BYOE: SeaKatz – an Underwater Robot

Dr. Iftekhar Ibne Basith, Sam Houston State University

Dr. Iftekhar Ibne Basith is an Assistant Professor in the Department of Engineering Technology at Sam Houston State University, Huntsville, TX, USA. Dr. Basith has a Ph.D and Masters in Electrical and Computer Engineering from University of Windsor, ON, Canada with concentration on 3D IC, MEMS and Testing. Dr. Basith has published several IEEE transactions, articles and conference proceedings over the last few years. His research interest lies on Robotics, Tesing of 3D IC, MEMS, Analog/ Mixed-Signal Devices, RF circuits, Low Power CMOS and Wireless Communication.

Mr. Emanuel A Sanchez, Sam Houston State University

Emanuel Sanchez Engineering Undergraduate Student

A student with a demonstrated history of working on engineering studies. Currently developing skills that are in demand. Skilled in AutoCAD, Mechanical/Subsea research, Inventor, Robotics, Electric Power. Currently in the search of an internship. Strong information technology professional with a Bachelor of Science - BS focused on Engineering Technology from Sam Houston State University.

SeaKatz: An Underwater Educational Research Robot
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Summary

The development of Remotely Operated Vehicles used in ocean explorations has posed many challenges over the years [1]. The opportunity from past experiences at the Marine Advanced Technology Education competitions inspired the student to create a small scale ROV(reduced price). The purpose is to educate students in learning the concepts of robotics. The robot will have a mixture of analog and digital applications. This project will help educate students on how robotics can apply in the marine and geospatial environments [2, 3]. Underwater robotics will show a different and challenging approach compared to conventional robotic systems. There is a great demand for technicians and engineers in the area of marine robotics, ranging from high school to university education [2][4]. We propose to build a simple ROV that can navigate through the environment and record information for the operators to analyze. The design and development consisted of keeping the project financially stable. This project is helpful for students to recreate and expand their creativity into unique designs based on Seaperch [2]. The Remotely Operated Vehicle consists of a structural frame, propulsion system, and analytical subsystem. The structural framework of the ROV uses polymers which is safe for the environment and useful for rigidity. The propulsion of the ROV will use analog DC power to the thrusters and give mobility through the underwater environment. Analytical subsystems (sensors) will apply with the usage of a microcontroller Arduino, as it can log (input/output) information from surrounding environments and report the information to the operator. An experiment was carried out in the pool of Sam Houston State University to prove the functionality of the built prototype.

Knowledge Context

Arm mechanisms are essential for ROVs since it gives the ability to grab and manipulate objects from a different point of view. Having a device to retrieve objects is what makes up part of the subsystems of the ROV. The mechanism would be powered electronically using the Arduino. Another alternative is using pneumatic pressure to the arm. Many of the ROV systems use electromechanical components that will enable the robot to interact with the environment.

The final product is designed to be durable and has a long expectancy of the harsh lab environment. The building process of the project is readily manageable with typical engineering lab resources and information. The alternative 3D printing process can efficiently reduce production costs and time, and examples such using AutoDesk Inventor to create 3D ROV parts will help students learn the process of design and development rather than buying parts [5].

Sample Applications

1. ***Neutral Buoyancy:*** Achieving the buoyancy force of the material density equaling to the fluid density, this will prohibit the object to either sink or float. For neutral buoyancy, pool noodles are cut into sections and installed on each side of the ROV. The installation of pool noodles offers a significant cost-effective way to adjust the buoyancy of the ROV. Adjustments are necessary when the total payload can mainly cause the ROV to sink; a needed correction applies to counterbalance.

2. ***Software interfacing and data acquisition:*** The sensors that mounted onto the ROV are microcontroller, computers, or other data acquisition modules that will help retrieve and analyze the data. Tools such as Arduino feedback display are helpful for engineering students to acquire data logged.

3. ***Rotational Motor Speed:*** Motors or servos installed on the frame will be driven from DC power and will give the change of torque and RPM directly proportionated to the voltage changes. The plotted information appears in a graph.

4. ***Propulsion:*** Data can be logged to find the peak force of the motors when applied to the resistance of a steady pool of water and compared when a current of water applies to the motors.

5. ***Cooling Efficiency:*** An advantage of most sealed electronic components is the ability to cool off by the surrounding environment. Water has better cooling properties than compared to air. Measurement will be recorded from the thruster's temperatures from the ambient air temperature and compared to being submerged into a body of water.

