ARCO's 2nd Generation Large Screen Immersive Visualization Environment

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Abstract

In 1996, ARCO began the construction of an Immersive Visualization Environment, which was completed in 1997. This environment was designed to allow us to use commercially available software, and to build proprietary immersive geoscience applications in order to reduce the cycle time and improve the accuracy of making well location decisions. This environment consists of a 10x10x10 foot CAVE™ like structure. During more than two years of experience, we found the very immersive CAVE™ like environment to be extremely valuable for working sessions of three to five people. We also found that meetings had to be limited to 15 people due to the size of our environment. Therefore, we developed a conceptual design of a second-generation system, which can be used for both high immersion work sessions, like the system we currently have, and predominantly large group presentations. At the end of 1998, MechDyne was contracted to do an engineering design of such a reconfigurable visualization environment. We budgeted for its construction in early 1999. The new system has flat screens, which are superior to curved screens, and has open and closed configurations. The closed configuration is ideal for a few people to work on their data in an immersive environment, while the open configuration is better suited for displaying their results to a much larger audience. The system is designed to be reconfigured from open to closed in about one hour.

BACKGROUND

In 1996, ARCO realized that the ability to interpret and extract usable information from 3D seismic data was not keeping pace with the rapid increase in the number and size of 3D seismic data volumes. Based on this and experience using desktop visualization techniques over the last several years, it was decided to fund a large effort in immersive visualization. The funding was done in stages. As we demonstrated success, we were provided additional funds to continually improve our computer hardware and visualization environment.

Starting in June of 1996, we began visiting different users and vendors of immersive visualization technology. Based on our combined visualization experience and these visits we decided to build a CAVE™ like structure at our Plano, Texas research facility. By the end of 1996, we had refurbished a room to hold our Immersive Visualization Environment and installed the screen frame, mirrors, and projectors. This system is basically a 10-foot cube. Images are rear projected onto three walls and front projected onto the floor.

The system was opened with "demos to management" in May of 1997 using two walls of the facility. By the end of 1997, we had all three walls and the floor fully functional. Originally, the facility was powered by an SGI Onyx with two IR graphics pipes, splitting one graphics pipe across two walls (or a wall and the floor).

The use of the facility was enough to justify a new computer to handle larger surfaces and data volumes. In March of 1998, we installed a Silicon Graphics Onyx 2 Reality Monster with 4 graphics pipes, 4rms/pipe, 8 250 MHz R10k processors and 5 gigs of memory. This new machine allows us to use one graphics pipe per wall.

Throughout 1998, the demand on the facility increased. We were doing more group presentations than we planned and expected, and found that more people wanted to be involved, and we therefore needed a larger facility. At the end of 1998 we contracted with MechDyne to do the engineering design of a reconfigurable immersive visualization environment, and budgeted for building this new environment in 1999.

ENVIRONMENT CONFIGURATIONS

One of our goals in building both generations of immersive visualization environments is to provide a high degree of immersion for a single head tracked user. At the same time, we wanted to minimize the amount of image distortion that those who collaborate with this user experience. We use this environment to develop new ways to interpret 3-D seismic data and plan wells that are not possible with other systems. In order to achieve our goals we are not able to just use "off the shelf" hardware or software. This is not a "necessary evil", but an opportunity to excel.

The new system provides the flexibility to work with either a small team, or larger partner, farm-out and managerial review meetings. It has the benefits of our current system and is flexible enough and large enough to handle many more people.

Figures 1, 2 and 3 contain conceptual views of our second-generation immersive environment.

MechDyne calls this type of immersive environment a MDFLEX SSVR environment (Surround-Screen Virtual Reality). Figure 1 shows the system in its closed configuration. This is basically the same as our current environment, except the walls are 10 feet high and 12 feet long instead of 10 feet by 10 feet and the floor is 12 x 12 instead of 10 x 10. Computer generated stereo images are displayed on all four “walls”. The images are computed relative to the location of a head-tracked user inside of the room. As the user moves, the images change to properly follow where they are looking.

Figures 2 & 3 show the environment in two different open positions. In Figure 2, the system is completely open. This allows us to show the displayed data to a much larger audience but we loose a lot of the immersion available in the figure 1 configuration. In figure 3, only one side wall is open. This is a good compromise. It allows a group to go from being partially immersed, to showing images to a larger audience.

IMMERSION

To obtain a high degree of immersion, a visualization environment requires at least the following five features: off-axis head-tracked stereo images, human navigation, a frame rate that keeps up with head motion, a large field of view, and the ability to reach out and touch instead of just sit back and point. Given a limited computer resource, tradeoffs must be made between these different features. It is the trade-off of these “features” that guided our work in building both immersive visualization environments.

