L'MAR II (Lake Michigan Amphibious Robot)

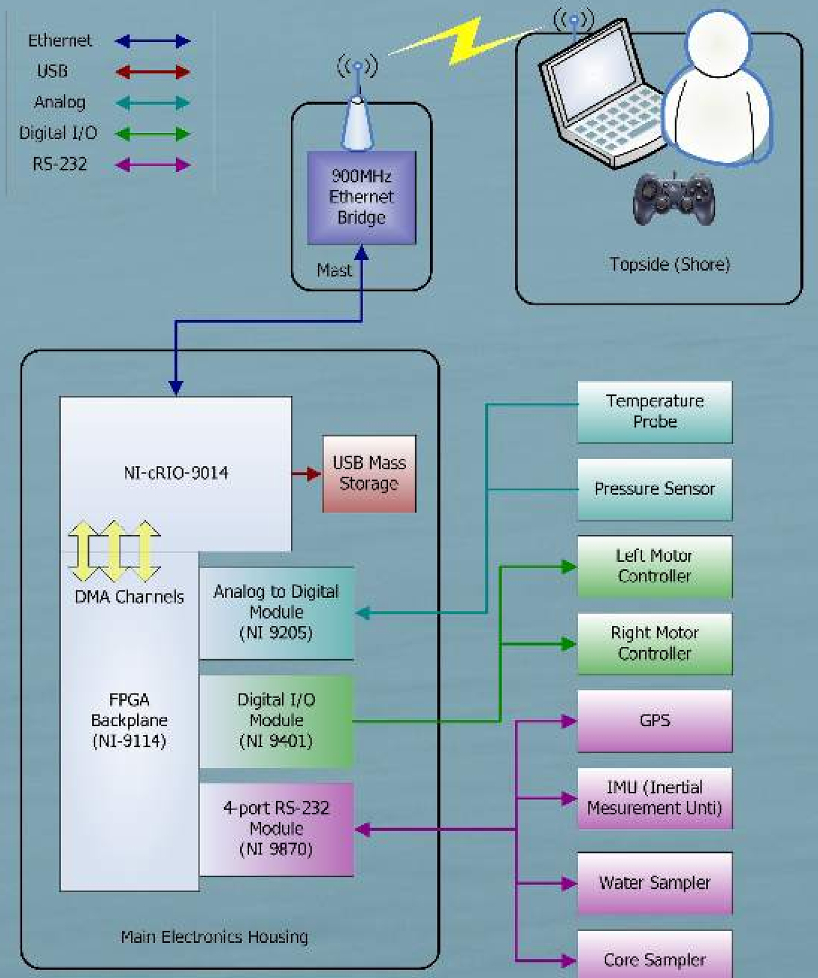
Design of an Autonomous Navigation System

Undergraduate: Samuel A. Bingham

Advisor: Dr. Thomas R. Consi

Abstract:

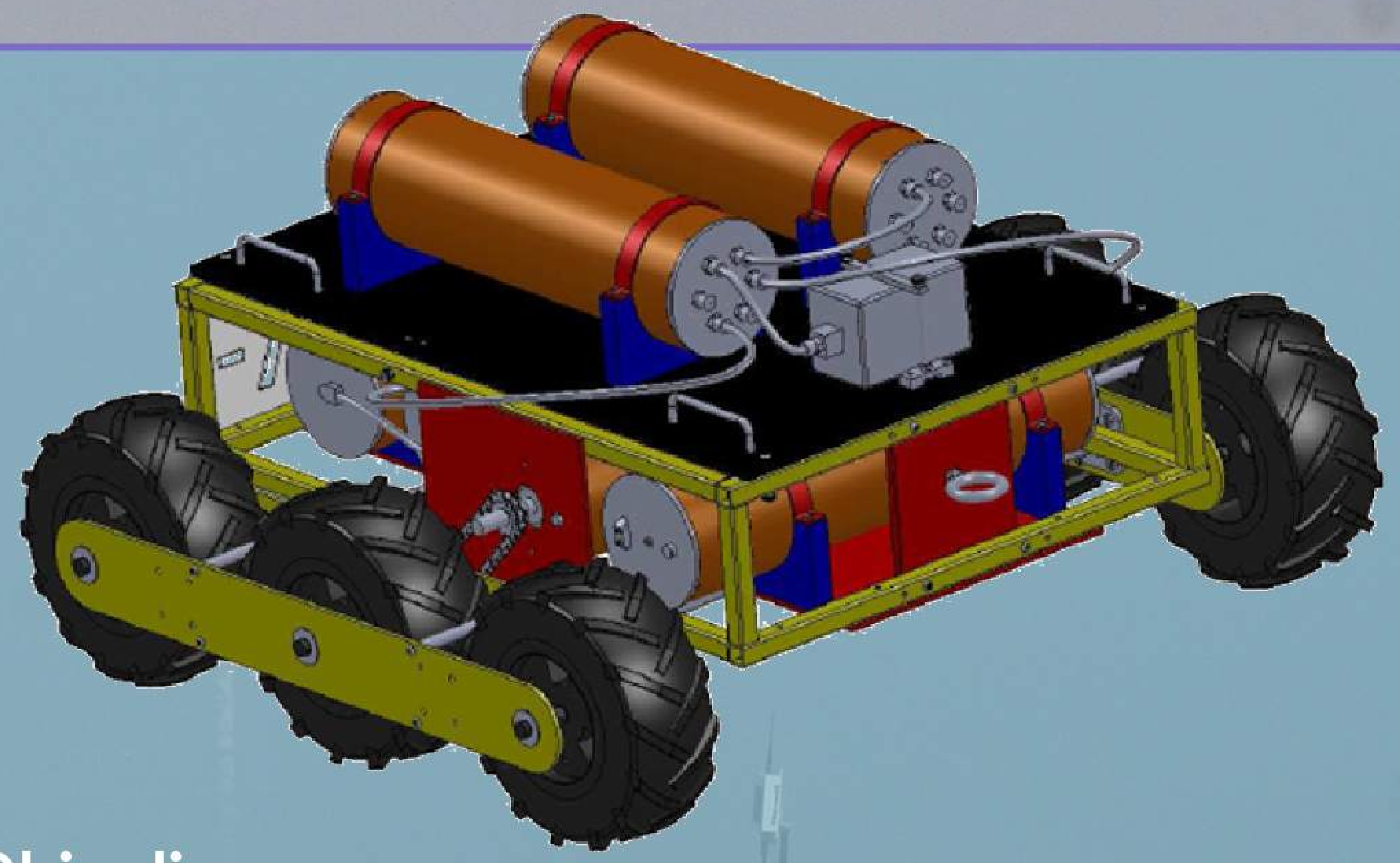
The surf-zone is a crucial region to study due to the amount of human interaction with the water. Although parts of the surf-zone are accessible from land, some of it is in water that is too deep to stand in and too shallow for most boats (2m depth). Along with the turbulence of wind and waves, it can be a challenging, if not impossible, to work in during inclement weather. Due to the importance of this region on health and recreation, a method of monitoring and sampling had to be created. During the summer of 2009 L'MAR (Lake Michigan Amphibious Robot), a bottom crawling robot, was designed to traverse from land into the water [1]. In the summer of 2010 L'MAR underwent many changes from the lessons learned over the previous year to become a reliable platform for scientific research [2]. In 2011 the goal of adding autonomous navigation was undertaken.



Electronic Signal Diagram

LMAR Specifications:

- Embedded Controller is National Instruments CompactRIO with 400Mhz PowerPC, 64MB RAM, and FPGA backplane for module interfacing.
- Software written in LabView
- Communications: 900 MHz Radio Ethernet Bridge
- Navigation: GPS
- IMU Sensors: 3-Axis Accelerometer & Gyroscope; Electronic Compass.
- Pressure & Water Temp. Sensors
- Optical Bench Plate Top Accommodates a Wide Variety of Experimental Payloads
- Stout & Stable to Resist Waves
- Base Dimensions: 1.07 m (42") X 1.10 m (43.5") X .393 m (15.5")
- Ground Clearance: 14 cm (5.5")
- Depth 1.5 m (5') set by radio mast
- Dry weight~127 kgf (280 lb), Displacement ~ 45.3kgf (100 lb)
- Power NiMH Batteries
- Propulsion: 2 Brushless DC Motors, one drives three wheels on each side



Objective:

To design and implement a basic autonomous navigation system on a real-time embedded system that will guide itself to a user defined waypoint.

Summary:

There are many ways of building an autonomous system, many techniques evaluated for use included dead-reckoning and Kalman filters but for the scope of this project a different route was taken utilizing PID and feedback loops for an automated heading control system. Additionally to simplify the problem scope some assumptions are made about the environment. Such as ignoring the curvature of the earth as our distances are small and ignoring the problem of obstacle avoidance for right now.

Movement between waypoints will require information about the vehicles current position and heading, for this a GPS, IMU, and some basic trigonometric principles to calculate the desired heading are used. Then the desired heading information is passed to a control loop that maintains the robots movement in the direction of that waypoint [Fig. 1]. These steps repeat on the embedded controller until the goal is reached or human intervention occurs.

