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YACHT ADAPTIVE SELF-TUNING PID CONTROL: AN H_∞ APPROACH

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Abstract. *Autopilot design for a yacht is more difficult than other type of motor-powered marine vessels because of the special characteristics of the motion of a yacht response to wind and other sea conditions. Robustness is one of the most important properties for the yacht steering autopilot. This paper develops a new method of tuning PD controllers by using an H_∞ control strategy. It is well known that the H_∞ control design normally yields a controller which is much more robust against disturbances. Hence the proposed PD tuning method via the H_∞ theory enhances the robustness of the PD autopilot for the yacht steering control.*
Keywords: Yacht modeling, Autopilot, Adaptive control, Self-tuning PID control, H_∞ robust control

1. **Introduction.** Yachts have existed for more than thousands of years as an original means of marine transportation. Since the advent of motor driven vessels, yachts have been used less for basic transportation than they were, but large numbers of yachts all over the world are still used for racing, fishing and for recreation. As a result, the demands for compact size, high performance autopilot for yachts have increased rapidly today. Even though only less attention has been given to automatic control of yacht motion, there is still increasing interest in developing intelligent yacht autopilots to meet the demands of recreational sailors, especially in North America and Europe. The work reported in this paper arises from a project being conducted jointly with a New Zealand company, aimed at designing a robust adaptive autopilot for yachts and other marine vessels.

The significance of the nonlinearities in yacht motion makes it almost impossible for a fixed parameter autopilot to be able to control yacht motions properly in all sea conditions. While a particular controller may be tuned for one particular set of operating conditions, but may make the yacht unstable in another set of conditions.

Various approaches to controller design in the face of these difficulties can be adopted. In this paper, a simple self-tuning PID controller tuned by using H_∞ strategy is developed. As is well known, Proportional-Integral-Derivative (PID) control strategy has been widely used in industrial and consumer electronics fields for decades owing to its simplicity and effectiveness. Today PID controllers have been designed by adopting kinds of advanced control strategies and reaching higher performances. As the key property of these kinds of PID controllers, self-tuning algorithms have been consistently investigated by researchers; improved tuning methods have been reported. For example, the refined Ziegler and Nichols approach [1]; the gain-phase margin method [2,4]; the IMC-based tuning method [3], the generalized prediction (GPC) control based method [5] and the