Faculty of Cognitive Sciences and Human Development

IMPLEMENTATION OF INTERACTIVE 3D SOFTWARE FOR INTERIOR DESIGN BY USING UNITY GAME ENGINE

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Final Year Project Report ☒

Masters ☐

PhD ☐

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IMPLEMENTATION OF INTERACTIVE 3D SOFTWARE FOR INTERIOR DESIGN BY USING UNITY GAME ENGINE

ANDRIAN TAM WAE JIH

This project is submitted
in partial fulfilment of the requirements for a
Bachelor of Science with Honours
(Cognitive Science)

Faculty of Cognitive Sciences and Human Development
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(2015)

The project entitled Implementation of Interactive 3D Software for Interior Design by using Unity Game Engine was prepared by Andrian Tam Wae Jih and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for a Bachelor of Science with Honours (Cognitive Science)

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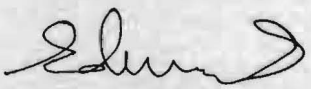

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TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Purchasing homes that are customizable has been a limitation to housing developers as they do not have the proper tools to present and communicate designs between the buyer and the contractor. Current homes are usually purchased based on stock layouts which can be chosen, but have limited choices. Housing developers want their potential buyers to be able to have the interior layout of their house as they wish. This includes the number of rooms, type of tiles and also built in furniture inside the house. With that, we propose to create a software which runs light but has high functionality and interactivity for potential buyers of houses to customize their home in a way that is understood by the housing developers through the internet by using a game engine. For this case, we will use Unity3D Engine to create a 3D editing software that can run on web browsers where users can use it as long as there is internet connection. This study uses various JavaScript and C# coding to implement computer graphic techniques such as Ray Casting and 3D object manipulation and selection techniques.

ABSTRAK

Pembelian rumah yang boleh diubah-suai adalah satu kekangan kepada pemaju perumahan kerana kekurangan alat-alat yang boleh menyampaikan maklumat serta membolehkan komunikasi yang berkesan antara pembeli dengan pemaju. Kebanyakan rumah yang dijual pada zaman ini hanya mempunyai pelan rumah sedia ada yang boleh dipilih tetapi pilihan yang ada adalah terhad. Pemaju perumahan mahu pembeli memperoleh pelan rumah yang dapat mengikut cita rasa sendiri, termasuk kuantiti bilik, jenis jubin serta perabot. Dengan itu, kami bercadang untuk membina perisian yang ringan tetapi mempunyai tahap kefungsian dan interaktif yang tinggi untuk pengguna perisian ini supaya ia dapat difahami oleh pemaju perumahan yang dilaksanakan dengan enjin permainan melalui penggunaan laman web. Untuk projek ini, kami akan gunakan Unity3D untuk membina perisian interaktif 3D yang boleh digunakan melalui laman web, asalkan pengguna tersebut mendapat sambungan internet. Projek ini akan menggunakan pengaturcaraan JavaScript dan C# untuk menjalankan teknik grafik komputer seperti "Ray Casting" dengan pemilihan serta manipulasi.

CHAPTER ONE

INTRODUCTION

Background of Study

Our manual and cognitive skills are naturally developed in a three dimensional environment and we are used to operating in it. (Green & Shaw, 2001) This means that three dimensional (3D) applications is used in our daily natural life and it is easier for people to handle interfaces which are three dimensional rather than just two dimensional (2D). Basic websites run on a 2D interface which is fine as some people are used to it such as plain texts or pictures. However, it will be more interesting to have a website which runs 3D interfaces especially for customization for products like homes, cars or computers.

Before a design can be implemented, its architecture should be user based. Who are the target users and how will they interact with the 3D interface. In the market, there are many tools that are usable for 3D navigation and selection but for this case, users are most likely going to use only a computer and the internet. There is certain knowledge that needs to be known before developing an interface such as the capabilities and needs of the user. (Green & Shaw, 2001) If the system is not enough or is more than what is needed, therefore the system would be inefficient. We would need to know the requirements of the targeted users and also whether they would need such system on the internet.

