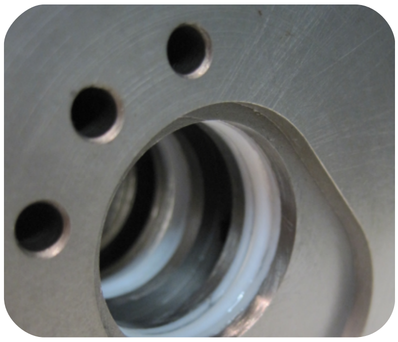
michael kokko
engineering & design portfolio

battlefield extraction-assist robot

what?	hydraulic, humanoid mobile robot
why?	military logistics and injured soldier extraction
when?	2007 - 2009

leg segments combine custom rotary hydraulic actuators (hip and knee) with electric-drive tracks

When I joined Vecna Technologies in August 2007 a small team had just begun designing articulated leg modules for the Battlefield Extraction-Assist Robot (BEAR). My first contribution was a high pressure, multi-channel, rotary hydraulic sealing design which remains an integral component of the legs. Throughout the following two years I led engineering support for the lower body -- designing, fabricating, and testing a number of substantial, multi-disciplinary hardware improvements. The scope of these initiatives spanned the mechanical, electrical, and hydraulic domains requiring unconventional, customized solutions to interface with existing hardware and meet restrictive loading and packaging requirements.



hydraulic channels integrated into structural components and rotary joints provide compact, efficient fluid routing

selected design solutions

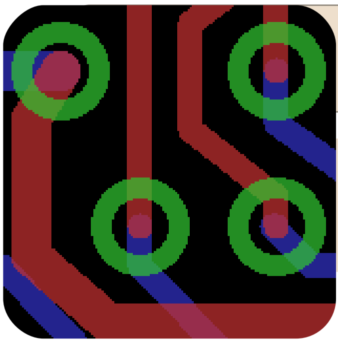
- routed hydraulic fluid through rotary joints
- redesigned leg hydraulic rotary actuator
- developed leg sensor monitoring electronics
- packaged numerous valving schemes
- improved leg track drive gearing efficiency
- integrated retrofit encoders into arm joints
- manufactured simple, robust metal treads
- diagnosed and repaired various fluid leaks
- prototyped novel leg actuator concepts

creative, out-of-the-box problem solving is a key element of maintaining and improving legacy hardware bound by stringent spatial and functional requirements

low-cost metal treads designed for ease of manufacture, assembly, and replacement

press & media

Vecna Robotics:	http://www.vecnarobotics.com/solutions/bear
Vecna BEAR Video 1:	http://tinyurl.com/mak-bear-episode1
Vecna BEAR Video 2:	http://tinyurl.com/mak-bear-episode2
IEEE Spectrum Blog:	http://tinyurl.com/mak-bear-ieeeblog
National Defense Magazine:	http://tinyurl.com/mak-bear-ndmag
Military Channel Footage:	http://tinyurl.com/mak-bear-milchan

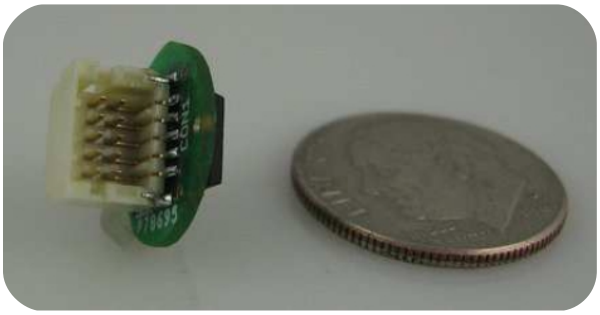


custom magnetic encoders

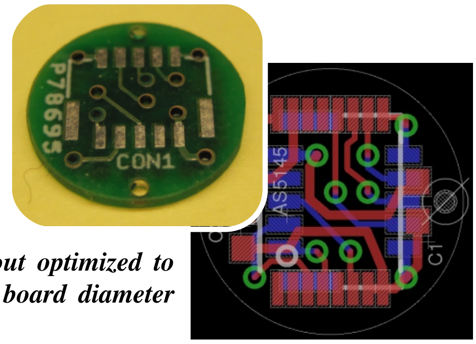
what?	miniature magnetic encoder
why?	angular shaft feedback in tight spaces
when?	2009

