

The Setting Up of a Virtual Reality Lab: The Unisel Experience

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1. INTRODUCTION

Visualisation is becoming a more and more important component of any engineering or science-related project. Advanced visualisation tools allow the simulation and viewing of increasingly complex models which in turn allow researchers and scientists to manipulate them in ways never imagined before.

Virtual Reality (VR) is a visualisation medium composed of interactive computer simulations that combine 3-D computer graphics and diverse technical systems that provide a large field of view and a stereo effect to the user, resulting in a feeling of being immersed or being present in the simulation. Using the Virtual Reality Modeling Language (VRML), the entire 3-D virtual world will be created where one can “walk” through (or around) the objects and manipulate them. The term “Virtual Reality” was initially coined by Jaron Lanier of VPL Research [1]. Other related terms include “Artificial Reality” [2], “Cyberspace” [3], and, more recently, “Virtual Worlds” and “Virtual Environments” [4].

The purpose of this paper is to share the knowledge and experience in setting up a Virtual Reality laboratory at Universiti Industri Selangor (UNISEL) City Campus in Shah Alam, Selangor. An overview of VR applications is first given, followed by a description of the Virtual Reality lab at UNISEL and our experience in setting up the lab until its full operations.

2. VIRTUAL REALITY APPLICATIONS

Virtual reality is used in many different applications, ranging from architecture and engineering to bio-informatics, medical science and entertainment.

Perhaps the most obvious applications of VR are in the fields of architecture, engineering and manufacturing, as illustrated in Figure 1. Virtual Reality helps to improve quality of design including its ergonomics by allowing many different design alternatives to be simulated, evaluated and selected in a

very short time. It also offers the user a “walk-through” view of the simulation so that problems can be found and design improvements can be made earlier and faster. “Virtual Prototyping” as this is called, significantly aids in testing and perfecting products (automobiles, aircraft, buildings, etc.) before actual construction. By simulating motions too, VR has found very useful application in the study of dynamic effects and fluid flow.

The medical field is another promising field of application for VR. Many medical applications use augmented virtual reality systems that help doctors in, for example, studying blood circulation inside the body, or visualising certain parts or organs of the body in virtual reality. In the pharmaceutical and biotechnology

industries, scientists use Virtual Reality to visualise and manipulate complex DNA molecules in formulating new drugs.

VR technology has also been extensively used in education and training in all the fields described above. With VR, students can learn more effectively as the 3-D representation and “walk-through” view of the simulation can ease visualisation and understanding of complex objects and structures. Besides, they can also have a hands-on experience in manipulating the objects such as by removing or swapping their components.

3. THE VR-LAB AT UNISEL'S RESEARCH AND CONSULTANCY UNIT (UPPU)

3.1. Choice of Set Up and Overall System Integration

There are two types of screens in a VR set up: a flat screen or a curved screen. Flat screens can be in a single wall configuration (i.e. single projection channel), or in a “powerwall” configuration (i.e. more than one projection channel but still only one screen in front of the user). Flat screens can also be in a “cube” configuration (e.g. CAVE™) with screens also on the left and right of the user. Flat screens provide higher accuracies and are used in most engineering and architectural set ups. The curved screen is more useful for simulation works (e.g. pilot simulations) and for entertainment (e.g. 3-D games, cartoon productions) since with such a set up, the user feels more immersed in the environment.

Appropriate for its intended use, UNISEL's VR Lab employs a 2-channel PowerWall set up. The overall network and system integration more is shown in Figure 2. The PowerWall set up is powered by Linux-based clusters running ICIDO (“I see I do”) virtual reality software. The image, created from various modeling and CAD/CAM/CAE applications, is projected on a large flexible flat screen. Together with its hardware and software,