First, the displayed images must be in stereo. Smooth motion of the data relative to the viewer can be used to give an illusion of immersion. This works for mono images due to the differential parallax of the various objects in the scene. Once the motion stops the relative distance of the objects from the viewer is lost, and the illusion of immersion is gone. This does not happen with stereo images. With a single stereo image the user can change their gaze and study various parts of the image or scene to determine the relative positions of different objects or geologic features. Therefore, a single stereo image can provide much more information than a small movie loop.

Second, we want to use normal human motion to change our perspective of the data. This implies that the location of the user’s head is tracked. Every time the user moves their head, a new set of images is generated so they see what they should see from their new location. This is human controlled parallax instead of a precomputed parallax that is provided by a movie loop. If we are walking around a fault, or a well, we want it to appear to stay stationary as we move – there should be a one to one relationship between the user’s motions and the motion of the virtual environment. Of course, we also need some interactions to move the data or ourselves in the volume to rapidly go from one place to another. In order to most effectively use human motion to navigate, we must rear project the images onto the screens so we will not cast a shadow on the part of the screen we are interested in looking at.

Third, this motion requires a fast computer, or a simple image, to keep the frame rate high enough that the user does not see a time lag between moving their head, and a new image being generated. One of the advantages of a large screen (versus a head-mounted display) is that a larger amount of lag between moving and the image update is acceptable. There is a trade off between image complexity or details and motion. It is possible to move the data in low resolution, and then freeze the location temporarily, while the image is put into a higher resolution. Alternatively, a small region of interest can be put in high resolution with having a minimal affect on the overall frame rate.

Fourth, since the user is moving themselves and their head around they are engaging their peripheral vision. We need to be sure that, as much as possible, their peripheral vision only contains data from the virtual environment. In our case, this means that the mirror for the floor projection is angled such that when the users look up, they are not looking directly at themselves. We also have the 10-foot high screens to keep the edge of the screens out of the users field of view in most situations.

Fifth, the environment is a working environment, which means we need to be able to interact with the data. We need to modify such things as our interpretation and well paths. To do this effectively requires the use of a 3D stereo cursor on images that remain stationary relative to the user. It is very hard to pick or interpret a moving surface or datacube.

IMAGE DISTORTION

In building any immersive environment, image distortion will be an issue. An environment at any one time is designed for a primary eye position. The images are generated for a pair of eyes positioned at a given location. As a person moves their eyes from this primary eye position, the images become distorted. The manner and amount of distortion varies depending upon the screen geometry and the viewing location relative to the primary eye position. It is important to minimize this distortion, but since it is still there – the other viewers should not be tricked in believing what that are looking at has the correct geometry.

Large screen immersive environments fall into two classes, those with segmented flat screens, and those with curved screens. On each flat screen, straight lines will always be straight regardless of the viewing location. However, as the view location moves away from the primary eye position, the lines will kink at the seams of the segmented screens. The curved screens can be a part of a cylinder, a toroid, or a sphere. On the curved screens, straight lines appear as curved lines as the viewing location moves away from the primary eye position. The amount of curvature increases the further the viewing location moves away from the primary eye position, and increases with degree of screen curvature. Since there is no major image discontinuity, it is hard to ascertain how distorted of an image you are seeing, and it is therefore easier to make a false interpretation.

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In both of our immersive visualization environments we chose to go with flat (rear projected) versus curved (front projected) screens. With a flat screen, we feel we can get superior immersion while having to do less work for the primary viewer and at the same time subjecting the other viewers to less image distortions. Since the image distortions for viewers away from the primary eye position are concentrated on the seams, they can be detected, and are less likely to lead to any false conclusions.

CONCLUSIONS

There is a variety of different spatially immersive or semi-immersive environments. The configurable flat-screen system allows the user to move around and explore the data looking from both the-inside-out and from the-outside-in. This requires rear-projected screens and the ability to head-track a user. It satisfies, in a single system, the needs of both fully immersive work sessions with small teams, and larger semi-immersive presentation sessions. Other systems, such as the front projected curve screens are better suited for those that want to sit back and "watch the game" or review the work of those that actually got in and did the investigation themselves.

ACKNOWLEDGMENTS

We would like to thank ARCO for allowing us to present this paper. We also need to thank David S. Campbell, without whose insight and support the immersive visualization effort at ARCO could not have happened. The images in this abstract were graciously supplied by MechDyne.

