TU-E2177 Operaatiotutkimuksen projektityöseminaari

Interim report: Pathfinding in agent-based people flow simulation

Client: KONE

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28.03.2016

1. Objectives

The main objectives of the project have not changed, and are as follows:

1) Define and characterize the typical user groups and hot spots of different types of buildings
2) Apply the findings of the first objective 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

The first objective has already been achieved and the results have been verified by the project employer. The second objective is ongoing and to be reached within the schedule presented in Chapter 3.

2. Main actions taken and brief results

Here we describe the key actions taken along with brief results of the project thus far. Tasks associated with project planning and interim reporting are not described here in order to avoid repetition.

Data collection & review

We have collected necessary data from five different locations. The data collection was guided by forms developed by KONE, including for instance characteristics of different user groups, hot spot networks, typical hot spots for each user group as well as other aspects of the building and people flow. We reviewed the data and sent it to KONE for further study. Additional reviews, conducted together in collaboration with KONE representatives, confirmed that the collected data was of sufficient quality and the accuracy of observations reasonable, when considering our limited observations. Our results indicate that user groups are in fact identifiable and separable with respect to their typical paths and several other physical and behavioural characteristics, although these user groups vary significantly in different types of buildings.

Literature review

Review of the literature has been conducted to a sufficient extent, albeit writing it formally is still in progress. The most relevant aspects in literature are related to people flow and crowd simulation, graphs for modelling the hot spot networks, and Dijkstra's algorithm for finding the shortest paths in graphs. Literature has inspired us in developing the structure of the model and support for the chosen approach exists.

Model structure specification

This is our first main task regarding our second main objective in this project. The structure of the model has already been specified in collaboration with KONE. The model defines default hot spot networks and user groups for a certain type of building, presented in the form of several matrices. This matrix-based information is then to be applied by the model to compute the paths taken by each user group in the hot spot network.

The hot spot network can in fact be modelled as a graph, and the corresponding matrices are typical node-arc–incidence matrices that contain available routes indicated by a positive distance between any pair of two hot spots. The problem to be solved with the model is not, however, a simple shortest-path problem between two nodes in the graph depicting the hot spot network. This is because we want to be able to model the fact that not all user groups simply take the shortest path between their start and end points: they may have additional preferences or restrictions which affect the paths they take in the overall hot spot network.

The characteristics of each group are going to be taken into account by using a set of Preference matrices. In practice, preferences for a certain user group are not necessarily strict, meaning that while a specific user group may prefer to visit some specific hot spots along their path to their destination, they may not be necessary for the entire group. Our approach to this problem is based on the notion that user groups can be thought to consist of several subgroups, for which all of the corresponding preferences are strict. This results in the Preference matrix being binary in nature: each node is either *must-go-through* (1) or *indifferent* (0). This formulation results in increasing the amount of different groups, but it results in higher overall simplicity of the model. Since we have already estimated the percentage shares of different user groups, it requires little effort to further divide these groups into subgroups based on the original percentage shares and our observations. Then, if some of the necessary conditions of a specific subgroup are not met, the members in the subgroup can be moved to the corresponding upper level user group.

Dijkstra's algorithm can first be used to find the shortest distances between each pair of vertices in the overall hotspot network. We may then use this information to create a subgraph that touches all of the specific subgroup's necessary hot spot nodes. This smaller problem, separately defined for each user subgroup, is now basically in the form of a simplified Traveling Salesman Problem. From each subgraph, we may solve the shortest paths that take into account the subgroups' preferences by e.g. checking all possible permutations of *must-go-through* nodes from start to finish. This should be computationally feasible assuming that the number of nodes is not very large, which is certainly true in our hot spot network setting.

As the focus of the model is on hot spot networks and user groups, which are considered as time-independent in our model, it is not in the scope of our project to take into account the simulation process –related factors, e.g. the time dependency of arrival which is typically modelled as a Poisson process. Our goal is to solve the pathfinding-related problems that can be considered static: the hot spot network or group preferences are not changing over time. Naturally, the results should still be applicable in a simulation-based, dynamic setting. We can of course assume a certain amount of people arriving at one point of time that can be leveraged in modelling the realized paths.

