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EMPIRICAL INVESTIGATION OF VISUALIZATION QUALITY FOR THREE-DIMENSIONAL (3D) OBJECTS OF 3D MAP ON MOBILE DEVICE FOR NAVIGATION AID

[1]ADAMU ABUBAKAR, [2]SARDJOENI MOEDJIONO, [3]TEDDY MANTORO, [4]AKRAM ZEKI, [5]HARUNA CHIROMA

[1,4]Department of Information Systems, Kulliyyah of Information and Communication Technology, International Islamic University; Malaysia
[2]Faculty of Information Technology, Budi Luhur University, Jakarta, Selatan, Indonesia
[3]Faculty of Science and Technology, Universitas Siswa Bangsa International, Jakarta, Indonesia
[5]Department of Artificial Intelligence, Faculty of Computer Science and Information Technology, University Malaya, Malaysia

[1]adamu.a.a@ieee.org, [2]moedjiono@budiluhur.ac.id
[3]teddy@ieee.org [4]akramzeki@iium.edu.my, [4]freedonchi@yahoo.com

ABSTRACT

Previous studies have shown some key factors that influence the success of visualization quality for 3D objects of 3D map on Personal computers (PCs) and Laptops', crucial to that is the 3D computational processing capabilities of PCs and Laptops. Unfortunately 3D applications on mobile devices are hindered by the lack of efficient mobile rendering interfaces, low computational resources and direct 3D rendering at interactive rates. Although recently there are several attempts of building complicated 3D map visualization tasks on mobile devices, yet there is still problem of visualization quality of 3D objects of 3D map on a mobile device, this could be attributed to salient features which this paper try to uncover. An experiment that is aimed at investigating how people visualized 3D objects and orient themselves with the 3D map view on a mobile device for navigation assistance was carried out. The result indicates that the size and shape of 3D objects of 3D map significantly aided orientation, but there are no significant differences between the size and color. The 3D map view can increase the user's sense of presence; however, 3D map projections tend to represent familiar scenes by collections of their 2D views. This paper shows visual variations of complex 3D map scenes on small-screen mobile devices, with a single object-centered 3D map projection.

Keywords: *3D objects, 3D map projection, Mobile device, Object-centered, Visualization*

1. INTRODUCTION

People visiting unfamiliar places and searching for particular locations require guides. In ubiquitous computing environment small computing devices such PDAs, smart phones that communicate wirelessly offers opportunity to be utilized for such guides. Ubiquitous here means that computers or computing are context that are spread everywhere at the same time [1]. Context here refers to any information that can be used to characterize the situation of an entity; and an entity is defined as the person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves [2]. The quality of Visualizing of 3D objects (Spheres Cylinders, Prisms) depend on it's the presentation. There are many factors that influence the success of visualization quality for 3D objects. Relative success of different appearances for 3D objects of 3D map presentation and view control are very crucial. Previous research have shown some key 3D visual variables namely; orientation, size, color value, color hue, position, shape, and texture [3], which, according to [4], have been proven in psychophysical research to guide visual attention. These variables are also used in modern visual saliency models [5]. With recent attempts of building complicated 3D map visualization tasks on mobile devices, visualization quality of 3D objects of 3D map on a mobile device is very important. This could be attributed to salient features which this paper provides the steps with which it uncovers those features.

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How people visualized 3D objects and orient themselves with the 3D map view on a mobile device for navigation assistance can only be determine by field experiment in order to understand the influence of 3D map view on mobile devices for navigation assistance. The representational differences of 3D map view are considered. This study undertakes an experiment, similar to the study performed by [6] in order to understand the influence of 3D map view on mobile devices for navigation aid. The representational differences of 3D map view are considered different model devices with 3D map of various sizes and shapes of 3D objects are used. Some sample of respondents participated in the experiment voluntarily. Data The experiment significantly were collected and analyzed with the aim at exerting visualization quality for 3D objects of 3D map on mobile device for navigation aid.

