Autonomous Underwater Vehicle (AUV) v1.0

AUV Society, Indian Institute Of Information Technology, Design & Manufacturing, Kancheepuram, Tamil Nadu, India

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Abstract — *The AUV project is aimed at providing an opportunity for students to broaden their knowledge of autonomous vehicles and underwater robotics. Made by dedicated students of IIITDM Kancheepuram, who share a common interest in the field of robotics, this vehicle is the first version made by the society, who participated in the Singapore AUV Challenge 2019 (SAUVC), as Team ATV. The team aims to make more advanced versions of the vehicle with the knowledge gained to take part in such underwater robotics competitions and initiate research and innovation in underwater robotics.*

1. Introduction

AUVs can be used for underwater survey missions such as detecting and mapping submerged wrecks, rocks, and obstructions.

Until recently, AUVs have been used for a limited number of tasks due to technological constraints.

With the development of more advanced processing capabilities and high yield power supplies, AUVs are now being used for more and more tasks with its roles and missions constantly evolving.

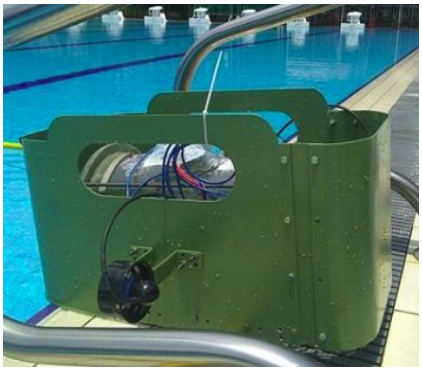

Figure 1. AUV v1.0 at SAUVC,2019

The AUV Society of IIITDM Kancheepuram is a team comprising of 8 members from the Mechanical, Electronics and Computer-Science department. This vehicle was the team's first attempt in creating an AUV, hence the focus was more on making a simple and modest design with most of the waterproofing done by the team itself. The vehicle used 4 thrusters an IMU chip, and a depth sensor were used for movement and navigation.

2. Mechanical Division

The mechanical division focused on the design, prototyping, fabrication and structural analysis of the vehicle.

2.1 Frame design

This design was selected based on its technical aspects and aesthetically pleasing nature.

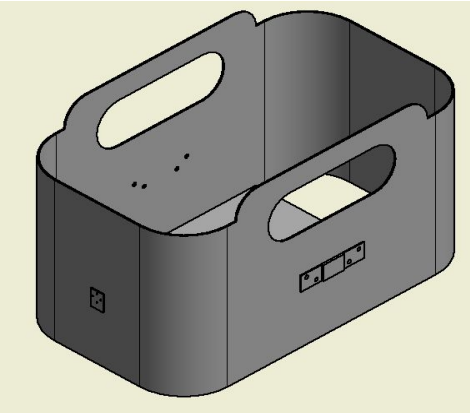

Figure 2.1.1 AUV FInal CAD Model

This design was finally selected as it was aerodynamically adept and also provided free spaces for the fluid to flow around the hull. The shape of the front of the vehicle was made to support the aerodynamic structure. Actuators were mounted on optimized positions of the frame for balancing of the vehicle.

Aluminium was used for fabrication due to its lightweight.

The vehicle had 4 thrusters which provided 4 degrees of freedom namely heave, surge, sway, yaw which satisfied our requirements.

2 out of the 4 thrusters were used for depth propulsion.

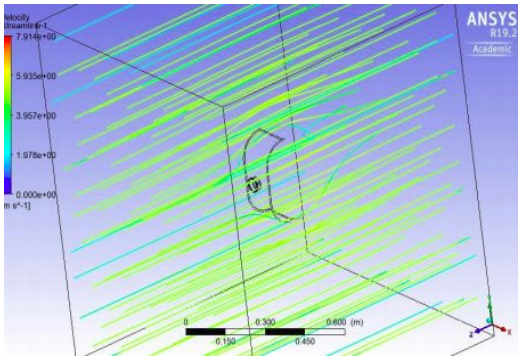

Figure 2.1.2 CFD Analysis

2.2 Pressure Hull

To minimize the drag forces, a cylindrical hull design was used. A pressure hull was employed to house all the electronic components. The design was made by considering the ease of control and constraints set by the competition.

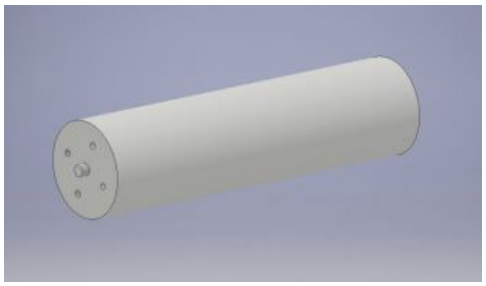

Figure 2.2.1 Pressure Hull

Acrylic was used for fabrication of this part due to its lightweight characteristics. Acrylic also helped in ease of fabrication. It also has good impact resistance.

