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High-Altitude Wind Energy for Sustainable Marine Transportation

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Abstract

This paper investigates the use of a controlled tethered wing, or kite, for naval transportation. Linked to a boat by light composite-fiber lines, the kite is able to fly between 200 and 600 m above the sea and to generate high traction forces. A mechatronic system named Kite Steering Unit (KSU) that is installed on the boat controls the kite and converts the line speed and force into electricity. Different from previous works, the boat is also equipped with electric propellers so that naval propulsion can be achieved both directly, i.e., through the towing forces exerted by the lines, and indirectly, i.e., through the electricity generated by the KSU that is fed to the electric propellers via a battery pack. The optimal system operating conditions that maximize the boat speed for the given wind characteristics are computed. Then, a model predictive controller is designed, and numerical simulations with a realistic model are carried out to assess the performance of the control system against the optimal operating conditions. The results indicate that, with this system, a completely green naval transportation system can be obtained, regardless of the wind direction.

Index Terms—Control systems, marine transportation, optimal control, wind energy.