

Stereoscopic Visualization across two Parallel Walls

Visualización estereoscópica a través de dos paredes paralelas

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Abstract

This paper presents the building of a stereoscope, which is formed with two parallel walls. The building of this stereoscope is based on the Wheatstone-type stereoscope. Due to the incorporation of some characteristics, we named this stereoscope “Wheatstone-Mora” environment. We propose to build stereoscopic environments of different sizes, in which, each wall can be built with projection screens, TV screens, and/or computer-controller monitors connected via network, and display a stereoscopic scene on them. We incorporate means performing unrestricted navigation around the 3D scene. This navigation can be controlled through several different input devices: a keyboard, a tracker, and a remote control. Furthermore, the user can move within the physical environment as long as he/she is always at the same distance from both walls. Finally, we evaluated, analyzed and showed the results of our environment.

Keywords: Stereoscope, Virtual Environment, stereographic

Resumen

Este artículo presenta la construcción de un estereoscopio, el cual está formado con dos paredes paralelas. La construcción de este estereoscopio está basado en el estereoscopio tipo-Wheatstone. Debido a la incorporación de algunas características, lo nombramos ambiente Wheatstone -Mora. Proponemos construir ambientes estereoscópicos de diferentes tamaños, en los cuales, cada pared será construida con pantallas de proyección, televisiones, y/o monitores controlados por computadora conectados a una red, y visualizar una escena estereoscópica sobre estos. Incorporamos medios de navegación sin restricciones a través de la escena 3D. Esta navegación puede ser controlada a través de varios dispositivos de entrada: un teclado, un tracker y un control remoto. Además, el usuario puede moverse en el ambiente físico, mientras el/ella mantenga la misma distancia en ambas paredes. Finalmente, evaluamos, analizamos y mostramos los resultados de nuestro ambiente.

Palabras clave: Estereoscopio, Ambiente Virtual, Gráficas estéreo,

1 Introduction

The creation of stereoscopic pairs is a few centuries old, one of the pioneers of the stereoscopy was Charles Wheatstone, with the article “On some remarkable, and hitherto unobserved, Phenomena of Binocular Vision” [Wheatstone,1838]. In that paper, Wheatstone described a technique used to create the illusion of depth. He built a stereoscope using two plane mirrors (see Figure 1A) and two slightly different drawings (see Figure 1B).

The two plane mirrors were inclined 90° against each other and set vertically upon a horizontal board as it is shown in the picture below.

This stereoscope is old, it was created in 1838 and it used two drawings. We propose to reuse it and incorporate some new characteristics in it.

In addition, some papers have been demonstrated that the building of stereoscopes using digital devices has generated good results, such as: “Obtaining Stereographics using a Two-Monitor System and a Set of Mirrors”, this paper shows in detail the method for building a computer-based stereoscope with a set of mirrors and it is based on the idea of a Cazes-type stereoscope [Aguilera and Mora,2008]. The results of this work were high resolution 3D graphics. Paul Bourke built a Holmes-type stereoscope in 2005, he used two iPods for displaying the stereo graphics [Bourke, 2005], this stereoscope allows seeing 3D graphic. “Visualizing graphs in three dimensions” and “Stereo and

motion cues for visualizing graphs in three dimensions” [Ware,2008], [Ware,2005] used the Wheatstone-type stereoscope for evaluating the visualization of 3D graphs.

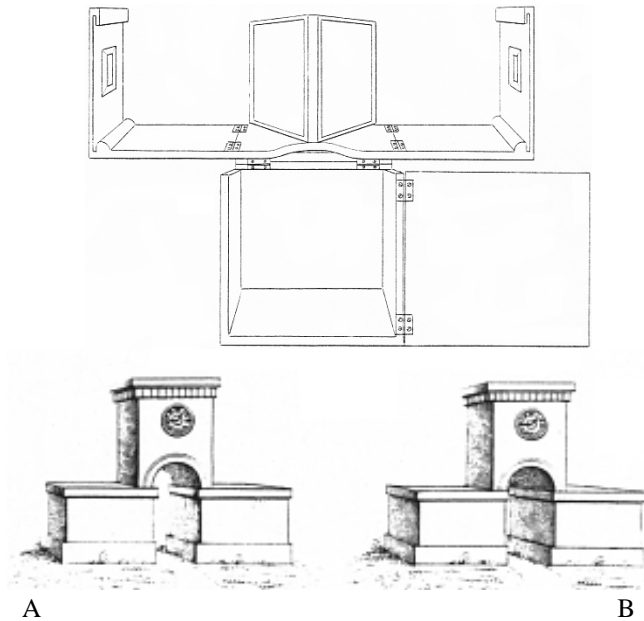


Fig. 1.A) A portable stereoscope built by Wheatstone [Wheatstone, 1852]
B) An example of the stereoscopy image made by Wheatstone [Wheatstone,1838]

2 Designing a stereoscope with two monitors

Wheatstone built a stereoscope for seeing drawings made on two cards of paper; the idea in this section is the building of the stereoscope using two monitors for seeing a stereo environment.

