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Encoding visual stimuli with a population of Hodgkin-Huxley neurons

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In recent years the increasing availability of multi-electrode recordings has led to the application of neural decoding techniques to the recovery of complex stimuli such as natural scenes. A linear decoding algorithm was presented in [1] for the reconstruction of natural scenes with recognizable moving objects using recordings from a neural population of the cat's Lateral Geniculate Nucleus (LGN).

Most of the current models of encoding in the early visual system (retina, LGN, V1) consist of a linear receptive field followed by a non-linear spike generation mechanism. In [2] we considered a neural circuit architecture consisting of receptive fields in cascade with an equal number of spiking neural circuits. The neural circuits investigated were integrate-and-fire neurons and ON-OFF neurons with random thresholds and feedback. We demonstrated for the first time a decoding algorithm for natural scenes and shown its dependence on the noise level.

Methods

We investigate a neural encoding architecture for visual stimuli consisting of classical receptive fields (center surround or Gabor) in cascade with an ensemble of Hodgkin-Huxley neurons. Recovery of stimuli encoded with an ensemble of Hodgkin-Huxley neurons with known phase response curves was achieved based on the I/O equivalence between Hodgkin-Huxley neurons and Project-Integrate-and-Fire neurons in [3]. The ensemble of Hodgkin-Huxley neurons considered here is assumed to have *unknown* phase response curves [4]. We provide a visual stimulus reconstruction algorithm based on the spike times generated by the ensemble of Hodgkin-Huxley neurons and demonstrate its performance using natural video sequences (movies). Fig. 1 shows a sample time instant (a frame of a movie) of the reconstructed (left) and the original (right) visual stimulus.

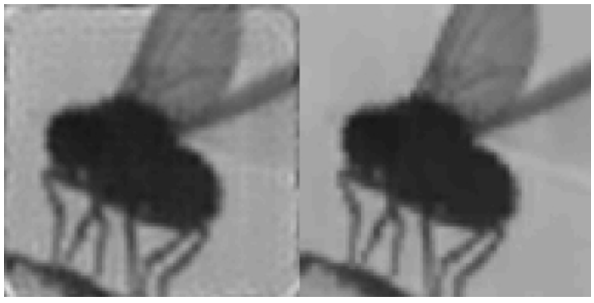

Figure 1

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