Georgia Tech Research Institute

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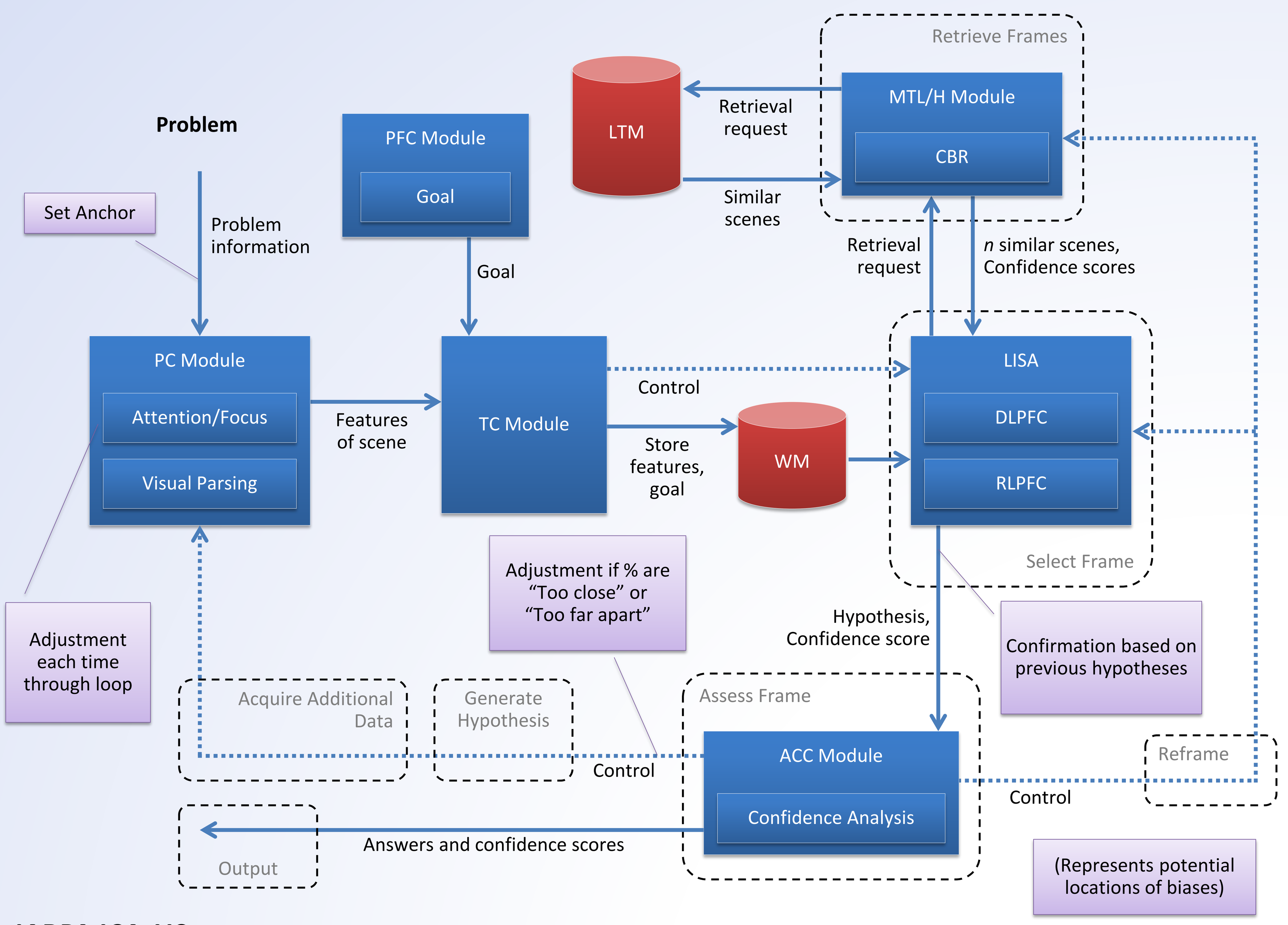
Georgia Tech Research Institute

