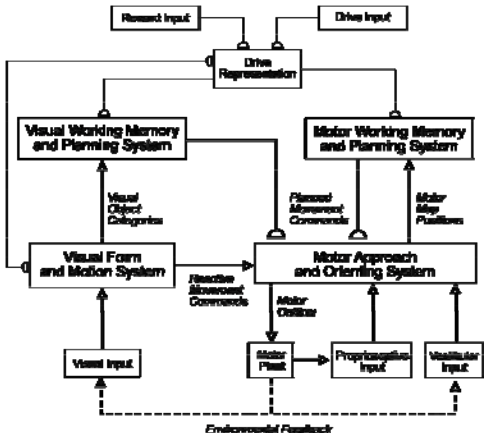
SOVEREIGN: A Self-Organizing, Vision, Expectation, Recognition, Emotion, Intelligent, Goal-oriented Navigation system

This research proposes the SOVEREIGN neural model that explains how an animal, or animat, can learn to reach valued goal objects through planned sequences of navigational movements. The SOVEREIGN model embodies a self-organizing real time control system that attempts to learn and perform such behaviors autonomously. As the name SOVEREIGN indicates, this control system unifies visual, recognition, cognitive, cognitive-emotional, and motor competences. This work, developed by William Gnadt and Stephen Grossberg, presents an end-to-end model that addresses issues within CELEST Thrust 1 (Learning in Visual Perception and Recognition) and Thrust 3 (Learning in Cognitive-Emotional Interactions and Planned Sequential Behaviors). We believe that this is the first neural model that embodies and coordinates such a wide range of behavioral competences.



SOVEREIGN's perceptual competences include on-line visual perception of a 3D virtual reality environment in which the model controls navigation. SOVEREIGN computes, in parallel, both visual form and motion information about the world. As in the brain, the visual form of objects is computed within a What cortical processing stream, whereas visual motion is computed within a parallel Where cortical processing stream. In this way, the brain can process both *what* objects are and *where* and *how* to find them.

SOVEREIGN's motor competences enable it to explore its environment for novel goal objects. During initial exploration of a novel environment, many *reactive* movements occur in response to unexpected and unfamiliar environmental cues. These movements may initially appear to be locally random, as an animal orients toward and approaches many local stimuli. As such an animal becomes familiar with its surroundings; it learns to discriminate between objects likely to yield a reward and those that lead to punishment. Such *approach-avoidance behavior* is often learned via a *perception-cognition-emotion-action cycle* in which an action and its consequences elicit sensory cues that are associated with them. Rewards and punishments affect the likelihood that the same actions will be repeated in the future.

The SOVEREIGN model thus contributes solutions to three key problems: How can an animal, or animat that embodies biologically-inspired designs, learn to balance between reactive and planned behaviors in a task-appropriate way? How can plans be learned during erratic reactive behaviors in such a way that, after learning, they can be read-out fluently at the correct times and in the correct spatial contexts? How, in particular, can an animat coordinate its reactive and planned behaviors so that its perception-cognition-emotion-action cycles of exploration, real-time vision, learned recognition, sequential working memory storage, learning of sequential plans, reinforcement learning, and planned action sequences are activated when needed as the animal navigates novel and familiar environments?