Dynamic Positioning System

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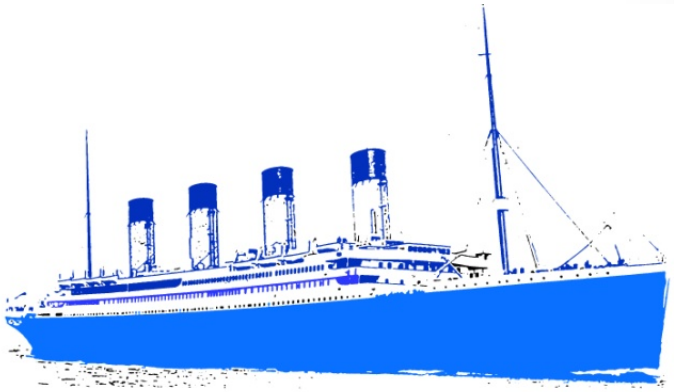


TITANIC
POSITIONING

Personal Introduction

- Bardia Bogharti
  - Input/Output Interfacing, Data Parsing
- Bengt Haunerland
  - Wind Disturbance, Thruster Allocation
- Lucie Hiltner
  - PID, State Estimation
- Yalda Majdi
  - Filtering, Data Parsing
- Carl Whalstrom
  - Display, Filtering

Presentation Overview

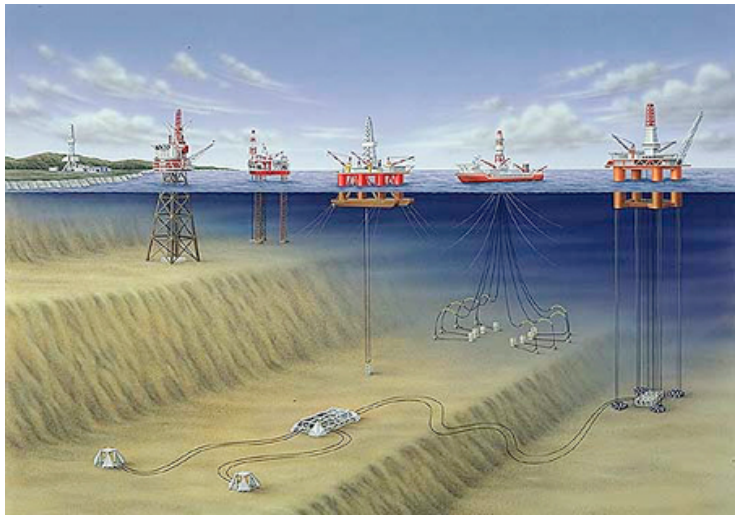
1. Introduction
2. System overview
3. Testing and Demonstration Video's
4. Financing
5. Schedule
6. Conclusion
7. Questions

Background

- Control system to maintain position and heading of a boat
- Uses sensors to read current position and external forces
- Uses the thrusters of the boat to compensate for drift due to external forces
- Proof-of-concept demonstrated on cart
- Future plan: install on boat

Applications

- Offshore drilling
  - Used to load extracted petroleum onto a transport vessel
- Oceanography
  - Marine research study of physical nature of the ocean
- Cruise ships
  - Slow cruises so that guest can enjoy luxurious views

