Abstract

Virtual reality allows for intuitive 3D interaction using head and hand tracking. However, many traditional 2D interfaces become awkward and cumbersome when translated to virtual reality (VR). This is due to the combination of fine input afforded by motion controls and the extra degrees of movement native to 3D space. One possible way to retain the usability of these interfaces is to have them adapt as they are interacted with.

This paper seeks to explore the implementation of adaptive user interfaces in VR and assess their effect on usability. By using error analysis and pattern recognition the interface could try to predict or suggest actions the user may be trying to perform. Two iterations of a 3D interface, one with adaptation, will be used to compare the usability in various ways. The result of this comparison should demonstrate the benefit of adaptive user interfaces for virtual reality. If so then complex tasks currently relegated to 2D interfaces could be brought into the intuitive world of VR.

Introduction

Virtual reality head mounted displays are rapidly becoming a part of mainstream games platforms. The launch of Sony’s PlayStation VR has been more successful than anticipated and the fears of motion sickness causing a repeat of the 90s VR trend are dissipating. HTC’s Vive headset along with Facebook’s Oculus provide a higher fidelity experience than PSVR but are in a higher price bracket. Each of these headsets provide similar experiences: displays for each eye to provide stereoscopic depth and full six degrees of freedom head and hand tracking via motion controllers. The six degrees of freedom break down into the three axis of translation: horizontal, vertical and forward/backward plus the three axis of rotation: yaw, pitch and roll.

These features combined provide a digital world and sense of immersion closer to reality than anything available to consumers in the past. The primary difference between headsets is the tracking method with HTC’s lighthouse laser tracking allowing ‘room-scale’ play areas as opposed to the optical tracking of the Oculus and PSVR lending itself to a sitting experience. On the horizon is the next step, AR and inside-out VR. This will allow a wireless experience and build upon the work being done in mobile VR by Google’s cardboard and daydream teams. Microsoft’s Hololens provides a glimpse at this future, a future of seamless multi-person interactions overlaid on our reality.

When comparing any of these experiences to those of traditional displays it is clear they have not yet replaced the universal language of 2D web pages, spreadsheets and mouse and keyboard. Although there is great promise for productivity in VR it currently focuses on narrow focused experiences. These almost all use minimal 3D that when trying to accomplish more complex tasks become clunky and cumbersome.

The project will look at how complex 3D interfaces can be made more usable using adaptive interfaces. It will reference concepts and techniques such as error analysis and user modelling explored by other researchers in 2D and 3D interfaces with a focus on motion controlled input in virtual reality.

Research Question:

“How can complex motion-controlled virtual reality interfaces be made more usable by employing adaptive interface techniques”

Aims and Objectives

Aim:

* Create iterations of a complex 3D interface for VR employing several adaptive user interface techniques.
* Use quantitative data gathered from error analysis to assess any benefits to usability the adaptive techniques have.
* Use qualitative data gathered from surveys to evaluate the overall effect of adaptive user interfaces.

Objectives:

* Research adaptive user interface techniques for 2D and 3D interfaces.
* Implement a complex 3D user interface for use in virtual reality.
* Employ the researched techniques for assessment.
* Create a system for error analysis to gather qualitative evaluation data.
* Have users test the iterations of the interface and feedback on their usability.
* Compare the various techniques using the qualitative and quantitative data gathered to evaluate their effectiveness.
* Using the comparisons evaluate the overall impact of adaptive user interfaces in virtual reality.

Context

User interfaces for digital technologies have been an area of research since the dawn of computing in the 20th century. The development of the Windows Icon Menu Pointer system (WIMPs) in 1973 at Xerox marked the beginning of graphical user interfaces as we know them and since then desktop computing has not evolved from that interface. Research has been done to create 3D interfaces but most still utilise the basic concept of applications having windows and being navigated using a pointer.

The language of WIMPs is so universal that is does not make sense to move away from it while using the same 2D displays and devices, with the arrival of touch-based phones and tablets there was a new paradigm of touching and swiping but the interfaces still adhere to the windows, icons, menus and pointers used for decades. The only difference is the pointer is the user’s own finger. Although these interfaces were at first clunky and tiresome and did not accomplish the same complex tasks as desktop computers that has slowly changed and now many people use their phone or tablet more than their personal computer, creating spreadsheets, writing emails and navigating web pages with their fingers.

