POSTER PRESENTATION

Population coding of ground truth motion in natural scenes in the early visual system

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As we move through our visual environment, the spatial and temporal pattern of light that enters our eyes is strongly influenced by the properties of objects within the environment, their motion relative to each other, and our own motion relative to the external world. Quantifying the distributed neural representation of luminance and motion in the early visual pathway is a critical step in understanding how scene information is extracted and prepared for processing in higher visual centers. We argue that it is important to model neural population responses to visual scenes with the rich complexity of the natural visual world. Current natural scene movies provide complex scene statistics but the uncontrolled nature of these stimuli limits their usefulness for understanding the visual code. Consequently, we have developed new image sequences of naturalistic scenes using computer graphics methods in which we know important physical properties of the scene including the camera motion, depth of objects, reflectance, illumination, etc. Additionally, we have recorded the activity of a large population of single neurons in response to these movies using a dense sampling of cells in the visual thalamus.

Preliminary analyses reveal that thalamic responses and thalamic correlated firing depends on several factors including the properties of the scene, the properties of the thalamic neurons, and the geometric arrangement of the thalamic receptive fields. Manipulation of the distribution of speed and direction of motion within the scene directly modulates the correlated firing across cell pairs in a non-trivial manner that appears to depend on more than just their axis of alignment. For some cell pairs, the structure of the spike cross-correlation was highly predictive of the stimulus manipulation (less precise for slower stimulus, shift in latency for reverse direction of motion). From a decoding perspective, therefore, these cases provide evidence for the possibility of decoding some aspects of the motion from the timing of firing activity. Although the “aperture problem” usually leads to multiple solutions to the local decoding of speed and direction of motion, decoding the activity of a population of neurons covering a larger portion of the visual scene could in principle overcome this limitation. However, measures across the entire sample suggest that the decoding process is much more complex and has to take into consideration the functional properties of each neuron such as latencies and temporal filtering characteristics in addition to the geometric relationship of the receptive fields. Taken together, our preliminary analyses suggest that controlled manipulation of the properties of the scene can provide a rich characterization of the functional diversity of the thalamic representation of the dynamic natural scene, which ultimately serves as the neural code entering primary visual cortex.

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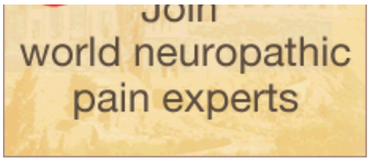

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