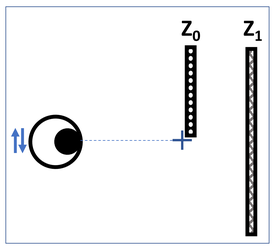
Microparallax is preferred over blur as a cue to depth order at occlusion boundaries

Dmitrii Tiron and Michael Langer
McGill University, School of Computer Science Montreal, Canada

Introduction

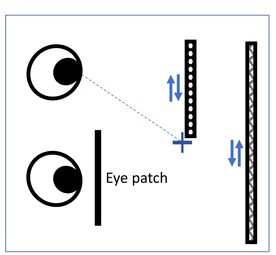
The strength of motion parallax as a cue for depth order has been studied mostly for large observer motion [1-3]. Here we examine small observer motions e.g. over a distance of less than one cm. We examine how well subjects can judge depth order from such small motions (or "microparallax"). We also consider the defocus blur cue. Previous studies of this cue have considered static images only, and have shown that this cue is unreliable [4-6]. We examined whether the cue would be more reliable when combined with microparallax.



Our hypothesis was that subject's performance would improve when cues are combined and microparallax would be the preferred cue.

Examples of motion and blur conditions:

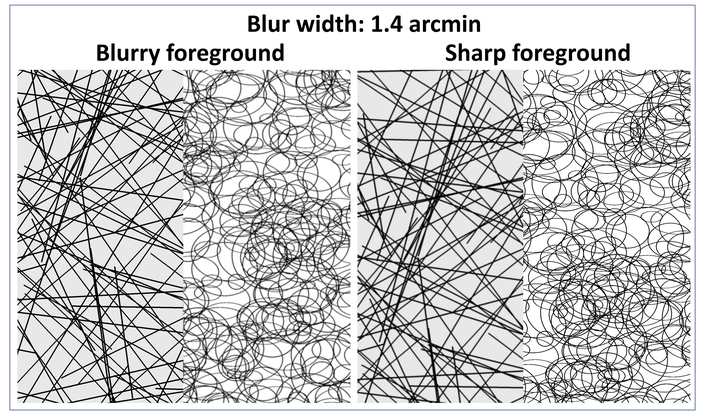
Z0 (m)	Z1 (m)	Head motion 20 cm	Head motion 2 mm	Pupil diameter 5.6 mm
		Motion parallax (deg)	Motion parallax (arcmin)	Image Blur (arcmin)
0.55	0.6	1	1	1
1	2	5	3	3
0.5	1	10	6	6

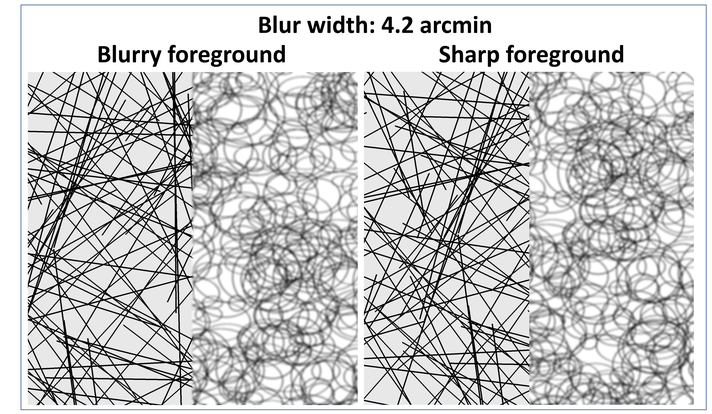


In our experiment, we used layered motion on a display screen rather than head tracking.

Method

- Equipment: 15.4-inch screen; 2880x1800
- Motion conditions:
  0, 1.4, 4.2, 6.9 arcmin
- Blur conditions (Gaussian):
  0, 1.4, 2.8, 4.2 arcmin
- 512 trials = 32 trials/condition * 4 blurs * 4 motions
- 667ms presentation time
- 25 naïve subjects
- Task: which side is closer?





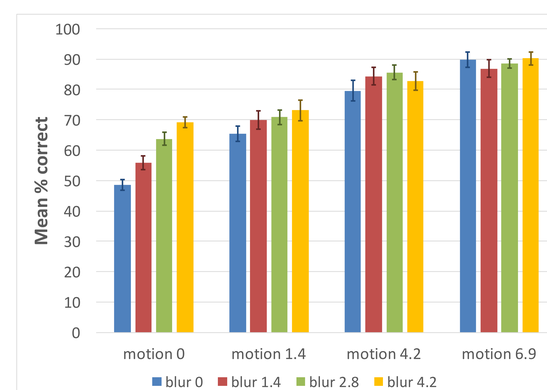
Results

- Data from 15 of 25 subjects are shown. (10 subjects were near chance for the practice set which consisted of easier conditions, namely larger motions and blurs).
- Percent correct increased with the motion distance, regardless of the blur level.
- Percent correct increased with the blur width when there was no or little motion. However, for the two largest motion conditions, blur width had no effect.
- Multiple linear regression model confirmed there was an interaction between motion and blur levels :

$$\%\ correct = 54 + 5 * (motion\ distance) + 4 * (blur\ width) - 0.6 * (CF),$$

$$\text{where } CF\ (compound\ factor) = motion\ distance\ * blur\ width$$

- Some subjects had a bias to perceive the blurred region as closer. e.g. For maximum blur level (yellow bars), subjects overall chose the blurred side to be closer in 60% of trials. (Details not shown).



In bar plot, values besides the labels *motion* and *blur* are in arcmin. Error bars represent standard error of mean.

Blur width (arcmin)	Motion distance (arcmin) 0.0	1.4	4.2	6.9	Mean
0.0	49	65	80	90	71
1.4	56	70	84	87	74
2.8	64	71	86	89	78
4.2	69	73	83	90	79
Mean	60	70	83	89	

Conclusion

- Motion parallax can be an important depth order cue at occlusion boundaries, even for very small motions that correspond to a few mm of translation of the observer.
- When motion parallax is sufficiently large, it is preferred over blur as a depth order cue. However, blur can still play a role when motion is small.

References

[1] Yonas et al, Perc. & Psych. 1987
[2] Ono et al, Perception 1988
[3] Yoonessi and Baker, JOV 2013
[4] Mather, G. Proc. Roy. Soc. 1996.
[5] Marshall et al, JOSA 1996
[6] Zannoli et al, JOV 2016

Acknowledgement

This research was supported by an NSERC grant to M. Langer.