 , 48	3rd buttom	no obstacle	1 time	3.0096	27.5	0:32:948
57	30 , 33	2nd buttom	no obstacle	no collapse	2.8224	20.5	0:29:80
58	30 , 30	2nd buttom	no obstacle	2 times	2.6568	22.0	0:34:156
59	30 , 29	1st buttom	no obstacle	no collapse	2.7792	20.5	0:27:705
60	30 , 57	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:29:406
61	30 , 54	2nd buttom	no obstacle	no collapse	2.7864	23.0	0:30:982
62	30 , 47	1st buttom	no obstacle	no collapse	2.6496	21.5	0:25:427
63	30 , 44	3rd buttom	no obstacle	no collapse	2.7216	20.5	0:24:948
64	30 , 39	1st buttom	no obstacle	no collapse	2.7	20.5	0:24:833
65	32 , 48	3rd buttom	no obstacle	2 times	2.772	26.5	0:35:647
66	32 , 26	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:26:251
67	31 , 76	3rd buttom	no obstacle	no collapse	2.6208	20.0	0:24:991
68	31 , 48	3rd buttom	no obstacle	no collapse	2.7432	26.0	0:32:766
69	31 , 42	2nd buttom	no obstacle	no collapse	2.628	19.5	0:25:524
70	30 , 84	3rd buttom	no obstacle	no collapse	2.7072	21.0	0:25:680
71	33 , 50	2nd buttom	no obstacle	no collapse	2.5128	19.5	0:27:275
72	34 , 48	1st buttom	no obstacle	no collapse	2.34	19.0	0:25:644
73	34 , 20	3rd buttom	no obstacle	4 times	2.4912	26.0	0:39:431
74	33 , 61	2nd buttom	no obstacle	no collapse	2.5416	24.0	0:33:770
75	33 , 60	3rd buttom	no obstacle	no collapse	2.4912	22.5	0:28:985
76	33 , 53	2nd buttom	no obstacle	no collapse	2.4696	19.0	0:29:201

Results of evacuation simulation and specifying evacuation time for each s participant

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	27 , 68	1st buttom	no obstacle	1 time	2.988	23.5	0:27:607
45	27 , 67	2nd buttom	no obstacle	no collapse	3.0096	23.0	0:26:118
46	30 , 26	1st buttom	no obstacle	no collapse	2.88	20.5	0:23:887
47	29 , 75	3rd buttom	no obstacle	no collapse	2.952	21.0	0:24:17
48	29 , 65	1st buttom	no obstacle	no collapse	2.88	21.5	0:33:53
49	29 , 56	1st buttom	no obstacle	no collapse	2.8584	25.0	0:30:644
50	29 , 53	3rd buttom	no obstacle	no collapse	2.8584	21.5	0:27:23
51	29 , 46	1st buttom	no obstacle	1 time	2.7432	27.5	0:35:472
52	28 , 86	1st buttom	no obstacle	1 time	2.9016	28.0	0:33:329
53	28 , 78	3rd buttom	no obstacle	no collapse	2.9304	22.0	0:24:434
54	28 , 63	3rd buttom	no obstacle	1 time	2.9232	22.5	0:34:908
55	28 , 52	3rd buttom	no obstacle	no collapse	2.8008	23.0	0:28:572
56	28 , 48	3rd buttom	no obstacle	1 time	3.0096	27.5	0:32:948
57	30 , 33	2nd buttom	no obstacle	no collapse	2.8224	20.5	0:29:80
58	30 , 30	2nd buttom	no obstacle	2 times	2.6568	22.0	0:34:156
59	30 , 29	1st buttom	no obstacle	no collapse	2.7792	20.5	0:27:705
60	30 , 57	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:29:406
61	30 , 54	2nd buttom	no obstacle	no collapse	2.7864	23.0	0:30:982
62	30 , 47	1st buttom	no obstacle	no collapse	2.6496	21.5	0:25:427
63	30 , 44	3rd buttom	no obstacle	no collapse	2.7216	20.5	0:24:948
64	30 , 39	1st buttom	no obstacle	no collapse	2.7	20.5	0:24:833
65	32 , 48	3rd buttom	no obstacle	2 times	2.772	26.5	0:35:647
66	32 , 26	2nd buttom	no obstacle	no collapse	2.8008	20.5	0:26:251
67	31 , 76	3rd buttom	no obstacle	no collapse	2.6208	20.0	0:24:991
68	31 , 48	3rd buttom	no obstacle	no collapse	2.7432	26.0	0:32:766
69	31 , 42	2nd buttom	no obstacle	no collapse	2.628	19.5	0:25:524
70	30 , 84	3rd buttom	no obstacle	no collapse	2.7072	21.0	0:25:680
71	33 , 50	2nd buttom	no obstacle	no collapse	2.5128	19.5	0:27:275
72	34 , 48	1st buttom	no obstacle	no collapse	2.34	19.0	0:25:644
73	34 , 20	3rd buttom	no obstacle	4 times	2.4912	26.0	0:39:431
74	33 , 61	2nd buttom	no obstacle	no collapse	2.5416	24.0	0:33:770
75	33 , 60	3rd buttom	no obstacle	no collapse	2.4912	22.5	0:28:985
76	33 , 53	2nd buttom	no obstacle	no collapse	2.4696	19.0	0:29:201
77	34 , 57	3rd buttom	no obstacle	no collapse	2.412	23.5	0:30:769
78	35 , 57	3rd buttom	no obstacle	no collapse	2.2608	23.0	0:32:222
79	34 , 65	1st buttom	no obstacle	no collapse	2.2176	19.0	0:27:74
80	35 , 59	1st buttom	no obstacle	no collapse	2.0016	18.5	0:35:388
81	35 , 63	3rd buttom	no obstacle	no collapse	2.0016	18.0	0:40:51

