Investigating the Capabilities of Miniature Autonomous Surface Vehicles through a Game of Pong

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Background and Motivation

- Autonomous Surface Vehicles (ASVs) are robotic vehicles that function on the surface of water bodies without operators
- The goal of this project was to create a game of pong using miniature autonomous surface vehicles (mASVs) through simulation and testing in a real-life environment
- Pong is a simple game that challenges the robots to sense or perceive and react to the movement of its opponent
- This project takes place on the surface of the water, which provides an unstable environment and a further challenge
- This application can extend to coordinating the movements of larger ASVs for tasks like exchanging materials or charging batteries

Methodology

- Three mASVs were used to represent the opponents and the ball
- mASV Ball:
  - The ball's angle of incidence needed to reflect when there was a collision with the boundaries or the opponents
- mASV Opponents:
  - Each opponent needed to use the position of the ball, the current angle of approach of the ball, and the algorithms the ball uses to move to plan their next waypoint
- Environment and Communication:
  - The Multi-Robot tank (MR Tank) was used for the experiments
  - OptiTrack was used to keep the positions of the mASVs in the tank and relayed that information to the command center
  - Reflective markers on the mASVs were necessary for OptiTrack to monitor their positions
  - Xbee and the microcontroller inside the mASVs were used to communicate with the command center and control the motors to move the mASVs towards waypoints in the tank
- For a run to be considered successful, there needed to be a rally between the two opponents

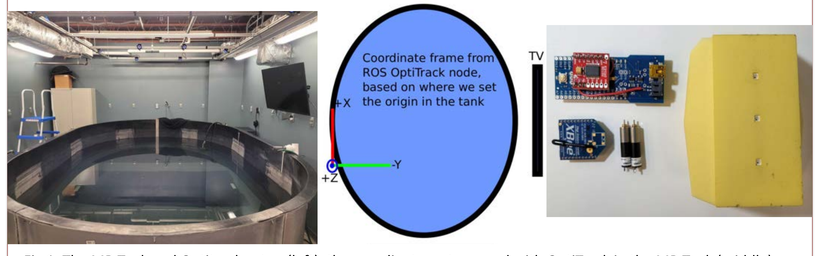
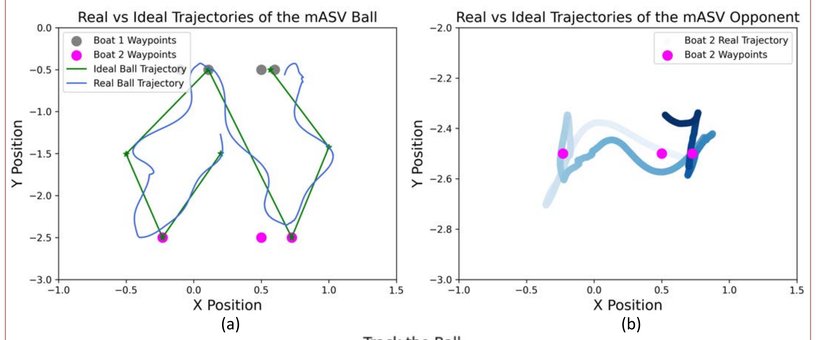
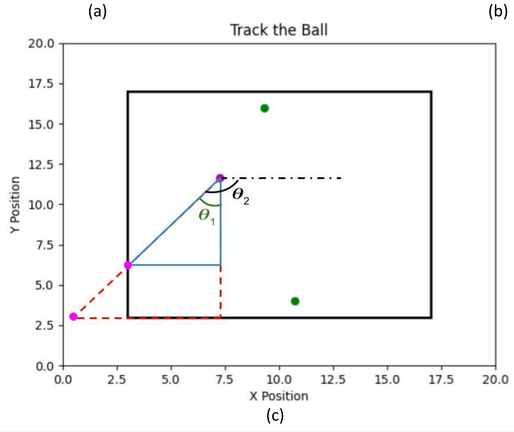


Fig 1. The MR Tank and Optitrack setup (left), the coordinate system used with OptiTrack in the MR Tank (middle), and the mASV parts disassembled (right) - including the motors, Xbee and microcontroller, and the body

Experimental Results

- The mASVs were deployed in simulation and in the tank multiple times to develop the script and algorithms
  - Progressed to pong through other sub-projects to understand how to generate waypoints and the controller on board the mASVs
- There were consistently successful rallies with up to four returns per mASV opponent once the script was finalized
- Data was collected on the positions of the mASVs at all times as well as the actual desired waypoints





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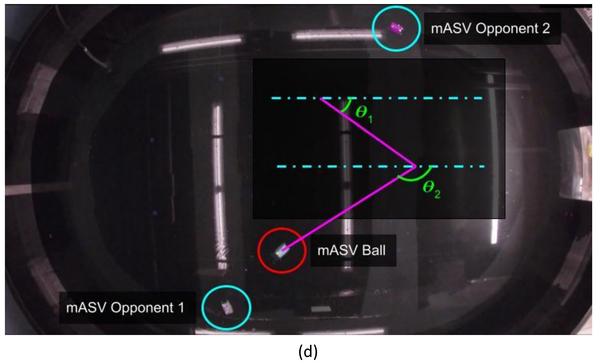

(d)

Fig 2. (a) The trajectory the mASV ball followed during two returns for each ball vs. the ideal path given the waypoints followed; (b) The trajectory and waypoints followed of one of the mASV opponents during these returns; (c) A capture of the simulated version of the experiments; (d) A capture from the real-life experiments in the MR Tank

Discussion

- While the simulations were successful everytime, it was far more difficult to gain consistency with the real-life experiments
  - In simulation, there are no real errors due to the ability to adjust the speed of the opponents movement and ball following its ideal trajectory
  - In the real-life experiments, the movement of the mASV ball is less predictable and there are constraints like the maximum speed of the mASVs
- The simulations and OptiTrack also used different coordinates systems, which added difficulty to the transition
  - These difficulties include translating the calculations for the mASV ball under the new coordinate system and boundaries
- The movement of the mASV ball often did not follow an ideal path due to the shifting environment of the water
- Overall, there was success in both the simulated and real-life versions of Pong using mASVs
  - This success is notable because the mASVs were subject to a fluid-like environment and constant external forces

Conclusion

- The goal of this project was to create a game of pong using mASVs
- A script was developed that successfully allowed the mASVs to play a rally of pong
- Areas of improvement could be getting the mASVs ball to move closer along the ideal path, as well as finding a way to have the mASV opponents better maintain their position while waiting to receive the ball
- Future work includes introducing teams of opponents, introducing gyre-like flows to the environment, or introducing noise to the OptiTrack data, all while still maintaining a stable rally of pong

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