Grenze International Journal of Engineering and Technology, January Issue

A Novel Survey on Vive Pro 2

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***Abstract*—This paper presents a comprehensive review of the HTC Vive Pro 2, a premium virtual reality (VR) headset developed by HTC, by synthesizing recent research and industry trends. Motivated by the rapidly evolving landscape of VR technology, the research aims to evaluate the performance and features of the Vive Pro 2 in comparison with other VR headsets. The methodology involved a meticulous examination of various aspects of the Vive Pro 2, encompassing its display, optics, tracking, audio, and comfort. Performance metrics such as visual quality, field of view, refresh rate, tracking accuracy, and latency were rigorously assessed to provide a detailed understanding of the headset's capabilities. Additionally, technical specifications, compatibility with VR platforms, pricing, and marketing strategies were analyzed to gauge its market positioning. Key findings underscore the Vive Pro 2's superiority in resolution, field of view, and overall user experience over other VR headsets. The ergonomic design and immersive audio features further enhance its appeal to VR enthusiasts and professionals. Insights gleaned from the literature survey unveil the broad applications of VR technology across domains such as education, real estate, tourism, and healthcare. Practical implications of the study include aiding consumers and professionals in making informed decisions regarding VR headset selection, especially for applications necessitating high visual fidelity and immersive experiences. The Vive Pro 2 emerges as a top choice for individuals seeking premium VR experiences, with potential applications spanning gaming, education, training, therapy, and beyond. This research illuminates the transformative potential of VR technology and underscores the importance of continuous innovation in enhancing user experience. The findings pave the way for future advancements in VR hardware and software, propelling progress toward more immersive and engaging virtual environments.**

***Index Terms*—Virtual, Reality, Vive Pro, Smartphones, Education, VR.**

I. INTRODUCTION

Virtual reality (VR) technology has revolutionized the way we perceive and interact with computer-generated environments. By simulating three-dimensional activities in real-time, VR engages users through various sensory channels, providing an immersive experience like never before. Traditionally, VR environments leverage head-mounted displays (HMDs) or Cave automatic virtual environments, offering users a seamless transition into virtual worlds. These advancements come with improved features such as higher resolution screens, increased refresh rates, and wider fields of view, all at more affordable costs compared to earlier systems.The emergence of VR technology has spurred innovation from major corporations like HTC, Valve, Samsung, and Sony, leading to the development of cutting-edge VR devices such as the HTC Vive, Samsung Gear VR, and Sony's Morpheus VR head-mounted display. These devices offer users an array of features including high frame rates, wireless controllers, and gesture-tracking functionality, enhancing the overall immersive experience.

Grenze ID: 01.GIJET.11.1.549

VR controllers, in particular, have become indispensable tools, enabling users to interact with virtual environments in a lifelike manner. Technologies like the 'Lighthouse' laser locating system adopted by HTC Vive further improve tracking accuracy and reduce latency, enhancing user engagement and satisfaction. In this paper, a thorough examination of the HTC Vive Pro 2 is conducted, a premium VR headset developed by HTC, to evaluate its performance and features in comparison to other VR headsets. Through a comprehensive literature survey, system architecture analysis, and outcome discussions, aim is to provide valuable insights into the transformative potential of VR technology and its implications for various industries.

