Novelty detection via linear adaptive filters

Branch of study: Control and Systems Engineering

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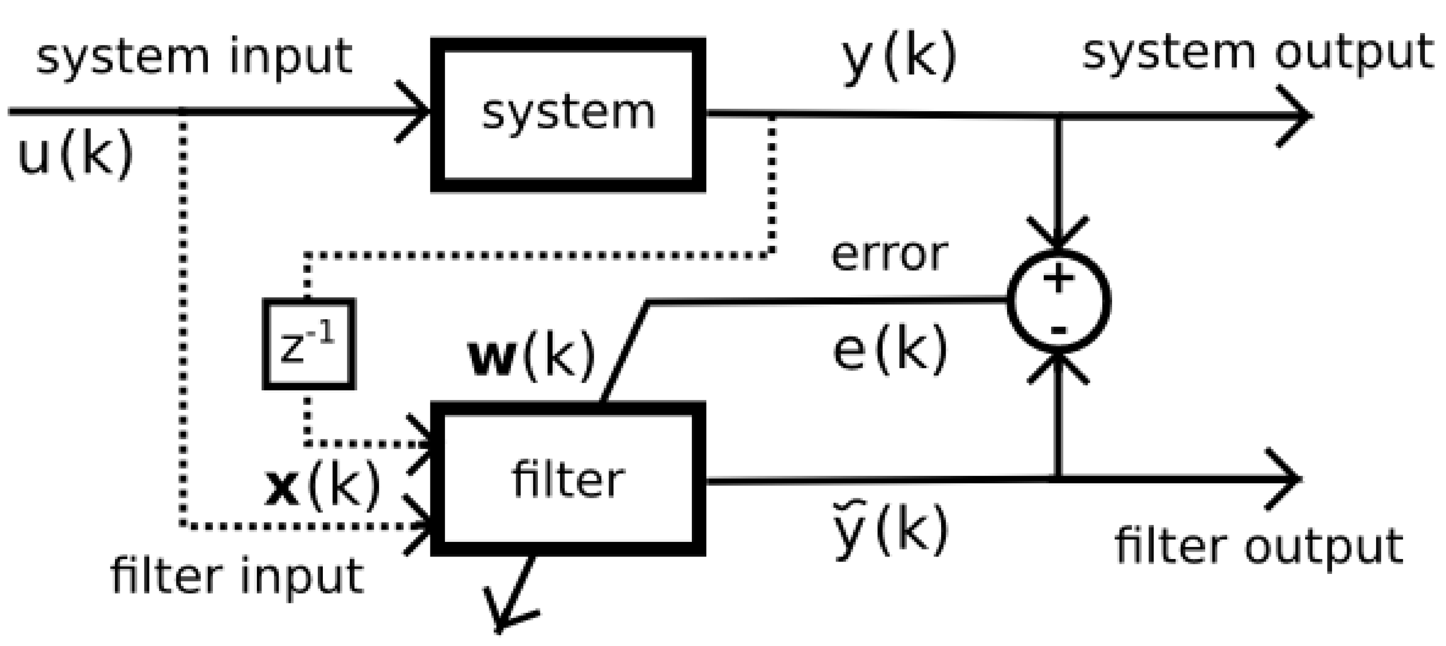
Thesis Objectives

1. Development of an adaptive novelty detection method suitable for online data streams processing.
2. Development of a fast adaptive novelty detection method applicable with fast adaptive algorithms.
3. Development of an adaptive novelty detection method robust against concept drift and non-stationary data.

#1 Objective

The proposed method - Error and learning based novelty detection (ELBND) - can use any adaptive filter that supports prediction setup:

