Relationship between the Helmholtz shear of vertical meridians and disparity statistics in natural scenes

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The theoretical vertical horopter is a line passing through the fixation point and perpendicular to the horizontal plane, when the fixation is symmetric and on the horizontal median plane. However, the empirical vertical horopter measured psychophysically deviates from the true vertical, as its top inclines backward with an angle. Thus the two corresponding retinal images of the empirical vertical horopter also deviate from the theoretical corresponding vertical meridians of the two eyes. The average angle between the two empirical vertical meridians is 2 deg, which is called the *Helmholtz shear* of empirical vertical meridians. Explanations were proposed that this shear has an ecological value by bringing the ground to vertical horopter to aid in navigating the world. Further evidence was found in cats and owls. They have a much larger shear than humans, which matches their typical height and fixation distance.

We investigated the relationship between the distribution of environmental distances and fixation distances to the Helmholtz shear of the human vision system. The scene distances along the vertical median plane are especially interesting, since the empirical vertical horopter is located on the vertical median plane. We measured binocular disparities from range maps of outdoor and indoor natural scenes (Yang & Purves, 2003) along the vertical median plane, assuming the fixations to be symmetric and horizontal. We found that the disparity distribution of the vertical median plane within a 60 deg range of elevation (±30 deg below and above fixation) has a close relationship with theoretical binocular disparities between two empirical vertical meridians below eye level. The disparity distributions above eye level do not agree with the Helmholtz shear. But it is easy to prove that a closer fit exists if more fixations are deployed on the ground, which seems plausible during many real life activities.

Methodology/Approach: *Theoretical/Computational*
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