

## Modeling, Analysis and Control of Underwater Vehicle

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**The company Marin Mätteknik (MMT) has developed a new type of underwater vehicle which is called SROV. In this project, we develop a mathematical model describing the SROV, and use this model to investigate alternatives to the current control system.**

MMT is a maritime survey company supplying clients with high-resolution data. Mapping of the sea floor is oftentimes carried out prior to hardware installation on the bottom. For instance, a typical work task assigned to the SROV is to chart a corridor on the sea floor prior to installing a power transmission cable between two mainland nodes. The SROV has been designed to allow for larger operational velocities, cutting operational time consumption and increasing cost efficiency. The current control system of the SROV is functional, but some unwanted oscillations are present in the resulting system velocities. This is not desired by MMT, as survey data is affected in a negative way. By deriving a mathematical model of the SROV, we may gain knowledge about the behavior of the system that can be used to remove the oscillations. Another advantage of having a model describing the SROV, is that simulations testing different control structures may be carried out at the office. This saves time and money, as the need for in-field experiments is reduced. It is also easier to investigate possible changes to the design of the SROV if a simulation model is available.

For the purpose of controlling the SROV, a Model Predictive Control (MPC) algorithm was identified as a possible choice. A particularly attractive feature of the MPC algorithm is that it can take constraints on the input signals into consideration. In our project, simulations of the system response when being controlled by the MPC structure are very promising. All

oscillations experienced using the current controller are in the resulting simulation. However, one must bear in mind that the MPC algorithm is model-based. This implies that the controller is sensitive to changes in the dynamics of the SROV. In other words, we cannot change the load or the physical appearance of the SROV too much before a new model has to be estimated to ensure good performance. This may not be desirable, as experiments using the SROV have to be performed in order to estimate a new model. This takes time and consequently costs money.

In our project, a Linear-Parameter Varying (LPV) model is suggested as an approximation of the SROV dynamics. Different structures have been estimated, and the resulting performances have been compared. It turns out that one LPV model is more suitable for the purpose of describing the SROV than the others. However, there are shortcomings that have to be addressed in a future study. Briefly, some of the system states have proved more difficult to model than others. The underlying reasons for this may be several. Possible future work include an increase of the sampling frequency used during the trials, and to change the way the propellers of the system are actuated. It has also been found that a slight change to the design of the SROV may improve the performance of the control system. By adding one thruster to the current thruster configuration, the simulation results were improved.

## References

1. Ferling, O., Modeling, Analysis and Control of Underwater Vehicle, M. Sc. Thesis TFRT-6049, Lund, University, Dept. Automatic Control, Lund, Sweden, 2018