Racks were used for housing the hull and batteries which was fabricated from an aluminium alloy which provided a high strength to weight ratio.

All the materials were chosen in such a way that they could sustain pressure in depth.

Figure 2.2.2 Rack used for electronics assembly inside the hull

The upper rack housed the hull whereas the lower rack housed the batteries and the picking mechanism.
One of the end caps of the hull was completely sealed while the removable end was sealed using bore seals. Extreme caution was taken while sealing the pressure hull.

Figure 2.2.3 Bore seals used for obtaining a leak free interface at the end of the pressure hull

5 slots were drilled on the removable cap to incorporate the cables for the motors and camera. All of the holes were sealed using cable glands and O-rings to provide a leak-free interface.

Figure 2.2.4 Cable glands and O-rings used for sealing the holes on the removable cap

2.3 Picking Mechanism : Hand and Gripper

The team selected a gripper design as per the competition requirements which was to pick up and drop a ball.
The gripper designed by the team uses a mechanism where a servo motor was used to provide a reciprocating motion. The motor was subjected to a lead screw mechanism which was connected to a link which was responsible for the grip.

3. Electronics Division

The Electronics team worked together with the CS team for making the brain of AUV v1.0. They focused on

i) Power system
ii) Navigation and Control system

We used a microcontroller (Arduino Mega) for the navigation system and a Raspberry Pi for the Image processing system.
The below diagram shows the flow of information and power across the brain of AUV.

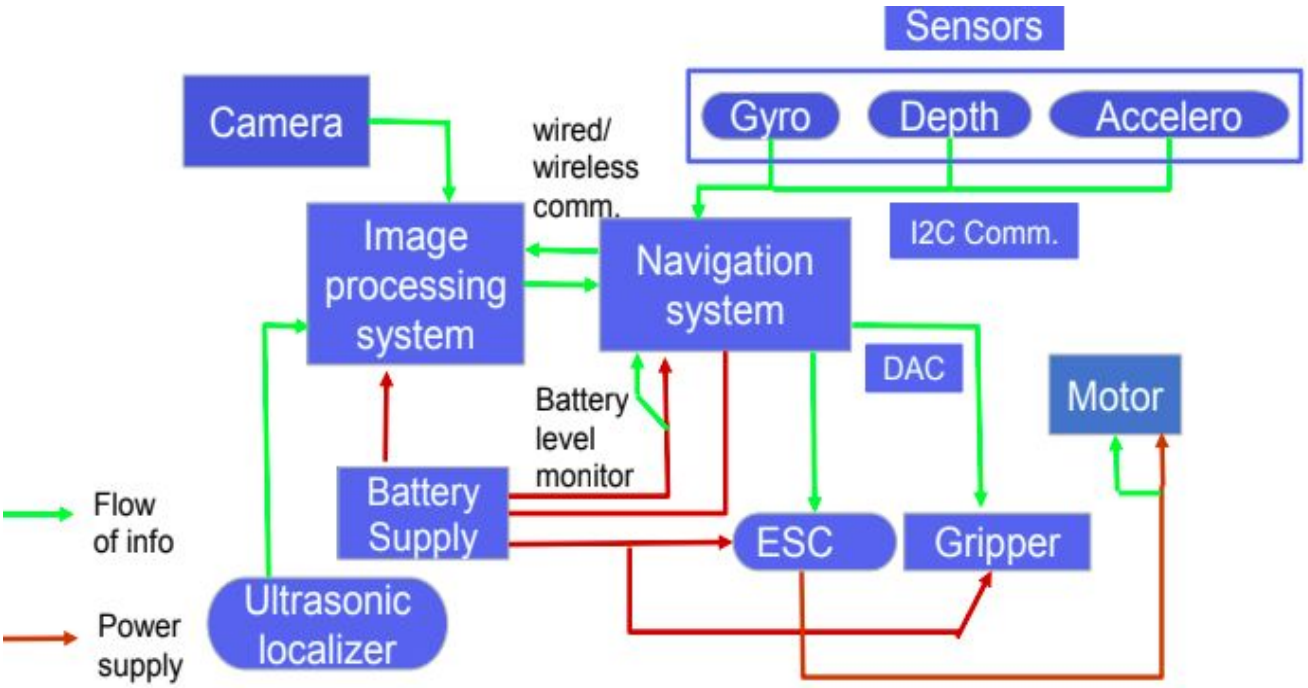

Figure 3.1 Architectural diagram

3.1 Power system

After looking and comparing two main parameters - efficiency and power of thrusters, all the power calculations were made. Two 3S LiPo batteries of 5200 mAh each were used in parallel for powering the vehicle.