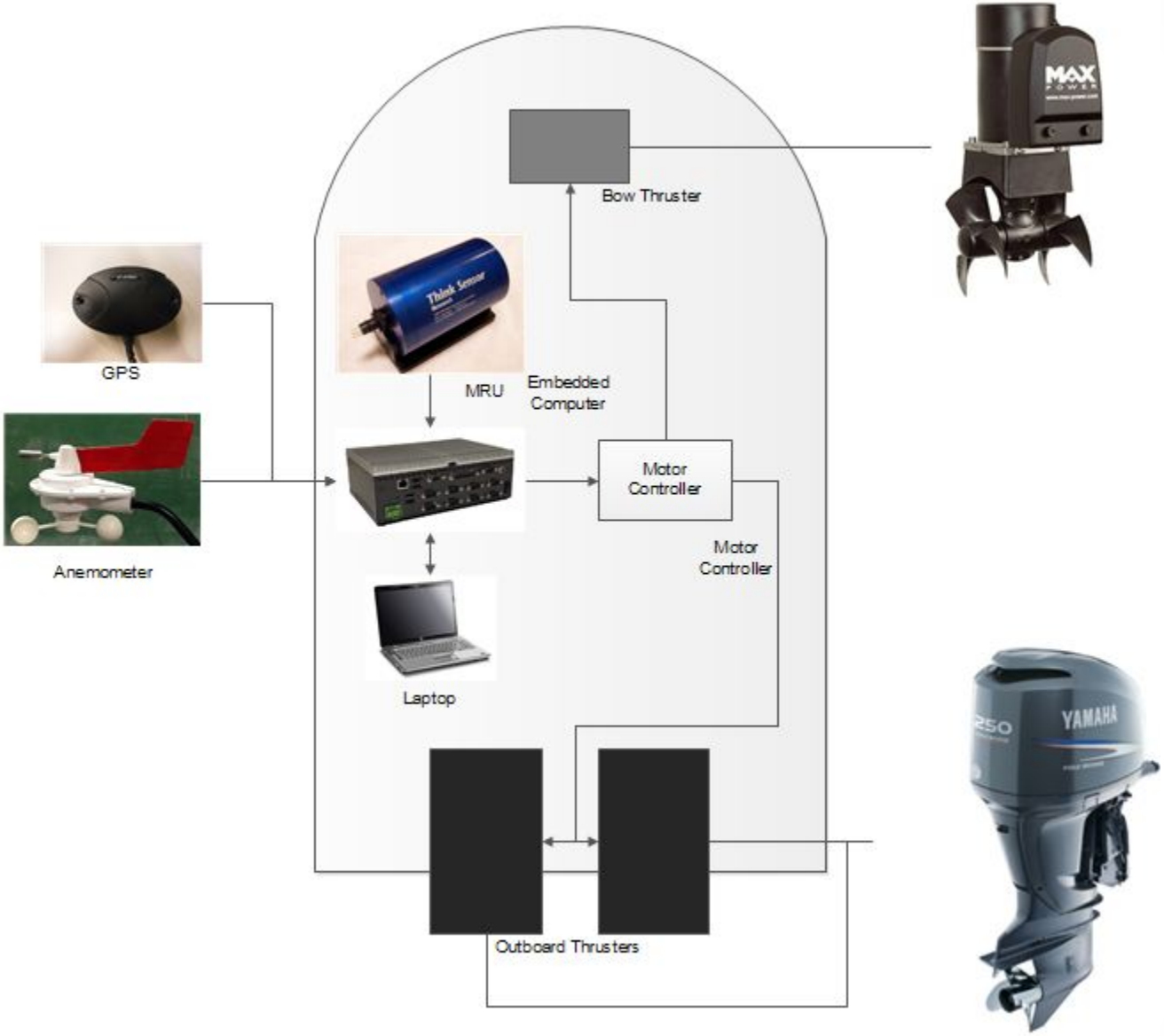


Motivation

- Market competition
  - Few vendors – Kongsberg
    - based out of Norway
  - Field service is costly and takes too long
    - Since there are limited suppliers
- Learning Opportunity
  - System design
  - Interfacing between software and hardware
  - Project planning
  - Bringing a product to market with a startup -> practical work experience

System Overview

- DPS-0 is a dynamic positioning system that has manual position control and automatic heading control
- The system uses 3 input sensors: a GPS, motion reference unit (MRU), and wind sensor (Anemometer)
- The control system is implemented in C++ on an embedded computer, which communicates with a display computer


Bow Thruster
GPS
MRU
Embedded Computer
Anemometer
Motor Controller
Motor Controller
Laptop
Outboard Thrusters

