# Agent-Based Simulation of Human Behavior In the Case of Dangerous Events

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***Abstract*—The present world is struggling to a greater extent, with the problem of ensuring security. Hence the growing demand for simulations of dangerous events. Most of these events involve people's participation. In the case of large groups, it is easier. However, the problem remains of simulating the actions of individuals, especially those who are under the influence of strong emotions that usually accompany such events. The authors have attempted to solve this problem based on solutions previously used only in the computer games industry. The work discusses the basic assumptions, implemented mechanisms, and results of the first tests of the use of these mechanisms in simulations of building evacuation processes. The work consists of the following parts: Introduction, review of existing solutions, the proposal of a solution, description of the implementation, and discussion of the results so far.**

***Keywords— Security, human behavior modeling, agent-based simulation.***

## I. Introduction

The need to ensure that safety is one of the basic human needs. To ensure them, all knowledge available to man is used. No wonder, then, that the simulation of non-safe phenomena has been used since the possibilities of computers allowed them. However, most of the currently used algorithms have the disadvantage that it does not allow to investigate how human emotions can affect a simulated phenomenon. Our research aims to introduce the influence of emotions to the variables under consideration in the simulation process. This is intentional because human emotions have a very significant impact on the course of activities such as the evacuation of the building or the course of the attack. This is especially important when the dangerous phenomenon is the result of intentional criminal activity, not the forces of nature.

For research reasons, we have focused our research on the problem of simulating the evacuation process of a building. The simulated cause of evacuation can be both a natural phenomenon (fire, construction disaster), as well as a detrimental operation (bursting of an explosive charge, attack with a firearm, attack with a melee weapon).

## II. State of the Art

### A. Approaches To the Problem of Evacuation Simulation

In their work [1] Eric D. Kuligowski and Richard D. Peacock, and later [2] from Bryan L. Hoskins, carried out a detailed breakdown of the evacuation models. As you can see in these combinations, many models propose the use of a global approach to simulated people, which assumes that we study the overall flow of people. In such models, it is not possible to introduce individual behavior of people, as they do not exist as individual objects. It is also unintentional to simulate with these models the situations resulting from the intentional operation of the units present in the building since their impact is usually limited to individual units, and to a lesser extent to the flow of people as a whole. In the case of models treating individual evacuees individually, we can notice that the models that do not take into account the specific behavior of persons prevail or they consider them in a previously determined, deterministic way. However, more and more times there are more and more models attempting to simulate behavior in a more realistic way, through a combination of scenarios and random factors. It should also be noted that despite the manufacturers' declarations, one can not speak in such simulations about the use of artificial intelligence as a factor controlling evacuated units. What is called AI by producers is only a more complex system of assumptions and random factors. It does not contain a basic learning factor for the definition of AI. At the same time, it seems that it is not advisable to introduce self-learning systems for such simulations because in reality, people who are getting involved in the evacuation, for the most part, have no previous experience with this process.

Another issue in discussing existing models is the way in which the route that evacuees are moving. Many models assume that it will be the optimal route, without taking into account the knowledge of the participants of the event. A large group of models assumes that all people are moving in the same direction, which is usually true in the case of events such as fire, but it can be a problem when other situations are simulated. Another problem is whether during the movement the influence of neighboring people is examined. This is important when trying to simulate such situations as panic during the evacuation, where the greatest threats are precisely the result of the interaction of individuals.

The last aspect to which we would like to draw attention is the way of presenting the evacuated area. At present, the models considering evacuation on the plane prevail. The third dimension is either omitted or used only in visualization. This prevents a full analysis of the "field of vision" of the simulated persons, which translates into a higher level of abstraction in making decisions about behavior. It is also difficult in such an environment to carry out simulation of use firearms, because, as demonstrated by experience, in such situations the key factor was often the possibility of hiding from the attacker, and these opportunities resulted mainly from three-dimensional nature of rooms.

### B. *Analysis of Requirements*

Due to the fact that criminal activities are becoming more and more serious, it seems that the current approach to the problem of evacuation must change. Today, when planning an evacuation, in the majority of cases only the fire hazard is taken into account. Potentially, it creates weak spots in the building's security that can be used to attack. To counteract this, during the simulation, not only fire scenarios or similar risks should be considered, but also potential criminal activities. In order to be able to interpret the simulation results effectively, it is advantageous that they should be carried out on the same model. After tracing the available solutions, we decided that we need a model that meets the following requirements:

- Enables simulation of criminal activities on par with natural phenomena
- Can simulate various behaviors of people, including non-rational ones, resulting from emotional states resulting from an event
- It is possible to simulate complicated interactions between people
- It is possible to differentiate the parameters of simulated persons
- It is possible to carry out a large number of simulations at a reasonable time with various parameters and variants, which are also automatically created.
- The predicted route of movement is dynamically created on the basis of information available for a specific person.

Similar models are used in the video game industry to create opponents for players - bots. Hence, we decided to use the solutions used in creating games, as it is about simulating the influence of emotions, interactions and the ability to make decisions under the influence of stress.

## III. PROPOSED MODEL

According to the classification contained in [1] and [2], the created model can be defined as a behavioral model with risk assessment capabilities, models that can simulate any type of building, continuous Grid/Structure, individual perspective, conditional and probabilistic behavior, inter-person distance movement, and 3d space modeling.

The basis for the model is the use of objects - agents with the ability to interact with the environment.

Each agent has a set of statistic defining its capabilities in the reception of information and in its impact on the environment. These statistics can change during the simulation. They can be divided into two categories, "psychic", responsible for the reception of stimuli and "physical" responsible for interacting with the environment. In addition, the agent may have assigned markers that indicate sensitivity or insensitivity to specific factors. At the current stage, a model using six statistics is tested:

- Speed - determines the speed of the movement
- Strength - defines the possibility of an impact on the environment
- Durability - defines resistance to the influence of physical factors, reduces penalties to speed and strength for such factors as the strength of other people or smoke
- Knowledge - knowledge of the area, affects the chance to choose a better route without using the signage
- Perceptiveness - a feature that increases the chances of choosing a route based on marking and reacting to changes in the environment
- Mental resilience - a factor determining how the agent is influenced by psychological factors

Each factor affecting the agent has the following parameters: a range of impact (distance or line of increase), type of interaction (physical/psychological), and effect (modifiers to the characteristics of the agent). All impacts are modified by random distribution. Also included is a marker of non-sensitivity or vulnerability. The insensitivity mark decreases five times, and the vulnerability marker increases the factor's impact on statistics five times.

The path is determined as follows: first, it is tested by means of a random factor modified by the perceptive eye, or the agent sees where there is a way out of a particular room. If so, the road is defined as the route with the smallest cost of interactions towards the evacuation marker. If this is not the case, a random test is performed with the feature of knowing if the agent still chooses a good exit. If not, it moves to the site where the impact is the smallest. It is not necessary to create a separate principle of following the crowd, because in this case the lowest cost usually causes such behavior.

Emotional effects are simulated by modifying characteristics - for example, panic is defined as an increase in strength and endurance along with a decrease in perception and knowledge. The influence of physical factors is simulated in a similar way, for example, smokiness means a decrease in strength, speed and perceptiveness.

As you can see the basic principles of the model are quite simple, which allows for easy implementation and good computational efficiency.

## IV. The Planned Assessment Method

At the moment, it is planned to evaluate this model with two methods. First, the simulation results are compared to the passage of real events. Unfortunately, this must be real cases, not exercises, because this model focuses on phenomena that do not occur during tests. The second method is a comparison with other models, mainly with the BENTLEY SYSTEMS Legion model as the have most similar functionally.


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