Development of a Simulation Platform for ROV Systems

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Motivation

In most marine operations today, there is a low level of autonomy. In ROV operations, a human operator normally controls the ROV. This is a time consuming task, and is highly depending on the skills and experience of the operator.

By introducing a higher level of autonomy in the operations, a number of challanges related to control appears. To develop advanced control algorithms, a robust simulation environment to verify and test algorithms is needed. The control system can be tested on a simulated vehicle, which is both a lot cheaper and faster than if the controller was to be tested on the real process.

Scope of Work

The goal in this thesis is to develop a simulation platform for ROV systems. The platform should provide models of all systems required to simulate ROV operations, and make it easy for users to implement their own algorithms. Basic systems required are controllers, guidance systems, estimators/filters, sensor/navigation models and path planners, as well as a dynamic ROV model to estimate the resulting ROV motion based on control input and environmental conditions.

The simulation platform must be module based. This requires that the software for the different ROV systems are separated and organized, and a communication protocol between the systems must be developed. The implementation should be done such that it is possible to switch between modules of the same type, as shown in figure 1.

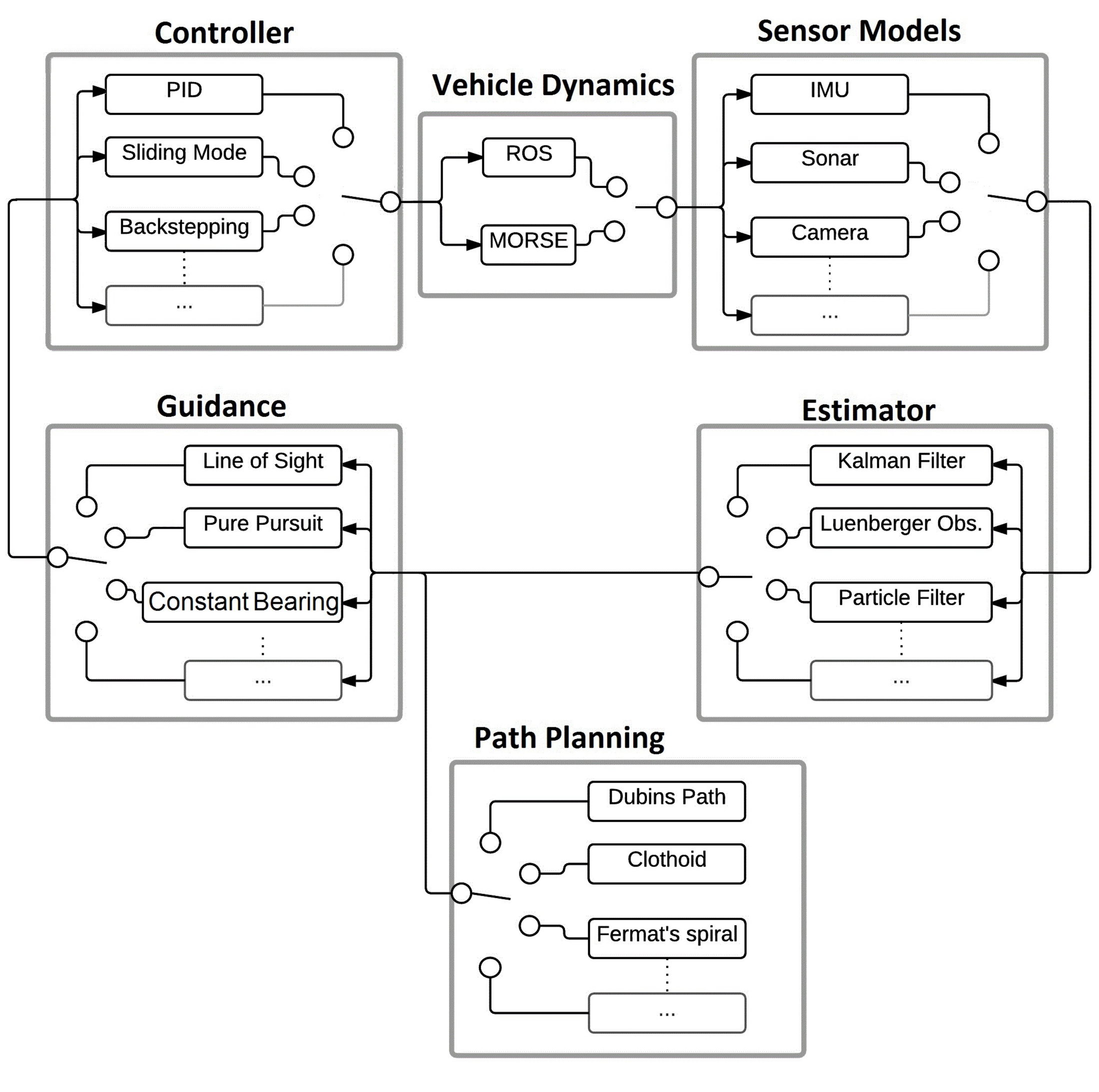

Figure 1: Simulation loop layout

The long term goal is to make the simulation platform open source, and invite other developers to contribute in the simulation platform development. For this to be possible, development guidelines must be defined.

Software

The simulation platform is developed mainly using the open source meta-operating system ROS (Robotic Operating Systems, [1]). ROS provides software management which is used to structure the software developed for the platform.

