You Liu, Qing Shen, Dong-li Ma, Xiang-jiang Yuan. Steering control for underwater gliders. *Frontiers of Information Technology & Electronic Engineering*, **18**(7):898-914. http://dx.doi.org/10.1631/FITEE.1601735

Steering control for underwater gliders

Key words: Autonomous underwater glider; online system identification; steering control; adaptive control; optimal control; energy saving control; process in loop (PIL)

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Motivation

- Steering control for an autonomous underwater glider (AUG) is very challenging due to its changing dynamic characteristics such as payload and shape.
- Steering controller should be adaptive to changing ocean environments such as current.
- Since the electronic power stored on AUG is limited, energy saving performance should be taken into consideration during steering controller design.

Main idea

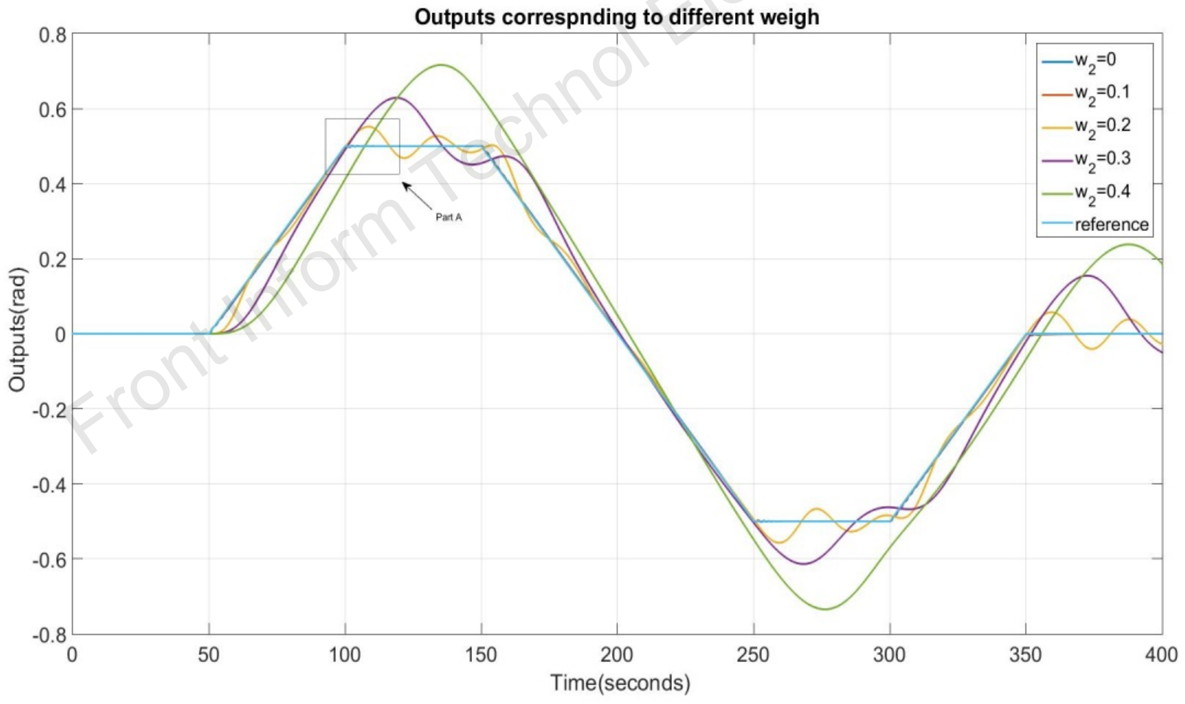
- An online polynomial estimator is designed to update the yaw dynamic model of the AUG, and an adaptive model predictive control (MPC) controller is used to calculate the optimal control command based on updated estimated parameters.
- The MPC controller uses a quadratic program (QP) to compute the optimal control command based on a user-defined cost function.
- The cost function has two terms, focusing on output reference tracking and move suppression of input, respectively. Move-suppression performance can, at some level, represent energy-saving performance of the MPC controller. Users can balance these two competitive control performances by tuning weights.

Method

1. A polynomial estimator is designed to represent the current linear single-input, single-output (SISO) yaw dynamic model.
2. The adaptive MPC controller optimizes this cost function by using the KWIK algorithm to determine the optimal manipulated variable (control input) sent to the servomotor during every control interval.
3. To find and solve potential problems in advance, we did processor-in-loop (PIL) simulations before the in-lake test.

Major results

- The reference tracking performance of our controller can be optimized by tuning weight w_2 during PIL simulation.



Major results (Cont'd)

- Move suppression performance can be improved by tuning weight w_2 during PIL simulation.

Conclusions

- The steering controller proposed in this paper is adaptive to a changing environment.
- The controller can at some level save energy.
- Reference tracking performance of our controller is optimized.
- Reference tracking performance is validated in lake trials.