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Data assimilation with artificial neural networks self-configuring by MPCA

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Abstract

Artificial Neural Networks (ANN) are computational techniques that present a mathematical model inspired by the neural structure of biological organisms, acquiring knowledge through experience, which have been a technique successfully employed in many applications on several research fields and currently under intensive research worldwide. ANN with learning supervised have emerged as excellent tools for deriving data oriented models, due to their inherent characteristic of plasticity that permits the adaptation of the learning task when data is provided. In addition to plasticity, ANN also present generalization and fault tolerance characteristics that are fundamental for systems that depend on observational. Although much has been studied, there are still many questions about the ANN models that need to be addressed. One of the main issues of research in supervised ANN is to search for an architecture optimum. In this paper, the determination of optimal parameters for the neural network is formulated as an optimization problem, solved with the use of meta-heuristic Multiple Particle Collision Algorithm (MPCA). The MPCA optimization algorithm emulates a collision process of multiple particles greatly inspired on two physical behaviour inside of a nuclear reactor absorption and scattering. The cost function has two terms: a square difference between ANN output and the target data (for two data set: learning process, and the generalization, and a penalty term used to evaluate the complexity for the new network architecture at each iteration. The concept of network complexity is associated to the number of neurons and the number of iterations in the training phase. In this work, two types of neural networks are used, the radial basis function network (RBF) and recurrent Elman. Here, the self-configuring networks are applied to perform data assimilation to emulate the Kalman filter is carried out with linear 1D wave equation.