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A Survey on CAVE Technology and its Applications

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ABSTRACT

Virtual Reality is the creation of a computer generated environment which can be used for immersive study of any given concept. Using VR any type of fictional or non-fictional environment can be generated and experienced using a Head Mounted Device (HMD) and an optional controller for interacting with the environment. CAVE technology enables user to experience VR in a room scaled environment which uses projectors or LCD screens to display the computer generated scenario. This paper studies the CAVE technology along with its working and various applications which use the same.

Keywords : Virtual Reality, CAVE, Sustainable Development, Projection Paradigms, Mobile Technology

I. INTRODUCTION

Virtual Reality(VR) is a technique for simulation of real or virtual world by applying the theory of immersion into a virtual 3-D space in which stereoscopic vision, sense of hear, sense of touch & sense of smell are very similar to that of real world within a certain area. A definition of VR can be given as: "Virtual Reality is a scientific technology of human-machine interaction for understanding and simulating the real or virtual environment into a 3-D space much similar to that of real environment & experiencing the nature in a certain range by emerging & showing physical presence into that environment using high performance computers along with sensory equipment like gloves, headsets etc." VR changes the way we experience a lot of things- games, websites, movies, specialized learning & training etc. VR has been around for the last three decades, but it is displayed either on a computer monitor, a projector screen, or with a virtual reality headset called head-mounted display. By putting the headset & going nowhere, one can get transported to anywhere. VR also refers to remote communication environments which provide a virtual presence of users with through telepresence and tele-existence or the use of a virtual artifact (VA), either using standard input devices such as a keyboard and mouse, or through multimodal devices such as a wired glove or omni directional treadmills. This advancement of technology which is bringing the media closer to the real life has put its footprints in mostly all the real-world applications. Facebook's acquisition of oculus & valve's collaboration with HTC has served to bring VR into mainstream & Google cardboard initiative has brought it to the masses. Today, the various applications of VR are in the field of gaming, entertainment, medical, training & education, social networking, business, marketing etc.[5]

CAVE is an acronym of cave automatic virtual reality (VR). It is an immersive technology that uses a number of pointing projectors or flat displays positioned between three to six cubical room-sized

space. The CAVE was invented by Cruz-Neira et al. in 1992. The wall graphical presentation must be with high-resolution due to the close viewing range which needs small pixels to possess the imagination of reality. Diverse technologies have been proposed to promote CAVE. However, some popular limitations in existing CAVE systems have not been addressed yet: Space Allocation: CAVE requires adequate space for its materials. The space allocation of CAVE varies according to its model. Allocated space might be permanent.

Mobility: The setup of the CAVE in particular space is considered nearly constant. It is not easy to move the CAVE setup to another area.

Power Consumption: In order to operate the CAVE, required devices and computers with associated projectors must be switched on. However, the environmental and power consumption metrics are not considered.

Cost: The cost of the CAVE is high, including high-enddevices, projectors, walls-sized displays, and the cubical metal room.

II. RELATED WORK

The CAVE was invented by a team of researchers at Electronic Visualization Lab at University of Illinois'. It was created for a challenge of making one-to-many visualization instrument that uses large projection screens. The CAVE is generally 10 x 10 x 10 inches cubical room placed in darkened room. Modern CAVE systems can project walls using reflected mirrors placed and adjusted between high-resolution projectors. The projection requires specific setup to ensure more immersive environment to avoid edges between walls[1].

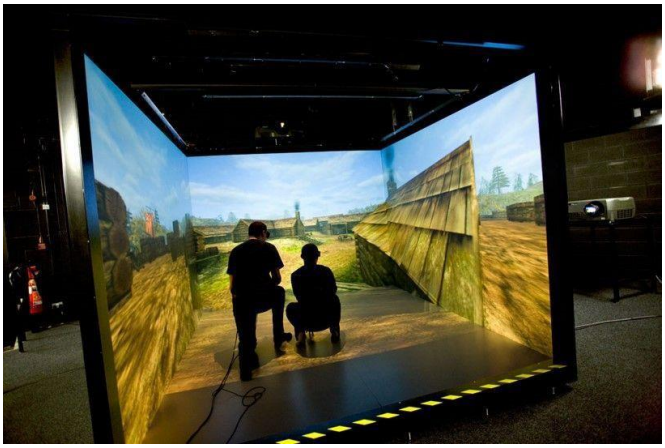


Fig. 1 : Mobile-CAVE architectural model [1]

