Narrative Indoor Navigation – An Approach Using Annotated 360-Degree Camera Documentation

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Abstract. This study investigates the impact of narrative navigation and 360-degree camera documentation on indoor wayfinding. By analysing data collected through user studies, the research aims to uncover the effects of these factors on individuals' ability to navigate and remember information within indoor environments. The study utilises a 360-degree camera mounted on a helmet to capture immersive videos, and participants with diverse navigation expertise will navigate a pre-determined route. Focusing on a complex building within the University of Augsburg campus, the study aims to annotate visible indoor landmarks and explore the potential of narrative navigation and 360-degree video in enhancing indoor navigation effectiveness.

Keywords. Narrative indoor navigation, 360-degree videos, mental map, landmarks, wayfinding

1. Motivation and Research on Indoor Wayfinding and Landmarks

As an everyday task that occurs frequently, indoor wayfinding has received much attention from researchers, especially nowadays when outdoor navigation technology is developing rapidly. It is easy to see that the factors influencing the completion of this task are not only technical (e.g. location accuracy, data display, data loading, etc.) but also social (user

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characteristics, attention, external environment, etc.). This section reviews the current state of research on indoor wayfinding and landmarks over the last five years.

1.1. Social part

Several studies have explored various aspects of indoor wayfinding. Lin et al. (2019) found that repeated exposure and mental stress affect the completion of indoor wayfinding tasks in virtual reality. Li et al. (2019) simulated complex indoor environments to investigate how environmental factors influence people's route choices. Gender differences were examined by Zhou et al. (2020), revealing preferences in information attention and decision-making but not in route reading. Additionally, Wang et al. (2019) highlighted the impact of navigation systems on spatial memory, suggesting the need for system designs that minimise cognitive load and support memory retention to enhance wayfinding performance.

1.2. Technical part

Besides social factors, technological factors are crucial to assist users in indoor wayfinding tasks. Depending on the role in the wayfinding task, the technical aspects can be divided into a landmark recognition component and a localisation component.

1.2.1. Landmark identification

Zhu et al. (2019) developed a scoring system to analyse spatial object saliency, providing insights into factors influencing saliency and aiding in designing effective navigation systems. Afif et al. (2021) introduced a computer vision-based object recognition system for indoor wayfinding, enhancing navigation techniques and improving the wayfinding experience. Kim et al. (2019) proposed a navigation system combining crowdsourcing and landmarks, harnessing collective intelligence to improve navigation accuracy and information richness.

1.2.2. Positioning

Zhu et al. (2019) introduced a mobile phone video-based method for accurate indoor localisation, improving tracking reliability in complex indoor environments. Fusco et al. (2020) developed a real-time smartphone application using computer vision for indoor localisation, contributing to accurate and accessible techniques for integrated wayfinding applications. Zhang et al. (2019) proposed a framework for identifying indoor activities, enabling the development of robust activity recognition systems for personalised and context-aware indoor navigation experiences.

This study diverges from Zhu et al. (2019) by focusing on the potential application of 360-degree video range in indoor navigation. Traditional

indoor wayfinding often involves searching for specific items, such as a book in a library, requiring attention and using various tools. 360-degree video recording can address this by identifying more visual cues, like specific signs or books, and creating a "mental map" that guides users directly to their desired location.

2. Methodology

This study assesses how narrative navigation and 360-degree camera documentation impact indoor navigation. By comparing different techniques, the research aims to uncover their effects and advantages on individuals' ability to navigate effectively within indoor environments. The details will be written below:

- Data Acquisition Equipment: To capture immersive videos of the indoor environment, we will use a 360-degree camera mounted on a helmet (see *Figure 3*). Continuous recording will be ensured by employing a power bank as a reliable power source.
- User Study Design: The user study will involve recruiting participants with diverse levels of expertise in navigating indoor environments. To assess their navigation abilities, a preliminary questionnaire will be administered. Participants will then be tasked with navigating a pre-determined route designed by the researchers. Following the navigation exercise, a subsequent questionnaire will be employed to evaluate participants' spatial awareness and memory recall during the navigation process. Additionally, participants will be requested to create a mental map based on their experience with navigation aided by 360-degree camera documentation. This user's study is a within-subject design. Below in *Figure 1* is the user study flow:

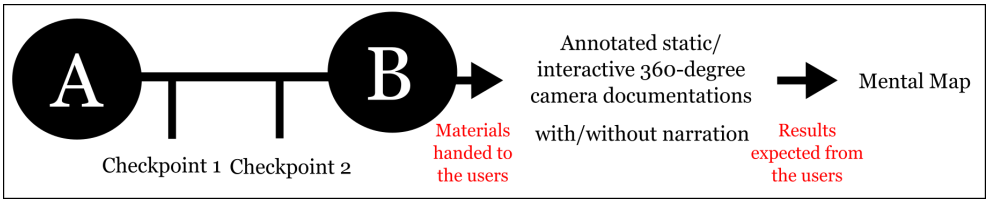

Figure 1. User Study Design Scheme (Source: Authors).

