Architectures of Intelligence

Assignment 6: Alphabet-Arithmetic in Nengo

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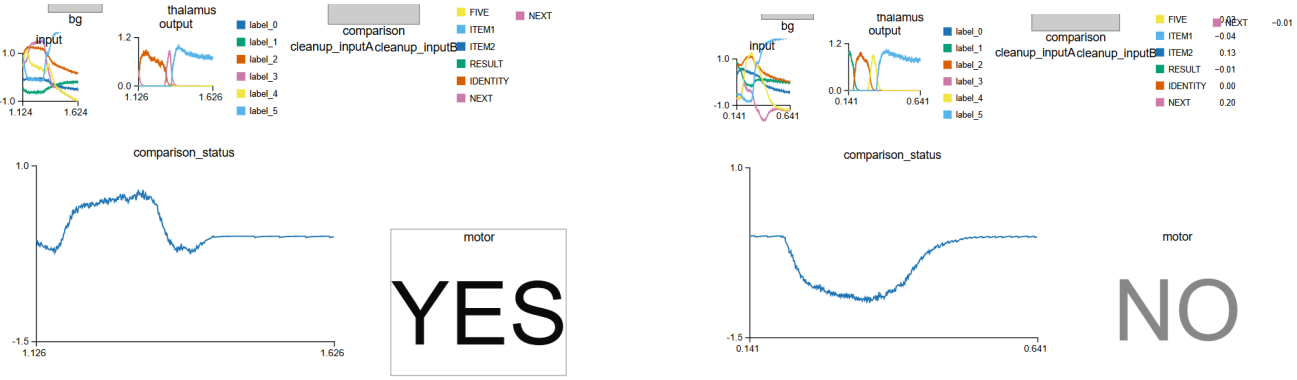
Part 1



(a) B + TWO = D

(b) B + THREE = D

Figure 1: Model responses

Part 2

1. Semantic pointers in Nengo are represented as high-dimensional vectors, initialized using a fixed random seed. These vectors are highly efficient for encoding information, but they are prone to interference or noise in high-dimensional spaces. In the case of "C + ONE = D," the model makes an error because the vector for ONE is likely similar to the vector for FOUR. As a result, facts involving "+ FOUR" are sometimes retrieved instead of the correct fact containing "+ONE". This reflects similarity drift in the representation, where high-dimensional vectors unintentionally overlap. To confirm this hypothesis, we could calculate the similarity between ONE and FOUR using the dot(ONE, FOUR) function to see if their vectors are closely aligned. A high output would constitute a closer relation.

2. Implementing counting in the model requires the use of circular convolutions, as demonstrated in the tutorial exercises, to simulate incrementing numbers. Actions should then be added to compare the current count to the goal using the dot() function to assess similarity. For learning, incorporating a learning rule is necessary. Hebbian learning (unsupervised) would allow the model to dynamically store new facts as they emerge during operation. Unsupervised learning updates the direct memory autonomously. Alternatively, PES learning (supervised) could be used if explicit feedback is provided.

3. Nengo's modular design necessitates a dedicated Comparison component for comparisons. In contrast, ACT-R allows comparisons directly within the Basal Ganglia actions, resulting in a more integrated and efficient approach. ACT-R models cognition as an internally streamlined process, where reasoning and comparison can happen within the same mechanism. Nengo is modular and has distinct systems for individual cognitive functions.

4. Nengo mimics brain-like parallel processing, allowing for distributed and simultaneous computations. This flexibility and scalability make it suitable for modeling various cognitive tasks. On the other hand, ACT-R has a rule-based architecture optimized for symbolic reasoning and task-specific problem-solving, making it easy to implement and particularly effective for structured tasks.