The open source simulator MORSE (Modular OpenRobots Simulation Engine, [2]) is also used in the development. MORSE provides visualization and physics simulation.

Methods

Fossen's robot-like vectorial model for marine craft [3] is used for the mathematical ROV model, and implemented in both ROS and MORSE. Line of Sight guidance is used for the guidance systems, and simple PI and PID controllers are developed for heading control, depth control, speed control and dynamic positioning.

The method used for communication between the modules is provided by ROS. All modules developed except the MORSE dynamic is implemented as ROS nodes. A node is a process that performs computation, and ROS provides methods for communication between the nodes.

When launching ROS, a Master Node is started that makes it possible for the ROS nodes to communicate with each other. A node can publish messages on a topic, and other nodes can subscribe to these messages. The principle is shown in figure 2. This quality is utilized when switching between different modules in the simulation loop.

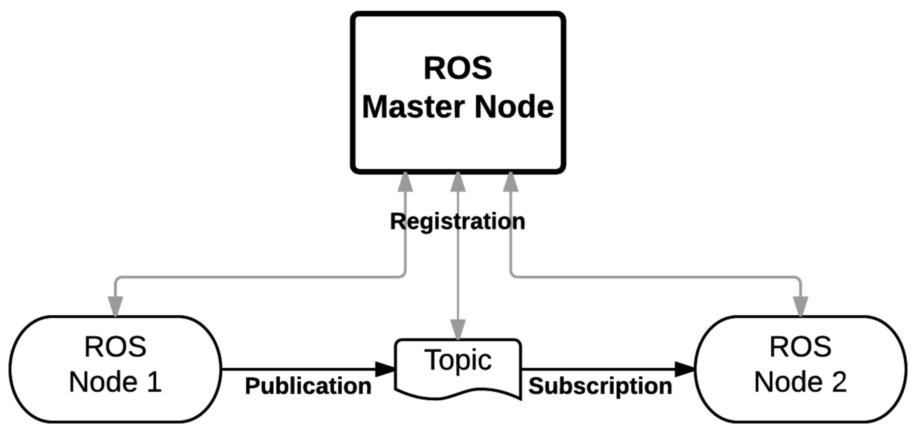

Figure 2: Node communication

A configuration file is developed for initializing the simulation platform. The configuration file holds information about the ROV that is to be simulated, about the thruster characteristics and about which modules to include in the simulation loop.

Results and Conclusion

The dynamic models developed are tested and evaluated. The model made in ROS manages to simulate the ROV motion with satisfactory results, as the estimated motion was as expected in all simulations done. The dynamic model made in MORSE still have some issues that needs to be worked out. The biggest problem is that it does not manage to process information given by the controller fast enough. This problem may be due to the way MORSE subscribes to ROS topics.

