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Implementing a Virtual Reality Environment on Android Smartphones

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ABSTRACT: Virtual Reality (VR) aims to provide immersive visual experiences of real-world scenarios on head-mounted displays. One aspect of VR devices involves the use of innovative interfaces, and the development of new virtual reality applications. Unfortunately, this is one of the most inaccessible technologies for all but the best-funded educational programs in the world, almost exclusively limited to the developed world. The reason for this lies in the expense of what is largely prototype display hardware, and the accompanying application development and experimentation tools. We made use of a low-cost open source platform that is Android, thus requiring the most minimal of hardware and computing infrastructure. We demonstrate how functionality that is typically limited to devices costing thousands of dollars, can be provided to students and educators with access to just a Mobile System such as Android. Android being a convenient hardware platform is a boon for developers allowing them to spend less effort and time to realize their ideas. We managed to design our own custom HMD that can encase almost any android phone and is easily accessible.

KEYWORDS: Head Mounted Display, Interfaces, Haptic, Auditory, Simulation, Gyroscope, Accelerometer, Magnetometer, Compass, Virtual Reality Environment, Stereography, Reality Engines, 3D Modeling, Position Tracking, Graphics Processing, Logic Processing, Virtual Reality GUI, Real Time VR View.

I. INTRODUCTION

Virtual Reality refers to a high-end user interface that involves real-time simulation and interactions through multiple sensorial channels. Virtual reality appears to offer educational potentials in the following areas: data gathering and visualization, project planning and design, the design of interactive training systems, virtual field trips, and the design of experiential learning environments.

However, virtual reality is still a developing field with constant advances being made. These advances need to be tested to determine how accurately a system is modeled with this new set of tools. The devices that exist in the current market are extremely expensive and price around \$700 USD (48000 INR) and are available only in developed countries. Countries such as India have barely had a glimpse of VR and its true capabilities.

We have designed a VR HMD that makes use of an android smartphone as a platform for our VR application. This device costs under \$5 USD (350 INR) and is capable of working on any android device that meets our specifications.

Our designed application "VR-NEXUS" acts as a platform for an immersive VR experience. It includes features such as the ability to view all kinds of 3D/360 media. There is also the functionality to browse the internet in VR which has never been done before. YouTube and YouTube 360 are also supported as they are the most accessible form of free VR media.

II. RELATED WORK

- Paper: Affordable Altered Perspectives - Making Augmented and Virtual Reality Technology Accessible.
Author: Phillip Peralez Santa, Clara University
This paper describes how a simple low cost VR kit can be built using an android smartphone and used to provide a VR experience similar to expensive HMD devices.
- Paper: Depth Augmented Stereo Panorama for Cinematic Virtual Reality With Focus Cues
Author: Jayant Thatte, Jean-Baptiste Boin, Haricharan Lakshman, Gordon Wetzstein, Bernd Girod, Stanford University



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This paper describes the depth augmentation system that is required in a HMD to provide immersion to the user and explains its working in detail.

- Paper: Geometric Considerations for Stereoscopic Virtual Environments. Presence,
Author: L. Hodges, E. Davis
This paper describes in detail the process of rendering a 3D world in a virtual environment via stereoscopic devices.
- Paper: Android Operating Systems.
Author: Saurabh Bhardwaj, PriyankaChouhan, Richa Sharma
This paper mentions software design platform on Linux Kernel for mobile devices.
- Paper: Development of mobile Application for Android Platform.
Author: Li Ma, Lei Gu, Jin Wang.
The paper describes about basic tools such SDK, Java required for Android Platform to run Applications on android phones

III. COMPONENTS OF VR-NEXUS

- **DISPLAY:** The display is the device that sends the photons to the retina. In VR headsets the displays are preferred to be a high-resolution LED screens similar to those found in the current-generation mobile handsets.
- **POSITIONAL TRACKING:** VR headsets must quickly and accurately sync the imagery rendered to the headset display to the orientation of the user's head. The speed and accuracy of this correspondence is the primary factor in preventing motion-sickness for the user, and therefore requires a method of tracking the orientation of the headset. Entry-level VR headsets provide *three degree-of-freedom (3DoF)* rotational information using on-board gyroscopes, while high-end systems such as Oculus Rift and HTC Vive use stationary external hardware to track or provide reference for all *six degrees-of-freedom (6DoF)*.
- **GRAPHICS PROCESSING:** Processing data into a matrix of pixels that can be sent to the VR headset for display to the user is handled by the *Graphics Processing Unit (GPU)*. For PC-based VR (Oculus Rift, HTC Vive) these GPUs are generally stand-alone PCIe cards that are snapped into the PC's motherboard, while for mobile handset VR GPUs are generally single chips that are permanently installed in the handset.
- **LOGIC PROCESSING:** Beyond graphics rendering, VR experiences will require additional logic processing such as physics simulation, GUI, and system interface functions that are handled by a Central Processing Unit (CPU).
- **INPUT DEVICES:** While VR can be experienced passively, with no real interactivity beyond controlling one's angle of view, most VR experiences require some form of user input. This can be as simple as single-tap interfaces like that of a VR HMD or more complex position-tracked controllers like those of the HTC Vive.