Results of evacuation simulation and specifying evacuation time for each s participant

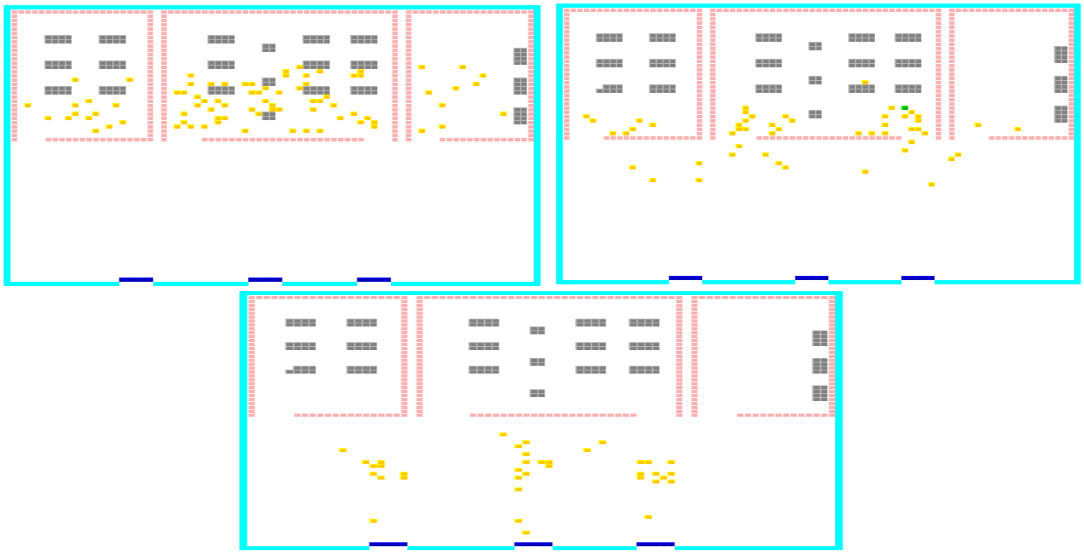


Evacuation time of 81 participants in the line graph for scenario #No4A

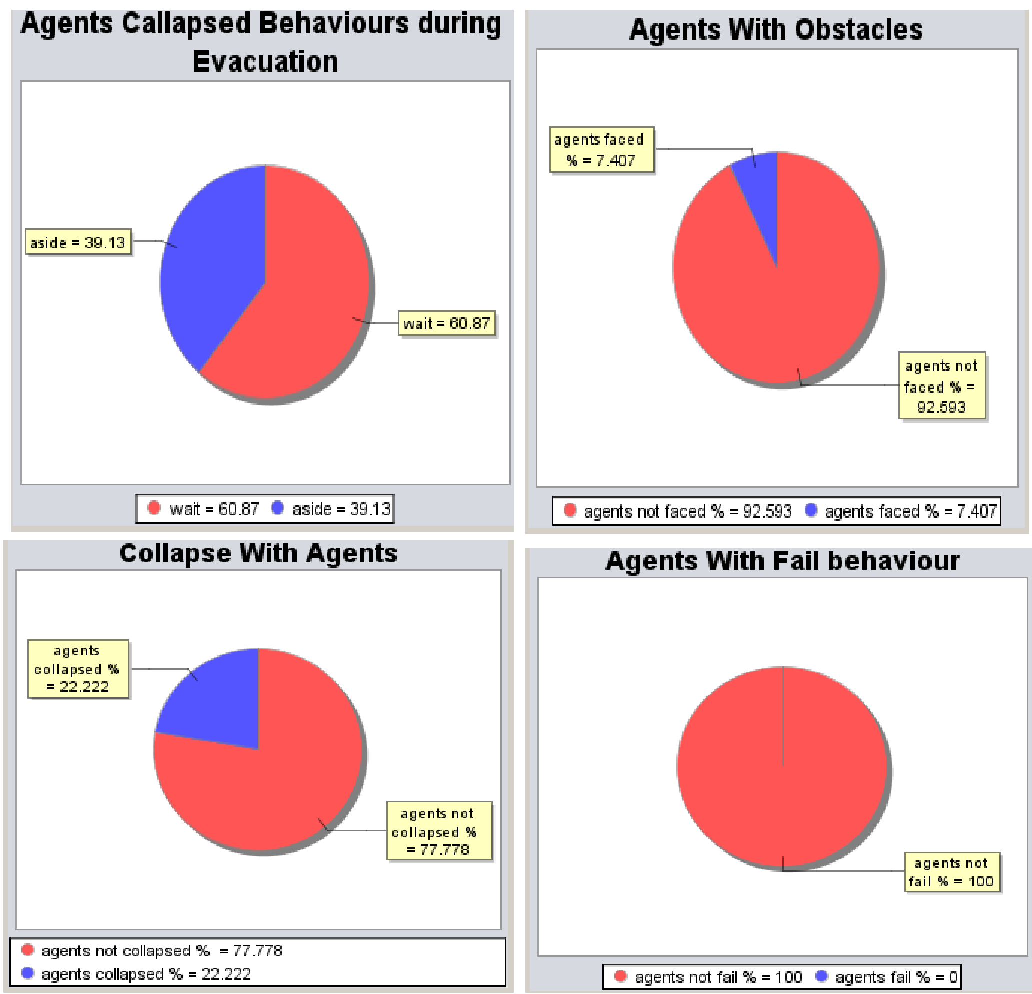
Scenario #No4B:

