ExPixel: PixelShader for multiplex-image hiding in consumer 3D flat panels

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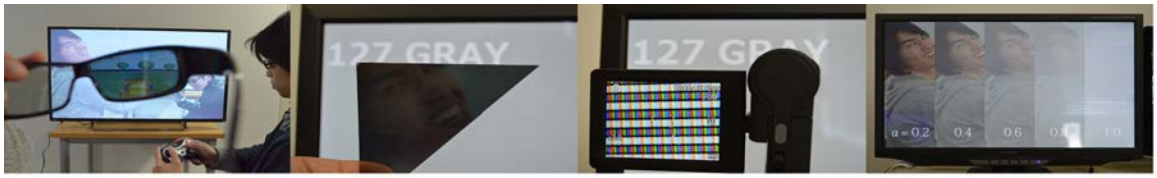

Figure 1: *(a) Final result of ExPixel and the hidden game system on Unity 3D. (b) A circular polarization filter can show a hidden image. (c) Microscopic image of pixel blending; an image is hidden but not shown to the naked eye. (d) Hidden/shown blend ratio testing on Mitsubishi RDT234WX-3D.*

1 Motivation: adding new value to the current 3D display

In recent years, 3D technology has become so widespread that the technology alone no longer fascinates viewers. New breakthroughs are necessary to keep the audience entertained. Thus, a generic multiplexing technique using existing 3D stereoscopic technology was developed. This breakthrough 3D technology enables the viewing of two contents in one single screen at the same time. It is considered to meet users' expectations. The application of multiplex-image hiding techniques to the widespread consumer 3D flat panels without any hardware modification can be valuable in terms of the new usage of 3D devices.

2 Challenge: multiplex-image hiding on 3D flat panels

Polarization glasses, a passive 3D stereoscopic technology that shows two images with the parallax to the right and left eyes, are currently the most widely used 3D technique in virtual reality and movie theaters. In previous research, ScritterHDR and 2x3D were proposed to realize multiplex-image hiding using a multi-projection-based technique [Nagano et al. 2010; Fujimura et al. 2012]. These techniques are valuable in maintaining the resolution in large displays, such as in theaters. However, the stacked projector setup is complicated and requires a large space for consumer use at home. The application of the multiplex-image hiding imagery technique was used on a 3D flat panel based on an existing line-by-line polarized device, such as Xpol and/or CINEMA3D. In this line-by-line method, each line is designed for either the left or the right eye, and the two lines right above and below it are to be seen by the other eye. A 3D stereoscopic view is seen when this setup is viewed with polarized glasses. As a first result, multiple imagery works well in most consumer products. Two images A and B are turned into images made of odd and even pixel lines, respectively, and combined to display image AB on a flat panel screen. This approach is similar to the SimulView technique by SONY's passive 3D display. For hidden imagery as a new function, each image is mapped into a limited range of actual devices, such as 0-255, and image cancelation considers gamma correction. Images A and B are compressed as A' and B' and share one range of pixel values with blend ratio (alpha). A set of images B' and C is generated (C = A' - B', ideally). C can be made from the negative image of B' and combined with image A'. Image C is then merged with B and displayed on the screen. When a gray image is assigned to A, images C and B' cancel each other out and turn into a neutral gray image. However, image B is effectively hidden from the audiences (Figure 1b). Hidden image B' can be seen using the polarization filter. Figure 1d is a testing chart for several blend ratios on various consumer passive 3D flat panels.

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3 ExPixel: PixelShader for line-by-line multiplex hiding

Using the above algorithm, image C may be placed on the even line and image B on the odd line. This multiplex hidden image is called "ExPixel." A real-time PixelShader technique operates this algorithm on GPU.

$$MultiplexHidingShader(y) =$$
$$\{Out_{\mathrm{even}} = (a' - b'), Out_{\mathrm{odd}} = b'\}(y \bmod 2)$$

To make this multiplex-image hiding method accessible, Unity 3D plugin was developed for the easy use of programmers andartists in creating new games and contents. "ExPixel" increases the interactivity of current display. Therefore, game developers and artists have a new way to express themselves and create new types of works.

References

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