# Doctoral Colloquium—Towards a Better User Interface of Augmented Reality Based Indoor Navigation Application

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***Abstract*—Navigation service is a widespread geoinformation service and can be embedded in an augmented reality (AR). In this work-in-progress, we aim at a user interface of AR-based indoor navigation system, which could not only guide users to destinations quickly and safely, but also improve users' spatial learning. We designed an interface for indoor navigation on HoloLens, gathered feedback from users, and found that arrows are an intuitive aid of orientation. Semantic meanings embedded in icons are not self-explaining, but icons with text can serve as virtual landmarks and help with spatial learning.**

***Index Terms*—augmented reality, indoor navigation, user interface, spatial learning**

## I. Introduction

Navigation is essential in daily life. Service developments from 2D maps to real-time positioning via GNSS (Global Navigation Satellite System) have changed a lot the way how people navigate. Meanwhile, more immersive visualization technologies such as augmented reality (AR) are now easily available, allowing people to navigate in a more fun-making way, and influencing at the same time how people perceive their surrounding environment with potential side effects. A careful study of perceptual and cognitive issues is necessary to guide the design of a better user interface for navigation.

In this work-in-progress, we focus on indoor navigation for two reasons. In the modern society, people spend most (87%, according to [1]) of their life indoors, but this does not necessarily mean that they do not move at all. They do move and navigate from one location to another in various scenarios, such as in museums, hospitals or at airport. Besides, compared with outdoor navigation, indoor navigation service needs AR technology more urgently as GNSS signals are not seamlessly available and stable in indoor environments.

Our research has two aims: firstly, to identify which information is essential for indoor navigation; secondly, to explore how to visualize such information and design the user interface of an AR application for an effective, safe and informative navigation.

In this paper, we use augmented reality to refer to both augmented reality and mixed reality.

## II. Related Works

### *A. Cognitive Influence of Navigation System*

Navigation applications are widely used. People from all over the world use self-adapting or interactive navigation aids, during walking or driving, outdoor or indoor. Both academic and industrial society work hard to improve navigation services.

However, this common use of additional help could gradually weaken people's geospatial ability [2], [3]. As current navigation aids seldom take spatial learning into consideration, users may still don't know the route after several visits. This could result in severe consequences when people could not even quickly find exits in emergency cases such as evacuation during fire or other disasters. Therefore, navigation service should not only guide users to destination as quickly as possible, but also help them preserve or even facilitate their cognition capability such as remembering the area so they can navigate themselves afterwards.

Understanding how people find their way without navigation aid could help building such "educational" navigation apps. Researchers explored how people navigate indoor by themselves and found landmarks are important for indoor navigation. Specifically, Ohm *et al*. classified landmarks into four categories (Architecture, Function, Information and Furniture) and found functional landmarks are referred to most for indoor navigation [4].

### *B. Influence of Augmented Reality*

AR has been widely used in different areas, such as healthcare [5], education [6], manufacturing [7], navigation[8], let alone gaming. With the new technology becoming mature, researchers have already taken cognition and usability in AR in consideration [9].

There are some common perceptual and cognitive issues for AR applications, for example, lack or mismatch of depth cues [10]. Advanced hardware could provide better sense of depth by larger Field of View, better occlusion and quicker response. However, some factors would continue influencing users' perception and cognition, such as vergence-accommodation conflict and attention distribution between virtual and real world.

These afore-mentioned common cognitive issues have a distinctive influence on AR aided navigation. First, in some

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applications users interact with virtual objects within arm reaching distance, e.g. manufacturing. However, users also need information about distant objects during navigation thus a good sense of depth is required. Secondly, different from other uses, navigation runs as users move a lot. Although AR could create quite immersive experience, it must keep users aware of the physical world for both safety and reuse purpose. While virtual information can help navigating, too much information in AR degrades awareness of unexpected events [11] thus endangers the users during walking. Further investigation about which information should be included and how to present in the AR system[12]. For example, As previous research shows, using AR in navigation can impair route retention [13], it could be helpful if a local map is added in the AR screen.

This work-in-progress aims at a better user interface for AR-based indoor navigation, which should not only help users reach destination, but also improve their spatial learning.

## III. Methodology

We conduct on-site experiments and improve the user interface iteratively based on users' incremental feedback and performance.

### A. *Study Area*

The study area should meet two criteria: a) the building is complicated per se and indoor navigation aid is needed; b) common visitors have good reasons to revisit it and they need to navigate within the building themselves.