Same condition #No4A, evacuees familiar with the exits

Appendix E



The first floor created and participants distributed through the floor



Analyzing emergency behaviors appeared during the evacuation process

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
1	24 , 49	2nd buttom	no obstacle	no collapse	6.1704	25.0	0:7:487
2	24 , 46	2nd buttom	no obstacle	no collapse	5.9904	24.0	0:8:302
3	24 , 44	2nd buttom	no obstacle	no collapse	6.012	23.5	0:7:910
4	24 , 41	1st buttom	no obstacle	no collapse	5.8968	23.5	0:8:883
5	23 , 32	1st buttom	no obstacle	no collapse	6.1632	24.5	0:7:358
6	23 , 24	1st buttom	no obstacle	no collapse	6.2784	24.5	0:6:537
7	22 , 84	3rd buttom	no obstacle	no collapse	6.3072	25.5	0:6:241
8	22 , 66	3rd buttom	1	no collapse	5.9832	25.5	0:8:854
9	22 , 65	3rd buttom	1	1 time	5.9112	26.0	0:9:986
10	22 , 58	2nd buttom	no obstacle	no collapse	5.9976	24.5	0:8:447
11	22 , 55	2nd buttom	no obstacle	1 time	6.048	26.0	0:9:651
12	22 , 41	1st buttom	no obstacle	no collapse	6.2784	24.5	0:6:494
13	21 , 66	3rd buttom	1	no collapse	6.1272	26.0	0:7:967
14	21 , 60	2nd buttom	1	no collapse	6.1272	28.0	0:8:433
15	21 , 55	2nd buttom	no obstacle	no collapse	5.9688	26.0	0:9:280
16	20 , 81	3rd buttom	no obstacle	no collapse	5.9904	26.5	0:8:803
17	20 , 75	3rd buttom	no obstacle	no collapse	6.1776	25.5	0:7:388
18	20 , 57	2nd buttom	1	no collapse	6.2928	25.0	0:6:781
19	26 , 39	1st buttom	no obstacle	no collapse	5.9328	22.5	0:8:105
20	25 , 80	3rd buttom	no obstacle	no collapse	5.7528	23.5	0:9:248
21	25 , 57	2nd buttom	2	1 time	5.7024	27.5	0:13:36
22	25 , 52	2nd buttom	no obstacle	no collapse	5.8968	24.0	0:8:797
23	24 , 83	3rd buttom	no obstacle	no collapse	5.7312	24.5	0:9:631
24	24 , 58	2nd buttom	no obstacle	2 times	5.7168	25.0	0:12:736
25	24 , 50	2nd buttom	no obstacle	no collapse	5.9112	25.0	0:9:114
26	26 , 40	1st buttom	no obstacle	no collapse	5.6232	22.5	0:10:48
27	26 , 76	3rd buttom	no obstacle	no collapse	5.0112	23.0	0:13:947
28	26 , 54	2nd buttom	no obstacle	no collapse	5.3496	23.0	0:12:152
29	26 , 51	2nd buttom	no obstacle	no collapse	5.2128	22.5	0:12:431
30	26 , 50	2nd buttom	no obstacle	1 time	5.1696	25.0	0:14:641
31	27 , 42	2nd buttom	no obstacle	no collapse	4.6728	21.5	0:15:656
32	27 , 61	3rd buttom	no obstacle	no collapse	4.5288	22.0	0:18:209
33	28 , 26	1st buttom	no obstacle	no collapse	4.6224	22.0	0:15:710
34	28 , 43	2nd buttom	no obstacle	1 time	4.14	22.0	0:19:562
35	28 , 45	2nd buttom	no obstacle	no collapse	3.5424	22.0	0:22:140
36	29 , 17	1st buttom	no obstacle	no collapse	3.132	21.0	0:24:594
37	28 , 60	2nd buttom	no obstacle	no collapse	3.0096	23.5	0:26:892
38	29 , 59	2nd buttom	no obstacle	no collapse	3.0384	21.5	0:24:506

Results of evacuation simulation and specifying evacuation time for each s participant

