# Creating of autostereoscopic displays with random lenticulars by hyperview approach

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A micro lens array for an autostereoscopic display is usually calculated and manufactured according to certain pixel dimensions. Because of the fixed design, such a lens sheet cannot used for other pixel sizes. But by using a huge amount of perspective views within the hyperview screen matrix, it can be demonstrated that random lenses can be used for different pixel sizes.

## 1 Introduction

The viewing conditions of autostereoscopic displays are mainly defined by the design of an optical array and the pixel properties of the underlying flat panel display. To achieve the desired viewing situation, a certain number of perspective views is projected in an optimum viewing distance, which is known as "sweet spot".

As in this arrangement the lens is designed according to the pixels, it is quite unlikely that the same lens may fit into another 3D display arrangement with other pixel dimensions. On the other hand the diamond milling of the manufacturing drum for lenticular sheet production is relatively expensive and non recurrence engineering (NRE) costs applies with every new design.

To reduce these NRE's, it is might be desired, to use the same lens for different pixel sizes and viewing distances.

It will be shown that this result can achieved by calculating a huge amount of (virtual) perspective images with very low resolution within a precomputed combination rule (Hyperview matrix).

## 2 Application restrictions of a lenticular sheet

A common 3D display consists (at least) a pixel based flat panel display and an optical overlay (i.e. a lenticular lens array) mounted straight on the panel surface or in a certain distance

This lenticular can be placed in front of the display in straight or slanted arrangement in front of the pixels. As in an "of the shelf" lenticular the focal plane is usually located at the optical flat and in front of an LCD there is always a cover glass, the lens sheet must be reversed to bring the pixel plane into focus.

For adjustment of an existing lenticular to certain pixel sizes, there are only a few parameters which can be changed. In **Fig. 1** the lens is placed in the distance *z* front of a flat panel display. It is obvious that this distance can't be shorter than the thickness of the cover glass and not much longer than the focal length of the lens. But as the screen size $d_S$ and the lens pitch $d_L$ is fixed, the only changeable parameter to adjust the lens to the pixels seems to be the observers distance $a_O$.

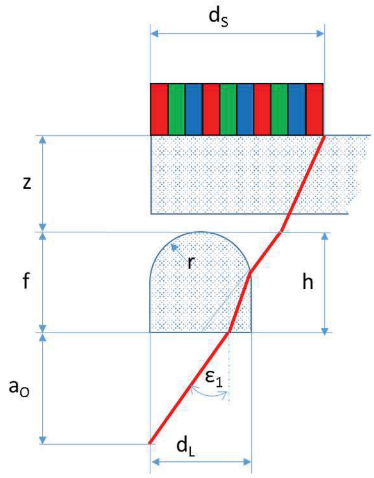


***Fig. 1*** *Adjustment parameters for existing lenticulars*

However, the observers distance is one of the key input functionalities of a 3D display, so there is only a little margin for change. As mentioned, it is also possible to slant the lenticulars (**Fig. 2**). The slanting angle is often used to reduce unwanted moiré effects (i.e. Philips [1]), but can't reach high values to avoid the loss of 3D impression. The influence might be not strong enough for a perfect match of pixel and lens.

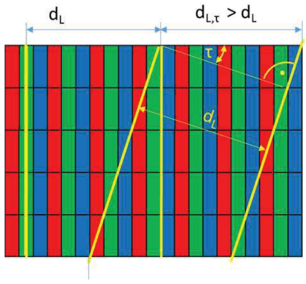


***Fig. 2*** *Slanted lens*

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In result of this observations, the application of an existing lenticular is restricted. The only other option is now to adjust the screen image.

## 3 Hyperview matrix

The initial purpose of the Hyperview matrix was the combination of more perspective views within the screen image [1] to improve the quality of a 3D presentation. Now the same matrix can be used to create virtual pixel sizes to introduce the ability to adjust a lenticular to the screen.

A Hyperview matrix is a 2dimensional description of all perspective views for the screen image of a 3D display. As every single subpixel could contain a different part of a perspective view, a Hyperview matrix can contain millions of different values.