Figure 3 shows how the calculated x-position of the ROV differs between MORSE and ROS when the ROV is set to move in circles. When simulating in 200 seconds, MORSE has only simulated about 180 seconds, while ROS is able to simulate in real time.

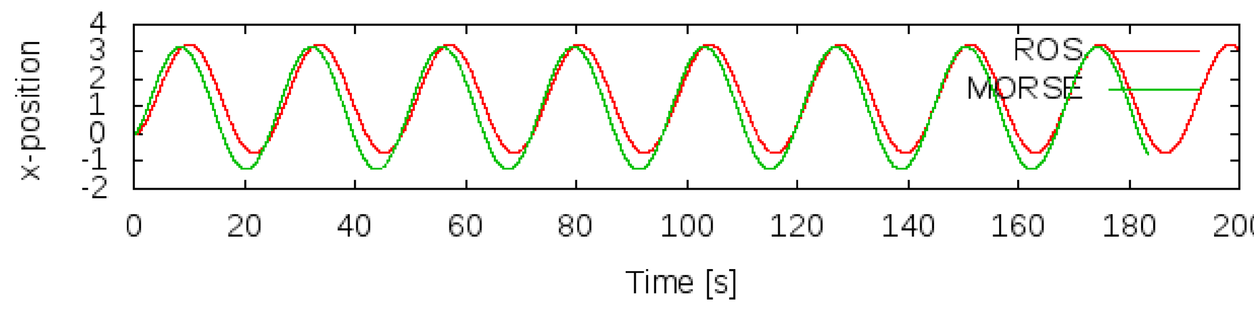

Figure 3: Comparing results MORSE and ROS

The developed controllers and guidance systems give satisfactory results. Figure 5 shows the ROV path when it is controlled to go in a lawn mower pattern with current present. Figure 4 shows how the ROV is visualized when running the simulation platform.

