- Wednesday, July 8, 1998
  Headcentric Depth Perception

3.0 Casper Erkelens, The director of the Helmholtz Institute in Utrecht, Holland gave a talk on "A computational model of depth perception based on headcentric disparity" (This summary has not yet been approved by Casper)

3.1 His thesis was that horizontal and vertical retinal disparities can only be sensibly interpreted if information about eye position is available also. If you take eye-in-head position then you can obtain "the visual direction of each point relative to the head". Using this "head-based disparity information" is potentially much more useful to a person and turns out, in a sort of recursive way, to make it easier to take eye movements into account.

3.2 There are two, classic coordinate systems, Fick and Helmholtz (and many more non-classical ones). If you imagine a line sticking out of a hypothetical eye, you can paint a Fick system by moving first up/down and then rotating left/right in regular steps. On a globe, this looks like the conventional system of latitude and longitude. In the Helmholtz system you do the left/right first. When projected onto a flat surface, the Fick has straight horizontal lines and curved up/down lines whereas the Helmholtz system is sideways with straight vertical lines and curved horizontal lines. Not surprisingly perhaps, since he is the director of the Helmholtz Institute, Erkelens chose the Helmholtz system.

3.3 Choosing a point half way in between the eyes as defining the position of the head, Erkelens worked out the headcentric disparities for each point on a fronto-parallel plane (marked up in a Helmholtz grid) for different distances. Since these are in head coordinates, eye-in-head position is irrelevant. He then calculated the azimuthal (left/right) disparity and the elevation (up/down) disparity for each point of the Helmholtz grid (which he laid out flat as the x/y plane). The azimuthal disparity varies across this x/y space, forming a curve with the largest disparities in the centre. The values (and the curvature) are largest for close objects. The elevation disparity does not vary either across the x/y space or with distance.

3.4 Errors in eye position (necessary to calculate the disparities and the directions) lead to systematic distortion of these relationships. Erkelens showed that errors of horizontal, vertical or cyclotorsional (rotation around the line of sight) eye position information in either the vergence or version systems (ie. six combinations) produced six distinctive distortions in the distribution of elevation disparities.

3.5 By integrating over the whole field it is theoretically possible to identify the extent of all six of these distortions in a given view, calculate the amount of eye movement that caused them and correct for them. But can the system do this?

3.6 Erkelens presented subjects with various large visual displays containing such distortions as vertical shear, changes in vertical scale or various vertical disparity distortions. He them compared performance with the predictions of conventional retinally-based disparity models and his own head-based disparity model. Subjects had to identify the visual direction of points in the image.

3.7 Relying on retinal disparities alone would result in predictable distortions for some of these manipulations. It turned out that performance was not very good and did not directly support either model. But at least the head centric model is THEORETICALLY good because it removes vertical disparities and the perceptual distortions that they would otherwise introduce are not seen perceptually.

Casper Erkelens