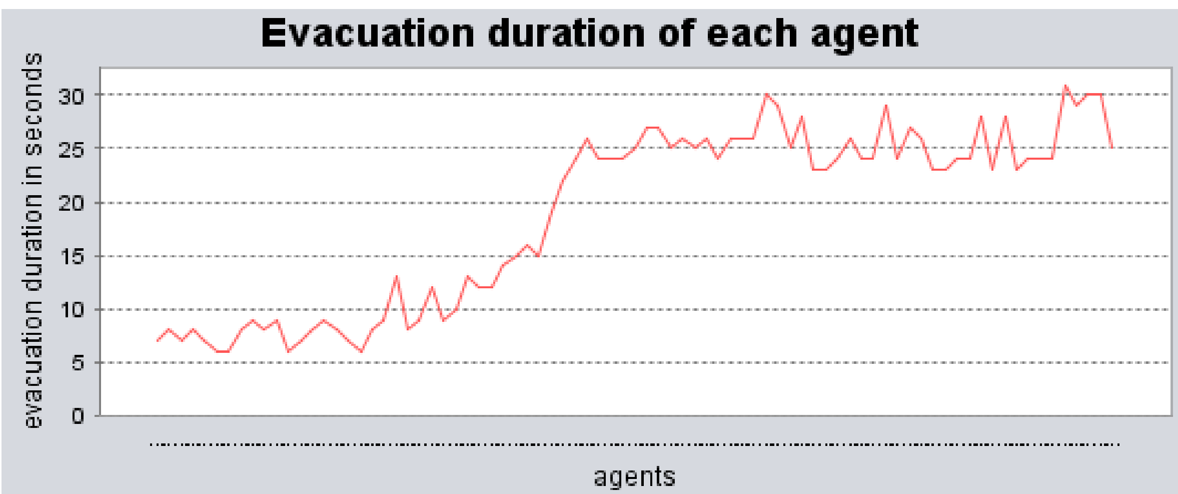
Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
39	28 , 52	2nd buttom	no obstacle	no collapse	3.1968	22.0	0:24:709
40	29 , 24	1st buttom	no obstacle	no collapse	2.9592	21.5	0:24:988
41	29 , 82	3rd buttom	no obstacle	no collapse	2.8584	21.5	0:25:566
42	29 , 53	2nd buttom	no obstacle	1 time	2.8584	22.5	0:27:255
43	29 , 46	2nd buttom	no obstacle	1 time	2.9808	22.5	0:27:946
44	29 , 42	2nd buttom	no obstacle	no collapse	2.968	21.0	0:25:392
45	29 , 30	1st buttom	no obstacle	no collapse	3.0096	21.5	0:26:407
46	31 , 85	3rd buttom	no obstacle	no collapse	2.88	21.5	0:25:540
47	31 , 51	2nd buttom	no obstacle	1 time	2.952	22.5	0:29:800
48	31 , 48	1st buttom	no obstacle	no collapse	2.88	20.5	0:24:386
49	31 , 27	1st buttom	no obstacle	1 time	2.8584	20.5	0:29:706
50	31 , 24	1st buttom	no obstacle	1 time	2.8584	21.0	0:26:48
51	30 , 59	2nd buttom	no obstacle	no collapse	2.7432	21.5	0:26:357
52	30 , 54	2nd buttom	no obstacle	2 times	2.9016	25.0	0:30:838
53	30 , 53	2nd buttom	no obstacle	1 time	2.9304	23.5	0:29:322
54	30 , 58	2nd buttom	no obstacle	no collapse	2.9232	21.5	0:25:779
55	30 , 44	2nd buttom	no obstacle	2 times	2.8008	22.0	0:28:886
56	29 , 78	3rd buttom	no obstacle	no collapse	3.0096	21.5	0:23:614
57	32 , 23	1st buttom	no obstacle	no collapse	2.8224	19.5	0:23:545
58	32 , 20	1st buttom	no obstacle	no collapse	2.6568	19.5	0:24:413
59	31 , 87	3rd buttom	no obstacle	no collapse	2.7792	20.5	0:26:53
60	32 , 67	3rd buttom	no obstacle	no collapse	2.8008	19.0	0:24:237
61	32 , 63	3rd buttom	no obstacle	no collapse	2.7864	20.0	0:24:313
62	32 , 46	2nd buttom	no obstacle	2 times	2.6496	22.0	0:29:957
63	32 , 45	2nd buttom	no obstacle	no collapse	2.7216	20.0	0:24:779
64	32 , 26	1st buttom	no obstacle	1 time	2.7	20.5	0:27:872
65	34 , 29	1st buttom	no obstacle	no collapse	2.772	20.5	0:26:873
66	33 , 68	3rd buttom	no obstacle	no collapse	2.8008	19.0	0:23:83
67	33 , 66	3rd buttom	no obstacle	no collapse	2.6208	19.0	0:23:976
68	33 , 45	2nd buttom	no obstacle	no collapse	2.7432	19.5	0:24:73
69	33 , 40	1st buttom	no obstacle	no collapse	2.628	19.5	0:24:533
70	33 , 31	1st buttom	no obstacle	no collapse	2.7072	20.0	0:28:411
71	34 , 38	1st buttom	no obstacle	no collapse	2.5128	18.5	0:23:822
72	35 , 27	1st buttom	no obstacle	no collapse	2.34	18.0	0:28:64
73	34 , 78	3rd buttom	no obstacle	no collapse	2.4912	19.0	0:23:336
74	34 , 68	3rd buttom	no obstacle	no collapse	2.5416	18.0	0:24:321
75	34 , 43	2nd buttom	no obstacle	no collapse	2.4912	19.0	0:24:573
76	34 , 41	1st buttom	no obstacle	no collapse	2.4696	19.0	0:24:739

Results of evacuation simulation and specifying evacuation time for each s participant

