From Neuroscience to Engineering: a Spiking Neural Network Model of Dynamic Vision Based on Fruit Fly Visual System

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In recently years, the technologies of unmanned aerial vehicle (UAV) and autonomous vehicle (AV) have advanced rapidly. However, the visual-guiding systems of most of these technologies are energy intensive and are not suitable for power-limited small vehicles. Inspired by fruit fly's highly efficient visual system, we designed a neuromorphic system for dynamic vision and combined it with the spatial orientation memory system and the decision network for navigation. The first component of the system is a retina-inspired optical flow algorithm. It is improved from the classic Hassenstein-Reichardt detector model by the inclusion of spatial filters. The improvement allowed us to significantly reduce the required number of detectors. The second component is a motion-detection neural network. It is based on the concept of T4/T5 neurons in lobula plate tangential cells (LPTC)of the fruit flies. In the network, every motion-detection neuron has a preferred motion state and detects the motion state of image sensor through a neural competition mechanism. The third component is an obstacle-detection neural network. It is inspired by the LC11 neurons of the fruit flies and can detect small objects in the foreground. The fourth component is an object-tracking network that is inspired by the fruit fly spatial orientation memory mechanism in the central complex. It can memorize the object's motion state and reduce the computation when the motion state does not change. Our work demonstrates how knowledge in neuroscience can help with designing energy-efficient engineering systems.

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