Meeting Inspiration

We should have spare parts of everything for competition in the case that something breaks. Talk to advisers about competition funding, grants? Make sure to pay attention to the details of the pool that the actual competition is at, that way we know what conditions to anticipate when testing next year. How do you get the most out of your testing time at competition? Prequalification, take this into account when planning next year’s sub building. Take fabrication of obstacles into account for testing and in the year plan. Bring a refillable bottle of water to comp. Social media presence – Instagram, facebook, ??, do we have a list of all the parts that were used this year? What should we talk about in the video? What prizes could we potentially win this year?

Competition Inspiration

After competition we should have a big meeting with everyone to pick apart the sub and learn everything we can about the way the current sub works. Then we should have a meeting with just next year’s people to go over this document and brainstorm. 360 camera? Change computer vision method. 2 subs or 1 sub? What are the main constraints we have in terms of mechanical and electrical? \*\*what are the main things that need to be changed about the sub for next year? Needs to weigh less, need to be buoyant without having to add and subtract weights, use the same thrusters, definitely change the computer vision method. We need a plan for competition next year and a list of things to remember. Re Alan:: Monrovia waterjet, pcb way, anodizing – danco, mcmastercarr cad files and any prototyping, grabcad open source uploads of cad files (Arduino mega, etc), finite element analysis – learn how to use it to reduce weight and save money, do not rely on 3d printing for housings – it is great for prototyping and mounting – it is part of the system but should not be a main part of the system, we have ansys simulation (contact information, mention that we are a comp team and we will be sponsored, senior design has it for free the student version only has a limited mesh size), routing hardware – if they say it’s impossible to route cables theyre lying can use solidworks electrical, allied electronics is good for components secondhand components fuses cases resistors relays pots etc (thruster board built entirely from that), never request quotes from xeometry because their stuff tolerances and locations are not accurate and they charge premium, ims metal supply in Sunnyvale for aluminum and metal scraps cheap and any metal you want they have a show room that has like anything you could want, get friendly with blake send an email at the beginning of the semester saying that we might need help with things later on just to let him know, take a machining class and you can use the shop whenever you want, funding paperwork? How do we get asi funding? Make a list of things that we need so that we can ask for them from sponsors!!! What platform should we use for **keeping deadlines** and communicating?

Journals for Better Understanding and Inspiration

Kennesaw State 2017

<http://www.auvsifoundation.org/sites/default/files/RS17_KennesawState_Paper.pdf>

Water jetting reduces weight on the overall sub. They use 8 BlueRobotics T200 Thrusters (each 20lbs of thrust) peak forward thrust of 5.1 Kg\*f at 16 V and a peak reverse thrust of 4.1 Kg\*f at 16 V. 8 electronic speed controllers regulate the thruster speeds receiving instructions from a PixHawk autopilot through pwm. Want all possible degrees of freedom – roll, pitch, yaw. Design the sub as a box first then decide how to waterjet afterward. We want ever so slightly positively buoyant. Make sure waterproof housing is rated for at least 20ft depth. Acrylic is a good material for housing – clear enough for cameras, has little effect on buoyancy, lightweight. Aluminum flanges containing o-rings to waterproof, holes cut in these flanges to contain waterproof connectors with one able to be removed. 6062-T6 aluminum sheet to act as heat sink plus ABS 3d printed parts. Savox servos, 22kg\*cm of force. Hydrophone signals pass through U-Phoria UMC404 4-input usb audio interface for digitization and timestamping. An analysis on the files finds the four loudest frequencies at any give time between (25 - 40) kHz with a Fast Fourier Transform (FFT) at each interval. It records the loudest frequency as the closest pinger and assigns a timestamp. The sub uses the timestamps in conjunction with an equilateral triangle array to determine a heading which is output into a vector. The vector is converted into /rc/override for the MavROS package [9]. Multistar 10000mah lipo batteries. Hobbyking lipo voltage checkers connect to Arduino and deactivate it at a certain low voltage. Circuit maker > eagle cad: superior parts library (check out solidworks too…). IMU – changes in orientation in the 3 major axes. One of the cameras is a Point Grey Chameleon CMLN-13S2C and the other is a ZED 2K Stereoscopic Camera. Separate the computer tasks from propulsion. They use buck converters to step down for sensors&controllers (5v) and leds (12v) and a usb-200 intelligent dc-dc buck boost converter to get 19.5v for powering the computer. Can custom program the buck-boost to vary the voltage and current and can monitor the battery output V. Use ROS with Sub\_Ai\_State\_Manager, and YOLO\_Objective\_ Executer, PI\_Loop. our software division deemed the use of machine-learning based object detection more economical than the creation of traditional hand-crafted detection algorithms. The recent success of YOLOv2, a Convolutional Neural Network designed for object detection and localization, at various datasets such as Microsoft COCO: Common Objects in Context and PASCAL Visual Object Classes persuaded the software division use a network with a similar architecture. Because YOLO is a large network, it is very prone to overfitting if trained from random initialization on a limited amount of data. To reduce this risk and allow for learning from a smaller dataset, the method of fine-tuning a pretrained model is employed. MavROS serves as an all-in-one package to control movement of the submarine [6]. Virtual RC values are published to the /rc/override channel as well as the Flight Mode for the IMU: a px2 Pixhawk. We used a flight controller for drones because there is an open source community for AUVs and remotely operated vehicles (ROVs) from BlueRobotics [7]. They created the Ardusub project fork from ArduPilot, and their firmware easily wraps into MavROS and MavLink [8]. PI control: The PI controller is a variation on the PID controller. By omitting the derivative, quick implementation of a movement package and reduction of the amount of tuning necessary for our controller become possible. It takes two points from the field of view: one provided by YOLO and one provided by the center of the camera. The program uses both the differences in the x and y directions to calculate the distance between the two points and obtain the error. It then processes the error through the control loop and outputs a data point that is converted into an RC value published to MavROS. ROS supports interface with Arduino.

