VOL. 10, NO. 23, DECEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

EXPLORING OLDER PEOPLE'S EXPERIENCE WITH AUGMENTED REALITY (AR) APPLICATIONS

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ABSTRACT

Latest development of mobile technology has opened another opportunity for augmented reality to be implemented in the mobile device platform. Mobile augmented reality enhances mobile users experience by combining computer generated images in real environment. There have been limited studies which investigate the use of augmented reality among older people. This pilot study aims to explore older people's experience in terms of attitude and potential barriers when they are interacting with augmented reality applications. Qualitative methods including interview, focus groups and observation were used to understand their experiences with augmented reality applications. Results indicated that, there were some barriers faced by older people in engaging augmented reality applications such as AR interface and interaction style, and familiarity with AR applications. Result showed that, they found AR applications could be beneficial for certain occasions or conditions like people in remote areas such as for outdoor and disabled users of mobile applications.

Keywords: augmented reality, mobile applications, experience, older people.

INTRODUCTION

Nowadays, people have become increasingly dependent on mobile devices to in their daily lives. They use mobile devices for a wide variety of social and work purposes such as information search, entertainment, networking and many more. Latest development in mobile technology especially smartphones and computer tablets has created an opportunity for augmented reality (AR) applications to be implemented in the mobile platform. This is because mobile applications help people carry out their activities more efficiently and effectively.

Augmented reality aims to simplify user's life by bringing virtual information and merging it with its immediate surroundings and eventually enhance the user's perception and interaction with the real world [1]. However, very little is known about the use of AR applications among older people particularly in terms of the issues when they are interacting with AR applications.

This research aims to explore older people's experiences interacting with augmented reality applications. It also attempts to understand their attitudes and possible barriers they face while interacting with the applications. A deeper understanding of these situations is needed in order to assist developers in designing AR interface and applications that would be beneficial to older people.

AUGMENTED REALITY (AR)

Augmented reality (AR) is defined as "a real-time direct or indirect view of a physical real-world environment that has been enhanced/ augmented by adding virtual computer-generated information to it" [1]. Noh, Sunar and Pan [2] have simplified the AR definition as "a combination of real object and computer-generated data where virtual object are blended into the real world". AR is used to create an integrated visual (place or object) experience directly to user views without any delay [3]. The purpose of AR is initially to improve real world by overlaying computer generated image or data on top of it. Figure-1 explains the AR continuum that differentiates between AR and virtual reality (VR). Milgram and Kishino [23] developed the Milgram's Reality-Virtuality continuum to extend clearly the range between real environment and virtual environment. Mixed reality environment consists of real, augmented reality (AR), augmented virtuality (AV) and virtual reality (VR) environment (Figure-1). AR is closer to the real world while AV is closer to pure virtual environment.

According to Milgram and Kishino [23], virtual reality (VR) technology immerses users in a synthetic world without seeing the real world. On the other hand, AR technology enhances users' sense of reality by superimposing virtual objects upon the real world in real time. Meanwhile, augmented virtuality (AV) technology combines the element of real world with that of the virtual environment [23].

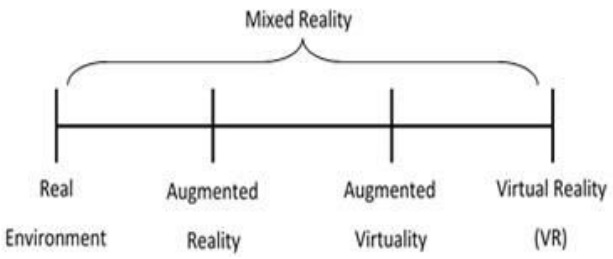

Figure-1. Milgram's Reality-Virtuality continuum.

Azuma [4] proposed three criteria to determine the augmented reality application; (i) combination of real and virtual objects in a real environment, (ii) alignment of real and virtual objects with each other; and (iii) the application runs interactively, in 3-dimension (3D) and in real time. The early AR applications run on personal

desktop computers and require the user to wear bulky head mounted displays (HMDs) to view the computer generated data and tangible interface objects. The AR applications are successfully used in certain domain areas such as industrial assembly, surgical training or gaming [5]. However, due to the cost of the system, lack of expertise [5], lack of attractive and lightweight [3] have caused the previous AR technologies less accepted.

