Project 13: Liquid state machines and interval timing

1) Build a simple liquid state machine, loosely following Maass et al. (2002): a recurrent neural network with leaky integrate-and-fire neurons and random weights, connected to a linear readout. Train the readout weights with ordinary least squares to perform an interval timing task, where a stimulus of a particular duration is presented to the network, and the readout estimates elapsed time. Show how timing accuracy changes with interval duration. Does the model exhibit higher variability as a function of duration, similar to what is observed behaviorally in humans and other animals (see for example Figure 1c in Wang et al., 2018)?

2) How does timing performance change as a function of the network properties, such as excitation-inhibition balance and the distribution of recurrent strengths? How does this relate to the "separation property" discussed in the Maass paper?

3) The model is an example of a "population clock" (Buonomano & Laje, 2010). What is some evidence for population clocks in the brain? Why does the Wang paper claim that their results are inconsistent with the population clock hypothesis?

References:

Buonomano, D. V., & Laje, R. (2010). Population clocks: motor timing with neural dynamics. *Trends in Cognitive Sciences, 14*, 520-527.

Maass, W., Natschläger, T., & Markram, H. (2002). Real-time computing without stable states: A new framework for neural computation based on perturbations. *Neural Computation, 14*, 2531-2560.

Wang, J., Narain, D., Hosseini, E. A., & Jazayeri, M. (2018). Flexible timing by temporal scaling of cortical responses. *Nature Neuroscience, 21*, 102-110.