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## **Pyramid Image Codes**

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All vision systems, both human and machine, transform the spatial image into a coded representation. Particular codes may be optimized for efficiency or to extract useful image features. We have explored image codes based on primary visual cortex in man and other primates. Understanding these codes will advance the art in image coding, autonomous vision, and computational human factors.

In cortex, imagery is coded by features that vary in size, orientation, and position. We have devised a mathematical model of this transformation, called the Hexagonal oriented Orthogonal quadrature Pyramid (HOP). In a pyramid code features are segregated by size into layers, with fewer features in the layers devoted to large features. Pyramid schemes provide scale invariance, and are useful for coarse-to-fine searching and for progressive transmission of images.

The HOP Pyramid is novel in three respects: 1) it uses a hexagonal pixel lattice, 2) it uses oriented features, and 3) it accurately models most of the prominent aspects of primary visual cortex. The transform uses seven basic features (kernels), which may be regarded as three oriented edges, three oriented bars, and one non-oriented "blob." Application of these kernels to non-overlapping seven-pixel neighborhoods yields six oriented, high-pass pyramid layers, and one low-pass (blob) layer. Subsequent high-pass layers are produced by recursive application of the seven kernels to each low-pass layer.

Preliminary results on use of the HOP transform for image compression show that 24-bit color images can be coded at about 1 bit/pixel with reasonable fidelity. Future work will explore related codes and more detailed comparisons to biological coding, and applications to motion processing and shape perception.