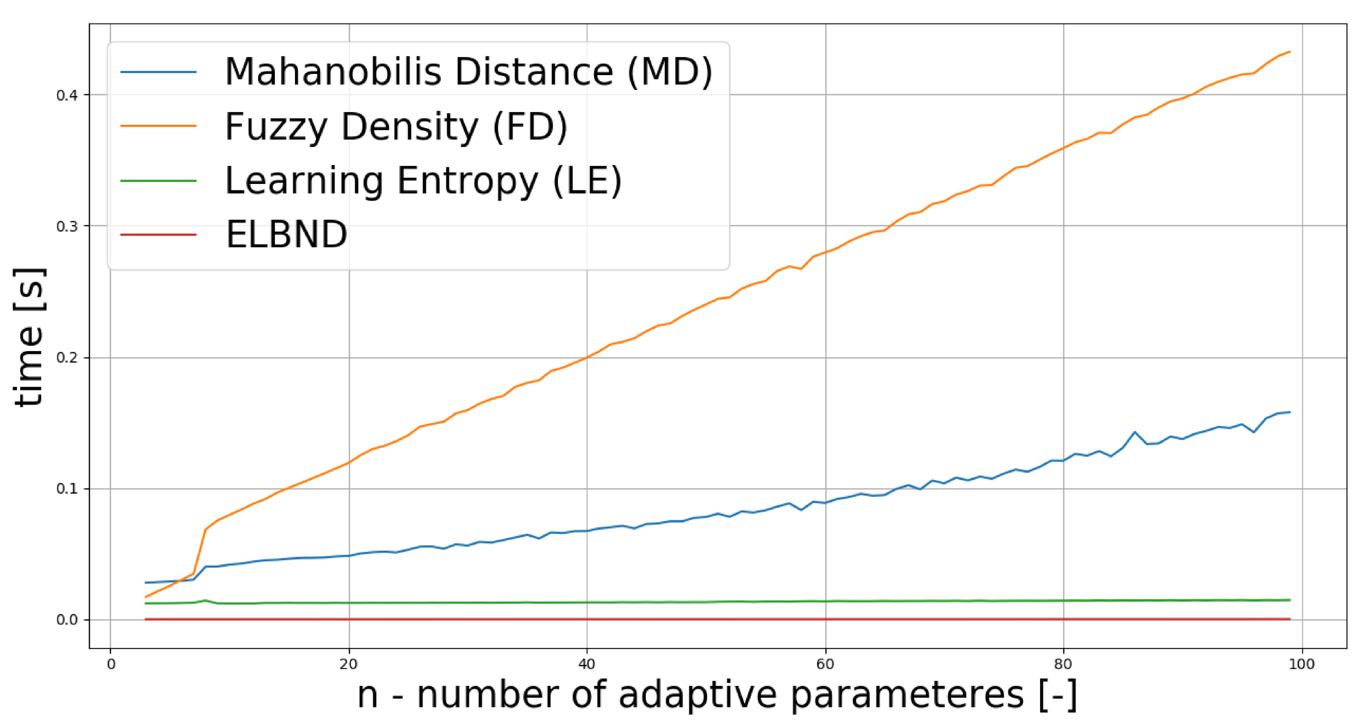


This prediction setup is suitable for online use. Many different adaptive algorithms can be used in the adaptive filter via ELBND method novelty detection, for example: LMS, NLMS, RLS, GNGD [1-4].

#2 Objective

Table 1: Time complexity and number of operations for one iteration of ELBND algorithms, n is the number of adaptive model parameters.

order	operation	complexity	additions	multiplications	note
1.	$o_1 = \mathbf{\Delta w(k)}e$	$O(n)$	0	n	-
2.	$o_2 = \|o_1\|$	$O(n)$	0	0	abs()
3.	$\max(o_2)$	$O(n)$	0	0	max()

