Pompeii: Evacuation Simulator with Neural Network and Genetic Algorithm

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Abstract

This paper provides a research in the field of human behaviour in case of an emergency. The problem at hand is namely the creation of a simulator of a building in case of an accident. This work covers many already implemented solutions, takes into account their advantages and disadvantages and provides a final resolve for the task. The highlights of the resulting simulator are the different individuals with ranging characteristics that, therefore, make different choices in the same situation. This way the most realistic outcome for an emergency in a particular building could be examined and the right measures could be taken so the casualties could be avoided. Examples for such are more exits, better marking of the evacuation routes and better access to them.

Keywords— Evacuation, Human Behaviour, Machine Learning, Genetic Algorithm

Introduction

The question about the safety in different buildings is of great importance for our everyday life. The danger of casualties in case of different emergencies is strongly related to the plan of the given building. Many constructions don‘t have enough exits or they are not situated in the best possible positions which could lead to slowering of the evacuation.

There are many possible solutions to this problem, available with the help of the computer simulation, although just a very few of them could fulfill all the requirements. The result should show the expected behaviour of the individual, but one should take many details into consideration, as not all people show the same conduct. Clear examples for that are:

- the speed of different individuals (that could vary depending their age)
- their previous knowledge about the building

- their vision at the moment of emergency, as this could easily be altered (for instance by the smoke in case of fire).

Thus they are not expected to choose the shortest route to the exit rather make many micro-decisions that are most optimal for the momentary situation. Even if they do, it is not sure that it would be safe and they could use it.

Background

There are various reasons for the casualties during a fire emergency. The most popular belief is that the main one is the so-called "crowd panic" that causes the individuals to make irrational decisions that lead to their perish. This popular assumption is shown to be wrong by various studies. "After five decades studying scores of disasters such as floods, earthquakes and tornadoes,one of the strongest findings is that people rarely lose control." - Clarke2002

There are three misconceptions about human behavior in the event of an emergency including:

1) Employees respond to an alarm immediately which describes that in the event of an emergency people wait for additional signals, discuss each other whether it might be just a false or test alarm and thus waste seconds that can make a marked difference between life and death.

2) As soon as people discover that an alarm is for real, they will panic, whereas, in reality, panic is neither an automatic nor a particularly typical response.

3) In the actual event everybody only thinks of saving themselves. The theory of group affiliation strongly contradicts this statement, as it dictates that most of the people would not only try to self themselves, rather also the other members of their group.

In the light of the last few statements one could easily conclude that the reason for most of the casualties lies beyond the individual and is rather a part of his environment, ones behavior being a rather predictable constant.

In fact, the root of the problem after some studies is that majority of fire protection systems in buildings are put in place with false and incorrect expectations with respect to how people actually react in emergency situations. This explains the need of deeper study in direction of human behaviour in cases of emergency which could lead to its better understanding and better precautions could be taken, a deed indeed being in great help for decreasing the risk of casualties during different emergencies.

Possible solutions

1. Finding the shortest path with a simple algorithm from one point

   This solution gives the most basic understanding of the possible outcome of such accident, as it provides the best evacuation plan, although it doesn‘t give any additional insight for any real case. One could easili come to the conclusion that an individual is not very likely to choose the shortest path as he could not have the knowledge needed for that - this is rather a question of luck than anything else.

2. Creation of a graph and its examination

   Other possible decision could be the creation of a graph, its nodes being the doors and the edges connecting the doors in one room. They are weighted and have two main values - the time needed to reach the next door and the capacity of the given hallway. This is a reference to a common problem during evacuation - narrow corridors that cause jams and increase the time needed. This solution could be implemented with a combination of Dijkstra‘s algorithm, Maximal Flow Algorithm and Genetic Algorithm. The final result would give the answer to the question: "What is the maximal number of people that could safe themselves in an emergency?". It takes into account the number of people, the capacity of the corridors and thanks to the genetic algorithm it also covers the fact that most people won‘t use the most optimal path.