We use the main campus of Technical University of Munich as study area. Buildings constructed in different periods are connected to their neighbours, making up a huge indoor space. Buildings don't have the same floor heights, but the indoor environment looks identical with white walls and grey doors, and there is a lack of visually salient landmarks.  Besides, some large lecture halls were separated into several smaller ones and given new room numbers with a mixed and confusing numbering system. The users, mainly students and staff members, have to revisit the building for their study and work and make sure that they arrive at the right room. Thus it is an ideal study area for this study.

### B. *Device*

Microsoft HoloLens (1st generation)[1] is used in this study. It is untethered, highly mobile and hands-free, thus suitable for navigation.

We used Mixed Reality Toolkit (MRTK) v2 and Unity[2] to develop the application.

### C. *Initial Interface Design*

For the initial user interface, we combine step-by-step instruction and virtual semantic landmarks on the interface (Fig. 1). Step-by-step instruction is commonly used in navigation applications to guide users to destination quickly. In situation of lack of visually salient landmarks, virtual semantic landmarks could potentially help users to locate and keep orientation in indoor environments. Other information, for example, distance to destination or interactive maps, is not displayed in order to maintain a clear view and keep users' attention mostly to the physical world.

Green arrows are used to indicate direction. They are put on the floor, in the middle of the corridor, 5 meters away from each other on the forward direction. The distance is shorter between the neighbour arrows around turns.

Icons are used to indicate semantic landmarks encouraging users to explore more about the room. The icons (made by freepik[3]) are located in front of the room and will always face the user. The holograms are rendered between 0.3 to 10 m.

Fig. 1. Example of 1st version of interface.

### D. *Experiment I*

Two participants were asked to use this application to follow a predefined route indoor. They visited the study area before, but were not familiar with it. The author walked about 2 meters behind the participants to keep them in track. Both participants successfully got to the destination. After the walk, the participants were asked about their experience and opinions towards the interface.

The participants reported that the green arrows point to the directions quite clearly and attract most visual attention. However, the icons failed its purpose. One participant could not understand the meaning and the other could not even remember the icons after the walk.

While participants got to the destination safely, they mentioned that they didn't pay much attention to their physical surroundings. They were not sure where they were during the walk, though they had been there before.

### E. *Experiment II*

As the participants in experiment I reported that the green arrows are too dominating, we changed the color to yellow to make arrows less prominent (Fig. 2) and expected users to pay more attention to the surroundings. Text is added below the icon (e.g. "Administration" in Fig. 2) to provide a clearer instruction to the users.

1 https://docs.microsoft.com/en-us/hololens/hololens1-hardware
2 https://unity.com/
3 http://www.flaticon.com

Four other participants took part in Experiment II with the altered user interface. They were asked to follow the displayed route and informed that there would be following questions about the route afterwards. After the walk, they were required to draw a sketch map of the study route.

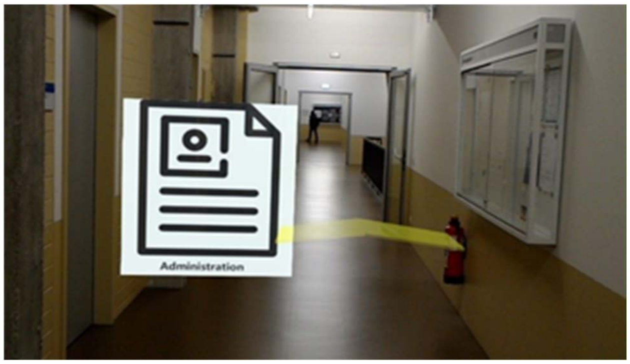


Fig. 2. Example of 2nd version of interface.

All participants reached the destination and three of them drew a sketch map showing what they had perceived.

According to the feedback from our participants, arrows are an intuitive indicator. Although the participants were informed about route-related questions before the walk, they did not pay much attention to the surroundings. Virtual landmarks are visible as POIs (point-of-interest).

As sketch maps show, one participant remembered the turns incorrectly, i.e. remembered a left turn as a right turn. Other three participants remembered the turns correctly (two left turns), and they mainly drew functional landmarks (elevators and stairs), which are in line with previous findings that such landmarks are more important for indoor navigation [4]. Two participants correctly drew the landmarks indicated by virtual icons, indicating that virtual landmarks can help with spatial learning.