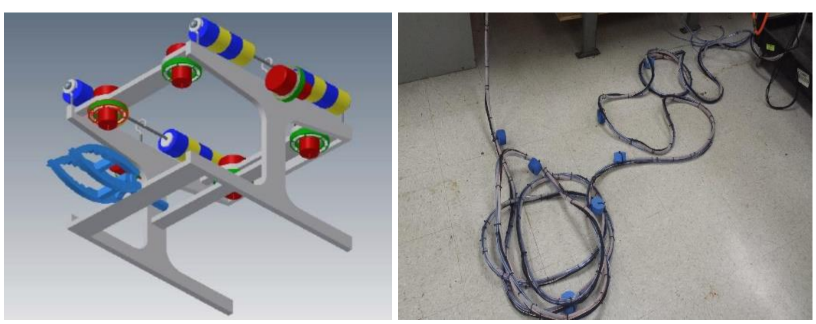
6. ***Waterproofing:*** All electronic components must be able to withstand the pressures of the water and from corrosion. A pressure sensor installed on the ROV will stay updated with the fluctuations of water pressure. Different techniques of waterproofing such as using candlewax and marine electrical liquid to seal the connections from underwater.

ROV Pure Design

The underwater robot was constructed with a polymer such as Polymerizing Vinyl Chloride (PVC). The boxed shape of the ROV has an opening; this gives access to objects underwater. Another widely known approach is to use an H- Frame design (Figure 1a) as it provides more symmetrical access to the environment. The propulsion system will have sealed 600 gallons per hour bilge pump motors that will apply propulsion force to the ROV. The energy will be sent to the final drive of the propellers and will give a steady motion of direction for the ROV. The prototype has all the power transmitted through a control box, tether (electrical leash), and finally sent through the electric motors (Figure 1b).

Hardware

The buoyancy system of the ROV will be customized using "pool noodles" and will be modified to reach its peak neutral buoyancy and equal balance positioning. A great alternative of 3D printing buoys will give a better duration of part expectancy than its counterpart of pool noodles. VEX Robotics components apply to create a simple underwater arm mechanism by using electronic servos to open and close the claw or by using a pneumatic tank to send air pressure through the pressure lines and into a pneumatic piston-driven actuator. Most of the hardware material make up of stainless-steel parts and durable polymers to endure the environment. Due to the ROV exposed to saltwater, we strive to minimize the use of metals as it can attract surrounding wildlife. A tether (harness) connects the control box to the ROV as it will send power from the operator's analog input. The tether fortified with insulators; this will avoid chaffing and reduce wear and tear. Thruster motor mounts will be essential to position for its peak maneuverability through the body of



(a) (b)

Figure 1: (a) H-Frame Design on Inventor and (b) Tether example from previous experience

water (Figure 2). There are testing and development of hydrodynamics for the ROV frame. It is a way to test the body of water through the ROV frame and how it will react. Plastic sealed containers will be reinforced to waterproof the electronic components as it navigates through underwater pressures.

Electrical/Electronics

Components of the built ROV includes analog and digital systems, based on the previously acquired knowledge from several college courses (Control Systems and Automation, Solid State Electronics, Digital Electronics, Microcontroller Applications, Principles of Engineering). The propulsion system will be managed from DC 12V power and directed from the control box. The control box consists of Double Pull Double Throw Switches, which can switch the polarity of the thrusters and lead a specific direction for the ROV (Figure 2). The transmitted input signals from the control box send through the tether; then, the electric power branch to each of the thrusters. The thrusters are sealed bilge pump motors in which are modified for the underwater drivetrain. The powertrain of the ROV will be using analog technology to have fewer areas of troubleshooting and consistent reliability. All sensors and analysis tools will be used under the data acquisition module, Arduino. Using the Arduino will help display the data logged to analyze specific areas of the ROV's surrounding environment. Waterproofing of the electrical components will be a significant role for this project, as water does not go at all with electricity (Figure 2). A basic "check engine" diagnostic code tool incorporated into the ROV. The water level sensor will be a major alarm to alert the operators that water is rising quickly to the onboard electronics of the ROV. This alarm system gives an important alert signal to retrieve the ROV safely. Bluetooth connectivity is in consideration for the Arduino as it can display information and reduce the amount of exposed wiring from the tether. The main power distributed to the thrusters will be sent through the tether. The feedback from the sensors will be sent to the Arduino and back to the surface using a Bluetooth module.

