Identifying the Steering Dynamics of an Autonomous Surface Vessel

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Introduction

- Autonomous surface vessels (ASVs) are unmanned boats that can be used to automate data collection and reduce the need to perform manual, labor-intensive sampling tasks in applications such as environmental monitoring or infrastructure inspection.
- However, automating an ASV can often be challenging since it requires extensive outdoor testing and steering controllers may be sensitive to platform changes, such as the addition of new payloads, biofouling, or assembly variations.

Objectives

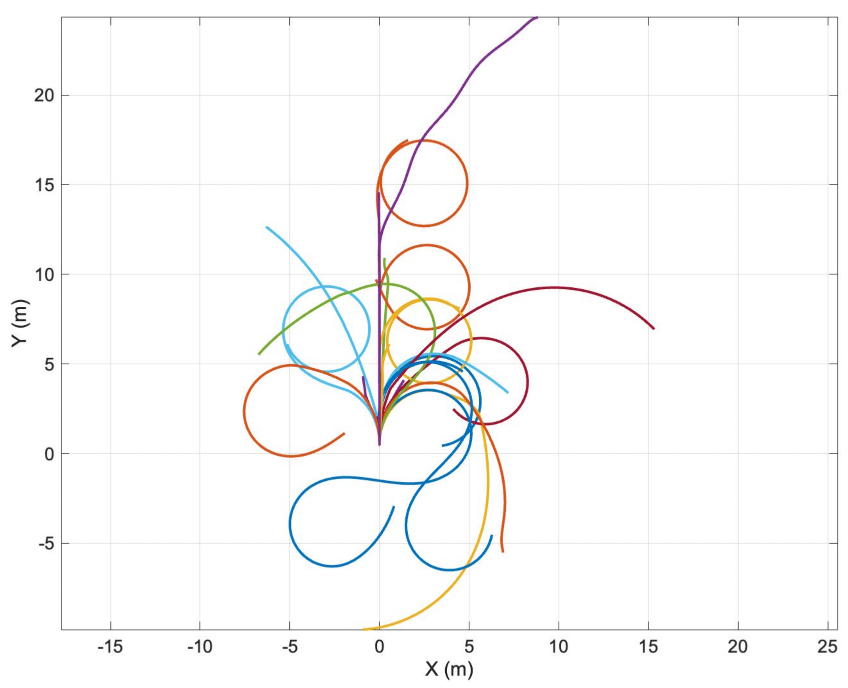
- Use experimental and simulated data to identify models of ASV steering dynamics to support follow-on automation tasks, such as waypoint following and multi-vehicle collaborative sampling.

Methods and Data Collected

- Embedded system controllers were programmed to collect data onboard the ASV during manual maneuvering tests at Hechenbleikner Lake on UNC campus.

The ASV collecting experimental data on UNC Charlotte's campus

- Five tests performed following different types of paths: a straight line, counter-clockwise circle, a clockwise circle, zig-zag, and figure-eight.
- Onboard telemetry recorded GPS position, yaw heading, yaw rate, motor RPM, and controller PWM input signals.
- A marine systems simulator[1] was modified to generate numerous ASV simulations for developing the system identification approach prior to experiments.



Example 25 randomly simulated ASV paths used for system identification prior to experimental testing

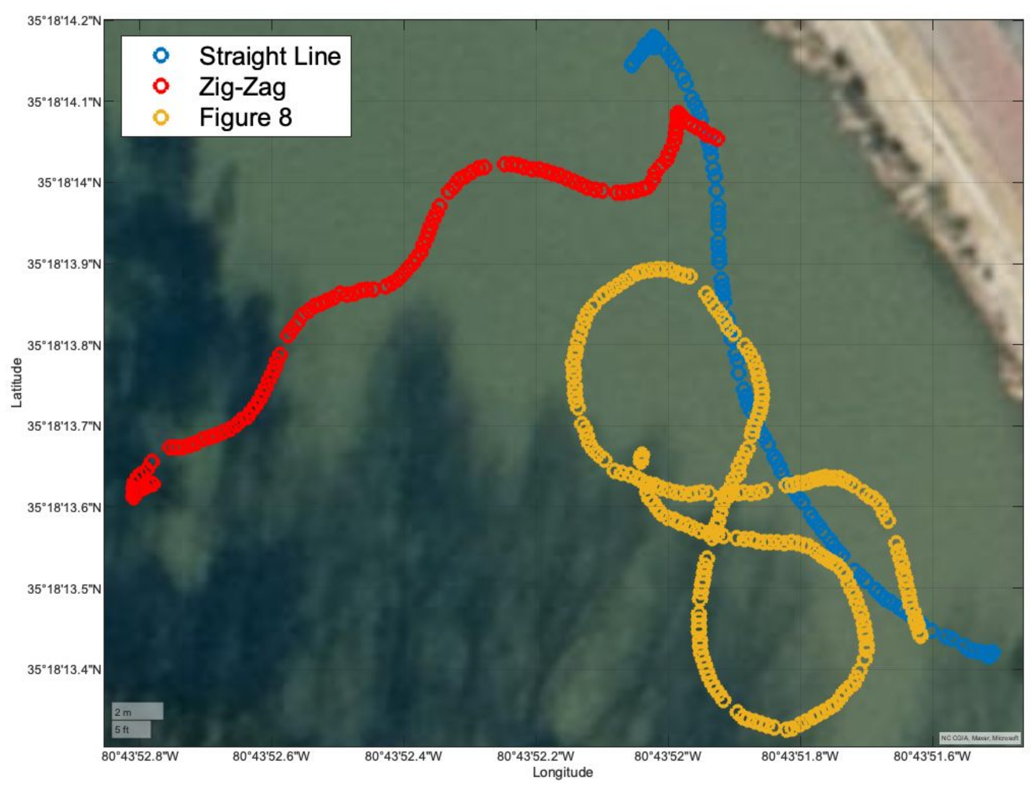
- Steering dynamics were approximated by Nomoto 1st order model [2]

