MOTION PERCEPTION

Organized by Jim Todd and Wim van de Grind

Object Motion and Optic Flow

Eli Brenner
Neuro-ethology group, University of Utrecht, The Netherlands

Our sensation of motion is mainly based on the shifts of deformations in the image that reaches our eyes as we move around, i.e., the optic flow. Such information can give us direct access to our retina's movements in relation to the static environment. The present study examines whether this source of information on 'retinal motion' is used to evaluate object motion. In particular, whether it is used to separate shifts of the object's image on the retina that are due to motion of the object, from those due to the observer's displacements. Of course, additional information on the orientation of the eyes in the head and of the head on the body will always be required for locating objects relative to oneself, for instance in order to pick them up.

Subjects were asked to keep their eyes on a target as it moved across a stationary background on a computer screen. I examined how the speed of the target had to be changed for the target to appear to continue moving at the same speed when the background too started moving. The background consisted of a simulation of the inside of a room; depth being suggested by perspective, and occasionally stereopsis. The motion of the background either suggested rotation of the observer's eyes, or observer locomotion parallel or orthogonal to the motion of the target.

Moving the background clearly influenced the perceived velocity of the target. For simulated rotation of the observer's eyes, the perceived velocity remained constant when the target maintained its velocity relative to the background. For simulated observer locomotion parallel to the target, optic flow predicts that the perceived velocity depends on the distance of the target. However, presenting the target at different distances (by presenting different images to the two eyes) did not affect the subjects' settings: The perceived velocity remained constant when the relative motion of target and background was maintained. For simulated locomotion orthogonal to the direction in which the target is moving, the results fit the predictions on the basis of the optic flow, as long as the changes in the distances are specified by stereopsis as well as changes in perspective and size; subjects do not see the target change size, although its image on the retina obviously does. In several control conditions, the target size does appear to change, and subjects do not correct fully for the simulated ego-motion.

When judging object motion, our own movements appear to be derived from the visual information. However, the adjustments do not always conform with predictions based on the optic flow. Moreover, stereopsis also plays an important role when ego-motion changes the distance to the trajectory of the target.

The Perception of Globally Coherent Motion

Ennio Mingolla[a], James T. Todd[ab], and J. Farley Norman[ab]
a. Center for Adaptive Systems, Boston University, Boston, MA, U.S.A.
b. Department of Psychology, Brandeis University, Waltham, MA, U.S.A.

How do human observers perceive a coherent pattern of motion from a disparate set of local velocity measures? Our research has examined how ambiguous velocity measures along smooth contours are spatially integrated to obtain a globally coherent perception of motion. Observers viewed displays containing a large number of apertures, with each aperture containing one or more contours whose orientations and velocities could be independently specified. The total pattern of the contour trajectories across the individual apertures was manipulated to produce globally coherent motions, such as rotations, expansions, or translations. When the displays contained only straight contours extending to the circumferences of the apertures, observers' reports of global motion direction were biased whenever the sampling of contour orientations was asymmetric relative to the direction of motion. Performance was improved by the presence of identifiable features, such as line ends or crossings, whose trajectories could be tracked over time. The reports of our observers were consistent with a pooling process involving a vector average of measures of the component of velocity normal to contour orientation, rather than with the predictions of the intersection-of-constraints analysis of 'velocity space'.

Spatial Discriminations for Motion-Defined Form

D. Regan, S. Hamstra, X. H. Hong, K. I. Beverley,
D. Giaschi, and A. C. Kothe
Human Performance in Space Laboratory, I.S.T.S., York University, Toronto, Canada

