Time-Invariant Recognition of Spatiotemporal Patterns in a Hierarchical Cortical Model with a Caudal-Rostral Persistence Gradient

We describe a hierarchical connectionist model of cortex that performs recognition and recall of spatiotemporal patterns (sequences). Our goal was to find an architecture invariant to presentation speed. A key feature of our model is that persistence, i.e., the length of time a unit (neuron) tends to remain active when it becomes active, increases from the bottom hierarchical level (i.e., primary sensory cortices) to higher levels (i.e., more rostral cortices). A growing body of evidence supports long persistence times for rostral neurons (Fuster & Alexander, 1971) and, more generally, a caudo-rostral persistence gradient (Uusitalo et al., 1996). In the simulations reported here, persistence doubles from one level to the next (the levels are bidirectionally connected). Thus, a set of cells that becomes active at level L_J (an L_J code) will be active during, and therefore form top-down (TD) and bottom-up (BU) associations with, two successive L_{J-1} codes. The model's internal levels are organized into winner-take-all competitive modules (CMs). We provide simulation results demonstrating that the model can learn multiple complex sequences (sequences in which the same state can recur multiple times) and then recognize novel sequences that are non-uniformly time-warped and noisy versions of the previously experienced sequences. The model's robustness to time-warping results from the fact that L_{J+1} codes are active during several successive L_{J-1} codes. The occurrence of any of those L_{J-1} codes while L_{J+1} is active will result in recognition.

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