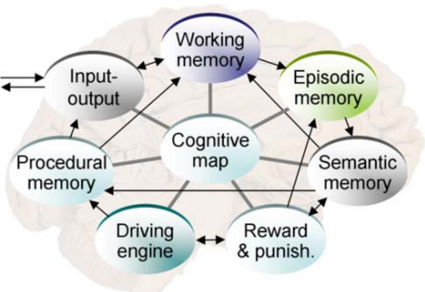
George Mason University

Krasnow Institute for Advanced Study

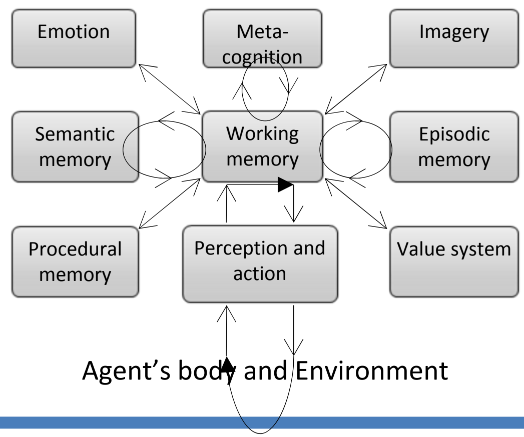
- Lead investigators and current team members:
  - Kenneth A. De Jong, Giorgio A. Ascoli, and Alexei V. Samsonovich (presenter)
- Research areas of interest, which are also areas of qualification and unique capabilities:
  1. Biologically-inspired cognitive architectures (Samsonovich, De Jong & Kitsantas, *International Journal of Machine Consciousness*, 1, 111-130, 2009)
  2. Connectionist modeling of the hippocampal formation (Samsonovich & McNaughton, *JN* 1997; Samsonovich & Ascoli, *Learn&Mem* 12, 193-208, 2005)
  3. Semantic cognitive mapping of natural language (Samsonovich & Ascoli, *Frontiers in AI & Applications*, 157, 111-124, 2007; *PLoS One*, under review)
- Specific capabilities of partners that our group is seeking are:
  1. "Peripheral" cognitive capabilities: signal-to-symbol, NLP, VR simulators
  2. A strong computational model of neocortex
  3. Automated extraction of synonym and antonym relations from corpora