The remaining part of this paper compresses of four sections apart from this section. Section 2 is the present the visualization of 3D map. Section 3 present the experiments and section 4 provides the result, finally section 5 present the conclusion.

2. VISUALIZATION OF 3D MAP

3D Described an object which has three dimension of measurement: Width, height, and depth represented as coordinates in a Cartesian coordinate system denoted as X, Y and Z [6] respectively. Visualization is a process of forming mental model of data, thereby gaining inside into that data [7]. This means that visualization meant constructing a visual image in the mind [8]. Stuart et al. [9] propose six major ways in which visualizations can amplify cognition with regards to physiological point of view. However, 3D visualization is important in many field, the common advantages gain in all areas is clear and precise information displays that depends on the capabilities of the perceiver. 3D visualization attributes on mobile device in similar to were proposed by Mosmondor et al. [10]. It is a fact that human visual systems are built to perceive the shapes of 3D surfaces and that human perceive in order to operate on the environment. Thus experiments are required on the scale and dimensionality of presentation of 3D map in mobile devices and interaction [8].

Visibility of 3D objects determining a visible set of a given object generated by from a scene. Various algorithms to the approach are available aimed at providing appropriate visual presentation of 3D objects [12]. Visibility culling from view spectrum of 3D object and level-of-detail of 3D object are the general techniques used for 3D visualization. Visibility culling technique reduces 3D object complexity by hiding large parts of a given object [16]. However, this will provide fast interactive frame rates and free browsing in the entire 3D space, thus If an object is beyond a plane of the view frustum, it won't be visible. Contrary to this technique is the level-of-details of 3D object that may be required in some certain cases[16]. This means the visibility culling will not be suitable, for example in medical studies. Although it's a fact that geometry described properties of a shape that remain unchanged even if it's subjected to transformation [15]. Visualization of 3D objects in mobile devices exhibit the three common 3D primitive transformations that can be performed on vertices [12]. This includes translation, scaling, and rotation. Translation of 3D object shows a moving or displacement of a certain distance. Whereas Rotation indicated the rotating vertices about an axis going through the origin and Scaling shows enlarging or shrinking of the size of vector components along axis directions [15].

2. 1 Field Experiment on 3D Map Visualization

The field experiment was not aimed at evaluating mobile device capabilities to use 3D maps; instead, it was aimed at how people orient themselves with the 3D map view on a mobile device for navigation assistance. Thus, two fundamental tasks must be executed in the experiment. The first task is to determine the similarity between the 3D map view on a mobile device that corresponds to the participant's location in reality, and the second task is to evaluate 3D map view in a small-screen mobile device capability for navigation, in other words, whether the 3D map is suitable as a navigation aid or not. To extract those salient features that could influence the relative success of different appearances for 3D map presentation and view control, visual variables, including orientation, size, color value, color hue, position, shape, and texture, were used [3], which, according to Wolfe and Horowitz [4], have been proven in psychophysical research to guide visual attention. These variables are also used in modern visual saliency models [5]. In addition to the traditional success measures, we collected procedural data in the form of the participants' eye movements when solving the experiment tasks. In this manner, we hope to not only identify which visual variable works best but also to demonstrate how this variable works best. This approach will lead to acquiring an understanding of the relations between the references of reality and 3D map view in a small-screen mobile device.

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2.2 Participants

A total of 21 participants participated in field experiments. All of the participants had previous experience using in-car GPS navigation systems. Nineteen of the participants were male, and two were female. In this group, 65% belonged to the age group of 25 to 40 years, and 35% were in the age group of 19 to 24 years. In terms of smart phone usage and awareness of the presence of 3D maps on mobile devices for navigation assistances, their experience was average

2.3 Experimental Task and procedure

To avoid experimental biases and to ensure that our results do not trivially reflect the learning of 3D map functionalities, which would occur if the 3D map were not known to the participants, we selected participants who had an awareness of 3D maps on a mobile device but who had average experience in 3D model manipulations and 2D map legend translations, and we presented pre-field awareness instructions to them.

