The Autonomous Lifeguard Project

Darrel Deo, Shehadeh Dajani, David Goodman, John Ash

UNIVERSITY OF CALIFORNIA SANTA CRUZ

JACK BASKIN SCHOOL OF ENGINEERING

Senior Design Project

Autonomous Lifeguard Group

Emergency Marine Response System

Abstract

The Autonomous Lifeguard Group has developed a system that provides rapid support to distressed swimmers. It is composed of two sub-systems: a command center, which will locate the swimmer, and autonomous water vessel, which will navigate to the swimmer. The command center is an encoded tripod with a mounted scope that will be located on a Lifeguard's post. A Lifeguard will center the scope on a distressed swimmer and at the push of a button, location information will be sent to the vessel. The vessel, docked in open water, will navigate to the swimmer upon receiving this information. Once the location is reached, the swimmer will grab hold of the vessel and await the arrival of a Lifeguard. Figure 1 illustrates a mock scenario.

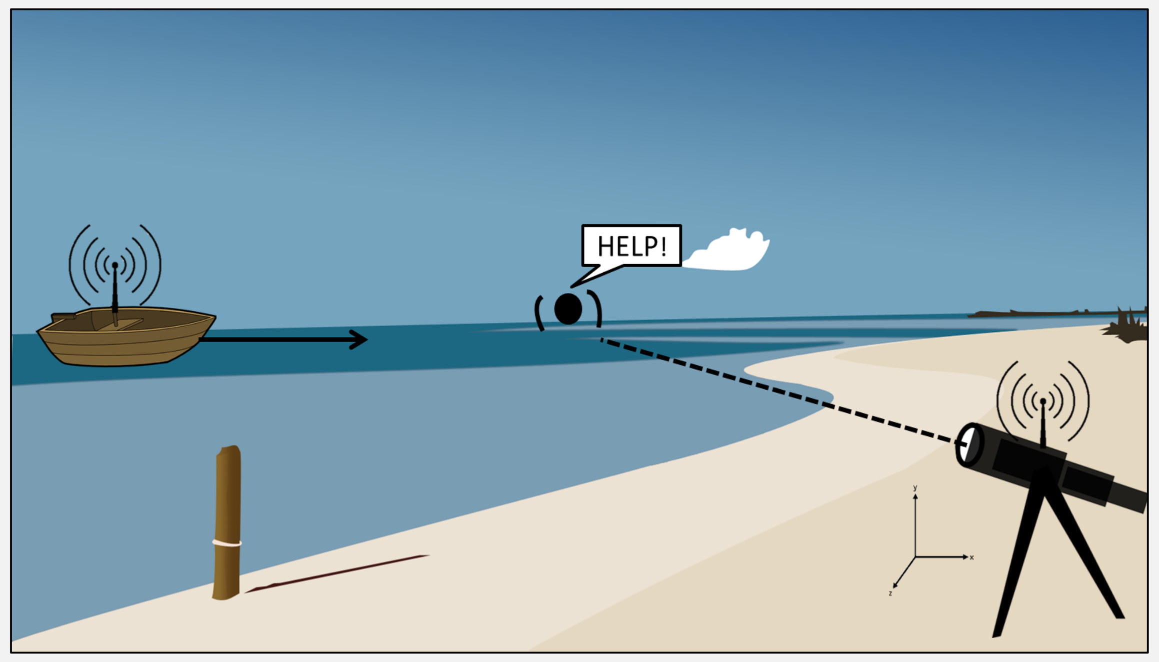

Figure 1. **Mock Scenario:** *The command center (ComPAS) locates the swimmer and sends location information to the vessel (AtLAs) who navigates to the swimmer.*

Top-Level System Diagram

The two sub-systems are defined by their unique array of sensors, actuators, and user-interfaces. They communicate via wireless protocol using XBee modules and a radio receiver for manual control.

