Introduction
In natural environments, motion parallax supports both depth and distance perception.

But what happens if we do not know how far we have moved or receive conflicting information?

Prediction: Under visual motion distortion, the discrepancy between virtual and physical motion parallax affects human perception of depth and distance of an object. With increasing gain, a decrease in depth of the fold will be associated with a decrease in perceived egocentric distance.

Stimuli & Conditions

- A fold stimulus: two wall-oriented planes connected at a common vertical edge covered by Voronoi texture.
- A pole stimulus: black and yellow stripes
- Ocularity: binocular & monocular (right eye view)
- Head motion: stationary & parallax motion (across 20 cm at 0.5 Hz)
- Head motion gains: 1/2, 2/3, 4/5, 1, 5/4, 3/2 and 2
- Distances: 1.3 m, 1.4 m and 1.5 m

Tasks & Apparatus

- **Tasks** # 1: Adjust the angle of the fold until the surfaces appeared perpendicular while maintaining motion status, i.e. stationary or motion parallax at 0.5 Hz timed to a metronome beat.
- **Tasks** # 2: Upon completion of task # 1, stand still and match the position of the pole to the remembered position of the apex of the previously seen fold.

Apparatus: Oculus Rift S or Quest in Rift S emulation mode

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Analysis & Discussion

The width of both planes was varied from trial to trial by a factor of \( \omega \), so the depth is first divided by width factor:

\[
D = \frac{\text{width}}{\omega \cdot \cos \theta}
\]

Depth settings were further normalized by subtracting the individual mean:

Normalized depth = \( D - \bar{D} \)

where \( \bar{D} \) is the averaged value of \( D \) across all conditions for an observer.

Results

Fig. 1: 3D depiction of test dihedral stimulus with apertures (left image) and the test pole stimulus without apertures (right image).

Stimuli were rendered on Oculus Rift S. Observers input their angle adjustment using the hand controller.

Fig. 2: Stimuli were rendered on Oculus Rift S. Observers input their angle adjustment using the hand controller.

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- **Task # 1:** Adjust the angle of the fold until the surfaces appeared perpendicular while maintaining motion status, i.e. stationary or motion parallax at 0.5 Hz timed to a metronome beat.
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Fig. 3: 3D depiction of test dihedral stimulus with apertures (left image) and the test pole stimulus without apertures (right image).

Fig. 4: Adjusted angles of the fold, averaged across all observers. Dashed lines are stationary results (gain = 1) but plotted across gain axis.

Motion gain only impacted angle adjustments when viewed monocularly.

Fig. 5: Top-down view: possible perceptions (black) of an adjusted fold (red).

Fig. 6: Normalized depth and distance of fold averaged across all observers.

- Increasing gain decreased depth and distance settings of the fold when viewed monocularly.
- Object depth and distance were overestimated for small gains and underestimated for large gains (but less than predicted).
- Our results were consistent with the inference that observers were able to ignore extremely unnatural motions, particularly under binocular viewing.

Conclusions

- The fold was perceived as smaller and closer and adjusted to be flatter (bigger \( \theta \)) as gain increased; observers perceived the fold as more slanted than it was under large gains.
- The effect of the gain manipulation was minimal under binocular viewing.
- Humans have flexible compensatory mechanisms which make the visual system tolerant of visual/kinesthetic mismatch.
- In our study, it appears that binocular information calibrates motion parallax-defined, depth and distance cues under gain distortion.