Expert Systems with Applications 38 (2011) 3192–3198

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Falling sheet envelope method for non-destructive testing time-dependent signals

J.A. Pérez-Benitez [a,*], L.R. Padovese [b]

[a] Departamento de Física, Facultad de Ciencias Naturales, Universidad de Oriente, Av. Patricio Lumumba s/n, 90500 Santiago de Cuba, Cuba
[b] Departamento de Engenharia Mecânica, Escola Politécnica, Universidade de São Paulo, Av. Prof. Mello Moraes, 2231, 05508-900 São Paulo, Brazil

ARTICLE INFO

Keywords:
Envelopment
Neural networks
Non-destructive methods

ABSTRACT

In this work, an algorithm to compute the envelope of non-destructive testing (NDT) signals is proposed. This method allows increasing the speed and reducing the memory in extensive data processing. Also, this procedure presents advantage of preserving the data information for physical modeling applications of time-dependent measurements. The algorithm is conceived to be applied for analyze data from non-destructive testing. The comparison between different envelope methods and the proposed method, applied to Magnetic Bark Signal (MBN), is studied.

1. Introduction

The envelope of time-dependent signals has become an important tool for signal analysis (Choi & Jiang, 2008; Feilat, 2006; Jiménez, Muñoz, & Duarte-Mermoud, 2007; Oppenheim, Shafer, & Buck, 1999; Oppenheim, Willsky, & Nawab, 1998; Sheen, 2008; Sheen & Hung, 2004). For these propose it has been developed many signal envelope methods, using the Hilbert Transform-based envelopes (Feilat, 2006; Feldman, 2008; Jiménez et al., 2007; Qin & Zhong, 2006), the FFT Transform-based envelopes (Choi & Jiang, 2008; Sheen, 2008) and more recently some extensions of these methods using Wavelet-base Transform methods (Jiménez et al., 2007; Sheen & Hung, 2004). These methods are of fundamental significance for vibration engineering and voice processing and recognition methods and they are suitable for real-time signal inspection and for vibration modes analysis.

On the other hand, the application of signal envelope methods for analysis of signal of non-destructive testing (NDT) measurements has also become an important research tool (Carvalho, Rebello, Sagrilo, Camerini, & Miranda, 2006; Pal'a, Stupakov, Bydzovsky', Toma's, & Nova'k, 2007; Pérez-Benitez, Capó-Sánchez, Anglada-Rivera, & Padovese, 2005). However, in this case, it is very important the preservation of physical information contained in the signal, since the Signal amplitude vs time is correlated to physical models (Pal'a et al., 2007; Pérez-Benitez et al., 2005). It is common in NDT signals, the presence of very low and/or high sharp noise, superimpose with the "real" signal. The knowledge of the physical nature of the signal it is important to decide the smoothes of the envelope.

Furthermore, in NDT analysis, it is usually required the analysis of long data sets. In particular, long data sets are necessary when the statistical study or Neural Network approaches are used (Carvalho et al., 2006). The need of increase the speed of data analysis and reduce the quantity of data stored without reduce the accuracy of outcomes, is a common challenge for this kind of studies.

It has been shown, that the vectorial magnitudes such as power spectrum and envelope of the signal are more effective for NDT characterization, than the scalar magnitudes such as root mean square and maximum value of the signal (Carvalho et al., 2006). These vectorials magnitudes contain significantly more information than the scalars ones. However, the fact that their analysis requires much time and store memory limits their use. For example, the use of the signal envelope when used as neurons for the Probabilistic Neural Network, for classification of NDT measurements, involves a high quantity of data (the data in the hidden layer most contain all the envelopes of the pattern data for distance calculation). The envelopes obtained using the traditional methods (even more the smoothes) necessitates to compute the Hilbert and/or Fourier Transform of the entire the signal. This fact increase the computation time unnecessarily, if we only need a pre-classification of the data in order to applied a successively approximation method.

The present work is undertaken to create an envelope algorithm that allows a fast and low memory cost approximation of the signal envelope. At the same time the method will be flexible enough to preserve the physical information contained in the signal according to user considerations.

2. Methods and materials

All the experimental data come from Magnetic Barkhausen Noise measurements of AISI/SAE 1006 samples for different values

* Corresponding author.
E-mail addresses: benitez@cnt.uo.edu.cu, benitez_edl@yahoo.es (J.A. Pérez-Benitez).

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doi:10.1016/j.eswa.2010.09.007

of plastic deformation (0%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%). The experimental setup is described in Alberteris Campos, Capo -Sanchez, Perez-Benitez, and Padovese (2008). The measurements were made along the easy axis direction on the unloaded condition. The computational tests were made using a micro-PC CPU Intel Pentium 4, 3.0 GHz, 2 GB RAM. The envelope algorithms were made in MATLAB 7.0.