At Vecna Technologies I designed a variety of custom solutions for delivering precise angular feedback to robotic systems based on Austria Microsystems' line of magnetic encoder integrated circuits. This work involved developing a thorough knowledge of the sensors and the underlying technology, as well as characterizing their performance in a variety of mechanical configurations. After evaluating many similar commercially-available sensor packages, I designed a custom encoder Printed Circuit Board (PCB) which provides access to shaft position in three formats (quadrature, PWM, and direct serial) and can be configured to interface with either 3.3- or 5-volt controllers.

Vecna Robotics now designs these magnetic encoders into most new systems because of their small size and ability to deliver both absolute and incremental output. I have personally designed both new and retrofit mechanical interfaces to employ these sensors in a variety of applications.



small form factor magnetic encoder packages neatly in systems with tight spatial constraints

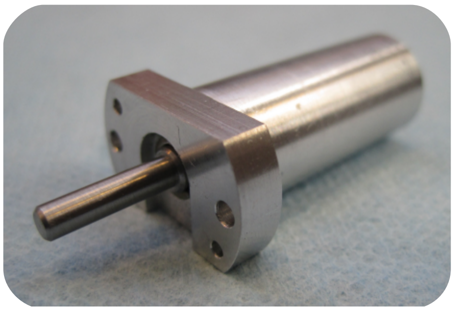


trace layout optimized to minimize board diameter

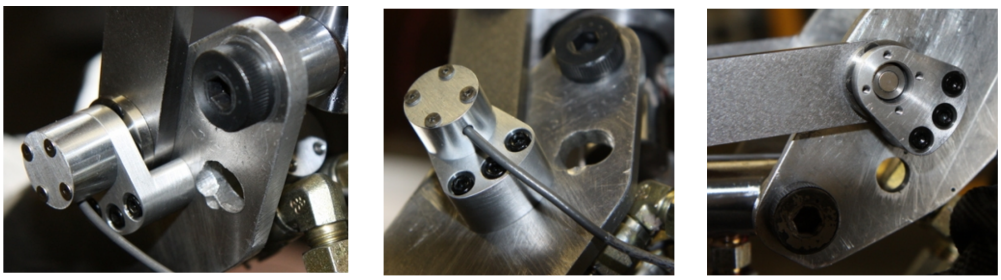
custom encoder adaptations

- monitoring BEAR leg positions
- commutating BEAR leg track motor
- sensing four BEAR arm joint angles
- controlling a two DOF hydraulic manipulator
- general use as a miniature shaft encoder

incremental output encoder circuitry packaged for mounting to and commutating a brushless dc motor



convenient shaft encoder housing packages circuit board for quick integration with general purpose applications



custom encoder mounts and shafting designed to retrofit sensors on bear robot arm joints

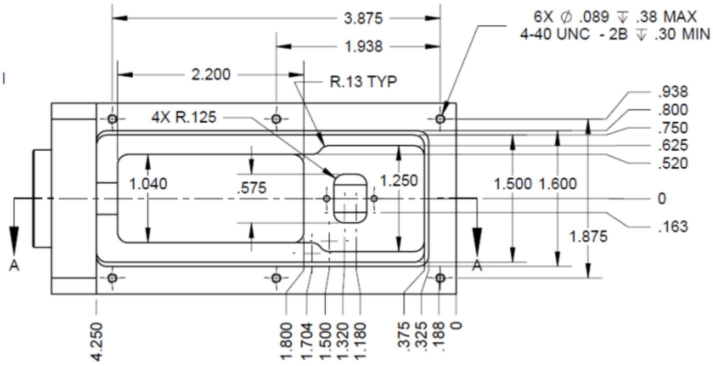
rfid timing wand

what?	hand-held rfid reader/writer wands
why?	timing runners in a 5K road race
when?	fall 2009