Figure 1a, b, c: Example VR Applications in Engineering

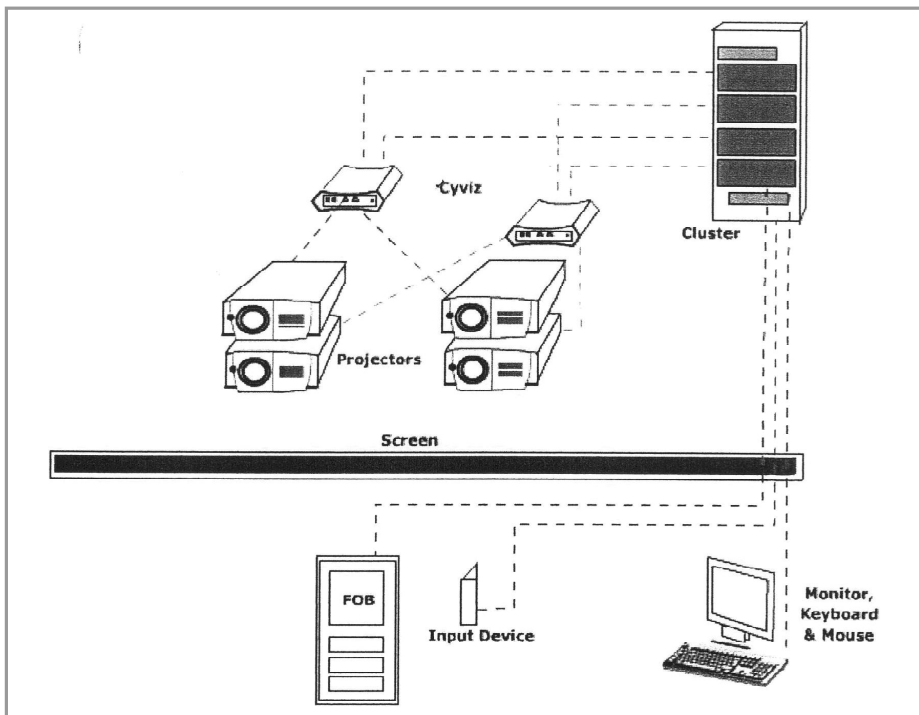


Figure 2: Overall network and system integration diagram

the UNISEL set up is said to be the most technically advanced in the country. Similar set ups have also been used by many large automotive companies such as BMW, Volkswagen and Daimler-Chrysler in Germany.

3.2. Hardware

Hardware for the UNISEL VR lab basically consists of 4 Linux-based clusters, 4 sets of Christie “Vivid Blue” projectors (including filters), a Cyviz “xed.1” blending processor, a Stewart “Silver wall” screen, Ascension “Flock of Birds” motion tracking system, a set of input device and polarised 3-D glasses.

The 4-node Linux clusters (Figure 3a) drives each of the 4 projectors and also powers the 2-channel PowerWall. All four Linux nodes in the cluster must run concurrently to produce two images at each channel. The Master Linux node also houses the graphic system and runs the IDO virtual reality software as well as various modeling and CAD/CAM/CAE applications. As for the graphic system in the clusters, “QuadroFx” was chosen in view of its superior performance and cheaper initial and maintenance cost compared to its competitors.

The projection system (Figure 3b) is one of the most important components

of a VR set up. Each of the 2 channels in the PowerWall set up requires 2 separate projectors to produce passive 3-D stereo images to the user (one for the left and one for the right eye). Thus, for a 2-channel set up, a total of 4 projectors were needed. The “Vivid Blue” high quality multimedia projectors have full SXGA resolution of 1280x1024, capable of giving very sharp and clear images.

The Cyviz xed.1 Soft Edge blending processor, (Figure 3c) is located between the clusters and projectors. It processes display signals from the clusters and integrates the whole VR system.

The projection screen, 6m wide and 2.6m high, is a custom-designed flexible rear projection screen made by Stewart Filmscreen Corporation. This screen uses Techplex150 materials, which has a dark tint for additional contrast and is excellent in rooms with wide viewing angles and where high ambient light is a concern. This screen is fixed in a retractable frame.

Interface between the user and the VR software module is provided by the input device in the form of a joy stick and a head tracker. The device controls and perform manipulations within the immersive environment and is linked to the Ascension “Flock of Birds” tracking system.

The Ascension Flock of Birds (Figure 3d) is a 6 degrees-of-freedom tracking system which can track the position and orientation of the user without restrictions, delay or lag. There is also no need for a clear line-of-sight between sensors and transmitter as blocking is never an issue.

