WASP Project Course 2021

Docking and planning for unmanned boats

Background

Performing autonomous mission/tasks at sea consists of many different tasks. Manoeuvring and navigating at open sea is different from manoeuvring and navigating in confined areas such as a harbour. In this project we will explore autonomous docking of an unmanned surface vessel, USV. The docking scenario would be to have the USV approach a dockside, with human only assisting in mooring, or having it move onto a trailer. A future extension of this application is to perform docking to other vessels in, for example, sea rescue operations.

The problem itself consists of positioning, motion planning and control. Example of previous work is [Martinsen et.al. 2019, 2020]. This project can provide novel insights for manoeuvring of small and wind sensitive vessels with precision in confined areas.

Field test are expected and as test platform the aim is to use the Piraya vessel, as seen on trailer in figure below. Piraya is a member of the WARA-PS family, is equipped with various sensors and has an interface for control of the throttle and rudder.

Today, an operator in these situations controls the vessel. The procedure for controlling it includes learning of boat specific aspects such as the inertia/drifting and taking the wind into account when docking not to damage the equipment.

Constraints: On location at WARA PS-occasions in Västervik (September) if travel restrictions etc. permits. TBD extra session in November.

Participants

Industrial partner: Saab Kockums, Karlskrona. Additional support from Swedish Sea Rescue Society.

Industrial supervisor: Jens-Olof Lindh; jens-olof.lindh@saabgroup.com

Academic supervisor: Anders Robertsson, anders.robertsson@control.lth.se, Lund University

Coordinating WARA representative: Jesper Tordenlid; jesper.tordenlid@combitech.se

Suggested WASP PhD students (Competence requirements): Competence or interest in one or more of the following fields: Motion planning and control, positioning, visual detection.

Challenges to investigate

There are multiple challenges to investigate in this project and depending on the participants specific interests the focus may be different. The main challenges can be divided into relative positioning, motion planning and control.

Relative positioning will be needed in order to relate to fixed structures such as the dockside or trailer. Various sensors are at hand. A map will be helpful for some fixed structures but not for others that would need other identification such as the exact position of the trailer. LIDAR and/or GPS-RTK are expected to be used as primary sensor together with the map. Cameras are available for further classification. The trailer and dockside may be equipped with markers to ensure feasibility. Use of simultaneous localization and mapping, SLAM, may help in gaining the necessary situational awareness.

In order for the USV to position itself for docking it needs a plan considering the manoeuvrability of the vessel and the available space. In difference to e.g., parking a trailer here the environmental conditions of wind and waves need to be considered. Control and motion planning theory will need to be studied together with boat specific aspects (propulsion, maneouver, inertia/drifting etc) and experience of human controllers. Suggestion is to make use of model based predictive control that considers wind as a parameter.

Possible extensions are to add dynamic object to the scenario, varying start and stop conditions such as also entering and navigating through the harbour.

Resources

The Piraya vessel with support team from Saab Kockums.

- Sensors (e.g. Optical, LIDAR, wind meter, GPS, compass)
- Control commands can be issued as speed/course and/or throttle/gear/rudder
- ROS Interface possibilities
- Boat model as input for simulation and controller design
- Support with field tests
- Support with data acquisition and software integration
- Access to WARA-PS simulation environment

Deliverables

- Experimentation and demonstration
- Media material for presentation of work and demonstration
- Project report

References

A. B. Martinsen, A. M. Lekkas, and S. Gros. Autonomous docking using direct optimal control. In Proc. 12th IFAC Conference Control Applications in Marine Systems, Robotics and Vehicles. (CAMS), volume 52, pages 97–102. IFAC, 2019.

A. B. Martinsen, G. Bitar, A. M. Lekkas, and S. Gros. Optimization-based automatic docking and berthing of ASVs using exteroceptive sensors: Theory and experiments. IEEE Access, 8:204974–204986, 2020.

Keywords

USV, autonomous vehicles, motion planning, docking, control, localization, SLAM, object classification