Recently, the latest mobile devices infrastructure that equipped with powerful processing machine, higher resolution screen, high definition camera, lightweight and various environment sensors, create a perfect environment for AR to be used in mobile platforms [1,5,6]. The increasing ability in mobile devices (Figure-2) has affected AR evolution from using (a) head mounted display, (b) computer tablet, (c) handheld to (d) mobile phone.

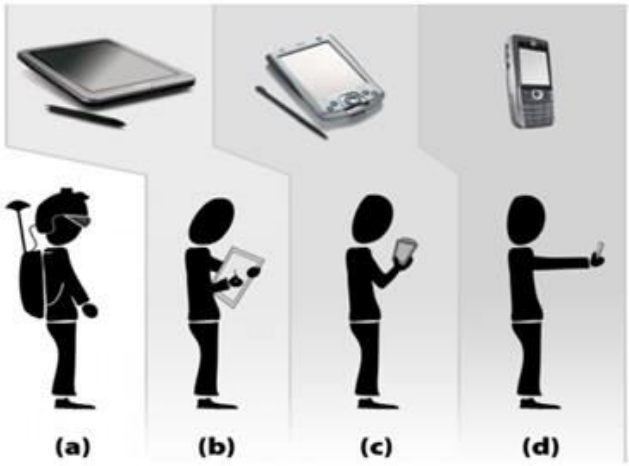

Figure-2. Evolution and miniaturisation of mobile AR [7].

There are three AR factors required in developing mobile AR: tracking, interaction and visualisation [5]. AR tracking can be executed based on the following: i) sensors (Global Positioning System (GPS), compasses, and linear accelerometers); ii) computer-vision methods (fiducial markers, natural feature tracking, global localization systems, on-fly reconstruction); and, iii) combination of sensors and computer-vision methods. However, implementing tracking in mobile platform creates technical challenge due to the limitation in the mobile devices processing power [5]. Initially, AR tracking only performs well in small workspaces and is fully optimised with objects and environment that have rich surface features [3].

Meanwhile, the interaction for mobile AR application is called a 'magic lens'. The magic lens is where the user views the physical environment through the device screen. Table-1 presents the mobile AR interaction technique and challenges.

The last AR factor is visualisation. The output of AR visualisation relies heavily on computer graphics which requires the use of photorealistic rendering technique [5]. Factors such as registration, occlusion and shadow, contribute to better virtual integration. Besides creating realistic AR images, information visualisation is also important in mobile AR where the amount of information displayed should consider user's attention and density of mobile display.

Table-1. Mobile AR Interaction Techniques and Challenges [3].

INTERACTION	DETAILS/EXAMPLE
Embodied interaction	Done through the device movement and the touchscreen. Examples include navigation, pan-and-zoom by moving the device relative to the scene, actions triggered by changes in the device's orientation or distance, screen gestures, or by tapping on the touchscreen.
Tangible interaction	Based on direct manipulation of known objects. Usually, the user reaches into the scene and moves objects that exist in the real world such as making the object appear or disappear from the view, or changing the object orientation and position.
Ray picking	Involves selecting an object by casting a virtual ray through a location on the screen into the environment and selecting the first object the ray hits
Layered pie menu	Involves moving the device to select from a hierarchical menu. The user moves the phone closer to or farther away from the display to scroll through menu levels.

OLDER PEOPLE

Definition of Older People

There are various definitions of older people according to different areas of study. In the area of gerontology, older people are defined as persons aged 65 and above [24]. Meanwhile, the World Health Organisation (WHO) has defined older people as persons aged 60 and above [25].

In addition, older people are also defined as persons that are eligible for pension [26]. According to the Organization for Economic Co-operation and Development (OECD) countries, especially those in Europe (i.e., United Kingdom, Italy, Sweden, and Switzerland), the retirement age is at 65. In an Asian OECD country like Japan, the retirement age is 64 [27]. In Malaysia, compulsory retirement age is now at 60 [28].

