

Objective

This project aims to create a robust control system for a fully autonomous sailboat, which is modeled by a predictive framework. By predicting the motion of the hull, adjustments in the controls can be made to keep the heading of the boat in the direction specified by its local pathfinding.

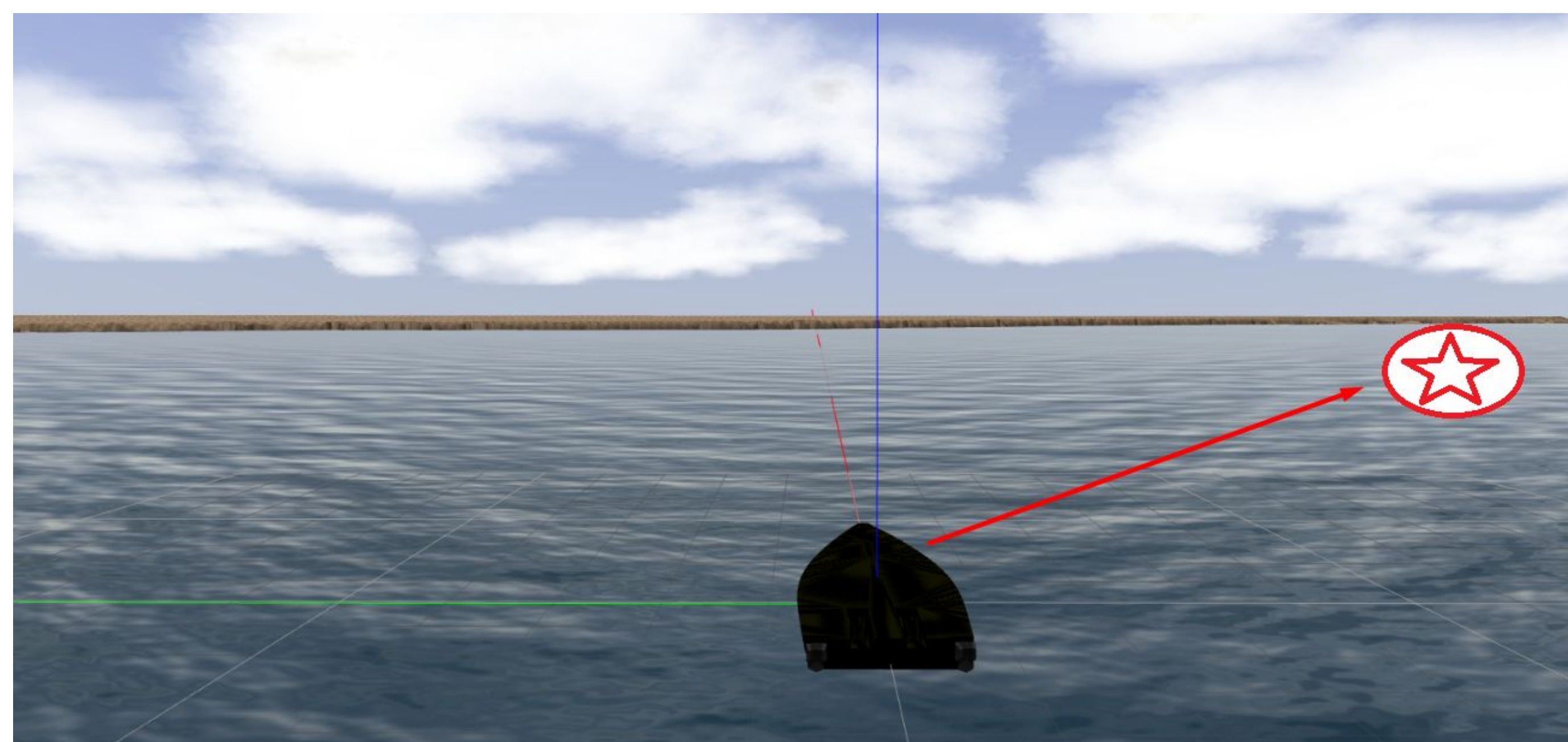


Figure 1: Using model predictive control to keep the boat on path to its destination

