Non-linear adaptive filtering with kernel functions: an overview

Weifeng Liu[(1)], Cédric Richard[(2)], José C. Prìncipe[(3)], Simon Haykin[(4)]

[(1)] Amazon.com
Seattle, WA 98104, USA
weifeng@amazon.com

[(2)] Université de Nice Sophia-Antipolis
Parc Valrose, 06108 Nice cedex 2, France
cedric.richard@unice.fr

[(3)] University of Florida
Gainesville, FL 32611, USA
principe@cnel.ufl.edu

[(4)] McMaster University
Hamilton, Ontario, Canada
haykin@mcmaster.ca

Abstract

Dynamic system modeling has played a crucial role in the development of techniques for stationary and non-stationary signal processing. Most existing approaches have been built on the following three pillars due to their inherent simplicity from conceptual and implementational points of view: the linear model, the mean-squared error criterion, and the adaptive least-square learning algorithm. However, there are many practical situations, e.g., in communications and biomedical engineering, where the non-linear adaptive processing of signals is needed.

Kernel-based algorithms have been a topic of considerable interest in the machine learning community over the last ten years. Their attractiveness resides in their elegant treatment of nonlinear problems. This paper presents a comprehensive introduction to non-linear adaptive filtering drawn on the theory of reproducing kernel Hilbert spaces. We use this framework to derive the kernel least-mean-square algorithm. We also introduce briefly the kernel affine projection algorithms and the kernel recursive least-squares algorithm. Next, we address the main bottleneck of kernel adaptive filters, i.e., their growing structure. Finally, we demonstrate through experiments on real and synthetic data the effectiveness of the proposed methods compared to conventional approaches.