Kill switch -

The vehicle had an emergency kill switch installed, which cuts the connection between power circuit and supply line.

The switch was fixed inside a box and sealed with its shaft outside for switching on and off.

3.2 Navigation and Control system

The navigation system takes input from sensors, communicates with the image processing system and then gives output to ESCs (which in turn drives the thrusters) and gripper.

Sensors -

i) Depth sensor -

We used a MEMS-based pressure sensor (MS-5837) which was sealed and made completely waterproof by the team.

ii) 9-DOF IMU chip -

This chip incorporates 3 sensors (accelerometer + gyroscope + magnetometer) and gives a combined data of all 3 as input to the navigation system.

We used bidirectional ESCs which takes input from the navigation system and drives the thrusters.

4. Computer-Science Division

The computer-science division focused input handling to ensure smooth communication all over the AUV.

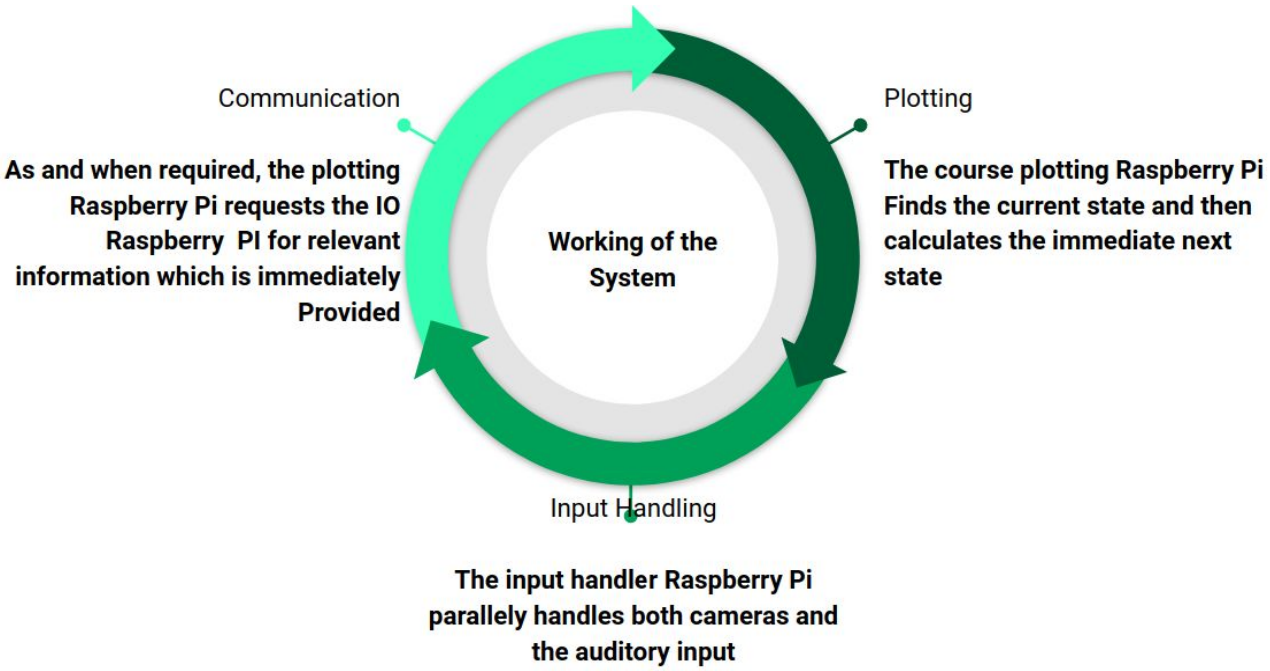

Figure 4.1 Image Processing System

4.1 Image Processing System

A camera was attached to the front of the vehicle to find the objects and it was connected with Raspberry Pi.
The detection was done using colour filters and transformations were used to find the relative size of the gate and then calculate the directions to go through.

Canny edge detection and hough line transform algorithms were used for detecting the objects.

Figure 4.1.1 Underwater gate detection

5. Result

Team ATV had a successful run with this vehicle at the Singapore AUV Challenge, 2019. The team was one amongst 40 teams selected all over the world to compete in the main challenge in Singapore. The team was placed as one of the top 17 teams to complete the qualification round with a timing of 46.5 seconds to swim 10 meters.

6. Future Plans

With the experience gained, we aim to make the next version of the vehicle with several upgrades, like more streamlined body design, advanced gripper, better and faster boards, high-resolution cameras for image processing and the use of ROS (Robotic Operating System) to ensure smooth communication among all the systems. We also aim to make the use of hydrophones for acoustic localization.

7. Acknowledgement

The AUV Society would like to thank everyone who helped us in the establishment of the society and our first vehicle. We would like to specially thank Dr. Selvajyothi K who supported and motivated us for our first attempt.

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