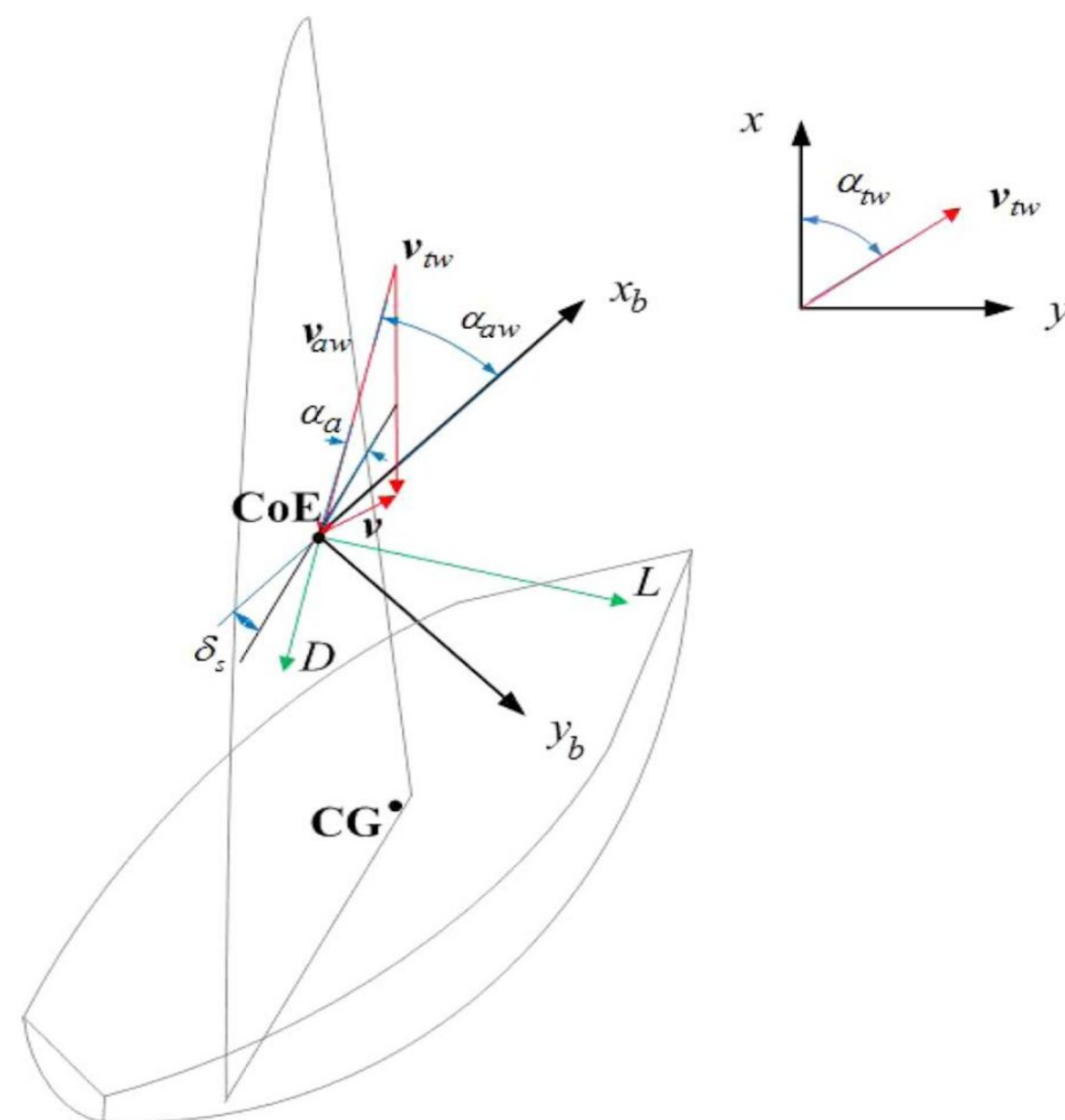


Figure 2: Wind velocity triangle and forces on the sail.

Methods and Materials

1. Gazebo Modelling

- Emulate the boat for testing in a realistic, non-destructive scenario before the boat is built
- Use Gazebo Fluid Dynamics simulations to validate MPC controller

