DaaS
Display as a Service

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ABSTRACT

5G is available and 6G is raised up from the Horizon. Those are creating new infrastructure in human life. XaaS is the activity to accommodate the all social previous systems to fit in new infrastructure in 5G/6G era. All display activity from R&D to Marketing must adapt to the new infrastructure as a DaaS, Display as a service. Since microdisplay was born, it has realized whole picture as a virtual world in front of human eye by the VR Glass. The display role has been changed. Now the display product is not just working the functional device but giving whole environment ruling the human life. At the Cambrian explosion, the creatures having eyes have been evolved drastically by learning real world. So the human can have whole changing world by VR glass may be evolved in totally new world. This study gives what is the new direction of the display. What is the new point of view for future new microdisplay with optics.

1. Introduction

The 1st industrial display CRT was developed in 1897. And about 70 years after, the LCD was developed by RCA in the 1960's. First LCOS as a microdisplay was announced by GE in 1970.

Since then, the VR concept with microdisplay with high magnification optics to covers all human sight by VR headset have been considered to create whole new world to realize as a new vision to the world as a virtual reality.

2. Cambrian Explosion

The earth was born 4.6B years ago. 1st 4B years, the creature was just simple cellular creature. But about 0.5B(500M) years ago, the Cambrian explosion happened. The variety of the creature in land, sea and sky were explosively born because the creature had "THE EYES" developed from a part of brain. Now since VR headset using microdisplay was created, human may see the virtual world which gives new concept for human by human brain. And human would create whole new world like next Cambrian explosion.

3. EYE

The whole outside object, which human can see, is projected through pupil and focused on retina. The whole retina has about 120M "Rod" nerve which senses just black and white contrast and brightness and 7M "Cones" nerve senses color. However, in the area of fovea, which focused the image, has only 7000 nerve combined Rod and Corns. The vision information trapped by 7000 nerve is converted by electrical signal in a brain. And these electrical signals are separated into digital signal and analogue signal in center of brain and combined again in back of the brain with several other brain information. About 100deg of human FOV area from the eye is called "peripheral vision" where human recognizes very low resolution. About 30deg of FOV is called "central vision" where human sees less focused image and not high resolution. Purely focused area, where human recognizes, is only 2deg FOV called Foveal Vision. The reason why human can recognize the whole sight is because human brain is rendering the whole image with helping by human eye's constant vibration called Micro saccade,

So when the image capture by the eye is exceed the brain data process ability, human brain cannot work properly. Then how does human brain work in VR environment?

4. As a human eye perception, how the eye catches the image?

4.1. Is the minimum resolution of human eye recognition surly one arcmin?

We are saying the human eye recognizable minimum resolution is one arcmin by 20/20 eye.

Please see Campbell Robinson Contrast Chart in Fig.1. In the left picture, there is the boundary of eye. Recognition in contract vs special frequency.

And Fig.2. is normalized Fig 1 and shows the relation of the eye MTF vs special frequency.

The one arcmin=60c/ degree is getting almost 0 MTF which is the area where human cannot recognize the contrast.

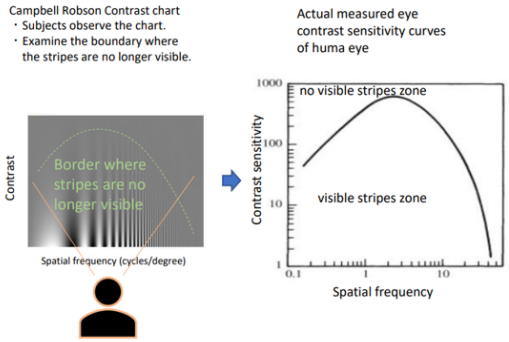


Fig 1: Contrast vs recognizable resolution by human eye

To formulate the contrast curve (Barten model).
Normalize it and define this as the MTF of the eye.

