A USABILITY STUDY OF INDOOR MICRO LOCATION-AWARE INTERACTIVE GUIDE APPLICATION IN MUSEUM: CASE OF NAMIBIAN INDEPENDENCE MUSEUM

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Abstract
Public participation and visitor satisfaction in museums are directly related to the experience of learning, discovery and involvement in motivating learning behaviours. In most cases visitors' experience is highly enhanced if they get a detailed knowledge on each artefact from the museum guides and this is critical to user satisfaction; however the ratio of human guides to visitors is always grossly inadequate. The purpose of this study was to look at alternative ways to enhance visitors' experience and satisfaction using latest wireless technologies in smart phones by providing video, audio and text format information of an iBeacon-targed artefact. A qualitative research approach followed by a constructive design, development and implementation was used in this study, with the main objective of producing an indoor location-aware interactive virtual guide prototype application that has sufficient usability qualities including ease of use, usefulness and stable transactions. This study was contextualized to Namibian museums using the Independence Memorial Museum as a test case.

Keywords – *Museums; Culture; indoor micro location-aware; virtual guide; Augmented Reality, Wireless; Smart devices; Bluetooth low energy (iBeacon); Interactivity.*

1. INTRODUCTION
Learning is voluntary in a museum environment; it is driven by curiosity, discovery, free exploration and the sharing of experiences with others as a result of interacting with exhibitions and the surroundings but the level of the actual realisation of these conditions can be very low. Museums are rich in history and cultural content, but are heavily challenged on ways to best present them to large groups of visitors while preserving the interest of each individual. Customary ways of touring museums, as it is the case in Independence Memorial Museum

(IMM) in Windhoek, present a number of challenges that prevent visitors to fully experience cultural and creative artworks value. Group visitors are bound to a human guide itinerary and schedule, preventing individual visitors freedom to explore deeper and longer any object of interest. Beside, artifact information is mostly limited to the physical tags or inscriptions attached to the artifact or pictures which do not give the visitor enough information on the object. This in return leads to limited individual movement, thus experience and time, because even if a visitor is to go alone she/he is often time bound to join a group that could have different interest. Visitors own level of experience is the biggest challenge due to the fact that even following the museum guides the visitors are still restricted to what the guide finds interesting and usually in big groups not all the relevant information is passed on to the visitors. In fact the ratio of human guides to visitors is always grossly inadequate.

Visitors' participation and satisfaction are directly related to the experience of learning, discovery and involvement in motivating learning behaviours (Ahmad et al., 2014). In most cases visitors' individual experience is highly enhanced if they get a detailed explanation on each artefact from the museum guides and this is critical to user satisfaction.

There was therefore a need to look for alternative practical and user friendly ways on how museums can enhance individual visitors experience using wireless technologies and interactive, interpretive and augmented reality applications on smart phones taking into consideration some of the most crucial factors such as time, support resources and visitors' interests and considering the increasing popularity of smartphones in Namibia. In fact a number of these visitors are already using smartphones to get around in their daily activities, which is an added advantage if one single application can direct them to and within the walls of the museum. With the help of Google maps a smart phone can identify the user's current location and provide an updated driving or walking directions to the museum. This project took into consideration the use of current indoor location of artefacts by means of Bluetooth low energy transmitters (i.e. iBeacons). iBeacon has significant advantages as compared to other wireless technologies, these include relatively cheaper hardware, less energy consumption, less dependent on Internet connections, and capability to receive and send notifications in background (Fard,Yuanzhu & Kyung, 2015). A local file server that responds to the file requests from the mobile application using the unique iBeacon numbers was developed, implemented and the overall system' usability evaluated .

2. RELATED WORKS

Visitor Experience and Satisfaction in Museums

Museum visitors have different agendas when planning their visits; this in turn determines the focus of each visitor and is a crucial point to be considered by the museum guides and the museum management at large. Visitors' participation (Ahmad et al., 2014) plays the biggest role in satisfaction and enhances the learning behaviours in museum. For most visitors in Namibian museums this experience is minimal due to paucity of information and publicity of such institutions.