II. LITERATURE SURVEY

Moses Okechukwu and Felista Udoka Exe summarized and categorized Virtual Reality, Its Types, Its Systems, and the advances that VR has made in such a way that it's easy to understand using numerical order titles and subtitles. They explained how we can live in our dreams through Virtual Reality and provided the conclusion that a lot of advancements have been made using VR and VR technology, enabling to do everything without even moving from our place [1]. VR has impacted all facets of human endeavors, such as manufacturing/business, leisure activities, exploration, defense, and medicine among others. The exciting field of VR has the potential to change our lives in many ways, cutting across all areas. Presently, there are many applications of VR, and there will be many more in the future. Manufacturing, education, simulation, ergonomic studies, simulation of assembly sequences and maintenance tasks, assistance for the handicapped, design evaluation, architectural walk-through, study and treatment of phobias, entertainment, rapid prototyping, and much more have seen the development of numerous VR applications. The limitation of the study is [2].The new or future technologies are not covered. The focus is mainly on the technological part of Virtual reality. Xiao You (2011), in his research paper entitled "Research and Practice on Application of Virtual Reality Technology in Virtual Estate Exhibition," explained that virtual reality technology has been widely used in various fields due to its rapid growth. The technical solution and methods of virtual reality technology in the virtual estate are explored in this paper [3]. However, there are still many theoretical problems and technical barriers that remain unresolved. Constant efforts, close attention, and bold exploration are necessary. The research provides a comprehensive explanation of the usage of virtual reality at the Real Estate Exhibition [4].
The limitation of the study is as follows-
This study does not cover the broad concept of VR, such as types and systems. This study is confined to the usage of VR in real estate exhibitions. According to their paper titled "Virtual Reality as an Education Tool for Learning in the Experience Age," Hu-Au and Lee explain the use of VR for education and the impact of technology on the education sector, highlighting the shift from the information age to the Experience age. This shift is attributed to the widespread online presence, where 91% of teenagers are observed to be online daily, engaging in activities such as gaming, live-streaming memorable experiences, sharing moments on Snapchat, or posting pictures on Instagram [5].
Various types of virtual reality enhance the experiential aspect of the learning process, including interactive learning environments, visual learning, learning by doing, Head Mounted Display (HMD) devices, and the user-friendly and flexible nature of VR. These features contribute to making learning memorable. Additionally, courses with VR applications provide students with diverse learning activities, which directly impact their performance in the learning environment [6].
Furthermore, VR functions have significantly benefited individuals with disabilities who may lack the linguistic or physical ability to experience real-world events. VR applications become essential in bridging this gap and ensuring a safe learning environment that mitigates the risks of unintended financial losses resulting from errors in the existing system. Consequently, the mandatory implementation of VR applications in teaching and training introduces a real-world system [7].
Since (2004) and Gutierrez et al. (2008) specifically emphasize interactivity as a crucial component of VR. This flexible definition allows for a discussion of a wider range of technologies relevant to tourism while maintaining a close relationship with VR [8]. The author discusses the transition from present VR technology to future VR technology, with a main focus on planning and management, exploring how virtual reality can be utilized as a substitute for tourism [9].The limitations of the study are as follows:
The research was conducted in 2008.The author's primary focus was on the VR. Gilson Giraldi, Rodrigo Silva, and Govan C. De Oliveira describe virtual reality, particularly when utilizing stereoscopic projections. The paper explains the impact effects of the projection model and gives a brief description of VR equipment and its types. In their introduction to the CAV, they also present a virtual room where multiple individuals can experience the same perception of reality simultaneously.

They highlight the various applications of VR in fields such as medical, military training, personnel training, education, entertainment, travel, and more. This field is known as virtual reality science [10]. The importance of virtual reality (VR) is emphasized in this paper, specifically focusing on VR science visualization in medicine and engineering. The fundamentals of VR devices and applications are explained, emphasizing the interaction with the computer-generated world in three dimensions [11].

This study has two limitations:

No survey was conducted during the work. The main focus was on implementing VR projects at LNCC, aiming to achieve the best outcomes. In this comparison of the HTC Vive Pro 2 and Valve Index VR headsets, Sebastian highlights the Vive Pro 2 as potentially the top VR headset of 2021. With a resolution of 2448 x 2448 pixels per eye, it surpasses the Valve Index's 1440 x 1600 pixels per eye, resulting in sharper images, especially noticeable in detailed applications. Moreover, the Vive Pro 2 boasts a wider field of view (120 degrees horizontally and 110 degrees vertically), enhancing immersion by allowing users to see more of their virtual environment.

It's also a great choice for professionals working in VR, as the high resolution and wide field of view are great for many tasks. [12].

III. SYSTEM ARCHITECTURE

The requirement of Vive Pro 2 are as follows:

HTC Vive headset has 2 OLED display panels in a resolution of 1080×1200 per eye, with a rate of 90 Hz. The view of the field is 110 degrees. It also has a proximity sensor, accelerometer, and gyroscope. In addition to the front-facing camera. Controllers and headsets use the positional tracking system. Below are the different types of Hardware component which includes Vive Pro 2-

- Computer workstation, Sensory display Head daub, BOOM (Binocular Omnidirectional Monitor), VDU (visual display unit)

Software components required for Vive Pro 2 are-

- Similar Software, 3D Modeling, 2D Graphics, Digital Audio Editing, Software Simulation

Below the given Table I contains a specification of system requirements:

TABLE I: SYSTEM REQUIREMENTS

Component	Recommended system requirements	Minimum system requirements
Processor	Intel Core i5-4590 / AMD Ryzen 1500 equivalent or better	Intel Core i5-4590 / AMD Ryzen 1500 equivalent or better
GPU	NVIDIA GeForce RTX 2060 / AMD Radeon RX 5700 equivalent or better	NVIDIA GeForce GTX 1060 / AMD Radeon RX 480 equivalent or better
Memory	8 GB RAM or more	8 GB RAM or more
Video output	DisplayPort 1.4 or newer required to use headset's full resolution	DisplayPort 1.2 or newer
USB port	1x USB 3.0 or newer	1x USB 3.0 or newer
Operating system	Windows 10, Windows 11	Windows 10

Details of front and side is as follows

Headset Strap

To attach the strap to your Vive Pro 2 headset:

Hold the headset with the front facing away from you. Position the strap so that the side with the adjustment dial is on the back of your head. Place the headset over your head, with the display facing toward your eyes.

