Implementation of a Virtual Reality Operating System (VROS) for the Next Generation of Computing

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***Abstract*—The end of second decade of 21st Century will convey a new generation of computers that are enabled by the Virtual Reality technology. This technology will push the boundaries by redefining the whole ways of human-computer interaction. The technology will not only enable the user to interact with the computers more intuitively but it also result in faster completion of tasks. This would be due to multi input and output technology. Our research paper solves the purpose of development by adding a component namely Virtual Reality Operating System (VROS) and gives insights about it. It concludes with the benefits and challenges of using VROS in the near future. We also conclude that as the research in this area is not focused widely, our initiative to develop a completely immersive VROS would be a great start up potential in future.**

Keywords—Virtual Reality, Augmented Reality, Operating System

I. INTRODUCTION

The advent and fast adaption in the field of virtual reality and its applications is becoming very common place to study in computer science. From its initial conception in science fiction leads to many novel setup such as William Gibson's 'Neuromancer' and movies like 'The Lawnmower Man', virtual reality (VR) has always had an appeal to people seeking the excitement of experiencing other worlds.

Reference [1] broadly defines VR as an advanced technology which is used to visualize large and complicated sets of data more easily whereas few other researchers concludes as the ability of humans to explore and interact with a spatial environment through a computer system or as a real-time interactive graphics with three dimensional models, which when combined with a display technology, gives the user immersion in the model world, and direct manipulation [2], [3].

Virtual Reality is an enabling technology for humans to experience a computer generated version of some other reality that surrounds them using all the senses, i.e. with the help of required input and output devices that the user is tricked to believe what he or she experiences is his or her true reality.

Reference [4] groups the fields of VR into five different areas depending on the interface presented to the user. These include:

- Window on the World Systems – these systems use the 2D displays to display 3D content in them.
- Immersive Systems – these use non-standard input and output devices to make the user feel that they are inside an environment rather than observing the system from the outside.
- Video Mapping – this involves mapping video onto a 3D object and changing the users' views of the video depending on their relative positions and orientations to the 3D object.
- Telepresence – this involves a user performing some action at a location which is being electronically reproduced in real time at a remote location.
- Mixed (Augmented) Reality Systems – it combines the real world with a computer generated environment.

This paper focuses mainly on an operating system for immersive VR system but also touches upon ideas for AR system as well. The idea to include AR is driven by the futuristic development having selective transparency and opacity that enables the development of fourth generation of HMDs. [5]

The core features of VROS are specifically focused around different hardware and software interacts with the operating system. It is intended that important aspects of VROS will be revealed like in order to fully utilize and interact within immersive Virtual Environments one needs a basic enabler – Operating System. Without an operating system each different device manufactured will intend to perform only few handfuls of tasks. There have been efforts towards creating virtual operating systems which rather mainly focused on creating virtual environments. Each has its specific uses and limitations, and none is capable to target general public.

By assessing the work done we aim to determine which features are most suitable to use for immersive virtual or augmented realities and provide the core features of such an operating system.

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Immersive VR systems typically involve the user utilizing some specific hardware devices to provide a greater sense of presence in the virtual environment. Presence is the degree to which participants feel they are somewhere other than where they physically are whilst immersed in a virtual environment application [6].This operating system is the biggest opportunity in the VR space usage in gaming. The company that first puts together a unified user experience, technology infrastructure and business ecosystem will dominate computing through the 2020s [7].

The researcher concludes that current user interface for computers is called WIMP (Windows, Icons, Mouse and Pointer Interface) which is the third generation of interface to be used on computers. But, has its limitation as it is hard to learn widgets and features, spending too much time in manipulating the interface, designed for 2D applications that do not scale well to the 3D realm and mouse or keyboard are not natural to the users so it takes no advantages of speech, hearing and touch. Work is being done on fourth generation of user interface called Post-WIMP which attempts to involve all the senses in parallel, utilize natural language interaction and involve multiple users. [8]

Presently, different devices like Oculus Rift, Sony Morpheus, HTC Vive, FOVE etc. are being prepared for launch in 2016. This will give the consumers a choice to select one according to the finances. None of them is complete in all senses i.e. if Oculus specializes in lowest latency visuals and is for gaming then FOVE specializes in eye-tracking. Therefore the different devices serve different purposes. The users and developers should buy different products as per their needs.

