International Cartographic Association
Association Cartographique Internationale

Indoor navigation map design based on the analysis of space characteristics

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Keywords: space characteristics, indoor element, indoor navigation, map design

Abstract:

The application scope of geographical information science is gradually evolving from large-scale to small-scale environments (Afyouni et al., 2010). The space that we are dealing with is no longer limited to outdoor spaces but is extended to indoor spaces. Facing the indoor structure of complex buildings, the demand for indoor location services such as navigation and emergency evacuation services is increasing. Indoor navigation maps are an important tool for people to arrive at their destination in large public buildings. There are a lot of indoor navigation services to help mobile users but there are still some gaps between map design and the navigation process, such as how to model the path of the multi-dimensional structure of indoor environments, quantify the visibility condition of indoor areas, and compensate for the lack of semantic annotation of indoor corridors (e.g., there are typically no road signs as in the outdoor case). Most existing application studies focus on indoor maps that visualize the basic indoor spatial structures, while few take into account the navigation process in buildings. From the scientific perspective, there are a lot of aspects for designing indoor navigation maps (e.g., 2D/3D, visibility, and semantics). However, it is unclear which type of design is most effective for aiding pedestrians in indoor wayfinding.

There has been some research on the design and representation of indoor maps. Nossum (2011) proposed a "Tubes" map representation method, which overlays the access information of different floors on the same plane, allowing users to understand the structure of each floor inside a building with the help of only one map. Li et al. (2013) studied indoor maps with multiple modes of representation on mobile terminals. They pointed out that both 2D and 3D maps significantly improved pointing and vertical navigation accuracy compared to the control condition with no map assistance, and argued that better visualization of the layered structure of the building could facilitate multi-level cognitive map development.

The indoor space has special characteristics as the building space is divided by numerous walls and rooms, which limit the user's visual reach and hinder the overall perception of the space. In the process of indoor navigation, relevant studies have provided auxiliary guidance information for turns and specific decision points, adding guidance images, text, and symbols to convey information to users (De et al., 2019). It is also necessary to provide good navigational aids for areas with poor visibility. For example, Pang et al. (2021) generated an indoor visibility map based on a navigation network in corridor space. There are no names for the passages in an indoor space, but there are some landmarks, which are important elements for people to communicate route information, either verbally or graphically, and can assist pedestrians in making route decisions when they are at a fork along a path (May et al., 2003). In both outdoor and indoor environments, landmarks are generally selected considering the visual, semantic, and structural salience of the objects (Zhu et al., 2021; Zhou et al., 2022).

Different from outdoor landforms, residential areas, water systems, vegetation, and other elements, indoor spaces are mainly artificially constructed entities. Indoor space elements refer to all the physical elements existing in the actual space, which describe the frame structure and local details of the indoor space. In map visualization, some elements are generally selected for mapping according to the map form, the specific purpose of the map, or the specific users (Ryder, 2015). According to the importance of the elements to the visualization of an indoor navigation map, the elements that

Abstracts of the International Cartographic Association, 6, 291, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-291-2023 |

are not salient enough for user attention and that have little or even interfering effects on reflecting the indoor navigation should be discarded.

Research Agenda: To solve the difficulties caused by the three characteristics of indoor spaces (3D structure, poor visibility, and missing path semantics) for user navigation, we will design indoor navigation maps that improve user experience based on existing maps. As shown in Figure 1, first, we will design and represent three-dimensional paths on an indoor navigation map, with different colors used to differentiate the paths on different floors. Second, we will quantify the visibility values of the indoor area by means of Depthmap (UCL Space Syntax), then extract the points with poor visibility on the navigation path, and collect the actual scene picture and navigation direction indication symbols of these points, which will add to the indoor navigation map. Third, we will extract visual landmarks around indoor navigation paths to provide users with landmark-based guided indoor navigation maps. In the presentation, we will discuss the three examples of indoor navigation maps identified, focusing on the practices and issues found in indoor navigation map design.

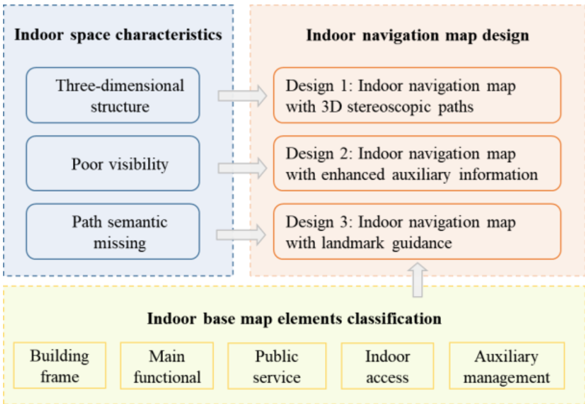

Figure 1. Indoor navigation map design base on the analysis of space characteristics

Acknowledgements

This research was supported by the National Key R&D Program of China (No.2021YFE0112300), National Natural Science Foundation of China (NSFC) (No.41871371), Postgraduate Research and Practice Innovation Program of Jiangsu Province (No.KYCX22_1571), and Foundation from the China Scholarship Council (No.202206860028).

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https://doi.org/10.5194/ica-abs-6-291-2023