Recent Advances and Challenges in the Development of Landmark-based Pedestrian Navigation Systems using OSM

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Extended Abstract

Literature shows that pedestrian navigation systems profit from including landmarks into navigation instructions (Ross et al. 2004). Landmarks serve as reference points supporting navigation decisions (Millonig & Schechtner 2007). Still, today's publicly available pedestrian navigation systems continue to use paradigms developed for car navigation, which use only street names and street network geometry to generate turn-by-turn instructions such as "In 500 meters, turn right into Main Street". In order to allow navigation by landmarks, it is necessary to provide more information (Elias 2003) and connect it to the pedestrian route in meaningful ways using a landmark navigation model (LNM). Current research aims to finally bring landmark-based navigation to the end user (Rousell et al. 2015, Graser 2016a) using data from OpenStreetMap (OSM). OSM is open and globally available and contains both information about the pedestrian network, as well as potential landmarks. Using OSM ensures that the LNM is widely applicable rather than restricted to a certain area with exceptional data sources.

This work summarizes recent advances, including our own (Graser 2016a, Graser 2016b, Naumann et al. 2016) and related publications, and discusses open challenges in the development of landmark-based pedestrian navigation systems using OSM. Landmark-based pedestrian navigation systems require the development of algorithms covering three main stages: 1) generating a suitable pedestrian routing graph, 2) extraction, weighting, and selection of landmarks based on their suitability and 3) generation of landmark-based navigation instructions. In the following we describe the advances and major challenges of the three stages.

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A graph dedicated to pedestrian routing consists of sidewalks, road crossings, squares or plazas and – only in case no sidewalks are available – roads and paths themselves as they are used for vehicle routing. In order to construct such a graph from OSM, it is necessary to deal with different representations of pedestrian infrastructure. Most notably, sidewalks can be represented as either separate line features or as attributes of the corresponding road feature. A suitable algorithm therefore has to construct sidewalks from attributes (Naumann et al. 2016) and be able to merge both representations, which is still an open issue. Furthermore, a pedestrian routing graph should also enable realistic crossing of open spaces, such as squares and plazas. Different approaches, including visibility graphs (Graser 2016b) have been proposed to tackle this issue.

Using landmarks from OSM requires the automatic extraction of a set of potential landmarks, from which the most suitable landmark is subsequently selected. Potential landmark features can be points, lines, or polygons. Current landmark selection algorithms deal with points and polygons (Rousell et al. 2015, Graser 2016a), but so far ignore linear features such as rivers. Another open issue is how to determine the visibility of landmarks from a certain decision point. Current approaches using line of sight estimation (Rousell et al. 2015) are computationally expensive and have issues dealing with potential landmarks which are modeled as points within polygons, such as multiple shops within a big building. On a similar note, selecting the most suitable landmark is complicated by the fact that not all sides of a building have the same visual salience. For example, a hotel might stand out if approached from the front but less so if approached from a different side. To the best of our knowledge, this issue has not been solved in any of the OSM-based LNMs.

Experiments using basic “car navigation” methods to generate instructions, have shown that these tend to produce too many navigation instructions, often in short succession. It is therefore necessary to develop algorithms to identify unnecessary instructions (Graser 2016a) or otherwise reduce the number of navigation instructions. While computation of prepositions (typically “before”, “at” and “after”) is straightforward for point landmarks, it is less obvious for polygon landmarks. The polygon centroid can serve as a generalization (Graser 2016a) but this can lead to suboptimal results for bigger polygon landmarks.

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