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Detection and diagnosis of model parameter and noise variance changes with application in seismic signal processing

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ABSTRACT

The change detection and diagnosis methods have gained considerable attention in scientific research and appears to be the central issue in various application areas. These applications need some robust change detection schemes to work well and separate the changes in the experimental conditions from the real changes in the system, especially for systems with arbitrary and non-stationary known or unknown inputs. The objective of the paper is to develop such kind of change detection and diagnosis scheme. In the first part of the paper we give the conceptual description of some classical change detection schemes based on sliding windows and likelihood techniques. Then, starting from these classical change detection schemes, a new algorithm able to discriminate between the model parameter and noise variance changes is presented. Finally, we include some Monte Carlo simulations for change detection in a second order FIR model and experimental results obtained in analysis of seismic signals, using the proposed approach.

1. Introduction

The problem of change detection and diagnosis has gained considerable attention during the last two decades in a research context and appears to be the central issue in various application areas such as: speech processing, image processing, analysis of biomedical signals, signal processing in cars, digital data transmission systems, underwater acoustics, geophysics, failure detection in controlled systems (aeronautics, chemical and nuclear processes, event detection of incident on freeways, leak detection for pipelines), econometrics, etc.

From statistical point of view, change detection tries to identify changes in the probability distribution of a stochastic process. In general, the problem involves both detecting whether or not a change has occurred, or whether several changes might have occurred, and identifying the times of any such changes. Specific applications may be concerned with changes in the mean, variance, correlation, or spectral density of the process.

Deeper interactions between the control, signal processing, and statistical communities recently contributed to the insight in the change detection problem in a significant way. In our opinion, a coherent methodology is now available to the designer, together with the corresponding set of tools, which enables him to solve a large variety of change detection problems in dynamical systems. It is interesting to see that the theory has been used in many successful applications, which is directly reflected in the number of patents [1]. Also, many books, journals and conference publications are concerned with these applications. Among these can be mentioned applications in mechanical engineering [2–4],

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