NOTE

A METHOD FOR CONTINUOUS-TIME IDENTIFICATION OF MOORED SYSTEMS

R. BELTRÁN-AGUEDO† and M. A. JORDÁN‡

Departamento de Ingeniería Eléctrica y Computadoras, Universidad Nacional del Sur
Av. Alem 1253, 8000 Bahía Blanca, ARGENTINA.
† *rbeltran@criba.edu.ar*
‡ *mjordan@criba.edu.ar*

Abstract— **In this paper a method for continuous-time identification for the class of moored semisubmersible marine systems based on totally measured states is presented. The exponential convergence of parameter trajectories is analyzed in the context of conditions for persistency of excitation (PE). A regression for the estimator is constructed containing generically 312 parameters to be identified. The presented analysis has revealed that the regressor must expand a space of only 24 dimensions instead of 312 for unbiased estimates. Under monochromatic excitation, PE conditions are expected to be satisfied only in chaotic behaviors. A case study of a real moored crane-platform is modelled and simulated to verify such conditions.**

Keywords— **Nonlinear Semisubmersible Dynamics, Moored Systems, Identification, Identifiability, Persistency of Excitation.**

I. INTRODUCTION

The increasingly growing complexity in ocean operations and design of marine structures and vehicles, imposes the necessity of modern methods and tools for stability analysis and control tasks. An important exponent of these systems constitutes the class of moored semisubmersible structures (platforms, barges, tanks, buoys, among others), which are set up for operations in harbors and offshore.

Moored marine structures are often characterized by transitions from linear to nonlinear behaviors under certain wave conditions, which make the operation to become unpredictable (Kreuzer, 1993; Dmitrieva and Lougovsky, 1997). In extreme cases such a nonlinear response can turn into chaos and may cause the floating structure to capsize. From practical viewpoints, small and large chaotic oscillations or subharmonics have to be avoided and controlled in order to attain safe and foreseen operations. On the other hand, they constitute one way to provide a good excitation for parameter estimation. In other words, bifurcations are undesired in the behaviour (and so control is requested) but beneficial for identification. As many physical parameter are slowly varying in time, control actions have to be intended in an adaptive way. The design of a generic adaptive law and its analysis for a case study is the chief matter in this paper.

A semisubmersible can be considered as a multibody system composed by subsystems interacting each one with the rest, *e.g.*, platform, mooring lines and load. The excitation sources result from waves, wind and currents. Physical parameters of interest are wave height, frequency, wave number, platform and load masses, active lengths of catenaries among others.

The use of modern tools for stability analysis, like Lyapunov coefficient diagrams and bifurcation theory, requires a detailed analytical model of the system, what in turns means, a precise knowledge of the physical parameters and model structure. Related with them are the hydrodynamic coefficients which are of pure mathematical provenience, but they play an important role in the determination of bifurcations (Kreuzer *et al.*, 2002).

The hydrodynamics of a semisubmersible is based on the Potential Theory for diffraction and reflection of waves. These methods use finite elements for computing the efforts of the fluid interaction with wet parts of the platform and are available in commercial programs. Usually, the results of the stability analysis have to be confronted with experimental results carried out in laboratories with reduced-scale models at relative high costs.

An alternative to the use of dedicated programs is developed in this work. It consists of parameter identification based on measured signals of the behavior, e.g., gyroscopic and cinematic states. This has the advantage that it can be performed on-line with a small amount of a-priori information. The algorithm can adapt automatically for changes of the mass, the operation points and changes of the environment if a forgetting factor or similar procedure is incorporated as in the classic form. Thus, stability analysis and controller design can obtain this information on-line and directly from on-board instrumentation.