
Geometry in neuroscience: the example of the visual cortex

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Abstract

How does the brain process sensory information so as to reconstitute a coherent, global representation of the world (this is the "Gestalt" problem)?

Vision has been a much studied sensory system to investigate this problem: anatomical and functional experiments have provided a fairly detailed description of the visual system in the brain, at least from the retina to the primary visual cortex also named V1, which is the area in the visual cortex receiving the signal generated in the retina and processing first the "low-level" informations such as orientation of lines, contrast, spatial frequency etc. This information is however essentially of local nature. How does V1 proceed to reconstitute from that a global geometrical information? This is a typical complex system with multiple spatial scales.

I shall first present a quick survey of the current state of knowledge about the anatomical and functional architecture of V1 and its mathematical idealization. Then I shall show how coupling this geometrical setup with physical modeling of neural networks can explain how visual patterns are generated in the brain even in the absence of sensorial stimuli (visual hallucinations). If time permits I shall present some recent results about the mathematical treatment of this problem.

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