

Emerging meso-and macroscales from synchronization of adaptive networks

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Most systems analyzed in the past years using complex networks are characterized by the presence of two important topological features: modular structures and scale-free degree distributions. Yet, an open problem is understanding how these characteristics can spontaneously emerge from the dynamics of the elements composing the system, i.e., without an external intervention. In this talk, we consider a set of interacting phase oscillators, in which the coupling between pairs of them varies according to their synchronization level; also, nodes have limited resources, thus restricting their connectivity. We show that such a competitive mechanism leads to the emergence of a rich modular structure underlying cluster synchronization, and to a scale-free distribution for the connection strengths of the units.

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Analyzing offline events through the mirror of online social networks

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Online social networks, are ideal platforms to exchange and propagate information. Due to the rapidly growing number of users, online social networks have become an increasingly important topic in scientific research. Recent studies have focused on determining the structure and dynamics behind these networks and characterizing user behavior. Following this trend we have studied how important events occurring offline are reflected on these online social networks. To this end, we have built the networks corresponding to the interactions taking place among users.

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Defibrillation mechanisms on a one-dimensional ring of cardiac tissue

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Defibrillation is a medical treatment used to terminate ventricular fibrillation or pulseless ventricular tachycardia. An electrical device via a pair of electrodes delivers controlled amount of electrical energy to the heart in order to reestablish the normal

heart rhythm. First generation of defibrillators applied monophasic shock, in which electrodes did not change polarity during the application of the shock. Later it was found that changing the polarity of the electrodes during the shock leads to better result with less energy applied. Optimal monophasic and biphasic shock release approximately 200 J and 150 J, respectively. It is desirable to use as less energetic shock as possible in order to reduce the damage done to the tissue by the strong electric current. However, to this day, there is no full understanding why biphasic shocks are better than monophasic shocks. To assess this question, we have used a bidomain model for cardiac tissue with modified Beeler-Reuter model for transmembrane currents. Modifications account for anode break phenomena and electroporation effect known to happen during defibrillation. We have studied three different types of protocols for shock application (i.e. monophasic; symmetric biphasic; and asymmetric biphasic shock) in a one dimensional ring of cardiac tissue. The size of the ring was chosen to exhibit a discordant-alternans dynamics. Results of the numerical simulations reveal that monophasic shocks defibrillate with higher rate of success than the two biphasic shock protocols at lower energies. On the contrary for higher shock energies, the biphasic shock are significantly more efficient than monophasic shocks. This latter result confirms the medical common wisdom about defibrillators. Moreover, in this study, we were able to identify and classify the different defibrillation mechanisms that happen in this system. One identifies four different types: direct block, delayed block, annihilation and direct activation. Which defibrillation mechanism prevails depends on the energy level, the current dynamic state of the system and the shock protocol. This study has permitted to uncover and confirm the experimental fact stating that biphasic shocks are more efficient (at high energy) than monophasic shock to defibrillate cardiac tissue.

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Some structural properties of multilevel networks

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The concept of multilevel network has been introduced in order to embody some topological properties of heterogeneous -type complex systems which are not completely captured by the classical models. In this talk we will present some metric and structural properties of multilevel networks, a new paradigm for networks with a mesoscaled structure.

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