Tracking sensors

The Vive Pro 2 typically uses SteamVR Tracking 2.0 base stations, which offer improved tracking accuracy and support for larger play areas compared to earlier versions.

Camera Lens

The HTC Vive Pro 2, like many virtual reality headsets, is equipped with built-in cameras to provide additional functionality beyond basic VR experiences. These cameras serve several purposes:

- Passthrough Mode, Room-Scale Tracking, Potential for Augmented Reality

Earphone
The HTC Vive Pro 2, like its predecessor models, does not come with built-in earphones. Instead, it features integrated audio functionality in the form of built-in speakers.
The integrated speakers are positioned near the user's ears within the headset itself, providing an immersive audio experience during VR gameplay or other virtual experiences.

Headset Button
The HTC Vive Pro 2, like many virtual reality headsets, features buttons and controls that allow users to interact with the virtual environment and navigate menus without needing to remove the headset. These buttons typically include:

- Power Button, Menu Button, Trackpad/Joystick, Grip Buttons, Trigger Buttons

These are some of the common buttons and controls found on virtual reality headsets like the HTC Vive Pro

Status Light
The status light on the HTC Vive Pro 2 is a small indicator light located on the front of the headset. This light serves several purposes to provide users with information about the status of the headset:

- Power Status, Connection Status, System Status

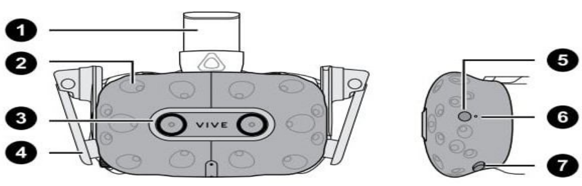
Understanding the status light can help users diagnose problems, ensure proper functionality, and troubleshoot issues with their HTC Vive Pro 2 headset.

Lens Distance Button
The "lens distance button" you mentioned typically refers to a feature found on virtual reality headsets like the HTC Vive Pro 2, known as the IPD (interpupillary distance) adjustment button or dial.
Here's how the IPD adjustment usually works on VR headsets:

- Manual Dial or Button, Software Adjustment

The Vive Pro 2 Headset's front view is shown in Figure 1.
The front view contains a headset strap, tracking sensors, camera lens, earphone, headset button, status light, and lens distance button. Details of the backside view is as follows:

Front and side



1	Headset strap
2	Tracking sensor
3	Camera lens
4	Earphone
5	Headset button
6	Status light
7	Lens distance button

Figure 1: Vive Pro 2 Headset Front View

Headset Cable Clip
A headset cable clip is a small accessory designed to help organize and manage the cables of a headset or earphone. It is typically a clip or clamp that attaches to the cable of the headset, allowing you to secure it to your clothing or other surfaces to prevent tangling and keep the cable in place.

Headset Cable
A headset cable refers to the cord or cable that connects a headset or pair of headphones to a device such as a computer, smartphone, gaming console, or audio player.
Headset cables come in different lengths, materials, and connector types.
Common connector types include 3.5mm audio jacks, USB, USB-C, and proprietary connectors depending on the device and headset model.

Volume Button
A volume button, often found on electronic devices such as smartphones, tablets, audio players, and some headsets, is a physical button or control that allows users to adjust the volume level of the device's audio output. Volume buttons are a fundamental feature that enhances the user experience by providing a quick and tactile way to control audio levels. They are commonly used in conjunction with audio output devices like speakers, headphones, and earphones, allowing users to customize the sound to their preferences.

Adjustment Dial
An adjustment dial is a physical control typically found on various devices and equipment to allow users to make precise adjustments or changes to specific settings. Here are a few examples:
Volume Adjustment Dial, Brightness or Contrast Dial, Temperature Control Dial, Focus Adjustment Dial, Time or Date Adjustment Dial, Power/Resistance Adjustment Dial.
The adjustment dial simplifies the process of changing settings compared to navigating through digital menus or using multiple buttons.

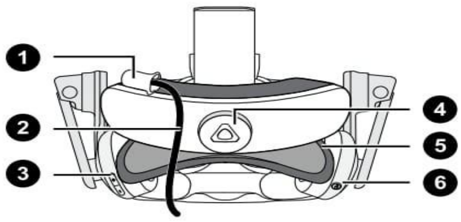
Headpad
The term "head pad" doesn't refer to a widely recognized or standard item. However, it's possible that it could be a term used in a specific context or industry.

