Hybrid Projection QR-LPD 3D Display Design

Wallen Mphepo
Chalmers University of Technology, Goteborg, Sweden
Display Institute, National Chiao Tung University, Hsinchu, Taiwan
wallen.ge94@nctu.edu.tw

Abstract: *3D Flat Panel Display designs are currently undergoing through a phase of transformation. The use of active image pixel projection mechanisms is bound to be the next stage in improved 3D flat panel displays. Numerous advantages are well known for these types of next generation designs however feasible methods to fully realize them are still scarce or on the drawing boards. In this paper shall be discussed one such a method that has the potential to achieve Simultaneous Viewer Super Multi-view 3D capability.*

Key Words: Super Multi-View; Parallax Barrier; Ferroelectric Liquid Crystals; Inorganic LEDs; Autostereoscopic 3D Displays; Hybrid Displays; QR-LPD

Introduction

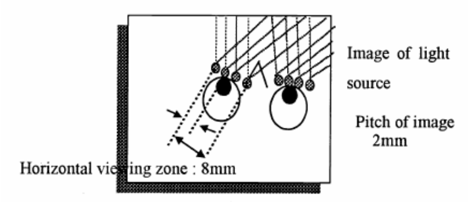
The race to designing a realizable multiple simultaneous viewers capable Autostereoscopic 3D Flat Panel Display especially for TV applications is very much real. However, the intensity of this competition sometimes appear to blinker our researching efforts from observing the peripheral developments in other far flung fields that when appropriately augmented and strung together can provide the potential breakthroughs necessary to hop and skip over the current formidable obstacles. Thus a conscious effort is hereby being postulated and a design developed based on proven experimental results in disparate labs from Asia, Europe to America.

Concepts

Super Multi-View Concept [1] has been described and suggested by different researchers. This is achievable when a stereo-pair of images is sampled over a narrow range of less than half the diameter of the average human eye's pupil. Thus we obtain two images with different parallax being able to enter one eye.

Sweeping angles instead of projecting stereo-pair images to points in front of the display plane has also been explored by various researchers [2].
This has the effect of generating multiple projected stereo-pair points from desired ranges to almost infinity.

Figure. 1



[Image Courtesy of [1]]

The large number and sampling capability of this method makes it achievable practically to obtain super multi-view. The z-range limit will only be a lower limit of the viewing distance not the maximum distance if this method is utilized.

Figure. 2

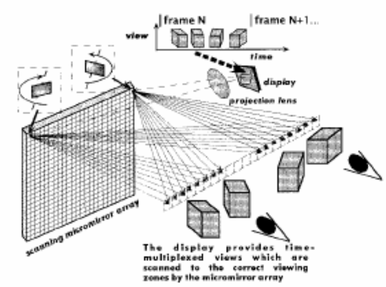


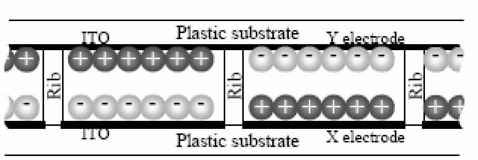
Fig. 2. Direct different 3-D scenes to the corresponding viewing zones by means of time multiplexing.

[Image Courtesy of [2]]

Since there are setbacks with the angular sweeping method described in [2] from its use of micromechanics a more capable approach is hereby proposed. This method has been tried and proven to be workable by other researchers in related 3D imaging field [3]. The method uses Ferroelectric Liquid Crystals' fast switching capabilities to act as the transient parallax barrier which thus enables angular sweeping yet without the complexity of micromechanics in digital micro mirror devices as applied in [2]. An improvement of this approach is to use Quick Response Liquid Powder Display Technology as it overcomes FLC shutters' current drawbacks.

Quick Response Liquid Powder Technology from Bridgestone Corp. has two most distinguishing characteristics that make it more than a qualified candidate for the crucial role of fast switching Transient Parallax Barrier. For one, it is a real barrier with highly tunable high light absorbing characteristics and second, it has switching speeds in the ranges of hundred times faster than regular liquid crystals. Both these capabilities have already been proven and documented[x].

Figure. 3



Plastic substrate based QR-LPD Structure
[Credit: Bridgestone Corp.]

This structure forms the basic core of the critical quick response transient parallax barrier. Modifications are also proposed to make this structure even more suited for the herein proposed design function.
[DIAG OF MODIFIED STRUCTURE HERE]

The above are the main concepts, among others, that are going to be applied in this proposed Transient Parallax Barrier 3 D Liquid Crystal Display design.

Amalgamating Technologies

With the major components of the technologies applied in the proposed design covered, a basic treatise of the mathematics involved and basic physical structures are now dropped in place.