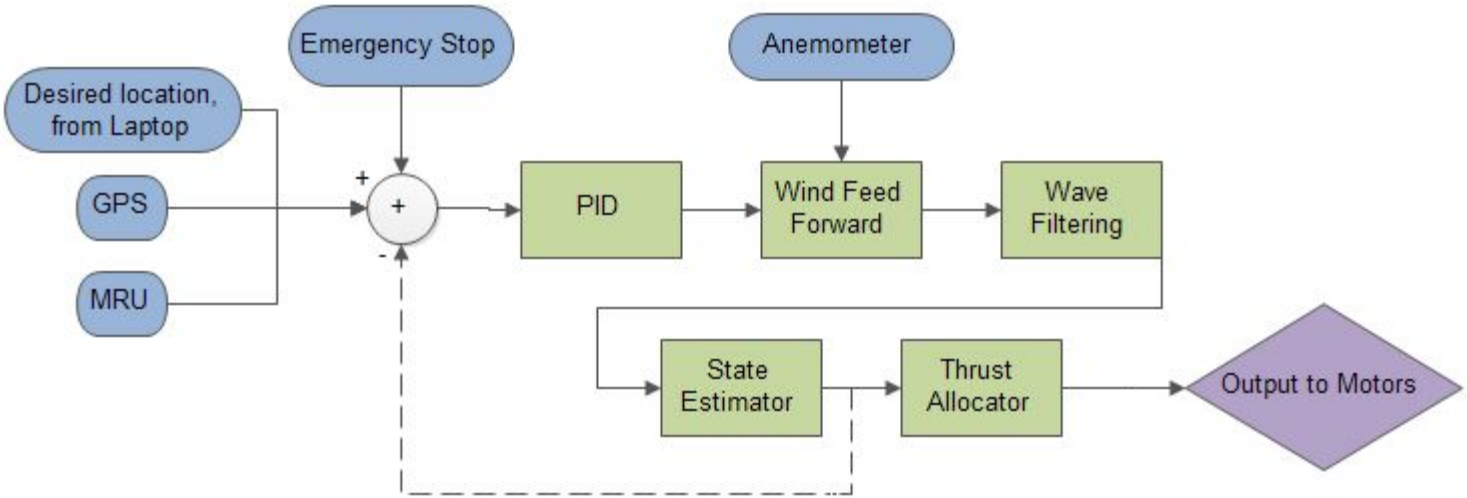
Input Sensors

- GPS
  - Provides latitude and longitude data

- MRU
  - Provides roll, pitch, heave, and yaw data

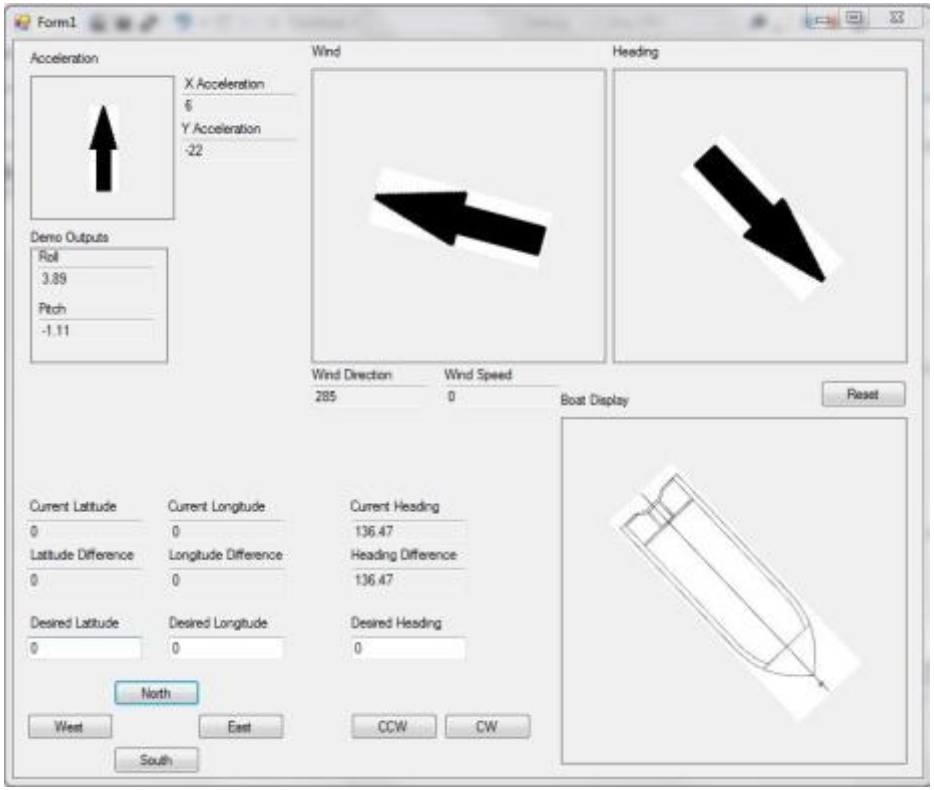
- Anemometer
  - Provides wind speed and wind direction

Controller


Emergency Stop
Anemometer
Desired location, from Laptop
GPS
MRU
+
+
-
PID
Wind Feed Forward
Wave Filtering
State Estimator
Thrust Allocator
Output to Motors

