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Reproduction of Wave Field from Spatiotemporal Discontinuous Wave Data

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ABSTRACT

We propose a method to reproduce the encountered ocean wave field by a ship in the experimental wave basin from the wave elevation observed on board of a ship discontiguously in space and time, based on the linear theory. The mathematical wave model is based on the Bessel function for a circular wave basin and estimated its parameters by the least square method. Wave elevation is assumed to be observed by the 3D camera and image analysis system equipped on board. This method and the mathematical model are validated with the results of numerical calculations and tank experiments.

KEY WORDS: Element absorbing wave maker, Circular wave basin, Bessel function, Stereo camera system, On-board monitoring system, Least square method, Arbitrary wave field.

INTRODUCTION

Naito *et al.* (1999) developed the circular wave basin (*AMOEBA*) with 50 element absorbing wave-makers installed all around the wave basin. Although it is a small basin with a diameter of 1.6 m and a water depth of 0.25 m, each wave-maker can be controlled independently, and arbitrary wave field can be reproduced in the basin. After that, large wave basins with the same concept were constructed at the National Maritime Research Institute of Japan (Tanizawa, 2013), the University of Sao Paulo (de Mello *et al.*, 2013), the University of Edinburgh (Draycott, S *et al.*, 2015), etc., and are practically used for performance evaluation and research and development of ships and marine structures.

All of the experimental wave basins are characterized by being able to generate arbitrary wave field due to their high wave-making performance, and can generate time-controlled waves at fixed points or stochastically controlled multidirectional irregular waves. As for ships, the former is mainly used to investigate maximal ship motion and structural response. The latter is used to estimate the mean added resistance in waves by the towing experiment or the mean added ship propulsive power in waves by the free running experiment.

As a possibility of the experimental wave basin in the future, it will be required to spatiotemporally control and reproduce the wave field actually encountered by the ship. This rationale is that ships and marine structures have come to be equipped with monitoring devices, and it has become possible to obtain video data of waves encountered and ship motion and response data at that time. Many of the video images of ocean waves taken on board capture the wave motion from concentration to diffusion, which is dangerous for ships. The main purpose of this device is to use for the performance evaluation, safety assurance, maintenance plan, etc. in the ship operation. On the other hand, it is also possible to support safe operation by predicting one period ahead from monitoring data, and to reproduce dangerous wave encounters and accidents by post-analysis and provide feedback for future operations.

In this paper, we propose a method to reproduce the spatiotemporally continuous ocean wave field in the experimental wave basin from the spatiotemporally discontiguous measured ocean wave elevation data. The purpose of this proposal is to reproduce dangerous wave encounters and accidents by post-analysis and provide feedback for future operations. Wave elevation are assumed to be observed at conspicuous points on the wave surface such as peaks of waves by the 3D camera and image analysis system equipped on board. These conspicuous points are variable depending on the wave surface, so that wave elevation data become discontiguous spatiotemporally. Due to this discontiguousness, the Fourier analysis method is not applicable for identifying parameters of the mathematical wave model. Therefore, we estimate the parameters of the mathematical wave model parameters by the least square method instead by the Fourier analysis method.

The mathematical model of the wave field consists of the Bessel function as the base considering the reproduction in a circular wave basin with element absorbing wave-makers installed around it, and it is in a linear assumption at infinite water depth. Within the linear assumption, we construct a method for reproducing the spatiotemporally contiguous wave field in a wave basin, and validate it by numerical simulation and tank experiment.

In the tank experiment, the position and displacement of objects floating