Normally museum's exhibit still pictures, text and passive models all of which do not provide any form of interactivity to the visitors. Hashim, Taib, and Alias (2014) explore the use of interactive display as a basis of technology integration, and notice that such integrations are very restrictive in that the displays are mounted next to the artefact and visitors are not given the opportunity to take the experience with back home. Ferrara and Sapia (2013) focuses on the use of technology by means of digital museums to create new learning environments in educating the community and its visitors, especially the youth as this knowledge gained can still be used in their schools subjects. The study also emphasises the importance of a personalized view or access to content in any learning environment. Ferrara and Sapia (2013) concluded that Technology offers different opportunities to learning institutions by integrating entertaining but yet informative content and stimulating the learning behaviours of most people.

Interactivity and Context-aware

The increasing use of mobile multimedia provides emerging services in entertainment and communication. Xiao and Rau (2009) analysed the impacts of interactivity and its interaction with context awareness in mobile phone advertisement. They observed there is a better effect of high perceived interactivity on mobile advertisement in a context-aware environment, beside other factors including personal variables like, but not limited to, user age, gender, previous experience, level of education. There are common features when displaying video content on mobile devices (Xaio & Rau, 2009), being for advertisement, information guidance, or navigation in terms of user perception and interaction with multimedia services. Museum determines the user context, therefore determine context-sensitive and related positioning systems (PGS, iBeacon, RFID, WiFi, etc) that can be deployed. Perceived interactivity is viewed in literature as a construct whose components differ from one type of communication to another. Xiao and Rau (2009), Gao, Rau, and Salvendy (2006) identified seven attributes or components, four of which in our view are most related in museum context. They are user

control, synchronicity, connectedness, playfulness. Van der Heijden (2003) and Dholakia et al. define user control as the degree of user intervention, the range of option in choosing the content, the task flow space to change viewing experience. They further argue that context-awareness motivates users to increase their involvement, which makes the service or product presented more relevant as compared to context- irrelevance.

The Use of Technology in Museums

The use of technology in museums has been getting much attention and so many studies are being done in different directions all in hopes of improving user experience. Some of these emerging technologies at the heart of museum community are Virtual Reality (VR), Augmented Reality (AR) and Web3D as indicated by Styliania et al., (2009) and Sommerauer and Müller, (2010). Due to a diverse contextual environment found in cultural institutions, there is a huge range of possibilities in addressing user experience. There are a few but impressive works reported in literature (Museums using Beacons to Enhance Interactivity, 2015). In recent years the integration has moved the focus of most museums to what is now termed as Science & Technology (S&T) museums. According to a study done in china (Zhang, Zheng & Ren.2013), the use of new media technology in museum exhibits and presentations is continuously increasing. Museums are however overwhelmed by the technology that their focus now turns to more entertaining the users. Zhang, Zheng and Ren (2013) consider that this is mainly due to inappropriate use of new media technology and hence this causes museums to divert from the original objective of being an educational institution. One popular technology is museum virtual guides, described (Bedard et al., 2006) as a digital representation of an artefact within a museum, shown on an electronic device such as mobile phone, PDA, Tablet and computer. In a museum this tools are mainly used to enhance users' personal and learning experience (Bedard et al., 2006).

iBeacon Technologies, Mobile Applications and Museums

Wireless technologies on mobile phones are being utilized in most museums systems; these include Bluetooth, WLAN, RFID, QR codes and NFC. Many studies (Karahocans, 2012; Smith, 2011; Schultz, 2013 & Brolla et al., 2013) have been done using the above listed technologies due to the features that they provide with regards to indoor navigations, video streaming and rapid data transfers. Mutual location of visitors and artefacts of interest is the

key to any museum system that aims to be both interactive and relevant throughout the visit. iBeacons as defined by Apple are “a new class of low-powered, low-cost transmitters that can notify nearby iOS 7 or later devices of their presence" (Smart Beacons., 2015) in addition iBeacons are now supported by Android devices version 4.3 upwards and with a Bluetooth 4.0 capabilities, and for calculating device proximity it relies on Bluetooth low energy (BLE) transmitters which are mostly found in all smart devices as of late. According to Apples (Getting Started with iBeacon. 2015), iBeacons can transmit over a distance of 50m, which if further influenced by the transmission power settings can be changed to suit the given implementation.

iBeacons uses are countless as more and more companies discover and exploit both the architecture and API’s of the new devices (Cavallini, 2015; Martin et al, 2014; Jacobs, 2014; Browne, 2014; Doljenkova & Tung, 2015). This study aims to use iBeacons attached on artefacts for locating smart devices in the museum mainly because as described above, they are small, relatively cheap and available on all smart devices.

