# RF-LISSOM model
## *development of orientation columns and ocular dominance*

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## Model

RF-LISSOM = Receptive Field Laterally Interconnected Synergetically Self-Organizing Map was designed to model primary visual cortex. Detailed description can be found in [1].

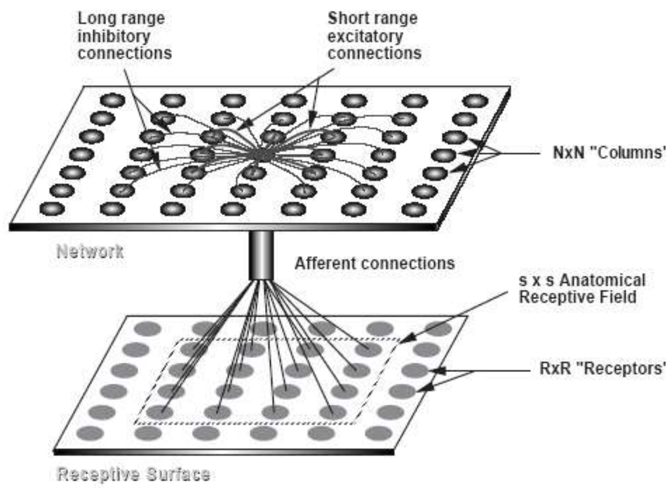


*Illustration 1* ***RF-LISSOM model*** *(taken from [1])*

## Simulation: development of orientation columns

In this case, networks is given the inputs consisted of simple images of multiple elongated Gaussian spots on the retinal receptors. After experiment a self-organization is observed.

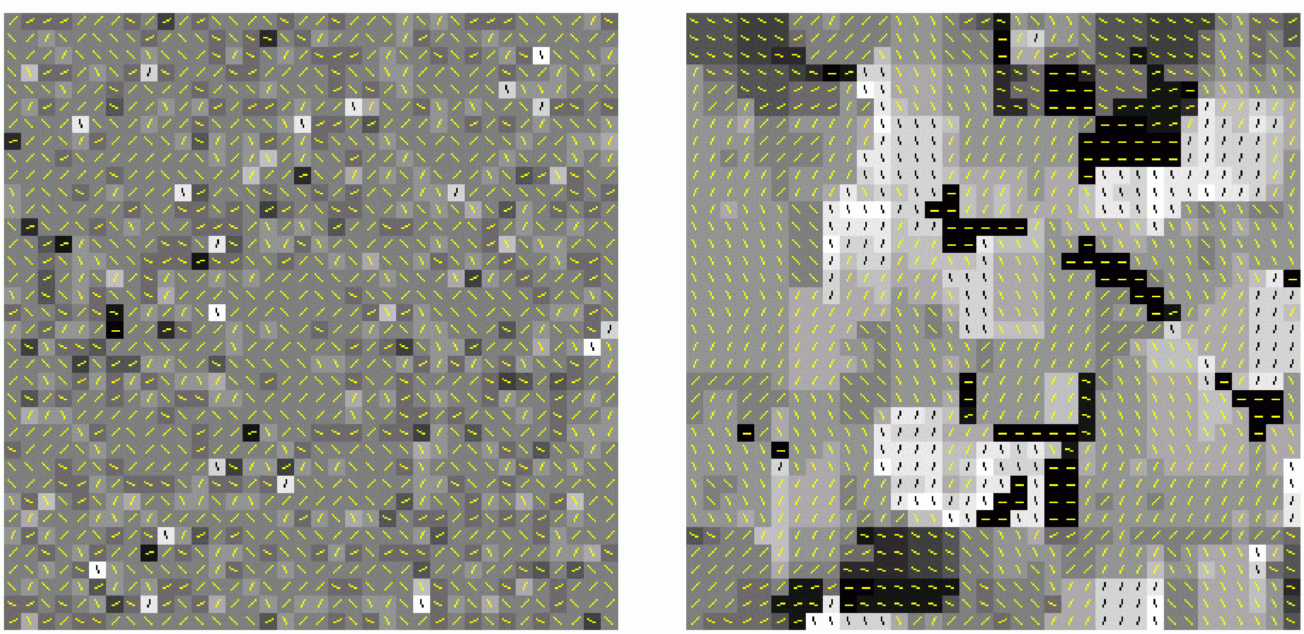

*Illustration 2* ***Initial*** *and* ***Self-Organized orientation map*** *36x36 central region of the map (72x72 neurons) each neuron in this map is shaded according to its orientation selectivity, from black 0° to white 90° a back to black 180° also yellow line in each square indicates the preferred selectivity. Every neuron was getting input from 6x6 afferent connection from retinal surface (24x24). Left fig shows the initial selectivity, right one after 15000 iterations.*

Presented results (ill. 2) were simulated on 72x72 neurons model, retina consisted of 24x24 receptors, every neuron was connected with 13x13 (or less if it was boundary) field of retina. Lateral excitation radius was 3, inhibitory one was 7. The lateral inhibitory connections were initially set to a Gaussian distribution N(0, 0.1) and the lateral excitatory connections to a Gaussian N(0, $\sqrt{15}/100$ ). The lateral excitation $\chi_E$ and inhibition strength $\chi_I$ were both 0.9. The widths of the oriented Gaussian input spots on retina were a=7.5 and b=1.5 . For every iteration, the network was give 4 steps for settling activity. The learning rate $\alpha_A$ decreased from 0.007 to 0.0028, $\alpha_E$ from 0.002 to 0.001125 and $\alpha_I$ was a constant 0.00025. The lower and upper thresholds of the sigmoid increased from 0.1 to 0.2 and from 0.65 to 0.77 . The were made 15 000 iterations. Note: increasing the learning rate, we can obtain self-organization faster but also we get unsolicited output without smooth transition between direction spots.

