Providing Individual Route Instructions for Indoor Wayfinding in Complex, Multi-Level Buildings

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Abstract. The present paper describes an interdisciplinary approach to personalized indoor wayfinding in complex multi-level buildings. Users are presented with individual visual route instructions on ambient displays in the environment. These instructions are provided by a modelling software which calculates individual paths through a virtual model of the building. Since users should be able to comprehend and learn such route instructions easily and quickly, the question arises which instructional format will foster human wayfinding most effectively in this scenario. An empirical study was therefore designed. In this study, egocentric, view-based visual instruction formats are compared to a map-based, allocentric format. Currently, data on route learning and wayfinding success are collected in a complex, multi-level building. The results of this study will contribute to the development of design guidelines for cognitively adaequate indoor route instructions, in particular for egocentric and animated visual formats.

1 INTRODUCTION

How can individual visitors be supported in finding their ways in complex buildings such as airports, office buildings and conference centers? According to the present approach, users are presented with individual visual route instructions on ambient displays in the environment. This pragmatic solution avoids challenges that are associated with mobile indoor navigation assistance (e.g., positioning). Individual route instructions are provided by a modelling tool which can calculate and present route paths through virtual models of multi-level buildings in a variety of visual formats. However, users must be able to comprehend and learn these visual route instructions easily. Therefore, an empirical study on route learning in a real multi-level building was designed. The aim of this work is to test which visual format is best understood and best learned in the intended scenario, and to develop design guidelines for cognitively adequate indoor route instructions.

1.1 Personalized route instructions in complex buildings

Route instructions on electronic ambient displays have been introduced by the *GAUDI* (Kray, 2005) system, which consists of a set of autonomous, portable displays that are embedded in the built environment. These displays guide visitors to temporary events by indicating the directions through arrows. The route calculation and presentation generation is limited by a two-dimensional model.

The present approach, based on the modelling tool Yamamoto (Stahl, 2006) starts with the outlines of rooms and corridors, however with height data, topology and definition of building levels and staircases included. A full schematic 3D model of the building is produced by semantic annotations (like 'this edge represents a door that connects two rooms'). The resulting model represents all structural elements like walls, doors, stairs, galleries, etc, including their function for wayfinding. In conjunction with a routing algorithm, Yamamoto automatically visualizes any path inside the building ego- as well as from allocentric perspectives. Route instructions are solely visual, not verbal.

The intended scenario for indoor wayfinding support is to present a visualization of an individual route to the user at route infopoints, which are realized as wall-mounted displays, spread throughout the building and capable to sense and adapt their content to the user.

1.2 Learning routes

Studies on environmental learning suggest that qualities of mental representations of the environment differ (Siegel & White, 1975), depending on the learning experience (e.g. Thorndyke & Hayes-Roth, 1982; Shelton & McNamara, 2004). Route knowledge is conceived as associative memory of an ordered sequence of landmarks and directions from egocentric views, such as experienced when navigating. Route knowledge might thus best be learned if a route is presented sequentially from the egocentric perspective.

Empirical studies on route learning in real environments, however, do not consistently support this idea. For instance, first-time visitors of a university campus, which were presented with route instructions at an information desk, preferred maps over a sequence of view-based photographs, and maps with landmarks actually fostered their route learning (Devlin & Bernstein, 1995). Passively viewing a route in a virtual environment did not transfer to wayfinding success in the real building, and virtual environmental training was not superior over studying a map with respect to wayfinding performance in the real building (Farrell et al., 2003). Actual indoor wayfinding behavior in reality might be affected by a number of factors, including the complexity of the architecture and individual strategies (Hölscher et al., 2006). Given the inconsistent findings, the present study investigates what route instruction format is most effective for route learning in a complex building, this in a situation that comes close to the intended scenario.