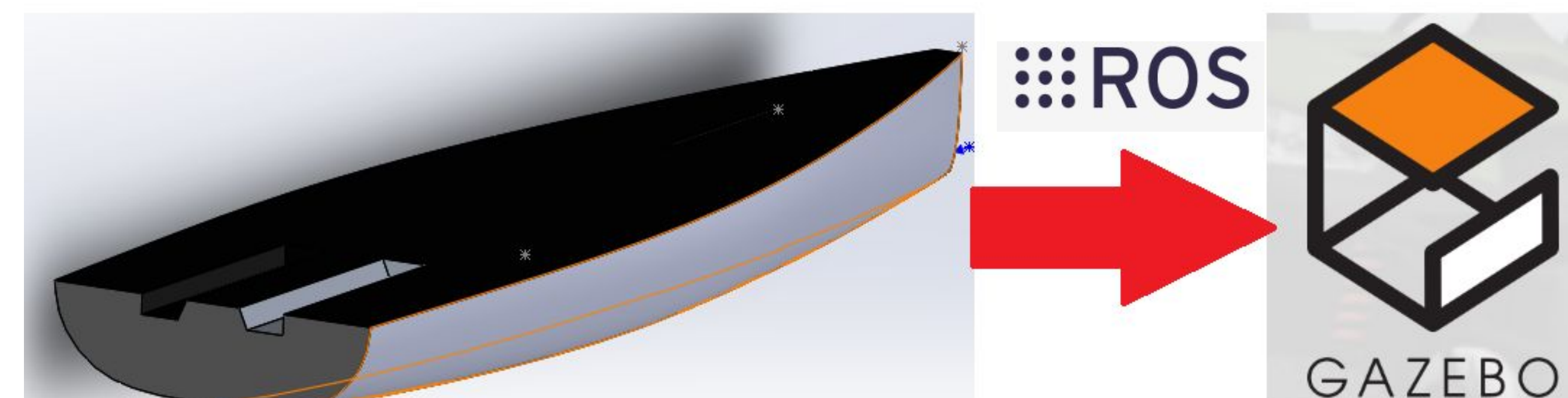


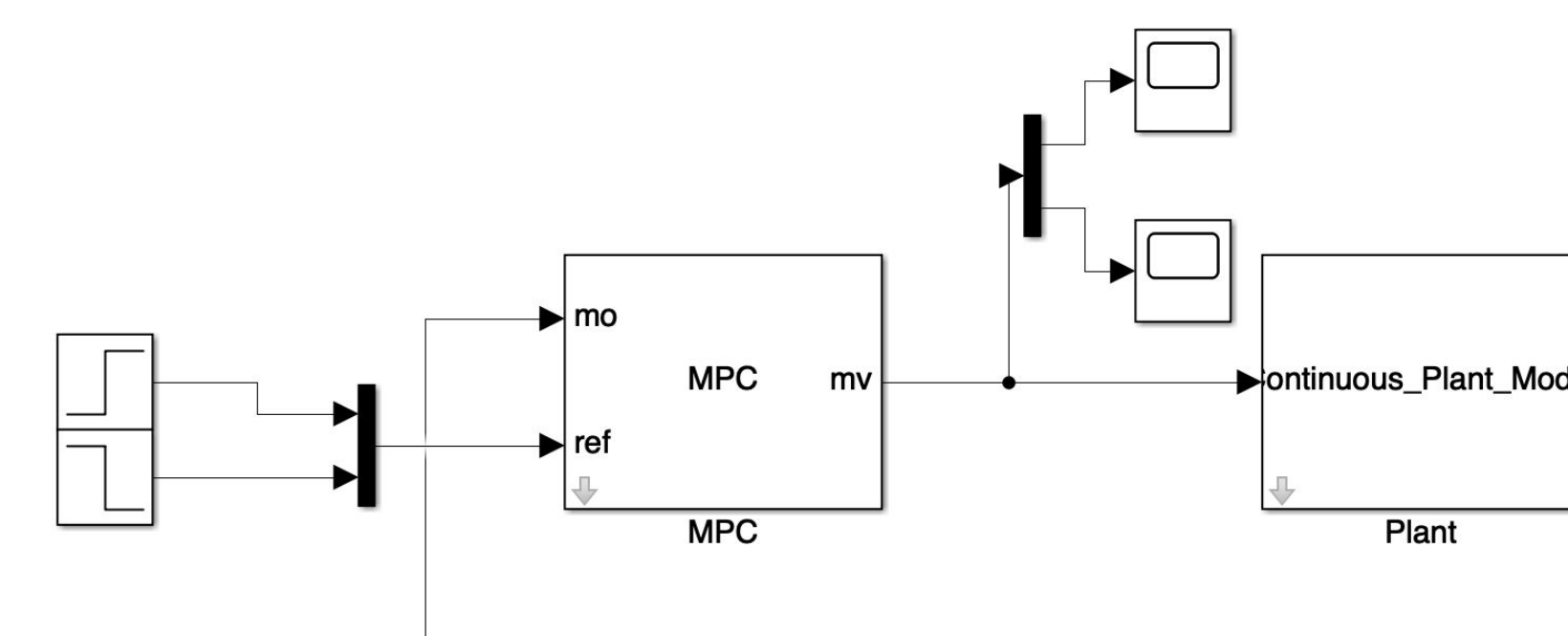
Figure 3: Import 3D boat model into Gazebo simulator for resting