3. Results and discussions

3.1. Envelope method description

Fig. 1 schematically shows the basics elements of the Falling sheet envelope algorithm.

It can be seen from figure that the Falling sheet is represented by a discontinuous line which is moving from top to the bottom

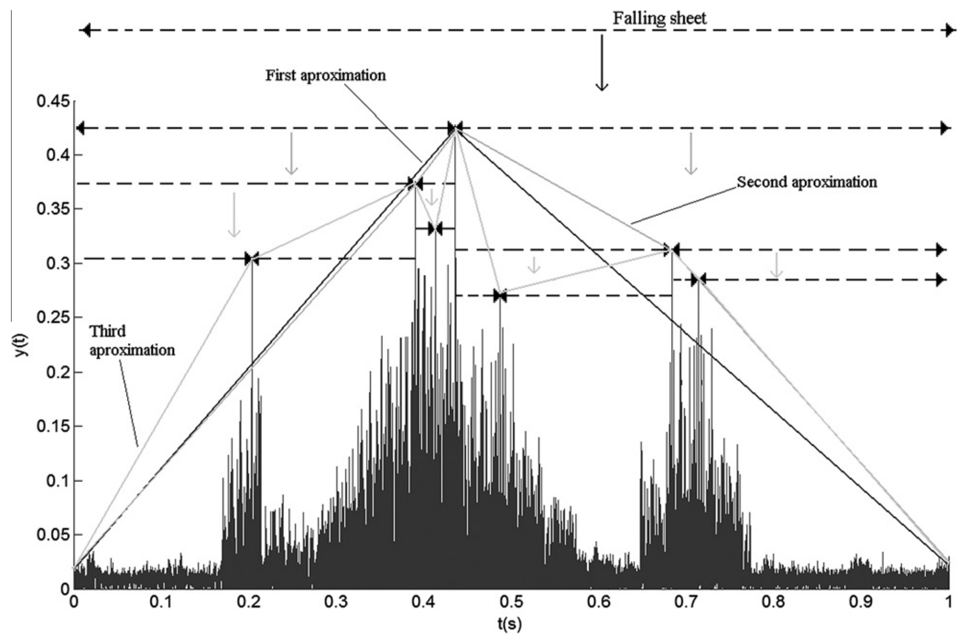

Fig. 1. Schematic representation of the Falling sheet envelope method.

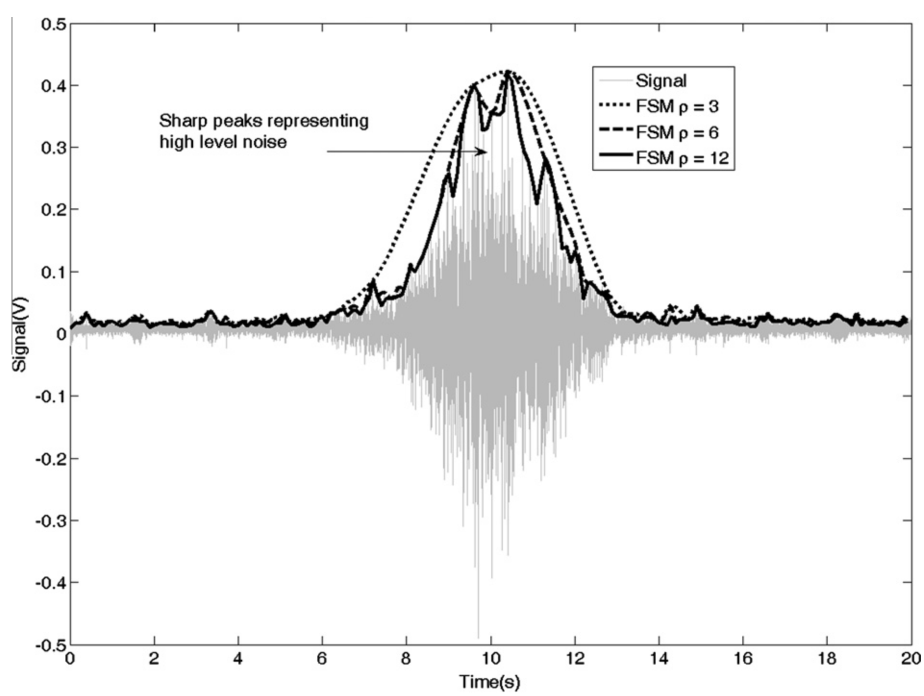

Fig. 2. MBN signal and the corresponding envelopes obtained using the FSM for different ‘‘rigidity" values.