Autonomous Underwater Vehicle

Data-Driven Dynamic Modeling of an Autonomous Underwater Vehicle

Student

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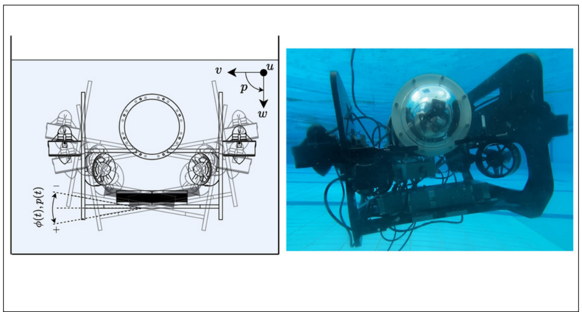
Ausgangslage: Autonomous Underwater Vehicles (AUVs) depend on precise dynamic models to design and assess navigation and control functions. This necessity arises from the fact that the motion of AUVs is predominantly influenced by hydrodynamic forces, buoyancy, and currents, which cannot be directly inferred from thruster commands. In many cases, system identification relies on specialized facilities, such as towing tanks or planar motion mechanisms, which can be costly and not always readily available. This raises the question to what extent a physically interpretable six-degree-of-freedom dynamic model can be identified using only open-loop pool tests and on-board sensing.

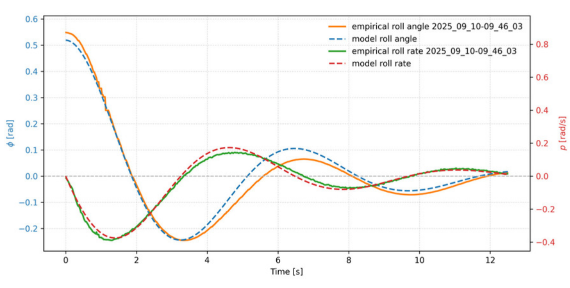
Ziel der Arbeit: The objective of this thesis is to develop a 6-DOF dynamic model for the in-house AUV at Nanyang Technological University from experimentally measured motion data. The vehicle is described by a standard marine craft formulation with separated rigid-body, hydrostatic, hydrodynamic and thrust contributions. Static and dynamic pool manoeuvres excite the relevant degrees of freedom and reveal the dominant parameters. The existing ROS-based sensor and control setup records the signals, which are processed in a reproducible analysis pipeline for parameter estimation. The resulting model is embedded in a nonlinear simulation environment serving as a platform for controller design and scenario studies.

Ergebnis: The thesis yields a validated nonlinear simulation model of the NTU AUV, with parameters identified from simple static tests and self-propelled manoeuvres in a swimming pool. For the investigated motions (surge, sway, heave and roll/pitch free decay), the simulated trajectories and body rates agree well with the measurements in time response and steady-state values. The results demonstrate that carefully designed tests, combined with a structured data-processing pipeline, are sufficient to obtain a practically useful and physically interpretable dynamic model. A first closed-loop position-hold simulation under current disturbance illustrates the suitability of the model as a basis for future studies on navigation and advanced control strategies.

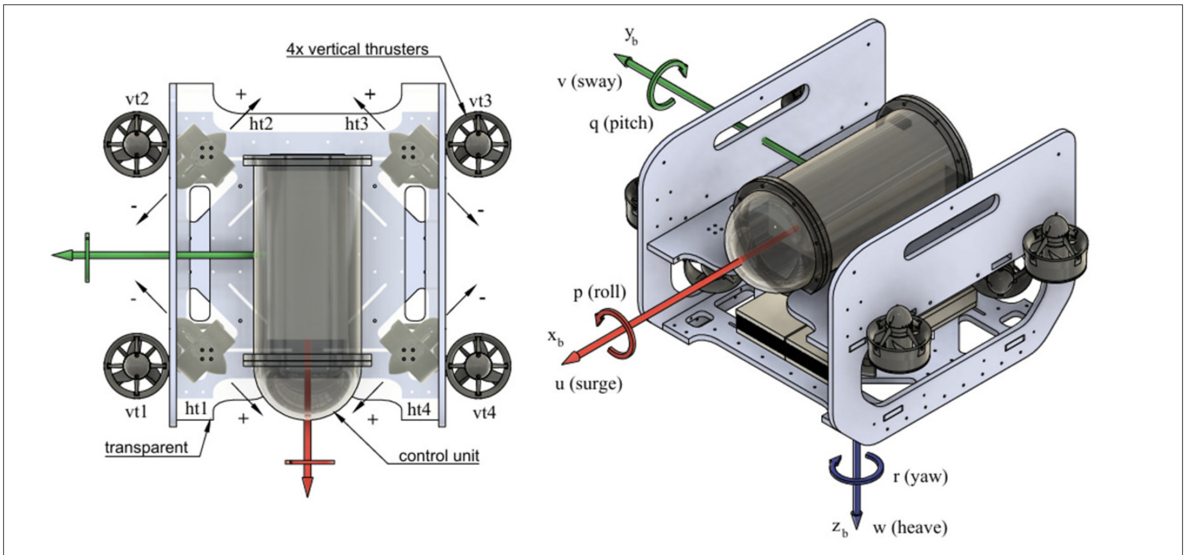
The NTU AUV platform during a decoupled free-decay in roll
Eigene Darstellung



Comparison between the simulated and the experimental free-decay in roll
Eigene Darstellung



Thruster configuration and 6-DOF motion nomenclature of the NTU AUV
Eigene Darstellung



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