The material used for building the stereoscope is:

- 1) Two monitors, with height h , width w and diagonal d , see Figure 2.A. When the monitors are of a different size, it is necessary to take into account that the final image size on each monitor must be equal, that is, if one is larger, then some portion of it will be wasted.
- 2) Two plane mirrors, about 12cmX7cm inclined at 90° . These mirrors are set by their common edges and they are assembled on a wood frame Figure 2.B shows.
- 3) A stereo environment generated by computer and/or stereo images such as photos, drawings, etc.

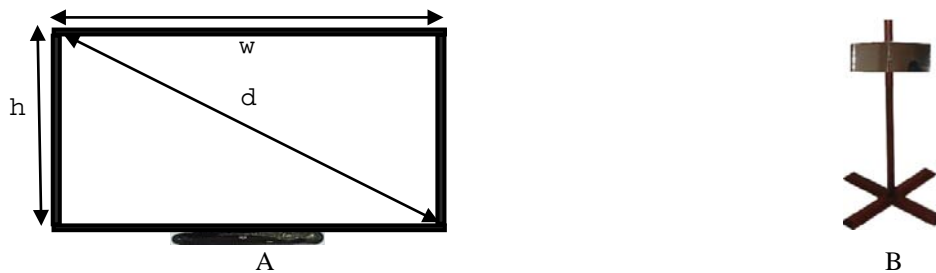


Fig. 2.A) A monitor with height h , width w and diagonal d . **B)** Two fixed mirrors

In [Vali,1966] it has been demonstrated that a good working eye-monitor distance for a stereoscope through the mirrors is roughly d , this is, the same as the diagonal. With this distance each eye should see roughly a whole screen, that is, not more not less. This implies that in the parallel world, the distance between walls cannot be greater than twice as d . Figure 3 shows two parallel monitors, the dotted lines are mirrors, the horizontal lines indicate us the distance between the mirror and the screens, finally, the arrows indicate the eyes' positions.

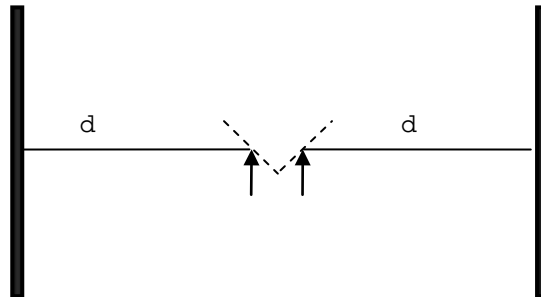


Fig. 3. Wheatstone-type computer-based stereoscope

This stereoscope requires having both images to be laterally inverted [Vali,1966].

Figure 4 shows the Wheatstone-Mora Stereoscope, the monitors are of a different size, but both images are of the same size. The monitors are set one in front of the other. The mirrors' frame is in the middle, the viewer would be set in front of mirrors. The images are created with a system interconnected via network, it is possible to navigate. We propose the use of a remote control for manipulating the movements of the environment when two laptops are used and a keyboard when two PCs are used.



Fig. 4. Wheatstone-Mora environment built with two monitors

3 Designing the virtual environment

Currently, there are different types of virtual environments, some of them are panoramic, type CAVEs, etc. In this paper, we propose how to build a large stereoscope with the idea of creating a new type of world. This world is simple and easy to build. It allows us to see 3D images without any lose of color, flickering or ghosting, using an equipment of a mid-range cost.

For building a two parallel wall world, it is important to consider the following:

- a) The walls of this world can be built with monitors, projection screens or plane TVs. In this work, the word "screens" will refer to any of these computer-controlled devices. Therefore, the size of the screens could be

different, but the size of the walls must be equal, see Figure 5 and notice that the left wall is formed with four screens, which together are as large as the right wall.