2. State Space Development

- Get the boat's equations of motion using its fluid dynamics in water and air, all of which are modeled by non-linear differential equations
- Linearize about current state

3. Controller Design

- Vary controller parameters so that the boat gets to the destination as fast as possible



4. Controller Validation

- Test the boat in the real water and see if the controller designed works on the real boat

Results

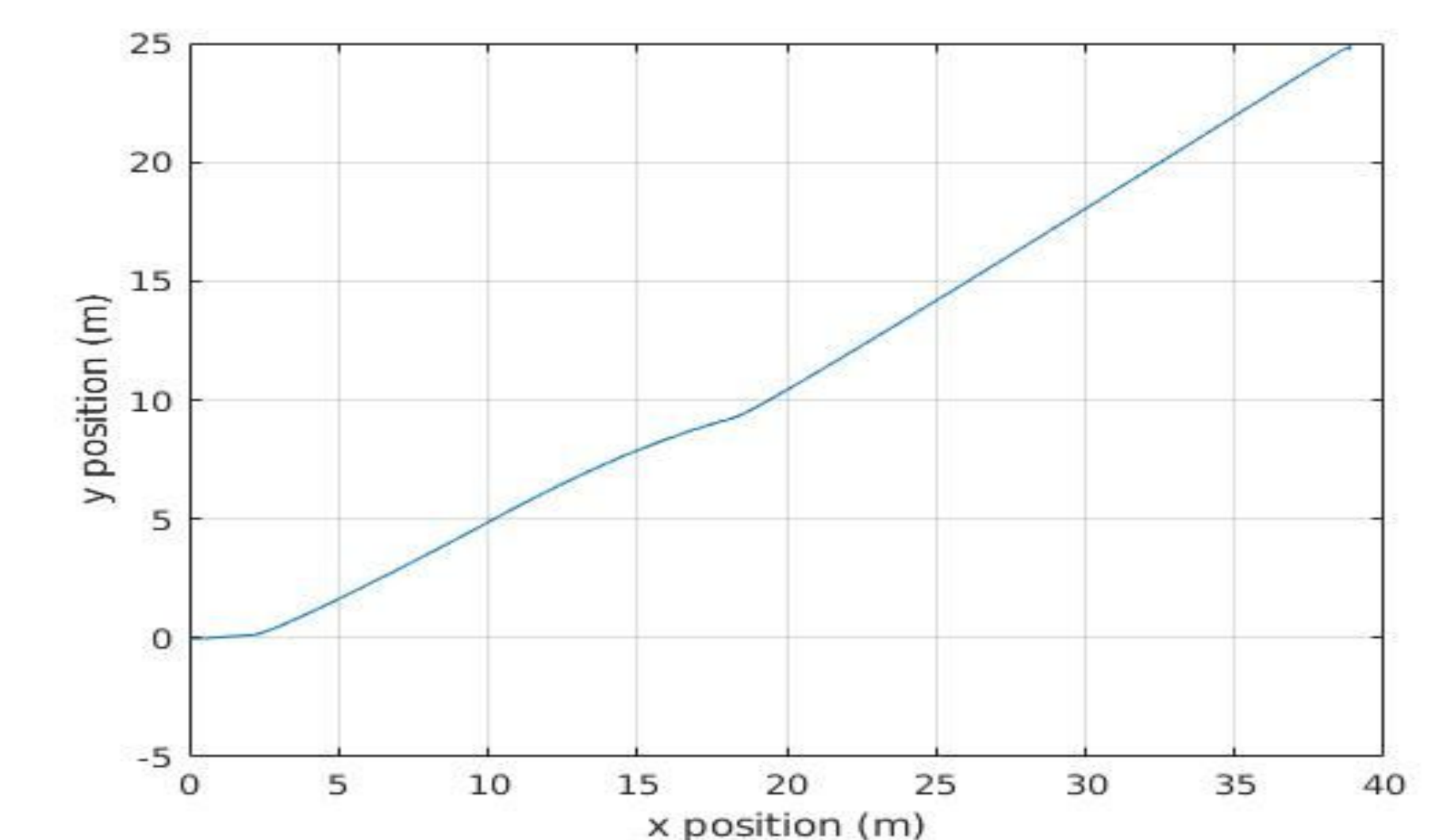


Figure 4: Position of boat under time evolution simulated in Gazebo.

