Development and usability evaluation of virtual guide using augmented reality for Candi Gunung Gangsir in East Java

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Development and usability evaluation of virtual guide using augmented reality for Candi Gunung Gangsir in East Java

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Abstract. Despite being one of Indonesian cultural and historical heritage, Candi Gunung Gangsir failed to attract many visitors especially from the younger generations. Lack of attraction and supporting facilities in the vicinity is one of the reasons. This research aims to develop an interactive virtual guide enabled by augmented reality that will increase the attractiveness of the object. The methods used in this research are product design and development steps with consideration of human computer interaction, and usability. Primary data of customer needs are collected on and off site through questionnaires and interviews. Customer needs are then used to generate several product concepts to choose 1 final concept from through concept selection methods. Literature review and interviews are conducted to create an accurate story line for the virtual guide. The chosen concept is then developed to become a final application which also tested against the customer needs through a survey method. The result of this research is an offline Android-based augmented reality application to scan the 17 markers to show a3-D virtual guide character on the marker and inform the visitor about history of that particular spot. The usability testing was conducted to 20 respondents and revealed that the application can attract them to visit Candi Gunung Gangsir.

1. Introduction

Candi Gunung Gangsir, located in a housing complex in Beji, Pasuruan, Indonesia, is believed to be built at the end of the 11th century or at the beginning of the Majapahit era and was once used as a shrine to worship the God of Prosperity. Despite being a cultural and historical heritage, it failed to attract many visitors especially from younger generations. Our preliminary survey observed the visitor to this site on a weekend barely reach 20 persons due to lack of attraction and supporting facilities in the vicinity. Although it has undergone a restoration, some parts of Candi Gunung Gangsir is already destroyed which make it difficult for casual tourist to interpret the site [1]. To help improving the attractiveness of the site, this research aimed to develop a mobile augmented reality application that can serve as a virtual guide for the visitors.

The application can also be used to preserve important knowledge regarding the architecture and history of the site and it will help to transmit the knowledge in a more effective way [2] by overlaying the information onto point of interest [3]. The increasing adoption pace of augmented reality (AR) in

the tourism sector [4] should make it easier to implement the application. Candi Gunung Gangsir is an outdoor site which provide a challenge in designing the application so that it must consider the ergonomic factors and product usability. Since there are no personal guides available at Candi Gunung Gangsir, we consider to create an application that can serve as a virtual guide for the visitors and bring us another challenge to create a good story line as it will be delivered in a virtual environments [5].

2. Related works

Using AR in to enhance engagement from user has gained more popularity as AR can help to create mixed reality by including virtual elements into an actual physical environments [6]. AR provide a means of improving users' experience and satisfaction. The use of AR in marketing is a promising and growing field [7] and it allows brand to enter consumer's domestic space with virtual offerings and has been practiced by leading brands such as IKEA, Wayfair, and Sephora [8] where the application enables customer to virtually try products. By providing additional information about the offering, AR can enhance a customer's real-world experience in interesting ways [9]. A personalized AR application should help customers in dealing with too much information provided by a common search engine [10].

The AR applications are also effectively implemented in the tourism business. Garau [3] used AR to improve the tourists' experience in Costello, Italy. AR has also been used for preservation purposes where knowledge of a heritage site is saved in the application. Haydar et.al [11] used AR to reconstruct underwater archaeological site and compared it with the virtual reality (VR). The historical information regarding Roman Theater at Byblos are used to reconstruct the site virtually [1]. Recently, Mah et.al [12] has generated a virtual tour to preserve the cultural heritage of Tampines Chinese Temple in Singapore. A mobile AR based on semantic web technology has been developed to provide contextual information about Injeongjeon Hall in South Korea [13].In Indonesia, Affan et.al [14] implemented AR as information and promotion media for Dieng tourism area.

Application design is not over once the application is ready to be released, it has to be reviewed for quality and improvement. A quality assessment helped the designer to identify shortcomings of the application's functionality [15] and use the information to improve the application. Usability is a popular metric for assessment where some design goals are used as the measurement dimensions [16]. Barnett et.al [17] used usability to evaluate mobile games users' experience in the view of first-time users. Yuan and Chee [18] evaluate their design of virtual tour guide using two dimension i.e. user satisfaction and agent's believability. Tahyudin and Saputra [19] used 4 dimensions i.e. text, graphic, animation, and interactivity to assess the user satisfaction of their application.