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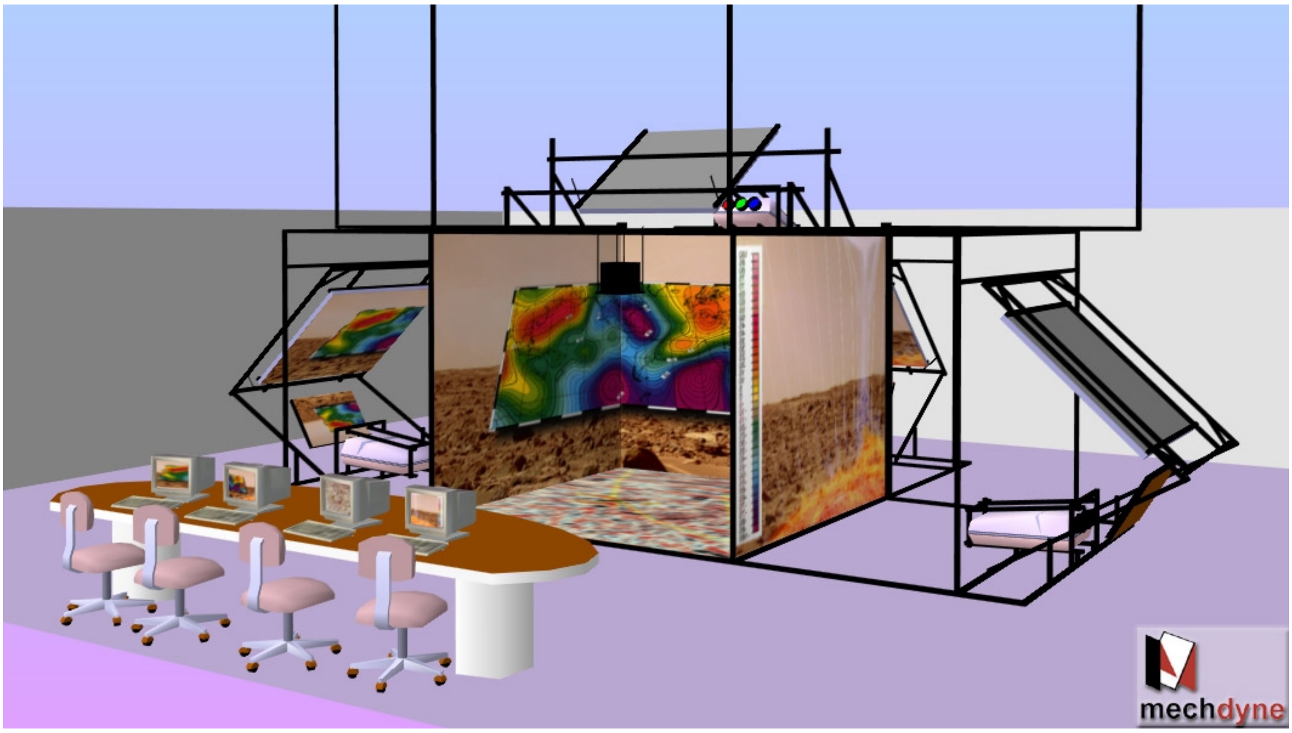

Figure 1: Conceptual design of a reconfigurable immersive visualization environment in the closed position. This is very similar to a CAVE™ or C2 design. The floor dimensions are 12 feet by 12 feet and the side screens are 10 feet high. In this configuration, the system allows for a high degree of immersion, but is not well suited for showing images or data to large audiences.

