Control of a Dual Fan Drive Catamaran

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Motivation

Robotic watercraft provide a low cost means to carry out environmental sensing and data collection.

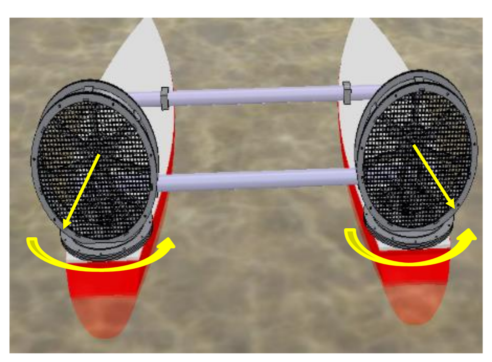
In some environments, such as swamps or fisheries, it dangerous for both the boat and the environment to use a platform driven by submerged propellers. In this case it is necessary to switch to fan drive.

A catamaran improves maximum sensor payload both in terms of size and weight of the sensors.

Introduction

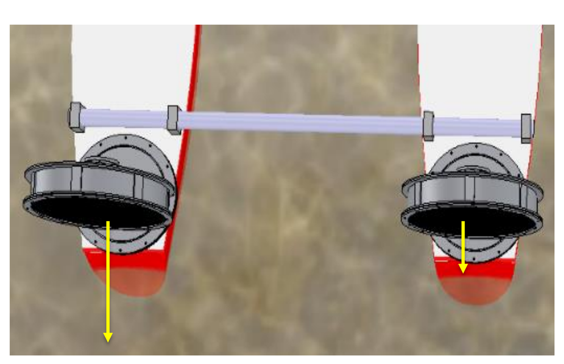
A dual fan catamaran poses an interesting control question. When using decoupled fans with rotating base plates there are four independent parameters that can be tuned to control the motion of the boat:

- Left and right fan speed
- Left and right fan orientation

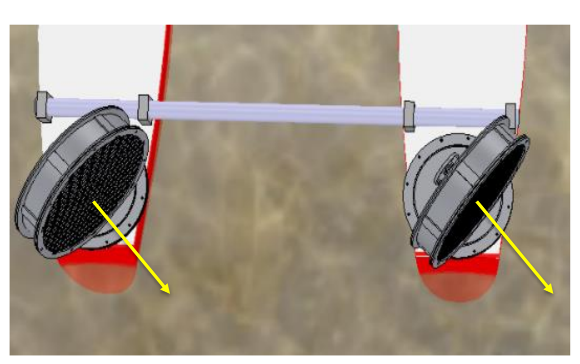


Four Degrees of Freedom in Rotating Fans

An additional control scheme is made possible by removing the rotational component in the fan base. In this case, turning can be achieved through differential drive - driving the fans at different speeds.



Differential Drive



Vectored Drive

Objectives

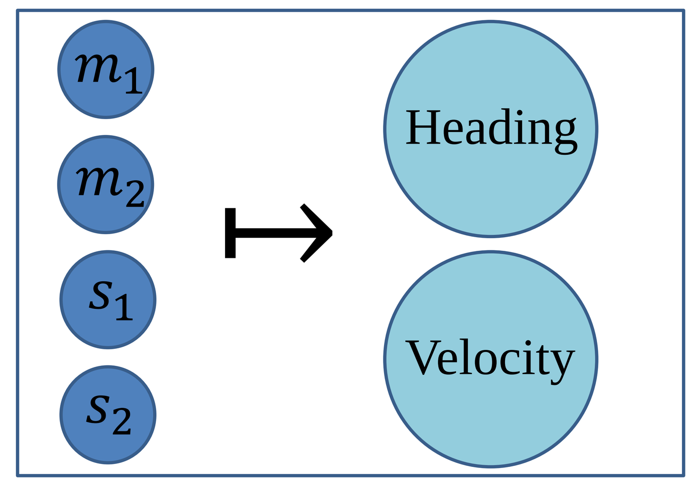
- Design and construct a working physical model of the dual fan catamaran with sufficient functionality to support autonomy.
- Develop a simulation model to test the control scheme in the V-REP simulation environment.
- Implement and experimentally evaluate the control schemes on the physical platform.