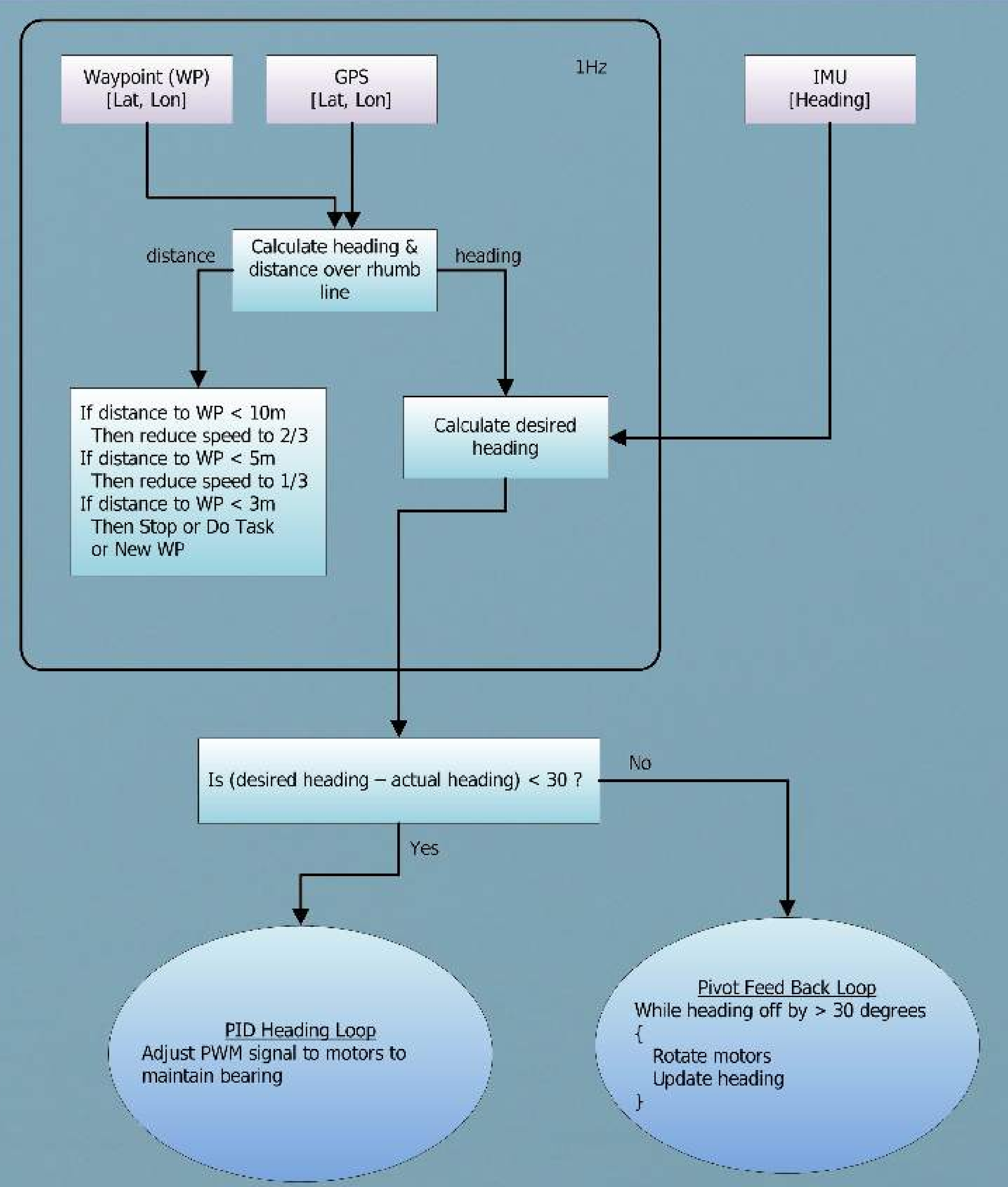


Figure 1. Waypoint Navigation Software Diagram

Conclusions:

The software is still being implemented , PID tuning will be the next challenge. Testing is planned for early this summer.

Looking Forward:

Implementing or integrating a dead-reckoning system may be worth it in the long run as odometry is useless in sandy terrain and the additional information could offset GPS inaccuracies. Additionally sensors for terrain sensing and obstacle avoidance could improve the autonomy of LMAR even further.

Acknowledgements:

Greg Barske, Randy Metzger, Bailey Zhao, Abishek Mehrotra, Mark Matson, Trevin Erdman, Brian Ardaugh, John Ringstad, Matthew Peterson

And the Office of Undergraduate Research at UWM, for their support throughout this project

References:

[1] Consi, T.R.; Ardaugh, B.R.; Erdmann, T.R.; Matsen, M.; Peterson, M.; Ringstad, J.; Vechart, A.; Verink, C.; , "An amphibious robot for surf zone science and environmental monitoring," OCEANS 2009, MTS/IEEE Biloxi - Marine Technology for Our Future: Global and Local Challenges , vol., no., pp.1-7, 26-29 Oct. 2009

[2] Consi, T.R.; Bingham, S.; Chepp, J.; Erdmann, T.R.; Mehrotra, A.; Ringstad, J.; Zhao, B.; , "Amphibious robots as rapidly deployable near-shore observatories," OCEANS 2010 , vol., no., pp.1-6, 20-23 Sept. 2010