DETERMINISTIC WAVE ELEVATION PREDICTION FOR REAL-TIME IMPEDANCE MATCHING CONTROL OF WAVE ENERGY DEVICES IN INTERMEDIATE WATERS

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Hydrodynamically optimal control in irregular waves requires synthesis of an acausal force, often approximated using wave elevation prediction [1]. The prediction duration, typically 15-30 s, depends on the radiation impulse-response function, and the exciting force kernel of the device. The present work investigates the fixed-point deterministic technique to utilize time-series wave elevation measurements 1000m up-wave of the device. A linear propagation model is used, so that the predicted wave elevation can be expressed as the output of a convolution where the kernel is the propagation impulse response function and the input is the up-wave wave elevation.

Our previous work with computer-generated waves has shown that the use of prediction yields large improvements in the device energy conversion efficiency in deep water [2]. The present work extends our deep-water propagation model for application in shallow-intermediate waters. An approximate dispersion relation is first investigated for accuracy, and a modified closed-form propagation impulse-response function is derived from it, for application in the depth ranges where the approximation is most accurate. Results are validated using computer-generated wave elevation time series. Next, the same propagation model is used with wave elevation time series measured in the Navy's maneuvering and sea keeping (MASK) basin, and predicted results at various chosen points are compared with actual measurements at those points.

Current results show marginally acceptable agreement at best, but can be utilized to gain insights into possible improvements needed for the intermediate-depth propagation model. Improved propagation models, and the effect of prediction errors on energy conversion are discussed. The merits and demerits of wave-prediction based wave-by-wave impedance matching control and other sub-optimal control techniques not requiring prediction are also discussed. It is noted that wave prediction requires at least one wave-rider buoy or other equivalent wave sensor, and hardware/software for communication and signal processing.

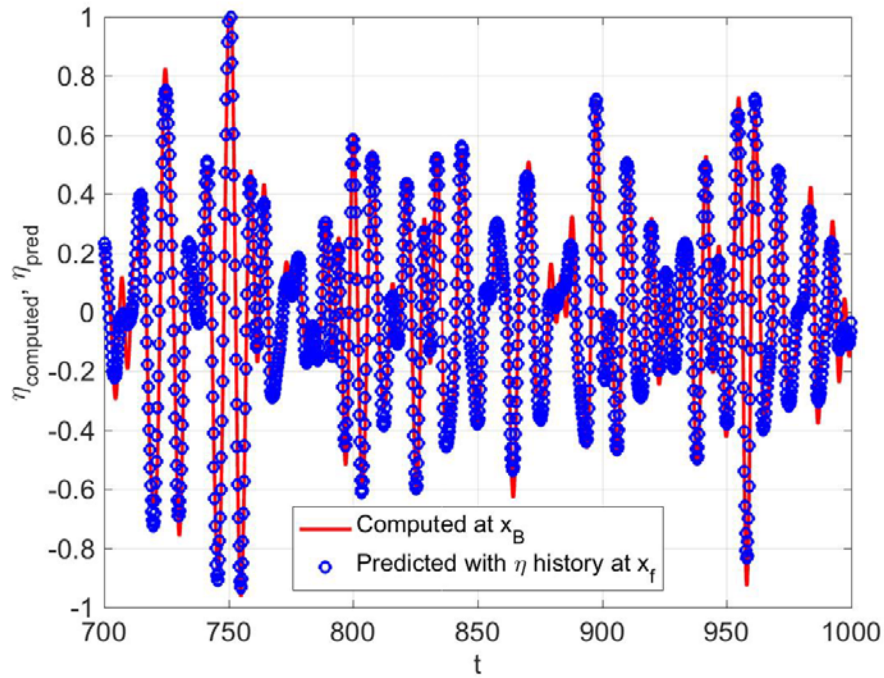

FIGURE 1. WAVE PREDICTION IN DEEP WATER, USING AN EXACT DEEP-WATER PROPAGATION MODEL.

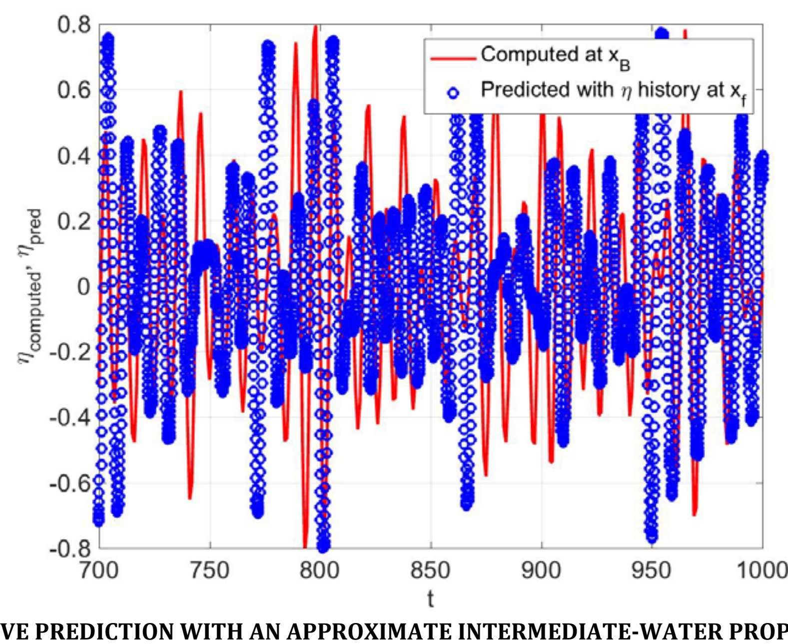

FIGURE 2. WAVE PREDICTION WITH AN APPROXIMATE INTERMEDIATE-WATER PROPAGATION MODEL. IMPROVEMENTS TO THE MODEL ARE IN PROGRESS.

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