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IMPLEMENTATION OF AUGMENTED REALITY AND PANORAMIC VIEW FOR INTERIOR HOUSE DESIGN

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IMPLEMENTATION OF AUGMENTED REALITY AND PANORAMIC VIEW FOR INTERIOR HOUSE DESIGN

TAN PEI LIN

This project is submitted
in partial fulfillment of the requirements for a
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Received for examination by:

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Date:

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Grade

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ABSTACT

The main purpose of this study is to implement Augmented Reality (AR) and panoramic view in interior house design. AR is defined as the overlapping of three-dimensional (3D) virtual objects with real environment. Iteration and Incremental Development (IID) application development process model was used to develop the application. Unity3D is the main platform used to build the application. Cooperative evaluation was carried out to test the functionality of the application. Three respondents who have a background in Human Computer Interaction as well as past experiences in using several mobile applications were chosen to be respondents of this study. The application was divided into several stages and was built from one component to another until the whole application was completed. This application was easy to use and gained positive feedback from each respondent. Implementation of AR and panoramic view in interior house design is still a new trend. Hence, further research and development can be carried out to improve its application.

Keywords: augmented reality, panoramic view, interior house design

ABSTRAK

Tujuan utama penyelidikan ini adalah untuk pelaksanaan realiti diperkukuhkan dan pemandangan panorama bagi reka bentuk dalaman rumah. Realiti diperkukuhkan ditakrifkan sebagai pertindihan tiga dimensi (3D) objek maya dengan persekitaran sebenar. Pembangunan lelaran dan peningkatan proses model pembangunan aplikasi telah digunakan untuk membina aplikasi ini. Unity3D merupakan platform utama yang digunakan untuk membina aplikasi ini. Penilaian koperasi telah dijalankan untuk menguji kefungsian aplikasi. Tiga responden yang mempunyai latar belakang Interaksi Manusia Komputer dan pengalaman mengguna beberapa aplikasi telah dipilih untuk menjadi responden. Aplikasi ini telah dibahagikan kepada beberapa komponen, dan komponen demi komponen dibina hingga keseluruhan aplikasi ini selesai. Aplikasi ini telah diterima oleh responden dan telah mendapat maklum balas yang positif daripada mereka. Pelaksanaan realiti diperkukuhkan dan pandangan panorama dalam reka bentuk dalaman rumah masih adalah trend baru. Oleh itu, penyelidikan dan pembangunan yang lebih lanjut boleh dijalankan untuk meningkatkan aplikasinya.

Kata kunci: realiti diperkukuhkan, pandangan panorama, reka bentuk dalaman rumah

CHAPTER ONE

INTRODUCTION

Background of the Study

This study focuses on the application of Augmented Reality (AR) in interior house design. AR is defined as the overlapping of three-dimensional (3D) virtual objects with real environment (Kirner, Zorzal, & Kirner, 2006). The technology augments the real environment with computer generated images, 3D objects, text or sound. As compared to virtual reality (VR), AR does not change reality but enriches it with digital data, making the virtual and real object coexist in the same space (Azuma, 1997).

Research Problems

Until the extension that research has made, there are only a few studies on the application of AR in interior house design. Most studies focused on the architects' design of buildings or reconstructions of archaeological sites such as project ARCHEOGUIDE which reconstructs cultural heritage sites in AR and Olympia in Greece is the first trial site (Vlahakis et al., 2002). Even though there are few studies about the application of AR in interior house design, however, the studies are focused on choosing furniture that is suitable for the interior house design. Studies on the applications of AR in interior house design which present the entity interior house design is rarely seen and the available studies only focus on the analysis of rather than the design and development of a mobile application to apply AR in interior house design.

Besides that, the conventional methods of presenting interior house design is limited to 2D drawings and 3D models (Pejić, Krasić, & Anđelković, 2014). Normally the 2D floor plan of the house will be printed at the advertisement. Meanwhile the 3D models presentation display the space photo realistically in the form of photographs or videos (Pejić et al., 2014).

With this method, an architect can determine the angle to be displayed. Architects can choose the perfect angle and space to display to attract potential house buyers. Thus, house buyers cannot have a complete view of the entity space before purchasing the house (Pejić et al., 2014).

Research Objectives

The research objective of this study is divided into the general objective and specific objectives.

General Objective

The general objective of this study is to implement AR and panoramic view for interior house design. Hence, a noble way is created to represent the interior design of a house.