2 EMPRICIAL STUDY

2.1 Wayfinding conditions

Route instructions generated by Yamamoto were based on a model of the computer science building on Saarland University campus. The building consists of separate functional areas with particular spatial structures. There is an open gallery system in the public area on the first floor, a large reading room and a reference library on the second floor, and there are rows of side-by-side office rooms in the third floor. For the study, two partial routes were chosen. The first partial route leads through the gallery system on the first floor to the library's terrace on the second floor, and the second partial route leads from the library to a particular meeting room on the third floor. In the empirical study, participants are asked to walk these routes successively in the real building after watching a visual route instruction presentation just before navigating the partial route.

Conditions differ with respect to the visual format of the route presentations: (1) floor maps in which the route is indicated by a line (Fig. 1), (2) a sequence of pictures of intersections and decision points along the route (Fig. 2), and (3) a movie which shows the movement through the model of the building from the egocentric perspective (Fig. 3a).

2.2 Pilot study

In a pilot study it was tested whether the view-based visualizations (Fig. 2, Fig. 3) derived from the model are easy to understand by themselves. Rating items asked for comprehensibility of several aspects of the presentation (e.g., architectural features and route indicators). 27 subjects watched and rated the picture condition, and another 36 participants watched and rated the movie condition. On the six-point rating scales, 69 % rated the comprehensibility of the movie condition positively (agree / strongly agree), while only 10 % rated it negatively (disagree / strongly disagree). In the picture condition, 65 % rated the comprehensibility positively, and only 9 % rated it negatively. These results indicate that the view-based, egocentric presentations generated by Yamamoto were comprehensible for the majority of the participants.

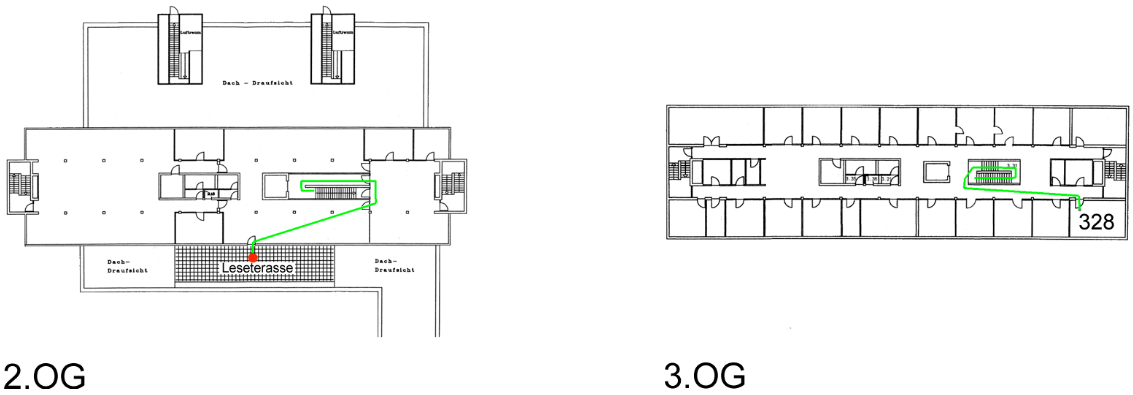

Figure 1: Map condition. Floor maps present a complete floor from an allocentric perspective. The route is indicated by a green line.

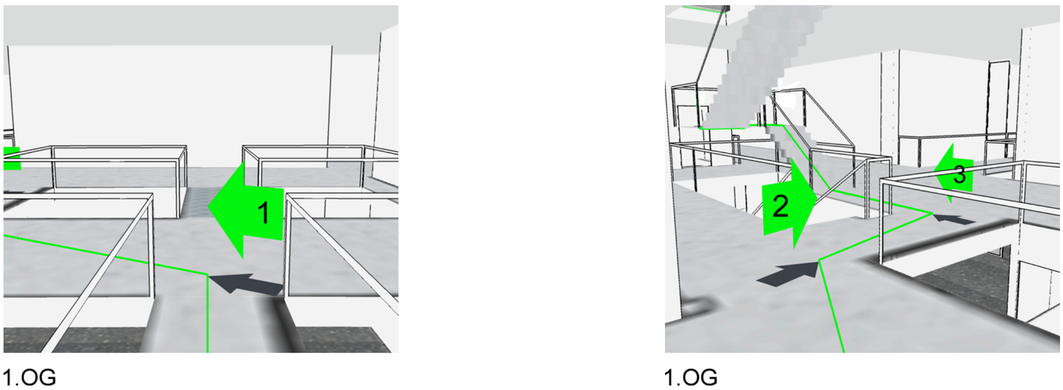

Figure 2: Picture condition. The figure shows two succeeding images out of a sequence of 9 images.