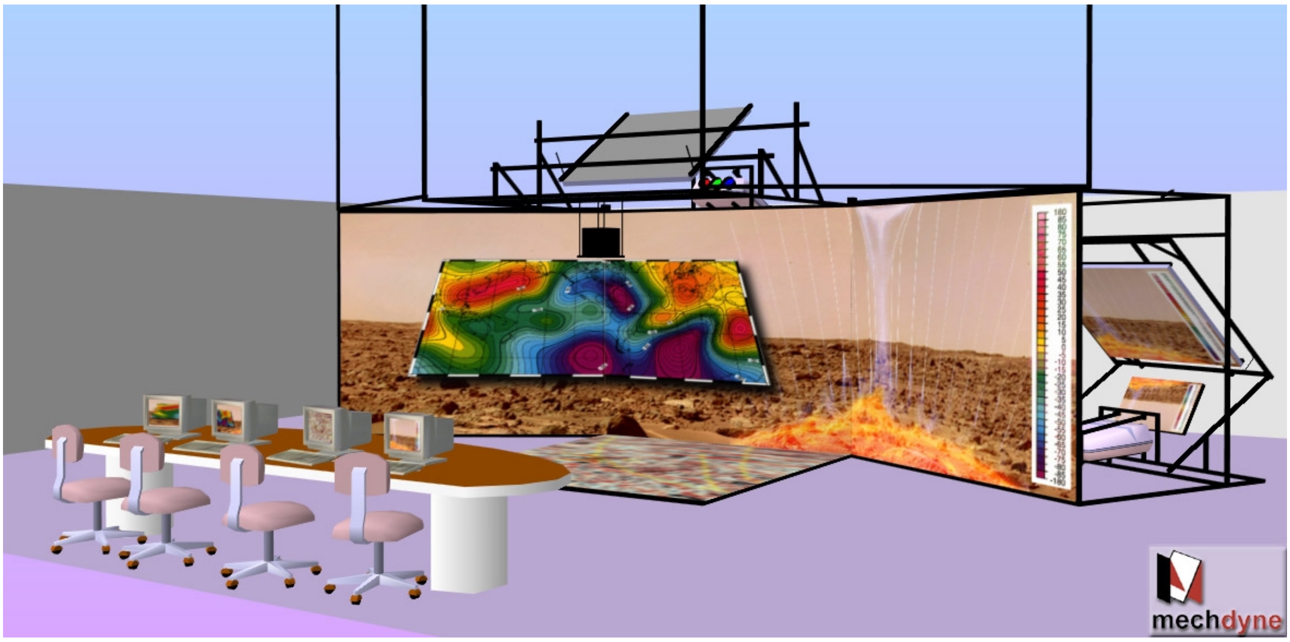

Figure 2: The same system as shown in figure 1, but with both side screens in the open position. Each side screen can has about 60 degrees of rotation from the closed position. In this configuration, the level of immersion is reduced, but it allows a larger audience to see the data and images displayed. This configuration is well suited for presentations to fairly large groups or teams.

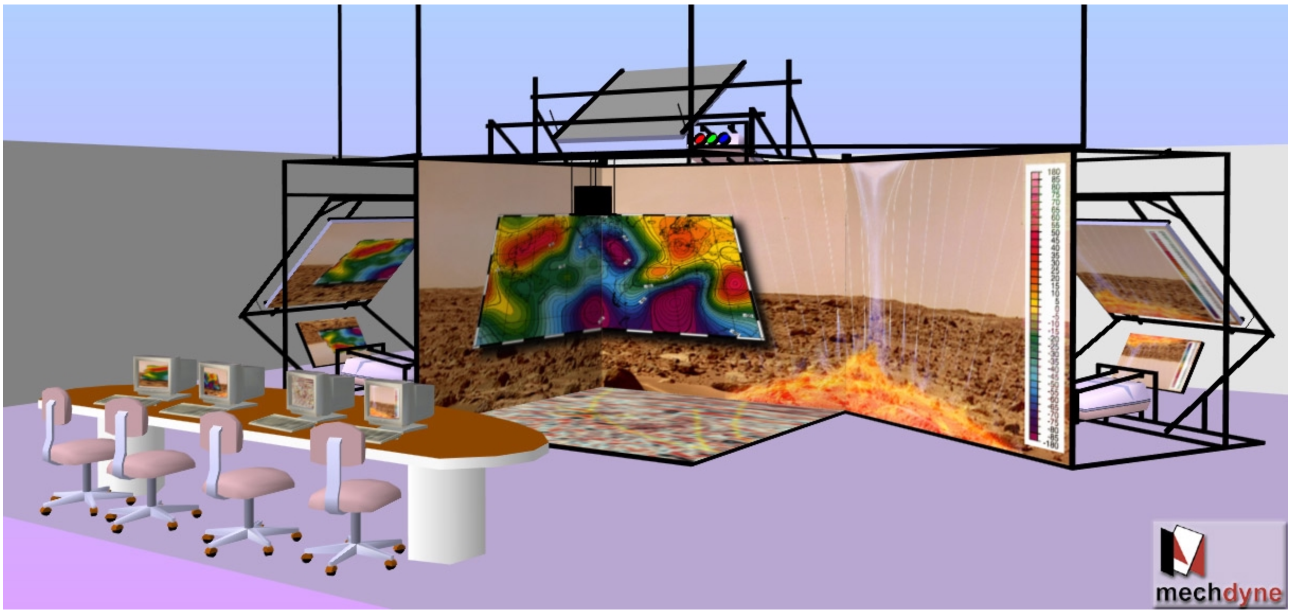

Figure 3: The same system with only one wall opened. This configuration allows us to readily go from a fairly immersive environment, to a presentation environment.