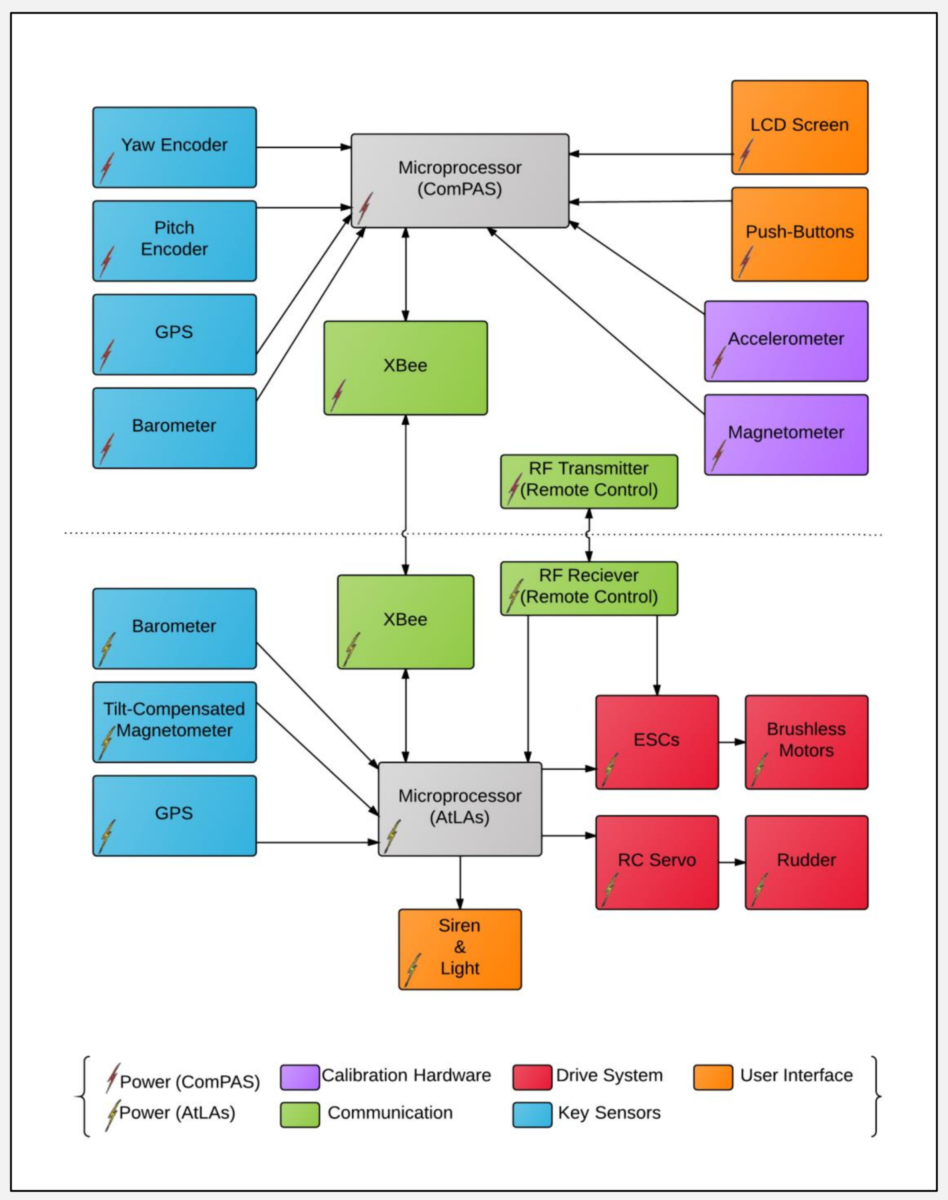

Figure 2. **Top-Level Block Diagram**

Command Center

Location by Triangulation Method

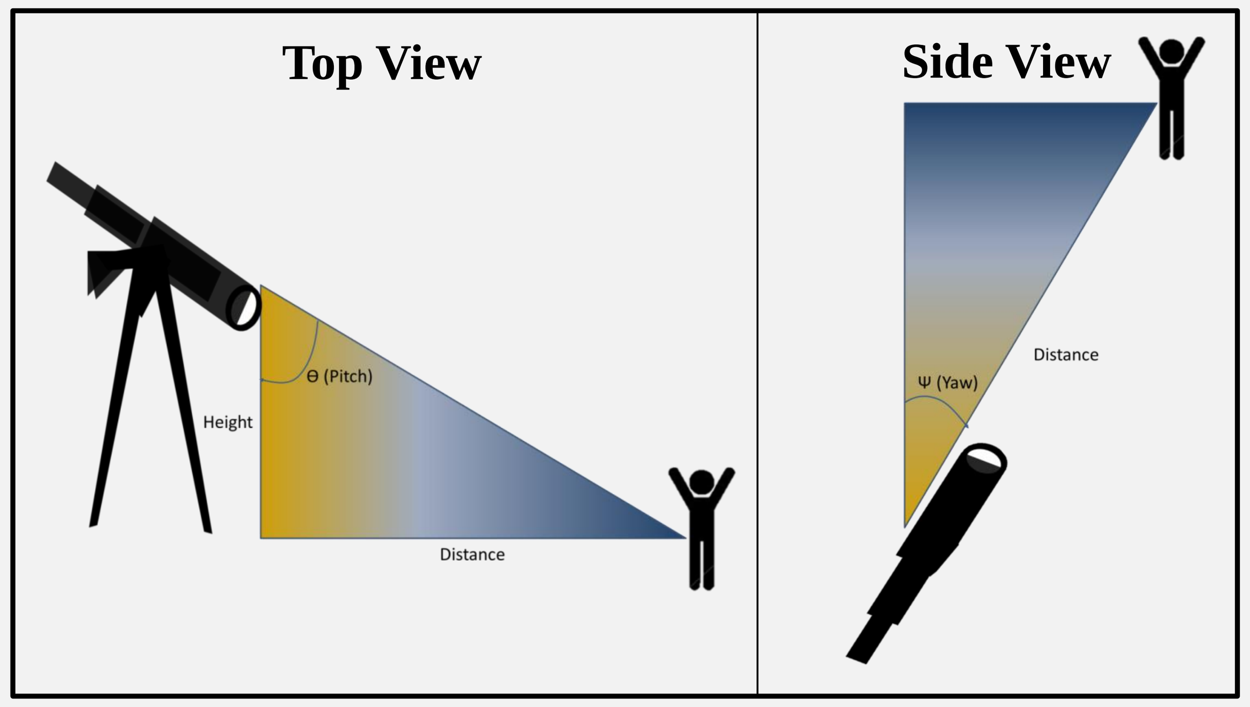

Figure 3. **Triangulating Position of Swimmer**

- Scope's crosshair is positioned on swimmer.
- **Engage** button is pressed, yaw and pitch angles read.
- Trigonometry performed on yaw, pitch, and height to obtain swimmer's relative position in NED(North, East, Down).
- NED coordinate is sent to vessel via wireless communication
- Vessel will calculate its own NED coordinate relative to the command center.
- Vessel navigates to swimmer.

Triangulation Error

When triangulating the position of a waypoint at large distances, sensors accumulate error based on resolution and nonlinearities, dynamic environments, and human error. This results in an ellipsoid of error, an example of which can be seen in Figure 4.

