Does it exist a general structure for adaptation/learning algorithms?

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Abstract

With the booming of neural networks, real-time system identification and adaptive control there was an explosion of the number of parameter adaptation/learning algorithms (PALA) which have been proposed. These algorithms have been introduced starting from a variety of points of view. In most of the cases only a qualitative analysis of their behavior is provided. The field becomes a kind of "fiddler's paradise".

Parameter adaptation/learning algorithms are nonlinear/time varying dynamic systems for which stability is a key issue. Taking into account their inherent feedback structure, passivity approach appears as a basic tool for understanding, analyzing and synthesizing PALA algorithms.

After a review of the basic gradient parameter adaptation/learning algorithm from a dynamic system perspective, a general structure for the PALA is introduced, which allows to guarantee their stability for any values of the learning rate (adaptation gain). Well known algorithms as : Conjugate gradients, Momentum back propagation, Nesterov, Integral+ proportional +derivative adaptation, PALA with leaking, etc, appear as particular cases of these general structure.

This general structure is characterized by the fact that the basic integrator structure of the gradient algorithm (the integrator is a positive real transfer function) is replaced by an embedded poles/zeros filter of any order which should be characterized by a positive real transfer function. The various algorithms mentioned above are particular forms of this general form and they will be analyzed from this perspective. The satisfaction of the positive real condition will provide bounds for the tuning of the weights occurring in various algorithms. Comparisons between various algorithms will be provided.

The case of continuous time PALA will also be briefly discussed.