

## **REVIEWER REPORT on PhD Dissertation Thesis**

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Title of Thesis: **Novelty detection via linear adaptive filters**

### **1. ACHIEVING THE OBJECTIVES OF THE DISSERTATION THESIS**

The aims of investigation are clearly defined in chapter 3 by three main objectives:

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

These objectives have been achieved by derivation, implementation and experimental analysis of newly developed adaptive novelty detection method named ELBND (Error and Learning Based Novelty Detection). This method is designed to be used with any supervised adaptive algorithm that has adaptive parameters and error.

### **2. ANALYSIS OF CURRENT STATE OF THE ART**

In the dissertation thesis, there is presented a nice analytical review of the current state of the art based on 61 cited publications. In the Introduction, there is explained what novelty detection is, its importance and implementation challenges. The current state of research in the field of novelty detection is presented in chapter 2, where the main approaches and directions in novelty detection field are introduced.

### **3. THEORETICAL CONTRIBUTIONS OF THE DISSERTATION THESIS**

The main theoretical contribution of the dissertation thesis is newly developed Error and Learning Based Novelty Detection (ELBND) method, which differs from all other published methods. The presented experimental analysis in the thesis features adaptive filters as the adaptive models used together with ELBND. Although the adaptive filters are one of the simplest adaptive algorithms, the ELBND algorithm is able to effectively utilize information produced by their operation. These are the main reasons why the development of this method is a nice contribution to the field of machine learning and signal processing.

### **4. PRACTICAL CONTRIBUTIONS OF THE DISSERTATION THESIS**

The dissertation's main practical contribution is validating the newly developed ELBND method for biomedical data processing - the detection of perturbations in ECG and the classification of

Alzheimer's disease from EEG signal. The presented two studies have demonstrated the abilities of ELBND to deal with non-stationary and offset real-time signal.

An important research result for practical application is confirmation that ELBND is much faster than the other methods.

## 5. SOLUTION METHODS USED, THEIR APPLICATION AND KNOWLEDGE LEVEL

Following the comprehensive review of state-of-the-art approaches to novelty detection, the author proposed a method called Error and Learning Based Novelty Detection (ELBND) which utilizes the adaptive parameters of a learning model and its error. Various types of adaptive filters have been used as the base for adaptive models. The idea behind this method is based on assumption, that the model error and the adaptive parameters of the model carry a different information about novelty of data, although both features are correlated. In my opinion, this approach is right.

The obtained knowledge during research has been presented in 10 publications (8 as the first author), mainly at scientific conferences (also world congresses), but there is also the most important one Current Contents publication in Neurocomputing (Q1).

## 6. FORMAL COMMENTS ON THE DISSERTATION THESIS

The dissertation thesis is divided into 7 chapters, including Introduction, Conclusion and References in the total number of pages 102. The thesis also includes a separate Summary. The formal level of the dissertation thesis is good, the dissertation thesis is very well legible without significant formal shortcomings.

Comments:

- a) The titles of tables are in the thesis unusually placed below the tables instead of above the tables.
- b) References to figures are mainly in the form "Figure x.y" but somewhere as "figure x.y" (for example on page 27, 39) or "Fig. x.y" (for example on page 56, 57, 62...).
- c) Page 42, 43: NLMS filter is mentioned twice instead of NLMF in the sentence "On the other hand, it is much harder to enforce stability of the NLMS filter than NLMS filter [71, 72]."
- d) Page 53: Figure 5.4 is unnecessarily placed already in section 5.1.1.1 Artificial data, while it belongs to section 5.1.1.2 Real measured data.
- e) Page 73, Table 5.6: "low" is missing in the sentence "Results for experiments with high level of noise are on the left side, the results for experiments with the level of noise are on the right side."

## 7. QUESTIONS AND REMARKS

- a) The thesis is written mainly based on author's published studies. It would be fine, if these studies were stored on CD as Appendix.
- b) Were all figures in the thesis prepared by author? Some of them are referenced as adopted from author's studies, but neither one is from another source.
- c) Page 42, 4.2.3. LMF adaptive filter: Why is "ELBND" mentioned for  $nd(k)$  calculation? For other filters there is just "novelty".
- d) Is any difference between vector  $\mathbf{I}$  in Eq. (4.24) and vector  $\bar{\mathbf{I}}$  in Eqs. (4.33), (4.34), (4.36)...?

## 8. CONCLUSION

Novelty detection is an important signal processing task essential for industry, and also biomedical applications. It is one of the oldest and the most fundamental tasks in machine learning field. From this point of view, the reviewed thesis titled „Novelty detection via linear adaptive filters” is an important contribution to the further development of science and technology in the research field of interest.

The author Ing. Matouš Cejnek has proven the ability to scientifically work and creatively solve complex research problems, so I **recommend** to defend his dissertation thesis.

In Prešov, April 15, 2020

prof. Ing. Ján Piteľ, PhD.  
Reviewer