The two field experiments begin after pre-field preparation in the laboratory, where the participants are given different mobile devices that contain both 3D and 2D maps. The first session of the experimental task involves presenting a mobile device that contains a 3D map to the participants; the participants then view and make a visual assessment based on what they see in the mobile device when the 2D map is given to them as well. This approach allows the participants to develop an understanding and become familiar with the experimental tasks. Then, at the end of the experiment, a structural interview is conducted to capture an in-depth understanding of the key visual features of 3D maps in the mobile device for navigation assistance. The second session is similar to the first, but the participants are asked to walk around an area to compare the 3D map presentation on their mobile device with what they see in reality. They are asked to pause at the point at which they see changes to allow the changes to be tracked (see Figure 1). Some of the 2D and 3D map views of the mobile device used by the participants are presented in Figure 2.

Figure 1. Participant Holding A Mobile Device Walking And Comparing The 3D Map View In The Mobile Device With The View In Reality

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Figure 2. Views Of 2D And 3D Maps In The Mobile Device Used By The Participants

Figures 3A and 3B are part of the second experimental session, which shows two participants walking; none of the participants appear to be engaging with the mobile devices, although one of them (from the right-hand side) is holding two mobile devices in both the left and right hand. The participants are walking to go around the Kuala Lumpur Conventional Center (KLCC) Park, which is located within the vicinity of Suria (KLCC) in Kuala Lumpur, Malaysia. KLCC is surrounded by many buildings, and it is a relatively densely populated area, where 3D map view on a mobile device would be very important in guiding people to locate unfamiliar places. The major task here is to be able to identify the physical features in reality when compared with the 3D map view on the mobile devices. In Figure 3C, there is a display in a 3D map view from a mobile phone displaying the tracked path followed by two participants and having red color points that comprise a circuit that indicates the path that the two participants followed. The tracked path comes as a result of an embedded application developed in a HajjLocator project by Mantoro [11] to track user locations. However, the 3D map display is the key attribute for this experiment, not the tracking of a user's location. The 3D map view is a realistic and manipulable Google 3D map. Figures 3D and 3E present four different maps, in 3D and 2D, on a mobile device for a navigation aid. The first on the left-hand side is the same as in Figure 3C, and it is the manipulable 3D map in a bird's-eye-view projection of the area within KLCC Park. The second on the left-hand side is a 2D map projection of the same area, whereas the two maps on the right-hand side are a fixed view Sygic pictorial 3D map presentation and a fixed view Garmin 2D map presentation of the same area in KLCC Park.

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Figure 3. Mobile Device Interfaces Used In The First Session Of The Experiment.

The appearance of the Google 3D map in Figure 3 is the same as Figure 2, but both of the maps are different from those on the left-hand side of Figure 3, which is designed in the Visualization of User Navigation (VisUN) project by Abubakar et al. [12]. To generate concrete facts from the respondents, an informative and useful representation that is different from 3D map view was shown to the participants. The average time spent by the participants for viewing is 20 minutes, whereas the interview lasted for up to one hour per participant. The second part of the second session of the experiment was undertaken in the city center of Kuala Lumpur in the vicinity of Merdeka Square (Dataran Merdeka), as shown in Figure 8. The experiment also aimed at identifying the physical structure that had the 3D map view on the mobile devices for comparison. The path followed by the participant in Figure 4 is also indicated in the mobile devices such that the participant could more easily compare what he sees in the mobile device and what is present in reality. This approach is also aimed at understanding the visual variables for 3D maps on mobile devices as a navigation aid.

