Estimation of Response Transfer Functions of Offshore Structures Using the Time-Varying ARX Model

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ABSTRACT

The purpose of this paper is to propose and investigate a new approach for estimating response transfer function of offshore structures with wave as excitation input. The approach is based on time-varying autoregressive with exogenous input (TVARX) model. This method is virtually unexplored in offshore engineering field, as a number of works have shown that transfer functions such as response amplitude operator are estimated based on discrete Fourier transform (DFT). Here, we outline a practical algorithm for TVARX model which uses expectation-maximization (EM) algorithm based on Kalman smoother to generate the transfer function. The method is then applied to sampled discrete wave as excitation input and the motion responses of offshore structures as output data, generated from simulated field measurements. The proposed approach outlined here has shown the tremendous potential in the estimation of transfer function. The results indicate that TVARX model produces accurate, smooth and less noise TF estimates over DFT method. TVARX model also allows for the creation of time varying transfer function (TVTF).

KEY WORDS: Motion responses; Kalman smoother; Time-varying ARX model; Transfer function.

INTRODUCTION

Generally, the motion responses of platforms and environmental conditions such as wind, wave and current are available in the form of field measurements, experimental and numerical data. The time history of such recorded data can be utilized to generate dimensionless form namely response functions (RFs) either in time or frequency domain, i.e. transfer function (TF) and response amplitude operators. This paper is addressed to generate TF from the available recorded data. This is motivated from the offshore monitoring campaign (Buchner, 2009; Boom, 2005) and physical model limitations (Chakrabarti, 1998) that transfer function can be used for modal analysis, dynamic response prediction, motion control systems design and damage detection of offshore platforms.

There are three transfer functions that can be generated from marine structures (Taghipour, 2008). The first is wave to force TF, second is force to motion TF and the last is wave to motion TF. This paper will work on the estimation of wave to motion TF due to the availability of data. In order to estimate the response transfer functions, DFT has been the most widely used technique. However, due to sea state exhibits nonstationary and nonlinearity, the method is not recommended anymore. It has been shown by prior researches such as (Huang, 1998; Hwang, 2003; Liu, 2000; Schlurmann, 2003). The non-stationarity and nonlinearity may also come from platform motions themselves. In other word, the proposed method is applicable in any