Applications of Metaheuristics in Brain Computer Interface and in the Reservoir Computing Paradigm

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In this presentation we describe two applications of metaheuristic techniques. We apply three well-known metaheuristic techniques: *Genetic Algorithm (GA)*, *Simulating Annealing (SA)* and *Particle Swarm Optimization (PSO)* in two research areas named: *Brain Computing Interface (BCI)* and *Reservoir Computing (RC)*. The GA family started in the 60's, the original motivation was to simulate the natural selection process. In the last 20 years, the GA trend has become increasingly popular for solving optimisation problems. The SA is a probabilistic metaheuristic that was inspired from the annealing process in thermodynamics. The PSO method is an algorithm for finding optimal points on complex search spaces. The technique is based on social behaviors of a set of particles (swarm).

A BCI is a functional interaction between the brain and an external device. The most widespread brain signal used in a BCI system is the *Electroencephalography (EEG)*. An important problem of the EEG-based BCI system consists in designing the EEG pattern classifier, which provides a mapping between the EEG signals and the mental states. In the EEG-based BCI experiment many signals are recorded from different locations in the brain. Then, we dispose of a high-dimensional time series data, which is most often affected by sources of noise. The selection of the EEG signals used for generating the EEG pattern classifier has impact in the classifier performance. We apply the metaheuristic techniques for selecting a *good* combination of EEG signals, in order to improve the classifier accuracy.

At the beginning of the 2000s, a new approach for designing and training a Recurrent Neural Network (RNN) has been emerged in the literature under the name of *Reservoir Computing (RC)*. In a RC model there are at least two well-differentiated structures. One is a RNN (in this context it is called a *reservoir*) that serves to expand the input data and historical information into a high-dimensional space. This projection can enhance the linear separability of the input data. Another one is a memory-less structure designed to be robust and fast in the learning process. RC methods have been shown to be useful for solving temporal learning problems. The setting procedure for defining the topology of the reservoir can impact on the model performance. We present an approach that uses metaheuristic techniques for defining the pattern of connectivity of a RC model. We present empirical results on simulated and real time-series benchmark problems.

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