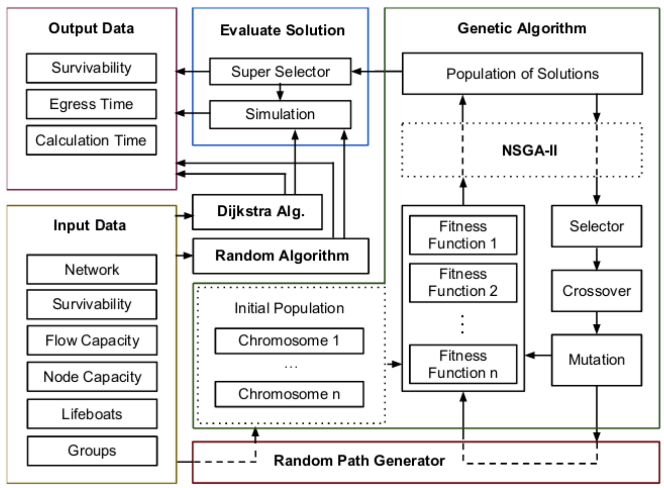

Figure 1: The overall system architecture with data flow

Although this could look like a quite suitable solution it still doesn‘t represent the case of real emergency, when some of the nodes and edges could be unavailable due to outside factors, like a fire in the hallway or smoke that tampers with the sight of an individual and therefore he couldn‘t choose this exit because of his impossibility of seeing it. This solution is still in the field of most optimal choices made and doesn‘t give any insight for a real situation, therefore proving its uselessness in this particular case.

Methodology

Computer simulation

The best method for finding the best solution is a simulation the whole process. This way it would be possible to not only find the weak points in the buildings plan, rather also observe the behavior of the objects and it would be easier to react properly to unexpected actions. The computer simulation consists of a 3D model of a building and of an object (MO = Main Object) that symbolizes a person. The target of the MO is to exit the building.

Main Object (MO)

The main object is the individual that tries to exit the building on time. It has many different characteristics, in their number his speed. With their altering one could change the characteristics of the whole individual and stimulate for instance the accessibility of an invalid to the exits. The speed varies also with the age - data suggests that people aged over 65 years old have double the chance of dying in a fire emergency.

Ray casting

The MO orients in its environment with the help of many rays that give information about the colliders ahead. This simulates a real-life situation when a person is in a room and has to choose an exit - the rays are the "vision" of the object. This way it could easily react to growing fire. With variation of the rays length one could simulate different disabilities. One example for this is the smoke in case of fire.

Neural Network

The human-like behaviour of the MO is implemented with a neural network. Its inputs is the information, gathered by the rays, and the outputs are the acceleration and rotation the MO should make.

Genetic Algorithm

The whole process is made with the help of a genetic algorithm. Every MO gets 20 clones with different DNAs, at the beginning they are generated at random. The DNA is the weights of the neural network. On the perish of every generation a new one gets created and by its creation the DNA of the two most elitist MOs are used. They go through mutation and crossing over so that the next MOs have behaviour close to that of their "predecessors".

Pathfinder

The fitness function of the algorithm should be implemented with a simple pathfinder, as the MOs should be evaluated. An algorithm as precise as Deijkstra for example could not satisfy the requirment for the movement to be as intuitive and close to natural as possible. This is why a pathfinder, probably to the closest door (not exits) could be the best fitness function for this case.

Implementation

Used technologies:

- Unity
- Blender (for the 3D objects)

