Modifying a biologically inspired retina simulator to reconstruct realistic responses to moving stimuli

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Résumé

The visual system constantly uses anticipation in everyday life. This is due to the existence of a delay between the perception of a visual stimulus and the neural responses it elicits (30 to 150 ms). Without this anticipation, a tennisman, for instance, would be unable to hit a moving ball. Neurobiologists first believed that the anticipation only happened in the visual cortex, but recent studies have shown that it starts earlier, in the retina. To better understand the state of the art and possibly propose new experiments, we are working on a retina simulator reproducing anticipation. Our simulator is grounded on recent advances in retina biology. The software is able to convert a visual scene into spike trains similar to those transmitted by the retina to the brain. It uses a three-processing-stage model mimicking photoreceptors, bipolar cells and ganglion cells. We updated the software by implementing a gain control mechanism inspired by Berry & al. (1999) in the bipolar layer, so as to reproduce motion anticipation in the case of simple trajectories. Thereafter, a second stage of gain control inspired by Chen & al. (2013) was implemented in the ganglion layer to account for two other features of motion processing : alert response and motion onset. In this case, the connectivity is ensured by the pooling of bipolar cells : each ganglion cell receives inputs from several bipolar cells located inside its receptive field. Responses to more complex stimuli (e.g. Brownian motion), however, require to add long-range connectivity. Our aim is to present the simulator and show how it anticipates motion, in simple and complex visual scenes, in comparison with experiments. Ultimately, we would like to use our reconstructed retina spike trains as inputs to a primary visual cortex simulator, and understand all the mechanisms lying behind anticipation at both levels : the retina and the primary visual cortex.

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