Todd Berk

Vessel Name: WASP

Type: SWATH (Small Waterplane Area Twin Hull)

Knowledge

- SWATH incorporates submerged pontoons. This increases the stability of the vessel because of the decreased water plane area. A small water plane area decreases wave excitations and increases stability.
- The ideal amount of free board the SWATH should have from previous experiments is 12".
- The damping coefficients and stiffness need to be very low in the system relative to the mass,which is contradictory to the normal. This is because these values correspond to wave tracking, which needs to be kept to a minimum.

Initial State of Vessel

The SWATH is not currently functional. There are two sets of Atmel controller boards, neither of which completely function. The wireless modem, power block, and robotEQ are mounted to a fabricated 1.5ft x 3ft wooden chasses. The rack of controller boards are in a separate cardboard box.

The following have been tested and function properly:

- Compass Board - PNI TCM3
- Compass Atmel Controller & LCD
- port thruster - Minn Kota Riptide 55
- Starboard thruster - Minn Kota Riptide 55
- Garmin GPS reciever - Garmin GPS18 PC
    - ~~Was unable to recieve any response over the serial, or connect to it using garmin software tools.~~
- RobotEQ 1500
- RoboEQ 3500
    - Paul Mahacek believes that this is a buggy board, but was unable to find anything "buggy"
    - There is a program called ROBORUN which allows you to run and test the motors, view power consumption, configure the controller, and update its firmware.
    - Settings in Roborun
        - Controller Input: RS232 w/ watchdog
        - Motor Control Mode: A and B Speed Separate
        - Channel 1 & 2: linear
        - Input Modes: no action
        - amp limit : 58
        - left/right adjust: 0%

        - acceleration: 682
- Multibeam
    - There was a short found in the cable
- Maxstream Xtend Wireless serial modem

The following do not currently function:

-

The following components have not yet been tested:

- ~~Atmel Motor Controller board~~
- ~~Atmel Communication Controller board~~

To Do:

Electronics:

- GPS positioning
    - Recieve and Parse NMEA data
    - ~~Suggest more accurate ETEK EB85A 32 Channel reciever~~
        - ~~2.4-3.3m accuracy compared to 15m of Garmin~~
        - ~~nmea standard~~
        - ~~well documented~~
        - ~~$99 from http://www.sparkfun.com/~~
- Compass & pitch, yaw, roll sensor
    - Try to reuse atmel compass board
        - need to obtain communcation protocol
- Remote manual control
    - ~~Joystick to serial solution can be adapted from earlier project of mine~~
- Controller
    - Use single microchip pic microcontroller
    - set up on protoboard
        - Create Circuit Diagram
        - Make robust Printed Circuit Board
            - extra pin headers for expansion
            - make sure ICD cable is short
            - double check RS232 level convertors
    - needs to be interfaced with:
        - Wireless modem

        - GPS
        - Compass board
        - RobotEQ motor controller
- PID autonomous Control
    - make quick system approximation in matlab simulink / mathematical approximation of transfer function
    - approximate Kp,Kd,Ki Gains
    - incorporate PID loop into microcontroller
    - log and analyze error
        - adjust constants
- Connect Multi-Beam
    - ~~requires own laptop~~
    - learn how to calibrate
    - interface multi-beam with gps
- SWATH BASE Program
    - ~~add refresh button to serial port list~~
- Case for electronics
    - ~~Pelican 1550: Interior Dimensions: 18.43" x 14.00" x 7.62"~~

Mechanical:

- Mount MultiBeam on swath
    - needs to be designed and machined mounts
- ~~Get otterbox for laptop~~
    - ~~connect to multibeam using watertight connectors~~
    - ~~power laptop from 12v. power supply?~~
    - Will use wireless networking instead
- ~~Disassemble and Clean thrusters~~
- Mount electronics inside otter box
    - ~~the box is already supplied~~
    - use watertight connectors for power and serial connector
- mount thrusters and batteries
- Test SWATH in tank

Single Microcontroller Board Design

- Advantages
    - cheap (each board could total less than $75)
    - compact

        - more reliable
        - less power consumption
        - Fast change outs (swap out/in)
        - quicker development (only have to program / interface / troubleshoot single board)
- Disadvantages
        - there is prior solutions existing with electronics to utilize
        - Complications with interrupts

- Requirements
        - minimum 4 serial connections
        - I2C connection Pins B6 & B7

