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Landmark-Based Indoor Navigation Model through Human Route Descriptions

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Abstract:

Considering the navigation for complex spaces in large buildings such as campuses, hospitals, public buildings, and shopping malls, where there is a high probability of getting lost, it is believed that a successful navigation approach for indoor spaces will positively impact our lives in the same way as solutions for outdoor spaces. The challenges arising from the structural complexity of buildings are increasing the interest in indoor map generation and the establishment of indoor navigation network models has become an important research topic. In facility management, there is a growing demand to identify human movement associated with indoor environments and to develop various applications for wayfinding that support human spatial cognition. In disaster and emergency management, indoor navigation is of great importance in the development of building evacuation scenarios. Outdoor navigation is widely used in navigation applications due to the positioning accuracy provided by GNSS. Due to the unavailability of GNSS indoors, the use of positioning systems such as RFID (Radio Frequency Identification), UWB (Ultra Wide Band) and WLAN (Wireless Local Area Network) is developing (Sen et al., 2024). Besides, the fact that outdoor spaces are surrounded by street networks makes it easier to establish a navigation network for the use of a navigation system. In contrast to outdoor spaces, indoor spaces are typically bounded by architectural structures. The lack of predetermined walking routes such as street networks or sidewalks, the fact that interiors contain structural elements such as columns and walls that restrict visibility, their differentiated structures depending on their architectural design, and their multi-storey structure generally make interiors more complex than exteriors.

In pedestrian navigation, the navigation process, which is one of the basic stages of indoor navigation, is a cognitive act. Pedestrians, as the end-users of navigation systems, follow the routes provided by navigation systems, create mental maps of the indoor environment during the navigation process, and regularly update their cognitive maps during their movements in the indoor environment to perform the navigation action. However, due to the complex and irregular nature of the indoor environment, the cognitive load of pedestrians may increase and this may lead to failures in wayfinding. In this respect, the routes provided by navigation systems to pedestrians to support the wayfinding process should be similar and appropriate to their cognitive maps of the indoor environment.

Graph-based representations are frequently used to summarize the complex structure of indoor spaces. Although there is a significant amount of work in the literature on creating a navigation network to support indoor navigation, a comprehensive navigation network has not yet been put forward due to the variable nature of indoor spaces. In the literature, indoor navigation networks are classified in various ways. According to the recently accepted classification of navigation networks are: (1) Corridor derivation, (2) Cell decomposition and (3) Visibility partitioning. According to the traditional and space syntax criteria, the Middle Point Relation Structure Segment Entrance (MPRSSE) navigation network in the cell decomposition category was found to be the most suitable network for users' wayfinding patterns (Vanclooster et al., 2014; Bilgili et al., 2023).

In addition to the human perceptibility of the automatically generated networks, there are problems with the thematic route calculation and the comprehensibility of the instructions given to pedestrians as a result of these calculations. Compared to metric-based instructions ('turn left after 10m'), landmark-based instructions ('turn left before the kitchen') can help users to identify the correct decision point where a change of direction is required and provide information for users to verify that they are on the right path to the goal (Fellner et al., 2017). It should then make sense to generate instructions in a network with the highest perceptibility in the literature by incorporating landmarks and actions derived from human route instructions into the overall shortest distance theme.

This study aims to integrate the landmarks and actions extracted by using Natural Language Processing (NLP) methods from crowdsourced human route descriptions collected on the Soleway web service (https://soleway.ugent.be/), which is a crowdsourced database that collects human route descriptions for indoor navigation (Ooms et al., 2019), into the indoor

navigation network (MPRSSE) to create a route guidance that reduces the human cognitive load in the act of wayfinding in indoor navigation. The experimental data consists of crowdsourced route descriptions obtained from a campus building. First, an NLP pipeline extracts qualitative spatial concepts from verbal route descriptions, and decomposes them into landmarks and actions. The pipeline takes human route descriptions for indoor routes as input. It segments sentences, tokenizes words, performs part-of-speech tagging, and dependency parsing to label spatial objects, explicit relationships, and actions. Then, the phrases are sorted into sequences integrating landmarks and actions into the navigation network (Sen et al., 2024). The landmarks and actions extracted from the route instructions are added to the MPRSSE network to obtain the route instructions. This approach offers a promising solution to the cognitive challenges of indoor route guidance by generating a landmark-based indoor navigation network model based on human route descriptions.

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