Appendix E

Agent ID	Start Location	Main Exit	Faced Obstacle No	Collapse with agent	Speed	Distance in meter	Duration (M:S:MS)
44	29 , 42	2nd buttom	no obstacle	no collapse	2.988	21.0	0:25:392
45	29 , 30	1st buttom	no obstacle	no collapse	3.0096	21.5	0:26:407
46	31 , 65	3rd buttom	no obstacle	no collapse	2.88	21.5	0:25:549
47	31 , 51	2nd buttom	no obstacle	1 time	2.952	22.5	0:26:800
48	31 , 40	1st buttom	no obstacle	no collapse	2.88	20.5	0:24:386
49	31 , 27	1st buttom	no obstacle	1 time	2.8584	20.5	0:26:706
50	31 , 24	1st buttom	no obstacle	1 time	2.8584	21.0	0:26:48
51	30 , 59	2nd buttom	no obstacle	no collapse	2.7432	21.5	0:26:357
52	30 , 54	2nd buttom	no obstacle	2 times	2.9016	25.0	0:30:838
53	30 , 53	2nd buttom	no obstacle	1 time	2.9304	23.5	0:29:322
54	30 , 50	2nd buttom	no obstacle	no collapse	2.9232	21.5	0:25:779
55	30 , 44	2nd buttom	no obstacle	2 times	2.8008	22.0	0:28:886
56	29 , 78	3rd buttom	no obstacle	no collapse	3.0096	21.5	0:23:614
57	32 , 23	1st buttom	no obstacle	no collapse	2.8224	19.5	0:23:545
58	32 , 20	1st buttom	no obstacle	no collapse	2.6568	19.5	0:24:413
59	31 , 87	3rd buttom	no obstacle	no collapse	2.7792	20.5	0:26:53
60	32 , 67	3rd buttom	no obstacle	no collapse	2.8008	19.0	0:24:237
61	32 , 63	3rd buttom	no obstacle	no collapse	2.7864	20.0	0:24:313
62	32 , 46	2nd buttom	no obstacle	2 times	2.6496	22.0	0:29:957
63	32 , 45	2nd buttom	no obstacle	no collapse	2.7216	20.0	0:24:779
64	32 , 26	1st buttom	no obstacle	1 time	2.7	20.5	0:27:872
65	34 , 29	1st buttom	no obstacle	no collapse	2.772	20.5	0:26:873
66	33 , 68	3rd buttom	no obstacle	no collapse	2.8008	19.0	0:23:83
67	33 , 66	3rd buttom	no obstacle	no collapse	2.8208	19.0	0:23:976
68	33 , 45	2nd buttom	no obstacle	no collapse	2.7432	19.5	0:24:73
69	33 , 40	1st buttom	no obstacle	no collapse	2.628	19.5	0:24:533
70	33 , 31	1st buttom	no obstacle	no collapse	2.7072	20.0	0:28:411
71	34 , 39	1st buttom	no obstacle	no collapse	2.5128	18.5	0:23:822
72	35 , 27	1st buttom	no obstacle	no collapse	2.34	18.0	0:28:64
73	34 , 78	3rd buttom	no obstacle	no collapse	2.4912	19.0	0:23:336
74	34 , 68	3rd buttom	no obstacle	no collapse	2.5416	18.0	0:24:321
75	34 , 43	2nd buttom	no obstacle	no collapse	2.4912	19.0	0:24:573
76	34 , 41	1st buttom	no obstacle	no collapse	2.4696	19.0	0:24:739
77	35 , 49	2nd buttom	no obstacle	2 times	2.412	19.5	0:31:307
78	35 , 58	2nd buttom	no obstacle	no collapse	2.2608	22.0	0:29:884
79	35 , 56	2nd buttom	no obstacle	no collapse	2.2176	22.5	0:30:830
80	35 , 60	2nd buttom	no obstacle	1 time	2.0016	20.5	0:30:489
81	35 , 75	3rd buttom	no obstacle	no collapse	2.0016	18.0	0:25:671

Results of evacuation simulation and specifying evacuation time for each s participant



Evacuation time of 81 participants in the line graph for scenario #No4B

Appendix F

Table 1 Unimodal standard functions [119]

Functions	Dimension	Range	Shift position	f_{min}
$\boldsymbol{TF1}(\boldsymbol{x}) = \sum_{i=1}^{n} x_i^2$	10	[-100, 100]	[-30, -30, … -30]	0
$\boldsymbol{TF2}(\boldsymbol{x}) = \sum_{i=1}^{n} \lvert x_i \rvert + \prod_{i=1}^{n} \lvert x_i \rvert$	10	[-10,10]	[-3, -3, … -3]	0
$\boldsymbol{TF3}(\boldsymbol{x}) = \sum_{i=1}^{n} \left(\sum_{j-1}^{i} x_j \right)^2$	10	[-100, 100]	[-30, -30, … -30]	0
$\boldsymbol{TF4}(\boldsymbol{x}) = \max_i \{\lvert x \rvert, 1 \leq i \leq n\}$	10	[-100, 100]	[-30, -30, … -30]	0
$\boldsymbol{TF5}(\boldsymbol{x}) = \sum_{i=1}^{n-1} [100(x_{i+1} - x_1^2)^2 + (x_i - 1)^2]$	10	[-30,30]	[-15, -15, ... -15]	0
$\boldsymbol{TF6}(\boldsymbol{x}) = \sum_{i=1}^{n} ([x_i + 0.5])^2$	10	[-100, 100]	[-750, ... -750]	0
$\boldsymbol{TF7}(\boldsymbol{x}) = \sum_{i=1}^{n} i x_i^4 + \mathrm{random}[0, 1]$	10	[-1.28,1.28]	[-0.25, …-0.25]	0

Table 2 (10 dimensional) multimodal standard functions [119]

Functions	Range	Shift position	f_{min}
$\boldsymbol{TF8}(\boldsymbol{x}) = \sum_{i=1}^{n} -x_i^2 \sin\left(\sqrt{\lvert x_i \rvert}\right)$	[-500, 500]	[-300, … -300]	-418.9829
$\boldsymbol{TF9}(\boldsymbol{x}) = \sum_{i=1}^{n} [x_i^2 - 10\cos(2\pi x_i) + 10]$	[-5.12,5.12]	[-2, -2, …-2]	0
$\boldsymbol{TF10}(\boldsymbol{x}) = -20exp\left(-0.2\sqrt{\sum_{i=1}^{n} x_i^2}\right) - exp\left(\frac{1}{n}\sum_{i=1}^{n}\cos(2\pi x_i)\right) + 20 + e$	[-32, 32]		0
$\boldsymbol{TF11}(\boldsymbol{x}) = \frac{1}{4000}\sum_{i=1}^{n} x_i^2 - \prod_{i=1}^{n}\cos\left(\frac{x_i}{\sqrt{i}}\right) + 1$	[-600, 600]	[-400, … -400]	0
$\boldsymbol{TF12}(\boldsymbol{x}) = \frac{\pi}{n}\{10\sin(\pi y_1) + \sum_{i=1}^{n-1}(y_i - 1)^2[1 + 10\ \sin^2(\pi y_{i+1})] + (y_n - 1)^2\} + \sum_{i=1}^{n} u(x_i, 10, 100, 4).$ $y_i = 1 + \frac{x+1}{4}.$ $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m\ x_i > a \\ 0\ -a < x_i < a \\ k(-x_i - a)^m\ x_i < -a \end{cases}$	[-50,50]	[-30, 30, ... 30]	0

