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Abstract

The Inner and External World Are Two Dynamical Systems Coupled by Attention †

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I will present a memory model that can account for many aspects of the presence of an inner world, ranging from object permanence, episodic memory and planning to imagination and reveries. It is modelled after neurophysiological data and includes many parts of the cerebral cortex together with models of emotion and arousal systems. Attention plays a crucial role as the interface between the inner and the external world and directs the flow of information from sensory organs to memory as well in the opposite direction as top-down influences on perception. The internal and external world can be seen as two dynamical systems that can be coupled or decoupled in different ways depending on the state of the organism and the task at hand.

The implemented model includes three interacting neural networks that roughly correspond to the ventral, dorsal and prefrontal areas of the cortex. The first component is the identification-network that learns different stimuli as collection of stimulus properties. It operates as a content addressable memory and recalls complete patterns based on partial inputs. The second component is the localization-network. It is similar to the identification-network except that its activity is constrained by a winner-take-all-rule implementing the constraint that binds each input pattern to one particular location, thus avoiding the binding problem. In addition to coding for different locations, this component increases the storage capacity of the identification-component and avoids spurious attractors. The attractors of the identification + localization components stores attended stimuli together with their locations. The final component is a 'prefrontal' working memory. It operates as a k-winners-take-all network and allows memories 'stored' in working memory to be more easily recalled than other memories.

In addition, there are slower predictive associations that works over time to predict the next state based on the current one. When allowed to run freely, these temporal associations will make the complete system transition between stable attractors over time in a way akin to day dreaming, effectively implementing a default state network. However, the memory system can also be put to use in a goal directed way. By allowing a general arousal system to increase the gain modulation, the system will instead replay experienced sequences to produce recall of episodic memories. This property can be used instrumentally for vicarious trial-and-error by allowing the sequence to run until a goal is reached, which will activate a value system. Several such forward sweeps can be used to select the course of action that leads to the highest expected value.