Now with virtual reality 3D interfaces are going through the same growing pains, with two hands used to interact as opposed to a finger or pointer. We have rarely make fine interactions using our hands without them being supported by paper or a canvas or a touch screen so the majority of 3D interfaces employ large accessible buttons and objects simplifying the task in order to improve usability. All of these interfaces have remained mostly static with each element providing a single function and never changing. Despite this much research has been done to try and make user interfaces more dynamic and adaptive. The closest this has come to the mainstream is the ‘intelligent’ interface of Microsoft Word, Clippy and the more recent voice assistants such as Apple’s Siri.

Adaptive user interfaces fall under a few categories in the area of research sometimes referred to as ‘interface plasticity’. ‘Plasticity in 3D UI’ gives an overview of the different types of adaptive user interface classifying them using two parameters, the adaptation time and the controller. Within these parameters an adaptive user interface is defined as being adapted by the system at run-time. One technique covered by ‘Error Analysis in Adaptive Interfaces’ uses the user’s failures while navigating and interacting to dynamically improve the interface. In Adaptive Hypermedia the adaptations of the interface rely on user modelling to tailor the environment and content to the user. Another technique is to model how the user interacts and begin suggesting or highlighting content the system deems relevant in the context of the user’s interactions.

Methodology

A template interface will need to be created initially to allow the iteration using various adaptive techniques. This interface will be in a draft state with the first technique for the feasibility demo due at the end of first semester. The first months of second semester will be spent implementing the various other adaptive techniques researched and ensuring the interface is complex enough to create an environment in which usability becomes a noticeable factor to the user. The interface will consist of an introduction during which the user will learn the basic interaction with the motion controllers and the basic navigation tools along with the function of the interface they are using.

The interface will essentially be a placeholder and required the user to manipulate elements in order to create tables and insert values into these tables. They will be able to copy the contents of the table elements as well as modify their properties such as size and colour. They will then be able to have the data they build up visualised in different ways with these visualisations being navigable in various ways. The static version of the interface will require the user to precisely select and perform each action while the adaptive iterations will suggest and assist in the user’s interactions. At least three techniques will be employed.

Basic error analysis of the user’s errors e.g. miss clicks, reversals and getting lost. These errors can then be used to predict and interpret the user’s intended action and try to rectify it by executing, highlighting or suggesting the action. These errors will also be used throughout the other techniques in order to gather data about how usable the interface is. Another implementation will be some form of pattern recognition. Building Markov chains of actions which can be referenced to predict the action the user is intending to take and suggest or highlight pre-emptively. One risk is if a new user is constantly having suggestions made and the interface is adapting they will perhaps struggle to learn the interface and know where to navigate in order to use it. One benefit of having the added space of 3D is that there is huge real estate for user interface elements to exist and interactions.

The application and interfaces will be implemented using C++ within Unreal Engine 4. This allows the rendering and projection for virtual reality as well as the tracking of the headset/controllers to be handled and the implementation will focus on the adaptive techniques. Simple graphics and 3D primitives will be used for visualisation in order to ensure the interface is the primary concern of the user as opposed to the graphics. The application should be device agnostic as Unreal Engine 4 supports each of the headsets and controllers, however if there are problems only one will be catered for and tested with.

Once these techniques and any others are implemented the evaluation of the interfaces will take place. Users will be fathered and surveyed through both the error analysis and feedback forms. This data will then be used to evaluate the effectiveness of each individual technique and the overall impact of adaptive interfaces for virtual reality.

Summary

The use of adaptive user interfaces should provide benefits to the usability of the 3D interfaces as well as the speed at which the user can interact with them. This will allow for more complex interfaces which perform more meaningful and productive tasks. With a future that could be rooted in virtual reality it is the opportune time to re-evaluate what an interface can be and how the it reacts to the user. With the promise of wireless headsets and augmented reality on the horizon traditional 2D displays no longer make sense, if our walls, floor and hands can be our displays then the interfaces will need to adapt along with those ever changing surfaces. Adaptive user interfaces are something that has been researched for a long time and now has a way to break in to the mainstream of our everyday interactions.

To improve upon the language of 2D interfaces is a challenge as they are so deeply engrained to our digital lives but does it not make sense for the ultimate interface to be one that is 3D, dynamic and responsive just like the world we live and breathe in?

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