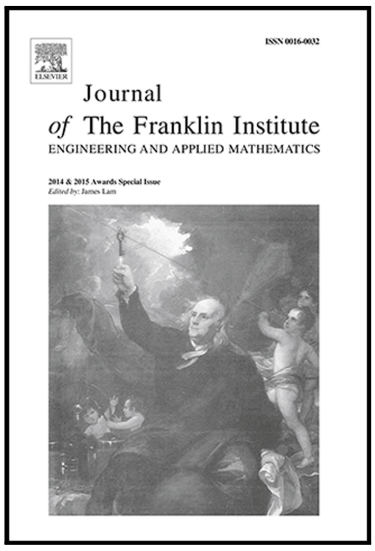

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Josip Kasac, Dubravko Majetic, Danko Brezak

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An algebraic approach to on-line signal denoising and derivatives estimation

Josip Kasac*, Dubravko Majetic, Danko Brezak

University of Zagreb,
Faculty of Mechanical Engineering and Naval Architecture,
I. Lucica 5, HR-10000 Zagreb, Croatia

Abstract

In this paper, a new algebraic approach to the on-line signal derivatives estimation is proposed. The proposed approach is based on the conversion of the truncated Taylor series expansion to the set of linearly independent equations regarding the signal derivatives. The nonhomogeneous parts of the obtained set of equations are convolution integrals, which can be transformed to the stable linear state-space filter realization. The proposed algebraic estimator provides stable convergence without the need for periodic re-initialization, as in the case of the conventional algebraic estimators. In contrast to the Taylor series-based tracking differentiators, the proposed estimator also provides an estimation of the arbitrary number of the higher-order signal derivatives. In addition, the tuning of the estimator parameters does not depends on the filter dimension. The efficiency of the proposed estimator is illustrated by the simulation examples and experimental results related to the monitoring of the surgical drilling process.

Keywords: Algebraic estimation; Differentiators; Signal denoising; Linear systems; Continuous-time filters

1. Introduction

The filtering and derivatives estimation of a measured signal is necessary for many applications, such as biomechanics [1], failure diagnostics [2], signal processing [3] or control engineering [4, 5], among others. Various methods have been proposed for derivatives estimation of noisy signals. Numerical differentiation using difference methods is a well-known direct approach to compute the signal derivatives [6]. However, numerical differentiation is an ill-posed problem, which means that small errors in the measurement values may lead to large errors in the derivatives estimate [7].

*Corresponding author
Email addresses: jkasac@fsb.hr (Josip Kasac), dmajetic@fsb.hr (Dubravko Majetic), dbrezak@fsb.hr (Danko Brezak)