DECISIONS-IN-MOTION: Neural decision making in moving agents.

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SMEs: Cambridge Research Systems, SpikeNet Technology

The research goals of the STREP DECISIONS-IN-MOTION are to describe the neural mechanisms used to guide behaviour in complex visual scenes, in which the living (or animated) agent is in motion and navigates to avoid stationary and/or moving objects. During the first two reporting periods we have explored motion-based image segmentation in the visual cortex, and we have begun to derive neural models that explicitly make use of a hierarchy of sensory areas (low-, mid-, high-level visual areas) to extract meaningful information about the location and motion of objects in the environment. We are currently integrating the model activities to form a common model of optic flow and independently moving object (IMO) analysis. These algorithms will be integrated to guide a robotic platform and a worn assistive device for patients with neglect.

Our unique cooperation bridges neuro- and cognitive sciences on the one hand, and computer science as well as robotics on the other. Our long-term aim is to endow artificial cognitive systems with efficient, human-like, image segmentation and sensory-guided decision making. Our short-term aim is to develop and implement prototypes for research in neuromorphic cognitive systems, such as a robotic testbed for the models arising from DECISIONS-IN-MOTION. This approach should lead to improved designs of augmented cognition systems. Our approach is to model the way the primate brain exploits visual information to segment object from self motion. In a further step, we will implement these algorithms in artificial cognitive systems. Over the last two years DECISIONS-IN-MOTION has made significant progress in identifying the neural mechanisms underlying the use of local and global motion detection to provide the agent with sensory-based information for fast decision making. A recent publication by project partner NORI from Amsterdam (Roelfsema, Tolboom and Khayat, 2007) shows how sequential information processing unfolds over the first 150 ms post stimulus to determine the responses of V1 neurons to task-relevant targets and irrelevant distractors defined by differences in motion. These results demonstrate that neurons in the initial cortical processing stage (primary visual cortex, V1) are closely involved in the sensory decision process.

DECISIONS-IN-MOTION has produced a fully functioning prototype for creating a virtual environment in the functional MRI scanner. MRI-Live can monitor the participant's eye position, shifts in gaze, blinking and fixational eye behaviour during brain-imaging measurements. The device is currently being used within the project to explore the way human observers search for IMOs in optic flow displays.

DECISIONS-IN-MOTION has also developed a fully functioning robotic test platform (WP9). Project partner SSSA from Pisa has been collaborating with other partners in the Consortium to provide real-time guidance of this mobile robot. Two cameras provide simulated binocular vision with conjugated saccadic-like scanning movements to search the immediate visual scene. Our goal is to develop algorithms to detect salient features in the optic flow (local velocity vectors) of the visual scene while the agent is in motion, and subsequently use this information for target tracking. Current work efforts now focus on closing the information loop to provide the algorithms that drive the cameras and the navigation with real-time information based on optic flow and independent moving objects.

DECISIONS-IN-MOTION has made significant steps towards developing a prototype for a visual assistive device that will employ the project's common model to assist patients with visual impairments (VisGuide). Industrial partner Cambridge Research Systems (CRS) has redesigned a digital camera to output pre-convolved video images to reduce data transmission to the model used by industrial partner SpikeNet Technology. This information will be used in a prototype of a head-mounted guidance system for patients with visual field defects and neglect. Based on the project's own results from partner from the University of Birmingham (BHAM) in which brain-damaged patients perform tasks in optic flow displays, VisGuide will assist patients while they navigate in an indoor environment. Moving or stationary obstacles will be detected by VisGuide. The Common Model will decide whether to send an acoustical warning to the patient (e.g., binaural cues for obstacle location). Prior visual and behavioural testing of the patients by partner BHAM assures that prior information about the patient's visual and cognitive impairments will be available to the algorithm to promote guidance and predict upcoming bottlenecks in sensory processing (i.e., comparable to tuning a hearing aid to offset the patient's auditory sensory loss).

One of the most important long-term goals of DECISIONS-IN-MOTION is to understand how human and primate brains extract object-and self-motion cues from complex dynamic visual scenes and how this sensory information is used to guide fast decision making. This enhanced understanding of biological vision has provided the Consortium with novel insights into the challenges facing animated agents that move through cluttered environments in search of specific task-related targets.

Roelfsema, P.R. Tolboom, M., Khayat, P.S. (2007) Different processing phases for features, figures and selective attention in the primary visual cortex, Neuron