BMC Neuroscience

Poster presentation

Open Access

Probing the visual system with visual hypotheses

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from Eighteenth Annual Computational Neuroscience Meeting: CNS*2009
Berlin, Germany. 18–23 July 2009

Published: 13 July 2009

BMC Neuroscience 2009, **10**(Suppl 1):P356 doi:10.1186/1471-2202-10-S1-P356

This abstract is available from: http://www.biomedcentral.com/1471-2202/10/S1/P356

Introduction

The ability of our visual system to categorize objects remains, to date, a challenging field of research. Most theories fall short at explaining how our visual system is able to find consistent visual solutions even under occluded conditions, to infer illusory shapes stemming from Gestalt rules, or to construct multiple interpretations in case of multi-stable perceptions. An alternative theory is that visual recognition is an inference process relying on exploration of multiple hypotheses, and may include high-dimensional attractors as solutions to visual problems. Testing this theory requires the development of specialized stimulation techniques, allowing one to control the amount of information that is delivered to the visual system.

Methods

We considered a 2-D lattice of black dots, held in place by elastic forces. The lattice was progressively deformed by displacing the dots towards informative points of an object. Information was quantified as the energy of a local Gabor Jet. By controlling a single parameter, we could progressively deform the lattice of black dots to include more and more information about the object of interest. Sufficient deviation from the regularity of the grid allows the visual system to infer the identity of the object, while progressively smaller amount of deviation poses more difficulty for recognition.

Results

Nine subjects were exposed to several instances of objects with varied displacement applied to the grid of dots. Subjects had to rate the visibility of those stimuli on a three point scale: responses "nothing", "uncertain" and "object seen". We found that by progressively manipulating the degree of distortion of the grid and introducing progressively more information about the object, the psychometric accuracy curves and the type-of-response curves indicate a smooth transition from the unperceived to the robustly perceived case.

Conclusion

Our novel stimulation paradigm allows for a precise control over the amount of information fed to the visual system. It has the advantage that no elementary visual features are present in the stimulus, and thus the visual system may only infer the object by using the statistical deviations from the perfect grid. When little information about the object is presented, the visual system struggles to reconstruct the object by exploring several visual solutions (hypotheses), thus yielding a robust uncertainty regime fruitful for investigating the attractor-recognition hypothesis.

Acknowledgements

Research was supported by a grant of the Romanian Government: ID_48/2007, Contract Nr. 204/1.10.2007 financed by MECT/UEFISCSU and a Max Planck-Coneural Partner Group.