Continuous Attractor Neural Networks, Short-Term Synaptic Depression, and Delay Compensation

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I will review the dynamics of continuous attractor neural networks, which process continuous dynamic information, such as position and direction, by generating its own internal state to track the changes in external inputs. Their dynamics is described by a combination of distortion modes, enabling us to study their tracking dynamics. I will then review how short-term depression enhances the mobility of the network states, leading to anticipatory responses. An effectively constant anticipatory time or zero-lag between the tracking state and the stimulus can be achieved. The anticipatory time covers the range of 10^1 ms and decreases mildly with stimulus speed, in agreement with head-direction experiments in rodents. Finally, I will explain the strong correlation between the intrinsic behavior and the tracking performance, reminiscent of similar relations in statistical physics. The displacement of the localized state relative to the stimulus during tracking is proportional to the intrinsic relaxation rate of the positional distortion of the localized state. Thus the parameter regions for delayed, perfect, and anticipative tracking correspond to static, ready-to-move, and spontaneously moving network states respectively. Furthermore, when the stimulus moves with the natural speed of the network state, the delay becomes effectively independent of the stimulus amplitude.