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Neural coding tools, based on Information Theory, applied to discrete time series: from electrophysiology to neuroethology

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We developed a method based on Information Theory [1] to the analysis of discrete time series applied to spike and pulse sequences in two different systems: Central Pattern Generator (CPG) motor neurons in the crustacean stomatogastric ganglion (biological and model neurons) and electrocommunication in weakly electric fish interacting with an artificial fish.

CPG motor neurons [4][5] in the nervous systems are responsible for the mechanical digestion flow of fluids from the stomach to the intestines. They present an extensive dynamic repertoire due to a large variety of ion channels and modulation mechanisms. The rhythm and the average discharge frequency of these neurons must be constant to ensure a proper muscular contraction, nevertheless there are patterns associated to a very detailed inter spike distributions in which muscular contraction do not take part [3]. What are these patterns for? Experiments were performed in a pair of pyloric CPG neurons with simultaneously intracellular recordings, both in control condition (intact CPG) and with a hybrid network where one neuron was replaced by a computational model (real time interface). Information theoretical analysis showed that a motor neuron is able to express information encoded in spike intervals (ISIs) from another one (both biological and artificial neuron) in a very fine time scale.

Weakly electric fish provide a wonderful opportunity to study and interact with a living intact nervous systems. Their electrical organ discharges (EODs) are not only complex signals that belong to the processing of environmental sensory information by the nervous system but they are also easy-to-detect. Each EOD generates an electric field that reaches a myriad of electroreceptors disposed to detect small changes in the cutaneous electric field. With this apparatus the weakly electric fishes are able to detect objects as well as social electrocommunication[2]. Using non invasive techniques in a freely moving fish we were able to record its organ electric discharges (EODs) for long periods (~ hours). Electrocommunication experiments were performed, in which electric stimuli sequences, mimicking the fish EODs, were sent to a measurement tank *via* artificial fish, both in real time and previously recorded sequences. Analysis using Information Theory tools revealed that the stimuli sequences play a significant role in the fish response.

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