There are several terms used to indicate older people. The common terms used to address older people are elders, elderly, older person, older adult, old folk and senior. These terms usually reflect their countries and cultures [29]. In this study, the term 'older people' refers to person aged 55 and above [30].

Older People and Mobile Device

The current older people are known as 'digital immigrants' [8] or non-'digital natives' [9] – meaning that they are born before the technological age. While rapid development of mobile technology such as advance interfaces, interactions and applications has increased the significance of the use of mobile devices among these digital immigrants, it has also left them struggling to use their mobile devices

There have been several issues faced by older people in using mobile device, such as mobile design (physical design and functionalities) [10, 31], health decline (cognitive and physical impairment) [11,12], motivational issues [11] and lack of support [13]. These issues are important to be studied especially in designing mobile applications appropriate for use by older people because they may hinder instead of enhance daily life activities which eventually increase life independence among older people.

EXPERIENCES WITH AUGMENTED REALITY

Augmented reality technology in mobile platform is still at infancy stage. Dunser, Grassat and Billinghurst [14] have reported in their findings that augmented reality studies mostly conduct evaluation based on augmented reality performance, usability, perception and collaboration. Nevertheless, apart from improper evaluation technique, there was a lack of investigation conducted to understand user experience in using augmented reality.

Miyashita, Meier, Tachikawa, Orlic, Eble, Scholz, Gapel, Gerz, Arnaudoz and Lieberknecht, [15] investigated user experience using AR museum guide application called The Lourve – DNP Museum Lab (TLDML). They found that only 9.7 percent of the users acted correctly according to the route guidance. They also observed, mobile users were having difficulties with small text size displayed during for animation content. In addition, new AR users felt confused during their interaction with the application. However, the interview results showed that users enjoyed using the AR application and the illustrations were easily understood.

In similar context of navigation, Mulloni, Wagner, Barakonyi, and Schmalstieg [16] investigated indoor position navigation (a conference guide application) using fiducial markers. The users were required to compare two applications, namely, a map without localisation (non-AR) and a map with a GPS-like real-time localization (AR). They found that users preferred using continuous navigation and discrete localisation (marker-based tracking-AR) compared to no-localisation (non-AR). In addition, ease of use, and user confidence were found to be significant when using discrete localisation.

In order to assist older people with declining spatial cognition, Kim and Dey [17] have developed a navigation display system onto the car's windshield. The system displays navigation information by superimposing it on the older driver's view (windshield) of the actual road. Based on the experimental results, there was a significant reduction in navigation errors and distraction-related measures compared to a typical in-car navigation display for older drivers.

In another study on augmented reality, Sato, Kobayashi, Takagi, Asakawa, and Tanaka [18] have developed a technique called voice augmentation in order to support older people in using online banking transactions and online shopping. This technique can assist older people who have problems of fear in making mistakes in using websites. The findings have shown that proper support (voice augmentation) from the system makes older people feel confident (especially for people in their 70s) to use online banking. It has also been discovered that older people prefer pre-recorded voice (humanly voice) compared to synthesized voice (digital voice).

Davidsson, Johansson and Lindwall [19] investigated the use of AR technology to support science education in secondary schools. EU Science Centre To Go (SCeTGo) project was integrated with AR technology which allowed students to visualize complex physical and natural phenomena using sound, touch and manipulation of virtual objects. They conducted in-depth interviews and found that students perceived learning as exciting and joyful, and were able to increase their motivation in learning. In addition, the teachers also showed positive acceptance of the AR technology to be used as educational supported tool.

Olsson and Salo [20] has carried out an investigation on the experience of early adopters interaction with AR applications. Interestingly, they used online survey to gather narratives of mobile users' experience when they started using AR applications. They classified the experience in two categorised; satisfying experience and unsatisfying experience. There were two ways that mobile users presented their satisfying experience using AR applications: i) AR applications i.e. usefulness of the application's content which creates elements of positive surprise, interface and interaction of AR that contributed to awareness and immersion, ii) mobile user i.e. creates empowerment, strong amazement and general excitement. Meanwhile for unsatisfying part, the experience were mainly results from inadequately in performing technology.

