MS-E2177 Operaatiotutkimuksen projektityöseminaari

Project plan: Pathfinding in agent-based people flow simulation

Client: KONE

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1. Background

This project was assigned to us by KONE, one of the largest elevator and escalator manufacturers worldwide. In this project work, we focus on the tactical level of pathfinding by collecting qualitative data from several locations of interest in order to distinguish different passenger groups and to gain insight on their patterns of movement inside the buildings. This data can then be applied to obtain more realistic people flow simulations.

The objective of people flow planning is to define a set of transportation devices and their corresponding parameters, such as speed, capacity and location, so that the people flow throughout the building is smooth and efficient. This means designing transportation services that result in feasibly short customer waiting times. This planning is often based on simulations of people moving inside the building, and the simulation results in turn depend on the modeling of the passenger characteristics and paths these passengers take. In order to achieve realistic simulation results, a model that describes how passengers find their way from start to destination is required.

Passenger pathfinding can be described via a so-called hot spot network. These hot spots are special locations in the building that serve some functionality to either some or all of the passengers. A typical example in a metro station would be the main entrance, through which all passengers must pass. The following hot spots depend on the characteristics and agenda of the passenger: some may need to buy a ticket, so their next destination could be either a kiosk or a ticket machine, whereas others who already have a ticket may proceed directly to the escalators leading to the station platform. The ultimate destination of different users may be the same, but the hot spots they visit between the extreme points may differ substantially.

2. Objectives

The primary goals of this project work are twofold: The first is to define and characterize the typical user groups and hot spots of different types of buildings. The aim here is to explain which user groups are the most prominent in each building, what are their typical user characteristics including speed, access and space demand, and what are the most typical patterns of movement inside the building that the members of this specific user group take. This means that we need to be able to differentiate between different user groups, which are separated by some key characteristics that are unique to that group.

After this data collection, the second goal is to apply our findings in developing a method which generates the hotspot network and finds the shortest paths for each typical user group, given a building with a set of hot spots. This method is to be developed by using Matlab to which both KONE and the student team have access. The shortest path part of the method will be solved by applying Dijkstra's algorithm, applied to the context of people movement. There will most likely be need for additional functionalities, including special cases where some of the typical hotspots are missing for some specific building, which then needs to be taken into account in the shortest-path problem.

3. Tasks

The tasks that will be carried out during the project are the following:

1. **Project planning with client**

   The first important part of the project is to discuss the primary objectives with KONE's representatives and to understand their needs. This is essential in ensuring that the project starts in the desired direction from the start. We also receive additional relevant information regarding people flow planning and already some information on the upcoming site visits for data collection.

Responsible: all

2. **Data collection**

   The real project work kicks off by the student group visiting several different sites, in which the typical user groups and the hot spot networks are qualitatively identified and documented. This is done by using an assessment form provided to us by KONE representatives. This assessment form is two-part: the first includes the main objectives (user groups & hot spots), and the second part has additional questions regarding ease of access and logic of the building's layout. Additionally, for each location a map is drawn where these hot spot networks are drawn to gain a more visual representation.

   Data collection is started early on, already before development of formal project plan. That is possible because data collection method is well-established and kick-off discussions with the client enabled cooperative setting of objectives and approach.

   Responsible: all

3. **Project plan development**

   After discussing the depth of the project with the client, a more specific project plan needs to be written. This includes all relevant information regarding the completion of the project: background, objectives, tasks, task scheduling, project resources and project risks.

   Responsible: all
   Lead: Jani

4. **Literature review**

   In order to gain some additional insight on people flow simulation from theoretical perspective, literature relating to the subject will be reviewed during the early parts of the project. This helps us design the model to be implemented in addition to which new ideas for the project work may be discovered. Emphasis is on literature relating to principle of least effort (e.g. Guy et al., 2012, 2010), Dijkstra's algorithm (Dijkstra, 1959) and people flow modeling in general.