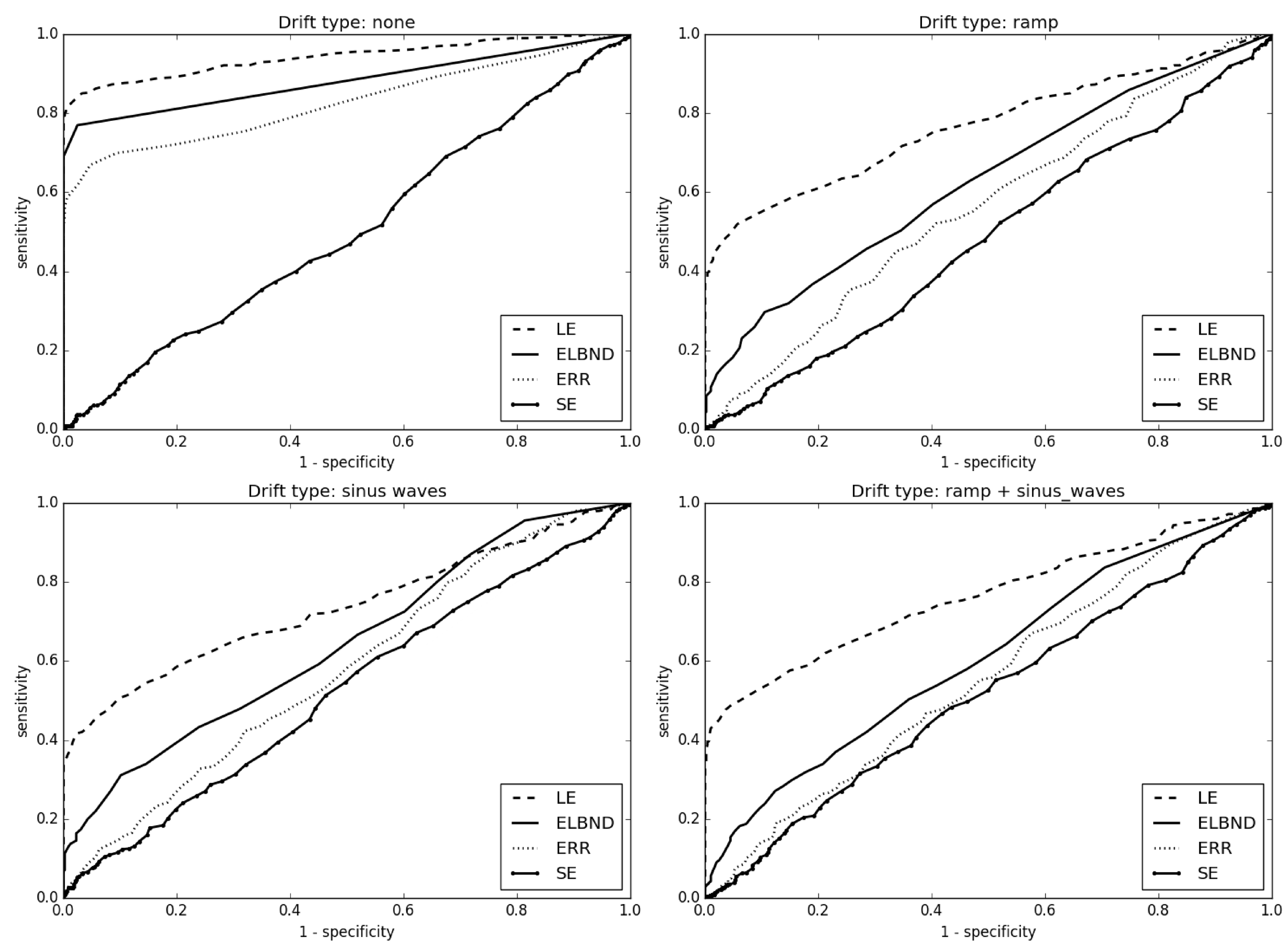


According to the Table and Figure above [3], the ELBND method is suitable for online use and can be considered fast in comparison with similar methods.

Motivation

Novelty detection is an important signal processing task. This task is essential for many industrial, and biomedical applications. However, most of the developed methods are not suitable for online use, and/or they are not suitable for use in unsupervised fashion.

#3 Objective



The ELBND method was tested with various types of non-stationary data with concept-drift and different types of noise [2,4]. Figure above shows that ELBND method can compete and in some cases even overcome other state of the art methods - Learning Entropy (LE), Sample Entropy (SE).

Conclusion

The proposed method (ELBND) accomplish all thesis objectives. It is computationally inexpensive and can handle data distorted in various ways - concept drift, heavy non-stationary origin, various kinds and levels of noise. Method is well tested on real and also synthetic data.

List of selected author's publications

[1] C. Oswald, M. Cejnek, J. Vrba, and I. Bukovsky, "Novelty detection in system monitoring and control with honu," in *Applied Artificial Higher Order Neural Networks for Control and Recognition*, M. Zhang, Ed. IGI Global, 2016, vol. 61, pp. 61–78.

[2] M. Cejnek and I. Bukovsky, "Influence of type and level of noise on the performance of an adaptive novelty detector," in *2017 IEEE 16th International Conference on Cognitive Informatics & Cognitive Computing (ICCI* CC)*. IEEE, 2017, pp. 373–377, ISBN 978-1-5386-0771-8.

[3] M. Cejnek and A. Peichl, "Rychlost adaptivní algoritmů pro detekce novosti," in *Nové metody a postupy v oblasti přístrojové techniky, automatického řízení a informatiky 2018.* České vysoké učení technické v Praze, 2018, pp. 91 – 99, ISBN 978-80-01-06477-1.

[4] M. Cejnek and I. Bukovsky, "Concept drift robust adaptive novelty detection for data streams," *Neurocomputing*, vol. 309, pp. 46 – 53, 2018.

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