The frames or videos of the 360-degree camera documentation are methodically ordered to ensure data accuracy, facilitating a coherent narrative progression. Participants are also encouraged to annotate the locations they encounter, contributing to documenting their cognitive processes. At designated checkpoints, rewards are provided to promote engagement and motivation. All the users will be assigned to user groups

based on their navigation skills, which will be measured by taking pre-questionnaires. Following *Table 1* represents the group of users we need in this study based on *Figure 1* above:

Interactive Video without narration	Interactive Video with narration	Static Frames with narration	Static Frames without narration
Expert	Expert	Expert	Expert
Novice	Novice	Novice	Novice

Table 1. User Groups (Source: Authors).

3. Data Collection and First Insights

Our case study at the University of Augsburg campus focused on the complex wayfinding within building D, which provides access to facilities like the cafeteria and library. Using an Insta360 ONE X2 camera, we captured 360-degree video footage to annotate visible indoor landmarks. Potential test subjects recorded frame numbers/IDs and pixel coordinates for reference. Two example frames of raw data are visualised in *Figure 2*.

Figure 2. Example of A Raw Data Frame (Source: Authors).

Within our annotation procedure, we integrate the option of defining video frame windows with varying pixel coordinates for the same indoor landmarks. This allows for a more detailed analysis. Our Mental Map Design incorporates a feedback loop to optimise our methodology. Our initial experiment used an Insta360 ONE X2 camera and a power bank mounted on a bicycle helmet (*Figure 3*). The investigation area includes the library, cafeteria, and lake (*Figure 4*).

Figure 3. Experimental Device (Source: Authors).

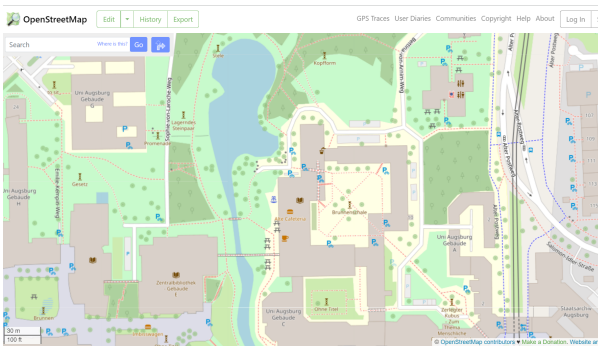

Figure 4. Study Area (Source: OpenStreetMap).

References

Afif, M., Ayachi, R., Said, Y., & Atri, M. (2021). A transfer learning approach for indoor object identification. SN Computer Science, 2(6), 424.

Kim, H., Kim, J. W., & Jang, B. (2019, January). Indoor positioning system using sensor and crowdsourcing landmark map update. In 2019 International Conference on Green and Human Information Technology (ICGHIT) (pp. 7-11). IEEE.

Zhu, J., Li, Q., Cao, R., Sun, K., Liu, T., Garibaldi, J. M., ... & Qiu, G. (2019). Indoor topological localization using a visual landmark sequence. Remote Sensing, 11(1), 73.

Fusco, G., & Coughlan, J. M. (2020, April). Indoor localization for visually impaired travelers using computer vision on a smartphone. In Proceedings of the 17th international web for all conference (pp. 1-11).

Zhang, W., Zhao, X., & Li, Z. (2019). A comprehensive study of smartphone-based indoor activity recognition via Xgboost. IEEE Access, 7, 80027-80042.

Wang, C., Chen, Y., Zheng, S., & Liao, H. (2018). Gender and age differences in using indoor maps for wayfinding in real environments. ISPRS International Journal of Geo-Information, 8(1), 11.

Lin, J., Cao, L., & Li, N. (2019). Assessing the influence of repeated exposures and mental stress on human wayfinding performance in indoor environments using virtual reality technology. Advanced Engineering Informatics, 39, 53-61.

Li, H., Thrash, T., Hölscher, C., & Schinazi, V. R. (2019). The effect of crowdedness on human wayfinding and locomotion in a multi-level virtual shopping mall. Journal of environmental psychology, 65, 101320.

Zhou, Y., Cheng, X., Zhu, L., Qin, T., Dong, W., & Liu, J. (2020). How does gender affect indoor wayfinding under time pressure?. Cartography and Geographic Information Science, 47(4), 367-380.

Zhu, Litao & Švedová, Hana & Shen, Jie & Stachoň, Zdeněk & Shi, Jiafeng & Snopková, Dajana & Li, Xiao. (2019). An instance-based scoring system for indoor landmark salience evaluation. Geografie. 124. 103-131. 10.37040/geografie2019124020103.