Cognitive Modelling: Final Project Part III

Vishal Sreenivasan (S4196392)

Jan 2020

0.1 Provide a summary of your approach and findings in the first two assignments.

The first two assignment results in producing the reproduction time bias and retrieval probabilities. The model takes the same number of participants, discrete time intervals and trials as presented in Acerbi[1]. The approach follows exposing the participants to different discrete intervals from different uniform distributions (conditions) and expect them to produce the intervals, thus observing the perception of time and reproduction. During each trial a random interval is selected from the distribution and stored in the declarative memory with a noise. After a certain duration, the interval is retrieved from the memory with a certain noise representing the motor noise. Memory is reset after each condition so that participants have no knowledge of the previous conditions, giving adequate importance to the current condition. Interval in seconds is converted to pulses to replicate the time perception of human brain.

First assignment produces a graph containing the initial intervals and their corresponding reproduction bias with the mean. All the conditions produce a linear response with the mean producing bias near to zero except for the medium peaked due to the presence of peaked interval resulting larger intervals skewed towards short intervals. The second assignment produces a graph containing the interval blocks and retrieval probability of each intervals. Probabilities in medium peaked condition result in peak at the high probability interval and it's neighbors whereas with decreasing probabilities for the rest of the intervals. Rest of the conditions produce a bell curve with a peak in the mean of the distribution.

0.2 What are the implications of your findings for the various modelling paradigms you've come across in (or outside) this course (including the neural network approach)?

ACT-R[2] modelling framework represents the working of human brain. The time perception in the paradigm is done explicitly. Since humans perceive time without an external clock representing time, dynamic neural networks provide a method to represent time implicitly using a layered network architecture. The inputs are fed to a layered unit of neurons which produce the input as the output much like the encoder models. Voelker & Eliasmith (2018)[3] show the correlation between time and memory is implemented using a delay line (or) a recurrent network producing a delayed output based on the threshold. This is a representation of memory where the network keeps track of the inputs before n seconds and reproduces it resulting in the delay during output. Using neural networks provides a contrast between an explicit time perception model such as ACT-R[2]. While ACT-R[2] contains declarative memory to store information, dynamic neural network's memory is represented by it's neurons and weighted connections.

0.3 What do your findings mean for our understanding of timing and the influence of memory on timing?

ACR-R[2] model contains a declarative memory (DM) for storing information. DM stores all the encounters with their corresponding activation functions replicating human memory to some extent. When an information is repeated several times over a period, it's activation becomes higher compared to the rest. The results of the experiments as explained in section 0.1, provides an understanding of time perception which can be compared with human brain. Most of the findings suggest that participants tend to retrieve mean intervals in a distribution or the interval with higher probability. Also participants struggle with larger intervals as humans do i.e., it is easy for humans to keep track of 2 seconds compared to 15 seconds. Time intervals are corrupted by noise when stored and retrieval in the memory. This can lead to corruption in retrieval of shorter and larger intervals since the probabilities are concentrated in the mean.

References

[1] L. Acerbi, D. M. Wolpert, and S. Vijayakumar, "Internal representations of temporal statistics and feedback calibrate motor-sensory interval timing," *PLOS Computational Biology*, vol. 8, no. 11, pp. 1–19, 11 2012. [Online]. Available: https://doi.org/10.1371/journal.pcbi.1002771

[2] A. J. R., B. D., M. D. Byrne, S. Douglass, C. Lebiere, and Y. Qin, "An integrated theory of the mind. psychological review," *APA PsycArticles*, 2004. [Online]. Available: ttps://doi.org/10.1037/0033-295X.111.4.1036

[3] A. Voelker and C. Eliasmith, "Improving spiking dynamical networks: Accurate delays, higher-order synapses, and time cells," *Neural Computation*, vol. 30, pp. 569–609, 03 2018.