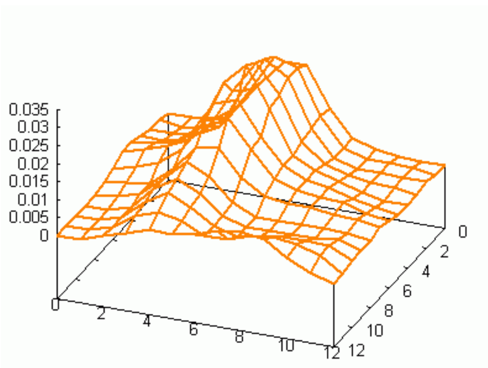


*Illustration 3 RF* ***90.01167°***

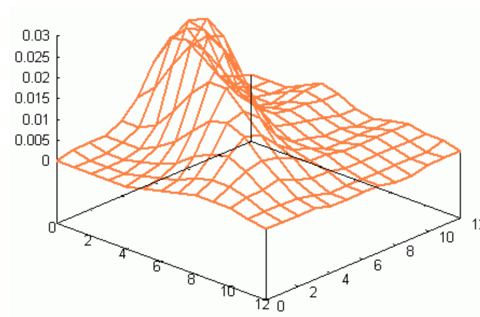


*Illustration 4 RF* ***142.4946°***

Resulting orientation map is are similar in structure to those found in primary visual cortex and results by [1]. The self-organization of afferent weights is similar as well. Some are highly selective (ill. 3 selective to 90.01167° and ill. 4 selective to 142.4946°), but others unselective (ill. 5)

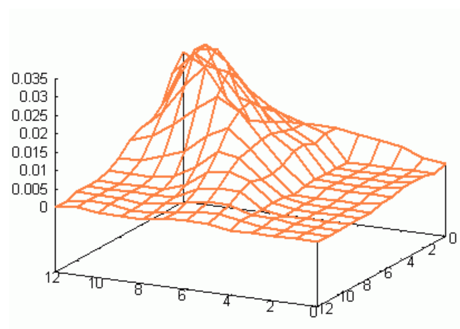


*Illustration 5* ***Unselective*** *RF*

After experiment, we have also inspected lateral weights. We have noticed, that some of them were so weak, that they have not any affect to output response. So we pruned those connections away. After pruning we have found out, that remains only these connections, that were connecting neurons with equal or similar orientation selectivity. In ill. 6 we can see remaining lateral connections after pruning weights less then 0.043 .

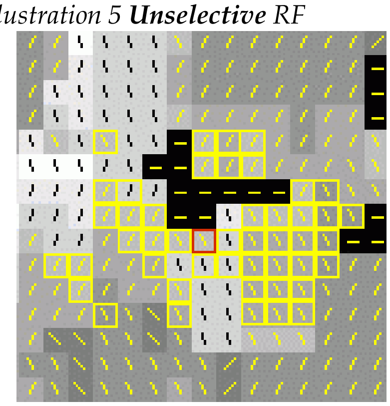

*Illustration 6* ***Lateral connections*** *central neuron marked by red square has lateral connections to those marked be yellow ones*

## Simulation: Ocular dominance

Contrary to previous simulation, we have now two retinas -- left and right -- to simulate development of ocular dominance. Most neurons have become monocular (ill. 7 and 8) but we can find binocular neurons too (ill. 9 and 10). Resulting dominance map of network is shown in ill. 11. We can observe large monocular patches. After experiment, neurons have stronger lateral connections to those with identical dominance selectivity.

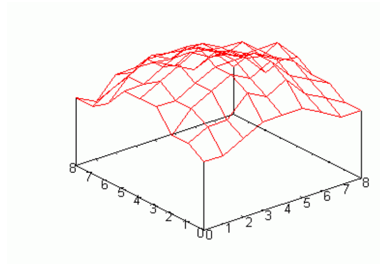

*Illustration 7 Left-selective neuron: afferent weights from left retina*

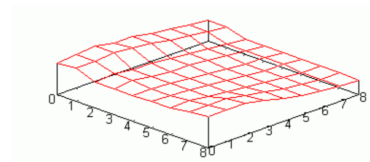

*Illustration 8 Left-selective neuron: afferent weights from right retina*

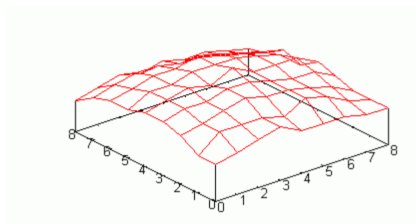

*Illustration 9 Unselective neuron: afferent weights from left retina*

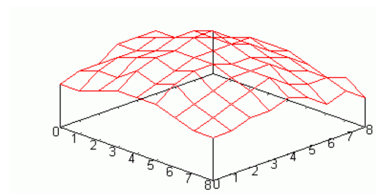

*Illustration 10 Unselective neuron: afferent weights from right retina*

*Illustration 11* ***Ocular dominance*** *-- black stands for left, white for right (left image – initial: random dominance, right image: self-organization of dominance after 5000 steps); used parameter – network 48x48 neurons, both retinas 18x18 receptors, receptive field for each neuron: 9x9, learning coefficients $\alpha$ 0.002 (all), lateral excitation $\chi_E$ 0.9, lateral inhibition $\chi_I$ 0.5, excitation radius 1, inhibitory radius 9, settling time 4 steps, Gaussian spot width 5.0*

## References

[1] Risto Miikkulainen, James A. Bednar, Yoonsuck Choe, and Joseph Siros, Self-Organization, Plasticity, and Low-level Visual Phenomena in a Laterally Connected Map Model of the Primary Visual Cortex