Shape and Depth Perception in 3D displays

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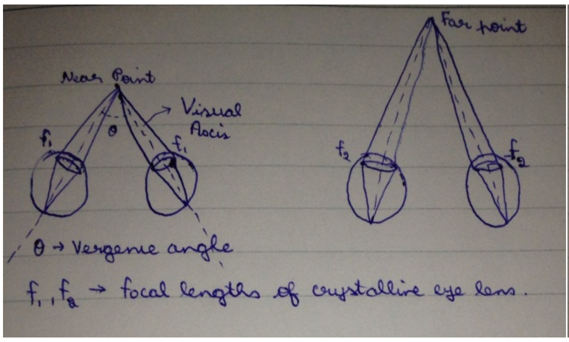
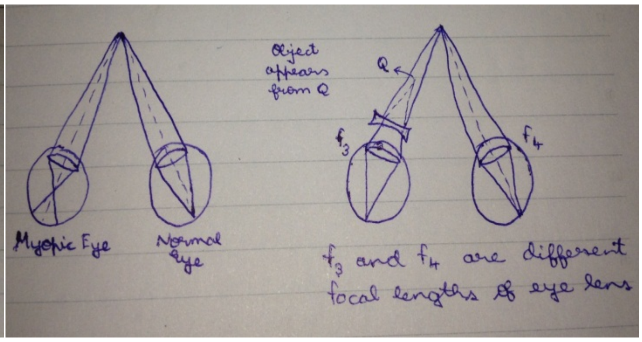
Ongoing Project

Eyes when viewing a particular scene, try to focus a 3D point in space and make an understanding of a scene. In a real world scene, both the eyes change its lens focal length equally to focus a point, which is the meeting point of the two visual axes.



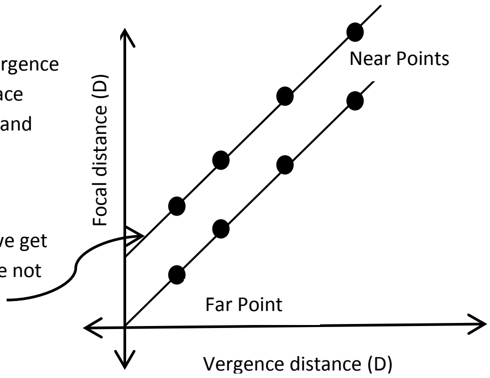


When one of our eyes becomes myopic (far point came closer), we use concave lens for that eye alone. Concave lens make a 3d point beyond the far point seeming to appear from a point that is visible with our eye while our other eye focuses the point. We can infer that focal lengths of our 2 eyes lens are different.

Our optical system faces two phenomenon- blur and disparity which are solved through self-accommodation (adjusting focal length) and vergence movements of our eye respectively.

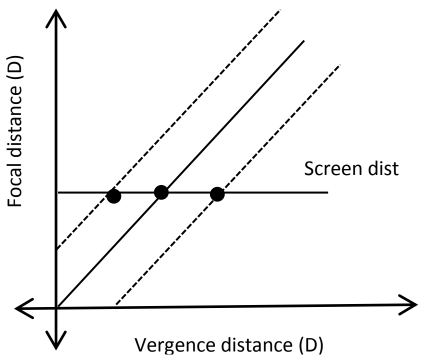
In real world, focal and vergence distances are same i.e. place where our eyes converge and focus are same.

If we put some optical correction to both eyes, we get a parallel line for the same not passing through origin.

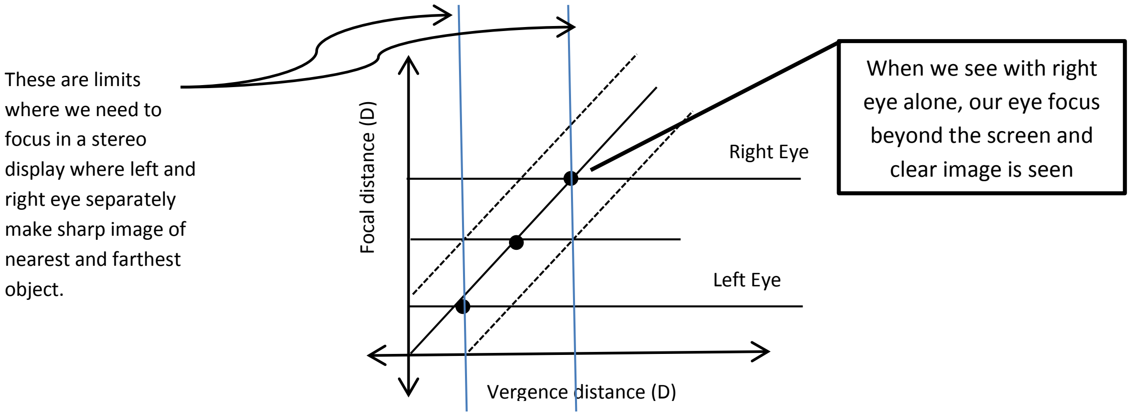


We have two eyes that help in depth perception. Generally, we have these images similar and our brain solves the correspondence problem between the images.

In a stereoscopic display, 3D visualization is tried on a 2D screen. This stereo display breaks the coupling of vergence and focal distances we saw earlier. This inconsistency is due to the constant value of focal distance (distance to the screen) and altering value of vergence distance (depending of depth of image contents in the scene).



Points oscillate between the dashed lines, which is zone of comfort, depending on image contents. Focal distance remains constant at the screen.



We can talk about vergence only when we see with both eyes. When we see with both eyes, the part that is sharp in left eye (spacial property) will be blurred in right eye and vice versa and this leads to binocular rivalry. The brain alternates between the two images irregularly (temporal property).

The difference in focal length of left and right eye lens (ΔD) used is always a constant because it is equal to width of zone of visual comfort for Binocular Vision.

1. When we look at that part of image that is sharp with left eye alone, can't our right eye alter its focal length of the eye as in the case of myopic eye to see the image sharp?
2. Can the usage of tilt and shift lens for the eyewear help in perceiving the blurred middle part? Can we use the same for the right eye when we see the left sharp part of image and vice versa?

Neural Adaption and Altering Focal length

In a stereo 3D display, if the depth of field is small enough then our eyes have the ability to adjust the vergence distance different from the focal distance to reduce the disparity. Here, the focal distance remains constant at the screen while vergence distance is varied to perceive the depth. As the depth of field increases, eyes begin to feel the symptoms of discomfort like eyestrain, headache, etc.

The above concept is the motivation for this problem. In accordance with the change of vergence distance to view the sharp image, we put up eye lens to make focal and vergence distance same. There are two effects experienced by our eyes- Dominance of eye with sharp image over the other and adjustment of focal length of the other eye to reduce the blur due to feedback system.

The eye experiences the effect of dominance due to the **neural adaption** in our brain. Our eyes learn to choose the appropriate image selection for the scene after a certain period of time. Though one of the eyes has a blur image and the other a sharp image, we perceive a sharp image. In addition to this, the eye that has a blur image tries to **adjust** its focal length different from the other to perceive a sharp image. This alteration may take some time.

Discussion: Adjustment of focal length in our eyes may take a very long time which is depended on the growth of our eye that is rare to happen in an adult eye. The case of

altering focal length differences in our eye has to be avoided. The difference always remains constant either zero for normal eye or any number for presbyopic eye.
Neural Adaption in our brain occurs to reduce the blur we perceive by deblurring operating on images of lost information.
There are two kinds of blur: optical blur and retinal blur.
There is reduction in sensitivity in our eye at high spacial frequencies due to optical limitations of the eye and spatial summation in nervous system.