Virtual Reality Operating System will solve the problem by providing a common ground for different hardware devices and software to run together. This will be a win-win situation for both the consumers as well as developers. Now-a-days the problem exists as the developers create different apps for iOS, Windows, Linux and Android to reach out all the people. It consumes their time and resources. If a VROS is not materialized then this problem will persist. A VROS will aid the developers by running their application across all the hardware devices and help users' access it at a single place.

The primary goal this paper is to outline the various efforts towards creating an operating system for VR. This will involve finding their advantages, lacking points and their usability in relation with a VROS. Our primarily goal concentrates on VROS to (Augmented Reality Operating System) as a combination that could be useful.

The research goals therefore include:

- Finding various efforts that were made to create a VROS and confirm the advantages and usability.
- Determine which of the above is most suitable to meet the needs of the users and developers.

Section II deals with related work in the field of VROS. The research work done towards creating a VROS is presented. Section III deals with the methodology to predict the advantages and challenges of previous works is determined. In Section IV the results from the study is presented. Section V details the conclusions gained from the research as well as detailing the future work that can be performed.

II. Related Work

In this Section we briefly discuss prior work towards creating an operating system for virtual world or efforts taken to create virtual worlds/environments. We also discussed the ongoing work in this field.

A. Phase 1 (before 1990s)

Virtual Reality is attributed to a few handfuls of pioneers in 1950s and 1960s. In 1962, film maker Mort Heilig created what might be the first VR system called 'Sensorama'. It had an arcade gaming style cabinet with 3D Display, a vibrating seat and a scent producer. He visualized it as 'cinema of future' but it failed to materialize.

Ivan Sutherland in 1968 demonstrated a periscope like video headset called the 'Sword of Damocles'. It was to complement what he envisioned in 1965 called 'The Ultimate Display'. This vision guided almost all the developments in the field of virtual reality.

Until the 1980s, much of the development was focussed on vehicle simulation and military training.

In 1984, a computer scientist Michael McGreevy began to experiment with virtual reality as a way to advance human-computer interactions.

B. Phase II (1990 to 2011)

In the 1990s the media latched on to the concept of virtual reality and ran with it. Edward R. LaHood in 1991 founded VREAM (virtual reality dream) which is a PC based software for authoring and viewing virtual environments. It includes in it VREAMScript, VREAM Virtual Reality Development System and VREAM Runtime System. VREAMScript is used to define the 3D environment, VREAM Virtual Reality Development System is used to build the virtual environments and VREAM Runtime System allows the end users to experience the virtual environments.

In 1997, Dr Carolina Cruz-Neira and a team of students at Iowa State University's Virtual Reality Applications Centre developed a cross platform virtual reality application development framework called 'VR Juggler'. It is open source under GNU LGPL License. [9]

In the last decade of 20th century, we witnessed the rise of World Wide Web. Since it was much more promising than the virtual reality, interest of people and media slowly got swayed away from the virtual reality. In 1995, VRML (Virtual Reality Modelling Language) was developed with aim to use in conjunction with the World Wide Web to give the users experience of virtual reality on their browsers.

Patrick says that Virtual Reality came and went in 1990s. The virtual reality was confined to industrial and research roles until 2013. In the 90s, industry gave up on VR as a workable consumer product and shifted focus on bringing to the market the World Wide Web. This was due to the fact that hardware and software of the 90s was not up to the task. He also says 'A

technological vision simply cannot be realized until its supporting technologies have passed a certain threshold.' [7]

C. Phase III (2012 to present)

In 2012, Palmer Luckey founded Oculus VR. This company builds head mounted displays and focuses on gaming community.