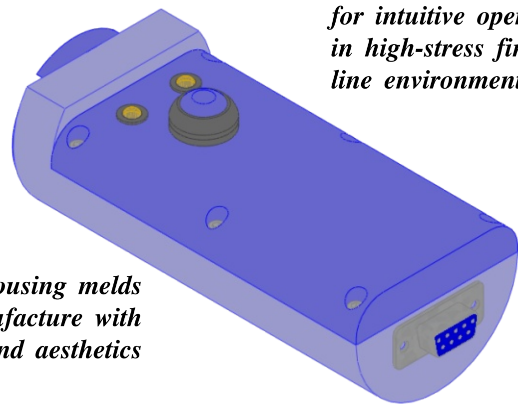
a single thumb-operated button controls the palm-sized timing wand device

As part of its "Healthy Communities" mission, Vecna Technologies sponsors and organizes the annual College Park Cares 5K road race near its corporate headquarters in Prince George's County, MD. In 2009 I designed and implemented a novel race timing system for the race. The system was centered around several custom, hand-held RFID reader/writer wands used by a team of volunteers to encode accurate finish times on RFID-tagged index cards for each runner. While not an optimal method of timing larger (500+ runner) races, each of our five wands performed as planned during the 2009 race, eliminating the need for an expensive and complex shoe-based chip timing system. This system required no more than wearing visible bibs from runners and left the timing team with a permanent physical record of race results.

volunteers equipped with wands record runners' times on rfid-tagged index cards



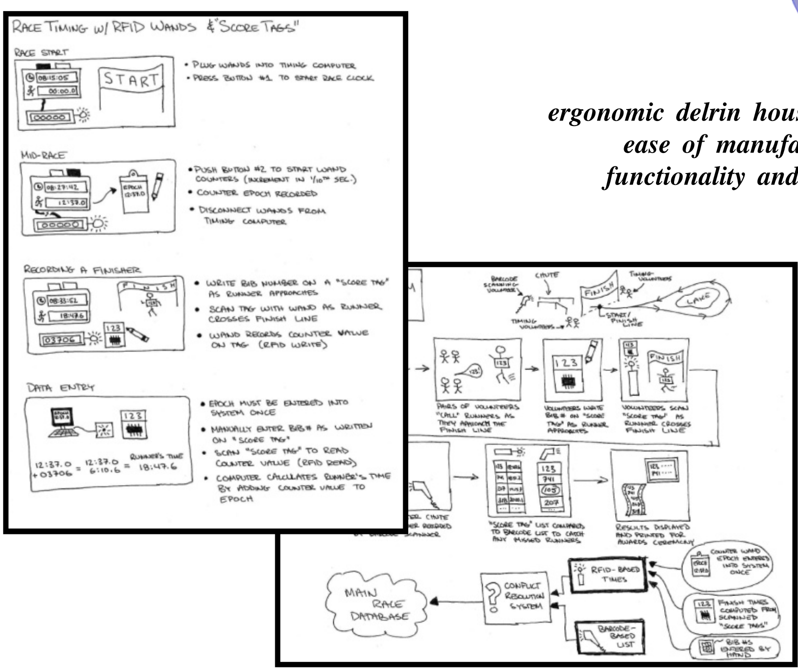
wand designed for quick-turnaround, low-volume, in-house production on a 3-axis cnc milling machine



simple user interface for intuitive operation in high-stress finish line environment

ergonomic delrin housing melds ease of manufacture with functionality and aesthetics

d-sub jack provides access to programming, debug, tag reading, and clock synchronization features



complex registration and timing system concept simplified using easy-to-understand sketches and flow diagrams

