

ABSTRACT

Theoreticians have proposed that correlations in the firing times of groups of neurons may be an efficient representational framework for information processing and the feature binding problem. In the last decade, many observations of synchronous oscillations in the brain have given support to the above proposal and have created much interest in understanding how synchrony arises. We analyze locally coupled networks of neurobiologically based oscillators in order to understand how synchrony and desynchrony arise, and we propose several oscillator networks for perceptual organization and feature binding.

We examine locally coupled networks of integrate-and-fire oscillators and find that they synchronize at times proportional to the logarithm of the system size. We create a means of desynchronization and propose a network for image segmentation. The abilities of this network are demonstrated using real images.

We examine locally coupled networks of relaxation oscillators. These neurobiologically based oscillators exhibit properties of fast synchronization and we derive conditions necessary to ensure synchrony occurs. Several types of desynchronous solutions are also examined.

We examine how the interaction between oscillators affects the time to synchrony. Our data indicate that a discontinuous interaction results in better properties of synchronization than networks with smooth interactions, regardless of whether the oscillators are of relaxation or sinusoidal type.

Also studied are relaxation oscillators with time delay coupling, a more biologically realistic model of neuronal behavior. Our analysis shows that a pair of oscillators can achieve loose synchrony for a wide range of initial conditions and time delays. We present simulations for larger networks.

In locally coupled networks of Wilson-Cowan oscillators a mechanism is shown for achieving fast synchrony (in one cycle) and we prove that networks of these oscillators after linear approximation can synchronize given a sufficient coupling strength. We also demonstrate a technique for desynchronizing multiple groups of oscillators.

A major theme of this work is examining how the rate at which oscillator networks synchronize is related to their size. We examine several different types of oscillators and find evidence for four different scaling relations, thus indicating one means of categorizing these systems.