In 2012, Hesham Wahba started working on his project called 'Ibex'. As he described it "I created Ibex as a fun project to get a working virtual reality desktop or workspace for the Oculus Rift when it finally comes out." [10]

Since 2012, few start-ups like XViREnt and Anarchist, and open source works like OSVR (Open Source Virtual Reality for gaming) are trying to find their places in this field. OSVR tries to integrate all the different hardware and software of VR to run on a single platform. XViREnt is a type of desktop virtual reality environment and Anarchist is also a desktop VR environment with dev tools and data visualization side projects. Individuals like Aaron Angert at the University of Texas at Austin have created Virtual Reality Operating System Mockup to test its practicality. [11] [12] [13] [14]

Dekko is another in the list of operating system but it is for Augmented Reality. It overlays the 3D stuff onto the real world in real time making the surroundings of the user like a game to play with. Watch the video to know more about it. [15]

It has been also reported that Google is also working on a VR version of Android and has hired engineers for this task. [16]. It has also acquired Magic Leap which is a VR/AR start up. This company has till date best Augmented Reality experiences as shown in their videos. It has applied for 97 patents in the field of augmented reality and a view of their work shows conversion of real world environment into a mixed world by keeping digitized elements over the elements of real world.

III. METHODOLOGY

It is intended that through comparison of each of the suitable work with the researcher vision of a VROS, results will be found which indicate the work is most suited to be accepted as a VROS and if in case none seems fit then how can the pre-existing models be made suitable for a VROS. This interpretation for virtual reality operating system is enabled by certain features of the head mounted display.

A. Head Mounted Display (HMD)

A VROS of future solely depends upon the hardware available to access it. It is assumed that HMD of future will look alike the third generation of HMDs [5].

Essential Features in a HMD would be-

- The HMD will have this special ability to selectively adjust the opacity of each of its constituting particles thus resulting in a complete immersive virtual reality headset or a normal glass at the will of the user. It is not suitable to go into detail as to how will it be done but chemists are working hard to develop such systems [17].
- HMD is equipped with hand tracking, eye tracking and full body tracking cameras and sensors that provide sense of touch and other necessary sensors that make the user unable to distinguish from real reality to virtual reality.
- Virtual Environments generated are non-distinguishable from their real counterparts.
- Sound system gives the user a real sense of presence.

The design should complement the user in daily life and be such that it does not hinder his activities. The design includes the crafting material, weight and other general features.

B. Virtual Reality Operating System (VROS)

An operating system is the backbone of any computing system present in the world today. We need a platform to perform functions like hiding of hardware type from the software resulting in using any hardware-software combination. Today's operating systems automatically performs resource management, memory management, time management, task scheduling, handling input/output, handling network communication, data and user security and other innumerable features.

A VROS will be developed using the best principles of today's best operating systems and acknowledging the failures of past to create the future of the virtual reality. The features provide a common base for hardware and software to interact with each other by hiding their identities from each other, so that any hardware can interact with the user's choice of software thus increasing the compatibility. This feature is inspired by the future estimation of present scenario of VR in 2015. VR Companies like Oculus, Sony, and HTC etc. are going to launch their first products in 2016. The market will be flooded with different VR devices to choose from if this diversification continues, resulting in buying specific devices for specific purposes, which may prove to be useful in extreme cases like military training. In general, As the user of VROS do not want to spend hundreds of dollars buying different products to meet their needs and as I said learning from the experiences of today's operating systems like Microsoft Windows, Mac OS X and Linux; a need will arise one day to unify and present all the general features in one package.

All the other features of today's operating systems effectively converted and managed for three dimensional purposes. For example, Memory allocation management for three dimensional system cannot be same as two dimensional system due to the fact that in three dimensional system the OS will be managing not one or two input devices like keyboard or mouse, but multiple input devices ranging from eye trackers, finger trackers etc.

Since hardware has ability of selective opacity, operating system presenting to its user the immersive feel will have to resort to simple design when used in conjunction with the real reality such that the reality is aided and not disrupted. Hence, it should be both AR and VR Compatible. It is not modeling of 2D windows system onto the 3D, but will be a whole new UI to interact.

It is intended to discover the prominent features of each of the work done previously in an effort to create a VROS so that they can be implemented to create the VROS that matches the vision of the researcher.