The most crucial aspect of the proposed Multiple Viewer Transient Parallax Barrier Super Multi-view 3D Display design is to be able to provide as many viewing points as possible where the viewers can simultaneous see images in 3D. In order to achieve this, using active parallax barrier methods, a very fast FLC or DMD Rear Projector and a very fast switching parallax barrier material is obviously needed to be able to project stereo pairs of 2D images to desired viewing points. Very fast projectors are usually not the problem but fast enough practical parallax barrier material usually is. In this case we propose to work with the recently developed and proven Quick Response Liquid Powder technology from Bridgestone Corp. whose quoted switching time has been verified to be under 0.2msec. Thus $0.2m\sec = 0.2/1000 = 0.0002\sec$ hence the Switching frequency in Hertz would be $f = 1cycle/0.0002\sec = 5kHz$. However, in order to get a smooth displayed video image each rear projected stereo-pair of 2D images should be displayed at the normal acceptable video refreshing rate of 60Hz [2]. Therefore the number of stereo-pairs that can be displayed at this rate is $Number\_Of\_3D\_View\_Points = \frac{5kHz}{60Hz \bullet 2} = 41$

This is a considerably high number compared to current maximum of 9 views for parallax barrier/lenticular lenses type of 3D FPDs. Obviously more than sufficient for a typical Home Theater Family Environment 3DTV application.

The next step is to come up with a way to actually distribute these viewing points and how to handle them on the display and active transient parallax barrier. There are several mathematical models and derivations available in the literature, however, for our case we chose the highly dynamic algorithm & method proposed and experimentally proven at NYU's Media Research Lab [4] [5]. The algorithm was also modified and enhanced in order to take into account the super multi-view boundary conditions.

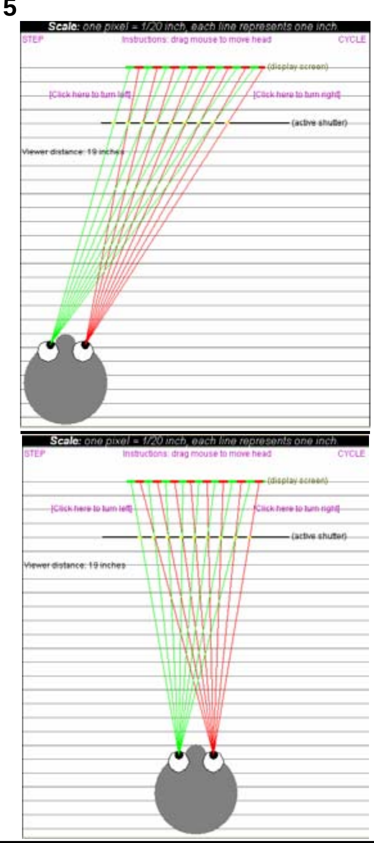
Computed Simulation Results

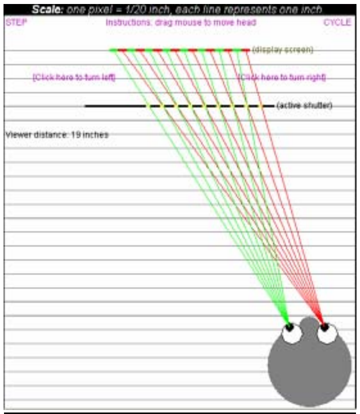
The simulation results illustrated below show the relative distribution of views, parallax barrier shutter openings and stereo-pair pixel image positions for multiple simultaneous viewers.

The Added Value & Impact

Impact on (i) NYU Media Research Lab's 3D Display Mathematical Algorithm to become 3D Super Multi-View capable.(ii)Larger number of simultaneous 3D views on low cost parallax barrier platform.(iii) A technologically capable alternative 3D Display design incorporating the unique desirable properties of the new QR-LPD as the Active Parallax Barrier for Thin 3DTV.(iv) Realization of the elusive low cost approach for a commercially justifiable number of multiple viewer 3DTV, among other applications.

Figure. 5





Time Multiplexed Simultaneous Views From Hybrid Projection QR-LPD 3D Display Screen Sequence

Reference

1. Toshio Honda, Daisuke Nagai , Masaya Shimomatsu "Development of 3-D display system by a Fan-like Array of Projection Optics" *Proc. SPIE* Vol. 4660

2. Jun Yan, Stephen T. Kowel, Hyoung J. Cho, Chong H. Ahn, Gregory P. Nordin, and Jeffrey H. Kulick "Autostereoscopic three-dimensional display based on a micromirror array" *Applied Optics* Vol. 43, No. 18 20 June 2004

3. Christopher W. Connor, Neil A. Dodgson, E. Moore, Timothy D. Wilkinson, Adrian R.L. Travis. "Design of an autostereoscopic endoscope for abdominal surgery" January 1999 *SPIE* Vol. 3595

4. Ken Perlin, Salvatore Paxia, Joel S. Kollin, "An Autostereoscopic Display" SIGGRAPH 2000 *Conference Proceedings*. New Orleans, Louisiana. July 23-28, 2000.

5. Ken Perlin, Chris Poultney, Joel S. Kollin, Daniel T. Kristjansson, Salvatore Paxia, "Recent Advances in the NYU Autostereoscopic Display" *Proceedings of the SPIE*, Vol. 4297. San Jose, California. January 22-24, 2001