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Integrating Existing Indoor Navigational Aids into Data Modelling and Route Planning

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Abstract. In this paper, we propose a concept of providing indoor navigation services by integrating existing navigational aids. We firstly conducted an in-situ experiment in two buildings with human subjects performing wayfinding tasks. The results suggested that people naturally refer to existing indoor navigational aids during navigating and signs were the most frequently used aids. We then integrated signs with their semantics into a graph-based indoor data model and indoor route planning. We intend to design a proof-of-concept indoor navigation system that aims at providing better navigating experience.

Keywords. Indoor navigation, Navigational aid, Sign

1. Introduction

People spend most of their time indoors. With the increasing complexity of large-scale public buildings (e.g., universities, shopping malls and transportation hubs), people get lost easily. Indoor navigation systems are developed to meet this need. Current indoor navigation systems often adopt classical pathfinding algorithms in route planning, without considering the topological constraints and existing navigational aids. They usually provide distance based and turn-by-turn instructions (Kargl et al. 2007, Li et al. 2017, Rehman & Cao 2017). This kind of systems may confuse users during navigating and make navigation less pleasant (Reilly et al. 2008). In addition, they may reduce users' spatial awareness and lead users to overreliance on the navigation systems.

Pointed out by environmental psychologists, existing indoor navigational aids (e.g. signs, floor plans and kiosk maps) have huge influence on wayfinding, because they explicitly represent the overall configuration of the environment (Conroy 2001, Vilar et al. 2012). Reilly et al. (2008) showed that combining kiosk maps with an indoor navigation application could help users gain spatial knowledge. Experiments in virtual environment indicated that people naturally rely on signs as long as signs are available and that signs are preferred to floor plans in certain situations (Vilar et al. 2012, 2014). Nevertheless in a virtual environment, people may have difficulties in estimating position change and travel direction, thus bring about different findings with reality (Meilinger et al. 2008).

We therefore conducted an in-situ experiment to confirm people's reliance on existing indoor navigational aids during navigating. Based on the results of the experiment, we integrated signs into a graph-based indoor data model and developed a route planning method considering the semantics of the signs. Since the experiment is beyond the scope of this paper, we only briefly describe it in *Section 2.1*. Then, we present our method of integrating signs into the indoor data model and indoor route planning in the rest of *Section 2*. The expected results are in *Section 3*. *Section 4* summarises the paper and describes the future work.

2. Methodology

2.1. Indoor Wayfinding Experiment

We conducted an experiment in two buildings with distinct navigational aids, the Albertina and the main building of Vienna University of Technology. 28 participants (16 female, 12 male, age: M= 29, SD = 6.77) with no visiting experience to either building were recruited. In the experiment, the participants were required to find three targets in each building. Their main tasks were to describe the wayfinding options they had at decision points, the hints revealing the destinations of these options, to make their decisions, and to justify them. The participants had to think aloud while performing wayfinding tasks.

We analysed the participants' verbal protocols. The results confirmed people's reliance on existing indoor navigational aids during navigating and indicated that signs were the most commonly used aids.

2.2. Integrating Signs into Indoor Data Modelling

Afyouni et al. (2012) divided indoor data models into geometry-based and symbol-based ones. They noted that symbol-based models are more suitable for representing semantic information. Hence, we integrate signs and their corresponding semantics into a graph-based model by Yang and Worboys (2015).

The generating of the navigation graph starts from enhancing the combinatorial map (Edmonds 1960, Worboys 2012) with geometric information. Then, a simplified dual map of the enhanced combinatorial map and its supergraph are constructed. They then position the nodes and the edges with their topologic, geometric and semantic information, which are called navnodes and navedges respectively. They classify navnodes into several types such as portals, simple rooms, elevator wells and simple stairwells, etc. In this step, we introduce an extra type named *signs* to represent the directional signs in a building. The semantics of the signs such as the destinations and their related directions are associated with the navnodes as well. In the next step, the navedges are computed and the semantics of them are derived from their corresponding navnodes. Multiple floors are joined by linking the navnodes denoting elevators and staircases in the navigation graphs of individual floors. The signs and their semantics are therefore integrated into the indoor data model.

2.3. Indoor Route Planning Including Signs

Indoor route planning begins with using traditional graph traversal algorithms to detect all the possible routes from a starting point to a destination. Then, all the traversable routes are selected based on the semantic constraints. According to the semantics of the signs, we choose the routes that include signs containing the destination. For example, if the destination is easily reachable when a user arrives at one of the signs containing the destination, a route will be generated directing the user to the corresponding sign first, and guiding them to follow the sign further to the destination. By generating this kind of new routes, we provide more alternatives for users to select, apart from shortest and fastest routes.

3. Expected Results

The expected results are an indoor navigation data model considering signs, and a route planning algorithm.

4. Conclusion and Outlook

We propose a concept of integrating existing indoor navigational aids into navigation services, intending to bring better navigating experience.

We firstly conducted an in-situ experiment in two buildings with human subjects who had to think aloud while performing wayfinding tasks. The results confirmed people's reliance on existing indoor navigational aids during navigating and indicated that signs were the most frequently used aids.

We then integrate signs into a graph-based indoor data model and indoor route planning. Route instructions will be generated accordingly. A proper visualization of the indoor environment with relevant signs highlighted will also be investigated. In the end, we will design a proof-of-concept indoor navigation system and evaluate it with human subjects.

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