3. RESEARCH APPROACH & STRATEGY

A preliminary baseline study was done to gain a somehow deeper understanding of the current museum situation. Observations were also carried out on the visitors and staff members to supplement the results of the questionnaires that got thirty respondents. The first part of the questionnaires had four questions that targeted the museum staff and covered the challenges faced by the museum guides. This study also outlined the most used mobile platforms in Windhoek (Android and iOS), and hence the design and implementation of client application only concentrated on these two platforms. A constructive design structure was used in that different prototypes were developed following interactions with both users and management of IMM, hence to determine a suitable system design for our proposed solution. An extended survey with eighteen questions in total was then conducted on twenty-six museum visitors and most of the responses (with 100% feedback) correspond to those given by the staff members.

4. BASELINE STUDY FINDINGS

Preliminary study showed that the number of visitors has by all means exceeded the museum guides, staff members are still concerned on the ratio of the human guides to the visitors, since the majority (80%) still responded that increasing the number of human guides was the solution, 50% of museum staffs responded they were using Android and the other 50% were

on iOS while all of them indicated they prefer the new system to work both on PC and mobile device. The extended survey revealed that 45% of visitors were using Android, 23% Windows and 15% Apple mobile phone respectively. They have heard of the museum through recommendations from friends and family, and the minority have heard it through Internet or via Television, raising a concern about poor awareness translating in actual low turnout for the museum, and justifying the need for a new technology-based guide with potential to have greater impact on visit turnout. Most respondents also said that the museums were mainly seen as an educational institution, confirming ICOM, (2007). The overall rating by visitors, in terms of their experience, satisfaction, as well as interaction with museum guides and artefact relevance was between good to excellent; visitors' interaction with museum guide is average and that the artefact are more relevant to most of the visitors, as indicated in Figure 1.

Responses on what solution to improving user's experience and satisfaction showed that 44% preferred the increase in number of human guides, while an equal ratio of 44%, preferred an increase on information offered to visitors per artefact. These two responses can however be considered as complementing each other in the sense that more human guides leads to more information offered to the visitors; and a few 12% however indicated an improvement on the exhibits or artefacts. The survey hence tried to sensitize the visitors to the ethics of being tracked or monitored using iBeacon technology as a solution to increase information on artefacts through interaction as they move through the museum. An equal share of respondents stated that they either do not mind or mind about being tracked as they move through the museum (Figure 2); in addition a larger part also stated that they were not sure.