Cal Tech 2017

<https://www.robonation.org/sites/default/files/RS17_Caltech_Paper.pdf>

Separate power and battery systems for actuators and for computers and sensors. 3-axis cnc machining: HSMWorks. 5-axis cnc machining: MasterCAM. Electronics are implemented modularly; each subsystem is managed by a specific PCB. This minimizes the chance of an error in one part of the system causing failure within the rest of the system. The thrusters and pneumatic solenoids use a separate power system to avoid noise and interference with the rest of the electronics. The microcontroller system consists of five boards: the core board, the sensor board, a pneumatics board, a servo board, and the hydrophone board. Each board is equipped with a STM32F407VG microcontroller as the STM32F407 provides many integrated peripherals. These boards communicate over an RS485 bus network in order to efficiently pass messages between subsystems. The core board (Figure 6) is responsible for handling communication between the Intel NUC™ computer and the rest of the microcontroller system. Messages between the computer and the core board consist of a message ID and five bytes of data. Computer to core messages are parsed by the core board and handled by sending the data to another microcontroller board as an RS485 data packet. Data packets received by the core board are sent to the computer through a USART. The sensor board (Figure 7) uses an ADC to poll the Omega PX-319 depth sensor and a GPIO to poll the motor kill switch in order to provide continuous updates to the computer about the state of the vehicle. The sensor board is also used to control the WS2812B LED strip that is used to provide visual feedback about vehicle. The servo board drives the three servo motors which control the gripper. It converts angular position information to pulse widths and asserts the PWM signals. The pneumatics board (Figure 8) uses optoisolated GPIO signals to control four electromagnets. An Omega PX-319 pressure sensor filtered using a second order Bessel filter and processed by an ADC on a microcontroller measures the vehicle’s depth to within an accuracy of 1-2 inches. The vehicle has two AVT GuppyPro cameras with 120° wide-angle lenses. The cameras are positioned 45° below the horizontal axis to provide full coverage of obstacles in front of and underneath the vehicle. Hydrophones: Four Teledyne TC4013 piezoelectric transducers mounted in a square pattern listen for the sonar signal. The current from the transducers is converted to a voltage across a 100 MΩ resistor. The signals then pass through a JFET input stage preamplifier with a DC servo to increase the signal amplitude. A 4th stage differential active filter is used to attenuate signals above 200 kHz to prevent aliasing. A quad channel simultaneously sampling 16-bit ADC is used to digitize the differential analog signals at 400 kHz / channel. The signals are then processed on a STMF407VG and the heading information is sent to the computer via UART. A Fourier transform is used around the pinger frequency to extract the phase information. The heading is computed using the phase differences between the four sensors. IPC library publisher-subscriber model. Instead of using ros they made a c++ architecture and wrote their own framework. Communicate with the computer using ethernet and ssh. To deal with both of these issues, we implemented a custom 11-dimensional extended Kalman filter (EKF), whose state includes the vehicle’s translational velocity, position, translational drag coefficients, inverse virtual mass, and net buoyant force. The prediction step uses an algebraically-linearized Newtonian dynamics model with linear drag. A Kalman filter is well suited to this task because it can first estimate the drag coefficients of the vehicle by comparing the applied thrust to the measured velocity. Then it can use these drag coefficients to estimate the vehicle’s position based on the known thrust being applied. The output of the Kalman filter is a unified state estimate that includes the vehicle’s 3-D position, orientation, translational velocity, and angular rates, all of which are periodically published to the Robot State IPC channel. LQR > PID (mit drake library for solving lqr). Takes no time to tune an lqr controller. Finally, we profiled our thrusters using a strain gauge to determine the mapping from motor power level and battery voltage to physical thrust. Inverting this relation allowed us to generate the exact thrusts requested by the LQR controller. Mathematica error logging???

