Stereoscopic Vision Comfort

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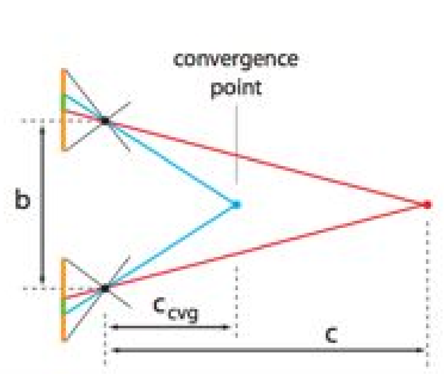
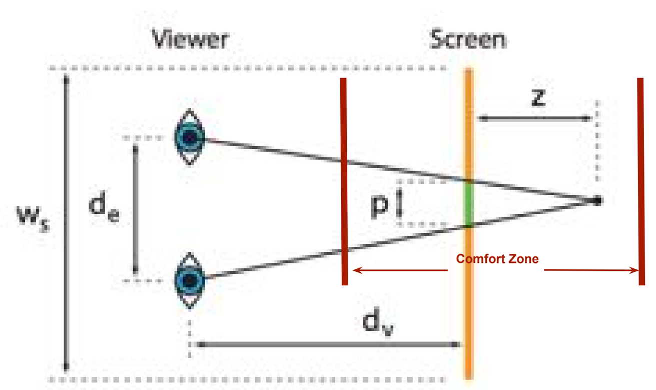
Motivation

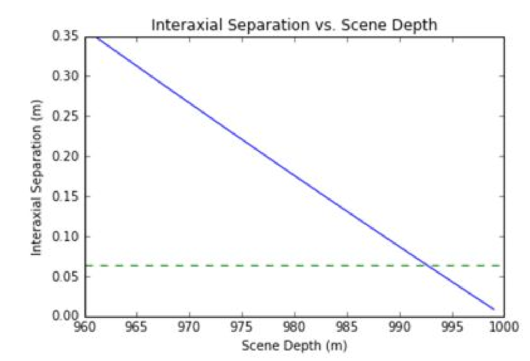
- Excessive disparities in stereoscopic content cause visual fatigue and discomfort.
- Shibata et. al determined a ***comfort zone*** around the physical display [2].
- By manipulating ***camera convergence*** and ***interaxial separation***, virtual content can be mapped into the comfort zone.
- However, mapping large distances to the comfort zone can diminish the stereoscopic effect. There is a need for a balanced approach.



Stereo capture model



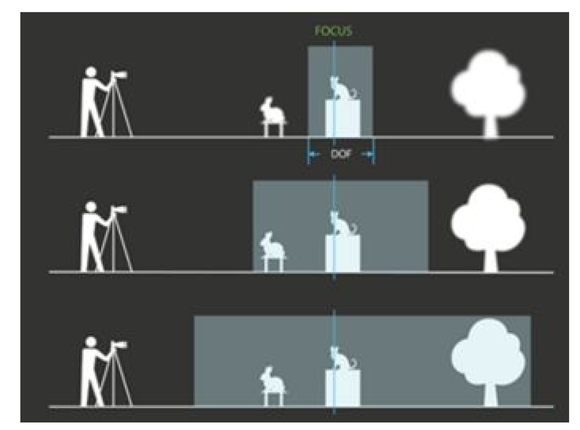
Viewer-screen model



Interaxial separation obtained after mapping volumes of increasing depth to comfort zone

