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Abstract: Current motion models such as the Reichardt detector and the motion energy model rely heavily on the neural delays of single cells. It is not clear, however, whether neurons in the motion processing pathway of primates have the temporal organization to support this assumption. Moreover, it is well-known that cortical areas have numerous recurrent connections – a feature that is conspicuously absent from almost all motion models.

We trained a motion model based on an Elman recurrent neural network on simulations of rightward moving random patterns and corresponding motion sensitive cells that were measured in area MT of macaques. The recurrent network captured the temporal dynamics and speed tuning properties of the measured neurons, which shows that explicit temporal delays are not needed and can be implemented with recurrent connections.

We probed the network with physiological methods allowing us to compare its features with properties of neurons in the motion processing pathway. First, the network generalized well to all rightward moving random input patterns, sinusoidal gratings and reverse phi motion. Second, reverse correlation revealed that the spike triggered average of the output unit was small. Third, spike triggered covariance analysis exposed two significant excitatory and inhibitory filters. The excitatory filters were in anti-phase and had a space time slant that correlated well with the preferred speed and direction of the output unit. The inhibitory filters were also in anti-phase but had, surprisingly, a slant to lower speeds in the anti-preferred direction that accounted for an accurate generalization of the model to leftward moving input patterns.

We conclude that a recurrent network may be a good alternative to the temporal delay lines dependent motion models; it incorporates the response properties of feed-forward models, matches known anatomical and functional connectivity, and can account for known imperfections in the percept of motion.