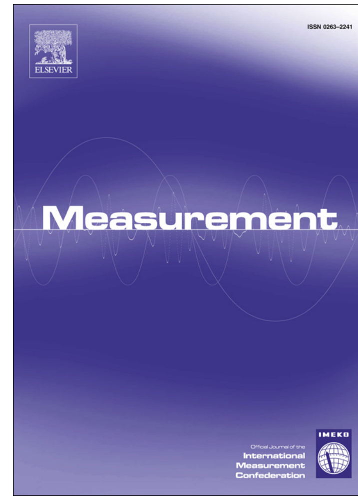

Structure analysis and denoising using Singular Spectrum Analysis: application to acoustic emission signals from nuclear safety experiments

O.I. Traore, L. Pantera, N. Favretto-Cristini, P. Cristini, S. Viguier-Pla, P. Vieu

PII: S0263-2241(17)30115-X
DOI: http://dx.doi.org/10.1016/j.measurement.2017.02.019
Reference: MEASUR 4604

To appear in: *Measurement*

Received Date: 3 November 2016
Revised Date: 10 February 2017
Accepted Date: 13 February 2017

Structure analysis and denoising using Singular Spectrum Analysis: application to acoustic emission signals from nuclear safety experiments

O.I Traore[a], L. Pantera[b], N. Favretto-Cristini[a], P. Cristini[a], S. Viguier-Pla[d,c], P. Vieu[c]

[a] *Aix-Marseille Univ, CNRS, Centrale Marseille, LMA, Marseille, France*
[b] *CEA, DEN, DER/SRES, Cadarache, F-13108 Saint-Paul-lez-Durance, France*
[c] *Institut de Mathématiques de Toulouse, 118 route de Narbonne, F-31062 Toulouse Cedex 9, France*
[d] *Université de Perpignan via Domitia, LAMPS, 52 av. Paul Alduy, 66860 Perpignan Cedex 9, France*

Abstract

We explore the abilities of the Singular Spectrum Analysis (SSA) to characterize and denoise discrete acoustic emission signals. The method is first tested on simulated data for which different types and levels of noise are considered. It is then applied on real data recorded from nuclear safety experiments. The results show an excellent ability of the SSA to characterize the corrupted signal and to detect structural changes, even for low signal-to-noise ratio. For denoising purposes, the quality of the results depends mainly on the separability between the source signal to be estimated and the noise. However, whatever the case, the main components of the source signal are clearly identified when the components associated with the noise are removed.

Keywords:
acoustic emission; singular spectrum analysis; structural changes detection; signal denoising; nuclear environment.

Introduction

Reactivity Initiated Accident (RIA) is a nuclear reactor accident which involves an unexpected and very fast increase in fission rate and reactor power due to the ejection of a control rod. The power increase may damage the fuel clad and the fuel pellets of the reactor. The French Alternative Energies and Atomic Energy Commission (CEA) operates a pool-type reactor dedicated to fuel behavior study in RIA conditions.

Several non-destructive methods are used to inspect the reactor and to get information on the behavior of the fuel clad and the fuel pellets during the experiments. The acoustic emission (AE) technique is a powerful tool dedicated to structure health monitoring which has also the advantage of being simple to adapt to nuclear-oriented purposes. This technique is generally used to monitor real-time processes which emit acoustic waves. It is used to detect and/or monitor defaults and cracks in materials (e.g.[1]), and to monitor the compaction of various powders (e.g. [2, 3, 4]), including nuclear fuel powders [5, 6]. Some works also focus on the correlation between acoustic signatures and physical mechanisms during tests (e.g. deformation, fragmentation, rupture...) (e.g. [7, 6]). This methodology is of interest for characterizing the structure health in RIA conditions. However, since the complex environment of the nuclear reactor makes signals noisy, applying this methodology first requires an efficient signal denoising.

Email address: traore@lma.cnrs-mrs.fr, toumarissiaka@gmail.com (O.I Traore)