   Responsible: all, specifics will be decided later

5. **Data review**

   After the data collection, the data needs to be combined and refined so that it can be presented to the people at KONE. The data is most likely going to be reviewed by them, perhaps together with the student group. Specific details regarding this are still unknown at the time of writing this report.

   Responsible: all

6. **Model structure specification**

   After verification of data, the model structure needs to be specified. This includes the layout, inputs and outputs of the model. This will be done in cooperation with KONE.

7. **Interim report development**

   Another brief report will be written in the middle of the project to show our progress and findings up to that point and possibly include changes in our project goals and tasks, if deemed necessary.

   Responsible: all

8. **Model implementation**

   After specifying the model structure, it then needs to be implemented. This will be done by using Matlab, since it is the program that KONE uses.

   Responsible: all, specifics will be decided later
   Lead: Jani and Saku

9. **Model validation & verification**

   When the model has been built, it will be validated to ensure that the model makes sense and can be of actual use to the client. This is likely to be done both internally in the group as well as by the KONE personnel.

   Responsible: all, specifics will be decided later
   Lead: Jani and Saku

10. **Final report development**

    As the final part, a larger written report of the project work and its results is going to be done. This includes all relevant information regarding the outcome of the project and the steps taken to achieve it.

    Responsible: all
    Lead: Sami

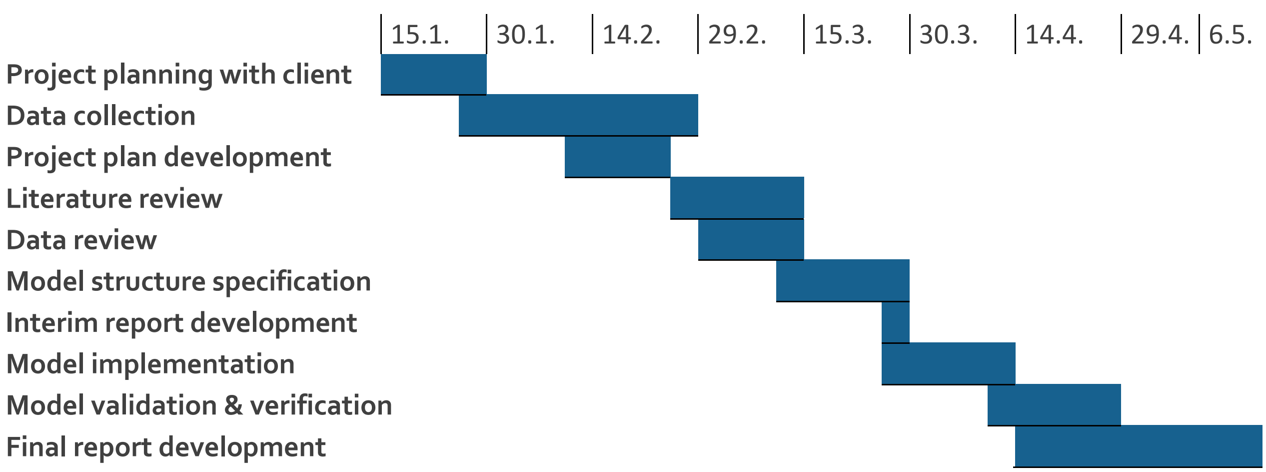
4. Schedule

The project schedule is presented below. This is only a rough sketch depicting the planned progress of the project. The actual completion times may somewhat differ from this plan. The most important dates/deadlines are as follows:

26.2. Presenting the finished project plans

1.4. Presenting the interim reports

6.5. Presenting the final reports



5. Resources

Our core project team consists of three people all of whom have background in both Industrial Engineering and Management and Operations Research, as well as work experience from related fields. The project tasks are distributed evenly among the project group, and each person's strengths are being taken into account. Jani and Saku lead modeling, while Sami leads final report development and project management. Other tasks are divided based on resource availability and realized workload.

Important supporting resources include the course personnel, Professor Ahti Salo (Aalto University) and course assistant B.Sc. Teemu Seeve (Aalto University). The course personnel provide additional feedback and suggestions during this project.