TABLE I. Table of comparisons between various VR works

S. No.	Name	Purpose	Suitablity as VROS
1.	Sensorama	Cinema	No because it is big in size.
2.	Sword of Damocles	VR HMD	No because it was just a demonstration
3.	VREAM	To create and view virtual environments	Somewhat related as it can help an OS in developing its environments.
4.	VR Juggler	Application Development Framework	Somewhat yes as it is hardware independent and used to develop applications for VR systems.
5.	Ibex	VR Desktop	No because it is projection of 3D on 2D screens.
6.	OSVR	Hardware and software independent platform for gamers.	Somewhat yes. The ideas can be taken as it performs few functions of an OS but it is not an OS and focusses on gaming.
7.	XViREnt	VR MMORPG Platform	No
8.	Anarchist	VR Desktop Environment	Somewhat related.
9.	Dekko	AR OS	Somewhat related.
10.	Google VR	Not much information is available.	Not much information is available.

C. Sensorama

This machine was intended to bring changes in the cinema industry but this dream of Morton L. Heilig could not materialize because of the size vs usability of this machine. For a man to use, it needs space approximately thrice the size of a man. It had lacking visuals, but this idea of Morton L. Heilig to include in it aroma, vibrations, wind etc should be duly appreciated as this is the feature that is found in none of the devices created later.

Clearly, Sensorama is not an OS because it performs only one task of showing movies and hence cannot be extended to variety of tasks. What we can learn from this is the idea of vibrational feedback, aromas and windy feel; though we have no evidence as to how it was done at that time, also the size of the machine played a major role in imbibing in it these features.

D. Sword of Damocles

This idea of computer scientist Ivan Sutherland was motivated by his vision 'The Ultimate Display'. The headset looked like Fig 3.

It was a model only and was not functional. It was for display purposes only and intended to show his idea of how VR Headset should like in future which is true as seen in Oculus VR today.

E. VREAM

It is an authoring and viewing tool which includes in it a scripting language, development system and a runtime system. It is used to create virtual environments in three dimensions and also for experiencing the same. It does not hardware and software compatibility and cannot be put in category of an operating system; but it creates an operating environment and ways to experience it. But it is limited by what is created for the user to see and experience.

F. VR Juggler

It is an application development framework. It is used to develop applications for VR Systems which are independent to run on hardware devices. It is like Android Development Tool but without an Android OS.

Hence even it does not compare with the idea of VROS, but this definitely can aid in application development and hence in the production of a VROS. His research of different virtual development environments has aided this term paper a lot. He saved our time by his valuable research in helping us to zero upon VR Juggler as one of the best tool present today to aid us in achieving our goals. [18]

G. Others

Ibex, Dekko, OSVR, Google and other works done after 2012. The works done after 2012 are more centred towards gaming. Ibex is the only one, but it is also a virtual reality desktop that is, 3D Virtual World on 2D Systems and does not serve the need. [10] OSVR, XViREnt etc. are all focusing towards different genres of gaming. [11] [13] Dekko shows potential through its video documentary, but except that not much is available to know about it. [19]

It is reported too that Google is working towards creating Android in VR and has hired tens of engineers for it too. [16] Magic Leap is the closest competition for VROS because of its ability to modify as per its environment.

IV. RESULTS

This Section describes the results in detail. The results are obtained through the observations made by the experimentation. Since the beginning of virtual reality in 1950s, no effort has been made towards development of fully immersive virtual reality operating system. But efforts have been made to create virtual environments and virtual objects and methods to run and experience those predefined virtual environments.

The developments done before 2012 were more inclined towards industrial and military applications and the developments done after 2012 are more focused on gaming industry. The Head Mounted Displays are advancing day by day due to its potential in general consumer market and the advancement in hardware technology.

VR Juggler can help in development of applications for VR system since it is OS independent and hence in development of virtual reality operating system too. [18] [9]

A working OS for Augmented Reality has already been made and deployed. It is in its initial stages and work is being done on it to further improve it. The name is Dekko. [15]

A combination of AR and VR is unbeatable in all the aspects and hence an AR/VR OS has lot more potential than VROS alone, but the technology has yet to be evolved to reach out to AR, so focusing on VROS only is the best decision.