Problem Statement

The development of this system is made to create a website that is capable of running 3D software online. In other words, this study is trying to implement a portable 3D editing software. To be precise, the study hopes to implement an online 3D software where users or customers may be able to customize an interior of a house based on their liking before purchasing it. The

common way of buying a house these days is when a potential buyer has to visit a sales office or go to the house and discuss the designs with the house developers. Nevertheless, most houses these days already have a fixed interior design. With the use of this system or website, potential buyers can actually customize the interior layout of their future house and submit to the housing developers for further comments and invoice of final price.

Another issue is that implementing 3D softwares online is very big. 3D softwares run lots of commands, images and polygons including effects and certain simulations. Implementing such softwares online can take up a very large amount of internet bandwidth which causes internet delays and also very long loading time which can be frustrating for users. The use of a 3D game engine may help to compress all these files into a java programmed software but retain its original functionality.

It is important to create this website as this will be the future of e-commerce and it goes to a whole new level where potential buyers don't just choose the most suitable house, but make their dream home. Besides discussing layouts with the developers, potential buyers may even be able to have a glimpse of their future home with the 3D software rendered. After they set up their own layout, there can be a final view where users can view their home from an angle of a virtual person in that virtual home.

Research Objectives

General Objectives

The objective of this research is to develop a website which can function as an online 3D editing software for potential buyers of houses.

Specific Objectives

1. To implement Unity 3D software in online user's customization for interior house design
2. To find out the effectiveness of the software in terms of functionality and efficiency.

Significance

This study will contribute towards a real life application in the business world. It will innovate the basic functions of e-commerce into a medium that's interactive, personalized, customer eccentric and also customizable, before potential buyers purchase a product. In this case, we are focusing towards customizable homes via the internet before potential buyers purchase their new home. This interface will also give an edge to potential buyers to know what they can expect from their dream home.

Limitations of Study

This study is carried out by students and lacks the heuristic knowledge of housing estate sales and marketing departments. This study's main focus is to be user centric in terms of Human-Computer Interactions through the user interface but is assuming the needs of users as computer users and not of those who are purchasing homes. This means that the software that will be created will be effective with the interaction between the computer and user but not personalized towards users who are buying homes. Unity 3D also has limited tutorials where it will be challenging to use the software appropriately and effectively. Making an e-commerce interactive software is different from creating a game, which is the main purpose of Unity 3D.

Operational Definition of Terms

Interactive

A design that is supposed to respond towards actions or commands.

Three Dimensional (3D)

A virtual or physical object which has 3 dimensions in terms of length, width and height.

Interior Design

The art or job of planning the internal layout of a building.

e-Commerce

A form of business or market which is done through the internet virtually.

Human-Computer Interaction

The communication between a computer system and it's user.

Virtual Reality/ Virtual Environment

An environment that is unreal which is created by a computer which represents real objects.

Summary

This chapter explained briefly on the basic knowledge needed before proceeding with reading this study more thoroughly. The next chapter will explain the related studies done and theories involved in more details.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter reviews the importance of interactive 3 dimensional (3D) systems or techniques for designing in a virtual environment (VE) by just using a web browser compared to other conventional techniques like 2 dimensional (2D) sketches.

Dimensions

Knowing dimensions is important to understand the effective ways of visual communication between a user and the system and back to the user.

2D presentations are helpful in creating precise relationships whereas 3D presentations are efficient in giving qualitative understanding and presenting ideas to others (Springmeyer, Blattner, & Max, 1992). Dimensions can be simply understood as the measure of size of its covering properties topologically. A line is known to be one dimension, where a square is 2D and a cube is 3D. Human beings perceive the world in a 3D form like dreams, imaginations and by looking at physical objects. The world is a sphere, a pen is cylindrical and we don't see other human beings flat as they have the 3rd dimension. Communication with one another through 3D representations makes it easier for understanding as human beings themselves live with it.

