An Approach To Reduced-Order Modeling and Feedback Control For Wave Energy Converters

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Abstract

Wave energy holds great promise to be part of the alternative energy portfolio that will provide independence from fossil fuels. As wave energy converter (WEC) technologies mature, designing effective control strategies to extract maximum energy, extend device life, coordinate WEC operation within an array, or mitigate negative impacts of a WEC becomes an increasingly important area of research. However, developing tractable models for the real-time computation of WEC control signals is challenging.

This thesis is concerned with developing a model reduction approach for control design that is suitable for application to high fidelity computational fluid-structure interaction. There are many approaches to model reduction; in the last two decades, much attention has been focused on the proper orthogonal decomposition and other singular value decomposition (SVD) type methods. In the control literature, the balanced truncation is an established approach to model reduction. Balanced POD is a computational approach related to the proper orthogonal decomposition in order to compute balanced truncation of a control system. The work presented in this thesis is the investigation into the applicability of a recently developed model reduction technique, Balanced POD, applied to a WEC fluid-structure interaction problem. We first model a one-dimensional fluid-structure interaction model arising in WEC dynamics heuristically, then design two control strategies for the tracking control of the WEC. Finally, we address the problem of estimating the type of information that can be available to the WEC controller and developing estimates of wave heights and forces that are suitable for control design. The simulation results clearly demonstrate that the reduced order models can successfully capture the fundamental nature of WEC dynamics and can be readily used for control design.

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