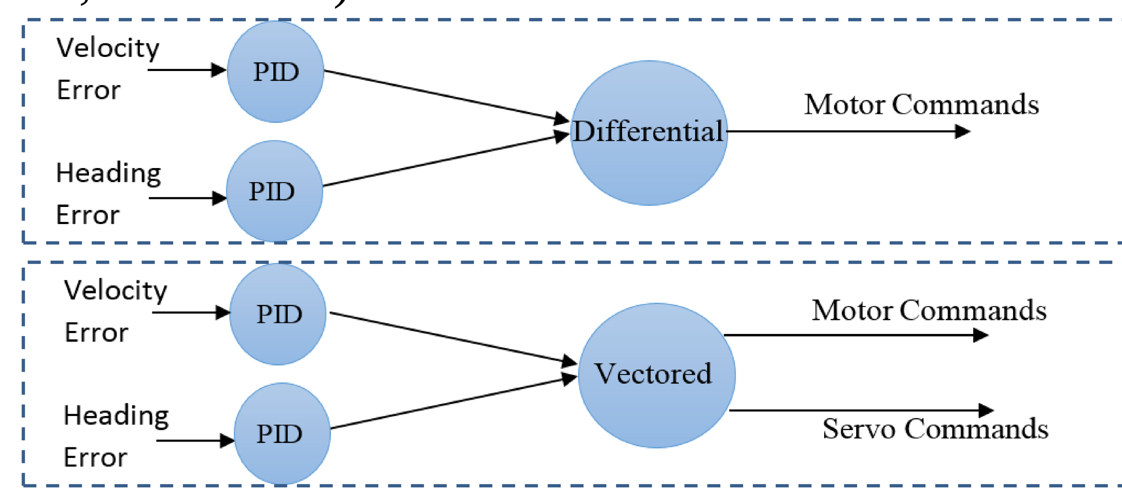
Implementation

Control

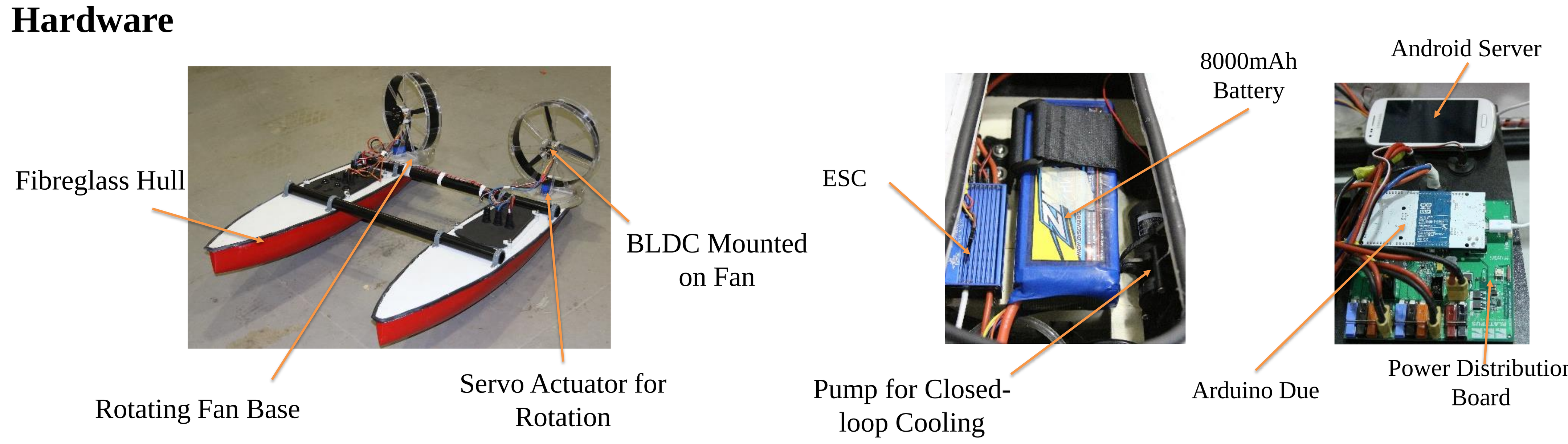
The state of the catamaran is defined by its heading and velocity. In the case of fully decoupled dual rotating fans, there are four controllable parameters. Accordingly, the system is under-determined. Two intuitive constraint schemes are synchronous fan vector drive (motor 1 = motor 2, servo 1 = servo 2) and asynchronous fixed fan differential drive (servo 1 = 0, servo 2 = 0).