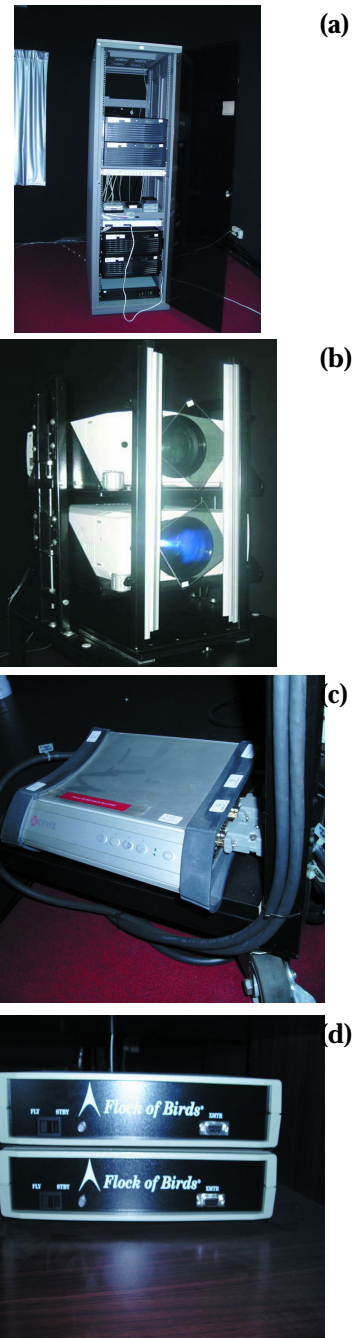


Figure 3: Among the hardware installed (a) Linux-based cluster (b) Vivid Blue Projectors (c) Cyviz blending processors (d) Flock of Birds tracking system

The polarised 3D glasses enable the display of passive stereo generated by the Linux clusters for the left and right eyes.

3.3. Software

The three basic VR software which are currently installed in the system are “IDO:Review”, “IDO:Connect Standard” and “IDO:Cooperate”.

The IDO:Review allows the user to import 3D objects from compatible software and view or manipulate them within the VR environment. Among the files that are readily supported by this software include .wrl (VRML), .iv (Inventor), .obj (Wavefront Object), .stf (Stereolithography) and .model files. The IDO: Connect Standard is a 3D data adapter which directly converts other 3-D data files into VRML and connects them to the IDO:Review. Among the popular CAD/CAM/CAE and modeling application that can be converted are CATIA, NASRAN, AutoCAD 3D, MIKE21, ProENGINEER, IDEAS FEA and NASRAN FEA. The IDO:Cooperate software allows different teams of engineers and scientists with similar VR hardware/software set up but in different locations to work together on the same project .