More sophisticated designs can be presented in 3D while simpler ones can be showed in 2D (Jackson, 2011). Although 3D is a very important tool to present ideas efficiently, it isn't perfect on its own. As mentioned above, 2D views are helpful in showing relationship of things between each other and thus, using both 3D and 2D for interaction allows users to see more and get a bigger picture of what is going on.

Besides the idea of having a bigger picture, using both 3D and 2D together also helps avoid disruption towards designs, productivity or communication with employees or suppliers (Jackson, 2011). Moving from 2D to 3D directly is risky although it has a high chance of a prosperous outcome. People would have to go through a change which includes training and understanding before 3D can be fully utilized. To be safe, integrating and transitioning 3D with 2D is a more dynamic way to create presentations instead of completely dropping 2D out.

Human Perception

Perception is the way people think and understand everything that happens around us, no matter physical or purely mental. In a 3D interface design, it is essential to create an interface that is effective towards the users understanding, create affordance and lower cognitive load.

Affordance is the understanding of an object and knowing based on its properties how the object is used (Norman, 2002). For example, when there is a chair, the user knows it's for sitting down and when the user sees a car, it is for transporting people from one place to another. An object of high affordance means that it is easier to recognize its main function than having to read a manual or heuristically figuring out its purpose. The ability for people to easily perceive an object the way it is designed to be gives a high level of affordance. Having a high level of affordance also means that people do not waste time and can quickly use that object right away especially if it is used for the first time. In relations to this study, the interface of the software should have high affordance where users who use them for the first time will have no problem with interacting with the software.

Conceptual short-term memory (CSTM) is an ongoing buffer and processor of perceptual stimuli, like a user viewing an object, and information from the long-term memory represented briefly which allow distinct and meaningful structures to be recognized (Potter, 2012). This

theoretically means that short-term memory is related with perception. While a user perceives an interface, we do not want to increase their short-term memory load or even their cognitive load. Shneiderman (2004) mentioned that a good design should reduce short-term memory load in his 8 Golden Rules of Design. Reducing short-term memory load helps to allow users not to contain too much information at the same while using the interface. For example, if an interface is not labeled properly and has icons that users are not familiar with, the user has to find out its function and remember it if they have to navigate back to that function. More information on Shneiderman's 8 Golden Rules of Design will be explained in the interface design section.

Placing importance to human perception helps to give a greater focus to the needs of the user. An interface should be designed and developed in a way that is easy, simple and comfortable to be used by the user. This indeed will also help users in getting their goals done efficiently and more quickly.

Interaction

Overview

The communication between the user and a system or interface is called interaction. Generally, good communication creates better efficiency and reduces mistakes, which should also be the same for interaction.

The user's baton is the input devices and the interaction techniques involved with it (MacKenzie, 1995). They set, bound, and get a set of tasks and responses, and somehow inoculate a personality on the entire system. The way the user uses a system can influence the system by the way it responds back to the user. A general flow of a human-computer interaction works is as follows:

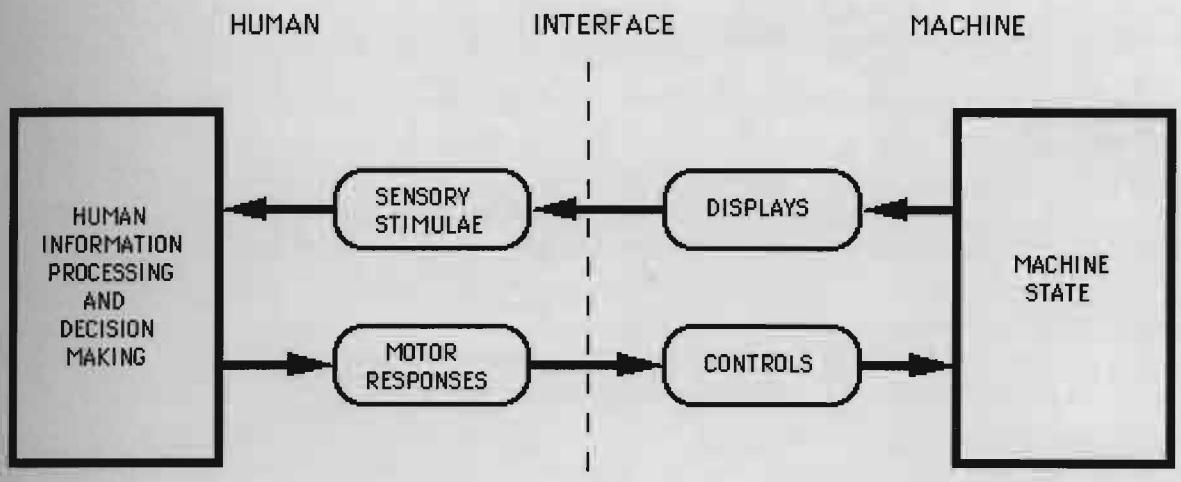

Figure 2.3.1(a): The interaction process between the user and system

To understand an interaction process better, we will look back to Norman's (2002) seven stages of action:

1. Specifying the Goal
2. Forming the Intention
3. Specifying Action
4. Execution of Action
5. Perceiving the System State
6. Interpreting the System State
7. Evaluating Goals and Intentions based on the System State

The basic process of interaction begins when the user has a goal and thinks of what needs to be done. After knowing what to do, the user executes the action via input devices into the system where the system will respond or change in state. After the user receives feedback through their stimulus, the user will process and decide whether the goal is achieved or not. The cycle continues until the main goal has been achieved. A good interaction is when all these stages have

been fulfilled and the user reaches the goal quickly and easily. This is where the interaction techniques play an important role in creating a good system. The factors that affect interaction are the input and output devices and also the user interface and system.

Input Devices

There are a wide range of state-of-the-art input devices out there for 3D interaction but it will be narrowed down to a simple keyboard and mouse. This is because the system we are creating is an online system which is targeted to users who uses the internet with their laptops. Having users to use or purchase other 3D input devices will be costly, effortful and time consuming, which already defeats the purpose of improving lives of human beings.

Users are able to send commands via pull-down menus, toolbars, and keyboard shortcuts in graphic interfaces (Lane, Napier, Peres, & Sándor, 2005). Menus and toolbars are easier to use but keyboard shortcuts are faster and more efficient. For example, it is generally known that the button *Ctrl* + *S* means "Save" a document or file and it can be done in 2 actions. This is faster than having to go to the *File* menu and click *Save* which is 4 actions which includes moving the pointer to the menu, clicking, moving the pointer to the option and clicking again. However, having to remember keyboard shortcuts arises an issue; the increase in short-term memory load. If the user is not familiar with the shortcut, the user will always have to remember it.

According to the schema theory, users remember based on the schema or models that has already been formed by them (Golbeck, 2002). It will be easier for users to learn how to use a new software if it follows a familiar design or schemata. This means that the shortcuts used has to be consistent to the shortcuts used on most softwares of today. This will help users learn and be able to use the software more quickly without increasing their cognitive load.

Users can interact with 3D objects using an image plane by placing the mouse pointer over the object in the image plane and clicking to select the object (Pierce, et al., 1997) . In most conventional softwares like Autodesk 3Ds Max, Blender and Cinema 4D, the use of a mouse and keyboard is very common to navigate around a 3D environment. In 3Ds Max, moving the pointer with the middle mouse button lets users rotate their view around an object. Lane, Napier, Peres, & Sándor also added that selection of a wide range of things using a keyboard can be difficult while using a mouse is more effective in selection.

From the information above, we can conclude that a mouse and keyboard are effective input devices although they are provided generally for personal computers and laptops. This shows that efficient interaction techniques with a keyboard and mouse can be achieved for 3D software interfaces online.

Interface Design

The user interface is the part of a system where a user can communicate with it (Galitz, 2007). The interface is where the user can command and give a series of tasks via input devices and also receive feedback, information and results from the system.

