A Model of Binocular Gaze Estimation

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INRIA Rhône-Alpes, 655 avenue de l'Europe, Montbonnot 38334, France.

Binocular image-pairs contain information about the three-dimensional structure of the visible scene, which can be recovered by the identification of corresponding points. However, the resulting disparity field also depends on the orientation of the eyes. If it is assumed that the exact eye-positions cannot be obtained from oculomotor feedback, then the gaze parameters must also be recovered from the images, in order to properly interpret the retinal disparity field.

Existing models of biological stereopsis have addressed this issue independently of the binocular-correspondence problem. It has been correctly assumed that *if* the correspondence problem can be solved, then the disparity field can be decomposed into gaze and structure components, as described above. In this work we take a different approach; we emphasize that although the complete point-wise disparity field is sufficient for gaze estimation, it is not in fact *necessary*. We show that the gaze parameters can be recovered directly from the images, independently of the point-wise correspondences.

The relationship between binocular vergence and the resulting epipolar geometry is derived. Our algorithm is then based on the simultaneous representation of all epipolar geometries that are feasible with respect to a fixating oculomotor system. This is done in an essentially two-dimensional space, parameterized by azimuth and viewing-distance. We define a cost function that measures the compatibility of each geometry with respect to the observed images. The true gaze parameters are estimated by a simple voting-scheme, which runs in parallel over the parameter space. We describe an implementation of the algorithm, and show results obtained from real images.

Our algorithm requires binocular units with large receptive-fields, such as those found in area MT [1]. The model is also consistent with the finding that depth-judgments can be biased by microstimulation in MT [2]; if the artificial signal generates an 'incorrect' set of gaze parameters, then we would expect the subsequent interpretation of the disparity field to be biased. Our model could be tested using binocular stimuli based on the *patterns* of disparity that we describe. We note that these patterns are geometrically analogous to parametric motion fields. It has already been shown that such flow-fields are effective stimuli for motion-sensitive cells in area MST [3]; we predict an analogous binocular 'gaze-tuning' in the extrastriate cortex.

Acknowledgments

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References

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