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Editorial

Special Issue on Smart Control of Ship Propulsion System

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Currently, smart technologies are rapidly gaining popularity in various industries, including the maritime sector. The concept of smart ships has become a critical factor in the maritime industry's efforts to achieve low-carbon, environmentally friendly, and sustainable green development. The development of all-electric propulsion and innovative hybrid ship propulsion systems is a priority to improve the efficiency of ship propulsion systems. However, reducing harmful emissions from shipping remains a challenge for the industry. The specific environment in which ships operate requires intelligent control design of increasingly complex propulsion systems to achieve high efficiency and safety. Therefore, this Special Issue aims to describe the intelligent control of ship propulsion systems. In this regard, this Special Issue presents studies addressing new methodologies (comparative analysis, experiments), as well as presentations of simulation-based case studies or innovative test studies for the design of ship power systems.

Ren et al. [1] propose a hierarchical collaborative control energy management scheme of the ship propulsion system to cope with the substantial volatility and uncertainty of the output power and load demand of a hybrid electric ship propulsion system. In the first-layer control scheme, tracking control of the maximum power point is realized by adding an oscillation detection mechanism and establishing a dynamic perturbation step. In the second-layer control scheme, the voltage and frequency deviation problems are solved based on a two-layer coordinated control strategy. The multi-objective particle swarm optimization algorithm is improved in the third-layer control scheme. The results show that the control strategy solves the problems of the steady-state oscillation phase and deviation from the tracking direction, proves its effectiveness in the day-ahead optimal scheduling strategy, and verifies the superiority of the proposed layered coordinated optimization control schemes.

Zhu et al. [2] develop the global hybrid model of shipboard power systems (SPS) and consider discrete control events and continuous system dynamics. The hybrid model of each zone is established separately according to the zonal power distribution structure, which realizes external attack events and actual damage from the viewpoint of zone autonomy. The simulation results show that the hybrid model can concretely describe the hybrid dynamic evolution process of SPS driven by discrete events as well as still provide valuable insights on evaluating the sophisticated dynamics into the confrontation phase.

Liu et al. [3] discuss a joint control method LQRY-SMC and add a genetic algorithm to optimize the weighting matrix parameters to cope with poor stability in the longitudinal motion control of hydrofoil craft. It can reduce the heave displacement and pitch angle in the longitudinal motion of the fully submerged hydrofoil craft. The simulation results show that the LQRY-SMC method improves the global optimal-control stability and prevents the attack of the hull, deck wetness, and damage to instruments due to the influence of longitudinal motion on hydrofoil crafts.

Zhao et al. [4] present a nonlinear model predictive control method for the boiler-turbine system with fractional order cost functions. Utilizing a fractional order cost function instead of an integer order cost function simplifies the configuration of the weight-factor

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matrices in the cost function and improves the control performance. The experimental results demonstrate that this fractional-order MPC method improves the control performance compared to the conventional MPC method.

Cuculić et al. [5] propose a power disturbance classification method for hybrid-electric ferries based on a wavelet transform and a neural network classifier. Based on the accuracy, precision, confusion matrix, and other parameters, the classification models for different discrete wavelets have been analyzed. The analyzed results show that the proposed model can be applied successfully for disturbance detection and classification of the considered ships, which contributes to improving the safety and reliability of the power supply.

Wang et al. [6] present a novel cubature formula and maximum correntropy criterion (MCC)-based robust cubature Kalman filter. The fifth-order split-difference-maximum entropy cubic Kalman filter (DD-MCCKF) framework is finally constructed by utilizing the fully symmetric cubic criterion and higher-order split-difference. The experimental results show that the proposed filter has higher tracking accuracy and better numerical stability than other common nonlinear filters using fewer cubic points in a non-Gaussian noise environment.

Altosole et al.[7] develop the implementation of a simulation model for cycloidal propellers. It assesses the performance of cycloidal propellers in terms of the generated thrust and torque, without resorting to consuming and demanding computational tools. The proposed method can also be used in the design phase to predict the behavior of a ship in terms of performance, stresses, response time, and energy/fuel consumption assessment.

Acanfora et al. [8] discuss a simulation approach to the representation of the ship motions in waves, interacting with the propulsion system behavior (diesel engine and propeller). The numerical model presented herein is capable of accounting for non-linearities that arise from the hull dynamics. Combining a prime mover with a battery for smoothing out propeller load fluctuations can optimize a ship's propulsion efficiency in huge waves.

Altosole et al. [9] analyze the behavior of a marine DF engine with different turbocharging configurations and fuel modes. By validating the dual-fuel engine simulation model, two different fuel types are combined with a hybrid turbocharger to analyze and compare the engine load variations. Ultimately, the proposed simulation method shows that a significant improvement is possible in the overall efficiency of the system, leading to better ship power management.

Vrijdag et al. [10] discuss the application of deterministic identification techniques to DC electric marine drive systems. A nonlinear and a linear model are developed to represent the dynamic behavior of a marine propulsion unit, and the main parameters to be identified are defined. This approach enables the rapid identification of unknown system parameters, and its application to simulation models can support condition monitoring and detect system failures or degradation.

As Guest Editors of this Special Issue, it is our pleasure to convey our heartfelt gratitude to the authors who have worked so hard on this collection of papers. It is an absolute honor to collaborate with a sea of such gifted peers, and we sincerely thank them for their sweat and toil in making this Special Issue possible. Each article provides original opinions on the subject matter, which mirrors different perceptions and methods regarding the smart control of ship propulsion systems.

We admire the seriousness of each author's attitude towards research and the depth of their thinking about the issues. Thanks to practicality and earnestness, the contents of the articles are scientific and rigorous. At the same time, we believe that this Special Issue will bring tremendous benefits to readers. Once again, we would like to thank you for your dedication to this Special Issue.

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