Adaptive User Interfaces for Virtual Reality

**Abstract**

**Context:** Virtual reality head-mounted displays provide intuitive tracked input for 3D interaction. In many applications the user experiences the environment from within, naturally looking around and reaching out. This causes a paradigm shift in user interface design: away from traditional 2D menus and toward object based 3D worlds. Although handheld tracked controllers are accurate when objects are within reach, interaction at a distance is more complicated.

**Aim:** This paper seeks to explore the possible benefits of adaptive interfaces on usability in virtual reality. The research will focus on using handheld tracked controllers as input. By implementing systems that monitor the user’s actions and assist them in various ways the interface can be made adaptive, perhaps improving ease-of-use.

**Method:** Several iterations of a complex 3D interface will be developed. Each will employ a different adaptive technique along with a traditional static interface for comparison. A system for recording the actions and errors made during use will also be implemented. Around 10 users will be gathered to complete a series of tasks within each iteration of the interface. They will then be surveyed to assess how usable they deemed each version to be.

**Results:** Taking into account both the quantitative data gathered by the system and qualitative data from the surveys an evaluation of each technique employed and the static interface will be made. Using these an overall comparison between adaptive and static interfaces in virtual reality can be drawn.

**Conclusion:** Virtual reality is poised to become the new means of digital interaction and it makes sense to reassess the way the system can respond to our interactions. Adaptive user interfaces could enable new levels of productivity and precision in virtual 3D environments.

**Introduction**

Virtual reality head mounted displays are rapidly becoming a part of mainstream entertainment. 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 are higher fidelity experiences at a higher price than Sony’s offering. Each of these headsets provide similar experiences: displays for each eye providing stereoscopic depth and full six degrees of freedom head tracking and hand tracking via wireless controllers.

These features combined provide a sense of immersion closer to reality than anything available to consumers in the past. On the horizon is the next step, augmented reality. This will allow a wireless experience and build upon the work being done in mobile virtual reality by Google’s cardboard and daydream teams. Microsoft’s Hololens provides a glimpse at this future, one of seamless multi-user interaction overlaid on reality.

When comparing current virtual reality experiences to those of traditional displays it is clear they have not yet replaced the universal language of 2D windows, pointers and mouse and keyboard. This project will look at how complex 3D interfaces can be made more usable by creating dynamic, adaptive interfaces. It will reference concepts and techniques such as gaze-base interaction, error analysis and user modelling explored previously by other researchers in 2D and 3D. The transition to 3D poses new challenges for interface design. The addition of depth and lack of an edge to the user space are both new concepts to deal with.

**Research Question:**

“How can complex virtual reality interfaces be made more usable by employing adaptive user interface techniques?”

**Aim:**

* Create iterations of a complex 3D interface for virtual reality, 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 on usability.

**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 on usability 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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