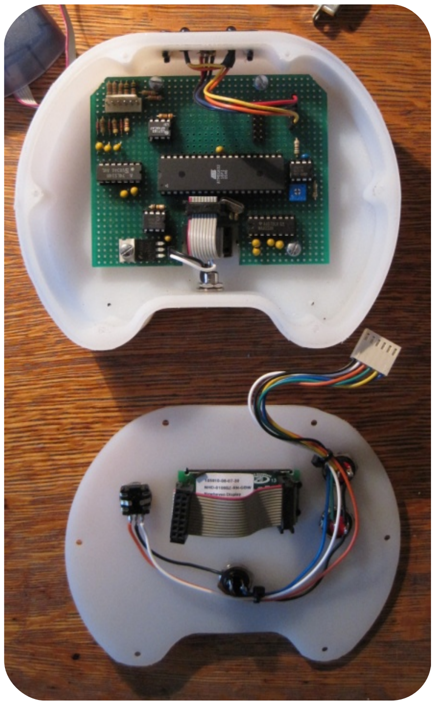
simple tv remote control

what? intuitive universal remote control with display
why? reducing tv complexity for seniors
when? fall 2009

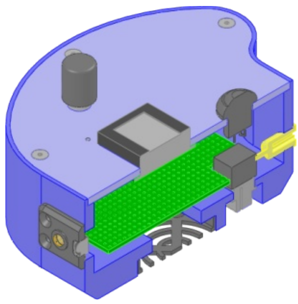
Watching television has become a remarkably complex task. In many households viewers juggle multiple remotes to control televisions, set-top boxes, DVD players, and integrated media centers. Modern entertainment systems are loaded with advanced features and one-time settings that appeal to certain market segments but remain untouched by most consumers during routine operation.

After suffering a mild stroke my 92-year-old grandmother faced new challenges in many of her daily activities, especially those involving sequential procedures. Realizing that her television frustrations stemmed mainly from an options overload, I designed an built this remote which gives her direct access to the small subset of TV and cable box features she actually uses.

The only controls on the unit are an "all power" button, a volume knob, and buttons for navigating up and down through a list of preprogrammed channels. Both the name and number of the current channel are shown on a high-contrast back-lit display. Family members can easily add or remove channels using a laptop via an RS232 interface. The device's large form factor and integrated grips make it easy to hold and greatly reduce its chances of being misplaced.

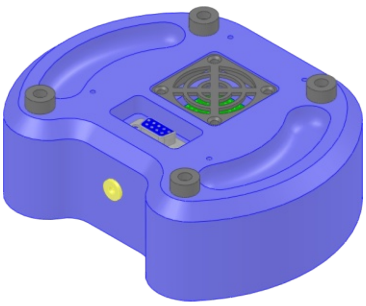


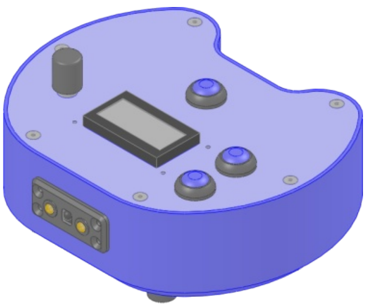
prototype electronics fully contained within the remote



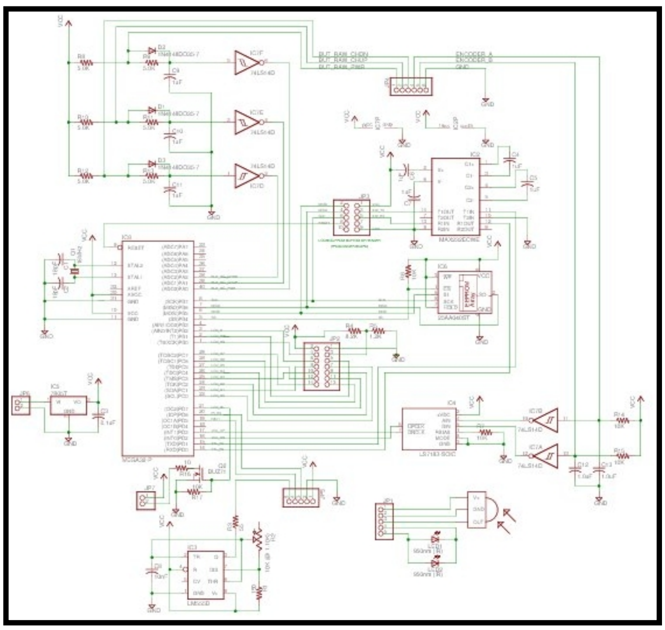
packaging designed for ergonomic operation and ease of manufacture using available processes

