Usability Analysis of 3D Maps for Pedestrian Navigation for Different Demographic Profiles

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Abstract. 3-Dimensional (3D) maps may provide the users with a more real-world like view in comparison with the 2-Dimensional (2D) maps. 3D maps offer more degree of freedom in movement to the users, a first-person perspective view and other dynamic details such as time of the day, weather could also be incorporated. This paper demonstrates the evaluation of the usability of 3D maps for navigation purposes, in several general aspects including recognizing landmarks and using these visual cues for navigation among different representative user-groups. The 3D model was designed to replicate the High Street, Stratford, London, UK. The participants of the survey were required to explore the model, identify and memorize the landmarks and form a mental map. They were also asked to reproduce the route they took in a 2D paper map and answer a questionnaire on their perception of their own cognitive abilities and their response on the performance of the 3D model. The results confirmed that the usability can vary among users of different demographic profiles – age, gender and language and familiarity with 3D technologies. It also showed that with some improvements in level of details incorporated in the model and design, 3D maps could become a useful tool for navigation purposes.

Keywords. Navigation, Landmark, 3D Maps

1. Introduction

Wayfinding is a complex cognitive task fundamental to all human beings and the level of complexity could be affected many factors, including the level of familiarity with environment (Farr et al., 2012). The process of wayfinding includes interaction with one's surroundings, and landmarks could be used for positioning and orientation (Basiri et al., 2016), since they are easily recognizable. The uniqueness of the landmarks is defined relative to the environment it is present and since pedestrians move at relatively slow-

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er speed, it allows them to notice these unique features/objects (landmarks) in the environment they are navigated through.

3D maps allow for more degree of freedom in movement, more interaction with the surroundings, easier self-positioning and self-orientation through a realistic portrayal of the outside world and first-person perspective view. The rapid improvement in technology and 3D modelling software enabled the creation of interactive and dynamic maps which could be implemented in the user's mobile devices without consuming a lot of data and storage space (Haeberling, 2002; Oulasvirta et al., 2005). The realistic view offered by the 3D maps could be helpful for non-native people such as tourists since they don't have to follow the written and spoken instructions offered by 2D maps. In 3D maps, the viewpoint of the user can be set to the user's current view, so that the use can match the real world with the 3D components of the map (Maehara et al., 2002).

In this study, a model of a 3D urban setting was developed to analyse the usability of 3D maps. Another focus of the study was the influence of language in wayfinding and whether it could become a barrier for people who are non-native English speakers. The analysis of the usability was done with the purpose of examining the general attitude and experience of the representative user group with 3D maps and was studied from the following aspects: (A) interacting with objects around them, and (B) recognizing and memorizing the important features/objects, i.e. landmarks.

This paper structured as follows; next section explains the experiments and section 3 discusses the results of the conducted survey. Finally, there is a conclusion and future work section.

2. Experiment

The study site used to build the 3D model is in High Street, Stratford, London, E15, the UK. Stratford is a part of the London Borough of Newham. The study site is popular among tourists as a cultural and leisure centre. This helped achieve one of the primary objectives of the study which is analysing the usability of the 3D navigations apps among non-English speakers or tourists.

The primary applications used for constructing the model were SketchUp and Unity 3D. The model was created using basic shapes in Unity 3D to ensure minimum file size. Some models (for e.g. bus-stops) were imported from 3D warehouse in SketchUp. The textures for the geometry were obtained from Google street view, Google images and from photographs of the study site. Then the terrain (parts of roads and pavements) was baked to NavMesh to make sure that it is walkable. The classic skybox from Unity asset store were added to the scene and then was exported as WebGL build.

2.1. Survey

The rationale of the survey was to collect the responses of the participants, which in turn would reflect their views on the proposed 3D navigation system. The participants were recruited after making sure that they are unfamiliar with the study area. 35 participants (see Table 1 and figure 2) were asked to explore the 3D model and were presented with a series of representative images. Few of these were images of buildings which were present in the model and others were images of buildings inserted at random. The participants were asked to pick the buildings that they can recognise from the model and on which side of the street it was located. The participants were not required to use the 3D city model as a navigation app and explore the study site. Hence, the time spent on the tasks were not measured. There were required to answer a questionnaire to collect the following details: their demographic profile, familiarity with 2D and 3D navigational applications, their perception of their own cognitive abilities, the level of communication between the participants and the app, the level of details and interaction provided by the app, and the level of user satisfaction.

The 3D model developed in this paper, is a combination of various objects representing different features of the study site – including the terrain, buildings, infrastructure and other street properties. Figure 1 shows two instances of the 3D model of the location created using Unity 3D.

