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An Indirect Method for the Identification of Ship Manoeuvring Characteristics

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Abstract

The development of highly automated inland waterway vessels (IWV) is a reasonable approach to compensate the lack of qualified personnel, to allow economic transportation as well as to shift cargo from the growing amount of congested roads to inland waterways. Depending on the automation level, automated systems need to be capable of solving navigational situations up to a certain level of complexity. For instance, CCNR automation level 3 [1] requires automated collision avoidance but relies on the ship master as fallback option. Higher automation levels such as 4 and 5 do no longer rely on the ship master as fallback option. Even for non-automated or remotely operated ships, collision avoidance and track planning systems are of interest. In contrast to seagoing ships which mostly operate in regions with wide space, IWV fairways are restricted, traffic density is relatively higher and complex flow situations occur more often. Any kind of track planning or collision avoidance system for IWV therefore needs to operate in confined fairways and tolerate ships navigation closely to each other. Consequently, those systems require an accurate prediction of the own ship's path and preferably also the other ships' paths to allow the planning of maneuvers allowing maximum safety and minimum energy consumption.

Classical approaches to predict ship maneuvers involve mathematical models describing the ship motions in dependence of operational conditions and external forces. These mathematical model are of two types, the so called modular models and formal models (Abkowitz-type). Modular models describe the maneuvering behavior of ships using a sum of its components such as hull, propeller and rudder. Each component is considered as independent module and the interaction between them is modeled by coefficients obtained from experimental tests, see [2, 3]. Those models are typically applicable to various operating conditions including different combinations of thrust and motion direction. Formal models are based on Taylor-series expansion with a reasonable limitation of coefficients, see [4, 5]. They are sufficiently applicable especially when operating conditions differ only moderately from the equilibrium condition and provide a high accuracy under these conditions. Both types of mathematical models require the identification of coefficients for the individual ship before they can be applied.

Direct and indirect methods for the system identification can be applied. A direct system identification involves either captive model tests or numerical simulations (full or model scale) with pre-defined ship motions. A large number of tests or simulations is required to identify the coefficients of complex models. In contrast, the indirect system identification can be employed to determine maneuvering model coefficients using free-running model or full-scale trials or simulations. During those trials, the ship is not restrained. Its path, orientation and kinematic values are measured. Thus, this method can be applied even to full-scale ships during operation which allows even an adoption and refinement of maneuvering models during ship operation. However, the challenges of the methodology are its sensitivity to environmental influences (e. g. due to wind) and the performance of the fitting process using optimization algorithms. In the presentation, we will give an introduction to the indirect system identification method and its validation developed in the course of the FernBin project.

Literatur [Formatvorlage / Stylesheet: Überschrift 1 / Heading 1]

[1] Central Commission for the Navigation on the Rhine (2018): *First International Definition of Automation in Inland Navigation*. CCNR Press Release, Strasbourg, France

[2] H. Söding (1984): *Bewertung der Manövriereigenschaften im Entwurfsstadium.* Jahrbuch der Schiffbautechnischen Gesellschaft

[3] P. Oltmann and S. D. Sharma (1984): *Simulation of Combined Engine and Rudder Maneuvers using an Improved Model of Hull-Propeller-Rudder Interactions*. 15. ONR-Symposium, Hamburg

[4] M. A. Abkowitz (1964): *Lectures on Ship Hydrodynamics – Steering and Manoeuvrability*. Hydro- og Aerodynamisk Laboratorium, Report No. Hy-5

[5] P. Mucha and O. el Moctar (2015): *Revisiting mathematical models for manoeuvring prediction based on modified Taylor-series expansions*. Ship Technology Research, Bd. 62, Nr. 2, pp. 81-96