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Autonomous Inland
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ELLA – A Platform for Automation of Harbor Maneuvers

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Abstract

Among the open tasks for the automation of navigation and steering, maneuvering in confined spaces such as harbors and lock entries poses a large challenge. The reasons are manifold, high requirements on positioning and localization accuracy being one of them. Trajectory control of ships is difficult at large drift angles, during stopping, and during crabbing / traversing. Typical propulsion and steering devices used in merchant ships offer only limited thrust, lateral force and yaw moment compared to the ship's inertia. Finally, choosing the optimum type of maneuver for path planning and trajectory planning not only requires to take into account the individual ship, its loading condition, corresponding maneuvering capabilities, and the surrounding topology. Several environmental factors need to be accounted for in addition: bathymetry, currents, waves and swell, wind, traffic situation, just to name the most important.

The project ELLA addresses those issues above related to trajectory planning and control, while problems related to localization and interaction with surrounding traffic are put aside. Our approach is to build a small inland cargo vessel (scale 1:6) for dedicated training of port maneuvers in a sheltered environment and equip it for automated maneuver training using machine learning approaches. The vessel is intended to replicate the motion characteristics of a 86 m cargo vessel through scale similitude of hull lines as well as propulsion and steering devices, Fig. 1. The vessel will be equipped with a variety of sensors for on-board sensing and environmental perception. Still being in the design stage, the vessel will enter into operation in 2022. Modular design of the hull enables future modifications of the hull shape and the propulsion and steering systems, so that maneuvering characteristics and capabilities can be varied. This paper describes the design concept of the vessel with a focus on the robotics system and sensors.

While the primary research topic of the project ELLA is autonomous maneuvering, the vessel's design allows for using it as a general-purpose open research platform for developing and testing sensor technology and automation systems. To our knowledge, it will be the first such open platform that confronts automation systems with the complex challenges of maneuvering inland cargo vessels. The software architecture of the robotics system is based on the industrial capable ROS2 for data exchange between the individual modules of the sensing, guidance, navigation and control subsystems. This architecture facilitates replacing hardware and software components, rendering the vessel an ideal platform to test and demonstrate a variety of systems and subsystems, either individually or interacting with other components. The small scale enables the use of standard automotive sensor technology (e.g., Lidar, distance meters) and thus helps quantifying the potential of dedicated sensors tailored for real-scale applications. The vessel's modular and flexible design allows for exploring sensor set-ups for environmental perception and identifying optimum arrangements for the specific needs of autonomously maneuvering vessels.

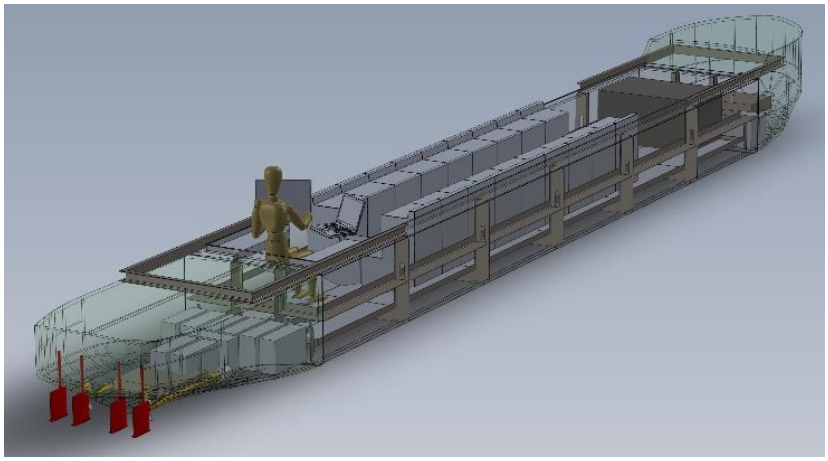

Figure 1. CAD model of the small-scale inland vessel ELLA showing main hull structural elements and ballast tanks along with major outfitting and equipment components