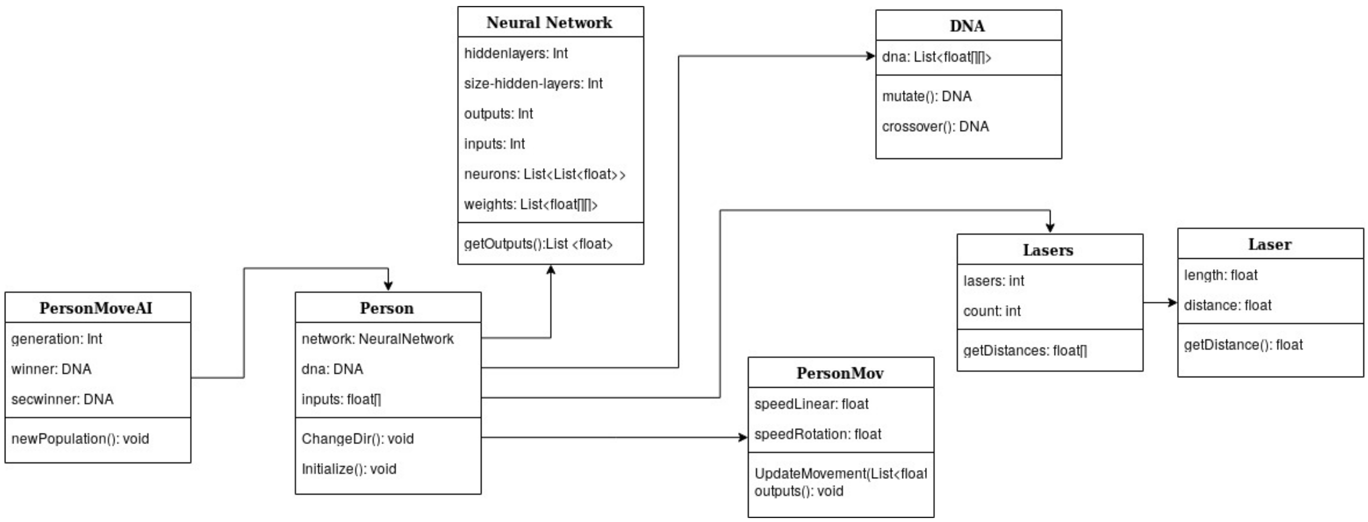

Figure 2: The overall project architecture

The project has working neural network at the moment that trains the objects properly. After some training there were even successful objects that ran away from the building. At the moment the project reviews only cases of fire.

Problems

1. Fitness function The fitness function is yet to be implemented. At the moment the MOs are chosen after the principle of the last one alive, which leads to them going around in circles. This has to get in order with the implementation of the pathfinder and setting the elitist ones as those that reach a position that is closest to the exit.

2. Fire Better implementation of the fire, as for now it is spreading in the 8 main directions (east, west, north, south and the diagonals) from the source and goes beyond the borders of the building.

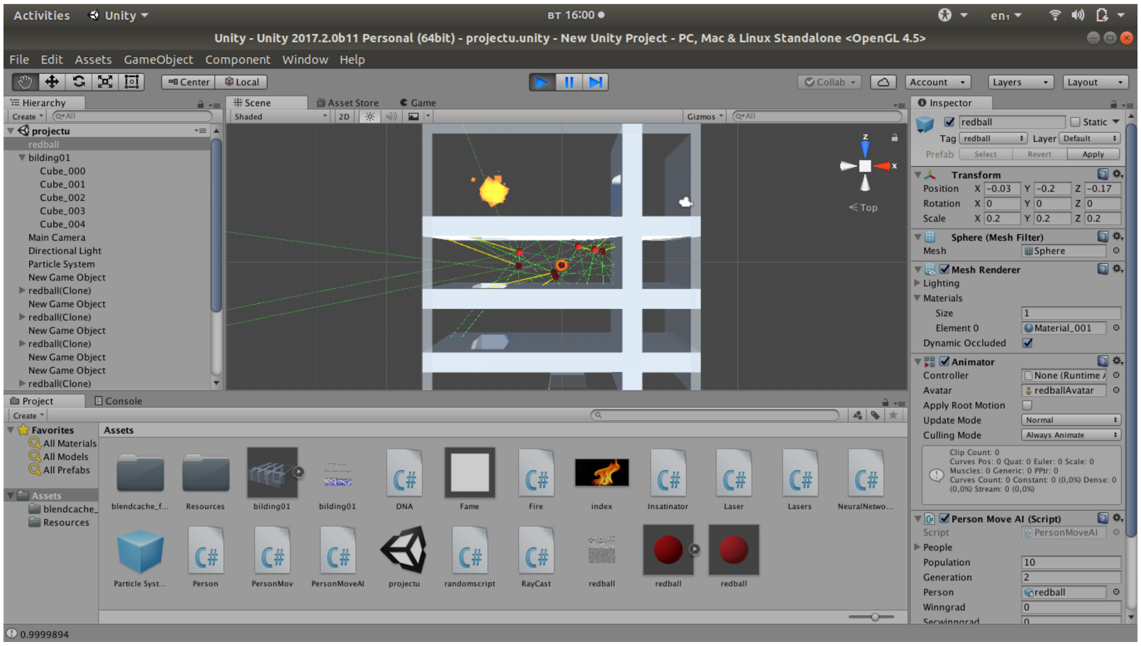

Figure 3: Screenshot of the project

Future development

1. The problems that occured to get solved
2. Adding different types of objects
3. Making more models of buildings and adding implementations for multiple-story ones
4. Adding more possible emergencies, as earthquakes, floods and terrorist attacks
5. Connecting to an experienced specialist in the field and making a more in-deep research
6. Adding more psychology-related settings
7. The project should not only find the weak points, rather suggest solutions to the problem and better plans.

Conclusion

This project solves an actual problem from our everyday lives. The research covers many possible solutions, evaluates them and chooses the best one. The result could be a great product that improves the safety level and helps safe lives in case of accidents(**?**).