An Exploratory Study for Evaluating the Use of Floor Visualisations in Navigation Decisions

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ABSTRACT

Different environmental cues can influence our spatial behaviour when we explore unfamiliar spaces. Research shows that the presence of other people affects our navigation decisions. To investigate the use of this environmental cue as a navigation aid in novel environment, we first explore visualisations that represent historical presence of people. We carried out an exploratory study (n=12) to examine whether and how people understand and use floor visualisations to make their navigational choices. Results suggest that floor visualisations have influenced participants' navigation decisions. Our findings showed that implicit visualisations were difficult to interpret compared to explicit visualisations. Thematic analysis of participants' interpretations revealed a contextual interpretation of explicit visualisations and non-contextual interpretation of implicit visualisations. Additionally, thematic

KEYWORDS

Navigation; presence of people; floor displays; thematic analysis; exploratory study

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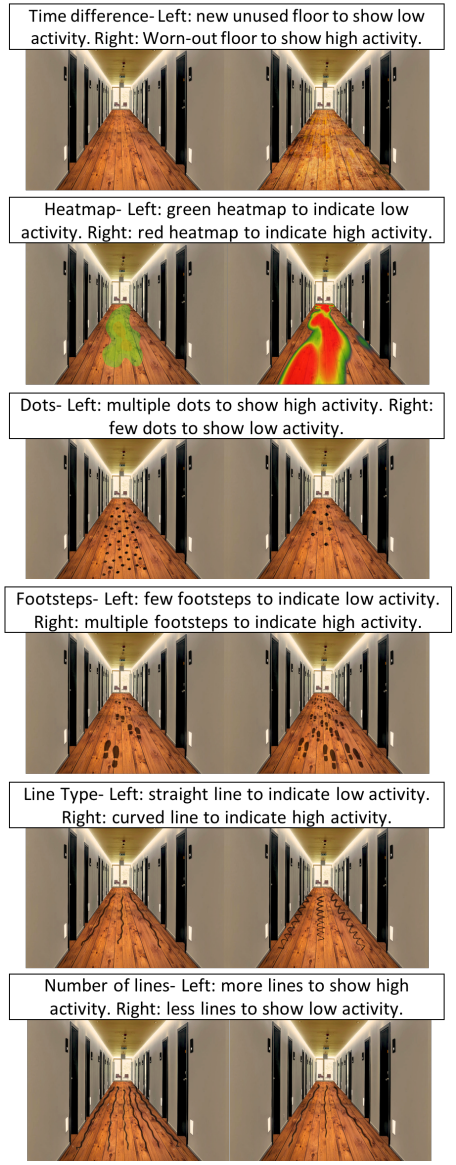

Figure 1: Selected visualisations to represent information about historical presence of people.

analysis revealed that spatial behaviour is influenced by several factors including self-centredness, environmental features and the presence of others. These design insights will inform the design of history-enriched floor interfaces that direct people in the built environment.

INTRODUCTION

Humans have a natural tendency to follow the traces of other people in unfamiliar environments [5, 6]. Previous work [3] suggests that people act as attractors and that the spatial behaviour is significantly influenced by their presence. This implicit social cue can be utilised to aid in navigating unfamiliar environments. In particular, in situations where less attention is paid to directional signs (e.g. while exploring new spaces) and movement direction needs to be controlled. With the recent technological advancements, it is now possible to embed this social cue in everyday objects and spaces. For instance, floors can be augmented with navigation information about other people [8] and used to guide people in their navigational choices.

In order to assess whether and how people understand and use information about historical presence of people in their navigational choices, we brainstormed different visualisation designs, developed prototypes and ran a study. There are many design trade-offs to consider when presenting information within buildings (e.g. trade-off between aesthetics of environments and explicit information presentation). Visualisation design should show historical presence of people without affecting the overall aesthetics of the environment. Therefore, we explore in this design space both explicit and implicit (i.e can be embedded in floors without affecting the aesthetics of the environment) visualisation designs that can be used to represent historical presence of people. Based on the selected designs, we created low-fidelity prototypes and ran a study to evaluate them. Results suggest that the visualisations have influenced participants' navigation decisions. Additionally, we found that participants described implicit visualisations using non-contextual interpretations whereas explicit visualisations were described using contextual interpretations. This work is part of a research project that aims at exploring and understanding the use of social cues as an unobtrusive navigation aid.