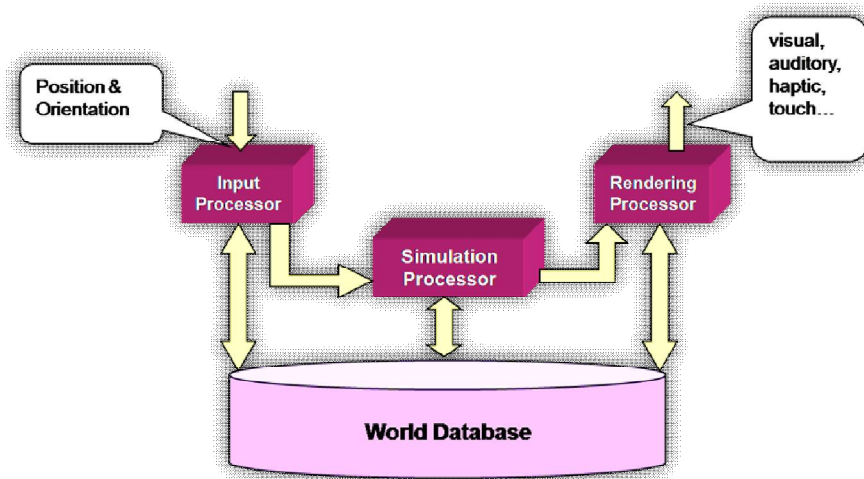
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IV. ARCHITECTURAL DESIGN



VR-Nexus Architecture

- Input:**
 The input to the system is given by the gyroscope in terms of X, Y, Z axes (yaw, pitch and roll) which is used for head tracking, while the magnetometer detects a fluctuation in the magnetic field generated by the magnetic switch on the HMD, this acts as a click for the cursor on the VR interface.
- Input, Simulation & Rendering Processor:**
 The job of the Input Processor is to transmit input data to entire system with minimal lag. The Simulation Processor takes input from user to determine the actions taken in the virtual world. The Rendering Processor creates the sensations that act as output to the user wearing the device. All this processing is handled by the Smartphone itself without having to rely on external processing power.
- Output:**
 The output is given to the user via the display of the smartphone using stereo vision. The screen is divided into 2 parts, one for each eye respectively. This creates the illusion of reality and provides an immersive interaction with VR-Nexus.

V. SYSTEM REQUIREMENTS:

Software Parameter	Software Requirement	Hardware Parameter	Hardware Requirements
OS	Android 4.1+	Processor	1.2 GHz
SDK	19	RAM	1 GB
Kernel	3.10.28-g9ed69b8	Screen Size	4"
Display Resolution	720p	Storage	512MB
Display Frequency	60Hz	Additional H/W	Gyroscope, Magnetometer


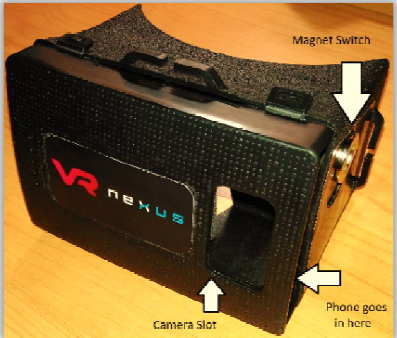
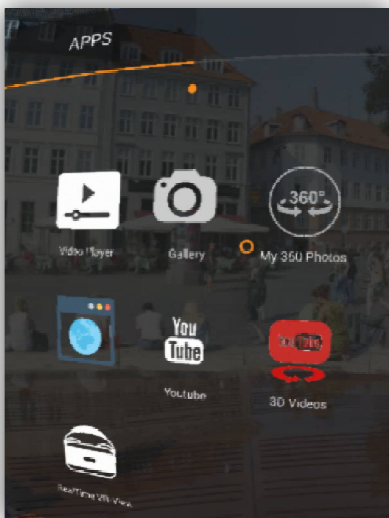
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VI. RESULTS

