Researchers develop new control method that optimizes autonomous ship navigation

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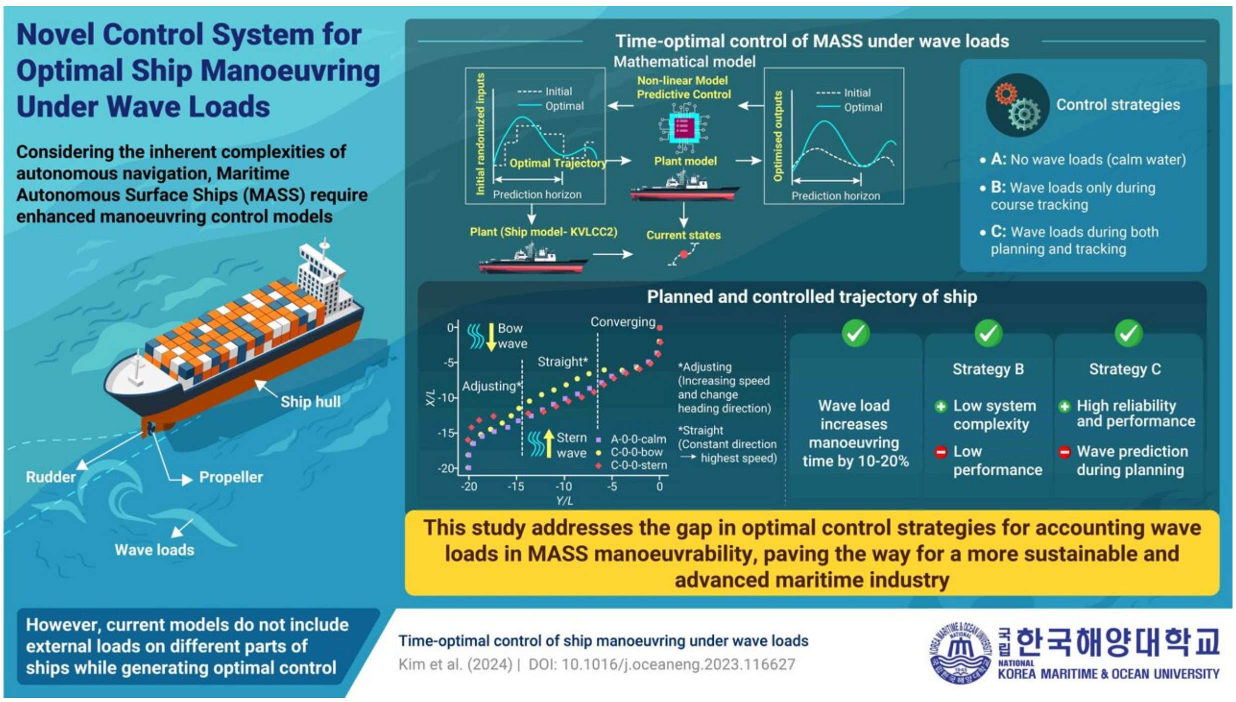

This innovative control method accounts for the wave loads present in real sea conditions that affect the maneuvering performance of autonomous ships, providing an optimized controller for time-efficient navigation. Credit: Daejeong Kim from Korea Maritime & Ocean University

The study of ship maneuvering at sea has long been the central focus of the shipping industry. With the rapid advancements in remote control, communication technologies, and artificial intelligence, the concept of

Maritime Autonomous Surface Ships (MASS) has emerged as a promising solution for autonomous marine navigation. This shift highlights the growing need for optimal control models for autonomous ship maneuvering.

Designing a control system for time-efficient ship maneuvering is one of the most difficult challenges in autonomous ship control. While many studies have investigated this problem and proposed various control methods, including Model Predictive Control (MPC), most have focused on control in calm waters, which do not represent real operating conditions.

At sea, ships are continuously affected by different external loads, with loads from sea waves being the most significant factor affecting maneuvering performance.

To address this gap, a team of researchers, led by Assistant Professor Daejeong Kim from the Division of Navigation Convergence Studies at the Korea Maritime & Ocean University in South Korea, designed a novel time-optimal control method for MASS. "Our control model accounts for various forces that act on the ship, enabling MASS to navigate better and track targets in dynamic sea conditions," says Dr. Kim. Their study was published in *Ocean Engineering*.

At the heart of this innovative control system is a comprehensive mathematical ship model that accounts for various forces in the sea, including wave loads, acting on key parts of a ship such as the hull, propellers, and rudders. However, this model cannot be directly used to optimize the maneuvering time.

For this, the researchers developed a novel time optimization model that transforms the mathematical model from a temporal formulation to a spatial one. This successfully optimizes the maneuvering time.

These two models were integrated into a nonlinear MPC controller to achieve time-optimal control. They tested this controller by simulating a real ship model navigating in the sea with different wave loads.

Additionally, for effective course planning and tracking, researchers proposed three control strategies: Strategy A excluded wave loads during both the planning and tracking stages, serving as a reference; Strategy B included wave loads only in the planning stage, and Strategy C included wave loads in both stages, measuring their influence on both propulsion and steering.

Experiments revealed that wave loads increased the expected maneuvering time on both strategies B and C. Comparing the two strategies, the researchers found strategy B to be simpler with lower performance than strategy C, with the latter being more reliable. However, strategy C places an additional burden on the controller by including wave load prediction in the planning stage.

"Our method enhances the efficiency and safety of autonomous vessel operations and potentially reduces shipping costs and carbon emissions, benefiting various sectors of the economy," remarks Dr. Kim, highlighting the potential of this study. "Overall, our study addresses a critical gap in autonomous ship maneuvering which could contribute to the development of a more technologically advanced maritime industry."

More information: Ming Zhang et al, Time-optimal control of ship manoeuvring under wave loads, *Ocean Engineering* (2024). DOI: 10.1016/j.oceaneng.2023.116627

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