Mic Mute Button
A mic mute button is a feature commonly found on microphones, headsets, or other audio devices with an integrated microphone.
The description of the headset button and inner side view is as follows-

Nose rest
A "nose rest" could refer to different things depending on the context. Here are a few possibilities: Eyeglass Nose Rests, CPAP Mask Nose Rest, Virtual Reality (VR) Headset Nose Rest.

Lens Distance Button
As of my last knowledge update in January 2022, there isn't a widely recognized term or concept referred to specifically as a "lens distance button."

Back



1	Headset cable clip
2	Headset cable
3	Volume button
4	Adjustment dial
5	Head pad
6	Mic mute button

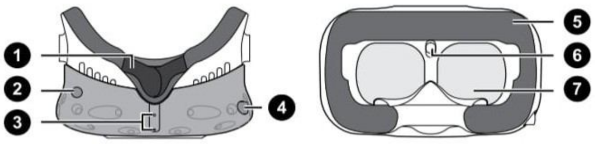
Figure 2: Vive Pro 2 Headset Bottom and Inner Side View

MIC
The term "mic" is a commonly used abbreviation for "microphone." A microphone is a transducer that converts sound into an electrical signal.

Interpupillary Distance Knob
The term "Inter-pupillary Distance (IPD) knob" refers to a feature commonly found on binoculars, microscopes, and virtual reality (VR) headsets.
Here are the contexts where you might encounter an IPD knob: Binoculars: Binoculars often have an IPD adjustment knob to accommodate the variations in the distance between individuals' eyes.

Face Cushion
VR Headsets: Face cushions are soft, padded components that come into contact with the user's face when wearing a VR headset.

Bottom and inner



1	Nose rest
2	Lens distance button
3	Mic
4	Interpupillary distance (IPD) knob
5	Face cushion
6	Proximity sensor
7	Lenses

Figure 2 Headset backside view

IV. Outcome Discussion

The evolution of virtual reality (VR) technology, driven by advancements in computer hardware, software, and virtual world integration, continuously blurs the lines between the real and virtual worlds. VR headsets, such as the HTC Vive Pro 2, aim to enhance user immersion across various applications, including gaming, medical simulations, and educational experiences. With its dual LCD screens boasting a resolution of 2448 × 2448 pixels and a 120Hz refresh rate, along with a wide 120-degree field of view, the Vive Pro 2 offers a premium VR experience. Additionally, its Hi-Res Audio Certification and integrated 3D spatial audio further contribute to its immersive capabilities. Compared to its predecessors and competitors, the Vive Pro 2 stands out with its larger workspace, providing users with twice the area compared to the Oculus Rift. Despite being slightly less accurate at heights, the Vive Pro 2 still offers commendable accuracy and minimal vibration, ensuring a smooth VR experience. Furthermore, the Vive Pro 2 boasts an impressive operating range of 7 meters, surpassing that of the Oculus Rift (4.25 meters). This expanded range enables users to move freely within their virtual environments, enhancing their overall immersion and freedom of movement.
In summary, the Vive Pro 2 emerges as a high-end VR headset tailored for gamers and VR enthusiasts seeking a premium and immersive experience. With its cutting-edge features and superior performance metrics, it sets a new standard for immersive virtual reality experiences.

V. Conclusion

In conclusion, our study sheds light on the privacy risks inherent in the Metaverse, demonstrating the impact VR can have on its users. Through an experiment involving 30 participants and VR-grade equipment, it effectively showcases the potential for privacy breaches within immersive virtual environments. The diverse range of VR applications and the simplicity of our demonstration underscore the multifaceted challenges posed by privacy concerns in VR.Moving forward, fellow privacy practitioners are encouraged to delve deeper into the intersection of privacy and VR, particularly in addressing emerging threats within the Metaverse. The findings serve as valuable discussion points for future VR headset development, emphasizing the importance of integrating robust privacy features, such as eye correction, into testing environments.Furthermore, as VR technology continues to evolve alongside mobile users, it anticipate further advancements in controller design. This evolution towards smaller, more aesthetically pleasing, and powerful controllers holds promise for enhancing user experience and accessibility. With ongoing technological development, the future of virtual reality appears increasingly bright, offering potential therapeutic applications in areas such as sports and sports medicine. Ultimately, our study highlights the potential for navigating and researching real-world scenarios on a scale previously unattainable, opening new avenues for exploration without inherent drawbacks.

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