AR is considered not a new technology, but the implementation in mobile platform is still at infancy level. Many studies were focusing on developing AR applications [15,16,17,18,19] and evaluation of AR were more likely as a testing phase among mobile users. Moreover, academic publications about user research on AR applications are so limited. User experience research is only in its early stages when considering the recent AR applications and other AR related technologies in general.
In this study, experience referred to older users' understanding and attitude in using augmented reality application [21]. The experience can be described in terms of, AR interface and interaction design issues,

expectations and capabilities, and familiarity handling AR application.

METHODOLOGY

Research Design

This study used qualitative approaches such as interviews, focus groups and observation. Conducting focus groups and interviews in this study allowed interaction between participants and produced more in-depth information within a short time [22].

Observation was conducted to analyse participants' actions with AR applications. Conducting observation allowed researchers to examine whether participants managed to use the applications well or that they were having difficulties with the applications.

Smartphones and computer tablets are considered as mobile devices in the context of this study.

Participants

There were five older people who participated in this study; two female and three male. All of them were 55 years old and above. Participants met all the criteria: i) fit older people; ii) owned at least a mobile device and; iii) had experience using mobile device for more than six months.

The participants were from different educational, financial and work backgrounds. Two focus group sessions with two members and one interview session were conducted with all participants.

Procedure

Participants were informed by their children and peers about the involvement in this study. The study was conducted at participants' home – using natural setting. During the interview and focus group sessions, participants were briefed about the nature of the study. Demographic questionnaires and consent form were distributed to participants.

Then, participants were given a mobile device equipped with AR applications. They were asked to use both applications. Whenever they had difficulties in using the applications, they could request help from researchers to assist them.

Interview and focus group were conducted after participants had direct hands-on experience with AR applications. This could help them to immediately articulate responses, suggestions and discussion. The interviews and focus groups were conducted using open ended questions. The questions were randomly asked to suit participants' conversations. Conversations and hands-on experience between the participants were video-recorded and transcribed.

Augmented Reality Applications

Participants were given a 5 inch-mobile device (smartphones) installed with two augmented reality (AR) applications. Both AR applications were free downloaded applications available in from the Android store.

The first of the two AR applications is Qiblat application. This application required participants to search direction (Qiblat) before performing prayer. It used GPS to track participants' position and compass to present Qiblat direction. Participants needed to stand-up while holding the mobile device, and turn around until the direction was found. Participants were also allowed to view certain Masjid (prayer places) based on GPS and compass.

The second AR application was an educational application that uses magazine as a fiducial marker to present information relevant to the magazine content. This application required participants to hold the device up in front of the marker until the video content was downloaded to be viewed.

Interview and Focus Group Questions

The questions were:

i- What are the advantages from these augmented reality applications?

ii- Do you encounter any issues in using augmented reality applications?

Data Analysis

The transcribed texts from the video recording were analysed using content analysis. Content analysis method is used to study content of communication presented in verbal or visual documentation [32]. There were few stages performed to analyse the data [32]:

i) Collected data were made into text (transcribing process).

ii) Data were coded and grouped into themes.

iii) Themes were examined to isolate meaningful pattern and process.

The content analysis process was performed manually due to small number of participants.

RESULTS AND DISCUSSIONS

Results of the research are categorised in two sections based on the interview questions: i) what are advantages of using AR applications, and ii) what are the issues older people faced when using AR applications.

Advantages of Using Augmented Reality (AR) Applications

Majority of participants agreed that the AR applications were useful to them and others. For Qiblat-AR application, they found it to be useful in helping users to find prayer direction in certain situations or conditions and remote areas such as outdoor. Since this application required participants to stand-up and turn around to find Qiblat direction, it was found to be more precise compared to normal Qiblat (non-AR) or compass application (which requires users to find solid space to use it).

"This application (Qiblat-AR) is useful especially for outdoor. Sometimes it is hard to find solid ground to use [the] compass to find prayer direction. So by using this application (Qiblat-AR), [we] can directly know where the direction by standing up."