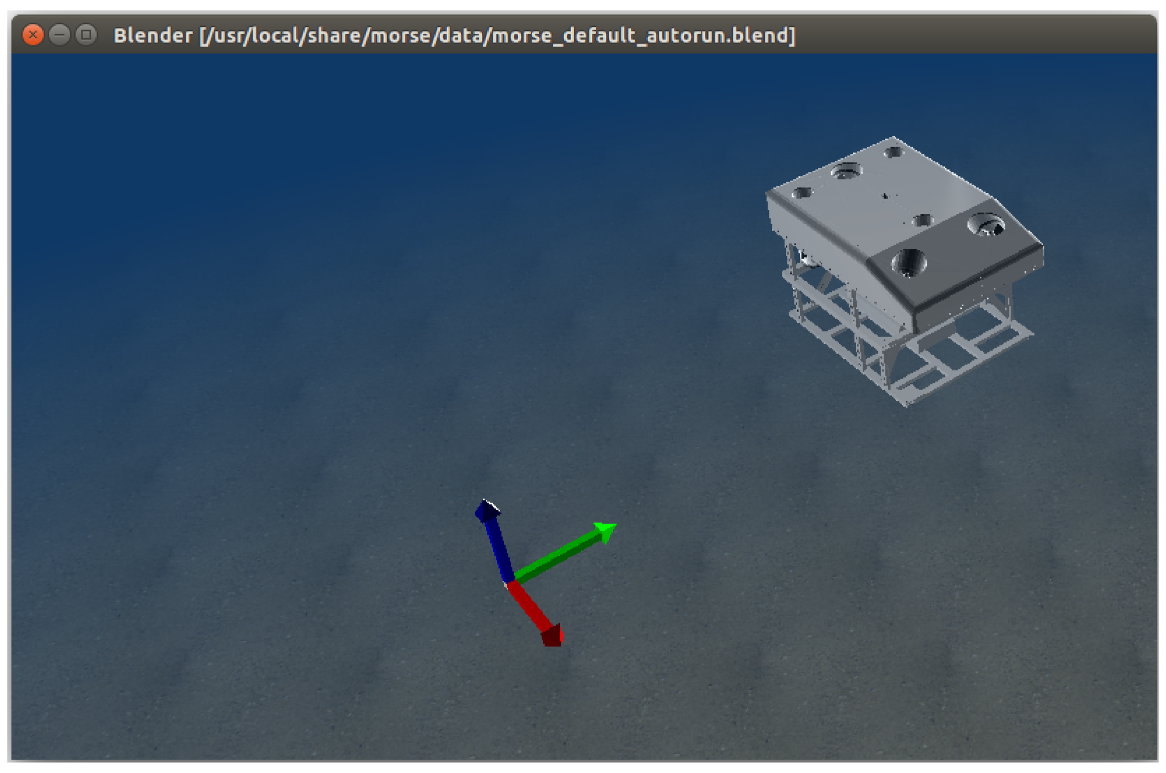

Figure 4: ROV Visualization

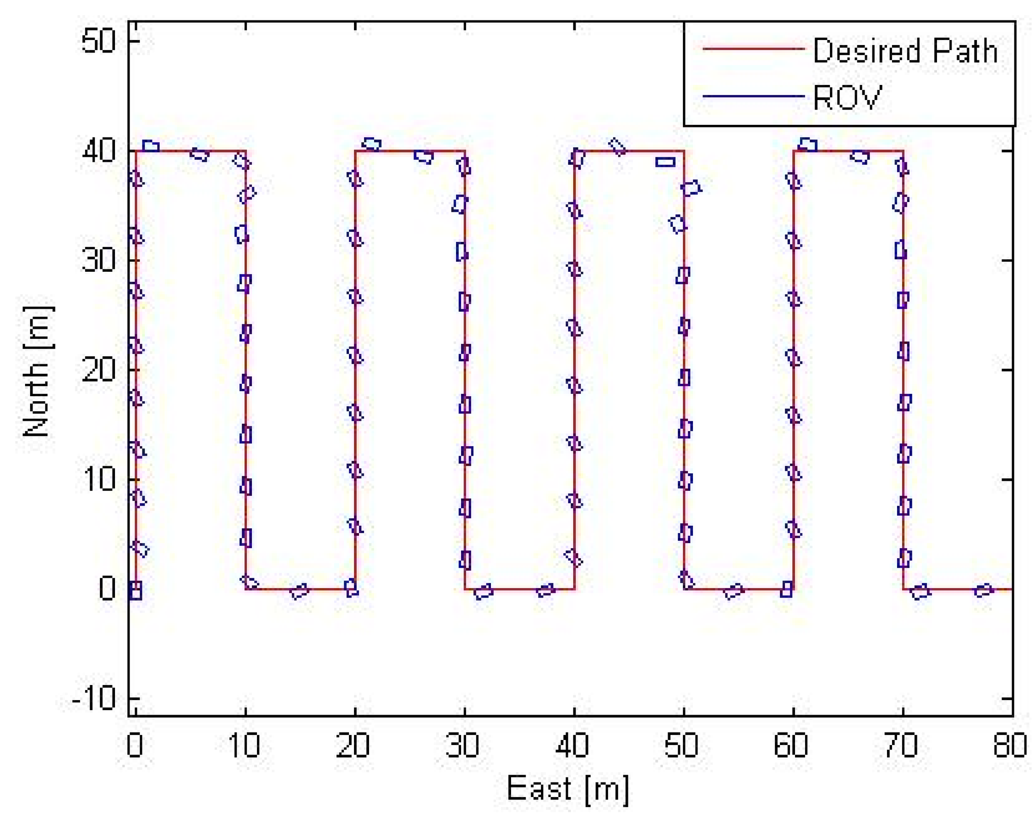

Figure 5: ROV path from simulation with 1m/s current from the west, ROS dynamics

References

[1] Quigley, Morgan et al *ROS:an open-source Robot Operating System*, ICRA Workshop on Open Source Software (2009)

[2] Echevierra, Gilberto et al.: *Modular Open Robots Simulation Engine: MORSE*. IEEE International Conference on Robotics and Automation (2011)

[3] Fossen, Thor I. (2011) *Handbook of Marine Craft Hydrodynamics and Motion Control*