Qualifications and Capabilities



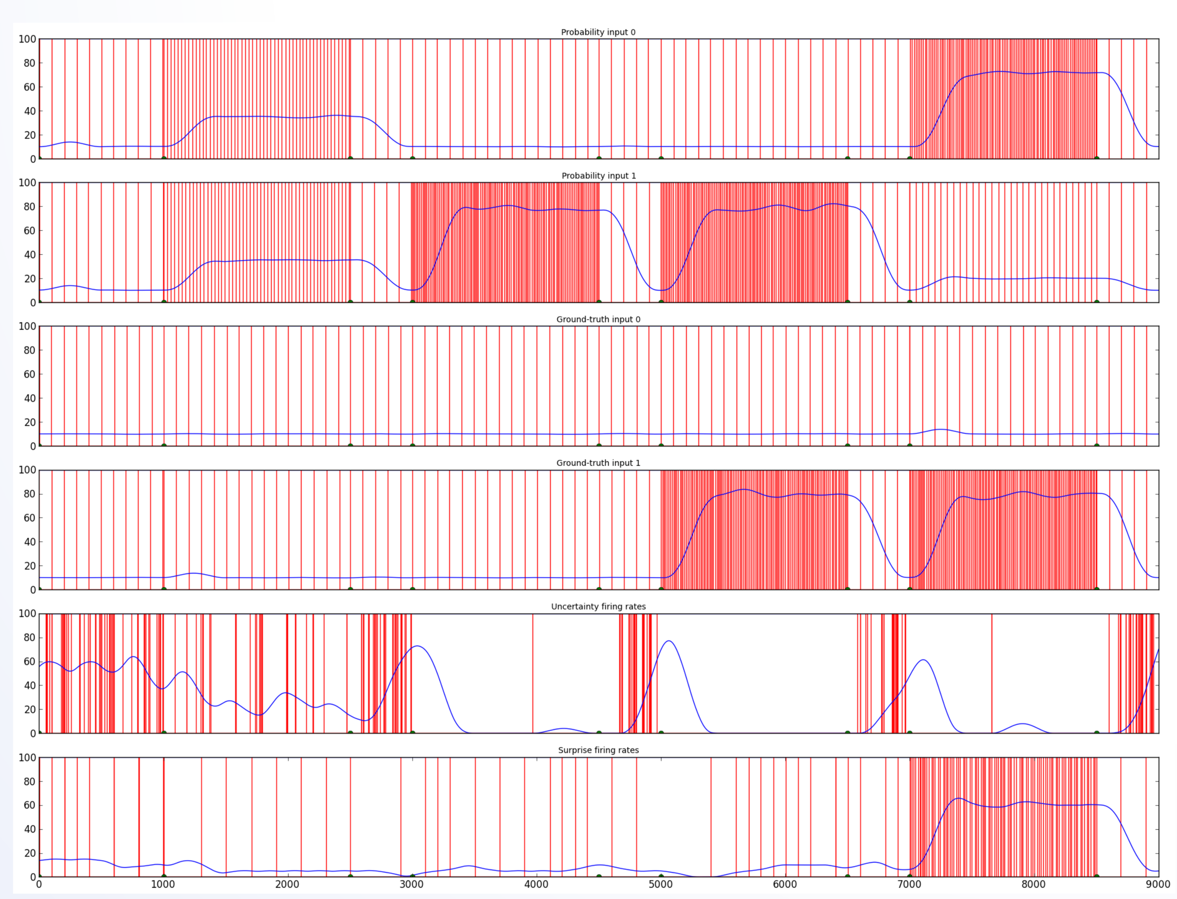
IARPA ICArUS

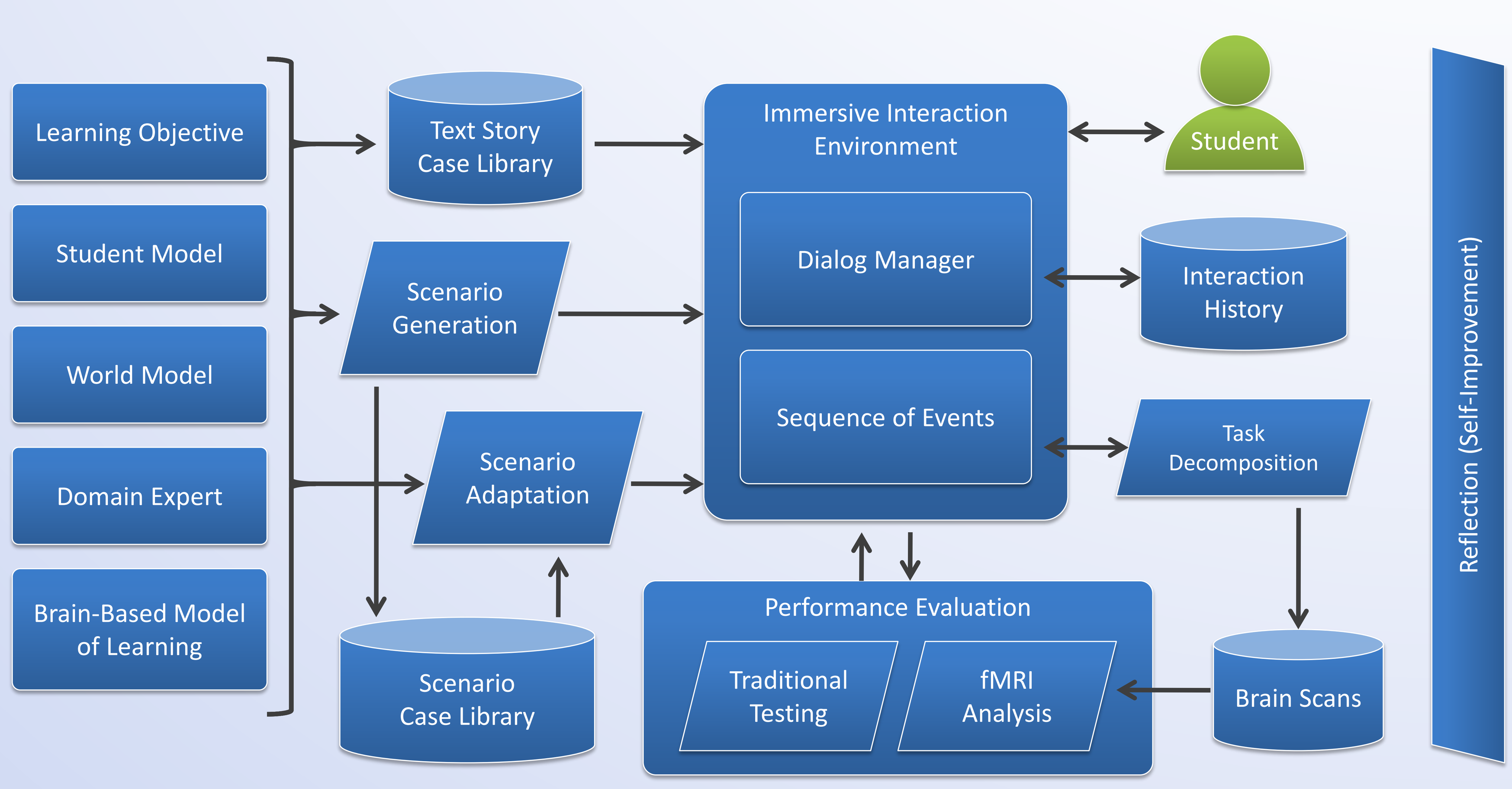
The objective of the ICArUS Program is to construct brain-based computational models of the process known as sensemaking. Sensemaking, a core human cognitive ability, underlies intelligence analysts' ability to recognize and explain relationships among sparse and ambiguous data. The GTRI team was part of a larger project team and contributed component models and neuroscience domain knowledge from the GT School of Psychology.

The diagram to the right shows 9000ms of simulated time. The six rows show the spiking times (red bars) and localized average spike rates (blue lines) of six cells:

- Rows 1 and 2: probability inputs 0 and 1
- Rows 3 and 4: ground truth inputs 0 and 1
- Row 5: ACC uncertainty output
- Row 6: ACC surprise output

The horizontal axis is time (ms), vertical axis in each row is spike rate (Hz).





Brain-Based Cognitive Architecture for Training (BBCAT)

- An architecture based on neuro-scientific models of student reasoning, learning, and emotion
- Integrate lessons from brain-based models of human learning and reasoning with student modeling, teaching and learning theories, and scenario generation
- Design of a system that can:
  - Assess an individual's learning and emotion
  - Dynamically adapt training activities to increase training effectiveness

Research Areas of Interest

The GTRI software modeling team consisting of the software modeling and machine learning GTRI researchers working in collaboration with neuropsychologists in the Georgia Tech School of Psychology have collaborated on several projects relevant to the MICrONS project. The most relevant is the IARPA ICArUS project in which we worked together to produce a spiking neuron model of the ACC which was integrated with component models from the larger ICArUS team into a model of sensemaking for the challenge problems. In addition, the GTRI team has experience with multiple machine learning, reasoning techniques and modeling techniques that can be applied to neural data and modeling.