$\mathbf{TF13}(\mathrm{x}) = \mathbf{0.1}\left\{\mathbf{sin^2}(\mathbf{3}\boldsymbol{\pi x}\mathbf{1}) + \sum_{i=1}^{n}(\boldsymbol{x_i}-\mathbf{1})^2[\mathbf{1}+\mathbf{sin^2}(\mathbf{3}\boldsymbol{\pi x_i}+\mathbf{1})] + (\boldsymbol{x_n}-\mathbf{1})^2[\mathbf{1}+\mathbf{sin^2}(\mathbf{2}\boldsymbol{\pi x_n})]\right\} + \sum_{i=1}^{n}\boldsymbol{u}(\boldsymbol{x_i},\mathbf{5},\mathbf{100},\mathbf{4}).$	**[-50,50]**	**[-100, … -100]**	**0**

Table 3 Composite standard functions [120]

Functions	**Dimension**	**Range**	$\boldsymbol{f_{min}}$
TF14 (CF1) $f1, f2, f3 \dots f10 =$ Sphere function $\delta1, \delta2, \delta3 \dots \delta10 = [1,1,1, \dots .1]$ $\lambda1, \lambda2, \lambda3 \dots \lambda10 = \left[\frac{5}{100}, \frac{5}{100}, \frac{5}{100}, \dots \frac{5}{100}\right]$	10	[-5, 5]	0
TF15 (CF2) $f1, f2, f3 \dots f10 =$ Griewank's function $\delta1, \delta2, \delta3 \dots \delta10 = [1,1,1, \dots .1]$ $\lambda1, \lambda2, \lambda3 \dots \lambda10 = \left[\frac{5}{100}, \frac{5}{100}, \frac{5}{100}, \dots \frac{5}{100}\right]$	10	[-5, 5]	0
TF16 (CF3) $f1, f2, f3 \dots f10 =$ Griewank's function $\delta1, \delta2, \delta3 \dots \delta10 = [1,1,1, \dots .1]$ $\lambda1, \lambda2, \lambda3 \dots \lambda10 = [1,1,1, \dots .1]$	10	[-5, 5]	0
TF17 (CF4) $f1, f2 =$ Ackley's function $f3, f4 =$ Rastrigin's function $f5, f6 =$ Weierstrass function $f7, f8 =$ Griewank's function $f9, f10 =$ Sphere function $\delta1, \delta2, \delta3 \dots \delta10 = [1,1,1, \dots .1]$ $\lambda1, \lambda2, \lambda3 \dots \lambda10 = \left[\frac{5}{32}, \frac{5}{32}, 1, 1, \frac{5}{0.5}, \frac{5}{0.5}, \frac{5}{100}, \frac{5}{100}, \frac{5}{100}, \frac{5}{100}\right]$	10	[-5, 5]	0
TF18 (CF5) $f1, f2 =$ Rastrigin's function $f3, f4 =$ Weierstrass function $f5, f6 =$ Griewank's function $f7, f8 =$ Ackley's function $f9, f10 =$ Sphere function $\delta1, \delta2, \delta3 \dots \delta10 = [1,1,1, \dots .1]$ $\lambda1, \lambda2, \lambda3 \dots \lambda10 = \left[\frac{1}{5}, \frac{1}{5}, \frac{5}{0.5}, \frac{5}{0.5}, \frac{5}{100}, \frac{5}{100}, \frac{5}{32}, \frac{5}{32}, \frac{5}{100}, \frac{5}{100}\right]$	10	[-5, 5]	0

TF19 (CF6) $f1, f2$ = Rastrigin's function $f3, f4$ = Weierstrass function $f5, f6$ = Griewank's function $f7, f8$ = Ackley's function $f9, f10$ = Sphere function $\delta1, \delta2, \delta3 \ldots \delta10 = [0.1,0.2,0.3, 0.4,0.5,0.6,0.7,0.8,0.9,1]$ $\lambda1, \lambda2, \lambda3 \ldots \lambda10 = \left[0.1 * \frac{1}{5}, 0.2 * \frac{1}{5}, 0.3 * \frac{5}{0.5}, 0.4 * \frac{5}{0.5}, 0.5 * \frac{5}{100}, 0.6 * \frac{5}{100}, 0.7 * \frac{5}{32}, 0.8 * \frac{5}{32}, 0.9 * \frac{5}{100}, 1 * 5/100\right]$	10	[-5, 5]	0

Table 4 The 100-digit challenge: CEC-C06 2019 standards [120].

No.	Functions	Dimension	Range	f_{min}
1	STORN'S CHEBYSHEV POLYNOMIAL FITTING PROBLEM	9	[-8192, 8192]	1
2	INVERSE HILBERT MATRIX PROBLEM	16	[-16384, 16384]	1
3	LENNARD-JONES MINIMUM ENERGY CLUSTER	18	[-4,4]	1
4	RASTRIGIN'S FUNCTION	10	[-100, 100]	1
5	GRIEWANGK'S FUNCTION	10	[-100, 100]	1
6	WEIERSTRASS FUNCTION	10	[-100, 100]	1
7	MODIFIED SCHWEFEL'S FUNCTION	10	[-100, 100]	1
8	EXPANDED SCHAFFER'S F6 FUNCTION	10	[-100, 100]	1
9	HAPPY CAT FUNCTION	10	[-100, 100]	1
10	ACKLEY FUNCTION	10	[-100, 100]	1

NOTE: Readers who concern to know more information about CEC benchmarks can access this paper [120].

