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Conference Paper · November 2019

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## Towards a User-Oriented Indoor Navigation System in Railway Stations

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**Abstract.** User demand has always been a driving force of indoor navigation research. In this study, we propose to conceptualise a user-oriented indoor navigation system, with the aim of improving user experience on indoor navigation in railway stations. We firstly conducted a series of stakeholder workshops to identify the most crucial future challenges towards a user-oriented indoor navigation system. Based on the findings from the workshops, a user study in Vienna central railway station was carried out to find out group-specific user needs. In the end, we will conceptualise a holistic indoor navigation system, considering group-specific user needs and technological innovations.

**Keywords.** Indoor Navigation, User Study, Railway Station, LBS



Published in "Adjunct Proceedings of the 15th International Conference on Location Based Services (LBS 2019)", edited by Georg Gartner and Haosheng Huang, LBS 2019, 11-13 November 2019, Vienna, Austria.

This contribution underwent double-blind peer review based on the paper. <https://doi.org/10.34726/lbs2019.58> | © Authors 2019. CC BY 4.0 License.

## 1. Introduction

Recent years have witnessed a trend in LBS research from outdoor environment alone to indoors as well (Huang et al. 2018). Navigation in indoor environments, e.g., shopping malls, museums, airports, and railway stations, caught researchers' attention, not only because of the developments of indoor positioning and indoor spatial data modelling (Huang et al. 2018), but also due to the increasing demand from the users. However, users vary dramatically in their age, gender, demographics, culture, and spatial ability, which all influence navigation behaviour and their perception of navigation guidance (Roth et al. 2017, Roth 2013, Keehner et al. 2008, Castelli et al. 2008). It is, therefore, necessary to identify user groups and investigate their special needs. Researchers have emphasised on user-centred design (Haklay & Tobn 2003, Norman 1988) and developed a user-oriented indoor navigation system in venues such as museums (Kaulich et al. 2017, Tscai et al. 2017).

As an important multifunctional indoor environment, many indoor navigation studies are dedicated to railway stations (Tabata et al. 2015, Fall et al. 2012), nevertheless, most of them focused only on indoor positioning. Current indoor navigation systems in railway stations are mostly distance-based and providing turn-by-turn instructions, which do not allow an overview and draw too much of users' attention. In order to improve user experience on indoor navigation in railway stations, we aim at conceptualising a user-oriented indoor navigation system. Aiming at tackling this issue, we focus on three research questions:

- 1 What are the most crucial challenges towards a user-oriented indoor navigation system in railway stations?
- 2 What are user group-specific needs towards an indoor navigation system in railway stations?
- 3 Can we conceptualise a holistic indoor navigation system, considering group-specific user needs and technological innovations?

## 2. Stakeholder Workshop

### 2.1. Methodology

To identify the most crucial future challenges towards a user-oriented indoor navigation system, a series of stakeholder workshops were conducted with representatives from the Austrian Federal Railways (OEBB). Participants' professional backgrounds and responsibilities ranged from diversity management, market management, communications, technology, to infrastructure, yet, all were engaged in developing an indoor navigation system of the

future. Workshops were conducted to specify the different user groups of railway stations, to discuss their needs and requirements, and to identify usual and unusual activities at railway stations. At the same time, workshops were conducted to get insights into existing infrastructural as well as technological contexts.

Each workshop started with a short introduction to the workshop's goals. Participants were then invited to discuss and share their perspectives. Notes were taken during the discussions, which were used at the end of each workshop to jointly prioritize the findings.

## **2.2. Results**

Based on the workshops, we identified a list of requirements that a future indoor navigation system for railway stations should consider (Fian et al. 2019):

- diversity criteria of existing and potential user groups as well as their group-specific needs
- connecting existing navigational aids available at railway stations, such as signs, floor plans, landmarks, colour coding system, and tactile guidance system in the physical environment, as well as applications on mobile devices
- potential innovative technological solutions for indoor navigation services
- existing and potential data sources
- the varying degrees of railway stations' complexities for indoor navigation

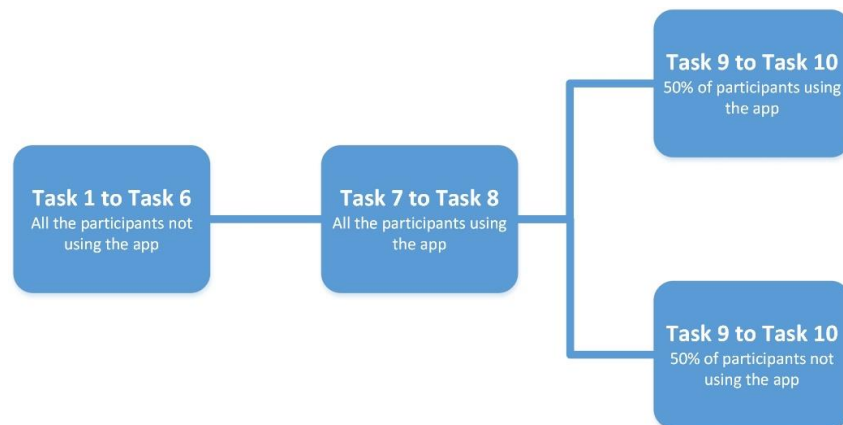
## **3. User Study in Vienna Central Railway Station**

### **3.1. Methodology**

In order to study group-specific needs in more depth and to assess the quality of available navigational aids at railway stations, a user study in Vienna Central Railway Station was conducted.