Good interface design doesn't just enhance user's experience but also increases productivity, like a company whose productivity actually increased from 25 percent to 40 percent because of the implementation of well-designed screens and another company saved about $20 000 from their operational cost because they redesigned just one window (Galitz, 2007). This is possible because of the use of good designs which understands how information has to be presented to the user which enhances their acceptance and comprehension together with ergonomics of the flow of eye and hand movements to prevent injury or cause the user to feel weak. Good interfaces are also aware of the limitations of the input/output devices and also the

software or system running the interface. Besides that, we also should consider a few theories or principles which can be a guide or requirement in the interface design.

Heuristically from experience, Shneiderman (1998) has proposed a collection of principles which are applicable in most interactive systems after through refinery, elaboration and interpretation. The 8 rules begin with the *strive of consistency*, where in similar situations, consistent sequence of actions should be done. Common terms should be used in applications of the same category to create a consistency. The next rule is to *allow frequent users to use shortcuts* which help the user run through the interface faster and have lesser steps to access what is intended. The third rule is that *feedback has to be informational*. Every task done by a user should have some form of feedback where the user knows that the interface is responding, for example, haptic feedback or error messages. A *design dialogue to yield closure* is also an important rule which notifies users that the sequence of tasks that was carried out has reached its goal and brings a sense of satisfaction to the user. The fifth rule is that the system should have a *simple error handling* in a way that errors are not easy to be made and if one occurs, it is detectable and solvable. The 6th rule works along with the previous which aids in *reversibility of actions*. This rule is called the permit of easy reversible actions. The next rule is to *support internal locus of control* where users get to feel superior to the interface by not being a responder but an initiator to the design. Last but not least, the designs need to *reduce short term memory load* by implying multi-windows or an interface that has lesser windows or pages so that information can be easily referred back. The more an interface fulfills these rules, the better is the user experience while using the interface.

Galitz (2007) also concluded that based on much research and experience, different strengths and weaknesses arise from different interface styles. There is no one interface design

that can completely fulfill every users need. For example, some users prefer the use of words more than graphics such as lists compared to icons. He also came up with a few points that an interface design is the best deciding factor of the ease of use of a design and not the interaction style. It is also important to consider users preference while choosing an interaction style. In majority of cases, words are more meaningful than icon and content is a critical component in an interface to avoid confusion. Last but not least, he added that the success of a good design is determined by the skills of the designers who follow the established principles of usability. Therefore, we should stick close with Shneiderman's Golden Rules.

Customization

Customization softwares that are available online has already been up and running for general purposes only. For home interior designing, there are websites like Sweet Homes 3D which allows users to make their own home via Java applet. However, this software is only used for general purposes and not by companies or real estate developers.

Mass customization has been rapidly growing to meet the needs of customers which uses just about the same amount of cost with mass production as market competition and demand has increased from customers (Dai, Li, Zhang, & Xu, 2003). More and more people desire for products of their own that suits their personal needs. It doesn't matter if it's of personal or commercial use, mass customization is an important component in the business market especially e-commerce as technology grows. Large companies including jumbo aircraft producer, Airbus are catering for each and every airline company who purchases their aircraft. However, one of the challenges is that customization using different software tools among different companies or engineers causes technical disruptions (Charette, 2009).

Previous research by Chaplin, Lyons, & Spierenburg (1996) was focusing on a LaHave House Project which implement an automated architectural design service. It consist of 3 major software components which are a design engine that creates a house design library, design development tool for selection, customization and visualization and building systemconfiguration software that converts houses into architectural drawings. The use of these 3 softwares help user choose, edit and finalize a design of their dream home to be built in the future. As our current research now is using a 3D engine, it should be able to do these 3 functions but better or more efficient.

Summary

This sums up the literature review on 3D Online Interactivity for Home Interior Designing Software. We can see the importance of the use of both 2D and 3D representations, human perception towards objects and efficient interaction in making a quality experience for the user.