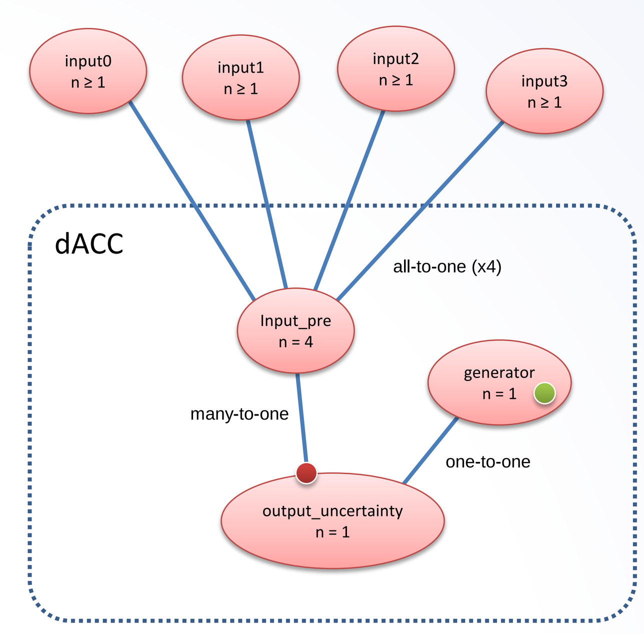
Computational Spiking Neuron Models

The anterior cingulate cortex (ACC) plays a role in monitoring and mediating brain activity during times of focused concentration.

Dorsal ACC (dACC) roles:
- Uncertainty monitoring
- Conflict monitoring
- Recognition of Surprise

Ventral ACC (vACC) roles:
- Reward/punishment recognition and learning

Spiking Model: Uncertainty



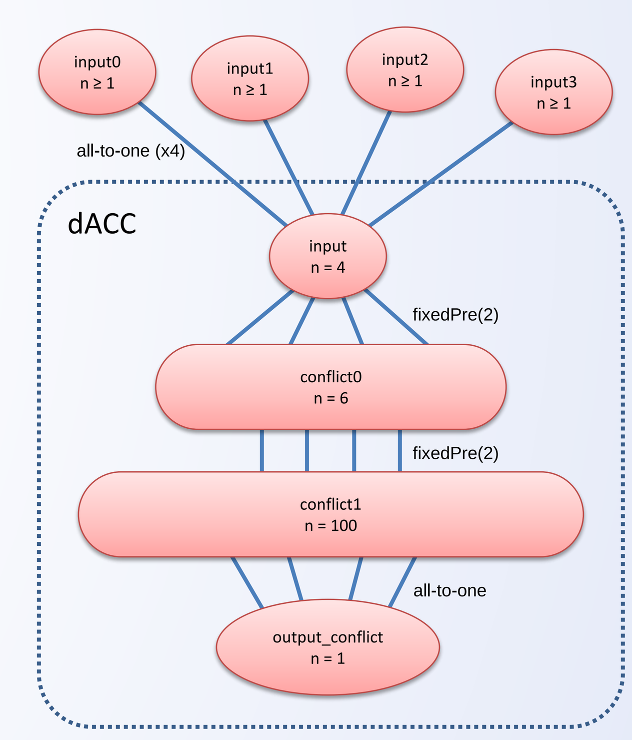
The ACC participates in the executive control loop by inhibiting working memory reset (in the basal ganglia) until uncertainty has been resolved; i.e. a response has been received by the medial PFC. The resolution of uncertainty is represented by:

- (In challenge problem task 1) the probability cells of groups A and/or B having firing rates noticeably higher than 10 Hz
- (In challenge problem tasks 2, 3, 5, and 6) the probability cells of groups A, B, C, and/or D having firing rates noticeably higher than 10 Hz
- (In challenge problem task 4) the probability cells of locations A, B, C, and/or D having firing rates noticeably higher than 10 Hz

