When ships sail in longitudinal waves, and the encounter frequency and wave length satisfy certain conditions, passage of wave crest and wave trough along the hull continuously amplifies the roll motion at half the frequency of encounter. This gives the onset of a resonance condition. The phenomenon can induce a rapid increase in roll motion that can reach 40 degrees or more. Recent incidents have shown that modern container ships and some fishing vessels are particularly prone to this due to their hull shape. Such incidents can result in damages counting to millions of USD. Theoretically, the resonance behaviour is well understood and it can be reproduced by quasi-periodic changes in parameters of nonlinear differential equations that describe ship motion. Practically, the challenge is whether detection and stabilization can be achieved in time to avoid damage. The research in this thesis has therefore two objectives. The first is to develop methods for detection of the inception of parametric roll resonance. The second is to develop control strategies to stabilize the motion after parametric roll has started. Stabilisation of parametric roll resonance points to two possible courses of action. One is a direct stabilisation through an increase of damping in roll, which increases the threshold that triggers the resonant motion. A second is to obtain a change in wave encounter frequency by means of changes in ship forward speed and/or heading. As direct stabilisation, this thesis considers the increase of roll damping by using fin stabilisers, which are controlled using integrator backstepping methods. As indirect stabilisation, a shift in the encounter frequency is considered by varying the ship forward speed. The speed controller is designed using nonlinear Lyapunov methods. The two control strategies are then combined to stabilise parametric roll resonance within few roll cycles. Limitations on the maximum stabilisable roll angle are analysed and linked to the slew rate saturation and hydrodynamic stall characteristics of the fin stabilisers. The study on maximum stabilisable roll angle are analysed and linked to the slew rate saturation and hydrodynamic stall characteristics of the fin stabilisers. The study on maximum stabilisable roll angle leads to the requirements for early detection. Two novel detectors are proposed, which work within a short-time prediction horizon, and issue early warnings of parametric roll inception within few roll cycles from its onset. The main idea behind these detection schemes is that of exploiting the link between the second harmonic of roll angle and the first harmonic of heave or pitch motions. A nonlinear energy flow indicator, which measures the transfer of energy from the first harmonic of heave or pitch into the second harmonic of roll, is at the core of the first detector. The second detector relies on a driving signal that carries information about the phase correlation between either pitch or heave and roll. A generalised likelihood ratio test is designed to detect a change in distribution of the driving signal. The detectors are validated against experimental data of tests of a 1:45 scale model of a container ship. The validation shows excellent performance in terms of time to detect and false-alarm rate for both the proposed detectors. The detectors are the main contribution of this research. The thesis also offers a contribution regarding modeling. A 3 degree-of-freedom nonlinear model in heave-pitch-roll of a container ship suitable for parametric roll resonance study is proposed. The model, which has been developed in collaboration with other researchers, provides a benchmark for the study and simulation of parametric roll over a large range of ship speeds and sea states. The results of this research have been published in articles enclosed in this dissertation and in an international patent application.

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