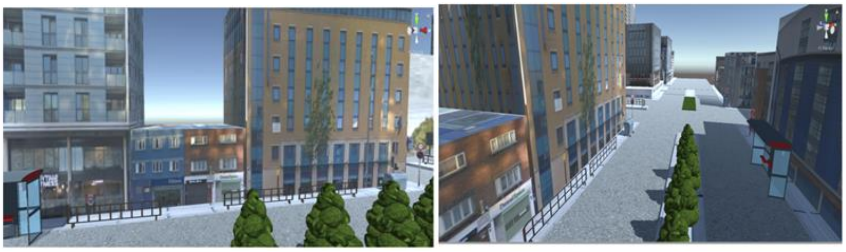

Figure 1. Two instances of the location on the created 3D model

3. Results

The 3D model was built so that the participants can travel from location A (Belvedere Olympic One Eighty, 180 High St, London) to location B (Londis, London E15 2HR). Figure 3 shows the path on Google maps for pedestrians to travel with visible landmarks along with the count of number of times each landmark was identified.

Among the non-English speakers, 74% of the participants were comfortable using the spoken instructions provided by the navigational apps. 26% of the non-English speaking participants were not comfortable following the spoken instructions provided by the navigational aids, and they depend entirely

the visual cues. 85.7% of the participants were able to relate the virtual world with the real-world scene and recollect the route they took in the 3D model. Only 5.7% of the participants were not able to relate the virtual world with the real-world scenes and recollect the route they previously took. Compared to the female participants the male participants were able to relate the 3D model with the real-world.

Category		Number	%
Age	18 – 26	5	14.3
	27 – 35	9	25.7
	36 – 49	17	48.6
	Above 50	4	11.4
Gender	Male	16	45.7
	Female	18	51.4
	Prefer Not to say	1	2.9
Native Language	English	18	34.3
	Non-English	17	65.7

Table 1. Demographic Profile of the participants

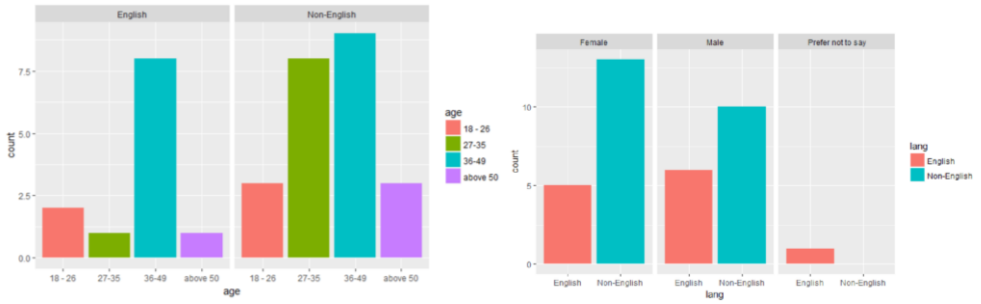

Figure 2. Bar-graph showing the CrossTable between age and language (left), Bar-graph showing the CrossTable between native-language and gender

Landmarks	Number of times	Percentage (%)
A	32	91.43
B	5	14.29
C	3	8.57
D	34	97.14
E	35	100
F	4	11.42
G	12	34.29
H	26	74.29
I	2	5.71

Figure 3. Location of the landmarks on the path traversed by the participants using the 3D marked in Google map (Google maps, 2019; Google street view, 2019)

There was no relationship between language and the ability to form a cognitive map. However, the tourists tend to observe their surroundings more compared to the natives, since they found it easy to remember directions

relative to landmarks. 82.86% of the participants thought the 3D model was able to convey the real-world entities and that with some improvements, the model could be useful to them for wayfinding.

4. Conclusion

This paper discussed the usability of 3D maps for pedestrian navigation among users with different demographic profiles. Another focus of the study was to analyse the influence of landmarks in wayfinding in 3D maps. These landmarks could be used for positioning and orientation in a 3D map. Compared to the male participants, the female participants seemed to have notice the surroundings and use the visual cues for wayfinding. Age was another constraint in the performance of the 3D model. The younger generation, due to their familiarity with 3D technologies were comfortable relating the virtual world with the real-world and with the use of controls and interfaces provided. From the field survey, it was observed that the non-English speaking users prefer not to listen to the spoken instructions while travelling in an unfamiliar environment and they depend on the visual display provided by the Google maps throughout their journey. In general, with more research on the end-user requirements along with some improvements in the design, 3D maps could become a useful tool in navigation across all demographic profiles.

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