simple, intuitive controls located on top surface of remote with programming and debug interface below

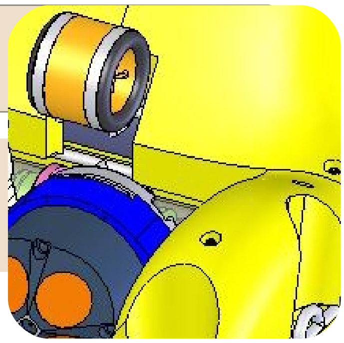




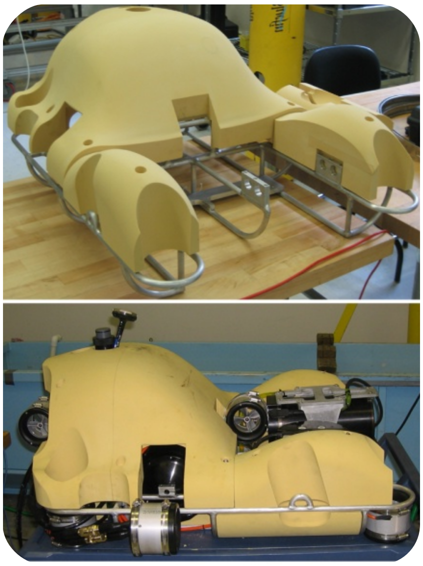
electronics provide flexible operation with infrared transmit and receive capabilities



autonomous underwater vehicle



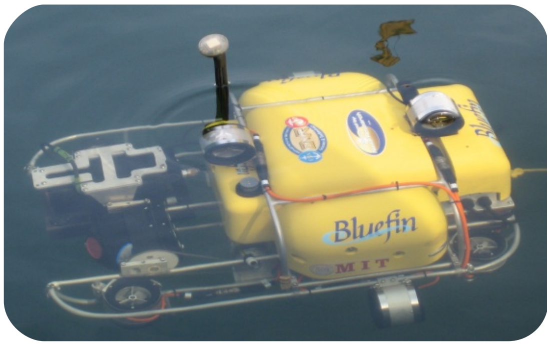
what?	hovering underwater robot
why?	improved mine detection performance
when?	fall 2005 - spring 2006



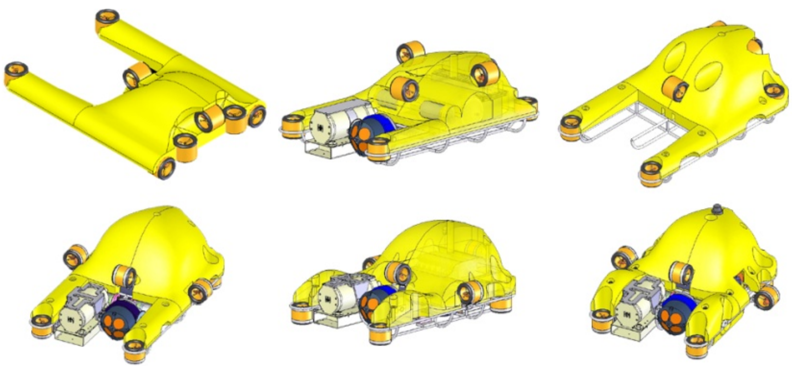
new foam design and actuator layout improve efficiency and vehicle dynamics

The Hovering Autonomous Underwater Vehicle (HAUV) is a joint venture between Bluefin Robotics and MIT's underwater robotics laboratories focused on autonomously inspecting ship hulls for mines. I joined the project as a graduate student in 2005 with the mission of redesigning the vehicle's packaging (buoyant foam and aluminum frame) to improve efficiency and dynamics along its two main axes of travel. This iterative, SolidWorks-based design process resulted in a second, more efficient and controllable vehicle.