Supplies Needed

~~ETEK EB85A 32 Channel Reciever - $99~~
~~http://www.sparkfun.com/commerce/product_info.php?products_id=8266#~~ (optional)
~~Prototyping board - already have~~
~~PIC 18F4520 MCU - Have one on hand, just order more free samples~~
~~USB Joystick - borrow from SCU~~
~~serial to usb adapter~~
~~RS232 level converters - MAX232N - There should be some lying around somewhere - there is~~
~~Misc. electronics components such as caps, resistory, DIP sockets, DB connectors... - should by laying around here~~
~~7805 vregs - lying around~~
~~Xtend modem - hopefully Paul can find this~~

Initial BASE station process flow chart

- Auto Mode
        - Send list of destination coordinates
        - Send list of velocities
        - send home coordinates
- Manual Mode (joystick)
        - read joystick
        - send duty cycle percentages for starboard / port motor
        - confirm receipt / error
- Recieve data string boat
        - Store in hashtable (associative array)

SWATH Process Flow Chart

All properties of swath should be stored in global prototype named swath and accessible such as swath.gps.long, swath.gps.lat,swath.compass.heading

- Receive Desired GPS coordinates from base (via interrupt)
    - Store Values Globally
    - disable interrupt flag during serial com
    - receive data
        - Home coordinates
        - Destination(s) coordinates
        - Velocity(s)
        - Gain values
        - Manual Control Override
    - return confirmation
    - enable interrupts
- ~~Retrieve current GPS Data(via interrupt?)~~ - DONE
    - Store values globally
        - gps data is stored in global struct variable GPS
            - i.e. get current latitude: GPS.now.lat
    - disable interrupt flag during serial com
    - recieve data
    - enable interrupts
    - parse data
- Retrieve Compass Heading
    - Store Value Globally
    - disable interrupt flag during serial com
    - send request
    - receive request
    - enable interrupts
    - parse data
- Return current properties to base station
    - disable interrupt flag during serial com
    - send serial data to base
        - Destination Coordinates
        - Current heading
        - Current Velocity
    - confirm receipt of data
    - enable interrupts
- Calculate Destination Distance
    - Store value globally
- Check if Destination Distance below threshhold (i.e. close enough to destination)

        - Check IF another destination coordinate exists
            - TRUE
                - Set next coordinate as destination
                - Re-calculate destination distance
            - FALSE
                - Set next Destination to Home coordinates
                - re-calculate destination distance
- Calculate Required Destination Heading
    - Store value globally
- Heading PID Control Loop
    - Determine Heading Error
    - Multiply by gain (K values)
    - adjust proportion of port / starboard thrusters
- Velocity PID control loop
    - Determine Velocity Error
    - multiply by K vals
    - adjust duty cycle of thrusters

Using Roboteq's built in PID control for Speed and Position

The Roboteq controllers already contain PID inputs for speed and position, and while they are intended for say a potentiometer on a shaft or shaft rpm feedback, it may be simply a matter of tricking them into performing Heading and Velocity control. The idea is to use digital to analog converters to convert the compass signal to a 0-5v denoting proportional 0-360 degrees.

-Abandoned - this was found unfeasible because of the requirements to have both speed and position control. The roboteq only has to ability to implement PID of either type on a single motor. You cannot do velocity and position with both motors.

Setting up heading / "position" control

- The roboteq takes in an analog signal of 0-5 volts

Big Picture BASE station

- Polls internet control center for GPS coordinates & velocities
- Relays to swath
- retains manual control & manual coordinate entry

Big Picture Internet Control Center

- Handle through Joomla! Content Management System Component

        - MVC - Model View Controller architecture for quick development
        - Contains user management and database functions already
- Interface to Google Maps API
        - great for plotting points / creating line vectors / tracking map clicks
        - easy to use
        - Can plot live location of SWATH
- Interface to Iphone

Source Code - PIC Controller and Base Station

- The source code for both the projects is backed up on the MBARI project server
- Location: \\Tornado\ProjectLibrary\Engr_Intern_Projs\Swath wasp\Berk 2007
- All the software needed has been placed into this folder. Install CCS-C, a great commercial compiler to compile the code - and you may also use a bootloader to update it, but the best solution I found was using the CCS ICD-U40 In Circuit Debugger and Programmer available from http://www.ccsinfo.com/ .
- To use code: Install the CCS software from the ProjectLibrary folder, and open the main.pjt
- The base station program was coded in Microsoft Visual C# express 2005 - freely available from microsoft
        - A great resource for programming C#, which is essentially a higher level of C++ is listed in the references.