## IV. Conclusion and Future Work

This first step work confirms that HMD augmented reality devices could be used for indoor navigation. Arrows are intuitive for leading the way. Virtual landmarks have the potential of supporting spatial learning. However, AR technologies, if improperly designed, may also induce safety problems. In the future, our preliminary results indicated by this work will be assessed by involving more users. Moreover, we will continue to explore with further scenarios various possibilities on how to raise users' awareness of physical world while using augmented reality based navigation and incidentally improve spatial learning.

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## References


[1] N. E. Klepeis *et al.*, "The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants," *Journal of Exposure Science & Environmental Epidemiology*, vol. 11, no. 3, pp. 231-252, Jul. 2001, doi: 10.1038/sj.jea.7500165.

[2] T. Ishikawa, H. Fujiwara, O. Imai, and A. Okabe, "Wayfinding with a GPS-based mobile navigation system: A comparison with maps and direct experience," *Journal of Environmental Psychology*, vol. 28, no. 1, pp. 74-82, Mar. 2008, doi: 10.1016/j.jenvp.2007.09.002.

[3] K. S. Willis, C. Hölscher, G. Wilbertz, and C. Li, "A comparison of spatial knowledge acquisition with maps and mobile maps," *Computers, Environment and Urban Systems*, vol. 33, no. 2, pp. 100-110, Mar. 2009, doi: 10.1016/j.compenvurbsys.2009.01.004.

[4] C. Ohm, M. Müller, B. Ludwig, and S. Bienk, "Where is the landmark? Eye tracking studies in large-scale indoor environments," in *ET4S 2014*, Vienna, Austria, Sep. 23, 2014, pp. 47-51.

[5] V. C. Cavalcanti, M. I. d. Santana, A. E. F. D. Gama, and W. F. M. Correia, "Usability Assessments for Augmented Reality Motor Rehabilitation Solutions: A Systematic Review," *International Journal of Computer Games Technology*, vol. 2018, Article ID 5387896, 18 pages, Nov. 2018, doi: 10.1155/2018/5387896.

[6] M. Bower, C. Howe, N. McCredie, A. Robinson and D. Grover, "Augmented reality in Education — Cases, places, and potentials," in *2013 IEEE 63rd Annual Conference International Council for Education Media (ICEM)*, Singapore, Oct. 2013, pp. 1-11, doi: 10.1109/CICEM.2013.6820176.

[7] S. K. Ong, M. L. Yuan, and A. Y. C. Nee, "Augmented reality applications in manufacturing: a survey," *International Journal of Production Research*, vol. 46, no. 10, pp. 2707-2742, May 2008, doi: 10.1080/00207540601064773.

[8] F. Debandi *et al.*, "Enhancing cultural tourism by a mixed reality application for outdoor navigation and information browsing using immersive devices," In *IOP Conference Series: Material Science and Engineering*, Florence, Italy, May 2018, doi: 10.1080/00207540601064773.

[9] K. Kim, M. Billinghurst, G. Bruder, H. B. Duh and G. F. Welch, "Revisiting Trends in Augmented Reality Research: A Review of the 2nd Decade of ISMAR (2008–2017)," *IEEE Transactions on Visualization and Computer Graphics*, vol. 24, no. 11, pp. 2947-2962, Nov. 2018, doi: 10.1109/TVCG.2018.2868591.

[10] D. Drascic, and P. Milgram, "Perceptual issues in augmented reality," In *Electronic Imaging: Science and Technology*, San Jose, CA, USA, Apr. 1996, doi: 10.1117/12.237425

[11] B. J. Dixon *et al.*, "Surgeons blinded by enhanced navigation: the effect of augmented reality on attention," *Surgical endoscopy*, vol. 27, no. 2, pp. 454-461, Feb. 2013, doi: 10.1007/s00464-012-2457-3.

[12] P. Renner and T. Pfeiffer, "Attention guiding techniques using peripheral vision and eye tracking for feedback in augmented-reality-based assistance systems," in *2017 IEEE Symposium on 3D User Interfaces (3DUI)*, Los Angeles, CA, USA, Mar. 2017, pp. 186-194, doi: 10.1109/3DUI.2017.7893338.

[13] U. Rehman and S. Cao, "Augmented-Reality-Based Indoor Navigation: A Comparative Analysis of Handheld Devices Versus Google Glass," *IEEE Transactions on Human-Machine Systems*, vol. 47, no. 1, pp. 140-151, Feb. 2017, doi: 10.1109/THMS.2016.2620106.