Novelty detection via linear adaptive filters

Branch of study: Control and Systems Engineering
Author: Ing. Matouš Cejnek, supervisor: Doc. Ing. Ivo Bukovský, Ph.D.

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:

\[
\begin{align*}
\text{system input} & : u(k) \\
\text{system} & : y(k) \\
\text{error} & : e(k) \\
\text{filter input} & : w(k) \\
\text{filter output} & : \hat{y}(k)
\end{align*}
\]

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.

<table>
<thead>
<tr>
<th>order</th>
<th>operation</th>
<th>complexity</th>
<th>additions</th>
<th>multiplications</th>
<th>note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \Delta w(k) )</td>
<td>( O(n) )</td>
<td>0</td>
<td>( n )</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>(</td>
<td>o_1</td>
<td>)</td>
<td>( O(n) )</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>( \max(o_2) )</td>
<td>( O(n) )</td>
<td>0</td>
<td>0</td>
<td>\text{max()}</td>
</tr>
</tbody>
</table>

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