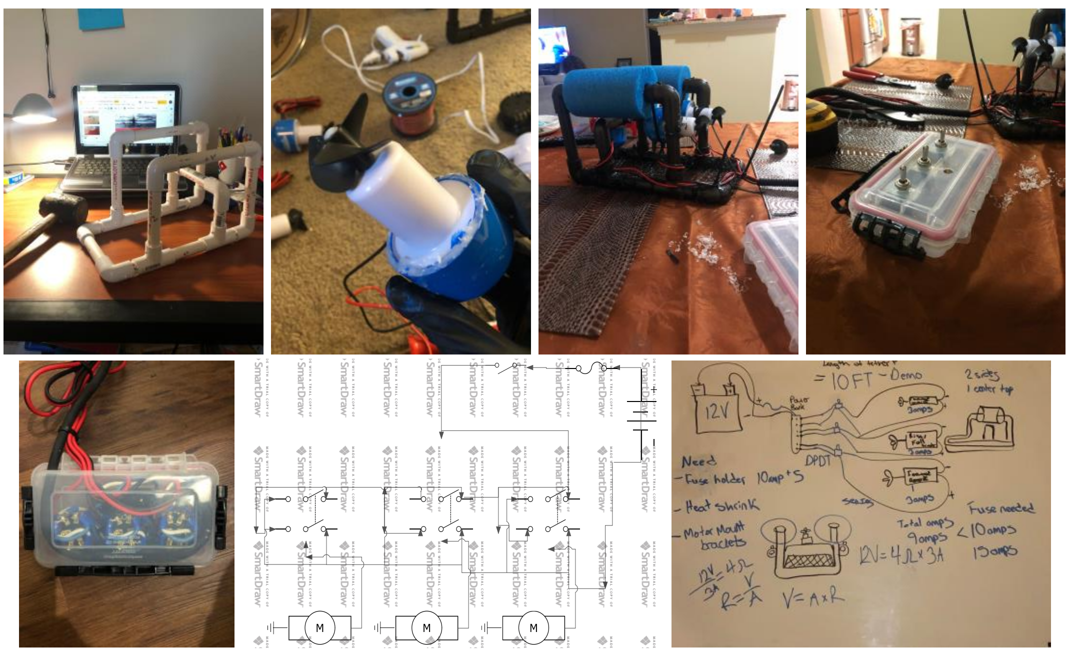


Figure 2: ROV Implementation Steps and schematic

Bill of Materials/Experiment

All materials came from Amazon and some from local stores. The selection of parts is due to quick availability and cost-efficient. There are websites like BlueRobotics, which offer a variety of ROV pre-made parts, but is expensive. So we grabbed a selection of easy to modify parts to fit underwater. For example, the conversion of bilge pump motors into thrusters give a great alternative than buying parts readily. In the experimentation phase, the functionality and reliability of the ROV was conducted in the university's pool: https://www.youtube.com/watch?v=TZi5vwTu27w&feature=youtu.be

Part	Description	Vendor	Price	QTY	EXT	DATE
Bilge Pump Motor	Modified for subsea thrusters	Amazon	8.99	3	**26.97**	06/19
14-gauge speaker wire	Part of power distribution 30 ft spool	Amazon	16.99	1	**16.99**	06/19
Eleggo Kit	Electronic components	Amazon	60	1	**60**	06/19
Pool Noodles	Adapted for ballast (buoyancy systems)	Walmart	2.99	1	**2.99**	06/19
PVC	structural frame	Home Depot	10	MISC	**10**	06/19
Control box	Housing for control switches	Walmart	3.99	1	**3.99**	06/19
Toggle Switches 3 Pack	DPDT switches (reverse polarity)	Amazon	7.95	1	**7.95**	07/19
Propellers (10 pack)	Incorporated with the thrusters	Amazon	10	1	**10**	07/19
Vex Robotics Parts	Constructing the claw	VEX	30	1	**30**	07/19
Motor Mounts	3D printed	N/A	N/A	N/A	**N/A**	06/19
Wire Netting	Payload area	Amazon	5.99	1	**5.99**	07/19
				Total	**$174.88**	

Conclusion

Our implemented prototype can withstand the water pressure of about 5 feet deep and can detect a visual aspect at the bed of the water. The Department of Engineering Technology has recently established a new robotics organization called "KatatroniX." This project has set an excellent foundation for STEM and ignited interests for potential students in the field of robotics. Through our experimentation of maneuvering the ROV, the clear outcome was usage of ROV in different engineering and technical applications. The student author attended at both regional and international competitions in 2015 [6].

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