# An Active Resistor Mesh Embedding Cortical Visual Processing

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In preattentive vision a vast arrays of intercommunicating, identical processes are carried out for perceiving edges by texture differences, depth mapping, computing optical flow, recovering local surface structure, segmenting images, etc. To perform these tasks in real time, analog hardware devices are required. Information is distributed, being mapped directly in the electrical variables, and computation is carried out massively in parallel with high efficiency and speed. Two steps can be distinguished when formalising these computations: 1) mapping the image onto an intermediate abstract representation by means of appropriate receptive fields and 2) arranging information in functional maps, thus generating useful image descriptors for subsequent processing. Relating these computations to the signal processing capabilities of active resistor meshes, may ensure the most efficient use of hardware. In this paper we extend the approach of [1] to not *homogeneous anisotropic meshes.* The mesh has different orientation-selective neurons organized on the same layer, to emulate the orientation domains in the mammalian visual cortex. In a discrete model, the orientation map is defined as a 2D array in which every node is associated with a preferred orientation ranging from 0 to $\pi$ radians [2]. Such orientation maps allow the fusion of information from different channels.

The starting point is an isotropic square grid network. The input image is a 2D distribution of current sources at the nodes of the grid. The shape of the node voltage response to a current impulse is similar to a Gaussian function centered around the excited node the convolution width depends on the conductance ratio (node-to-node)/(node-to-groud). To generate elongated Gaussian functions oriented along 0, $\pi/4$, $\pi/2$, $3\pi/4$ directions we consider four schemata characterized by the presence of an extra positive conductance. This resistor makes the network anisotropic and the shape of the voltage response loses its circular symmetry assuming an elongated form along the specific corresponding directions. Other orientations can be considered. By example, arranging two different schemata in a chess-board configuration, we obtain operators elongated along the intermediate directions. Spatial frequency selectivity of the whole network can be improved by resorting to Gabor-like convolution kernels. To this purpose, we add clustered inhibitory (negative) conductances along the direction orthogonal to the one to which the node is selective.

In order to design resistive networks that resemble the structure of real continuous varying orientation maps, we varied the pattern of interconnections in a continuous fashion. In this way, the voltage response of the network to a current impulse at a node presents anisotropic Gabor-like shapes with orientations varying from node to node in accordance to the orientation map. In this way, the resistor mesh, through local interconnections, can combine a limited set of operators enough to cover a wide range of features, and achieve functional interactions among the operators themselves.

The network can detect texture differences in an image using the responses of cells selective to the various orientations. If the test image is composed of repeated oriented elements, the cells in the regions of the map selective to that orientation have the strongest output. We have considered both synthetic and netural textured images. The network reveals itself particularly robust. The choice of the value of the resistances is not critical since the final orientation of the convolution kernels depends more on the topology of connections than on single resistance values.

## References

1. H. Kobayashi, et al. *IEEE J. Solid State Circuits*, 26:738-748, May 1991.
2. W.T. Baxter and B.M. Dow. *Biol. Cybern.*, 61:171–182, 1989.

S. Gielen et al. (eds.), *ICANN '93*