Our contact group inside KONE consists of Juha-Matti Kuusinen, Marja-Liisa Siikonen and Hannu Nousu. They play a central role in assessing our progress and ensuring that our work is aligned with their interests. We plan to have continuous communication both through e-mails and physical meetings to ensure that the focus of the project stays on track.

6. Risk evaluation & management

Here we assess the possible sources of risk during the project. The goal is to identify possible risks, including both their effect on the project and their probabilities, as well as reduce the effect of these risks and increase our readiness to deal with them, should the risks be realized. The risk probabilities are assessed qualitatively by estimating them on a discrete scale: Remote – Unlikely – Probable – Likely – Certain.

Risk	Probability	Effects	Impact	Prevention/Mitigation
Member absence / inactivity	Remote (<5%)	Delays in project completion, increased workload for other group members	Intermediate	Maintain good working environment, redistribute work if needed
Workload becomes too large	Unlikely (<10%)	Failure to meet project objectives	High	Discuss the scope with client / course staff
Poor collected data quality	Probable (<40%)	Increased workload	Low	Collect additional data, ask for advice, observe in groups
Poor model specification	Unlikely (<10%)	Model needs to be rebuilt	Intermediate	Ensure model includes all relevant information, discuss with client before actually building the model
Unsatisfactory model	Unlikely (<20%)	Model does not fit the client's needs	High	Good model specification, additional input from client, more Matlab experience

Disclosing confidential information	Remote (<5%)	Loss of trust from client, legal sanctions	High	Ensure before publishing the reports that they do not include any confidential information

These are the main risks identified by our group that may have an effect on the project. These risks are mainly focused on the workload and the objectives of the project, including both the data collection and the model to be built based on this data.

Member inactivity or absence is one risk, although highly unlikely, as everyone at this point is committed to the project. It is important, however, to ensure that everyone in the project group has something meaningful to do and that the tasks are distributed evenly.

There is also a risk that the project workload becomes too large, although the scope is quite well-defined at this point. In this case, additional discussions regarding the project scope will need to be done with our client and possibly the course staff as well.

Our data collection method might yield low quality data, which may be caused by bad timing at the site, some other external factors or observers' inability to discover the most relevant aspects relating to people flow. However, the data collection does not require very much time per site, and if one data collection time fails, we can always do it again without losing too much. We also observe in groups, facilitating discussions and correct emphases.

Regarding model specification, there is a risk that the model is poorly specified and therefore needs to be rebuilt. This can be prevented by keeping in contact with the client and ensuring that all relevant information is included in the model.

The model may turn out to be unsatisfactory to the client due to some lacking functionalities or for some other reasons. Good model specification and the sharpening of our Matlab skills should help us prevent this risk from occurring.

The group members have signed an NDA regarding the project, meaning that we must not disclose any information that is deemed confidential by KONE. This means that both KONE and the project team will carefully read the developed reports to ensure that they do not contain such information.

References

Dijkstra, E.W., 1959. A note on two problems in connexion with graphs. Numer. Math. 1, 269–271. doi:10.1007/BF01386390

Guy, S.J., Chhugani, J., Curtis, S., Dubey, P., Lin, M., Manocha, D., 2010. Pledestrians: a least-effort approach to crowd simulation, in: Proceedings of the 2010 ACM SIGGRAPH/Eurographics Symposium on Computer Animation. Eurographics Association, pp. 119–128.

Guy, S.J., Curtis, S., Lin, M.C., Manocha, D., 2012. Least-effort trajectories lead to emergent crowd behaviors. Physical review E 85, 016110.

VERSION HISTORY

Version	Approved by	Date	Comments
0.9	Jani	19.2.2016	First version, to be proofread and given additional input if deemed necessary by other group members
1.0	Sami & Saku	23.2.2016	Final, proofread and appended, version
2.0	Sami, Saku & Jani	2.3.2016	Comments given after project plan presentations are taken into account

Hyväksyjä Date Hyväksyjä Date