<p>VR-NEXUS:</p> <p>VR Nexus is a platform for interaction between the user and our HMD. It supports all android phones upwards of KitKat 4.1 OS. At its core VR Nexus is an android application but allows you to access a variety of VR functionalities that have not been available before in the market. It a new way of interfacing and experiencing Virtual Reality at very minor expense.</p>	
<p>HMD:</p> <p>A Head Mounted Display is a encasing for your phone and also houses the lenses that are used to view the display.</p> <p>We designed and 3D printed our own customized HMD. This HMD contains a small magnet switch that acts as input to the VR Nexus application.</p> <p>For the magnet to function it is necessary that the phone has a built in magnetometer. This combined with the gyroscope provides all the input to the system.</p>	
<p>GUI:</p> <p>The GUI for our app is made up of 3 UI frames each which give important to the user and allow for an immersive experience when using our HMD</p> <p>The 1st frame provides a live RSS channel of the user's choice. The 2nd Frame allows the user to "Quick Search" any YouTube video or a 360 YouTube video almost instantly. The Application Frame is a window to access all of our custom build applications for the VR Nexus. We have designed it such that multiple applications can be added to this system later on.</p> <p>There a quite a few customization features available in VR Nexus. The Autoclick allows for timed clicking without the use of magnetometer. A zoom feature allows users to increase the size of the entire UI. A wallpaper of the user's choice can also be chosen for the system here.</p>	

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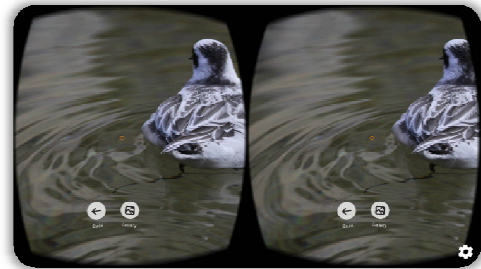
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VR Image Viewer:

There are 2 applications based on the VR image viewer, namely the *Gallery* & the *360 Photo Viewer*. One method for generation of images in virtual reality is the use of stereo vision. This is accomplished by creating two different images of the world one for each eye. This app allows us to view VR images. Tilting your head allows you to scroll through the images and head movement is used to view a 360 image.



VR Video Player:

3 applications are based on the VR video player, namely the *Video Player*, *YouTube* & *360 YouTube*. Each of these applications offers the basic functionalities of a video player such as seeking, volume control, skipping, etc.

360-degree videos, also known as immersive videos or spherical videos, are video recordings where a view in every direction is recorded at the same time, shot using an omnidirectional camera, YouTube consists of a vast library of such videos. During playback the viewer has control of the viewing direction like a panorama. This app is capable of viewing such videos and provide an immersive experience in doing so.



VR Browser:

The VR Web Browser is a basically a virtual browser that supports nearly any web content, including Adobe Flash.

This app uses a VR keyboard that is designed to work with the HMD. A single cursor is used to input the words for searching or other purposes.

The browsing experience on the VR browser is rich and comprehensive.

VR provides for seamless transitions between browsing and media without having to jump from application to application.



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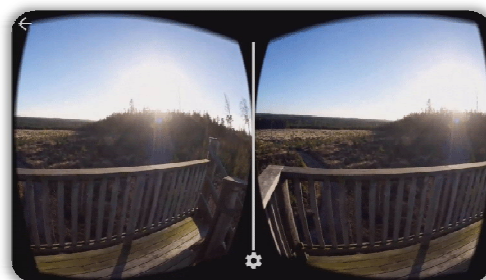
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Real Time VR View:

This application makes use of the phones camera to give the user a real time image of his/her surroundings in VR View. The original image that is captured by the phones camera is altered to generate 2 slightly distorted images to make the VR View possible.

This application was designed with convenience in mind. It allows the user to interact with the real world without having to remove the headset.



VII. CONCLUSION AND FUTURE WORK:

We successfully designed a VR Headset that is compact and light. VR-NEXUS is a collection of applications and a platform that allows interaction between the User and the HMD. Since the VR HMD uses already available hardware from the Smart phone itself there is no need to purchase any additional equipment such as a Graphic Card or Motion Controllers that are needed for both the OCULUS RIFT and the HTC VIVE.

Providing an Immersive VR experience on a custom HMD of the user's choice. VR devices cost up to 700\$ (48000₹), however our VR device is a low-cost alternative priced at 5\$ (350₹). It uses already available hardware from your mobile phones making it far more available to developing countries. The open source nature of our project makes VR more accessible and opens up development to a much broader world. The applications we develop act as a base to the VR system which can be improved with further iterations.

The ability to explore the design of a VR product with minimal expense and to verify its functionality using a prototype rather than building a physical HMD from start gives the VR-NEXUS a considerable advantage over other systems like the OCULUS and HTC VIVE.

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