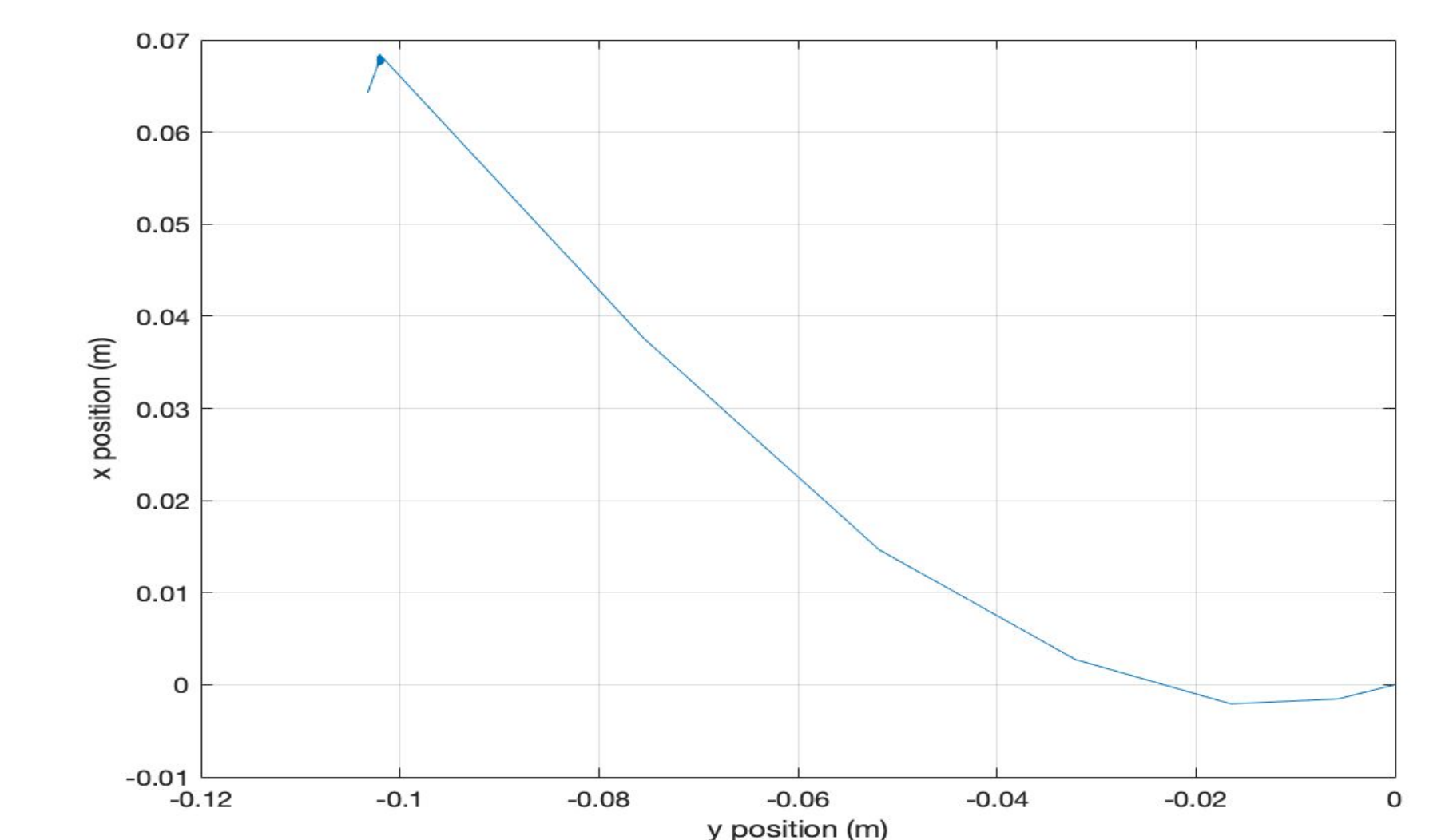


Figure 5: Position of boat under time evolution using linearized State Space.

Discussion

- Currently the boat's simulated behaviour in Gazebo differs from its governing physics equations
- Tuning parameters in the physics based model is required to reach conformity

Next Steps

- Model Validation
- Controller Design
- Controller Validation

Contact

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References

1. L. Xiao & J. Jouffroy, "Modeling and Nonlinear Heading Control of Sailing Yachts" in IEEE Journal of Oceanic Engineering - April 2014
2. N. Khaled & B. Pattel, "Practical Design and Application of Model predictive Control"
3. J. Melin, "Modeling, control and state-estimation for an autonomous sailboat" Uppsala Univesitet