BACKGROUND

When we navigate spaces we read, interpret and use many environmental cues. These include physical and social characteristics of the built environment. Physical characteristics such as the configurational features play an important role on the individual's spatial behaviour. For example, navigational choices are highly influenced by the visible number of angles (i.e. people prefer to take straighter path choices) [3]. Path width is another physical characteristic that influences individual's navigational choices (i.e. people prefer to take wider paths) [9]. Social characteristics of the built environment include the presence or the absence of other people. People tend to infer information about the space's importance and popularity based on these social cues [3]. Consequently, people often make their

navigational choices based on the traces left by others such as following a walking path in a forest. Our tendency to follow the traces left by other people has been extended and applied to the digital world to help users navigate complex information spaces [5]. Many websites utilise the activity patterns of previous users to guide new users (i.e. social navigation in information space) [4]. For example, YouTube's Views and Netflix's Trending Now show how often information has been accessed or is currently trending [2].

The recent advances in technologies make it feasible to incorporate social navigation cues within the built environment e.g. on walls,floors or objects. For instance, several floor display technologies were implemented to augment floors with information [1, 7, 8].

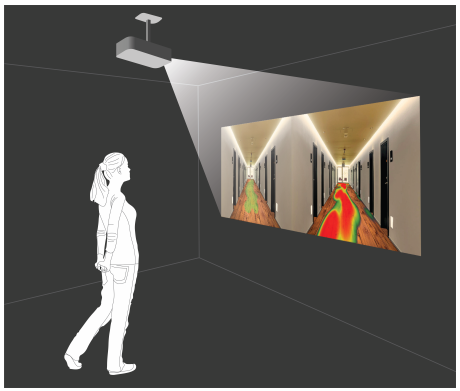

Figure 2: Experimental Setup.

METHODOLOGY

We brainstormed different visualisation designs, developed prototypes of the selected visualisations and ran an exploratory study to assess their use.

Prototyping

Low-fidelity prototypes allow communicating and evaluating design ideas with users at an early development stage. We therefore created six low-fidelity prototypes based on the top ranked ideas that were generated in the ideation session (See Figure 1).

Evaluation study

The aim of this study is to evaluate whether and how people understand and use floor visualisations to make their navigational choices.

Participants. We recruited 12 participants (7 female), aged between 19 and 27 years (M= 22.5 SD = 3) to contribute to the study. Participants were recruited in person and via posters at our institution. They were offered non-monetary reward at the end of the study.

Procedure. We conducted structured interviews to evaluate the following visualisations: time difference, heatmap, dots, footsteps, line type, number of lines (Figure 1). We asked participants to face a large projected display and to answer questions given by the researcher (Figure 2). We chose this setup to mimic a real navigation situation. The researcher followed the interview questions and took written notes of the participants' answers. In the first section of the interview, we presented the following scenario to participants:*"Imagine entering an unfamiliar building and while you are exploring the space, you reached a point with two path choices. Which one of the shown paths (A/B) would you take and why?"* We asked them to choose a path and to justify their selection in six situations. Next, we asked participants to provide their own interpretation of the meaning of the visualisations. Finally, participants were told that the the shown visualisations were selected to represent historical

Figure 3: Participants' path choices in the selected visualisations.

information about people who used these paths before, and they were asked to rank the top three meaningful visualisations. The interview took approximately 15 minutes to complete.

ANALYSIS AND RESULTS

Analysis of navigation decisions

We analysed the frequency of navigation choices for each of the selected visualisations (Figure 3). Our results showed that most of the participants (9 out of 12) selected the new floor compared to the worn out floor. Eight participants chose to take green heatmap path. Also, Eight participants preferred to take the path with less dots. In both the footsteps and line type visualisations, more than half of the participants (7 out of 12) selected the path with more footsteps and preferred the straight lines compared to the curved lines. Eleven participants chose the path with less lines.

We used thematic analysis to analyse participants' justification of their navigational choices. A team of two coders performed the analysis. Our analysis resulted in generating three themes that describe the factors that influenced participants' navigation choices. The generated themes include: selection based on a self-centred point of view, selection based on environmental features, selection based on the presence of other people.

Selection based on a self-centred point of view: Participants expressed feelings towards the visualisations (n=7), where n is the number of participants who reported their feelings in at least one visualisation. Some participants described paths as *"scary", "isolated"*, while others described paths more positively *"safe", "comfy", "assuring"*.
Participants explained that the floor visualisations triggered their curiosity and interest to take a specific path (n=4), where n is the number of participants who reported their curiosity in at least one visualisation. Participants reported that some paths are *"more interesting"* (P4) and that some visualisations showed that *"something is happening"* (P7). P4 stated that a path with more footsteps is more interesting to explore.

Selection based on Environmental features: Participants described the environmental aesthetics of the scenes to explain their navigational choices (n=11), where n is the number of participants who reported the aesthetics of the environment in at least one visualisation. For instance, participants reported that some paths are *"nice", "clean", "natural","new"*. P10 described the new floor as *"sleeker floor"* compared to the old worn-out floor. Other participants reported avoiding *"messy"* paths (P12). Also, participants expressed that their path choices were based on abstract visual features of the floor visualisation (n=8). For example, paths were described as having *"smaller red spot"* and *"straight lines"*.

