Heading Control Design Based on Self-Oscillation Identification Method Applied to Charlie USV

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Determining a model of marine vehicles for the control purposes can be a very time-consuming process. Having this in mind, in [3] a much faster identification method has been proposed based on the use of self-oscillation identification method. Here we demonstrate the use of the proposed method for heading controller tuning of the autonomous unmanned surface vehicle (USV) Charlie.

The Charlie USV is a small catamaran-like shape prototype vehicle originally developed by the CNR-ISSIA for the sampling of the sea surface microlayer and immediate subsurface for the study of the sea-air interaction, [2]. Charlie is 2.40 m long, 1.70 m wide and weighs about 300 kg in air. The yaw model of the vehicle has been identified using classical methods in [1] and can be described using a nonlinear model given with $I_r\dot{r} = \tilde{k}_{r|r|}r|r| + n^2\delta$ where n is the propeller revolution rate, δ is the rudder angle, $\tilde{I}_r$ is moment of inertia, $\tilde{k}_{r|r|}$ is linear drag coefficient. The idea of using self-oscillations to determine system parameters is described in detail in [3]. In short, the self-oscillation experiment is done in closed-loop which consists of the process itself and a nonlinear element. This way the system is forced into self-oscillations - combining the magnitude and frequency of the obtained self-oscillations in explicit expressions, process' parameters can be obtained. The greatest advantage of the proposed method is the fact that it is not time-consuming and that it can be simply implemented. It has also been shown that good results are obtained even when external disturbances are present, making the experiment itself feasible in real conditions.

The controller that is used is a I-PD controller. This controller is appropriate for control due to smooth controller output. The controller parameters are set so that the closed-loop transfer function is equal to some third order model function. This means that the controller parameters can be expressed as functions of the identified parameters, i.e. as functions of self-oscillations' magnitudes and frequencies. The yaw rate which is one of the inputs to the controller can be calculated either by using the Euler backward difference or by using the Kalman filter. The results shown here use the latter method.

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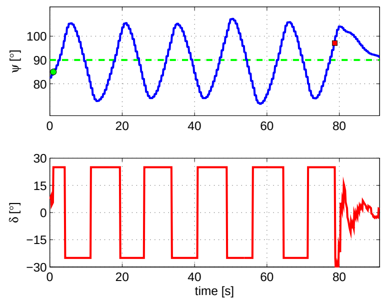

Fig. 1. Charlie's heading and rudder angle during one of the self-oscillation experiments (green circle marks the begining and red square the end of data recording).

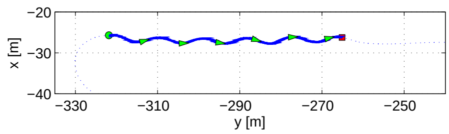

Fig. 2. Charlie's path during one of the self-oscillation experiments (green circle marks the begining and red square the end of data recording, dotted line is the path before and after the experiment).

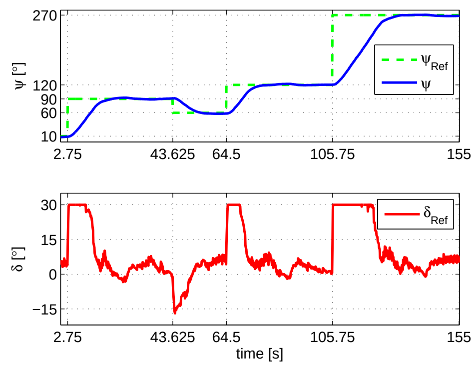

Fig. 3. Heading and rudder angle with the KF controller.

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