As an incremental hardware upgrade, the new "HAUV1B" design was required to reuse its predecessor's suite of actuators, sensors, and control hardware. After reconfiguring internal components and positioning thrusters closer to the vehicle's center of mass, I designed a streamlined foam shell to give the vehicle a slight positive buoyancy and neutral pitch. I worked with local shops to fabricate the new components and assisted with assembly and control tuning prior to graduation. My work on this project was funded under US Office of Naval Research grant #N00014-06-1-0043 and monitored by Dr. T.F. Swean.

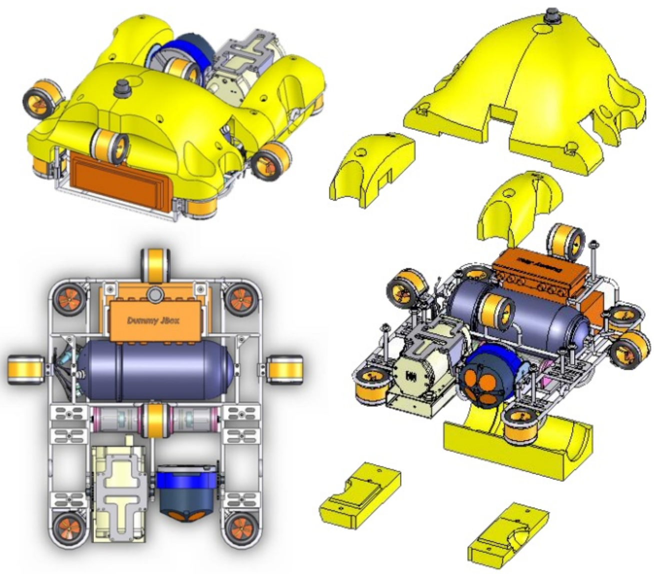


initial prototype affectionately nicknamed "spongebob" for its bulky foam and awkward dynamics

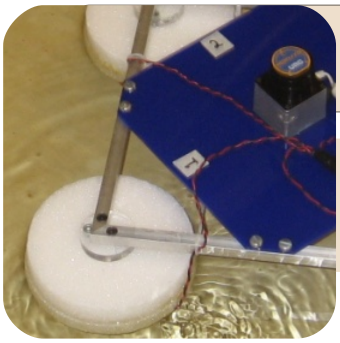


final vehicle design developed through iterative concept modeling and analysis

old (left) and new (right) vehicles

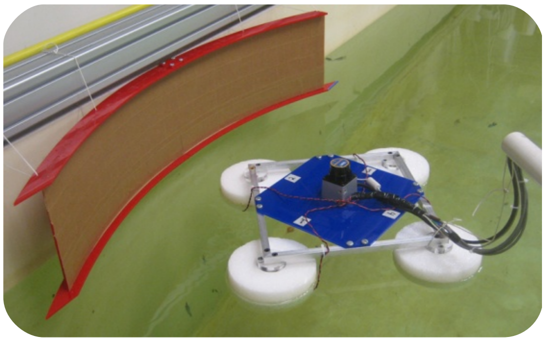


new vehicle comprises existing sensors, actuators, and control hardware housed in a redesigned frame and foam shell



raft robot

what?	floating, 3-degree-of-freedom robot
why?	testing navigation algorithms
when?	spring 2007

