Glass-free multi-viewers Full-HD 3D display using a triple liquid crystal barrier

Robin Lobel, October 2010

Fig 1. 3D Screen (illustration)

Abstract

This paper present a theoretical idea for a glass-free, multi-viewers full-hd 3d screen using a triple liquid crystal barrier.

1. Introduction and related works

So far very few technologies exists to display glass-free 3d content on a screen : for years we had lenticular lens network [1], an optical system similar to those 3d stickers and posters, but it has the disadvantage of dividing the horizontal resolution by 8, image appears blurred if one is not exactly in the right angle, and content must provide 8 different point of view (where stereoscopic movies provide only 2).
More recently, parallax barrier [2] screens have been developed, such as the screen used by Nintendo 3DS. Theses screens provide a very clear and sharp 3d rendering, but have the disadvantage of only working on small screens, for only one user located in the center area.

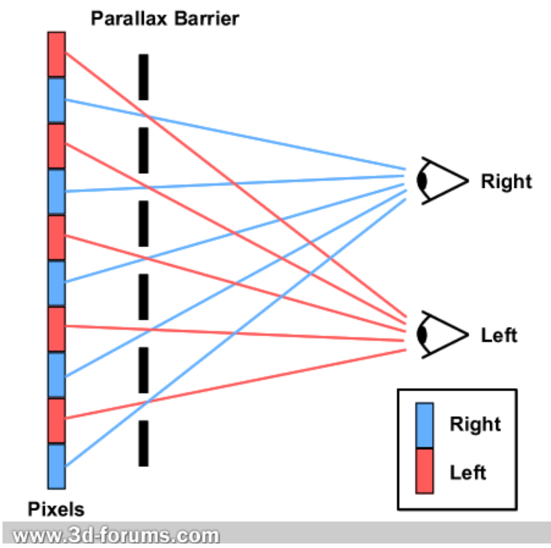

Fig 2. Parallax barrier

2. The idea behind 3d screen using a triple liquid crystal barrier

This research focus on extending the parallax barrier system so it can work on large, full-hd screens with multiple viewers.

For this project, the targeted system was defined as follow:

-a 27" full-hd monitor
-up to 4 simultaneous viewers, standing around 1m50 away from the screen.

This idea rely upon existing technologies : 240Hz LCD panels and face recognition and tracking system such as embedded in most modern cameras and camcorders.

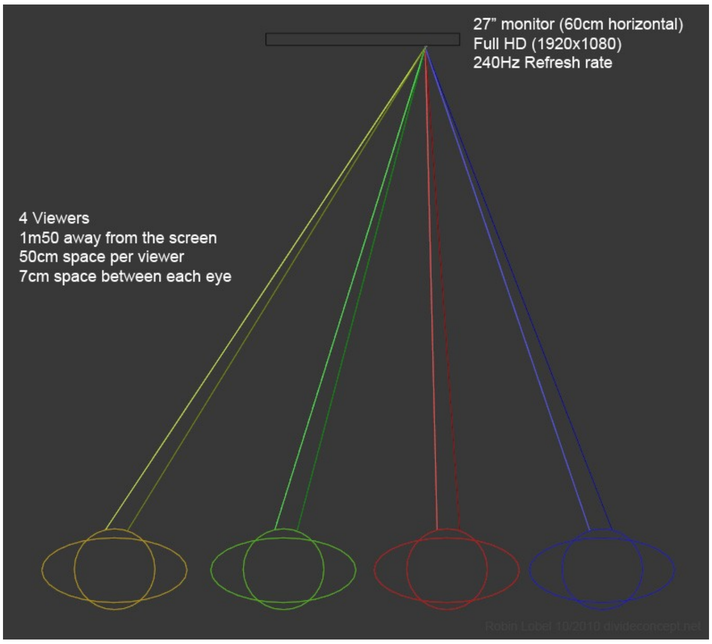

Fig 3. Screen / viewers configuration

Each viewer occupy about 50cm, and the average space between eyes is 7cm.
A video camera (not shown here, located on top or bottom of the monitor) detect and locate each viewer. Here's the system in detail, if we zoom on the focus point :