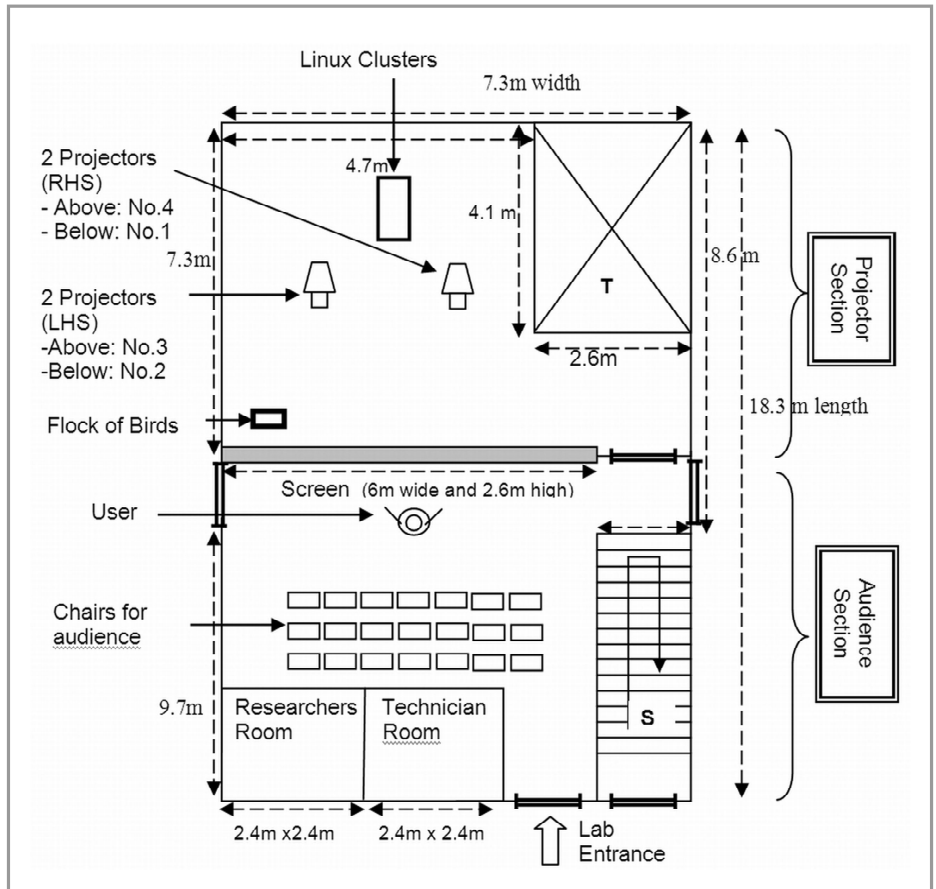


Figure 5: Actual floor layout of UNISEL VR Lab (Not to scale)

4. PROJECT IMPLEMENTATION

4.1. Planning and Scheduling

Realising the potential and benefits of VR technology, UNISEL, through its Research and Consultancy Unit (UPPU) embarked on a project to set up a VR laboratory in

January 2004. Contract for the setting up of the lab was given to a local company, Open Source Systems Sdn Bhd (OSS), with expertise and equipment procured from ICIDO GmbH of Stuttgart, Germany.

Based on a previously accepted design proposal, the scope of the contract included detailed design, supply, installation, tuning, optimisation, testing and commissioning of the entire VR

UNISEL VIRTUAL REALITY PROJECT IMPLEMENTATION																	
Phase	I							II							III		
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17 th to 70 th
1. Plan & Design																	
Detail Work Plan Preparation	■																
2. Implementation																	
Phase I VR Hardware Installation		■															
VR Cluster Installation			■														
VR Software & Tracking System Installation				■													
Phase I VR System Tuning & Optimization					■												
Phase I VR Training						■											
Phase II VR Hardware Installation							■										
Phase II VR System Tuning & Optimization								■									
Phase II VR Training									■								
3. Testing																	
Factory Acceptance Test																■	
User Acceptance Test																	■
4. Commissioning/Handing Over																	■
5. Maintenance and Warranty																	■

Figure 4: Project implementation programme

hardware, software and the system. The package also included a 12-month maintenance service for the lab. The complete implementation programme for the project is as shown in Figure 4.

Although the official contract period given was 9 months, the contractor was able to physically complete the project ahead of schedule. However, due to some administrative problems, the lab was only operational in January 2005.

4.2. Room physical requirements

The physical requirement for the VR laboratory room plays an important part as minor defects can affect the performance of the virtual environment.

4.2.1. Room layout

Ideally, the room should have an “open plan” design with no columns within the floor area to avoid obstruction to both image projection and sight. In the UNISEL project, the laboratory was built from a converted lecture room on the ground floor where all the necessary renovation work was carried out and completed prior to the actual setting up of the lab. The actual floor layout of the lab is shown in Fig. 6 and consists of a projector and an audience section.

4.2.2. Dimensions

The minimum size of the laboratory room depends on the maximum size of image intended to be projected on the screen as this will dictate the size of the screen and exact positions or “stand-offs” of the projectors. For the UNISEL project, it was specified that the screen must be large enough so that a real-size image of the Proton Perdana would fit in. The minimum size of the lab will also depend on whether projectors are in front or at the back of the screen (see 4.2.3). With projectors at the back of the screen and with floor dimension of 7.3m x 18.3m and ceiling height of 3.7m, the size of the UNISEL VR lab in Fig. 5 is about the minimum required to meet the specification. However, for optimum projection and users’ interaction, a bigger space would be desirable.