"When you place compass application, sometimes you are not sure whether the needle [pointer] of compass is showing the right direction. So to me, this (Qiblat-AR) application is 90 percent correct"

One of the participants suggested that Qiblat-AR application could be used as a supplement to the first Qiblat (non-AR) application. He mentioned that his mobile device was installed with two Qiblat (non-AR) applications. This action (which used two Qiblat applications) was to precisely inform participant about prayer direction. Therefore, by using second Qiblat-AR application, prayer direction could be ascertained.

"I use two Qiblat applications (non-AR). If both applications are showing the same directions, then it is good. I think this application (Qiblat-AR) can be used as second application."

Meanwhile, for educational application (AR), participants believed it would be beneficial for those who is blind, has problem with declining eyesight or reading problem. The application allowed participants to view video content downloaded from the interaction with magazine (fiducial marker). By listening to or viewing the video content, the application could help disabled users to gain knowledge from the magazine.

"This is good especially for older people. They can easily watch the video to understand the magazine content. So you do not have to read. This very good for those who have problem in reading or those who are blind."

"This application can benefit those who have problems in reading especially those who are slow in reading. This application can help them know what magazine is talking about."

"Yes, I can hear the video. For those who have diminishing eyesight, they can use this application. It is a convenience to us. Older people, they do not have good eyesight."

Both of AR applications were able to enhance older people experiences for spiritual activity and educational purposes. They found AR applications were useful and beneficial to them in certain occasions or conditions and remote places such as for outdoor or disabled users, i.e., those who are blind or have declining eyesight and reading problems. Older people can easily see the potential benefits and usefulness of a system and application, if the system and application can improve their daily life activities and not available through other channels, particularly from more traditional sources [21].

Issues with Augmented Reality (AR) Applications

Participants were having difficulties using both AR applications in terms of interface and interaction, and familiarity. Interface and interaction of AR application were different compared to other applications (non-AR) which did not involve real environment. Thus, for users who do not have knowledge or experience using AR may incur some difficulties operating it.

a) AR Interface and Interaction

Most of the participants sought the assistance from researchers to use both AR applications. They were not familiar with operating AR applications (see Familiarity with AR) as the interaction was quite different from their previous applications.

For Qiblat-AR application, it was revealed that four participants did not understand how to use the application. There were limited instructions given to participants on how to calibrate the compass, hold the mobile device and search for the Qiblat direction. Lack of clear instruction on how to operate application can create frustration among older people especially when they have high expectations on the benefits of the application.

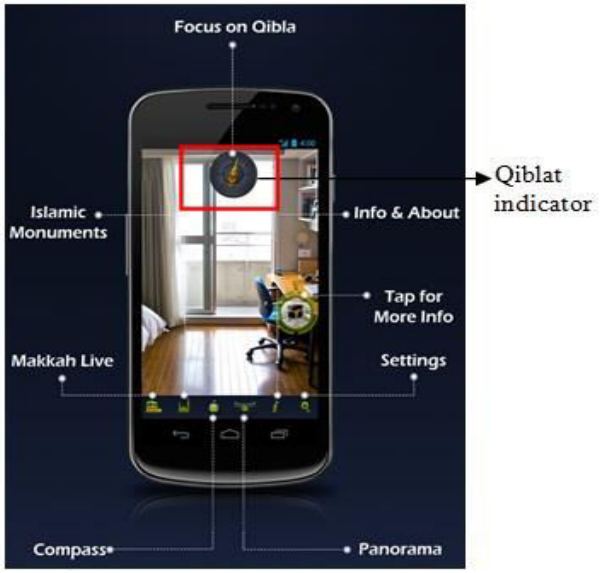

Figure-3. Qiblat-AR application – small yellow indicator.

In addition, majority of them also did not notice that the Qiblat indicator (yellow light) was flashing. The yellow indicator would inform mobile user the correct prayer direction. This was due to small light indicator in the middle of Qiblat compass (see Figure-3). Participants had the tendency to turn around very fast and missed the Qiblat indicator many times.

For educational AR application, majority of the participants did not understand how to operate the application because of no instructions were given. They also had difficulties to scan the magazine page since they did not understand the required distance between mobile device and magazine page. They did not scan the magazine page within the required distance which prevented the mobile device to download video content.