3. FIELD EXPERIMENT ANALYSES.

The data from experiment were extracted through. Major points on central issues or interesting details as deemed fit by the researcher are extracted [13] and categorized into themes. This approach allows the mass of data to be condensed into groups to identify the amount of usable facts gathered from the experiment. The time that it takes for the participants to detect the physical view of reality compared to the 3D map on mobile devices and the nature of the reactions during the experiment was observed.

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Figure 4. Mobile Device Interface Used In The Second Session Of The Experiment.

For each action and reaction of the participants during the experiment, visual variables were examined by asking the participants questions based on the structured interview questions. Questions were posed when the participants stopped. Then, after the end of the session, questions were asked again, to compare the participant's initial answers during the experiment and the new answer given after the experiment. The time taken for the participants to detect views from the device and to compare them to the physical features with respect to the relevant visual variables under study is presented in Figures 5-7.

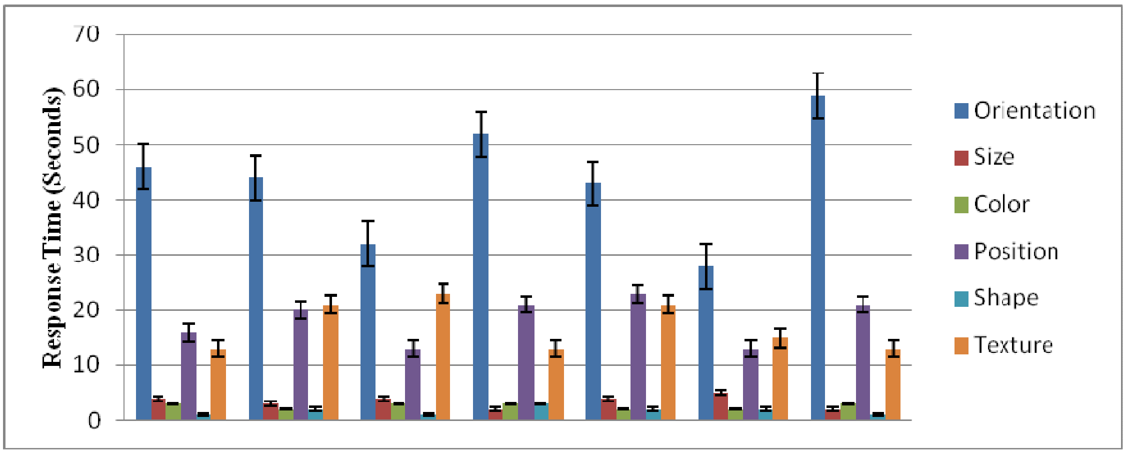

Figure 5. Participant 1 To 7 Response Time In Which Participants Could Detect And Compare The 3D Map View With Physical Features Around Them, Such As Buildings.

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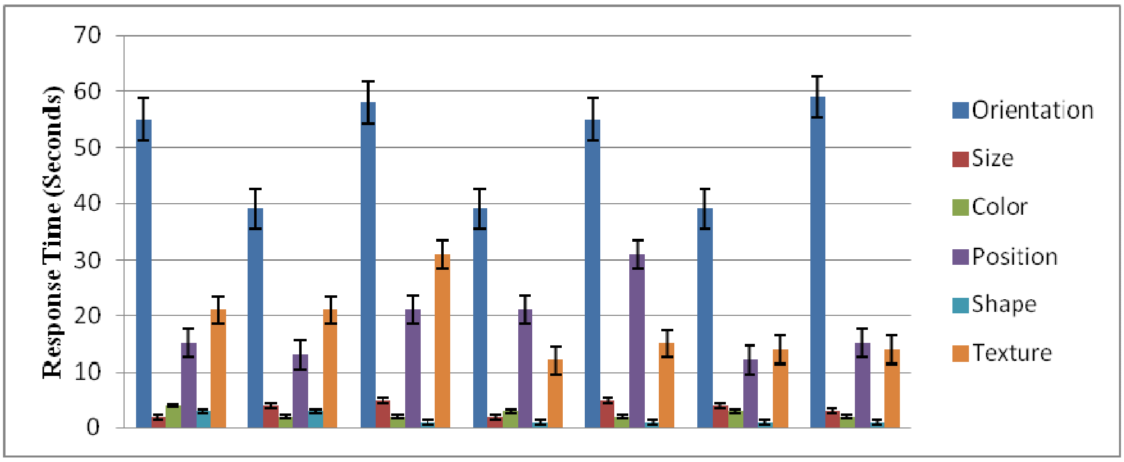