4.2.3. Using front or rear projection

Flat screen set ups can have projectors located at the back of the screen (rear projection) or in front (front projection). Rear projection is the one preferred and chosen for the UNISEL lab because there will not be any equipment blocking the audience’s view since all of them will be placed at the back of the screen. However, rear projection has a disadvantage as more laboratory space is needed to house a separate projector and an audience section. In a front projection, all the projectors and equipment are placed in the same section as the audience. Although this could mean savings in lab space, problems might not only be blockage to audience view but also blockage to image projection by the user him/herself.

4.2.4. Room interior

The projector section of the room should be dark, thus internal walls are also painted black. Black surface absorbs all the visible lights hitting the surface so that none will be reflected. This will enhance the 3-D effect of the virtual environment. Besides, all windows should also be covered with curtains to keep ambient light from entering the room.

4.2.5. Room temperature and humidity

The laboratory room must be air-conditioned at all times, particularly in the projector section. The air conditioning system should be maintained at a temperature of around 23°C. The humidity of the room must also be kept low.

4.2.6. Power supply

The electricity supply can be normal single-phase electricity but must be stable. Lightning arresters should be installed in the building to protect the expensive equipment from lightning.

4.3. Problems and difficulties encountered

A number of problems or difficulties were encountered during project implementation but most were considered minor and did not seriously hinder work progress. These are as follows.

4.3.1. Finding suitable room for the VR Lab

It was difficult to find a suitable room for the VR lab since the front-projection setup is unique while the required screen size (6m wide and 2.6m high) is considered large. The room must also be able to accommodate the projectors and at the same time be spacious enough to fit in a typical classroom-size audience of about 30 persons. Allowing for the structural framing around the four perimeters of the screen, this means the room must have at least a width of 6.6m, a clear ceiling height (with no cross-beams protruding below the ceiling) of 3.2m and a length of 20m. A room of such dimension and layout was not available at the City Campus at that time. The nearest to this was of that shown in Figure 5 but with two existing and non-removable features inside it, the fire-fighting water tank room (T) and the staircase structure (S). The staircase only affected audience capacity and so was not a big problem. The watertank room, however, did affect the positioning and stand-offs of the 4 projectors as its walls obstructed the “line of sight” of the projectors. To overcome this, the projectors had to be placed nearer to the screen, resulting in a slightly smaller projected image. Despite this reduced image and perhaps “under-utilisation” of the screen size, fortunately with some adjustments, a real-size image of the Proton Perdana was still obtainable with the lab.

4.3.2. Image Ghosting

Circular filters, installed immediately in front of the projectors, would allow 3-D image to be perceived even when the user’s head is tilted. However, the nature of these filters also allows some “image ghosting” (shadows on bright-coloured and high-contrast images) to appear which can badly affect the 3-D effects. To avoid this, the circular filters were replaced with linear ones to achieve greater image sharpness and accuracy.

4.3.3. Filter stand

The original filter stands were built-in (fixed) in front of the projectors, and did not allow fixing of the linear filters in place of the circular filters without also removing

the stand. To overcome this, a retractable stand was built that will allow only the filters to be replaced whenever necessary.

4.3.4. Network connection

During testing and commissioning of the lab, the internet service from the university's wireless network was frequently interrupted and slowed down the process of downloading the IDO software and testing of the IDO:Cooperate. Fortunately, this problem occurred only for a short period and with the help of wired connection, testing and commissioning were able to be done successfully.

5. CONCLUSION

Virtual Reality is an emerging visualisation technology that allows design engineers and scientists to view and interact with their simulated models as if being really present in the simulation. There are a number of considerations to take into account when setting up a Virtual Reality (VR) laboratory. The first is to know the purpose the lab is built for. If it is for prototype testing and designing

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(engineering or scientific applications), then the flat screen set up (such as UNISEL's 2-channel PowerWall) is most suitable. But if it is only for simulation works, then the curved screen set up would be more appropriate. Equally important is the specific room physical requirements that need to be met with regard to for example, room layout and dimensions, projection type (front or rear), room interior and room temperature and humidity.

Considering that VR is still new in Malaysia, we are faced with challenges associated with a small community in Research and Development in the field and industry awareness. UNISEL, being one of the first institutions of higher learning in the country to have set up a Virtual Reality lab, welcomes interested parties both from the public and the private sector to work together with UNISEL in developing and harnessing the potential of this technology towards mutual benefits. ■