RIEMANNIAN GEOMETRIES OF VISUAL SPACE: VARIABLE CURVATURE AND HORIZON

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Abstract

Two dimensional (2D) images of light beams reflected off the objects in space impinge on the retinal photoreceptors of our two laterally separated eyes. Nevertheless, we experience our visual percept as a single 3D entity—our visual world that we tend to identify with physical world. However, experiments point to different geometries in these two worlds. Using the binocular system with the asymmetric eyes (AEs), this article studies the global geometric aspects of visual space in the Riemannian geometry framework. The constant-depth curves in the horizontal field of binocular fixations consist of families of arcs of ellipses or hyperbolas depending on the AE parameters and the eyes' fixation point. For a single set of AE's parameters, there is a unique symmetric fixation at the abathic distance such that the constant-depth conics are straight frontal lines. Critically, the distribution of the constant-depth lines is independent of such fixations. In these cases, a two-parameter family of the Riemann metrics is proposed based on the retinal topography and simulated constant-depth lines. The obtained geodesics for a subset of metric parameters include the incomplete geodesics that give finite distances to the horizon. The Gaussian curvature of the phenomenal horizontal field is analyzed for all the metric parameters. The sign of the curvature can be inferred from the global behavior of the constant-depth ellipses and hyperbolas only when for the metric parameters for which the constant-depth frontal lines at the abathic distance fixations are geodesics.

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