Figure 6. Participant 8 To 14 Response Time In Which The Participants Could Detect And Compare The 3D Map View With Physical Features Around Them, Such As Buildings

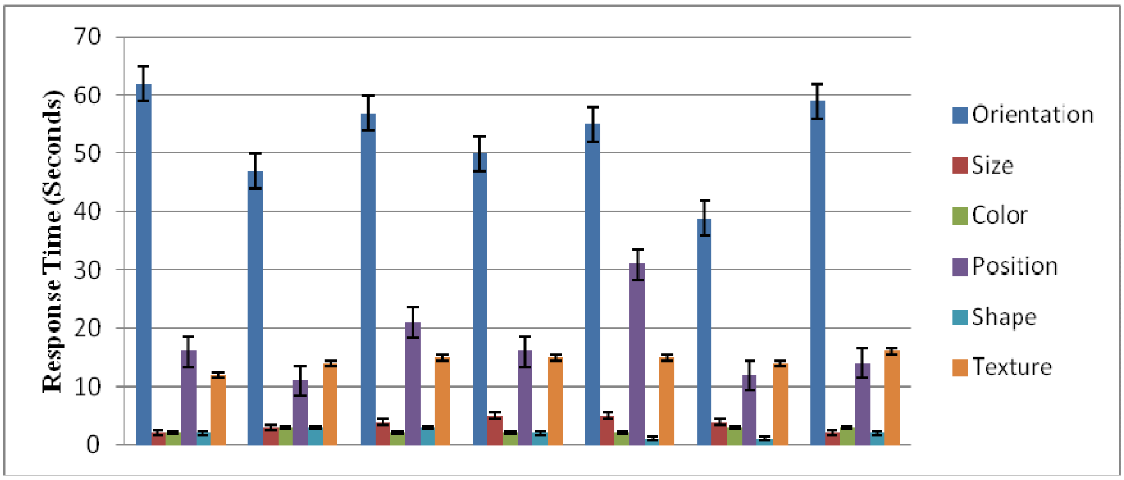

Figure 7. Participant 15 To 21 Response Time In Which The Participants Could Detect And Compare The 3D Map View With Physical Features Around Them, Such As Buildings

4. RESULT

Efficiency metric time is employed to identify how long the participants take to first detect specific features in the 3D map during the experiment. Figures 5-7 depict the average length (in seconds) until the participants detect the relevant part of the 3D map. Again, people are slowest to detect the orientation changes compared to the color and size.

Table 2. Descriptive Statistics Of The Visual Variables

		Orientation	Size	Color	Position	Shape	Texture
N	Valid	21	21	21	21	21	21
	Missing	0	0	0	0	0	0
Mean		48.0000	3.0000	2.2857	16.6667	1.9524	17.7619
Std. Error of Mean		2.10555	.25820	.18443	.67377	.17561	.99260
Std. Deviation		9.64883	1.18322	.84515	3.08761	.80475	4.54868

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Repeated-measures analysis of variance (ANOVA) reports a significant main effect for the six tested visual variables, F(6.623) = .004, p <.05. The size and shape are significantly faster to comprehend compared to the orientation, but there are no significant differences between the size and color. Orientation is significantly slower than the other test variables. The first observation that was made was the distance between the observer and the 3D map on the mobile devices. We discovered that the visual display becomes smaller as the mobile device becomes further away from the eye; however, this relationship is not always true (see Figure 8). The 3D map view can increase the user's sense of presence; however, 3D map projections tend to represent familiar scenes by collections of their 2D views. The visual variation of complex 3D map scenes on small-screen mobile devices, with a single object-centered 3D map projection (a smaller number of scenes), tends to change.

