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Poster presentation

Modelling selective attention with Hodgkin-Huxley neurons

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Background

We develop a large-scale brain-inspired model of selective visual attention, which is a generalization of our previous developments [1,2]. The global architecture of the model includes a Map Representation Module for feature detection, an Invariant Representation Module for visual scene representation and competition among objects, and a Central Assembly Module for top-down control of attention focus.

Map Representation Module (MRM)

The input image is projected to the MRM which includes several submodules for representation of the pixel's hue, brightness, and some other visual features such as orientation and contrast; each of these submodules uses a cubic architecture. Each representation cube contains several vertical layers, and each layer is a grid of Hodgkin-Huxley neurons. There is one-to-one correspondence between input image pixels and pixels in a layer of a representation cube. Object features are passed to the Invariant Representation Module.

Invariant Representation Module (IRM)

At the second stage of image processing, an invariant representation with respect to position, size, and rotation is created. This representation enables the organization of a competition among different objects which reflects bottom-up selective attention. Each object is represented by a group of excitatory locally coupled Hodgkin-Huxley neurons. Different groups inhibit each other until only one remains active, representing the selected object. Neurons are operating near the Andronov-Hopf bifurcation. Each neuron has an independent source of noise to produce either sparse spiking or coherence resonance [3]. The onset frequency can be trained through intrinsic plasticity, which has recently been observed in experiments [4].

Central Assembly Module (CAM)

The CAM is modelled by a group of Hodgkin-Huxley neurons which also operate near the Andronov-Hopf bifurcation. The CAM controls the dynamics of neuronal groups representing objects in the IRM and modulates its behaviour to realize the top-down attention effect.

Simulations show that the system sequentially forms an attention focus selecting the most salient object (in this case we consider the size and brightness of the object). CAM modulation enables control of a scan-path where the focus of attention moves. The system also demonstrates a competition between attention energy and external disturbance, comparable with phenomena observed in psychological experiments, such as Garner effect and Stroop effect.

References

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