Sources of Error:

- Encoder resolution: 14-bit
- Imprecise mounting of encoders
- GPS satellite hand-offs
- Atmospheric delay of GPS signal
- GPS receiver noise and quantization
- Barometer resolution and noise

Solution:

- Proper calibration of sensors
- Pseudo-differential GPS method to correct error caused by atmospheric delay.

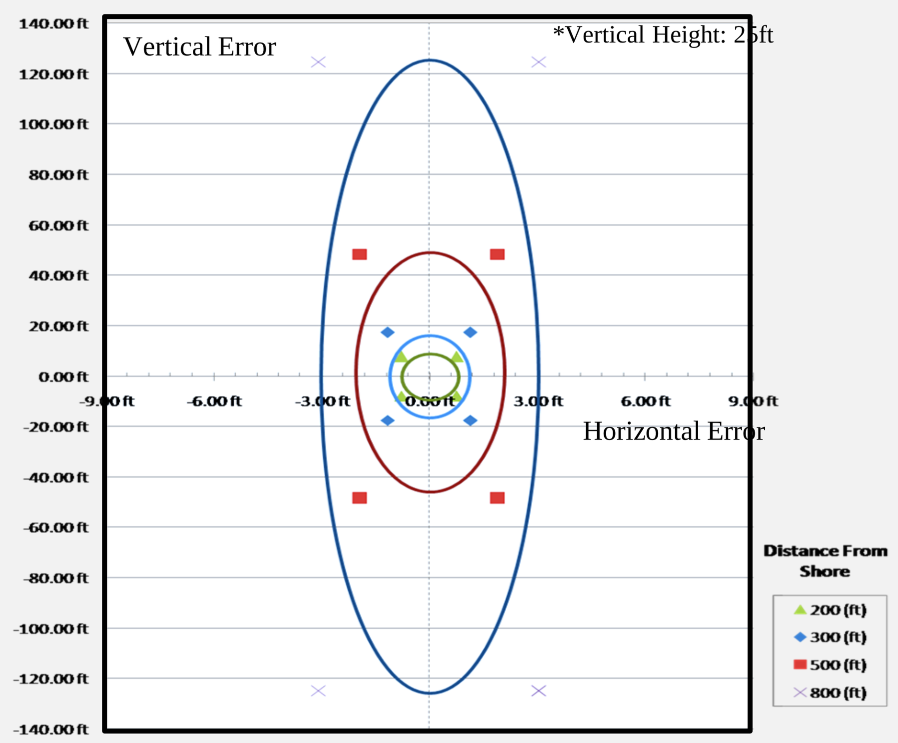

Figure 4. **Encoder Resolution Error**

Autonomous Water Vessel

The navigation procedure of the vessel relies heavily on the controller. Heading with respect to true north is the control parameter that is measured by a compass. The rudder is actuated to correct for the error in heading.

