Computation of Greatest Common Divisor for the Blind Deconvolution of Transient Impulsive Signals

Pablo Lecumberri, Marisol Gómez, Alfonso Carlosena (1)

Universidad Pública de Navarra
Department of Mathematics and Computer Science
(1) Department of Electric and Electronic Engineering
Campus de Arrosadía
E-31006 Pamplona
pablo.lecumberri@unavarra.es

1. Introduction

The goal of the work reported in this communication is the development of a method for recovering impact signals, or transient impulsive source signals in general, from sensor measurements. These techniques are to be incorporated into the design of smart accelerometers.

The classical approach for recovering impacting force signals consists in applying deconvolution techniques to the output signals, given a previous estimation of the system response, which must account for the effects of mechanical propagation and sensor response [1]. Therefore, the overall system response depends of the underlying mechanical structure and the position of impact and sensor, which may be unknown. As a result, in many cases that previous estimation is unavailable and the need for blind deconvolution techniques arises.

Blind identification / deconvolution is an active field of research, boosted by its application in wireless communications. Most methods developed in this area assume some statistical distribution for the input signal samples and compute statistics from the output signals time samples in order to deconvolve the signals [e. g. 2]. However, in the case of transient signals, we cannot rely on time averages to obtain valid statistics. Deterministic methods that do not assume any statistical prior, still require an estimation of the impulse response of the channels [e.g. 3, 4].

We propose a new blind deconvolution method for transient impulsive signals in a single input – multiple output (SIMO) system. The method exploits the data redundancy inherent to SIMO multichannel systems to obtain an estimation of the input signal. The method is built upon the assumptions of finite-length signals and channel diversity.

2. Results and Discussion.

When the assumptions of the proposed method are met, it can be shown that the input signal is actually the greatest common divisor (GCD) of the polynomials built with the time samples of the output signals as coefficients. Thus, a reliable numerical method for the computation of the GCD would allow to estimate the input signal blindly.

In [5], specialized matrices are studied in relation to the computation of the GCD. From results reported in that work we have derived a singular matrix pencil formulation of the problem. The method proposed ion [5] and solutions available for matrix pencils rely on matrix decompositions which are very sensitive to small changes in the data and thus not suitable for computing estimations from noisy data. Our method provides an estimation through the minimization of the pseudospectra [6] to avoid such instability.

The proposed method has been tested with both sinthetic and real data. Figure 1 shows one of the experimental set-ups for the acquisition of real signals, which consists of a steel cantilever beam hit by a sensorized hammer (Dytran Impulse Hammer 5850B). Table I shows the dimensions of the beam. Technical data of hammer and sensors employed can be seen in Table II.

	Length (mm)	Section (mm×mm)
Beam	625	30 × 8

Table I. Steel cantilever beam dimensions

	Sensitivity (mV/g)	Resonance Frequency (KHz)
Hammer	10	75
Sensor	10	50

Table II. Equipment data.

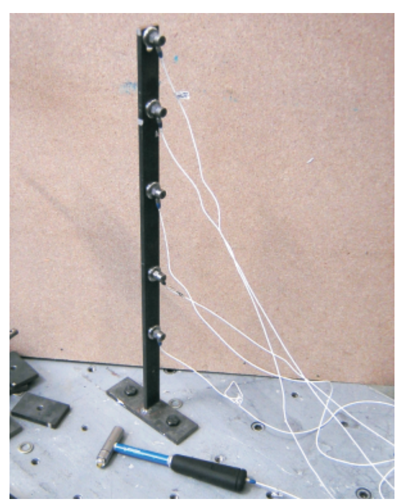

Figure 1. Cantilever beam with accelerometers and sensorized hammer.

Piezoelectric accelerometers (Endevco Isotron 751-10 Accelerometer) placed upon the beam on diferent positions provide the output signals of the SIMO multichannel system.

Signals are sampled at 1066 samples/second. Figure 2 (a) shows one of the output signals. In order to obtain finite-length signals so that the proposed method can be applied, the poles of the system are first estimated and their contribution filtered out. The result are finite-length signals modelling the zeros of the original ones (Figure 2 (b)).

Figure 2 (c) shows the impact signal provided by the sensor placed inside the hammer and the estimated one, obtained by the proposed method (after convenient delaying and scaling). The result is satisfactory in the sense that it approximates the shape of the excitation signal and allows to estimate its duration.

3. Conclusions

Motivated by the deconvolution of impact signals in mechanical systems, we have developed a novel numerical method for the computation of the GCD of polynomials. The experimental tests show the applicability of this method for estimating transient impulsive source signals blindly from sensor measurements. This is a problem that could not be resolved with previous blind deconvolution algorithms.

4. References

[1] E. Jacquelin, A. Benani, and P. Hameling, "Force reconstruction. Analysis and regularization of a deconvolution problem", Journal of Sound and Vibration, vol. 265, pp. 81 – 107, 2003.

[2] E. Moulines, P. Duhamel, J.-F. Cardoso, and S. Mayrargue, "Subspace methods for the blind identification of multichannel FIR filters", IEEE Trans. Signal Processing, vol. 43, pp. 516 – 525, 1995.

[3] G. Xu, H. Liu, L. Tong, and T. Kailath, "A least-squares approach to blind channel identification", IEEE Trans. Signal Processing, vol. 43, pp. 2982 – 2993, 1995.

[4] Y. Hua, "Fast maximum likelihood for blind identification of multiple FIR channels", IEEE Trans. Signal Processing, vol. 44, pp.661 – 672, 1996.

[5] R. R. Bitmead, S.-Y. Kung, B. D. O. Anderson, and T. Kailath, "Greatest common divisor via generalized sylvester and bezout matrices", IEEE Trans. Automatic Control, vol. 23, pp. 1043 – 1047, 1978.

[6] G. Boutry, M. Elad, G. H: Golub, and P. Milanfar, "The generalized eigenvalue problem for non-square pencils using a minimal perturbation approach", accepted for publication in SIAM Journal on Matrix Analysis and Applications.

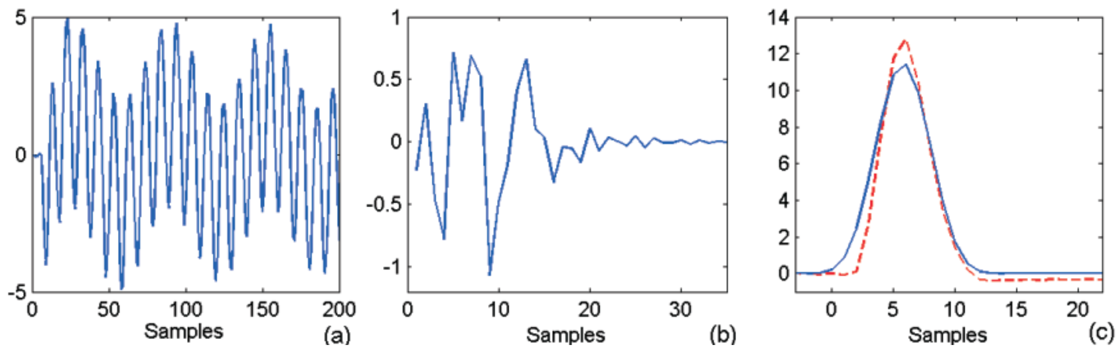

Figure 2. (a) Output signal provided by one accelerometer. (b) Output signal after removing poles contribution. (c) Measured (dashed) and estimated (solid) source signal.