- b) The number of screens on each wall depends on the virtual environment size.
- c) If the screens are identical, the number of screens is even.
- d) The viewer must see both images all the time, for avoid losing the 3D illusion.
- e) Every screen must be driven by a computer. Therefore, to drive all screens in the environment, a cluster of computers is needed. If some or all of the computers have video cards with two or more output devices, then the number of computers in the cluster decreases.
- f) It is recommended to have the computer cluster isolated from the internet, but interconnected via a local network, for avoid delay between screen when the environment is moving.
- g) The left and the right screens must display a stereoscopic environment, which have the characteristic of being slightly different.
- h) Two mirrors must be set on a support as large as 1.80cm. The mirrors must be adjusted to the viewer's height.

Figure 5 shows the environment on four plane TVs and a projection screen. A careful procedure must be taken in order to achieve a similar brightness level on both walls.

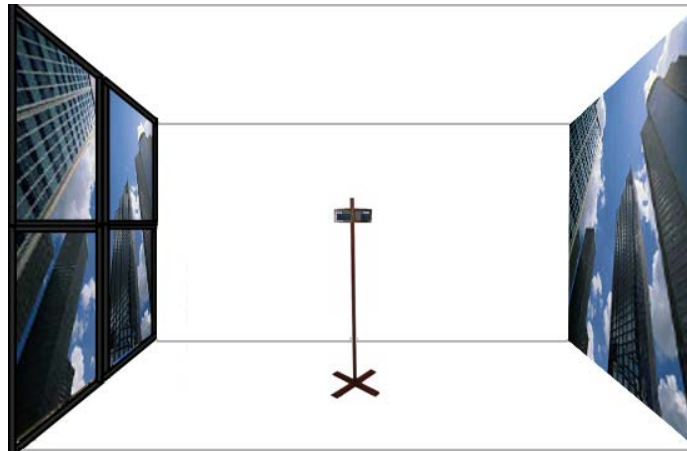


Fig. 5. Wheatstone-Mora environment built with four plane screen and a projection screen

For simplifying the process of building a large stereoscope we can use a PC, which includes outputs to two monitors, we must set the dual monitor mode and use two projectors. Using this basic equipment, it is not necessary to use any network.

Figure 6 shows the viewer interacting in the parallel environment. Two screens and two projectors are used. The technique of mirrors and projectors is suggested for reducing the requirements of real space.

4 Interacting in the world

The viewer can walk forwards or backwards, depending on the walls' size, but he/she must not move away from the middle imaginary line of the room, see Figure 6.A. In case this is not done, the mirror would reflect a smaller wall than the other one.

For having a correct visualization, the viewer must see both walls at the same time, because every wall has a different view. The left wall displays the left stereo image, while the right wall displays the right stereo image.

For seeing the environment with the allowed movements, we implemented two mobile viewpoints, which move in the same direction when the viewer walks forwards or backwards. In addition, this implementation allows us to build walls as large as desired.

Figure 6.B shows an incorrect viewer's position.

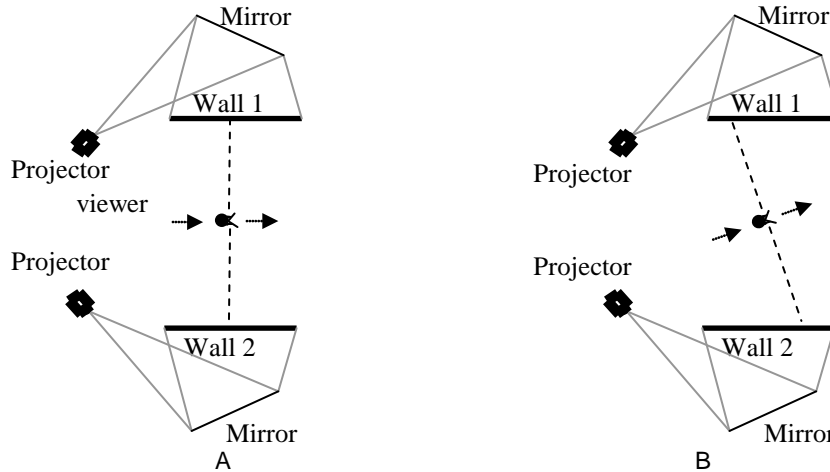


Fig. 6. Viewer interacting in the parallel world. **A)** Correct movement. **B)** Incorrect movement

Since the viewer's movements are restricted within the physical environment, the system allows unrestricted virtual navigation. This combination of physical/virtual movements provides a greater sense of immersion to the user. The virtual navigation includes tilt and yaw rotations, as well as forward, backward, upward, downward, leftward and rightward displacements, and it can be controlled through several different input devices: a keyboard, a tracker, and a remote control.

5 Evaluating the world

Two stereoscopes were built and evaluated by a group of 50 users.

The first stereoscope was built with two monitors of 26cmX16.5cm, and $d=30.79$, the distance between the monitors was of 61.580cm.