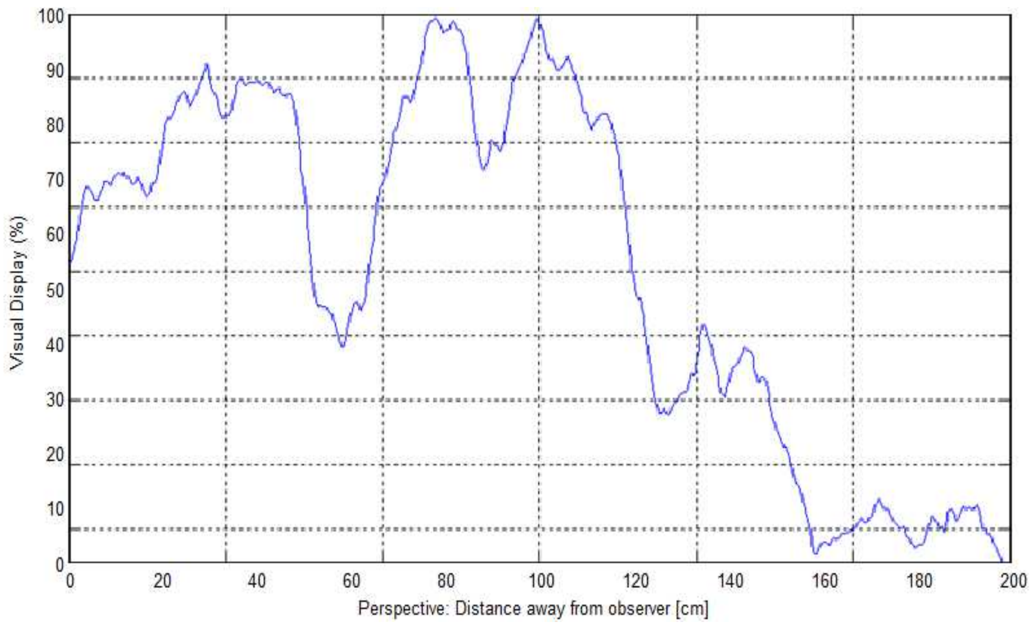

Figure 8. Visual interactions with the 3D maps on mobile devices

Because of the small screen size of the mobile devices, the 3D objects of 3D map are presented when they become too large; in reality, these features and landmarks appear to be too small in the device. Thus, there are some limitations on the perceptions of those landmarks from the user's perspective. Human visual perceptions of landmarks typically rely more on egocentric orientations, and spatial cognition ability declines with age [14].

5. CONCLUSION

This paper presents an empirical investigation of visualization quality for 3D objects of 3D map on mobile device for navigation aid. The motivation of the study comes as a result of the drawbacks of previous studies on key factors that influence the success of visualization quality for 3D objects of 3D map on mobile devices. Due to the complication of 3D map visualization tasks on mobile devices, experimental investigation was carried out aimed at providing the factors of visualization quality of 3D objects of 3D map on a mobile device, this factors could be a salient features which this paper try to expose them. The way people visualized 3D objects and orient themselves with the 3D map view on a mobile device for navigation assistance was found to be the key factor in navigating with the assistance of 3D map on mobile devices. The result of the study indicates that the size and shape of 3D objects of 3D map significantly aided orientation, but there are no significant differences between the size and color of 3D objects on 3D map. The 3D map view increase user's sense of presence and 3D map projections tend to represent familiar scenes by collections of their 2D views. There are visual variations of complex 3D map scenes on small-screen mobile devices, with a single object-centered 3D map projection. 3D map on mobile devices differs from real world space and other 3D presentation because mobile devices are small devices.

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