Navigation Systems for Pedestrians: Automatization of Data Acquisition

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Wayfinding is a vital part of our everyday life. Since it is our daily routine, hardly anybody realizes what a demanding task it is and that it requires certain spatial and cognitive abilities. To develop supporting tools for wayfinding, it is essential to know the mechanisms that control these processes. At present, there are a number of different electronic tools available aiding wayfinding: Personal Navigation Devices (PND), Mobile Phone Navigation Systems, GPS maps, Mobile guides, GPS watches, and off-line systems (so-called "route-planners"). Can one modify such systems in a way that pedestrians can use it? The problem is more complex than one might imagine at first sight. Field tests of GPS maps and car navigation systems show that they do not meet the requirements of pedestrian users. The main problem with navigation systems that are provided so far for car drivers are confusing instructions for pedestrians Car and pedestrian navigation differ in:

- Degree of freedom: car drivers are restricted to the street network (specifically to the lanes). Pedestrians are fairly free in movement.

- Velocity of movement: pedestrians are moving with a speed that is few times slower than the speed of car. That results in different perception of surrounding environment.

- Spatial resolution: because of our reduced velocity as pedestrians, we can observe surrounding environment in a more detailed way.

The differences between car drivers and pedestrians are classified when we elaborate a certain human wayfinding model, which could work for pedestrian users. Pedestrians have certain capabilities that allow them to interact with the environment. We are able to perform some physical operations, we can also act upon this environment and receive a sensory input in a recurring loop, which is shown as collection of the "knowledge in-the-world" and storing it as the "knowledge-in-the-head". This sort of interaction requires structuring the knowledge in a way that makes it easy to be mentally available, therefore we require a cognitive representation of this environment.

The graph that is used as a simulation of pedestrian navigation is different from the one used in car navigation. In car navigation system decisions are made at decision points. It is believed that this internal structure of decision points, although negligible for car navigation, must not be neglected for pedestrian navigation systems. In the presented wayfinding model we introduce the decision scenes, after considering the immediate environment in conjunction with the local decision points. We can define decision scenes as the local vista space around a particular decision point. It can be entered and left and its physical boundaries are fixed by buildings or other solid obstacles that prevent movement. These constrains are imposed by, for example, traffic lanes that are not suited for passage (excluding crosswalks). Decision scenes are adjacent to each other, forming a partition of the walkable space. As decision scenes are physically bounded, they can be entered and left. The borders between two decision scenes are labeled portals and connect neighboring scenes. The option of walking directly from one portal to another is represented by the complete graph constructed between the portals. Using this connection, direct navigation between portals is modeled without inclusion of the local decision point.

Differences between systems for drivers and for pedestrians imply that the data supplying them cannot be based on the same datasets. Therefore, there is a need to acquire data from a source and to keep costs low. Automatization of the process of data acquisition is thus required. The aim of this research was to process a raster map in a way that would result in obtaining navigationable space for pedestrians, additionally divided into decision scenes and concerning foundations of the wayfinding model. The following steps of automatization included: initial preprocessing of the data, binarization, skeletonization, and space tessellation using Voronoi diagrams.

The first step before processing the data, or getting data ready for further processing, was to analyze it. It was essential to investigate which pixel values correspond to which land use features. Having this information provided, the next step was to distinguish between areas that can be used by pedestrians and areas that cannot.

After analyzing raster data we binarized the map. The main aim of this step of processing was to prepare data for the skeletonization procedure. We had to analyze the data obtained so far after pre-processing stage, from the data consistency and correctness point. Binary images were used to distinguish between areas that are navigationable and non-navigationable by pedestrians. During this process we had to cope with problems caused by low quality of input data.

Having the binary image, we approached to perform skeletonization operation. An important approach for representing the structural shape of a plane region is to reduce it to a graph. This kind of reduction can be accomplished by obtaining the skeleton via a thinning algorithm. The most important result of the skeletonization is that it retains an object shape, and what follows, its topology.

The last step of automatization process was to create decision scenes. It was accomplished using space tessellation with Voronoi diagrams. According to the wayfinding model, the decision scenes were built around the decision points.

The most relevant outcome of this work is an elaborate consideration of automatic acquisition and processing of data provided for navigation systems for pedestrians. It is possible to automatically produce navigationable graph for pedestrian navigation systems. The main directions of future development are stressed principally on implementing this solution into mobile device that will be able to cope with the new system. What is also of significant importance, there are some improvements on the algorithm that have to be made. For example, we still do not know where we should put decision points along straight route. Creating decision scene in long sidewalk corridor is not always efficient and convenient.