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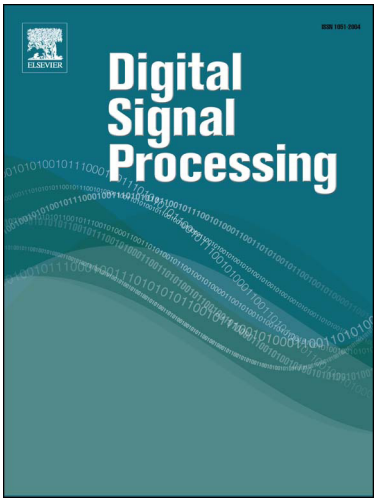

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Parameter identification of periodical signals: Application to measurement and analysis of ocean wave forces

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Abstract

This article presents an approach based on state observers to identify the parameters of an unknown periodic force exerted on a mechanical system. This approach comprises two stages and can be executed in real time by using only displacement measurements. The first stage goal is the estimation of the coefficients of a Fourier series that approximates the periodic force. From the estimated coefficients, the phase and the amplitude of the signal can be simultaneously computed; and from the estimated force, in a second stage, the frequencies of the signal can be estimated. To perform the tasks at each stage, two state observers were designed. To show the applicability of the proposed approach, the reconstruction of a wave force affecting a marine structure as well as the computation of the amplitude and phase of its spectral components was taken as case of study. The performance of the state observer was examined by means of simulations and off-line tests carried out with experimental data. Such a data were obtained by executing laboratory tests and measuring waves in the Caribbean sea.

Keywords: State observers, Fourier coefficients, mechanical systems, parameter identification, periodical signals.

1. Introduction

Many mechanical structures are subjected to periodic forces. Examples are pipelines or oil platforms subjected to ocean currents, wind and sea waves. Other examples are the Wave Energy Converters (WECs), which can harness marine energy using several operation principles such as vertical oscillation, overtopping and wave concentration. In any case, the design of the WEC itself as well as its mooring systems depends on the estimation of the forces impinging the device.

Likely these examples, there are many others in diverse engineering fields, for which the estimation of a periodic force in real time is required (e.g. power monitoring, vibration control and periodic disturbance rejection). Concerning this challenge, the principal contribution of this paper is the proposition of a real-time methodology to reconstruct an unknown periodical force exerted on a mechanical system as well as the identification of its parameters such as phase, amplitude, power and frequency.

Force estimation has been addressed by numerous authors (see for instance [1]) as well as real time estimation of unknown parameters of sinusoidal waves such as amplitude, frequency, offset and phase. In Table 1 and in references [2, 3], the reader can check some of the most important contributions on the concerning subject.

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