Notes and Comment

Blur patterns: A comment

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In a recent paper published in this journal (Harrington, Harrington, Wilkins, & Koh, 1980), it was argued that blur patterns, intensity gradients due to temporal response characteristics of the neuronal (retinal) elements, carry information about surface orientation (slant). While this may be true, it is certainly not true in the way suggested in the paper; the reasoning and conceptual framework upon which the paper is built is incorrect.

Harrington et al. (1980) argue that: "The lines of a blur pattern diverge or converge differently in different parts of the field of view, providing orientation information, and they also diverge and curve in specific ways during altitude changes, accelerations, and changes of observer-texture relations" (p. 293). The assumption, however, that the divergence in blurred (straight) lines produced by a rectilinearly moving observer (the main situation considered in the paper) contains information for surface orientation is incorrect. Unlike the general case of an arbitrary curvilinear motion of observer in the three-dimensional environment, in the case of a purely translatory motion the directions of the image ve-

Figure 1. The geometry of translational (relative) motion. The direction of image motion on the projection plane is independent of surface layout; it depends only on the position of the locus on the image plane relative to the location of the focus of expansion.

Figure 2. Computer-generated image velocity vectors produced on a planar projection surface by a simulation of a translating observer. The surface layout is illustrated in the inset. Observe that the direction of image motion at an image locus is determined only by the position of that locus relative to the focus of expansion (denoted by a "+"). Because the direction of the image velocity vector does not change as long as the direction of the observer motion does not change, the velocity vectors also determine the orientation of blur lines. The magnitude of each "needle" denotes the speed with which each point moves on the projection plane.

locities are completely independent of the surface layout; the information about the spatial disposition of the texture elements is contained only in the magnitudes of the image velocities, that is, the length of the blur lines (see relevant equations in Longuet-Higgins & Prazdny, 1980; Nakayama & Loomis, 1974; Prazdny, 1980). This is illustrated in Figure 1. Briefly, in a pure translation of observer with respect to a (stationary) surface, the motion of a texture element (P) is confined to a plane determined by the visual direction ($\vec{d}$) of the point and velocity vector of observer translation ($\vec{v}$). This plane cuts the pro-

Figure 3. Image velocities produced by a curvilinearly moving observer on a planar projection surface. The surface layout is the same as in Figure 2.

jection plane in a line (1) along which a given image element (Q) corresponding to P has to move. All such lines intersect in one common point: the focus of expansion (see Figure 2). It can be seen in Figure 1 that the direction of the line of image motion is independent of the distance (OP) of a given texture element to the center of projection. The divergence angle between the blur lines on the projection plane is determined only by their angular separation and their position relative to the focus of expansion (see Figure 2). Consequently, the mutual disposition of the (straight line) blur curves produced by a translating observer on the projection plane does not contain any information about the surface orientation. This can clearly be seen in Figure 2.

The situation is more complicated when the observer engages in a general curvilinear motion (i.e., when there is also a rotational component present). In this case, there is no unique divergence angle. Instantaneously, the velocity vectors of the image elements defining the blur pattern intersect at many different points scattered on the projection plane (see Figure 3).

While there is no general relation between the convergence/divergence angles of the blur lines and the surface orientation, it is not difficult to see the origin of the relationship between these angles and the estimated surface orientation as reported by Harrington et al. (1980). They confused, it seems, the static linear perspective (where, indeed, the divergence/convergence angles do carry information about surface orientation) with the effects of motion perspective. In Harrington et al.'s experiment, the viewed surface translated parallel to itself; the texture elements moved along straight lines on the plane and thus defined a set of parallel lines analogous to real parallel markings on the plane. The blur lines in the situation where the observer translates along a path parallel to the plane being viewed are equivalent to straight lines in static pictorial perspective, the difference being only in the length and the transient nature of the blur lines. Only in this special situation is there a correlation between the convergence/divergence of the blur lines and the surface orientation, but it is dictated by the laws of the static linear perspective and not by a functional relationship between the surface orientation and the direction of motion on the projection plane. In general, such a relationship does not exist.

In summary, Harrington et al. (1980) did not investigate the information for surface orientation contained in the blur patterns produced by a moving observer as they claimed. Rather, they were only measuring an equivalent of static linear perspective. Even as such, their experiment is inadequate.

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