The filling of a Hyperview matrix can be done by a simple equation, derivated from the 2dimensional form of the “universal 4dimensional formula” [2]. If any accessible element represents a perspective view $v_{x,y}$, the full matrix can be described by the two parameters $q_{AX}$ and $q_{BY}$.

$$v_{x,y} = mod(x \cdot q_{AX} + y q_{BY}, n) \qquad (1)$$

In this equation $x$ and y are just the position indices and $n$ is the total number of views.

## 4 Hyperview rendering

The perspective images can be rendered with any rendering program in principle. However rendering of thousands or millions of high resolution images could be time consuming. To speed up the process, the hyperview matrix can be used as “instruction set” for a renderer, to command the program to render only certain pixels from the camera positions according to the views stored in the matrix cells. This has be done here with the program “Renderjet”.

On the left in **Fig. 3**, the turntable setup for the rendering process is illustrated. The Hyperview matrix commands the renderer to calculate only the pixels from the cameras within the angle $\alpha_{n,active}$. By using this type of rendering and GPU parallel processing, the pixels can be directly drawn on the screen in real time. One the right of **Fig. 3**, there is a screen shot of the screen images calculated with a software from called “Renderjet”.

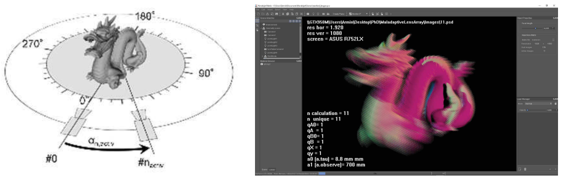


***Fig. 3*** *Turntable setup and screen image*

To create a 3D display, beside the content and the display, a 3D lens must be placed in front of the screen. By using a random lenticular (i.e. a cheap lens sheet used in 3D printing), the pixel size will most likely not fit to the lens pitch. In the following images, a standard lens sheet (Finnlens® 40 lpi) was used together with a screen pixel pitch of 0.1989 mm. Photographs were taken from 700 mm distance (**Fig. 4**). The q’s has been expanded for better explanation: $q_{AX}=q_A/q_X$, $q_{BY}=q_B/q_Y$

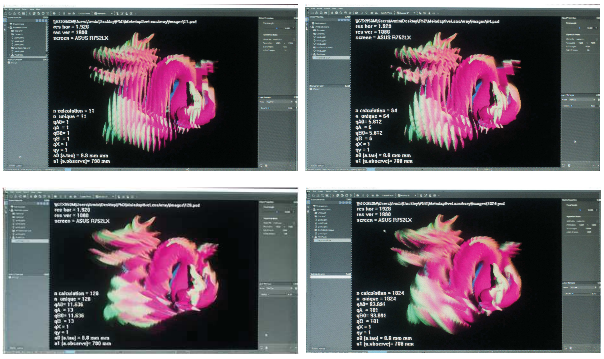

***Fig. 4*** *Lens induced moirés*

Just by a little change of $n$ and the $q$`s (with $q_A=q_B$), the moirés fading away by a higher number of views. If $q_A \neq q_B$, a perfect match of lens and pixels can be created which delivers a nice 3D impression (**Fig. 5**).

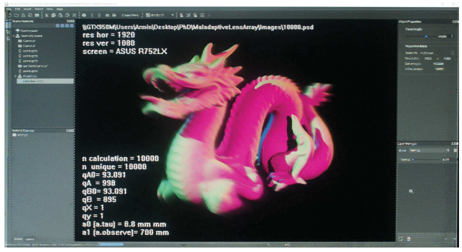

***Fig. 5*** *Perfect match*

## 5 Conclusion

The Hyperview approach has the potential to combine almost every optical array (i.e. micro lenses, lenticular, pin holes, zone plates, parallax barriers) with a wide range of flat panel displays to create an affordable 3D display by computational imaging without the need of expensive hardware.

A very high number of views allows perfect pixel matching and an adjustment of random or misaligned 3D lenses.

The Hyperview rendering process can be done in real time.

## References


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