دیزاینکردن و جێبەجێکردنی ئەلگۆریزمێک بۆدروستکردنی مۆدێلێکی دەرچون لە کاتی کتوپڕدا لەسەر بنچینەی
Improved Fitness Dependent Optimizer

نامەیەکە پێشکەشکراوە بە

ئەنجومەنی کۆلێجی زانست / زانکۆی سلێمانی

وەک بەشێک لە پێداویستیەکانی بەدەستهێنانی

بڕوانامەی دکتۆرا لەزانستی کۆمپیوتەر

(زیرەکی دەستکرد)

لە لایەن

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٢٠١٢ زانکۆی شیفیلّد، بەریتانیا

بە سەرپەرشتی

د. سۆران ابوبکر محمد سعید

پرۆفیسۆر

خەرمانان، ٢٧٢٠ | تەموز، ٢٠٢٠

پوختە

ژیانی مرۆڤەکان ڕوبەڕوی مەترسی دەبنەوە بە هۆی ڕودانی حاڵەتی کتوپڕ. بۆ بەدوربون لە ئەنجامە پێچەوانەکان (نەخوازراوەکان) وەک بریندار بون و مردن پلانێکی تۆکمەی دەرچونی بەپەلە گرنگە بونی هەبێت. لەمەوە، چەندین مۆدێلی جیاوازی دەرچونی پیادەڕەوی دروستکراوە، وە بەدواداچونێکی گشتگیر کراوە بۆ ئەم مۆدێلانە لەسەر بەکارهینانەکانیان، پشاندانەکانیان (لاسایکردنەوەکانیان) وە ئەو بوارانەی کە تێیدا بەکاردێن بۆ پێشنیارکردنی مۆدێلیکی گونجاو. هەروەها، مۆدێلە تازەکان باشتر کراون بۆ مامەڵەکردن لەگەڵ سیستمی دەرچون لە بیناکاندا لە کاتی روداوی کتوپڕدا. ئەم توێژینەوەیە ئەنجام دراوە بۆ دیاریکردنی ئەم مۆدیلانە وە ڕێگاکانی کە بەکاریان هێناوە لەڕوی تایبەتمەندیەکانی بەکارهێنانیان، تەکنیکەکانیان، ئەنجامەکانیان، پاشان کۆکردنەوەیان بە یەکەوە بۆ یارمەتیدانی توێژەرەکان کە بتوانن سودی لێوەربگرن لە بوارە جیاوازەکاندا وە بەکارهێنانی وەک ڕێنیشاندەرێک بۆ توێژینەوەی زیاتر لە داهاتودا. دواتر سودی لێوەرگیرا بۆ دیزاینکردنی مۆدێلێکی زیرەکی پشاندان "لاسایکردنەوە" بۆ ئەمەش Cellular Automata method (CA) هەڵبژێردرا بۆ پێکەوەبەستنی لەگەڵ بیرۆکەی Fuzzy logic وە K-Nearest Neighbors (KNN) وە هەندێک لە هاوکێشەی ئاماریی. ئەو مۆدێڵەی کە دیزاینکراوە بە وردی خێرایی هەر تاکێک لەسەر بنجینەی تایبەتمەندیەکانی،هەڵسوکەوتی هەر تاکێک لە کاتی کتوپڕدا ،وە کاتی دەرچون لە پرۆسەی دەرچونەکەدا دیاری دەکات. لە بەشێکی تری ئەم توێژینەوەیەدا ،یەکێک لە نوێترین ئەلگۆریزمەکانی کە لەساڵی ٢٠١٩ دا دروست کراوە ئەویش Fitness Dependent Optimizer (FDO) ە گۆڕانکاری تێدا کراوە، بەشێوەیەکی بەرچاو ئەم ئەلگۆریزمەی باشتر کردوە لەشیکارکردنی کێشە ئاڵۆزەکانی optimization. بۆ باشکردنی ئەم ئەلگۆریزمە لەم توێژینەوەیەدا بۆ تازەکردنەوەی شوێن کە لە FDO دا هەیە دو فاکتەرمان زیاد کردوە کە ئەوانیش Alignment and Cohesion ن کە ئەمانەش زیادکراون بۆ pace کە FDO خۆی پشتی پێدەبەستێت لە تازەکردنەوەی شوێن. هەروەها لە دیاریکردنی weights دا FDO هاتووە Weight Factor (WF) ی بەکارهێناوە کە سفر(٠) بووە لە زۆرترین حاڵەتدا وە یەک (١) بووە لە تەنها چەند حاڵەتیکدا. بەپێچەوانەوە، Improved Fitness Dependent Optimizer (IFDO) هاتووە (WF) ی کردوە بە شێوازێکی هەڕەمەکی لە نێوان [٠-١] ، وە بچوککردنەوەی ماوەکە هەرکاتێک fitness weight ێکی باشتری دەستکەوت. لەماوەی ئەم توێژینەوەیەدا، "IFDO" ئەلگۆریزم پشاندراوە، وە هاندانی پشت ئەمەش ڕونکراوەتەوە. پاشان "IFDO " تاقیکراوەتەوە لەسەر گروپێک لە هاوکیشەی ستانداردی کۆن کە ١٩ دانە بون وە