An Overview of GMU BICA

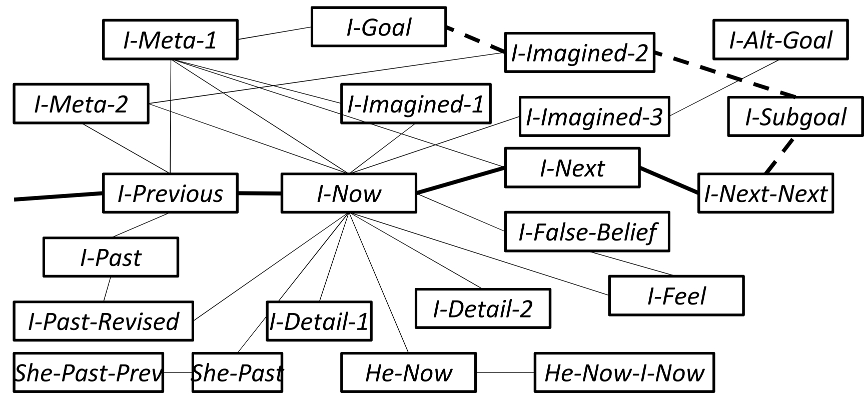


GMU BICA

Generic cognitive architecture

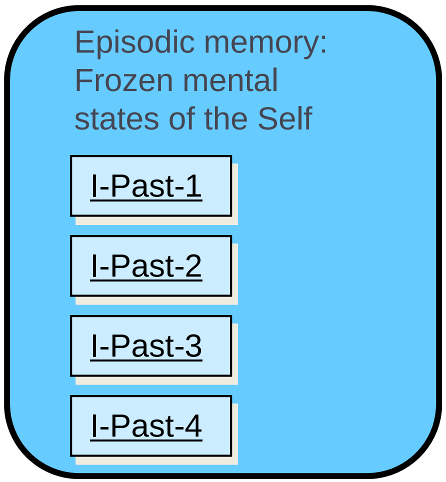


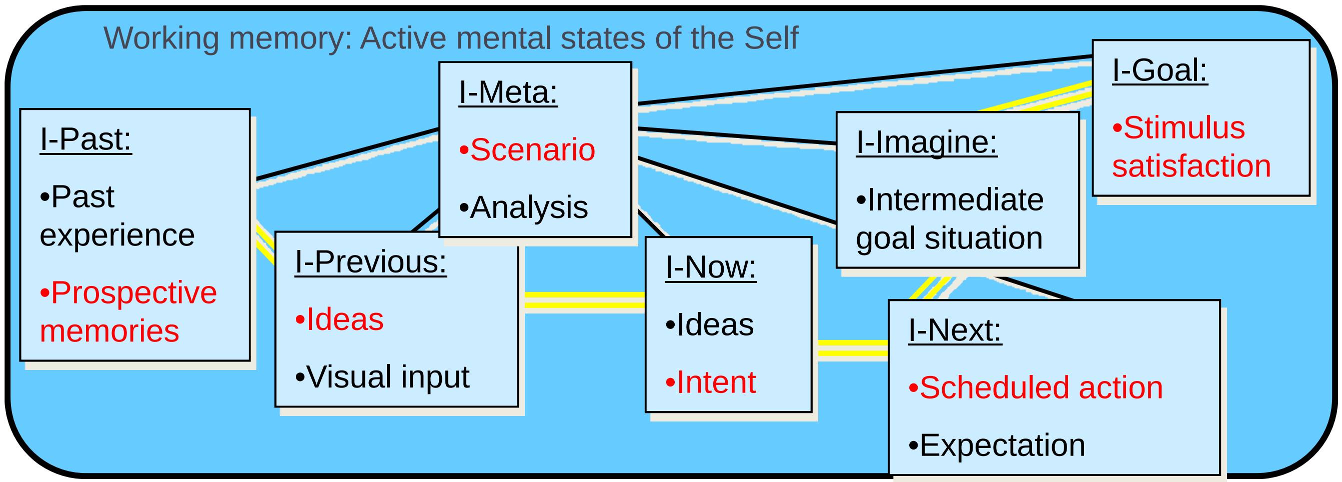
Taxonomy of mental state kinds



A ***mental state*** in GMU-BICA includes contents of awareness represented by schemas and specification of the instance of the Self who has the experience (labeled *I-Now*, *I-Next*, etc.)

- Each box is a mental state. Each bulleted string is an instance of a schema. The double line shows the current working scenario. Red color marks the focus of attention within each mental state.
- The framework allows the system to process a mental state from another mental state perspective, thereby providing a basis for various forms of metacognition and self-regulation.
- Working memory operates in series of voluntary action cycles: (perception, ideas, intent, action).
- Episodic memory consists of frozen mental states that once were active in working memory.



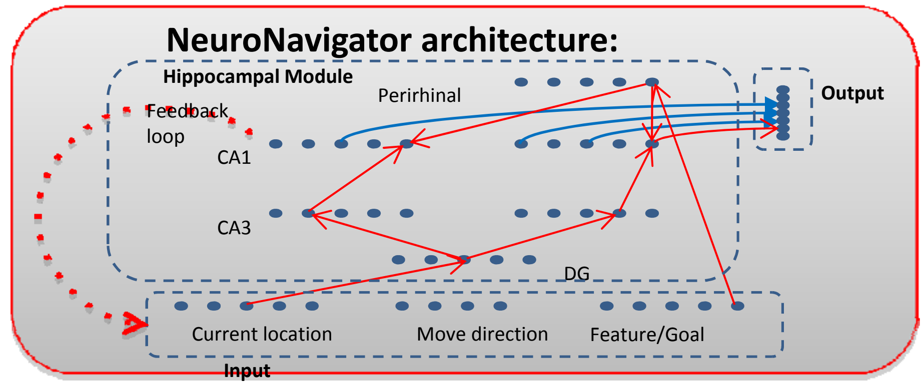


Goal: Human-level cognition and learning in a broad range of paradigms

NeuroNavigator: A microcircuit designed under SyNAPSE program

The model is capable of:

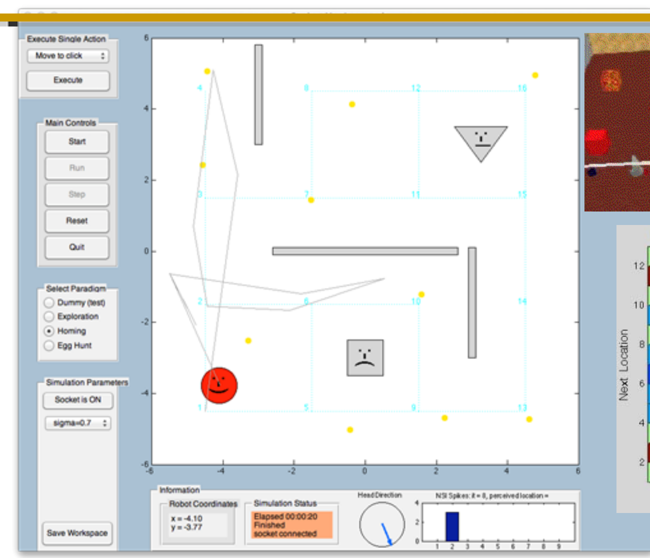
- Efficient exploration of space
- Spatial learning
- Navigation
- Non-spatial learning
- Cognitive problem solving
- Supports episodic memory retrieval
- Supports Theory of Mind (with multiple copies of the model)
- Reconstructs self-location from noisy input

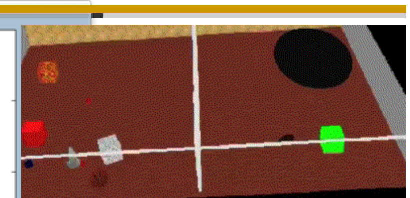


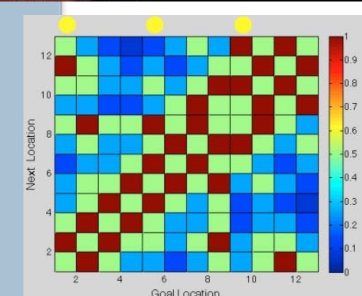
- 15K I&F neurons, 150K STDP synapes (~50% fixed)
- Activity very low. Time for decision making 100ms
- Tested scalability from 10^2 to 10^6 neurons

Key behaviors that have been demonstrated with the model include:

- Exploration and navigation of various virtual spaces: a 2-D indoor environment, binary and ternary trees, large hierarchical environments, CASTLE Laboratory
- Learning and solving logical problems: Hanoi Towers, Traveling Salesman
- Easter Egg Hunt: given a goal (egg), the robot finds a short path to it using remembered episodes of past experience.