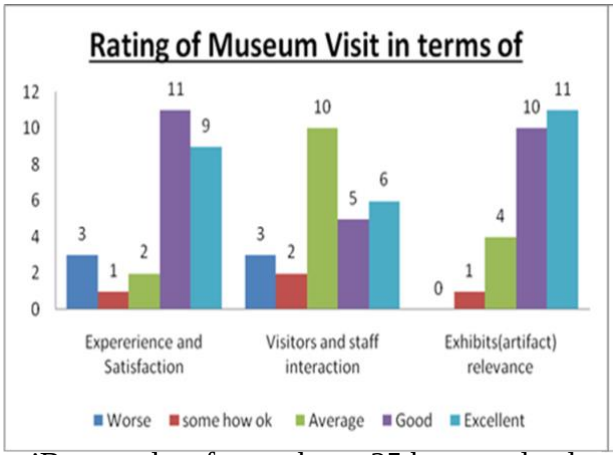

Figure 1: Overall ratings on museum visit

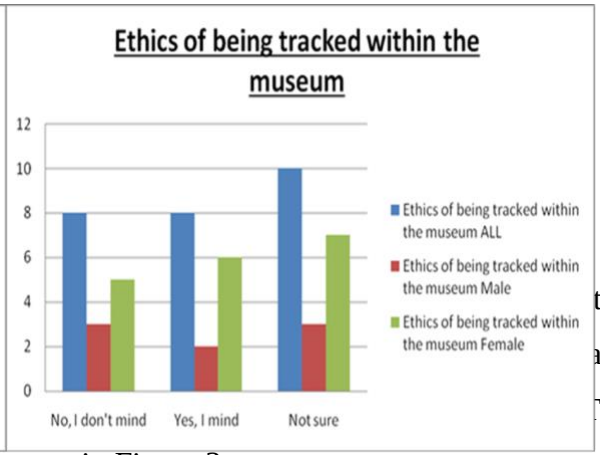

Figure 2: Ethics of being tracked within the museum

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iBeacon data format has a 25 byte payload as seen in Figure 3.

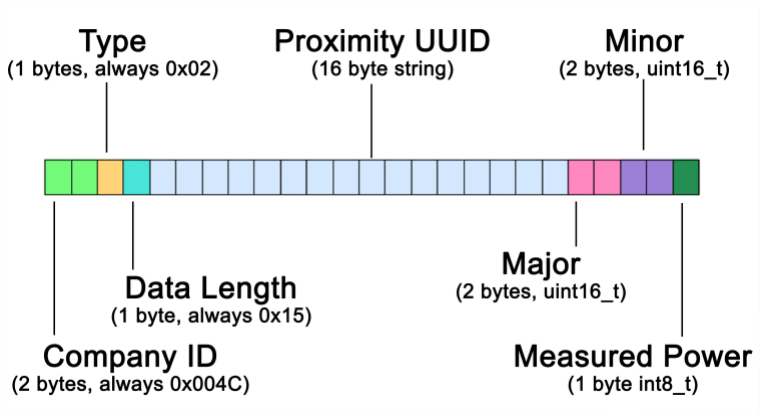

Figure 3: iBeacon data format

The Major value in our case was used to differentiate rooms within the museums and finally the Minor value if used to represent the specific artefact.

First Prototype Design

Preliminary study results were used to improve visitors' satisfaction by developing a mobile app. A native Android-based client-server application prototype called ***iMuseum*** was developed and combined two main wireless technologies: BLE (iBeacons) and WiFi.

iBeacons use unique numbers of the transmitters to locate indoor and track the visitors' current place within the museum. Once an iBeacon is detected the application sends the unique number to a file server to request the right content of the corresponding artefact at the visitor's location. The iBeacons also transmits their current estimated distance from the visitor's mobile device; this is used by the iMuseum application when making a decision on which artefact to notify the visitor that they are in its proximity. The WiFi use is mainly because of its high speed on data transfer and hence will be suitable for video streaming. The application is hence heavily dependent on a file server for all the artefact content. Both the file server and the mobile device must be on the same network, for our first prototype we hence used a Samsung pocket WiFi hotspot of which a personal laptop running a XAMPP server was used as the file server. The application sends out a notification of which the user has an option to either view the content or just ignore the notification and continue using the application as is. On the current iMuseum prototype every time the visitor selects to view content of any given artefact, the application downloads text or description, audio and video content temporary to the device and all this content is cleared once the visitor moves to a new artefact and hence the application loads new content. The data flow diagram of the iMuseum app is illustrated in Figure 4.