Specific Objectives

The specific objective of this study is to design and develop an AR application with panoramic view to display interior design of a house. AR and panoramic view application allow the potential house buyers to view the house design in 3D form and real images. AR will display the house in 3D model with pop-out effect. Once users click on the "Interior House" button, users will be brought into the interior house which present by panoramic view. Users can swipe the screen to have a look in the interior house design. Currently, house developers only display the interior house design in 2D form which is floor plan and it is printed out very small at the corner of the flyer. Users are required to have a rough imagine on the size and space of the house based on the layout given. Users will not have the feeling of presence in the space. This may cause users to have second thoughts and may lead them in making hasty decision. Hence, the image of the house is enhanced along with detailed information printed on the flyer to inform potential house buyers and to encourage them by having a look of the panoramic view developed by the application.

Besides that, this study also aim to evaluate users' perception of the AR application with a

panoramic view of the interior house design. After developing the application, developers will evaluate the users' perception of the application to examine users' acceptance of the application. Developers are required to ensure that this new developed application does not reinvent the wheel. Besides that, developers also need to evaluate whether the application can display the interior house design effectively, efficiently and most of all if it is able to satisfy users more than the current method of the simple, printed 2D land sketch of house interior on flyers.

Conceptual and Operational Definitions of terms

AR is defined as the overlapping of three-dimensional (3D) virtual objects with real environment (Kirner et al., 2006). With AR, users can view virtual object and the real environment as they coexist in the same space. VR technologies completely immerse users in virtual world while AR allows users to see the real world with virtual objects superimposed upon or composite with the real environment (Kirner et al., 2006).

Interior house design can be defined as interior space. It is closely related to architecture and interior decoration as well (Interior design, n.d.). The designer's goal is to produce architecture, site, function and visual aspects of the interior which are unified coordinated and harmonious, pleasing to mind and body and suitable to various activities depending on the amount of space (Interior design, n.d.). Design focuses on harmony of colors, textures, lightings, scales and proportion. Furnishings must be suitable for the space and the needs and lifestyle of the users (Interior design, n.d.). Design of nonresidential spaces such as offices, hospitals, stores and schools will focus on functions rather than aesthetic concerns (Interior design, n.d.).

Significance of the Study

The study has contributed in the field of knowledge and the field of practice.

The significance of this study in the knowledge field is to introduce a new way to display

interior house design. With the application of AR and panoramic view in interior design, users are able to view the interior of a house clearly. Users can have a look at every corner of the house in panoramic view by just swiping the screen. Designers can easily fulfill the needs of users just by taking note the changer request by the users and make changer afterward. Hence, a lot of time and cost is saved once the building has been built.

Besides, in the practice field, this study provides a new way to display interior house design. At the moment, the current way to display interior house design is only limit to 2D drawings and 3D models. The application provides an alternative method to display interior house design which using AR and panoramic view. This can be an interesting way to display interior design of a house and might replace the traditional way in future.

Scope of the Study

This study focuses on interior house design. The application developed will have the function to show the interior house design which allow users to have an overview of the house and help designers to make a changes in the interior design easily based on requests from buyers.

Summary

In this chapter, the general idea about the study and application was discussed. Augmented reality and panoramic view is gaining popularity nowadays. However, implementation of augmented reality and panoramic view for interior house design still a budding area to explore.

CHAPTER TWO

LITERATURE REVIEW

Augmented Reality (AR)

"Augmentare" in Latin word mean "enlarge, enhance, enrich" (Behringer, 2010). AR is an emerge experience which the real world is enhanced by computer-generated content that is tied to special location and / or activities (Yuen, Yaoyuneyong, & Johnson, 2011). AR allows digital content to be fully overlaid and mixed into users' perception of the real world (Yuen et al., 2011). Besides 2D and 3D objects, audio and video files, textual information and olfactory or tactile information can also be augmented (Yuen et al., 2011). These augmentations are aid and enhance the individuals' knowledge and understanding about the surrounding (Yuen et al., 2011).

According to Azuma (1997), AR can be defined using three characteristic:

a) Combination of real world and virtual objects

- AR allows users to see real and virtual information simultaneously in a combined view.

b) Interactive in real time

- AR must run at interactive frame rates so that it can be superimpose with real time information and allows users to interact.

c) Registered in 3D

- AR relies on the coupling between virtual and real which based on the geometrical relationship. This allows AR to render the virtual objects with correct placement and 3D perspective with respect to the real.