3. Development process methodology

The application development process is started with an exploratory data collection for users' insights through questionnaire targeting 100 respondents with age range of 17 – 25 years old, the number of respondents is adequate to represent the population based on Slovin's Formula with error tolerance of 10%. The data obtained from the survey are then used as considerations during the generation of application concepts.

The concept generation are done systematically by utilizing the concept combination table. Among the generated concepts, a selection process is done by comparing concepts against each other by using customer needs and its weight as selection criteria until one final concept is selected. The selected concept is then developed into a final product (Android application).

In order to get a better and more accurate information that will be conveyed through the application, an in-depth interview with historian, supported by literature review, was conducted so that the story line of the object's history, which is the main content of the application, can be plotted. Beside the story and timeline, some data regarding cultural aspects including how the people dress that is required to create the main character appearance in the application were also gathered

The augmented reality application is mainly developed using Unity 3D software while the assets (components) are developed using several other software such as:

- Corel Draw and Adobe Photoshop: designing markers, user interface, and 2D virtual guide character
- Cinema 4D, Zbrush, and Marvellous Designer: generating 3D character
- Adobe Audition: sound assets
- Android SDK: to create .apk file
- Vuforia SDK: to enable application reading the marker through android phone camera

After the application was developed, a usability testing was done by questioning 20 respondents fit to the target user group to ensure the human computer interaction is well considered by using 6 dimensions of usability [16] including: functionally correct, efficient to use, easy to learn, easy to remember, error tolerant, subjectively pleasing. We chose this metric not only because of its simplicity but it can also provide sufficient early feedback on the application without making it too hard for users to fill a more complex feedback questionnaire.

4. Results and discussion

4.1. Users insights, concepts generation, and concept selection

From the survey of 100 respondents, the frequency of visiting historical site is quite high as 67% claimed to visit at least once a year and the most visited site is Candi Borobudur. Only 11 respondents said that they already visited Candi Gunung Gangsir which confirms the lack of visitor to our object. 89% of respondents stated that they want to get more information on the history of the site and preferred the information to be conveyed through a video presentation and augmented reality instead of brochure, audio-only and in-site guide. The respondents preferred offline mobile applications (64%) while the file size should not exceed 300MB (74%). We identified 10 equally important needs that are expected to be delivered by the applications, as follows: ease of use, security, interesting interface, low file size, the use of augmented reality technology, the use of 3D objects, informative audio, and subtitles.

These insights helped us to generate 8 application product concepts by varying color scheme, type of marker, and the style of the virtual guide character as shown in Table 1. The evaluation of the concepts was done through concept screening that left us with 5 concepts which were then passed through the concept scoring which use the customer needs and its weight as the selection criteria where the score was given by comparing each concept with a reference concept.

Table 1. Concept Combination

Marker Type	Color Scheme	Character Style
Geographic	Basic	Modern character
Printed	Mixed	Classical Majapahit

The chosen concept is an augmented reality virtual guide application with basic color scheme, printed marker instead of geographical marker, and main characters designed to resemble the Majapahit era styles.

4.2. Content and assets generation

The main content of the application is information regarding the areas of interest within the main building of the site. We observe at least 14 areas of interest in form of relief carving on the body of the building and the photograph of the areas are unique enough to be used as markers to be scanned by the AR camera. Several examples of the markers are presented in figure 1. We also designed 3 additional markers as the place-holder for supporting information i.e. welcome greetings, the site architectural, and urban legend. The information required for creating the content is primarily gathered from in-depth interview with experts from Cultural Heritage Conservation Center (BPCB) Jawa Timur and supplemented by secondary data from the report on Candi Gunung Gangsir restoration in 2013. The data also helped us in designing the virtual guide character to resemble the persons from Majapahit

era. We designed 4 characters as shown in figure 2. The male characters are designed to wear sarong, while the female characters wrapped in seamless fabric. These characters are animated and dubbed during the presentation of each area of interest