Mapping from System Parameters to State Variables





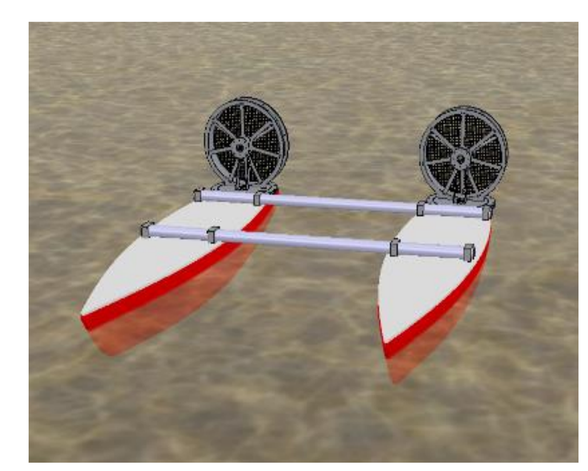
Hardware



Simulation

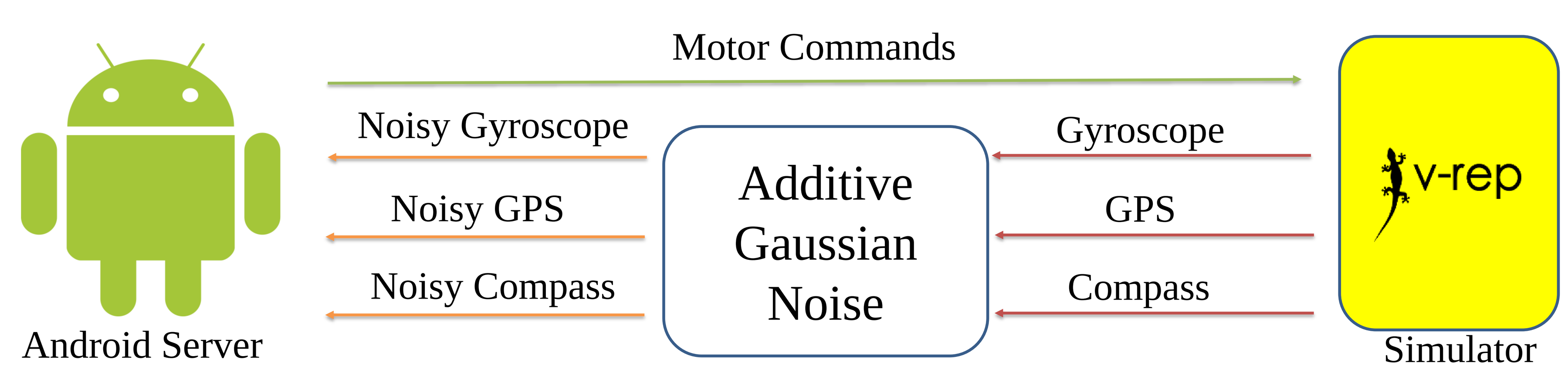
Simulation was carried out in the V-REP simulation environment. The boat was modelled by decomposing each hull into a user defined number of cuboids. The following physical effects were then applied to each individual cuboid:

- **Buoyancy ($\rho g V$)**
- **Current flow (Vector field)**
- **Drag ($bv + \frac{1}{2}\rho C_D A v^2$)**



Catamaran Simulation Model

The sensor readings obtained from an Android smart phone contain a high level of noise. To simulate this, the data obtained from the simulator was combined with a Gaussian random process.



Field Testing

Preliminary field testing has been carried out to determine the agreement between the simulated and physical models.

The tests carried out consisted of

- Step change in target heading target while stationary and while driving.
- Straight line driving and stopping.

GPS data was collected in each case to be post-processed and compared with the simulation results.

Field Testing of Catamaran

Preliminary Results

View the field test and the simulation using the QR codes below:

Field Test

Simulation

Conclusions & Future Work

A simulation model and physical platform have been realized. Further testing is required in order to evaluate the two proposed control schemes. Future work is detailed below:

- Evaluation and improvement of the fidelity of the simulation model.
- Evaluation of control schemes on physical platform.
- Development of a performance metric which could be used to evaluate a control scheme. Performance may be based on energy efficiency, the smoothness of the motion, etc., which would encourage the consideration of the four degrees of freedom.
- Integration of a more advanced control scheme such as a fuzzy controller to improve system accuracy.

References

[1] S. L. D. L. C. Ueng, "A ship motion simulation system," *Virtual Reality*, vol. 12, no. 1, pp. 65-76, 2008.

[2] A. S. S. K. U. K. O. v. S. Johannes Meyer, "Comprehensive Simulation of Quadrotor UAVs Using ROS and Gazebo," in *Simulation, Modeling, and Programming for Autonomous Robots*, Springer, 2012, pp. 400-411.

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