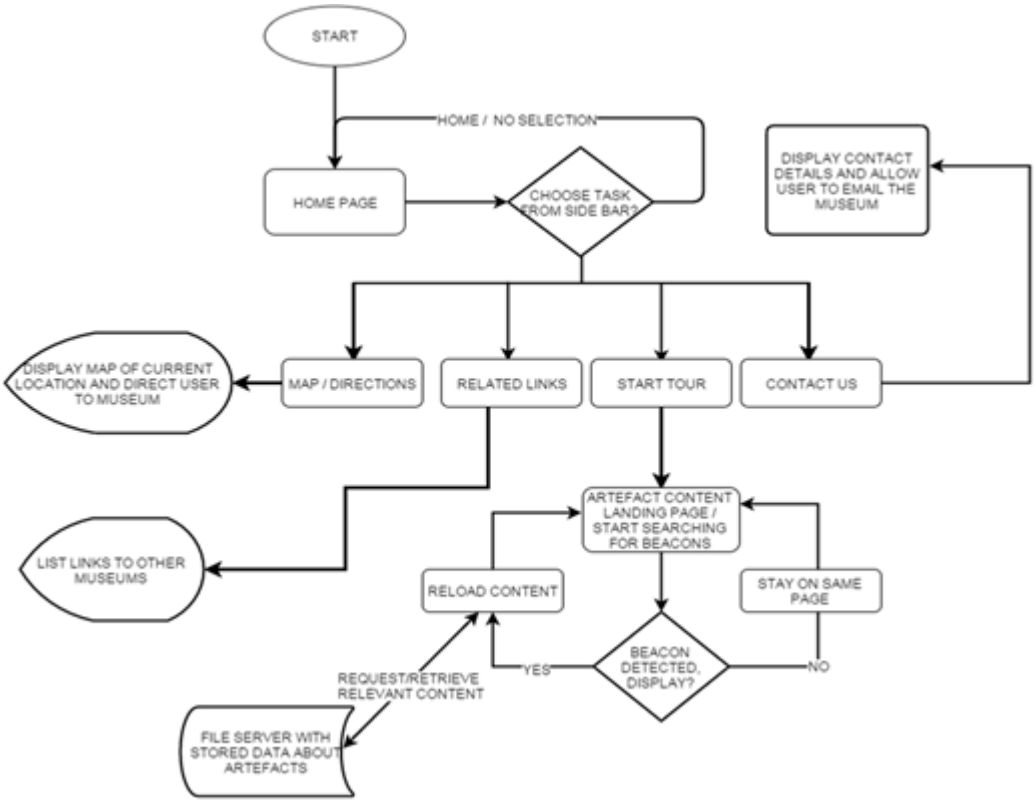

Figure 4: System flow for the iMuseum app

The application has a landing page of which the side bar has five choices including the home or landing page itself. Following the visitors or users selection a different page is loaded, most of these pages are for information display, but also highly interactive. Two main options exist, the map direction and the Start tour, with the former offering the visitors directions from their current location to the museum and the visitors gets to choose whether they want a turn by turn direction of which the app now uses native Android map to be accurate. The start tour option covers the main objective of the whole guided tour system of which it offers the visitors relevant content following their current location. Once this option is selected the app continuously listens to the beacons within its range and then picks out the closest one to notify the visitor. The notification offers the visitor an option whether they want to view content or ignore, if the visitor selects to view content then the app requests the content for the file server and hence displays it. The application also suspends any other notification until the visitor moves away or to a new artefact.

6. SYSTEM IMPLEMENTATION

iMuseum was implemented using Android studio version 1.1.0. Given Android device supports BLE specifications of iBeacons restricted the compatibility of the application to devices with version 4.3 and above. The application makes a HTTP request for content, the script checks for all the content of the given artefact and returns them as links to the client device, which is in turn loaded into the rightful places by the application. These content once loaded from the server allows the visitors to scroll though images, videos and the description is preloaded once a visitors accepts to view content when notified by the application. For fast loading the description is formatted in HTML and hence the application loads the return link into a Webview. This however is not the same for the Audio and Video components of which an actual video/audio file is returned and the mobile devices uses its native capabilities to render and play the resulting file. The content of the landing page (Figure 5) is however built into the application and hence it is only limited to a few images and text description but not video and audio capabilities.

Figure 5: Screenshots from the landing page

7. USABILITY STUDY RESULTS AND EVALUATION

This section gives an overview of the usability results of the first iMuseum prototype in IMM. A group of six users were selected to test the application and give their perceived evaluation of the application. Five of the users had Samsung Galaxy phones and had Android version 4.3 or above. The last user had an Acer tablet; this was mainly to see if there would be any major differences in the app operations. Participants were mainly computer science undergraduate

students and hence the result might not give a fair picture of the application used by ordinary visitors. Survey Monkey was used to run the usability survey; the results of the survey are summarised in the sub-sections that follow.