Figure 1.AR markers using areas of interest

Figure 2. The virtual guide characters

Figure 3. User interface

The next process is designing the application's user interface (UI) while ensuring the application must be easy to use. We chose a simple yet ergonomic user interface as shown in figure 3. The colour scheme is putting dark background and bright text to make it suitable with broad-daylight exposure. To align with the history of the site, we chose green background as it represents land fertility which can become a source of prosperity. The first button on the main page is designed to open the camera so that the user can scan the markers for virtual guide presentation. The second button will display text-based information of the site. Clicking the last button will close the application. The application file size is 146 Megabytes which is considered acceptable. Moreover, it can run in Android 4.0 version or newer, and smoothly runs on smartphones with 2GB of RAM.

4.3. Markers' placement

The markers will be placed near the relief carving so that the users can scan the marker while seeing the actual relief. The placement map is shown in figure 4. The marker is printed to fit into an A3 paper size (297 mm x 420 mm) where the virtual guide character will pop-up. The best viewing distance should be at 100 cm from the marker so that the virtual guide will be visible as a full adult person size as illustrated in figure 5.

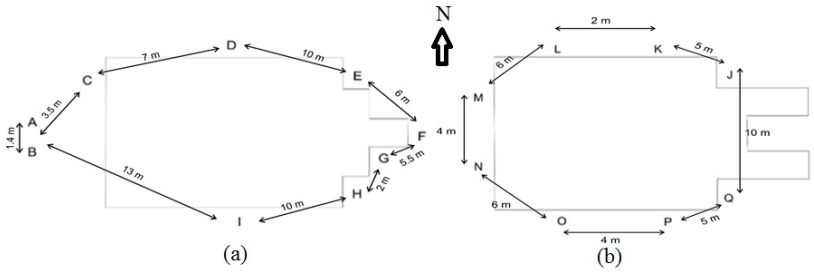

Figure 4. (a) markers placement on the ground floor of the building. (b) markers placement on the first floor of the building

4.4. Product and usability testing

Figure 5. Suggested viewing distance and virtual guide size illustration

Product and usability testing were done by installing the application on a smartphone and have it tested by 20 respondents that belong to our target user group i.e. aged between 17 – 25, living in urban area. The survey was conducted in Surabaya instead of in Candi Gunung Gangsir premise as it will enable us to measure the interest to visit the site after testing our application. We used the purposive sampling techniques to choose our respondents.

The respondents were asked to fill out post-trial questionnaire consist of 6 usability questions using 5-point Likert scale and 1 binary question to assess their interest in visiting Candi Gunung Gangsir should the application is available on the site. The result of the usability questions is summarized in table 1 which indicates positive response for the application as the mean of each dimension is at least 4. The test also suggests that 90% of the respondent agrees that the application will increase their interest in visiting Candi Gunung Gangsir. We believe that the application would be able to help the site attract more visitors.

Table 2. Usability testing result

Dimension	Mean	Std. Deviation
Functionally Correct	4,85	0,36635
Easy to use	4,80	0,41039
Easy to learn	4,90	0,30779
Easy to remember	4,60	0,50262
Error tolerant	4,40	0,50262
Subjectively pleasing	4,85	0,36635

5. Conclusion and further research

This paper provides a systematic approach in designing a mobile augmented reality application that will serve as virtual guide in Candi Gunung Gangsir, East Java that should help the site to attract more visitors especially from the younger generations. Virtual guide should give visitors a better experience and better information regarding the history of the site. The application can as well preserve the site's history and architectural information and transfer it in a more engaging virtual environment to the visitors. The usability evaluation shown a positive feedback on the application and give early hint on the rising interest to visit Candi Gunung Gangsir.

As the application is only a part of a total solution to improve attractiveness of the site, further research area can be explored such as making the virtual guide to be interactive with the visitors by implementing artificial intelligence resembling a real personal guide who can take questions and give answers. Other research can also take the implementation as the focus and measure by how much actual visitors that the site can attract.

