Input-unknown estimation for nonlinear wave energy converters: A tracking control approach

(Article begins on next page)

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Input-unknown estimation for nonlinear wave energy converters: A tracking control approach ⋆

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ABSTRACT

Given the increasing world energy needs, a substantial effort is being put by the scientific community towards achieving novel clean and sustainable energy technologies. Among these state-of-the-art energy extraction techniques, wave energy converters (WECs) have an enormous and untapped potential, capable of greatly supporting the pathway towards energy decarbonisation. Nonetheless, WEC technology has not yet achieved commercialisation, due to its current levelised cost of energy (LCoE).

One of the open challenges in the path to economic viability of wave energy conversion (WEC) systems is the development of suitable control strategies, capable of maximising energy extraction from the ocean wave resource Ringwood (2020) and consequently reducing the associated LCoE. Some of the most promising control architectures proposed to face this issue are based on the assumption that a representative model of the WEC dynamics is effectively provided. Such models are highly influenced by an external (uncontrollable) force, *i.e.* the so-called wave excitation force, which effectively represents the force exerted by the incoming wave field on the WEC system.

Given the characteristic features of the wave energy control design and synthesis procedure, and its associated controller architecture, a fundamental problem is that of designing so-called input-unknown estimators, able to provide an instantaneous estimate of the (generally non measurable) wave excitation force signal Pena-Sanchez et al. (2020). Most common approaches are based upon the specification of an internal model of the wave process (*e.g.* a random walk/harmonic model), and tuning consequently the estimator design parameters. Notwithstanding, this modelling presumption is faulty by its nature, along with the great difference of optimal parameter choice according to different sea states. An alternative approach relies on unknown-input strategies, estimation techniques which do not exploit modelling theories on the quantity to assess. In this paper, we present an equivalent controller-based approach Faedo et al. (2022) for the design of suitable unknown-input estimators for WEC systems, being able to
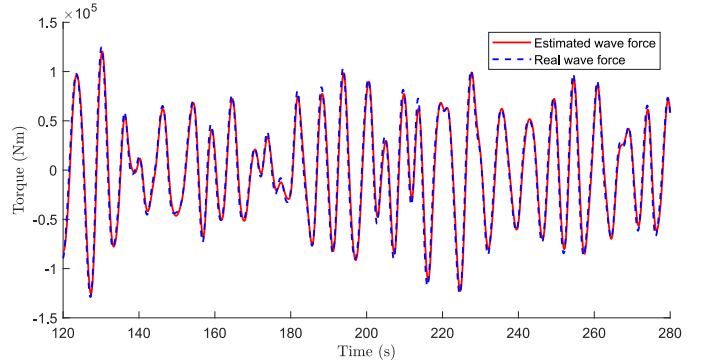
Fig. 1. Estimation performance comparison.

accommodate well-known hydrodynamic nonlinear effects characterising such devices Giorgi et al. (2020) while keep tracking of the wave excitation force. As shown in Fig. 1, the proposed strategy is demonstrated by means of a numerical appraisal in different sea states conditions, showing that the presented framework is able to consistently outperform standard and well-established force estimators utilised within the wave energy conversion field.

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