Manual Control

The swath utilizes a microsoft xbox 360 wireless controller, xbox wireless usb reciever, and pc for manual control.

- A program called SWATH BASE was written to take input from the xbox controller and output to the swath
        - Requirements & Steps To Modify swathbase program
            - Download Microsoft Visual C# Express (free)
            - Download Microsoft XNA framework (Free)
            - To Modify program open and edit SwathBase.proj
- Steps to Manually Control SWATH
        - connect wirelless link to serial port
        - connect microsoft XBOX usb reciever to computer
        - open SWATH BASE
        - Choose correct serial port and connect
        - Click on the "manual control" tab
        - click "enable"

        - press center "X" button on xbox controller
- Operation in Manual Mode
    - There are two analog joystick on the controller. The current implementation employs a tank style driving style, where the left analog stick controls the port thruster, and the right analog joystick controls the starboard thruster.

Communication Protocol

Two tiered levels for parsing strings of data.

Parameter Format:

$param1:value1$param2:value2$param3:value3$Param4:value4

Parsing:

- The parsing can be simplified by two respective split() statements or equivalent
    - the first split is the parameter delimiter ($)
    - the first split is the value delimiter (:)

Advantages:

- allows strings to be humanly understandable without interpretation
- Clears up ambiguity of ordered comma separated strings

Drawbacks:

- Additional Overhead of Parameter labels will slow communication ~~though at higher baud rates this could be considered negligible.~~
    - Care should be taken to use short 3 or 4 character abbreviations in parameter names

Operation of BasicX boards / dataturbine / matlab - simulink controls

On "shore" pc which links to boat

- Start dataturbine via shortcut on desktop
- a console window should appear with information such as current IP address and port number
- note the ip address and port number

On Controller PC with matlab / simulink and dataturbine installed

- Open matlab and change working directory to directory with control files
- Open dt_init.m and modify the IP address in two places to the shore ip address, as well as port number
- run dt_init TWICE in matlab console or until the function starts
- plug in joystick to USB port
- open simple_joystick.mdl in simulink
- press play on model
- move joystick to manually control boat.

Optional steps to enable Telemetry / Feedback

- In matlab console window type: rbnb_getOgi1(sink)

Roboteq 3500 Motor Controller

The roboteq 3500 motor controller is a convenient powerful board that can handle 2 channels up to 60 amps each.

- takes strings in form of !mnn where m is a, A, b or B and nn is a hex value representation of 0 to 127 (0 to 100%)
- Operation is set to A and B channel mixed where A controls forward / reverse, and B controls turning
    - In this mode, A and B cannot both be set to 100%, this will cause no turning

Initial Testing of Imagenex 837 "Delta T" Multibeam

- The multibeam requires 22-50 volts

- It connects via a ethernet jack and has IP of 192.168.0.2
- DeltaT.exe recieves and displays the data
- A network traffic meter was used to measure the data rate of the instrument. The data rate is constant for each setting. The range between the different settings was 55Kbps to 144Kbps. This is significant because it will allow the instrument to be used over a wireless access point or network extender.

notes

- ~~The DeltaT program is very buggy and takes a very long time to connect~~
    - this could be an issue with the laptop, try another computer if possible

- This issue was caused by a short in the cable, to troubleshoot connection issues, make sure to check all the pins for connectivity.
- The cable was "potted" by Jim in the machine shop and should be very durable

Design of Multibeam Mounting Bracket

- Internal diameter of pontoons is 14.125 inches.
- External diameter of pontoons is 15 inches
- Material is 3/4" UHMW
- Process of manufacture was waterjet cut

Battery Bags

The batteries are contained within two waterproof Watershed brand bags. They are certified to 150 submergible feet depth. Two 12v sealed batteries wired in parallel are put into the larger bag, while two smaller size 12v batteries fit in the smaller bag.

Waterproof Connectors for Battery Bags

The waterproof connectors for the battery bags are from Impulse Enterprises. These connectors were used because they are cheaper than seacon and subconn connectors.