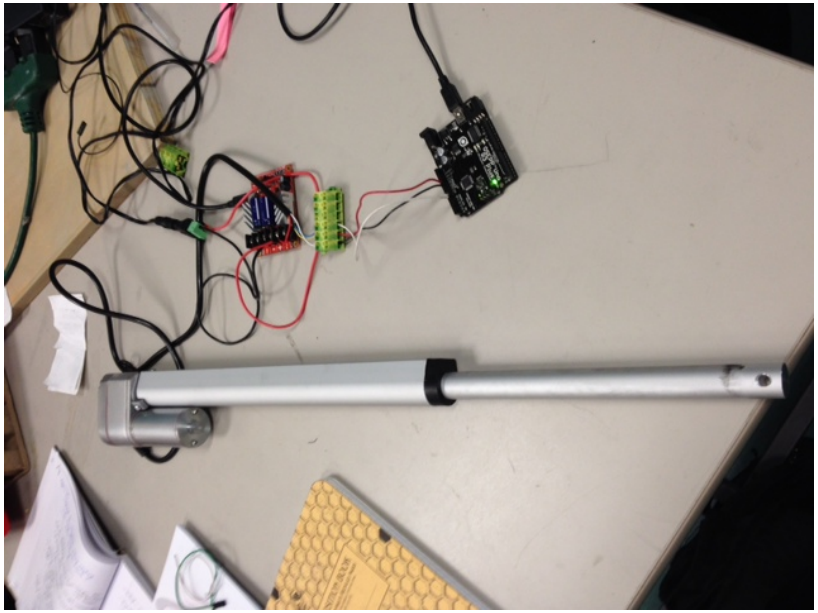
Display

- The display is on a laptop computer and interfaces with the embedded computer through serial connection
- The display shows the location and heading of the boat to give the operator feedback



Output Interfacing

- The DPS interfaces with the motor controller through a USB connection
- The thruster allocation outputs a magnitude and direction to the motor controller
- The motor controller connects to the motors



Testing Procedure

- Cart Test
  - Tested the MRU by rolling it in different directions
  - Tested the wind sensors by spinning the fan
  - Tested the GPS by moving the cart 10 meters
- Display Test
  - Can see visual feedback on display when the MRU is moving
- Boat Test
  - Unable to get a boat test because of maintenance issues on the boat

Testing Discoveries

- GPS resolution was greater than 15 meters
  - Solution: new GPS, state estimation
  - GPS documentation claimed accuracy within 1 meter
- Error string compensation
  - GPGGA string gave latitude and longitude information
  - Other strings read zero for latitude and longitude
- MRU data was lagging behind
  - Because code was updating on slowest sensor
  - Multithreading fixed this problem

Financing

Component	Cost Estimate ($)	Final Cost ($)
TSR-100 MRU	loaned from TSR	
GPS	loaned from TSR	
USB to 4-Port Serial	60	60
Embedded Marine Computer	1500	1500
Clipper Wind Sensor	1129	230
Cables, Connectors etc.	500	50
Use of boat (Fuel and Captain's time)	1000	
Motor Controller for steering Hydraulic motor	220	220
Linear actuators to attach to throttles	520	260
Total	**4929**	**2320**

Schedule

Milestones	Planned Due Date	Milestone Achieved date
Prepare Parts list	01/30/2014	01/31/2014
Inspect boat	01/30/2014	01/24/2014
Order Parts	02/15/2014	03/06/2014
Controller Implementation	03/1/2014	04/1/2014
Input implementation	03/1/2014	04/7/2014
Integrate and Debug	04/1/2014	04/15/2014
Implement on boat	04/1/2014	TBA

Summary of Project

- Titanic Position demonstrated a proof-of-concept dynamic positioning system
- MRU, GPS, Anemometer, motor controller and linear actuator were integrated
- PID Control system compensated for current drifts and mean wind forces
- The system controls the thrusters for station keeping

Tasks in Progress

- State estimation
- Code optimization
- Implementation of system on SFU test boat

What We Learned

- Project planning
- Design for a real time system
- Use of IDE and C++ libraries such as Eigen and NMEA
- Multithreading for input sensors to overcome latency issue
  - Use of mutexes to prevent conflicting copy of output signals
- Input and output interfacing
- Parsing serial data

What We Learned

- Display
  - Created a GUI that automatically refreshes data
  - Created a dynamic image to convey boat movement
  - Implemented serial communication between two computers for two-way data transfer
- State estimation
- Navigation concepts
- Standard-based design

Future Work

- Bringing the product to market
  - Demonstrate prototype on SFU test boat
  - Implementation of system on larger vessel through TSR

Future Work

Display Computer

- Marine rated integrated display system

Additional Hardware

- North seeking gyroscope
- Current Sensor
- Embedded computer

Additional Documentation

- Wiring diagrams
- User manual

Questions?