# Fire Together – Wire Together – Come Together


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The mechanical tension within axonal and dendritic connections has been proposed to explain structural features of the brain such as cortical folding [1]. Another feature, the structure of orientation maps, has been shown to minimize the length of horizontal connections in V1, given certain connection patterns as a function of orientation difference [2]. Other connection patterns would be length-minimized by orientation maps which have a structure that is different from that observed in biology. We take learned horizontal connections of a V1 model, and test whether their length minimization leads to a realistic orientation map.

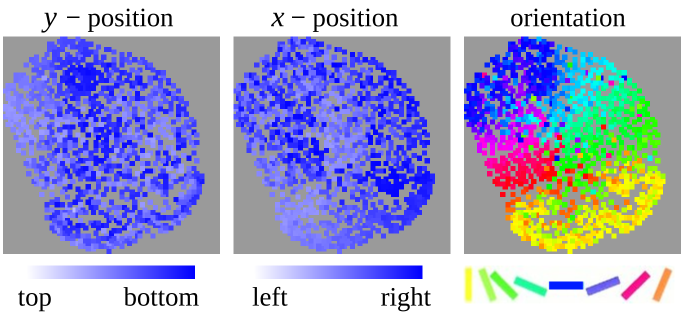
**Learning of Horizontal Connections** The horizontal weights of the model V1 constitute an associator network. They have been trained to memorize the edge detector neurons' activations $\vec{s}$ that follow presentation of natural images: initialized with $\vec{a}(t^0) = \vec{s}$ the activations $\vec{a}$ should remain stored within the recurrent activation uptate until $t^{end}$. Activation update, and learning rule are [3]:

$$\text{Activity update: } a_i(t+1) = f(\vec{w}_i\,\vec{a}(t)). \qquad \text{Learning: } \Delta w_{ij} \approx (s_i - a_i(t^{end})) \cdot a_j(t^{end-1}).$$

Hence, learning stops if the network activations $\vec{a}$ equal the upcoming activations $\vec{s}$. Such an associator network will remove noise, compute invariances, predict activations, or segment and bind via synchronization.

**Length Minimization by Cell Shifting** We modified the position of neurons on the model cortical sheet by lateral connection-dependent physical attraction. An additional distance-dependent repulsion prevents the map from collapsing into one point. This procedure performs a gradient descent on a weight length dependent energy function. After convergence, horizontally directed tension forces are in balance, i.e. forces on each neuron sum to zero. The results with 1024 neurons and a retinal input of $16 \times 16$ pixels show that the neurons arrange topographically and form an orientation map similar to a hypercolumn in V1.

The Figure shows the resulting map where each dot corresponds to one of the 1024 neurons. They have shifted into positions exhibiting local topography and smoothly varying orientation preferences. Here neuronal tension within the given weights is in balance.





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**References**


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