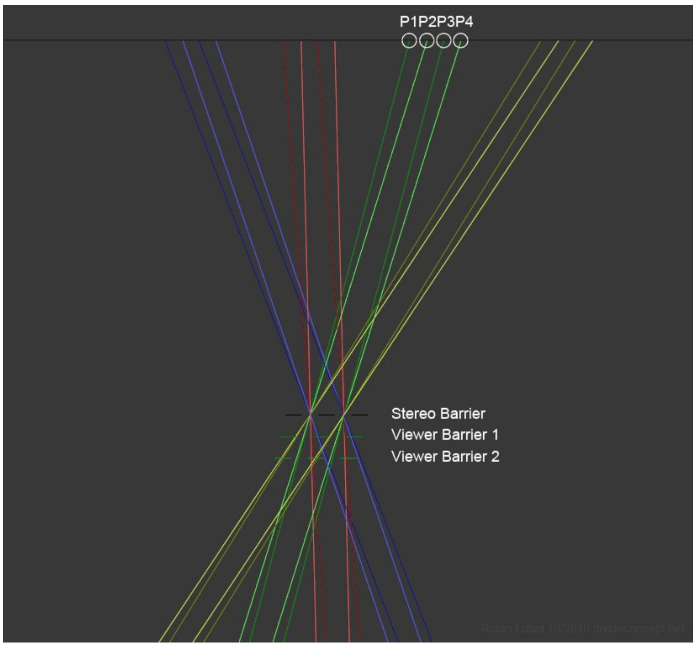

Fig 4. Zoomed area with liquid crystal barriers

The first barrier (here called “stereo barrier”) does not differ from a classic parallax barrier, except that it is achieved here through a 240Hz liquid crystal panel. The advantage of doing so is that we can virtually shift the position of the stereo barrier based on the position of each viewer, so that each eye actually receive a different pixel from the other eye.
Since on a LCD panel for each pixel we actually have 3 different shutters (red/green/blue components), we can if needed shift the stereo barrier by 1/3 pixel.

The other interest of working with a liquid crystal panel is that we can alternatively switch this vertical interlacement : on the first scan the left eye sees pixels P2 and P4, on the second it sees pixels P1 and P3 (the opposite for right eye). In the same way a 1080i60 television can display 1080p30 with no loss of resolution using interlacement.

The second and third barrier, called “viewer barrier” is here to filter each viewer separately; hence the need to have a 240Hz panel, so that each of the 4 viewers has a refresh rate of 60Hz (that's the refresh rate you have when using NVIDIA 3D Vision or XpanD glasses in movie theaters).
At this scale, the focus lines from each eye can be considered parallel (left eye P2 // left eye P4, right eye P1 // right eye P3), as sun rays can be considered parallel when reaching the earth.

Those viewer barriers adapt size and position based on the position of each viewer, creating a virtual tunnel only for the targeted viewer, fitting the rays from his 2 eyes.
It seems that a 1/3 pixel resolution and a double barrier is enough to have such a discrimination :

Fig 5. Viewer barriers filtering each viewer

If needed a higher resolution panel could be used here, since this is the main point of the system, which rely on the exact position of each viewer (as detected by the video camera).
All theses barriers (stereo barrier and viewer barriers) are about 1cm away from the display panel, considering the device (27” full-hd monitor, viewers 1m50 away from the screen).
We can also imagine disabling completely theses barriers (since they are dynamics), or use them for other purpose (such as private 2d or 3d viewing, hiding the content from other viewers). The system can be extended to 5 or 6 viewers, each viewer would get 50Hz or 40Hz refresh rate.
Also, since the Nintendo 3DS seems to works well from 10cm to 50cm (1:5 screen distance), it seems reasonable to think the system could work from 50cm to 2m50, allowing all kind of uses.

3. Future development

This is a theoretical idea which need to be verified, since I do not have the possibility to build a prototype myself. Feel free to contact me if you're interested in developing such a device.

References

[1] http://en.wikipedia.org/wiki/Lenticular_lens
[2] http://en.wikipedia.org/wiki/Parallax_barrier