The second stereoscope was of 3mX2.25m and $d=3.75$ m, the distance between the projections was of 7.5m.

The evaluation consisted of a test, which included topics like:

- Image fusing easiness
- 3D images quality.
- Depth perception in the 3D graphic
- 3D illusion on stereo moving scenes.
- Environments with solid/wired and mixed objects (solid and wired).
- The possible viewer's movements that are allowed and not allowed.
- Input devices used in the environment: a head-tracker, a remote control and a keyboard.
- Comfort of the stereoscope.
- Level of immersion.
- Sensation of seasickness.

6 Results

After a group of people used the two different stereoscope sizes, we asked them to answer a test, which allowed us to evaluate if they were able to see stereoscopy on stereo moving scenes, photos, wired and solid objects, etc. The results are shown in Figure 7.

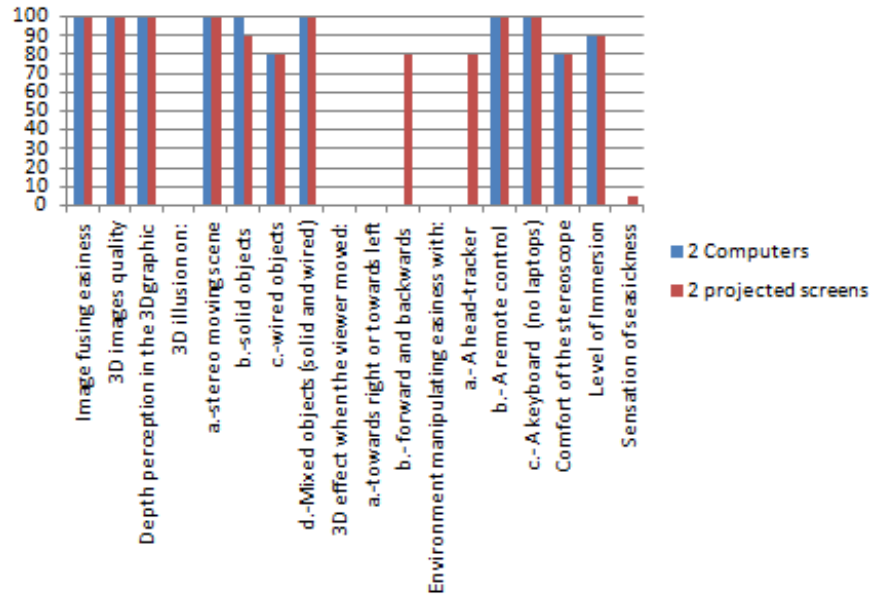


Fig. 7. Results

After we analyzed the chart, we concluded that the viewers had no difficulty for fusing both images. This stereoscope allows seeing real-size high-resolution images. The viewers had a clear perception of depth in an environment with both moving and static images. When the different objects were tested, the solid and mixed (solid and wired) objects were seen without any problem. The perception of the 3D illusion was somewhat harder in the wired objects. The use of the remote control and the keyboard showed to be more comfortable for the users than the tracker, due to the restricted user mobility. Due to the restricted movement, the viewers lost the 3D effect when they moved towards the right or the left during the test. The viewers could move forward and backwards without noticing any lose of the 3D effect. We conclude this is a comfortable and high level immersion stereoscope. Only 4 percent of the people felt a sensation of seasickness.

7 Conclusion

Although, the Wheatstone-type stereoscope is antique, it is possible to use it with very good results. With this idea, we exploded it and we used it for building a large stereoscope, which we consider as a new virtual environment due to the characteristics that it may have.

For example:

- The physical size of the world, this can be as large as the walls' size allows it.
- The virtual environment doesn't have any lose of color.
- The building of the world can be done with the equipment that any institution normally has; this is a didactic method and the smaller the environment, the lower the cost.

- d. The number of viewers depends on the physical size of the world. But the viewers should not cover the projection wall other viewer.
- e. The walls can be built with different screen sizes, but the walls must be totally built for having a good visualization.

This implementation produces high quality static or in movement stereo images, in different environment sizes, this technique does not use any overlapped image on the same screen. Due to this, it does not produce any flickering; the color depends on the used projectors, monitors or devices.

The disadvantages are: restricted movements and lose of the 3D illusion when the viewer does not see both images.

This world can be used in teaching, in stereoscopy museums, in videogames for enjoying 3d worlds and for people that enjoy creating stereoscopic imagery.

8 Future Work

-Incorporating new possible physical movements for the viewer. For example, the viewports could be placed to different viewer's heights.

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