Cornell 2017

Team Videos

Cornell – 2017 (1st)

<https://www.youtube.com/watch?v=C8axxrxS5yI&feature=youtu.be>

Far Eastern Uni – 2017 (2nd)

<https://www.youtube.com/watch?v=UJVvUSccS2I&feature=youtu.be>

Georgia Institute of Tech – 2017 (5th)

<https://www.youtube.com/watch?v=MXWCG1nhqKo&feature=youtu.be>

McGill Uni – 2017 (Best Pres)

<https://www.youtube.com/watch?v=df0z2ug74b4&feature=youtu.be>

Beaver – 2017

<https://www.youtube.com/watch?v=B3YQK3GJxAE&feature=youtu.be>

SDCC – 2017 (Best PR)

<https://www.youtube.com/watch?v=3mIx5nPxixY&feature=youtu.be>

<http://www.sdcityrobotics.org/?page_id=113>

Uni of Alberta – 2017

<https://www.youtube.com/watch?v=hx-erDH3-DI&feature=youtu.be>

Harbin Engineering Uni – 2017 (good video layout)

<https://www.youtube.com/watch?v=fqoO8j76VKc&feature=youtu.be>

Kennesaw State Uni – 2017 (bms, good small design, machine learning?)

<https://www.youtube.com/watch?v=T1NVPMpmgn0&feature=youtu.be>

Robonation Tech Talks

<https://www.youtube.com/watch?v=xA9bsGBx5vs>

<https://www.youtube.com/channel/UCQbovXzNNhW8jWZXaX8IIgA>

<https://www.youtube.com/watch?v=3WKRW-F2CGE>

<https://www.youtube.com/watch?v=pNySG7cXrNc>

2 sub proposal:

The scouting sub has the DVL and uses sonar for object detection. The 2nd sub is equipped with all the weapons systems and receives pinger signals from the scout telling it where to go. It has a depth sensor and navigates to the correct wavepoint location using \_\_\_\_\_\_. Once it reaches the obstacle, it uses a raspberry pi cv system for color detection and completes the tasks. Both have hydrophones and on-board pingers.

Maybe instead of sending wavepoints the scout uses sonar to detect the objects, sends a ping to the other one at the location of the object, then the other sub tracks the source point of that ping using the hdyrophones and goes there. No wavepoints at all and no relative positions needed. The first sub can just use sonar to get a 3d image of the whole pool so it can adjust its depth and speed without a dvl. The first sub would need to move more quickly than the other sub for this to be worth it.

Will my 2 sub idea work?

* Can one sub reach the objects without a dvl? How could this be done? Would it be too complex to be worth it? Which sub needs the dvl?
  + The DVL can read velocity in all 3 axes, calculates position underwater in all 3 coordinates, can stabilize, and calculate currents in the water.
* Can the scout get away with just sonar and no color detection?
* Is a raspberry pi sufficient for color detection?
* Can one sub give coordinates to another sub?
* What benefits would this give us over doing just one sub?