Besides, participants were also having problems with to hold the mobile device up facing towards magazine. This led to more time taken to download the video content since static hand was required to perform the downloading process (Figure-4).

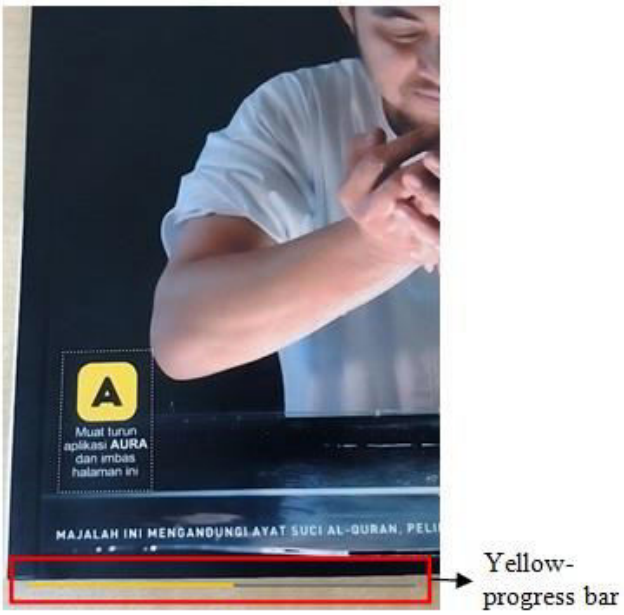

Figure-4. Educational AR- small progress bar.

Moreover, to view video content, participants were also required to hold the mobile device in front of magazine page until the video content finished downloading. Two of the participants suggested that the application was not appropriate for older people who did not have steady hands.

"..then it is not good for older people. It requires someone with steady and static hands to watch the video. It will become worse for those who have shaky hand."

"..what will happen if someone falls asleep during the process (watching video content)."

b) Familiarity with AR Applications

Three older men had experiences using Qiblat (non-AR) applications while two older women had no experiences at all using Qiblat (non-AR) applications. Thus, majority of older men had learning experiences and understood how to use Qiblat (non-AR) applications. The reasons why two older women had no experience in using Qiblat applications could be because they were depending on their spouse or family members to inform them about the Qiblat direction when they travel to other places.

"I did not install Qiblat application because I only travel with my spouse. So, I can easily ask him about Qiblat direction. Another thing is, I always travel to [familiar] places like my son's house or friend's house, so I can easily ask them about the Qiblat direction."

Majority of participants were not familiar using both augmented reality (AR) applications. This study was their first experience interacting with AR applications. The interaction using both AR applications were new to them and they required more time and guidance from others to learn using the applications.

"It is not that hard to use these applications (both AR applications), but it requires more time to learn [using them]."

"Nothing is easy. These applications can be learned [so that we are able] to use [it]."

Even though they required more efforts to learn the AR applications, they enjoyed the challenge of using unfamiliar AR interactions. Three of the participants requested researchers' assistance to download the Qiblat-AR application directly into their mobile devices after the interview and focus group sessions had ended.

Designing an AR application must include clear instructions on how to use and operate the applications. This is important especially for older people in order to minimise learning effort and difficulties arising from the complexity of the applications. Lack of understanding on how to use the applications may add frustration and demotivate them from utilising mobile devices

CONCLUSION AND FUTURE WORK

Augmented reality applications are able to enhance mobile users' experience and perception in using mobile devices. However, there has been limited investigation conducted to understand the use of augmented reality among older people.

This study has found that older people understand the potential benefits of using augmented reality applications that may be applicable in certain places (i.e., outdoor) and users (i.e., disabled mobile users). Some challenges in using augmented reality applications especially for first time users have been observed, especially in AR interface and interaction, and familiarity with new AR applications. However, it has been found that older people have enjoyed the challenges of interacting with augmented reality applications.

Further investigation is thus required to capture older users' interaction with augmented reality to deeply understand their issues and evaluate their experiences.

ACKNOWLEDGEMENTS

This work was funded by Research Acculturation Grant Scheme (RAGS12-052-0052) supported by Ministry of Higher Education.

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