7. The geometry of stereo correspondence

As our final example of interactions between orientations we turn to stereo. Thus far we have been considering interactions between orientations within cells driven by one eye; we now consider both of the ocular dominance bands. Abstractly this implies an important construction for the columnar machine: the ‘‘product’’ of two machines, one for the left eye and the other for the right eye. Mathematically this suggests working in the *product space* $(R^2 \times S^1) \times (R^2 \times S^1)$ and designing compatability structures that also take a ‘‘product’’ form.

We have developed such a product structure and an algorithm for computing stereo correspondences [2,54] that generalizes the tangent fields for plane curves to those for general space curves. A curve in three space can be described by the relationships between its tangent, normal and binormal [9]. As the curve moves across depth planes, there exists a positional disparity between the projection of the curve in the left image and the projection in the right image. However, there also exist higher order disparities, in particular ones in orientation. It is these types of relationships that can be capitalized upon when solving the correspondence problem. Rather than correlating left/right image pairs, we require that there exists a curve in three space whose projection in the left and right image planes is commensurate with the locus of tangent pairs, and their orientation, in a neighbourhood of the proposed match.

For the stereo correspondence problem, we are given two edge maps (one for the left camera and one for the right); each of these will be consistent (in the sense that they satisfy the monocular transport constraint); our goal now is to make them consistent with a local approximation to the space curve from which they project. Again, an osculating object is required and the one that we have derived [2] takes the form of a helix in (x, y, z). Based in this model it is possible to construct the compatibility fields that are required to facilitate responses of tangent pairs that are consistent with the same space curve. Examples of two compatibility fields are shown in Fig. 22 while the computation that results in using these structure in the columnar machine is illustrated in Fig. 23.

To conclude this section we observe that once again an early vision task, this time stereopsis, can be computed using the columnar machine when equipped with the appropriate orientation-based connectivity structure. Once again, these structures suggest a majority of connections between cells of similar orientations. Yet, connections between cells of significantly different orientations are intrinsic, not accidental. The only new aspect in connectivity that is required by the stereo compatibilities is links between monocular cells to

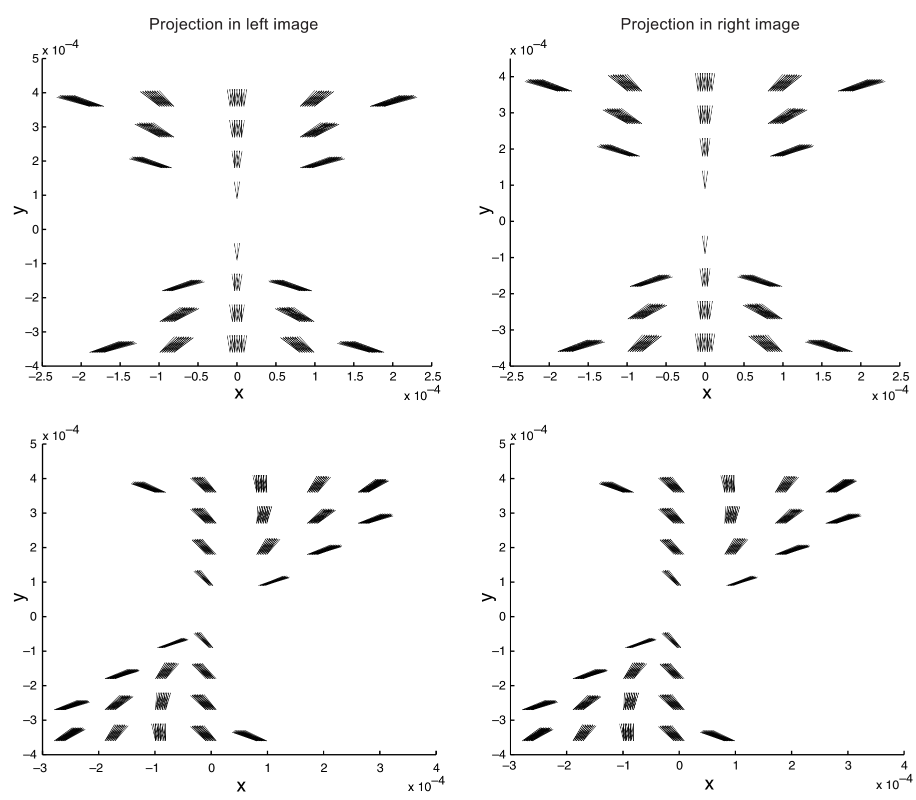

Fig. 22. Two examples of facilitory compatibility structures for stereo are shown. Note how they incorporate both position and orientation disparity; this is especially evident in the lower pair of compatibility fields which are tuned for non-zero values of curvature.