Selection based on presence of other people: Participants expressed that path usage have influenced their navigation choices (n=10), where n is the number of participants who reported usage in at least one visualisation. Some participants preferred to follow other people while others chose to avoid

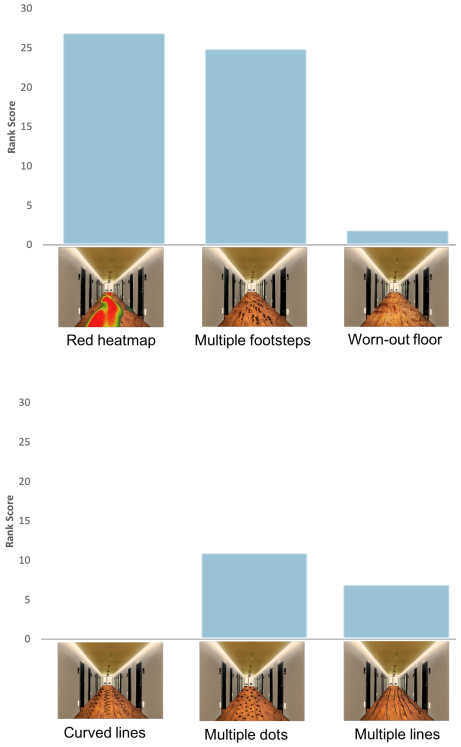

Figure 4: Visualisations Ranking of the six visualisations.

the presence of others. For example, participants described the chosen paths as having *"more traces"* *"more footprints"* and *"more people"*. On the other hand, some participants reported that their path choices were based on *"avoiding crowds"* or on taking the path that was *"used less"*.

Analysis of participants' interpretations of visualisations

We used thematic analysis to extract themes that describe how people interpret the floor visualisations. A team of two coders performed the coding. We identified two main themes to understand how people make sense of the floor visualisations: Contextual and non-contextual interpretations.

Contextual Interpretation: This theme considers the floor visualisation in the given navigation context and includes the activities that occurred in a path and the information that the visualisation provides. Participants described specific actions that occurred in the paths (n=4), where n is the number of participants who described the visualisations using a short term action in at least one visualisation. P12 described the number of lines visualisation as *"dragging things on the floor"* while P4 reported a *"bouncing ball"* in the line type visualisation. Another longer term activity reported by participants was walking. Participants expressed the meaning of the visualisations in terms of paths usage (n=11). P9 reported that the footsteps visualisation means that *"more people are walking.* Participants found that the visualisations provided useful information about the paths (n=11). For example, participants reported that the visualisations provided information about walking direction, number of people, movement type, time difference and cleanliness level.

Non-contextual Interpretation: This theme describes the symbolic interpretation of the visualisations without considering the given navigation context. Participants expressed the meaning of the visualisations using symbolic descriptions (n=9), where n is the number of participants who reported symbolic interpretations in at least one visualisation. For example, animals were reported by participants in different floor visualisations *"ants"* (P1), *"dogs"* (P5) and *"snake"* (P2). Other descriptions reported by participants included *"blood"*, *"monster"*, *"graffiti"* and *"art"*.

Analysis of visualisations ranking

We asked participants to rank their top three visualisations that best represent the presence of other people. The heatmap visualisation was selected by participants as their top choice followed by footsteps and then the dots visualisation. Figure 4 shows the ranking scores of the six visualisations.

IMPLICATIONS FOR DESIGN AND FUTURE WORK

This study investigated whether and how people use and understand floor visualisations about historical presence of people in their navigational choices. Our work will expand on this exploratory study by using the gained design insights to design history-enriched floor interfaces to direct people

in the built environment. This solution provides public spaces with unobtrusive cues that can guide people without affecting the exploration experience. Augmenting spaces with information is becoming gradually feasible as we continue to embed technologies in everyday objects and spaces. for example, with ambient displays, walls and floors can be augmented with navigation aids.

Our findings suggest that floor visualisations have influenced the participants' decisions. However, these decisions were based on misinterpreting some of the visualisations. For example, most participants preferred to avoid cluttered paths in the implicit visualisations and chose to take busier paths in the explicit visualisation (e.g. footsteps). The reason for this is that implicit visualisations were difficult to interpret whereas explicit visualisations were direct and clear. Additionally, we found that contextual interpretations were evident in explicit visualisations whereas implicit visualisations were interpreted out of context. Based on these insights, the design of the visualisations in our future work should provide a clear representation of the presence of other people to ensure correct interpretations.

The study also showed that the presence of others is not the main influential factor on navigation. Other factors to consider include self-centredness and environmental features. Participants considered these factors when the implicit visualisations were presented, however, in explicit visualisations, the presence of others factor was evident. Consequently, It is important to consider social and physical cues when assessing navigation decisions. The insights gained from this study will inform the design of our history-enriched floor display.

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