Indoor Pedestrian Displacement Simulation

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***Abstract*—Simulation tools are usually used to simulate traffic movement but pedestrian movement has not been studied very extensively. In this paper the simulation of pedestians moving inside a shopping mall in Estonia was created and visulized. It was done to improve the movement of pedestrians inside the building, for example during an emergency evacuation.**

I. Introduction

There are quite many tools around to simulate the movement of vehicles and pedestrians outside to improve traffic light cycles, road networks and find junction bottlenecks. The authors of [1], for example, simulated the behaviour of pedestrians during 2008 Beijing Olympics Games using LEGION simulation software. In a result, the case study reduced the duration of the peak hour, prevented some probable safety problems and raised the level of service in the exits area. The problem is that indoor simulations have not received the attention that outdoor simulations have. One paper developed a "model for simulation of pedestrian movements in Hong Kong MTR stations" [2]. They collected data to get an origin-destination (O-D) flow matrix and used PEDROUTE, which is a pedestrian simulation model, to simulate the movements of pedestrians underground and in railway stations. With indoor simulation the movement of pedestrians could be improved, for example during an emergency evacuation. Different models can be used to simulate pedestrian evacuation and in [3] the authors "proposed an improved solution based on genetic algorithm" alongside "social force model lattice, gas model, and cellular automaton model". The idea for this project was to simulate the movement of pedestrians inside a building to get a visualization.

II. Background

The idea behind this paper was to visualize and simulate pedestriands moving inside a specific building. The building chosen for this project is Ülemiste Keskus in Tallinn because it is a shopping center which means there might be large crowds inside and it would help to make the emergency evacuation plans better. For the project I used OpenStreetMap to get the map of the building and the corridors of the building which people can use to move around in, and also Simulation of Urban Mobility (SUMO) to simulate and visualize the movement of pedestrians. Other simulation tools for Linux are often not free of charge (for example Simwalk) but the goal was to use a free open-source software. That is why SUMO was chosen. Pedsim is a pedestrian simulation package for Linux which is written in C and is open-source [4]. The author does not have a lot of experience with C and SUMO is written in Python. Therefore, SUMO was a better fit.

A. OpenStreetMap

For this project OpenStreetMap was used to get the geographic data about Ülemiste Keskus. The data in OpenStreetMap is provided by volunteers who enter "data about roads, trails, cafés, railway stations, and much more, all over the world" [5]. There are other projects related to OpenStreetMap that specifically map indoor data, e.g. OpenLevelUp and ID-indoor [6]. Unfortunately it was impossible to export the data from these sites into a .osm format so that SUMO could convert it into a suitable network file. Therefore, it was best to use the data from OpenStreetMap.

B. Simulation of Urban Mobility

Simulation of Urban MObility (SUMO) is an open source road traffic simulation which can be used on different operating systems [7]. It can also handle large road networks. It has been available since 2001 and it is "mainly developed by employees of the Institute of Transportation Systems at the German Aerospace Center" [8]. With SUMO it is possible to visualize road vehicles, public transport (buses, trains, etc.), bicycles and pedestrians. Furthermore, SUMO is a suite of tools - it includes network generation tool (netgenerate), network convertion tool (netconvert) and tools to convert different data (O/D matrices, turn percetages, cross-section detectors) into trips. Also, it is possible to run the simulation with two options. The first option is the command line tool and the second option is the GUI application [7].

III. Implementation

Installing SUMO on Ubuntu is easy. It can be installed using `apt-get`. For the network map I exported a map of Ülemiste Keskus in Tallinn from OpenStreetMap. The output from OpenStreetMap is in .osm format which can be converted into .xml using SUMO's command line tool `netconvert`. The converted network map be seen in Figure 1. The blue ellipse in the map shows the location of Ülemiste Keskus. The roads inside the ellipse are corridors inside the shopping mall.

Since `netconvert` only converts nodes and edges into a network, it looses buildings, water, forests, parks, residential, commercial and industrial areas, shops and amenities. They

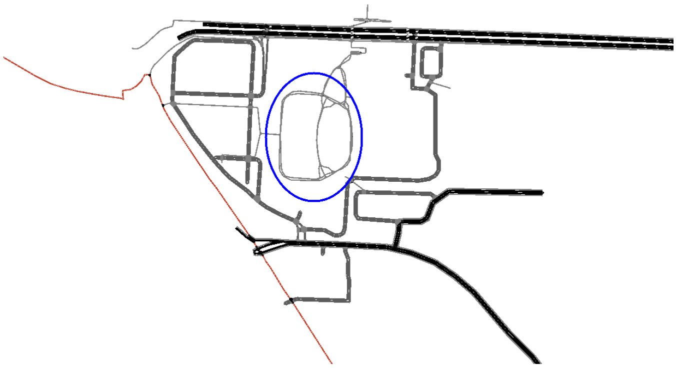

Fig. 1. Converted map from OpenStreetMap

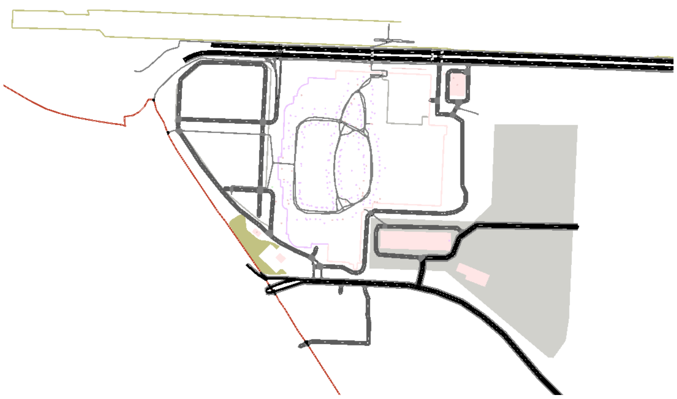

Fig. 2. Converted map with polygons

can be added back with the `polyconvert` command which "imports geometrical shapes (polygons or points of interest) from different sources, converts them to a representation that may be visualized using SUMO-GUI" [9]. The converted map with polygons added can be seen in Figure 2.

After the map is ready to be used, it is possible to move on to the simulation part of the implementation. SUMO's package includes 2 Python scripts that can be used to generate random trips. The first one is specifically for generating random pedestrian flow, but the downside is that it needs separate edge and node files. The network map that was generated from the OpenStreetMap data is one file that specifies both edges and nodes so it could not be used. The second file is for generating random trips. The options include specifying the vehicle class (bus, rail, pedestrian, bicycle, etc.), begin and end time of the simulation, weight edge probability by number of lanes or length. Moreover, there is a specific option `–pedestrians` which creates a trip file for people and not for vehicles.

IV. Results

In Figure 3 and Figure 4 the simulation is running. The blue numbers represent the id's given to pedestrians. When comparing Figure 3 and Figure 4, it can be seen that the pedestrians move around and some finish their route, i.e they are removed from the simulation. Pedestrians also appear on

Fig. 3. Snapshot 1 of the running simulation

Fig. 4. Snapshot 2 of the running simulation

the edge of the roads because only a selected area of the map is used in the simulation.

V. Conclusion

During this project, geographical data was downloaded from OpenStreetMap and converted into a suitable format for SUMO. Moreover, buildings, water, forests, parks, residential, commercial and industrial areas, shops and amenities were added into the converted map to make it more human-readable. Furthermore, random trips were generated for pedestrians and the simulation was run using the GUI version of SUMO. The visualization clearly shows pedestrians moving around inside and outside the selected building, Ülemiste Keskus. For future the simulation can be changed to improve the emergeny evacuation.

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