There are four different types of environment with different degree of modify, augment,

interface with or even replace individual's perceptions of reality (Yuen et al., 2011). The first environment is real world which also known as real environment (Yuen et al., 2011). Real world is the surrounding which is natural and user's familiar with. The environment which is on the opposite end of the environment is virtual world. Virtual world is also known as virtual environment or virtual reality (Yuen et al., 2011). In this environment, all the information are computer generated and totally unrelated with the location, objects or activities of the real world (Yuen et al., 2011). Users are fully immersed in the environment and do not know what happened to the real world.

There are two environments that exist between the real world and the virtual world which is augmented reality and augmented virtuality. Augmented reality uses real world as background and inserts computer generated content into it while augmented virtuality uses computer generated content as background and blended in and superimposed real world data (Yuen et al., 2011).

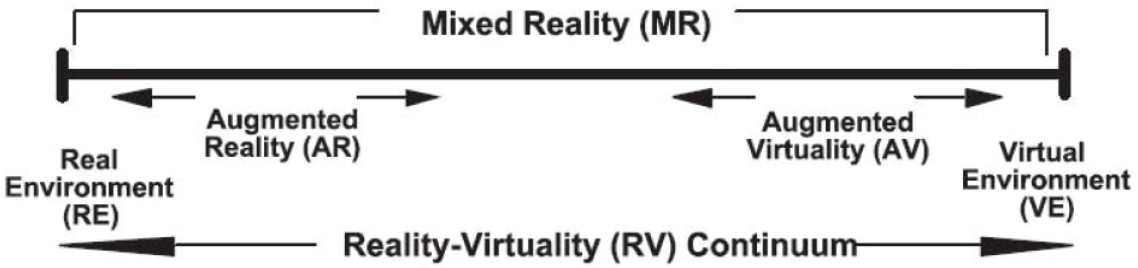

Figure 1. Reality-virtuality continuums. (*Augmented reality*, 2014)

AR is applied in many different fields such as manufacturing, maintenance and repair, medical, architecture, military and aviation and entertainment / infotainment (Behringer, 2010). However, this study will focus only on application of AR in interior design of a house from architecture area.

Interaction of Augmented Reality

Creating an appropriate technique for interaction between users and virtual content of AR

application is one of the most important aspects of AR (Carmigniani et al., 2011). There are three different types of interaction in AR application which are tangible AR interfaces, collaborative AR interfaces and hybrid AR interfaces (Zhou, Duh, & Billinghurst, 2008).

Tangible AR Interfaces

Tangible AR allows users to manipulate digital information with physical objects. Physical objects used have familiar properties, affordances; physical constraints make it easy to use (Zhou et al., 2008).

The good example for tangible AR is VOMAR application (Zhou et al., 2008). In this application user uses a real paddle to arrange virtual furniture in AR living room design. Paddle motions are based on gesture based commands such as place virtual furniture in the scene by tilting the paddle and delete the model by clicking the model. Paddle allows users with no prior experience with AR technology can create the 3D virtual scenes easily using paddle (Zhou et al., 2008).

Collaborative AR Interfaces

Collaborative AR interfaces support remote and co-located activities by using multiple displays (Carmigniani et al., 2011). This can enhance a shared physical workspace (Zhou et al., 2008). In remote sharing, collaborative AR interfaces is able to effort integrate multiple devices with multiple locations to enhances teleconferences (Carmigniani et al., 2011).

The example for collaborative AR is Shared Space application. Users found that the interface very conducive and intuitive to real world collaboration. The groupware support is simple and mostly left to social protocols (Zhou et al., 2008).

Hybrid AR Interfaces

Hybrid AR interfaces combines different but complementary interfaces to interact through a wide range of interaction devices (Carmigniani et al., 2011). It provide flexible platform for unplanned, where everyday interaction is unknown in advance on what type of

interaction display or devices will be used (Carmigniani et al., 2011).

The example for hybrid AR interface is VITA which is a collaborative mixed reality system for archaeological excavation. VITA combined see-through HMDs with multi-user, multi-touch, projected table surface, a large screen display and a tracked hand-held display (Zhou et al., 2008).

Application of Mobile Augmented Reality in Architecture / Interior House Design

The application of augmented reality in interior design can be divided into two types which is smaller scale as a model (Figure 2a) and 1:1 scale inside the space being arranged (Figure 2b) (Pejić et al., 2014).