The human visual system can achieve acute spatial discriminations for motion-defined (MD) form. In particular, the edges of a MD object can appear to be much sharper than the mean inter-dot separation (Regan & Beverley, 1984). This sharpness is not mere illusion, because the best values of vernier discrimination thresholds are similar for MD and contrast-defined (CD) dotted bars (Regan, 1986). Further, the best values of orientation discrimination (Regan, 1989) and the best values of shape discrimination (Regan & Beverley, 1984; Regan & Hamstra, in press) are similar for motion-defined and contrast-defined targets. Finally, the effects of presentation duration on orientation discrimination are closely similar (and the effects of dot lifetime roughly similar) for MD and CD bars (Regan & Hamstra, 1991). All this is consistent with the hypothesis that spatial discriminations for MD and CD form are mediated by a common neural mechanism. However, this hypothesis is refuted by recent clinical evidence obtained by requiring patients to read MD letters that are perfectly camouflaged within a random dot pattern, and are rendered visible by relative motion (Regan & Hong, 1990). Of 50 eyes of 25 patients with multiple sclerosis, 10 eyes showed elevated speed thresholds for recognizing MD letters, while contrast thresholds for recognizing CD letters were spared (Kothe, Regan, & Sharpe, in press). Of 20 eyes of 10 patients with multiple sclerosis, 9 showed elevated thresholds for recognizing MD letters, while speed thresholds for detecting the presence and for discriminating the direction of coherent motion were spared (Giaschi et al., 1991). In a study on 10 patients with brain lesions following neurosurgery this pattern of loss was associated with damage to parietal cortex.

References

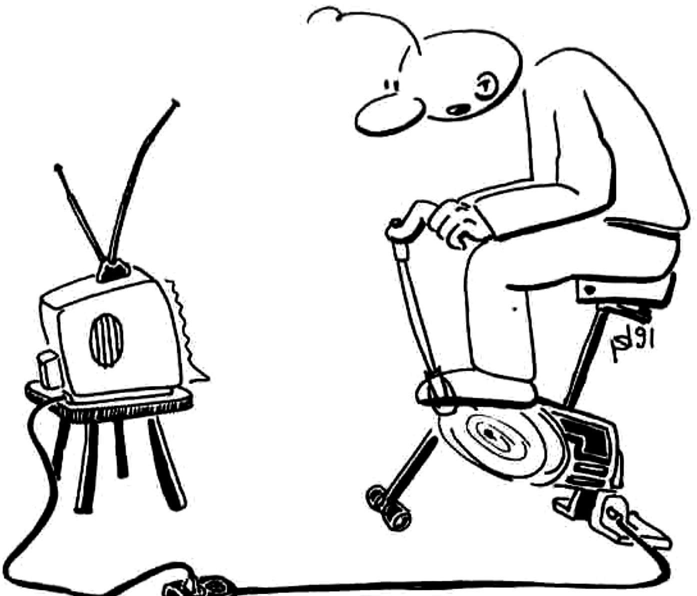
Giaschi, Regan, Kothe, Hong, & Sharp (1991). ARVO.
Kothe, Regan, & Sharpe (1990). ARVO.
Regan, & Beverley (1984). *JOSA*, *A1*, 433.
Regan (1986). *Spatial Vision*, *1*, 305.
Regan (1989). *Vision Research*, *29*, 1389.
Regan, & Hamstra (in press). *Perception*.
Regan, & Hamstra (1991). ARVO abstracts.
Regan, & Hong (1990). *Optom.Vis.Sci.*, *67*, 49.
Regan, Kothe, & Sharpe (in press). *Brain*.

Perceiving the Spatial Structure of Differential Motion

Joseph S. Lappin
Department of Psychology, Vanderbilt University, Nashville, TN, U.S.A.

Visible optical patterns are usually moving patterns. The spatial structure of moving retinal image patterns is generally believed to be a principal source of visible information about the spatial structure of objects and the spatial layout of the environment. Theoretical ideas about the underlying mechanisms often fail to shed much light on the basis for such visual achievements, however, and insufficient psychophysical evidence is available to give a clear picture of the visual sensitivity to this form of optical information.

Psychophysical evidence about visual sensitivity to the spatial structure of moving patterns has been obtained in recent experiments in which human observers detect and discriminate coherent structure in dot-patterns undergoing rapid random geometric transformations. We have found that (1) coherent structure and motion can be detected in patterns undergoing a variety of rapid random image motions—including translations, expansions, 2D rotations, 3D rotations, and additive combinations of these. Indeed, discriminability of coherent vs. incoherent motion is approximately equal to the detectability of any motion. Moreover, the visibility of coherent motion persists over varying temporal frequencies and in sets of low-contrast contours with heterogeneous scales of spatial resolution. (2) Qualitative characteristics of the differential motions of sets of at least 4 points provide visible information about the local affine structure of any smooth surface. (3) Local discontinuities of differential structure and motion are detectable in parallel—independently of the number of points and spatial area of the motion.



DRIVING THE PERCEPTION-ACTION CYCLE