The order consisted of:

- XSK-2(6/8)-BCL: $71.50
    - Bulkhead connector with a #6 and #8 receptacles
- RMK-2-(6/8)-FS + K-FLS-P on 14ft 8/2 SO: $178.00
    - Pigtail connector with 14ft cable and #8 and #6 conductors in the 14' cable
- XSK-4-BCL: $64.00
    - Bulkhead connector with 3#18 and 1#16 receptacles
- RMK-4-FS + K-FLS-P on 14 ft 18/4 SO: $60.00
    - Pigtail connector with 3#18 and 1#18 pins, and 4#16 conductors in the 14' cable

Contact information for Impulse Enterprises

Stanley Logan IMPULSE ENTERPRISE

Sales Engineer 8254 RONSON ROAD

800 327-0971 SAN DIEGO, CA 92129

P. 858 565-7050 www.impulse-ent.com

F. 858 565-1649 stanl@impulse-ent.com

Cleaning the Electric Thrusters

The electric thrusters should occasionally be pulled apart and checked for unusual wear, and cleaned, and bearings packed with grease. The motors should not be filled with any oil, as this will render then unusable until the oil is drained and cleaned out.

- Remove propellers by removing shaft retaining nuts / thumbscrews
- remove shaft pin and place in safe spot
- remove 2 metric bolts
- pull housings apart, note which side up up / down
- wipe magnets and internal housing down with cleaning solution
- wire brush contacts and commutator / brushes
- check o-rings
- reassemble

Assembly of the Boat

Assembling the boat and getting it ready to deploy is no small task.

Notes on assembly

- The voltage regulator on the electronics power board for 5V power will not provide enough current to power the wireless router
    - A temporary solution was made from a removed cigarette lighter plot off of the GPS
- A better electronics power cable needs to be made
- The bolts for the motor mounts on the starboard side are 2" long instead of 1.5" long, therefore very difficult to screw in.
- It is quite difficult to hoist the boat with the crane due to lack of mounting points
    - need to consider eye bolts in 4 corners?
- Hull covers will pinch fingers very easily and theres no real way to mount, need to put handles in and use screws to secure them.

First Tank Test

First Run:

- Needed Watchdog timer on microcontroller
    - Solution - One was implemented inside micro-controller loop
- Boat initially had too much flotation and too much freeboard
    - the flotation rings were removed and variable floats were deflated resulting in about 18"

of freeboard
    - Due to the batteries being mounted up high, the boat had a very topheavy C.G., becoming quite unstable.
- Boat was extremely overpowered

- Turning during reverse was backwards! LOL
- Boat ran for about 30 minutes
- The multibeam over wireless link worked well other than a few software crashes while trying to switch it to 120* wide. The sides of the tank and bottom could easily be spotted, though there was lots of noise as would be expected in a tank.

Second Run:

- A watchdog timer had been implemented
- A bug concerning spaces being contained within the microcontrollers string then being inserted into a hasharray was smashed
- A power scaling feature was implemented into the base software to allow power applied to motors to be limited easily during manual control.
- The reverse turning directions were flip-flopped - backing up is now more intuitive
- Speed Over Ground is being reported out of range while GPS status is V or bad, implement reality check
- Compass and Current gauges are working well
- All 4 variable bouyancy balls were inflated, 2 more were added to each side, and 3 inflatable rings on each side stabilized the boat until the batteries can be remounted.
- The boat was driven in nice circles about 2.5 hours without hiccups - SUCCESS!

Second Tank Test

- The test went very well, without hiccups or failures
- The heading control was tested and worked
    - The Integral Gain is too strong even with a value of 1, so it needs to be scaled further than the PD gains - done
    - The Integral Gain was also not being cleared when set to zero, and the prior value was retained when it was turned back on - this was fixed.
- Drove about 3 hours
- There is significant interference on the multibeam from the vibration of the motors

Navigation

A flat earth approximation will be used and allow for a constant heading, helping to stabilize the control system and save energy. The error for short distances is quite small

- Error: The fractional errors are of order (distance/R)^2. R is the Radius of the earth, equaling 6366.71meters. Assuming waypoints are no longer than 20km away, error is 1.9m at 20 kilometers. This is acceptable.
-

Heading Control

- Heading control has been implemented using PID loops, and works well
- The gains are adjustable real time to help with tuning
- a graph displays the desired vs actual heading of the vessel to show the response

First Harbor Test - 8-9-07

- The boat was operated for about 5 hours
- There were not hiccups at all - everything went as planned and hoped for
- Observations:
    - The bow sinks during full forward - this could be a ballasting issue - need more weight in back
    - The voltages on the motor batteries after a few hours of operation were individually 12.06 and 12.21 volts, and in series were the sum of those
    - The fully charged voltages of the motor batteries were 12.77 and 12.83 volts
    - The boat was quite stable and handled some small waves quite well
    - At the end of the day, the motors were making some terrible noise - Sounded like more motor brushes had broken
- Harbor Test To Do's
    - Log Velocity
    - Log desired velocity
    - Log GPS Timestamp
    - display velocity

References

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