The CAVE 2, built in 2012 succedded the original CAVE in many ways such as lower power consumption, Hybrid Reality Environments represent a new kind of visualization spaces that blur the line between virtual environments and high resolution tiled display walls. CAVE2 is the world's first near-seamless flat-panel-based, surround-screen immersive system. Unique to CAVE2 is that it will enable users to simultaneously view both 2D and 3D information, providing more flexibility for mixed media applications. CAVE2 is a cylindrical system of 24 feet in diameter and 8 feet tall, and consists of 72 near-seamless, off-axis- optimized passive stereo LCD panels, creating an approximately 320-degree panoramic environment for displaying information at 37 Megapixels (in stereoscopic 3D) or 74 Megapixels in 2D and at a horizontal visual acuity of 20/20. Custom LCD panels with shifted polarizers were built so the images in the top and bottom rows of LCDs are optimized for vertical off-center viewing- allowing viewers to come closer to the displays while minimizing ghosting.[3]

Table 1. Comparison of papers on CAVE Virtual Reality

Sr. no.	Paper Title	Year	Paper theme/ idea	Advantages and limitations
1	Designand implementation of Cave Virtual Reality[1]	2017	Mobile CAVE system.	Advantages- Describes advantages of mobile CAVE like Portability,Low Power Consumption,Low cost. Limitations- Low resolution imagery, High cost tracking cameras.
2	CAVE: An Immersive Technology - A Review[2]	2014	CAVE study and comparison with CAVE 2.	Advantages- CAVE has high Immersion, high resolution applications, helpful in research Limitations – Doesn't solve the issue of high cost, High power consumption, Immobility.
3	CAVE2: A Hybrid Reality Environment for Immersive Simulation.[3]	2014	CAVE 2 design and implementation.	Advantages- Wireless tracking,better graphics quality. Limitations – High Costsolve issue of High cost.
4	Virtual reality and the CAVE: Taxonomy,and interaction challenges interaction challenges[4]	2013	CAVE system application and challenges.	Advantages- Describes challenges faced by the CAVE system.
5	Virtual Reality Driving Simulation for Measuring Driver Behavior and Characteristics[5]	2017	Using a virtual simulator to assess driver	Advantages- Describes driver behaviour in VR.

III. METHODOLOGIES USED

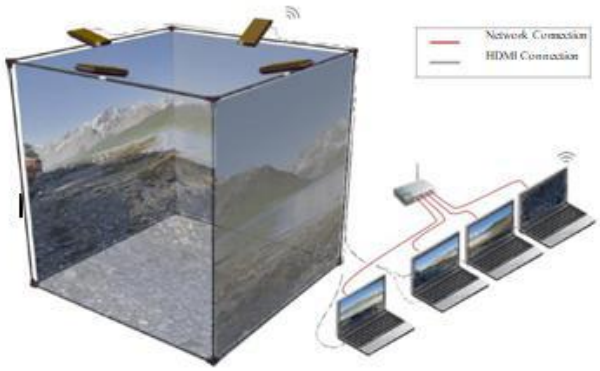
In order to build effortless mobile-CAVE, its pillars with light-weighted metal poles were used. These poles can be easily attached and detached from each other according to the desired size. The length of the three connected poles is three meters. The joints of pillars are 3D printed using Acrylonitrille-Butadiene-styrene (ABS) polymers . Screws are not required to make the setup. The holders were designed to put mobile-based projectors on the top of the mobile-CAVE. Digital devices, such as laptops or smart phones, can be placed next to the mobile-CAVE.The CAVE is designed to operate with mobile projector. Thus, projectors according to their specifications can be connected with wires, such as high-definition multimedia interface (HDMI) , or wirelessly with WiFi connection. The communication between devices is central. The main hosting device is responsible about establishing the connection. The hosting device can be also configured to connect external devices. This is useful to supply proposed system with collaborative mobile-CAVE virtual environments.