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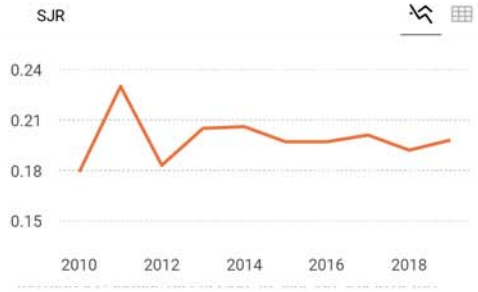

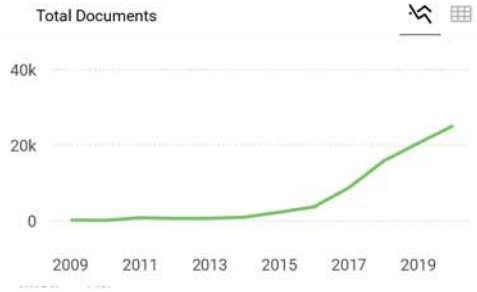

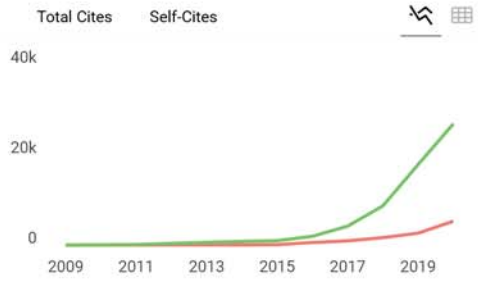

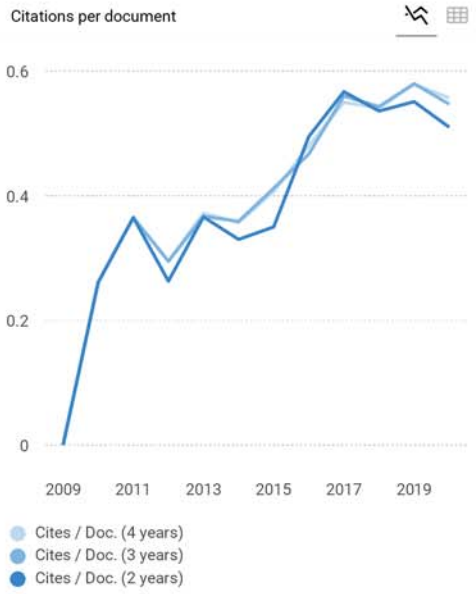

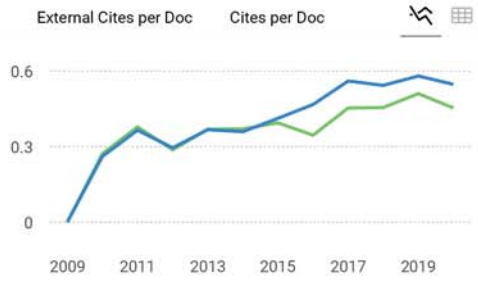

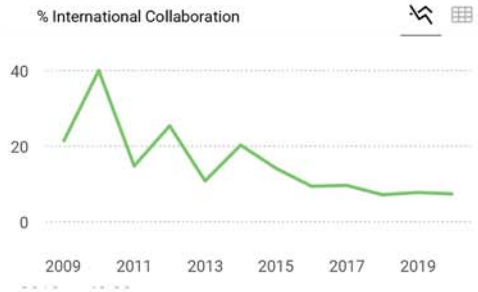

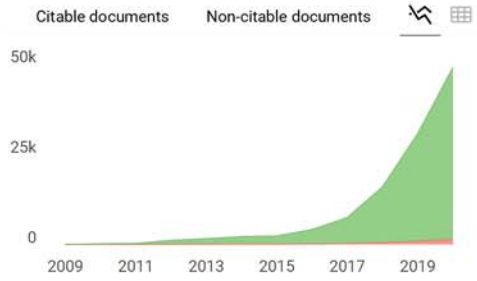

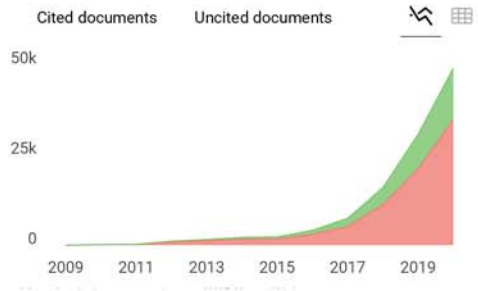

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