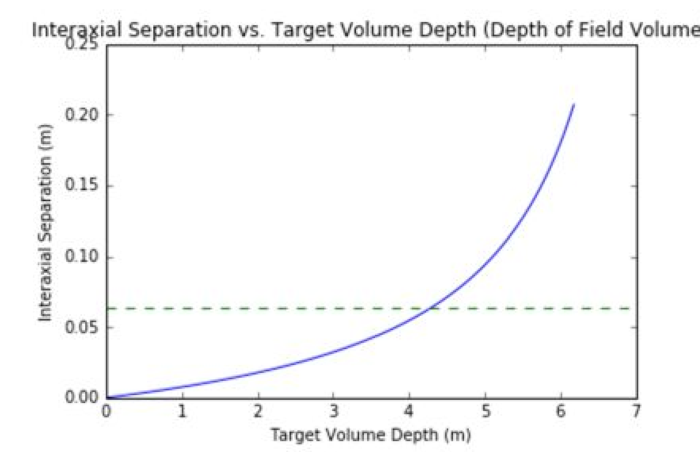
New Technique

1. In ***virtual space*** we determine the depth of field around the plane we believe the user to be focused on.



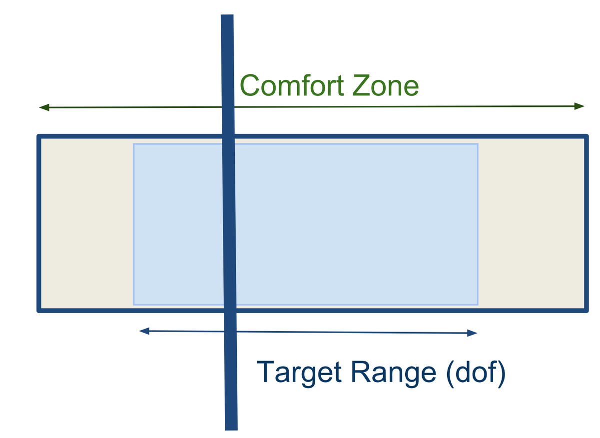
Cartoon illustrating depth of field

2. Having determined the ***near plane*** and the ***far plane*** we can determine the target volume depth that will give the desired interaxial separation.



Interaxial separation obtained for increasing target depth volumes, when field being mapped is 0.5m wide.

3. Align the volume around the screen, in the comfort zone, with margin in front so that nearby unfocused objects are also in the comfort zone



Target depth range must be aligned within the comfort zone.

4. Map the depth of field into the target depth range

$$c_{cvg} = \frac{c_1 c_2 \cdot (d_l - d_2)}{c_1 d_l - c_2 d_2},$$

$$b = \frac{c_1 c_2 \cdot (d_l - d_2)}{f \cdot (c_l - c_2)}.$$

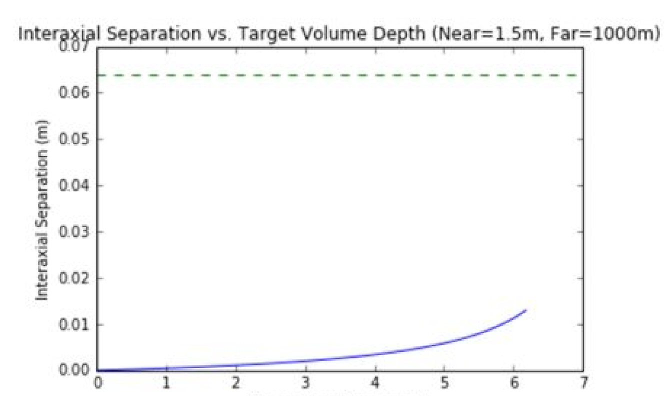
Equations used to determine stereo setting that maps the volume between c_1 and c_2 to a target volume characterized by disparities d_1 and d_2

Related Work

- Oskam et. al proposed a stereoscopic controller for real time gaming.
- The nearest and farthest scene depths are determined, and the complete range is mapped into the comfort zone [1].
- This approach aims to assist with stereopsis during interactive stereoscopic applications like games.

	Interaxial Separation (in mm)
Scene 1	5.87
Scene 2	8.42
Scene 3	5.88
Scene 4	5.90

Disparities obtained in our implementation of Oskam's approach for 4 scenes.



Interaxial separation obtained for increasing target depth volumes, when field being mapped is wide (1.5m to 1000m)

- A potential drawback: In scenes with large depth ranges (eg. near=1.5m, far=1000m) the stereo adjustment resolves to a very small interaxial distance.
- This impacts depth perception.

Experimental Results

PROPOSED approach: The method described above.
NAIVE approach: A stereo setup with interaxial distance 0.064 m and convergence distance equal to 1.7m (distance to screen). Proposed method was favored in 16/20 trials.

	Scene 1	Scene 2	Scene 3	Scene 4
Subject 1	PROPOSED	PROPOSED	NAIVE	PROPOSED
Subject 2	PROPOSED	NAIVE	PROPOSED	NAIVE
Subject 3	PROPOSED	PROPOSED	PROPOSED	PROPOSED
Subject 4	PROPOSED	NAIVE	PROPOSED	PROPOSED
Subject 5	PROPOSED	PROPOSED	PROPOSED	PROPOSED

User Study Results

The proposed method also yield larger interaxial separation when compared against those obtained With an implementation of [1] on the same scenes (see “Related Work” section).

	Interaxial Separation (in mm)		
	1st focal plane	2nd focal plane	3rd focal plane
Scene 1	13.10	-	-
Scene 2	11.73	52.89	23.00
Scene 3	20.43	23.00	125.71
Scene 4	16.02	110.84	23.00

Interaxial Separations obtained by the proposed method

References

[1] Oskam, Thomas, et al. "OSCAM-optimized stereoscopic camera control for interactive 3D." *ACM Trans. Graph.* 30.6 (2011): 189.
[2] Shibata, Takashi, et al. "The zone of comfort: Predicting visual discomfort with stereo displays." *Journal of vision* 11.8 (2011): 11-11.