$$\dot{r} = -c_1 r + c_2 u + b$$

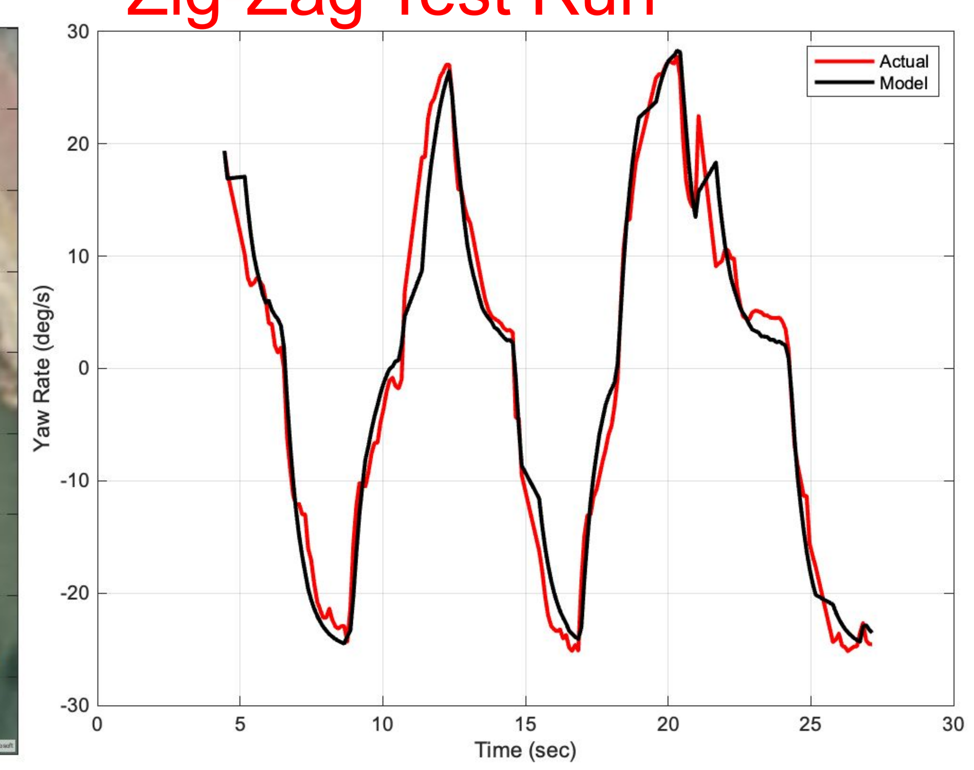
where r is the yaw-rate, u is the PWM input, and c_1, c_2, and b are constants.

Results

- Nomoto's optimization was used to generate accurate models of experimental yaw-rate data.
- An optimization problem was formulated to find the parameters of Nomoto's model that best fit the data in a least-square sense.



Zig-Zag Test Run



Discussion

- Using Nomoto's optimization, we were able to identify steering models within only a limited data set.
- Although the optimization can generate accurate models for individual runs, the resulting parameters did not always generalize well to all data sets. Alternative models may yield more accurate results.

Conclusion

- A method for ASV data collection and steering dynamics identification was developed. The framework will support follow-on ASV automation tasks in the future.

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References:

[1] Fossen (2018) Marine Systems Simulator [Source Code]. https://github.com/cybergalactic/MSS.

[2] Peeters, G., Boonen, R., Vanierschot, M., DeFilippo, M., Robinette, P., & Slaets, P. (2018). Asymmetric Steering Hydrodynamics Identification of a Differential Drive Unmanned Surface Vessel. IFAC-PapersOnLine, 51(29), 207–212.