V. CONCLUSIONS AND FUTURE WORK

Our paper has presented the idea of Virtual Reality Operating System. The work done towards creating a VROS and its features are described in detail and the results are then put forward.

The primary goal of this research project was to present the idea of a Virtual Reality Operating System for use by general public for their daily computing requirements just like we use Linux, Windows and Mac on mobiles and laptops these days. To accomplish this primary goal, several secondary goals were set. The first of these goals was to analyze what all efforts have been made towards creating one. The second secondary goal was to develop an understanding of each of the work done and determine their advantages and short-comings and then determine which one of those was most suited to the goal of the project.

In Section two the author presented several topics of discussion which were felt to have a bearing on the project. Works that have been done in order to hook up virtual reality and those related with an operating system for this were studied specifically with an emphasis on their most important characteristics.

Section three described the author's vision of a Virtual Reality Operating System and hardware (HMD) required for that. Different previous works were compared against the vision to see how they fit themselves against the vision laid or can be made to fit the vision. Each of those was compared in detail and their advantages or short-comings were given. Available opportunities were identified to make the best use of works done in materializing the OS in vision and conclusion was given against each if it fits or can be made to fit.

Section four described the results of the findings. A number of conclusions have been made. It is found that VROS has a lot of scope in near future and work on it will be accelerated as soon as stable HMDs and tracking technologies capture the market. The combination of AR/VR OS is unbeatable and is what author looks at in future. This work needs many great sets of skills and deep understanding of the field of Computer Science and funds to commercialize it. Power lies with big players like Google, Microsoft, Facebook and Apple etc. in creating a VROS because they have the funds as well as team of great people. The first one to launch will dominate the market for early years until a re-definition is brought up. This analysis is also complemented by Patrick Arnesen in his work [7]. It is felt that an OS for virtual reality will bring with it a huge shift in user interface we have today, and it will be more natural and intuitive. This will give rise to UI/UX industry too. This VROS will enable path for development for whole lot of useful applications. By making use of the current advanced technology of communication, these applications might benefit the mankind to a great extent, like online doctor consultation, construction design, travel and tourism, social media etc.

But, the idea of VROS is limited by the fact that present day graphics processing capabilities are not affordable for all the people as for example, the minimum hardware requirements to run these VR devices like Oculus need a very high end system. Also the computing capabilities need to be faster with a decrease in the size of the chips. The head mounted displays of today generation have just audio and visual technology. The hand tracking or gesture movement technology and eye tracking technology are still in their infancy stage and need time to develop to the fullest. A combination of all above is certainly bound to bring positive drastic changes to this industry.

In future it can be applicable to medical industry where VROS or the Virtual Reality can be implemented in computing. This improves the Virtual Reality industry by providing insights to medical practitioners as to how the brain works. [20][21][22] Similarly the space and deep ocean missions will try to utilize the power of VR to improve upon their findings and accelerate their work. [23]

Also, interaction in social media is definitely going to be changed. It has a great potential to employ the power of VR to bring the people closer [24]. Similarly in corporate

environments, collaboration among team mates will immensely help the industries in increasing their productivity. Also the entertainment industry is first to witness VR, so 3D Immersive movies which is a concept in its infancy today, is also one of the possibilities of VROS technology.

Scientific and Business data and their visualization will be lot more natural to comprehend and analyze. UI/UX industry will have a great opportunity to implement its skills in the VR systems since possibilities are going to be endless and the imagination will be the limit. Hence, User testing industry that collects the experiences of users for a certain product and then interprets these results to the creators of the software will bloom for the first few years after the launch of VROS; as soon as development of its applications starts.

Surround-screen projection based virtual reality (CAVE Automatic Virtual Environment) can be used to demonstrate VR Experiences of one person to many people at the same time.

The applications like VR Surgical Simulations can be developed for VROS to improve Operating Room performance of doctors. It will help reduce the errors and speed up the operations.

System for implementing multiple simultaneous meetings in a virtual reality mixed media meeting room. US Patent US 09/115,819 can be used to provide online classes in VR, removing stage fear and doing conferences. It has application in VROS.

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