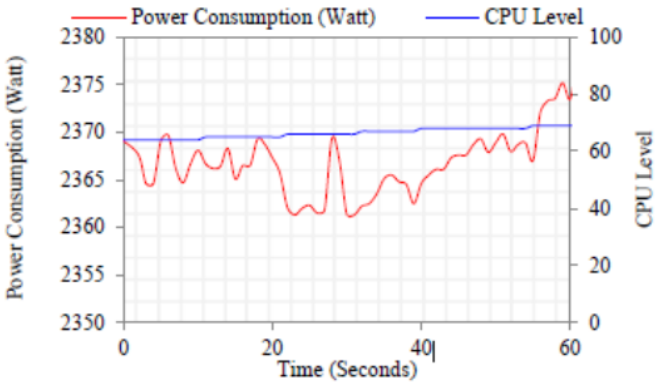
The setup of projectors is done manually by rotating projectors in their holders. An optimal picture is obtained when all displays have wide view with no splitting corners. The projection on the wall depends on the mobile-projector model.

Thus, the projection alignment may differ according to the projector model.

Comparison of power consumption of installed devices in the standard CAVE and the mobile-CAVE. The standard CAVE was equipped with four Christie DS+6K-Mirage projectors by Christie Digital 3 and four DELL Precision T7600 computers provided by DELL 4 . In our mobile-CAVE, we used four Sony MP-CL1A mobile laser projectors 5 and four ASUS ROG GL702V VR enabled laptops supplied with NVIDIA GTX 1070 6 and 24GB RAM. During the

operation of the simulation, CPU level of the main machine and the power consumption of each CAVE system was recorded. To measure the power consumption, we employed a custom power meter which takes power from the main power socket and provide power to the CAVE system. Figure 10 shows the CPU level and the power consumption in watt (W) for the two CAVE systems for one-minute operation. Figure 11 shows the average power consumption of the two CAVE systems. In fact, our proposed mobile-CAVE achieved the optimal power-saving level with acceptable rendered frame-rate synchronization. We noted that with the increase of CPU-processing level, the power-consumption is also increased. Consequently, the power consumption of the proposed mobile-CAVE is approximately 324.2±4.18 W while the power consumption of the standard CAVE is approximately 2367.5 ± 4.43 W.





(a) Tracing in standard CAVE

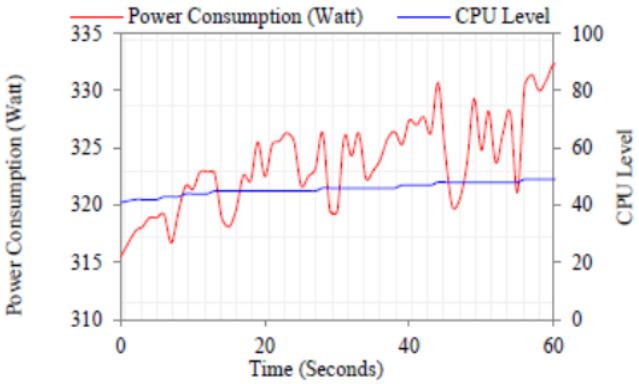


Fig 1 : Power Consumption Mobile-CAVE vs CAVE

IV.CONCLUSION

The CAVE has assured to be an efficient and persuasive VR model that expands the capability and increases the VR experience. It fulfills the purpose of presenting large angle view, making full color high resolution images, and permitting multi-person to work. The proposed mobile-CAVE solves some shortcomings of the standard CAVE technology. These shortcomings include, cost, mobility, re-usage of allocated space, and power consumption. The experimental analysis results showed the usage of the standard CAVE and our proposed one are nearly matching.[1] Future research efforts will consider the employment of low power consuming cameras to track the movement of the user. We have interest in presenting stereoscopic images through 3D mobile projection. In addition, the design and implementation of high speed wireless mobile-to-mobile communication is planned.[1]

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