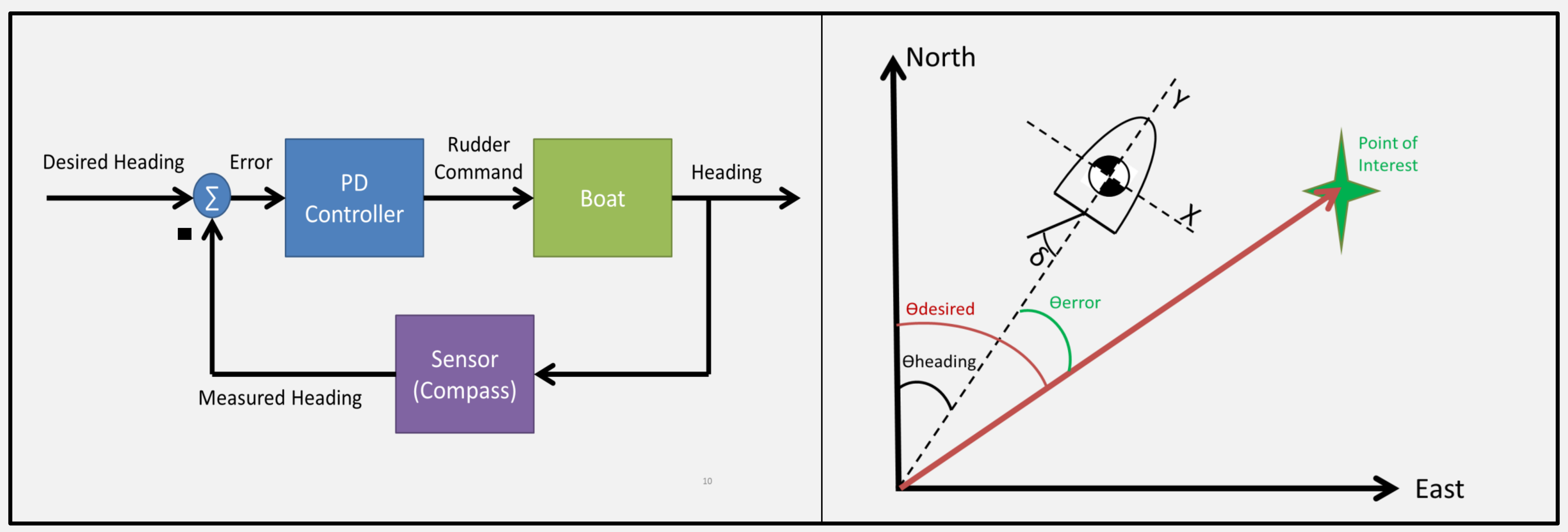

Figure 5. **Rudder Controller & Reference Frame**

Tests & Results

Command Center:

Test:

A known point at our target distance of 300ft was chosen. The command center, at varying heights, would locate the point of interest and return location information:

Vertical Height of Command Center (ft)	15	20	25
Error at 300ft distance (ft)	2.32	1.74	1.4

Findings:

Our command center is able to obtain correct location information within a maximum horizontal error of 2.32ft at our target distance of 300ft.

Autonomous Water Vessel:

Test:

GPS coordinate of a desired point is translated into a NED coordinate that is sent to the vessel. The vessel is to navigate to the point and stop upon arrival.

Findings:

Our vessel was able to navigate a lake to the point of interest from various initial orientations. The PD controller allows the craft to smoothly and quickly traverse water and reach the point.

Whole System:

The sub-systems work independently and are governed by their respective state machines. They are connected via the wireless communication that dictates which tasks are to be executed.

Future Work

Our Group has done extensive research and testing of sensors that can potentially sense humans. Thermal array, sonar, and microwave sensors have been explored, where preliminary results show that they posses the capability of human sensing. With further research, we wish to include this function on future iterations of the project.

To increase the robustness of our system, we hope to upgrade the materials used to fabricate both sub-systems. Sturdy materials and a larger water craft will allow the vessel to be deployed from various locations, including ships and helicopters, so that it may be deployed in disaster scenarios.

Our ultimate goal is to create a marine emergency response system that can be used by anyone in the event of an emergency or disaster.

Acknowledgements

The Autonomous Lifeguard group would like to extend their appreciation to:

Professor Gabriel Elkaim
Professor Patrick Mantey
Professor John Vesecky
Stephen Peterson
Max Dunne
Paul Naud
Private Donars

A special thanks to all of our private donors.

Kolsky Senior Design Baskin Engineering

TI university program ti.com/university