3. Tasks & schedule

There have occurred no changes in the tasks or division of responsibilities within the scope of this project. For more detailed information of them, please refer to the project plan.

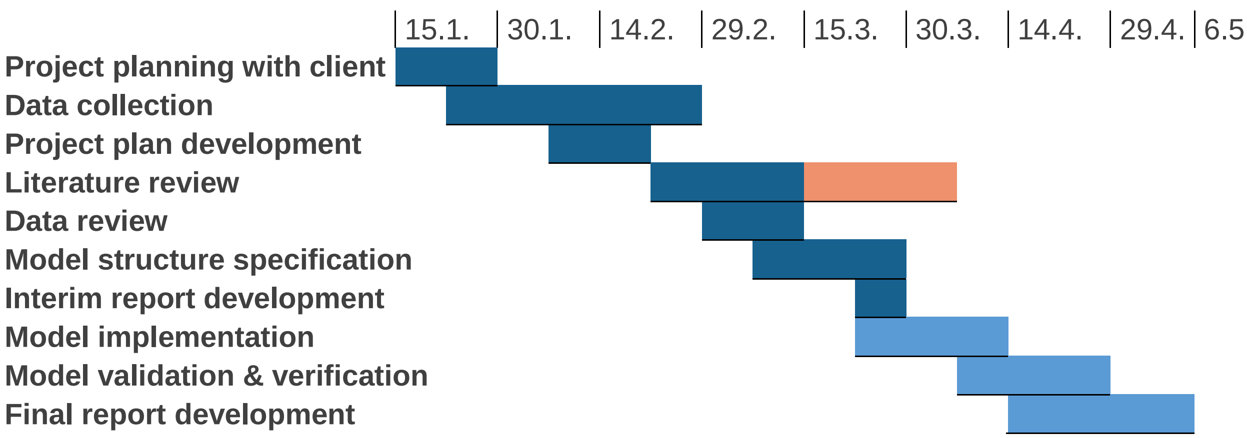
In comparison with the project plan, one change has been made in the schedule according to which task are carried out. The change is that the period for conducting literature review has been extended. Literature has been reviewed to an extent that suffices for implementing the model due to which it poses no problems for proceeding with other tasks. However, the original plan was to have the literature review already written while there still remain certain parts to be finished. The delay is caused by resource constraints and several overlapping tasks in a relatively short period of time.

All other tasks up to the model specification part has been successfully performed, but the implementation part is slightly behind schedule due to other obligations of the group members. During the coming weeks, the project group members should have additional time and resources available to focus on implementing the specified model. There should of course be enough room left to allow for minor changes and further specifications in the model if deemed necessary. All in all, completion of remaining tasks within the schedule seems very likely.

The project schedule is presented below. The most important dates to come are:

1.4. Presenting the interim reports

6.5. Presenting the final reports



4. Risk evaluation & management

The risks identified in project plan have not disappeared but the probabilities of most risks have decreased as a result of project progress and more elaborate information. None of the probabilities have increased, reflecting conservative and somewhat successful initial estimation, while only the probability of one risk (Disclosing confidential information) remained unchanged.

The updated risk probabilities are highlighted with orange in the table below. They are assessed qualitatively by estimating them on a discrete scale: Remote – Unlikely – Probable – Likely – Certain. The evaluations of effects, impacts and prevention methods have not changed after project plan development.

Risk	Probability	Effects	Impact	Prevention/Mitigation
Member absence / inactivity	Remote (<1%)	Delays in project completion, increased workload for other group members	Intermediate	Maintain good working environment, redistribute work if needed
Workload becomes too large	Remote (<5%)	Failure to meet project objectives	High	Discuss the scope with client / course staff
Poor collected data quality	Unlikely (<10%)	Increased workload	Low	Collect additional data, ask for advice, observe in groups
Poor model specification	Remote (<5%)	Model needs to be rebuilt	Intermediate	Ensure model includes all relevant information, discuss with client before actually building the model
Unsatisfactory model	Unlikely (<15%)	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