MH3 Extracting 3-D curvatures from images of surfaces using a neural network

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A network which extracts principal curvatures and orientations from images of simple surfaces using shading information was constructed with the backpropagation learning algorithm.[1] The surfaces were elliptic paraboloids with a parabolic cross section in depth, an elliptical cross section in the fronto-parallel plane, and a Lambertian reflectance function. The network finds the principal curvatures and directions at the centers of the surfaces over a wide range of values for those parameters, independent of illumination direction and the location of the center. Input is mediated by convolving the image with a hexagonal array of input units with overlapping circularly symmetric Laplacian receptive fields. Output is represented in a distributed fashion in the joint activities of a population of units whose sensitivities are 2-D Gaussian functions in a curvature-orientation parameter space. During learning, a variety of oriented and nonoriented patterns form among the inhibitory and excitatory synaptic weights associated with the hidden units, which are located between the input units and output units in the three-layer network.

We conclude that neurons which can extract curvature can have receptive field properties similar to those which were previously interpreted as bar or edge detectors. **(12 min)**

1. D. Rumelhart, G. Hinton, and R. Williams, Nature London **323,** 533 (1986).