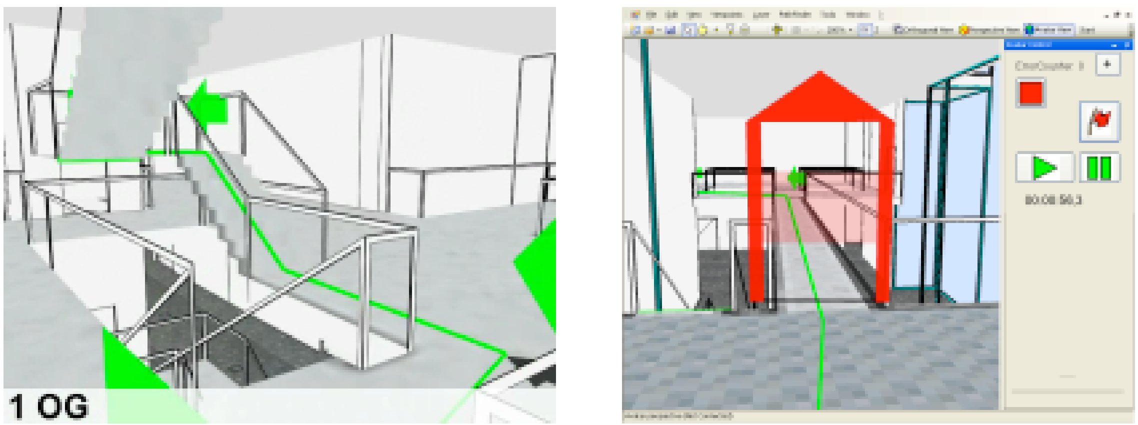

Figure 3a): Movie condition. Still image taken from the presentation. 3b): Experimenter's measurement tool.

2.3 Main study procedure

In each of the three wayfinding conditions, 12 subjects who were not familiar with the building navigate both partial routes successively. Participants receive the route instruction shown on a tablet PC at the beginning of the respective partial route. Both of the partial routes are presented in the same presentation condition. After watching the presentation, participants are asked to navigate to the destination without further assistance. The experimenter walks behind the participant and measures times and wayfinding errors. The experimenter uses a variant of the Yamamoto model as the measurement tool (based on the egocentric view, see Fig. 3b). During the walk, wayfinding times are measured at checkpoints introduced in the model, and errors are additionally registered. After the destination is reached, the participant is unexpectedly asked to navigate the route backwards. Again times and wayfinding errors are measured. Currently, the main study is in the data collection phase.

3 OUTLOOK

The results of the present study will contribute to the development of design guidelines for personalized visual indoor route instructions, which transform raw model views and route calculation data into cognitively more adaequate route instructions. This research goal corresponds to related work focusing on the transformation of maps for human wayfinding by description of choremes and schematization of maps (Klippel et al., 2005). We will focus here on the egocentric views (Fig. 2, Fig. 3). In general, these view-based presentations are composed of structural geometric primitives (walls, doors and stairs), however, functional meta-objects (particularly lines and solid 3D arrows as route indicators) are added to the scene. In the movie condition, turning actions are additionally visualized through the camera motion. The design decisions for these meta-objects and motions interact with the complexity of the architecture. Currently, we are working on a number of automatic design transformations to improve comprehensibility (e.g. understanding 180 degree turns, chunking of turns, removing turns which are unnessecary to show).

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