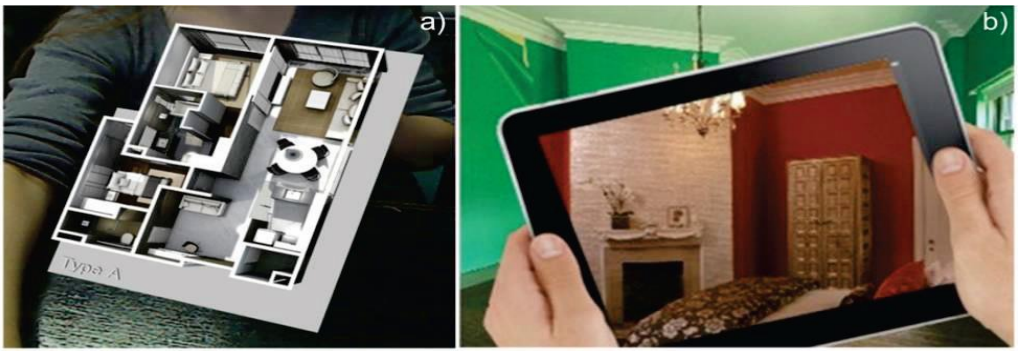

Figure 2. Display of interior design: a) small scale, b) 1:1 scale. (Pejić et al., 2014)

Smaller scale requires 3D model of the interior design, portable device, appropriate software and a marker. When the software starts, the portable device detect and scans the marker, the 3D model of the interior design will display (Pejić et al., 2014).

As for the 1:1 scale, 3D model, portable device, appropriate software and marker or GPS locating are all needed. Users are arranged inside the space. When the software starts, the portable device detect and scan the marker, it will display the newly design elements of the interior on the predetermined place. When the users change the position of the device, the view angle in real time also changes (Pejić et al., 2014).

Panoramic View

Panoramas can be defined as projections onto cylinders, spheres, cubes or any surfaces

which surround a viewing point (Brosz & Samavati, 2010). The viewing point also known as center of projection. It is a point where the viewer positions their eyes (Brosz & Samavati, 2010).

Recent advances in storage, computation and display technology allow development of virtual environment where users can feel immersed in a virtual scene and can explore by moving within it (Zelnik-Manor, Peters, & Perona, 2005). Furthermore, seamlessly integration between digital camera with computers, detecting and matching informative image features and good blending techniques allow photographers produce automatically mosaics of photographs which covering very wide fields of view and conveying the vivid impression of large panoramas (Zelnik-Manor et al., 2005). These mosaics are better than panoramic pictures taken with fish-eye lenses in many points such as wider fields of view, unlimited resolution requires cheaper optics and not restricted to the projection geometry imposed by the lens (Zelnik-Manor et al., 2005).

By detecting and matching visual features from different images, users may register the images automatically (Zelnik-Manor et al., 2005). Hence, users can map every pixel of every collected image to the corresponding point of the viewing sphere and get a spherical image that summarizes all information from the scene (Zelnik-Manor et al., 2005). Spherical image is the most natural display which users can display a scene of arbitrary angular width. Spherical image then will project onto a picture plane to produce panorama-on-a-page (Zelnik-Manor et al., 2005).

The well-known projection is linear perspective. It is also known as ‘gnomonic’ and ‘rectilinear’ (Zelnik-Manor et al., 2005). Linear perspective is produced by projecting the viewing sphere from the center of the sphere unto a tangent plane (Zelnik-Manor et al., 2005). During Renaissance, linear perspective is popular among painters. It is believed to be the only ‘correct’ projection because the line in 3D is mapped to the lines on 2D image plane. Besides

that, when the picture is viewed from the center of the projection, the retinal image is same as the original scene (Zelnik-Manor et al., 2005). However, linear perspective still has some weaknesses. Linear perspective can only display maximum 180^{o} of the scenes. When the scenes become wider, the degree of visual angle becomes very large compare to the one at center and become unbounded (Zelnik-Manor et al., 2005). Besides that, there is another streat (yan ge) limit to the size of visual field. Beyond 30^{o}-40^{o}, the architectural structures will distort even though the edges remain straight (Zelnik-Manor et al., 2005). In addition, the spheres which are not at the center of the projection will distort (Zelnik-Manor et al., 2005).

There are many alternative projections to produce panoramic view example like stereographic projection, geographic projection, Mercator projection and Transverse Mercator (Zelnik-Manor et al., 2005). All this projection can be categorized as global projections. Global projection does not depend on image content (Zelnik-Manor et al., 2005).

Stereographic projection is produced by using opposite pole of the tangent point as the center of projection. It is similar with postel projection (Zelnik-Manor et al., 2005). Postel projection is produced by taking measurement of the scene using thumb and scale the object on canvas base on the measurement. The angular measurement in the scene will become linear measurement in the canvas (Zelnik-Manor et al., 2005). This avoids the size in the periphery of the picture to distort. Although the line will be magnified at a higher degree but it is still less than linear perspective (Zelnik-Manor et al., 2005).

