VISUALLY-BASED NAVIGATION IN A CLUTTERED WORLD

How do humans use visual information to approach goals and avoid obstacles in cluttered natural environments? How does such a navigator compute the direction in which it is heading when its eyes and head continually move as well? A neural model is being developed by Andrew Browning, Stephen Grossberg and Ennio Mingolla in the NSF Center of Excellence for Learning in Education, Science, and Technology (CELEST) that processes image sequences from a mobile video camera to determine the direction in which the navigator is moving. This model incorporates a navigation module from earlier CELEST work by David Elder, Stephen Grossberg and Ennio Mingolla. These two models are being unified into a larger system for controlling visually-based navigation from video signals.

The present model clarifies neurobiological data about processes in the human brain that is called the Where processing stream, a subset of the visual system that is specialized for keeping track of objects of interest and our own positions in our environment. The model uses only visual information, from video and computer-generated image sequences, to compute "optical flow" and determine the path that the camera takes. The model does this in ways that mirror the operations of specialized areas in the brain's Where system. The model's computations of optic flow occur in a feedback loop that compares the model's present estimate of the camera's heading with incoming visual information. This combination of "bottom-up" and "top-down" computations makes the model's estimation of heading robust in the presence of noise, such as occurs with variations of lighting (e.g. cast shadows or glare from shiny surfaces) as a camera moves. The feedback loop is implemented in a manner consistent with self-organizing neural networks, thereby giving a method through which the model can be extended for self-calibration in an autonomous robotic system. The model clarifies the dynamics of brain cells involved in vision, while still performing well on life-like image sequences. This distinguishes our model from the majority of existing models, which either focus on brain mechanisms or on real-world applications, but not both. Figure 1 illustrates the outputs of the model.

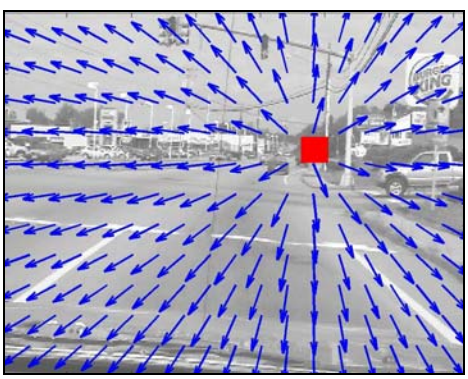

Figure 1: Example of Optic Flow Estimation (arrows) and heading determination (filled square). The Background image is a frame from a video input sequence, driving on suburban roads.

The model builds upon the motion processing equations of the 3D FORMOTION model (Berzhanskaya, Grossberg, and Mingolla, 2007, *Spatial Vision*, 20), which clarifies how the visual cortex combines object shape and motion information to generate globally unambiguous object motion signals from locally ambiguous image data. The present model is part of a broader CELES research program to track moving objects and visually navigate through a cluttered environment towards stationary and moving goals. The model contributes to the visual front-end of the system where the natural image sequences are processed, optic flow estimates are produced, and heading is calculated.