Architectures of Intelligence
Assignment 6

Group 13
Mirko Maragaira & Matteo Wohlrapp

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Zbrodoff in Nengo

1

If you present the model with "C + ONE = D" the model makes a mistake. Explain why that happens, and what it teaches us about the semantic pointer for TWO.

The actions the model takes are not based on exhaustive control structures like if-then-else rules or production rules in ACT-R, but rather utility values retrieved by calculations. These calculations include for example dot-products of a state and a vector which approximate one when the vector the state is holding is close to the ideal vector. Now some vectors representing symbols such as ONE or TWO may have very similar values and therefore the calculated values lead to similar results. This can then cause mistakes like the one witnessed with "C + ONE = D".

2

The current model only retrieves learned facts from memory. Which elements would you need to add to also make it count and learn? Try to think of all the different things you need, including the type of learning (see slides of lecture 10). You do not have to provide code, try to stay at a conceptual level (e.g., "actions to do xyz").

One way of implementing the counting and retrieving characteristic is to add an additional model. Included are two memory states, one for counting up with letters, the other one for counting down numbers to zero. The most difficult part here is to switch between the two processes after adding or subtracting one element. This can be done by creating a separate state as an indication of what action to take next and changing it after each process. Then, for both the letter and digit counting, a spa sequence similar to the one in tutorial 21 can be used. Now counting is implemented, however, the model is not able to learn yet. To do that, there needs to be a vocabulary defined. This means that before starting the model, we create a vocabulary and every time we retrieve a correct solution through counting, we add that solution to the vocabulary. Since we know the difference between what we want to represent, because we just counted, and what we represented, because it is still in the answer state, PES, a supervised learning technique can be used.

To add the components to the already implemented model of just retrieving, there needs to be a connection to react to a successful or unsuccessful retrieval in combination with reactions from the Basal Ganglia. We, therefore, start both the retrieval and the counting model in parallel. If the retrieval is successful, we use the information from memory, otherwise, we wait until the counting process is finished and then use the result produced.

3

One structural difference with the ACT-R model is that we cannot compare two model components in Basal Ganglia actions, something you often do in ACT-R (e.g., compare a retrieval slot with an imaginal slot). Instead, we have to add a separate 'Comparison' component. Explain what the theoretical implication is.

Since ACT-R modules map to different brain areas, comparing two model components means comparing information from different brain regions when applied to the context of the brain. The theoretical implication of adding a separate component is to have the information which is needed for the comparison in the same region of the brain. This means that when comparing different actions, the brain has to retrieve the information to the same brain area and only afterwards can compare them. This would imply that the brain cannot compare information from two different areas directly.

4

Compare the Nengo model to the ACT-R model of Assignment 2:

A

Give a theoretical advantage of the Nengo model.

In terms of the accuracy of the actual representation in the brain, the Nengo model has the advantage. With structural differences such as the inability to compare to model components and the calculation which is based on values and statistics rather than exhaustive productions, Nengo has the precision edge. Also, in contrast to ACT-R where there always has to be a fitting production otherwise, the model stops, Nengo produces further information following the defined rules based on calculations.

B

Give a theoretical advantage of the ACT-R model.

As seen in 1, finding errors or explaining why errors occur can be quite difficult in Nengo. That is because the model has a high level of complexity and therefore steps of the system are hard to trace. ACT-R in comparison allows for the production of a trace that shows in detail which productions are executed sequentially and as a result make the model more understandable. This also allows for the correction of modelling errors since it is easily traceable where the problem occurred.