The first part of the survey covers demographic details of the users. After participants interactions with iMuseum, the survey evaluated a few usability attributes, including the friendliness of the user interface, ease of access in terms of the application options and general application use, the usefulness of the application, how would they categorize the application (education or entertainment), the overall loading and operational speed of the application, whether the application behaved like other mobile applications that they were familiar with, whether they trusted the iMuseum and whether they would recommend it to other user, the screen navigations and the overall interactions between the screens. Participants were then asked to rate the functionalities of the application (Figure 6a), and give a final and overall perceived rating of the whole iMuseum application (Figure 6b).

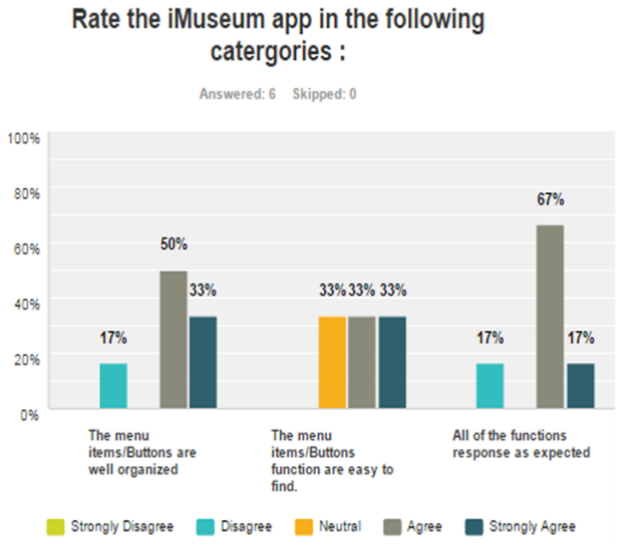

Figure 6a: iMuseum ratings by catergory

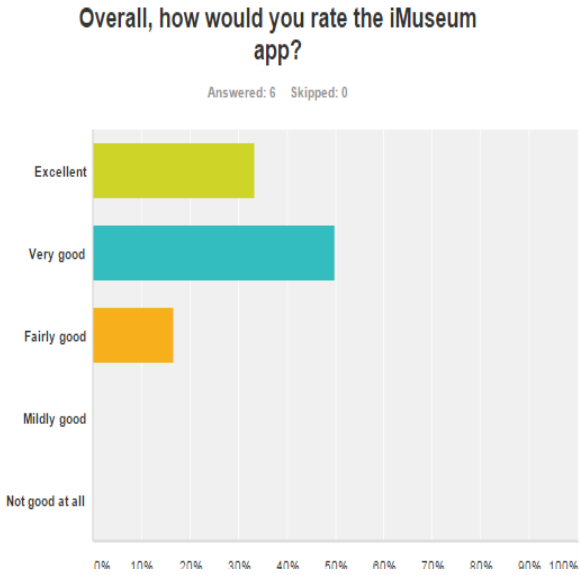

Figure 6b: iMuseum overall rating

8. CONCLUSION AND FURTHER WORK

A preliminary study was done on both the museum visitors and staff members to gain a somehow deeper understanding of the current museum situation, and how they think these could be improved. Our solution made use of a mobile application and wireless technologies to give the visitors unrestricted experience in terms of mobility, interactivity and relevance of the contents as per the artefact close by located while touring IMM museum. iBeacons was

preferred because it has significant advantages as compared to other wireless technologies. A local file server was set to respond to the file requests from the mobile client application using the unique iBeacon numbers. This paper presented essentially the implementation challenges of micro-location, and the usability qualities of the system as well as its functionalities and human ethical issues. A cross-platform version of the prototype application is currently being developed. Study of challenges encountered in the accuracy of indoor location is in progress. The museum will be able to offer relevant and personalised information without having an employee going around with everyone, and enable visitors to have deep and rich experience of artefacts through augmented historical context.

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