Formal models of visual perception based on cortical architectures

The model of cortical connectivity obtained as fundamental solution of the Fokker Planck equation [2,6] has been applied to the analysis of retinal images, to afford problems of grouping during the tracking of blood vessels [4]. Adding the feature of curvature and combining spectral analysis and spectral clustering algorithm, it has been possible to group different perceptual units in these images [1].

Then we have compared the results obtained through these models with functional data fMRI, in order to afford the problem of identification and reconstruction of images from fMRI activity [3,5,8]. Encoding and decoding models have been analyzed.

The first problem can be divided in two parts, the first of "model estimation" in which the model of receptive profile is estimated for every voxel; the second of "image identification" in which the cerebral activity is estimated starting from the model previously defined and selecting the image whose predicted activity is more correlated to the measured one. The estimation of the model parameters has been afforded using regression methods. In particular a modified version of the encoding model is presented, adding sparsity of the representation, a nonlinearity of logaritmic type to consider the structure of the cortex and a regularization in the Sub-Riemannian cortical structure. Through this decoding process, the identification performance of images was almost 99% and most of the representative voxels were in V1 and V2 zones.

In order to reproduce the reconstruction of the stimulus, the retino-cortical model has been used [7], primarily considering simple and artificial images. In the inverse mapping the idea consists of representing the fMRI response from the flattened cortex to the retinal coordinates. In this method the fMRI activity, obtained with the encoding/decoding model previously estimated, projected on the flattened V1 is interpreted as the image of the logarithmic function. In order to obtain the inverse mapping and so the fMRI response in retinal coordinates, we made a coordinate change using the exponential function. The results considering simple and artificial images seem very promising. The purpose is to improve the retino-cortical model in order to reproduce with this technique not only artificial images but also natural ones.

1 Bibliography

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