Geographic projection is produced first by wrapping a paper around viewing sphere to form a cylinder which meets the sphere at equator. Then project the meridians onto the cylinder by maintaining length along the vertical lines (Zelnik-Manor et al., 2005). However, geographic projection distorts the circle when large tilt angle (Zelnik-Manor et al., 2005).

In Mercator projection, scale of meridians are vary local hence the meridians keep in proportion with the parallels (Zelnik-Manor et al., 2005).

Transverse Mercator is most suitable to mapping areas which is elongated from north to south. This can produce panorama with little pan motion and large tilt motion (Zelnik-Manor et al., 2005). Vertical line is bending small near the meridian. Hence, if the pan angle is small, Transverse Mercator is the most suitable projection because it keeps the horizontal line straight (Zelnik-Manor et al., 2005).

(a) Perspective (b) Stereographic

(c) Geographic (d) Mercator

(e) Transverse Mercator

Figure 3. Different type of spherical projection. (Zelnik-Manor et al., 2005)

Summary

This chapter reviewed augmented reality. Besides that, interaction of augmented reality which is very important in augmented reality also reviewed. In addition, application of mobile augmented reality in architecture also reviewed to get some idea of the mobile application. Last but not least, panoramic view which will apply in the application also reviewed.

CHAPTER THREE

METHOD

Application Development Process Model

The application development process model that will be applied to develop the mobile application is iteration and incremental development (IID). IID is a development process which contains iterative developed cycle that involves continuous user feedback and incrementally added in features until the completed system at the end of each cycle (*Iterative and incremental development*, 2014). IID breaks the system into smaller parts and delivers each part in each of the iteration (*Iterative development lifecycle*, n.d.). Each smaller parts of the system are able to plan and deliver individually (*Iterative development lifecycle*, n.d.). The system is built using repeated process of analysis, design, construction and testing in each of the iteration (*Iterative development lifecycle*, n.d.).

The advantage of using IID is that developers can build a prototype of the system in the initial step and then evolve the prototype in each of the following iteration (*What is Iterative model-advantage, disadvantage and when to use it?*, 2014). In IDD, developers build and improve the prototype in each iteration. Hence, it can also help the developer to track the defects at an early stage and also to prevent downward flow of the defects (*What is Iterative model-advantage, disadvantage and when to use it?*, 2014). Besides that, by using IID developer can get the users feedback or result of technical testing in each of the iteration during testing. This can make sure the final system has fulfilled all the requirements and is user friendly (*What is Iterative model-advantage, disadvantage and when to use it?*, 2014).

Iteration and Incremental Development (IID)

There are four phases in IID which are inception phase, elaboration phase, construction phase and transition phase (Kruchten & Royce, 1996).

The first phase of the IID is inception phase. This is usually a phase which the scope and

objectives of the project are established (*Development methodologies*, 2014). The scope of this study will focus on the implementation of AR and panoramic view of the interior house design. While the objective of the study is to design and develop an AR application with a panoramic view to display interior house design. After the application has been built, evaluation of users' perception of the AR application with a panoramic view for interior house design is carried out to see whether the application can be accepted by users.

The second phase is the elaboration phase. In this phase, system requirements, risks and system architecture are established (*Development methodologies*, 2014). The system requirements for this application can be divided into two categories which is the hardware and software components. The main hardware components needed are personal laptop and an Android smart phone. While the software components needed for developing this application are Android SDK, Vuforia SDK, Unity3D, 3D Max and Google Camera. The risks of this application that developer might be facing are technical challenges when developing the application. The panoramic image might not be able to be inserted into AR application. Besides that, the panoramic view might not be able to swipe according to the users' desire.

The third phase of the development process is the construction phase. In this phase, analysis, implementation, design and testing of functional requirements will be carried out to produce production-ready code to fill in architecture components incrementally (*Iterative and incremental development*, 2014). In this phase, the system will be built with evolving the vision, architecture, and plans until the complete version of the system are ready for users (Kruchten & Royce, 1996). The process of analysis, implementation, design and testing will be repeated in this phase until the application fulfills all the requirements.

The next phase is transition phase. In this phase, the system will deliver to its operational environment and user community (*Development methodologies*, 2014). After getting the feedbacks from the users, further iterations within the transition phase will carry out to further