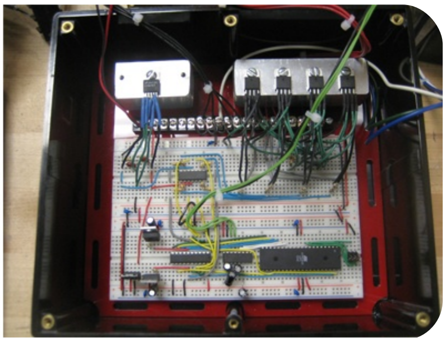


raft robot emulates acoustic sensors for validation of novel control algorithms

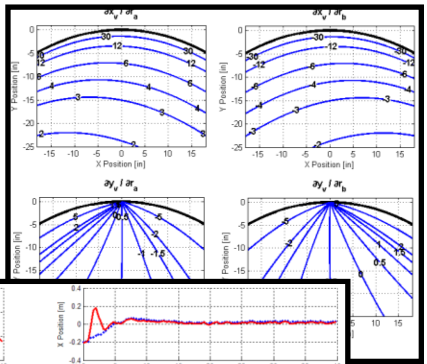
I love to build things, so when hardware scheduling conflicts stalled the progress of my graduate research I was excited to propose, design, and fabricate a lab-scale system that enabled unlimited testing. My thesis focused on developing novel Autonomous Underwater Vehicles (AUV) navigation algorithms so I simulated the important sensors, actuators, and system dynamics with a robust, inexpensive raft platform. Cost, performance, and speed of manufacture were all major considerations in this design which I took from concept to reality in a single semester.

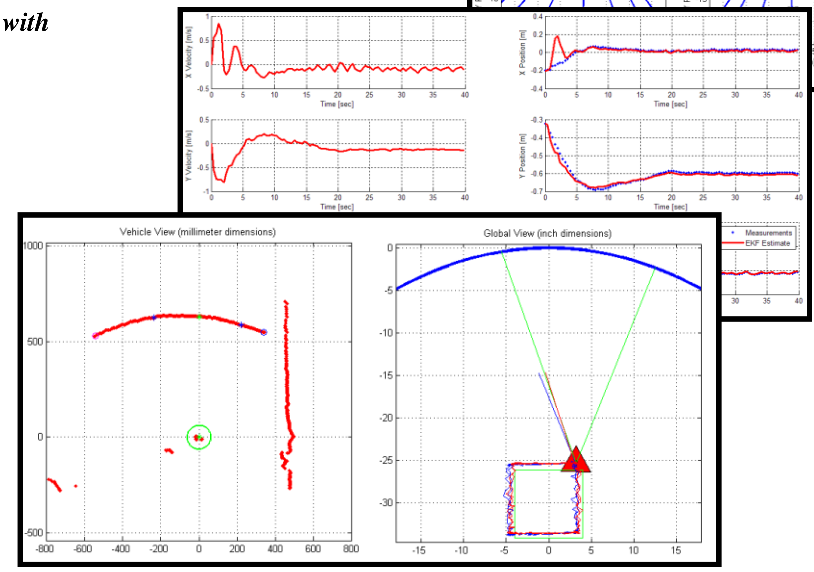
The raft robot mimicked our AUV's acoustic ranging sensor with a small laser scanner and employed four potted DC motors as surrogate thrusters. I implemented the control algorithm in C++ on a Mac Mini which interfaced with both the laser and a custom, microcontroller-based motor amplifier. The control system successfully integrated noisy sensor data with dynamic state estimates using a real time Extended Kalman Filter. This, in effect, enabled the raft to maneuver accurately in relation to a target with known geometry.

Upon completing this research I published the results in my masters thesis and presented a paper at the 2007 Field and Service Robotics Conference in Chamonix, France. My work on this project was funded under US Office of Naval Research grant #N00014-06-1-0043 and monitored by Dr. T.F. Swean.



custom microcontroller-based analog motor amplifier and control electronics interface with host pc via an ascii serial interface





low-cost thrusters constructed from potted dc motors

sensor, kalman filter, and control system simulation and analysis performed with custom matlab scripts

michael kokko
[mechanical] engineer
mit 2007
rpi 2005

mike.kokko@gmail.com
603.801.0055