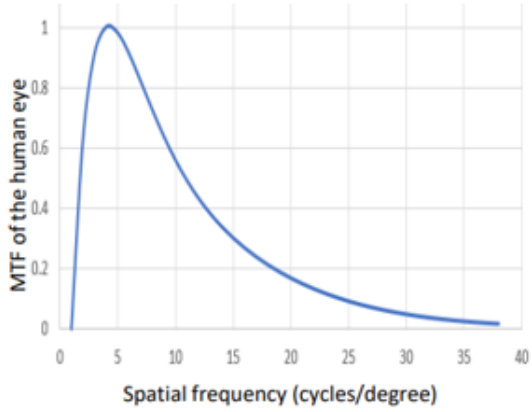


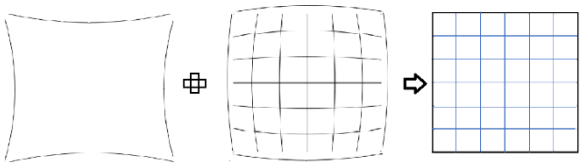
Fig 2: Normalized human MTF and Spatial Frequency

It is dependent on human ability. But even 30c/degree about equal to 2arcmin, the contract is only 5% which may be minimum human eye recognized level.
One arcmin is almost 0MTF to the eye. But it is totally individual people's ability.

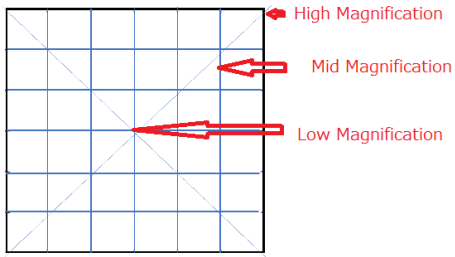
4.2. The image of microdisplay must goes through optics to enlarge the image.

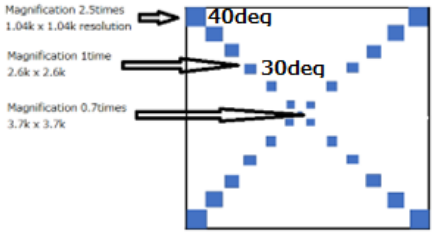
4.2.1. Displayable resolution to the eyes through over FOV 80deg optics.

The optics over FOV 80deg has a distortion. Normally the optics shall have so called pin cushion distortion. So the display image must compensate this pin cushion distortion of optics by Barrel shape display to get the square image to the eyes.



However, since optics has a distortion, the magnifications are differed in each location. Outer edge is higher magnification. Mid area is medium magnification. And the center is lowest magnification. So, in case of 2.6Kx2.6k with FOV90deg, at 45deg from the center (outer area) is higher magnification of 2.5times. And at 30deg of Mid area, the magnification is 1time. And at the center, magnification is 0.7times.





Degree from Center	Magnification	Input 2.6kx2.6k Data
		Resolution
45	2.5	1.04k x 1.04k
30	1	2.6k x 2.6k
0	0.7	3.7k x 3.7k

So this case the data input from outside 2.6kx2.6k which is same as display resolution, at 40deg of outer area, the display resolution becomes 1.04kx1.04k resolution. At 30deg of mid area, the display resolution is 2.6kx2.6k which is same as display resolution and input data. But at the center, the resolution becomes 3.7kx3.7k. So if the 3.7Kx3.7k data is input, 3.7kx3.7k resolution, which is 1.62 arcmin resolution, can be obtained at the center of this display even by 2.6kx2.6k display with FOV95 optics.

4.2.2. By high distortion optics over FOV80, especially at the center of the display where is human Foveal vision+ area (may be about 20deg round area) by microsaccade, the higher resolution can be shown even in lower resolution display.

Degree from center	Magnification	2 arcmin (30c/deg)
45	2.5	0.84kx0.84k
30	1	2.1kx2.1k
0	0.7	3kx3k

So in the foveal vision are around 20~25deg from center of the display where mostly usable area, the higher resolution of 3kx3k with 2 arcmin by FOV95 can be obtained using lower resolution display such as 2.1Kx2.1k display incase using smaller microdisplay with higher distortion optics over FOV80.

4.2.3. Foveated Rendering

Also, in case using higher distortion optics over FOV80 and combined the input data adjustment, the data clock can be adjusted in conjunction with gaze detection by foveated rendering. This may contribute lower power consumption to save battery energy for standalone VR glass driven by battery.

5. Summery

We may need more study about the brain work with eye movement. Also, Metaverse is new area to investigate. Now microdisplay with high distortion optics combination for VR glass can create true virtual image in whole your vision not to distinguish the separation of real and virtual world. The optics of the lager FOV has a shorter focal distance which enable whole VR headset is smaller and lighter, and also the power can be adjusted in lower level by foveated rendering which contribute lower battery power for future VR standalone headset.

Realization of virtual world by the VR headset may step to next dimension of human life as a 2nd Cambria explosion. And the display evolution will be proceeding as a DaaS in 6G era.