The aim of this study was to examine the navigation behaviour of different user groups and to identify their group-specific needs at railway stations. Using a multi-methodological research design that combined behaviour-related measures (eye movements using mobile eye-tracking, documentation of chosen walk paths, distances and walking times in the building) as well as data from semi-structured interviews and qualitative data using think-aloud-method, we wanted to identify factors that facilitate or impede participants' navigation at railway stations.

Based on the information provided by Austrian Federal Railways (OEBB), we firstly identified the major user groups. Our sample for the user study consisted of 36 participants, including 18 women and 18 men. The average age was 41 years ( $SD = 20.5$ ), with the youngest subject 18 years and the oldest 79 years old. They were characterised by high diversity in aspects of age, gender, mobility restrictions, familiarity with the train station and ethnic background. We chose Vienna central railway station as our experiment venue, because of its complexity and the digital services available there. Participants had to complete an ecologically valid use case including ten different search tasks that represent usual activities at railway stations (e.g. finding ticket machine, toilet) as well as unusual activities (e.g. finding hairdresser, flower shop). In addition to usual guides (e.g. signs, floor plans, staff, etc.), participants were instructed to complete some of the tasks by using a prototypical indoor navigation app by OEBB. *Figure 1* illustrates the flow of the tasks and the distribution of the tasks accomplished with or without using the app.



**Figure 1.** The distribution of the tasks accomplished with or without using the app.

### 3.2. Preliminary Results

The preliminary results of this study showed that the user group of older participants differed in their navigation behaviour from those of younger participants. While younger participants more efficiently used the navigation app to quickly find targets (*Figure 2*), older participants more often showed difficulties in properly using the app, which led to detours and therefore to long search times (*Figure 3*). Compared to the user group of younger participants, older participants in general showed preferences for analogue indoor navigation guidance.

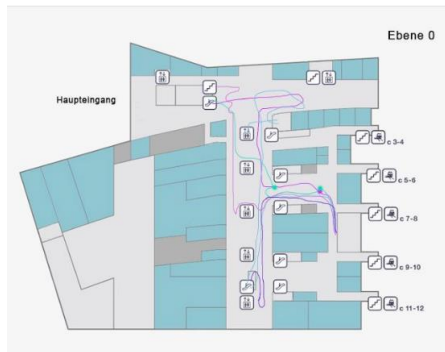


Figure 2a



Figure 2b

**Figure 2.** Example of trajectories of younger participants (<30) without using the app (2a), compared to using the app (2b) (Fian et al. 2019).



Figure 3a



Figure 3b

**Figure 3.** Example of trajectories of older participants (>60) without using the app (3a), compared to using the app (3b) (Fian et al. 2019).

## 4. Conclusion and Outlook

While the majority of younger participants were able to efficiently use both analogue and digital aids for quickly gaining an overview at the railway station and to complete the navigation tasks efficiently, older participants had problems finding their way in the railway station, especially when using the indoor navigation app. Thus, a user-oriented indoor navigation system in railway stations should consist of two parts: the navigational aids in the physical environment, and the navigation services on mobile devices. In accordance with the feedback given by the older participants, improvements on the navigational aids to ensure simple orientation at the railway station are needed: more salient and thus more effective placement of floor plans (e.g.

entrance areas, hot spots), user-friendly designed floor plans, and info screens.

In order to improve the navigation services on mobile devices, we plan to conceptualise a holistic indoor navigation system for railway stations, concerning technological innovations. We plan to model user profiles, based on the information in the ticketing system (users' demographic data, preferences, etc.), in the navigation system (movement behaviour, etc.), and their social media accounts. We will consider a railway station as a system of various processes. Thus, we are going to investigate the detailed infrastructures of railway stations and their functions and build a functional ontology of the integrated system. With this, we aim to enhance the user experience on indoor navigation in railway stations.

## Acknowledgement

This research is funded by ÖBB-Infrastruktur AG (owner, constructor and operator of the Austrian railway network) and BMVIT (Austrian Ministry for Transport, Innovation and Technology) in the VIF2017 project “Indoornavigation: Kundenorientierte Indoornavigation an Bahnhöfen”.

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