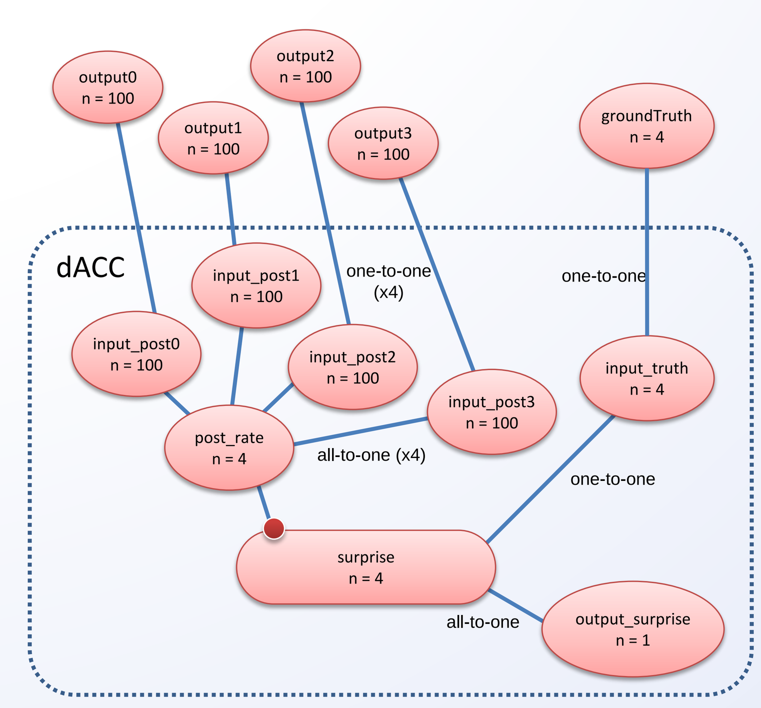
Spiking Model: Conflict

The ACC inhibits working memory reset (in the basal ganglia) until conflict has been resolved; i.e. no two responses are highly rated. Conflict is represented by:

- (In challenge problem task 1) the probability cells of groups A *and* B *both* having firing rates noticeably higher than 10 Hz
- (In challenge problem tasks 2, 3, 5, and 6) the probability cells of *at least two* groups A, B, C, and/or D having firing rates noticeably higher than 10 Hz
- (In challenge problem task 4) the probability cells of *at least two* locations A, B, C, and/or D having firing rates noticeably higher than 10 Hz



Spiking Model: Surprise

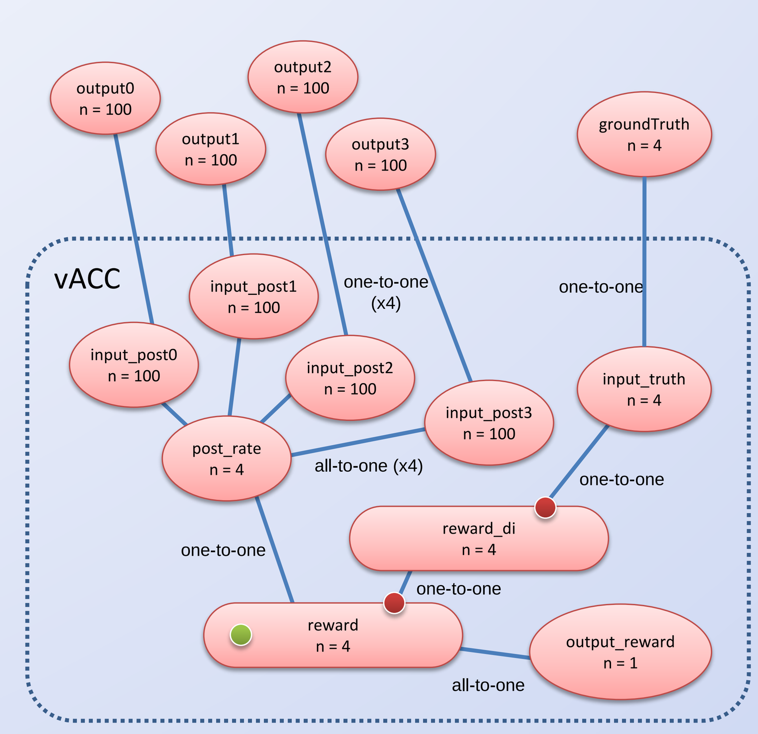


In all challenge problem tasks, the ACC recognizes surprise whenever the ground-truth answer is provided by comparing it against the confidence values of the previous reasoning process.

- The firing rate of the surprise cells is inversely proportional to the probability previously assigned to the correct response.
- Cells representing each ground-truth value attempt to excite the surprise output, while the cells representing the probability value of that response attempt to inhibit it.

Spiking Model: Reward

- The reward signal exists when the ground-truth answer matches the selected answer.
- Reward is highest when the assigned probability of the ground-truth answer was highest.
- "Guessing" the correct answer (while that answer is assigned a low probability) will result in a low reward signal.



● = inhibitory synapse ● = tonic spiking via current source

The GTRI team will supply cortical modeling at the neural level and machine learning based on neuroscience expertise and data supplied by Eric Schumacher of the GT School of Psychology

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