ئەنجامەکانیان بەراورد کراوە بە "FDO" و سێ ئەلگۆریزمی جیاوازی وەک Particle Swarm Optimization (PSO)،genetic algorithm (GA)، وە dragon fly algorithm (DA).زیاتر لەوەش ،"IFDO" تاقیکراوەتەوە لەسەر هەندێک لە هاوکیشەی ستانداردی تازە کە ئەوانیش " IEEE Congress of Evolutionary Computation Benchmark Test Functions (CECC06, 2019 Competition) نن. ئەنجامەکانیان بەراورد کراوە بە " FDO"و سێ ئەلگۆریزمی تازەی وەک (DA)،the whale optimization algorithm (WOA)، وە slap swarm algorithm (SSA). ئەنجامەکانی "IFDO " پشانی دەدات لەزۆربەی بارەکاندا باشترە وە لە بارەکانیتریشدا ئەنجامی چاوەڕوانکراوی هەبووە. لە کۆتاییدا "IFDO" بەکارهێنرا بۆ ئەو کارانەی کە لە ئێستادا ئەنجامدەدرێن واتە بۆ "real-world applications " کە یەکێک لەوانە ئەو مۆدێڵەیە کە خۆمان دروستمانکردووە. دیزاینەرەکان و شارەزایان دەتوانن ئەنجامەکان بەکاربهێنن بۆ بڕیارێکی باشتر لە سیستمی دەرچون لە بینادا.

تصميم وتنفيذ خوارزمية لنمذجة المحاكاة للإخلاء في حالات الطوارئ بناءً على
Improved fitness dependent optimizer

رسالة مقدمة الى

مجلس كلية العلوم / جامعة السليمانية

كجزء من متطلبات نيل الشهادة الدكتورا في علوم الحاسوب

(الذكاء الاصطناعى)

من قبل

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ذوالحجة، ١٤٤١ تموز، ٢٠٢٠

المستخلص

تواجه الأرواح البشرية مخاطر بسبب حوادث الطوارئ. تعد خطة الإخلاء الطارئة الكفوئة أمرًا بالغ الأهمية لتجنب العواقب السلبية ، مثل الإصابة والوفاة. ومن هنا تم تطوير نماذج إخلاء مختلفة للمشاة، وأجريت مسوحات شاملة حول هذه النماذج لمختلف التطبيقات والمحاكاة والظروف لتقديم نموذج عملي. علاوة على ذلك تم تحسين نماذج جديدة للتفاعل مع عمليات الاخلاء النظامي للمباني في حالات الطوارئ. هذا البحث يسلط الضوء على هذه النماذج وأساليبها من حيث ميزات التطبيق والتقنيات والآثار المترتبة عليها ومن ثم تجميع هذه النماذج لمساعدة الباحثين على استخدامها في مختلف الظروف وكدليل لتوجيه أبحاثهم المستقبلية و استخدامها في تصميم نموذج محاكاة ذكي جديد. تم اختيار نموذج الخلية المستقله (Cellular Automata) ودمجها مع تقنية المنطق الضبابي (fuzzy logic) وخوارزمية أقرب الجيران (KNN) اضافة الى بعض المعادلات الإحصائية لمعالجة المشكلة النهائية. النموذج المصمم في هذا البحث يحدد بدقة ما يلي؛ سرعات الأفراد استنادًا إلى خصائصهم، سلوكيات الطوارئ للأفراد ووقت أخلائهم خلال عملية الإخلاء. علاوة على ذلك ، تعد خوارزمية محسن اللياقة البدنية المعتمدة (FDO) أحد أحدث الخوارزميات التي تم تقديمها في عام ٢٠١٩. يقدم هذا البحث خوارزمية FDO محسنة (IFDO)واللتي تُحَسِن بشكل كبير من اداء خوارزمية FDO الأصلية في حل مشاكل التحسين المعقدة. تعمل خوارزمية IFDO على تحسين خوارزمية FDO عن طريق احتساب المحاذاة والتماسك ومن ثم استخدامهما مع وتيرة ال FDO في تحديث حالته. علاوة على ذلك، في تحديد الأوزان، استخدمت FDO عامل الوزن (WF) الذي كانت قيمته (٠) في معظم الحالات و (١) في حالات قليلة فقط. بينما خوارزمية ال IFDO اعطت قيم عشوائية لعامل الوزن (WF) ضمن نطاق [٠-١]، ومن ثم قامت بتقليل هذا النطاق كلما تم تحقيق قيمة وزن أفضل للياقة البدنية. خلال هذا البحث، تم اختبارخوارزمية ال IFDO على مجموعة من ١٩ وظيفة اختبار مرجعية كلاسيكية، وتمت مقارنة النتائج مع خوارزمية FDO وثلاث خوارزميات مميزة اخرى هي خوارزمية تحسين الجسيمات (PSO)، الخوارزمية الجينية (GA)، وخوارزمية ذبابة التنين (DA) ؛ اضافةً الى اختبارها في مؤتمر IEEE لوظائف الاختبار المعياري للحساب التطوري(CECC06, مسابقة ٢٠١٩). تمت مقارنة النتائج مع FDO وثلاث خوارزميات حديثة اخرى هي خوارزمية (DA) وخوارزمية تحسين الحيتان (WOA) وخوارزمية سرب اللافقريات البحريه (SSA). وقد أظهرت النتائج ان خوارزمية IFDO قدمت عرضا محسنًا في معظم الحالات ونتائج معقولة في الحالات ألاخرى. أخيرًا ، يتم تطبيق خوارزمية IFDO على التطبيقات الواقعية بما في ذلك نموذج المحاكاة لدينا كتأكيد على إمكانيته ويمكن للمصممين والخبراء استخدام النتائج لاتخاذ قرار أفضل في بناء نظام الإخلاء.