A Neural Network Model for Computing Depth from Stereopsis.

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Disparity between corresponding retinal locations provides information only about position relative to the plane of fixation and does not by itself give an accurate evaluation of depth in a viewer-centered coordinate system. In principle, other cues, such as vergence angle, can be used to determine depth when combined with disparity. Helmholtz showed that vergence by itself is not the primary depth cue used by the visual system, but these experiments do not rule out a possible role of vergence in normal viewing conditions. Interestingly, in monkeys, eye position is known to modulate receptive fields at all stages along the visual pathway, from the LGN up to the parietal cortex. However, it is not known whether eye position can modulate the selectivity of neurons to disparity.

Neural network models have been used to predict the response properties in populations of neurons underlying sensory and motor transformations (Zipser and Andersen, Nature 331, 679, 1988; Lehky and Sejnowski, Nature 333, 452, 1988). We have developed such a network model for representing depth from disparity and eye position. The feedforward network had three layers of processing units. A set of input units coded disparity in a distributed manner similar to that in the visual cortex, where a continuum of near, tuned and far neurons have been found, and one unit in the input layer coded eye vergence angle. The output layer was trained using the backpropagation algorithm to predict depth from eye position and disparity. The disparity tuning curves of the hidden units in the middle layer of a trained network could be classified along the same continuum of near, far, and tuned neurons. The eye position modulated the amplitude of the response of all the hidden units but not their general selectivity. For example, a near cell for one eye position remained a near cell for all other eye positions although the amplitude of the response changed with position. This prediction can be tested directly by single-unit recordings in the visual cortex of behaving monkeys.