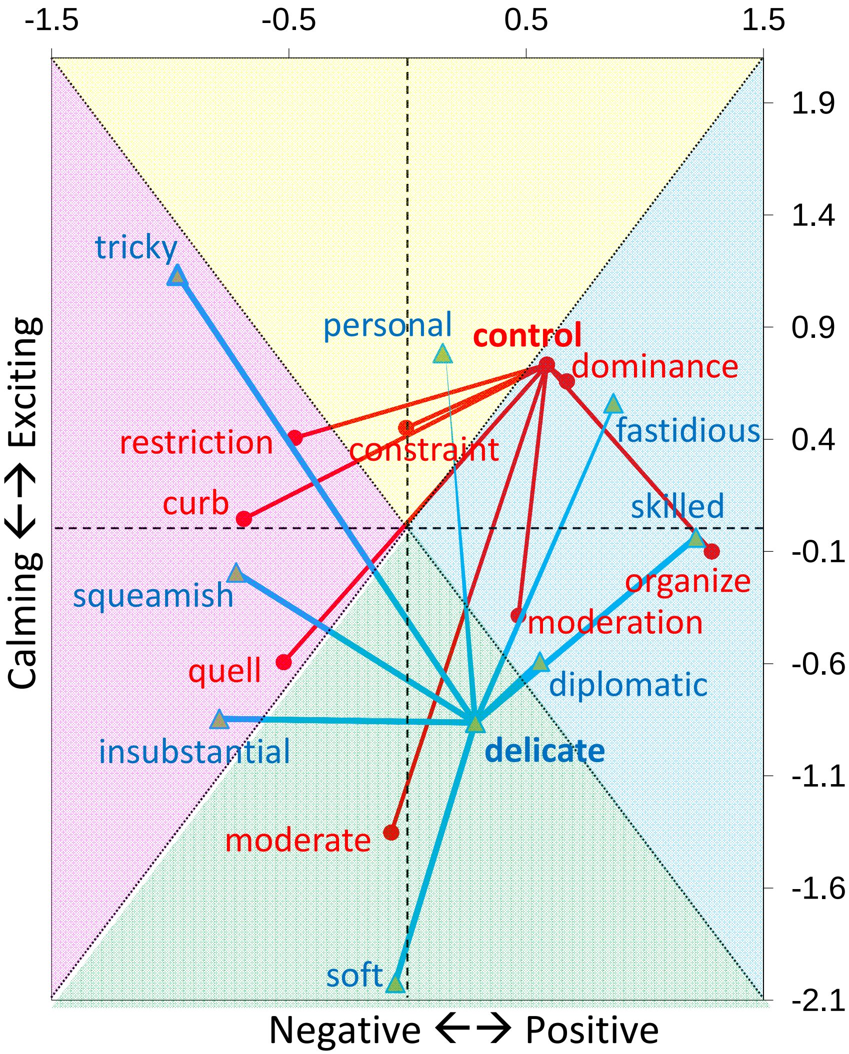




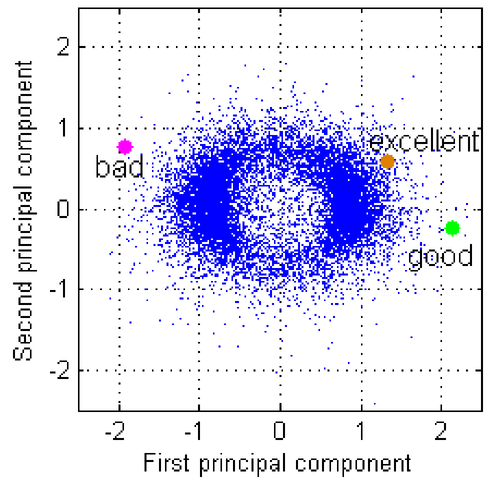
Our target is spatial learning and navigation based on a spiking neuronal network of 1,000,000 neurons with 10,000 synapses each

Semantic cognitive mapping of language

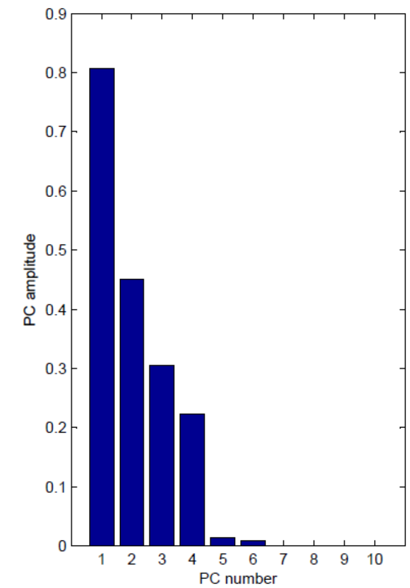
Goal: Automated semantic mapping of arbitrary data (text, images, internal representations of knowledge) based on given or detected relations of synonymy and antonymy



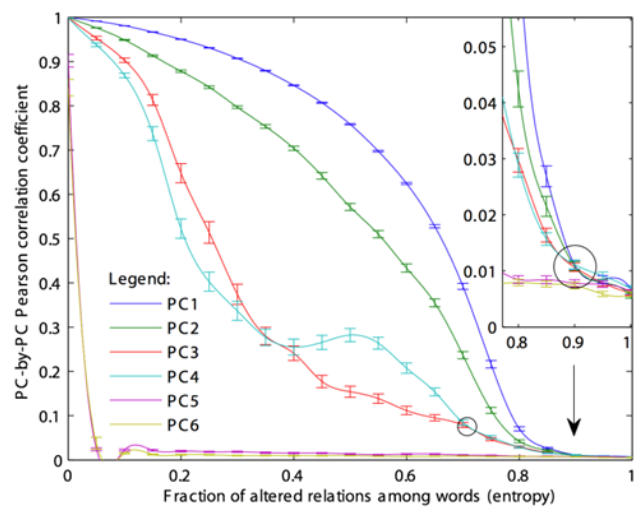
Examples of semantic twisting



Semantic map of English



Color map validation



Robustness of the map with respect to noise

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