Delhi Technological University

Autonomous Surface Vehicle

“RUDRA”

Abstract

RUDRA is an Autonomous Surface Vehicle (ASV) developed by a team of undergraduate students from Delhi Technological University (formerly, Delhi College of Engineering) to compete in the AUVSI Foundation' and ONR's 5th International RoboBoat Competition. This competition is organized by Association for Unmanned Vehicle Systems International (AUVSI) and US Office of Naval Research (ONR) at the Founders Inn and Spa, Virginia Beach, VA, USA. Team DTU ASV has pursued this endeavour for more than 5 months and has brought about many improvements in technology with time. This Journal Paper presents the various architectural, software and design changes made to achieve our 1st generation vehicle.

1. Introduction

1.1 Team

DTU-Team ASV is comprised of a group of four students. The team thoroughly analyzed the competition requirements and came up with a systems engineering approach to design the ASV to achieve the competition objectives.

A modular approach to design was taken; all systems were designed in modules and were thoroughly tested during development as well as integration stages. As a result the final system provided satisfactory results.

1.2 Mission Requirements Analysis

The AUVSI's Student RoboBoat Competition simulates a real world scenario. To meet this objective, the ASV must be capable of following a set of pre-defined waypoints while identifying obstacles & buoys. In addition to this, the ASV must be capable of performing four assigned tasks. Throughout the mission, the ASV should operate without compromising the safety of its operators as well as that of the environment in which it is operating. The mission requirements are further analyzed in the various sub sections below where they are co-related to the design decisions taken by the team.

1.3 Systems Engineering Approach

The project was divided into 3 phases:

- Conceptual Design
- Preliminary Design
- System Integration & Testing.

In the Conceptual Design phase, the team came up with threshold and objective requirements of *DTU ASV*. The system was analyzed thoroughly and various shortcomings were identified. Also, the systems of the other teams were studied carefully before coming up with a system for this year's competition. Many potential systems were considered, with an overall score being assigned based on the requirements. Finally, the system with the best overall score was chosen, with safety and reliability being key considerations. A schedule was then drawn up and work was divided among the team members. In Preliminary Design, individual modules were developed and extensive unit testing was carried out in the laboratory as well as in field testing. This proved beneficial as system integration was made much easier, due to reliability of the subsystems. In System Integration & Testing, the successfully tested modules were combined together and performance was verified in test runs. Weekly team meetings were held to ensure that work was progressing on schedule. Regular design reviews were also helpful in detecting and resolving problems at an early stage. They were also used as a good opportunity for carrying out quality control and safety checks.

1.4 System Overview

The team’s primary focus for this year was to ensure the reliability of the marine system, as well as to work on the imagery and communications systems. The overall safety of the system was also of prime importance.

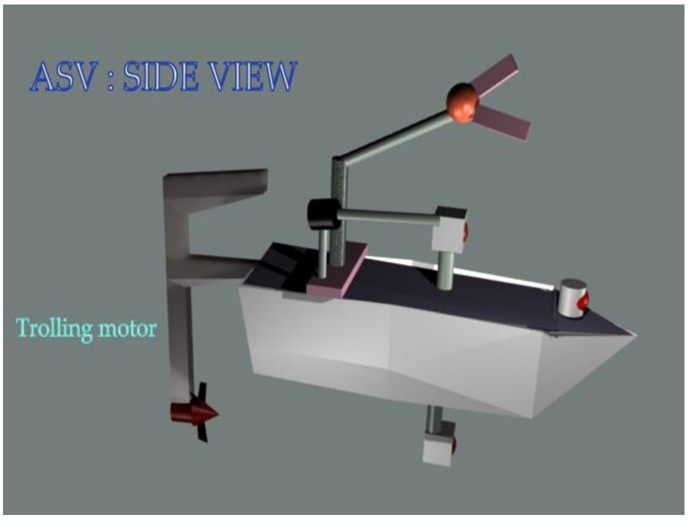
2. Design Systems

ASV is a mono-hull design, i.e., a hull which is constructed of a single water displacing body. It is a pointed bow which facilitates the ship's ability to cut efficiently through the water. It remains more stable in rough seas. Disadvantage involves more drag and hence more resistance to water. Boat frame was exclusively chosen of Aluminium because of the following facts:

- **Life Span**: The alloy 5000 and 6000 series are known for their high strength and corrosion resistance.
- **Weight**: Aluminium boats are lighter 30% than regular GRP boats, which means higher speeds achievements.
- **Impacts**: Aluminium is ductile and has low modulus of elasticity, thus it absorbs the energy of any impact and nothing happens to body.
- **Sun Exposure**: Aluminium is not affected by ultra violet rays.
- **Flammability**: Aluminium does not burn.
- **Moisture content**: Most of GRP boats have moisture content which causes dislamination and expiry of the boat life time.

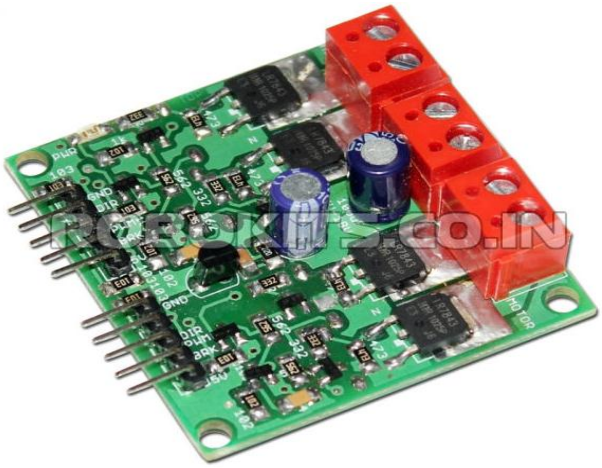
3. Propulsion Systems

Team ASV used a 30lb-thrust Minn Kota transom mount trolling motor.



4. Electronics

4.1 Dual DC motor driver



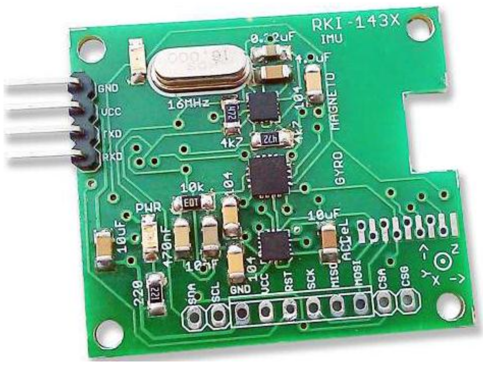
It comes with a simple TTL/CMOS based interface that can connect directly to the IOs of an MCU. It has a breaking feature that can guarantee immediate halt on the shaft of motors in most high power applications and also includes protection circuitry to avoid any electrical fluctuations affecting the normal operation of an MCU.

4.2 GPS Receiver MT3318 USB Module

MT3318 USB GPS Receiver Module is based on the MediaTek MTK MT3318 chipset. It has active patch antenna from Cirocomm. It can track 51 satellites simultaneously. It can be directly connected to the PC via USB port. It has onboard FT232 USB to serial converter of interfacing GPS with the PC’s USB port. GPS receiver is mounted on the PCB along with the 3.3V low drop voltage regulator, transmit, receive and power indication LEDs, Schmitt triggers based buffer for 5V to 3.3V logic level conversion and FT232 USB to serial converter.

GPS receiver gives data output in standard NMEA format with update rate of 1 second at 9600 bps. Receiver has onboard battery for memory backup for quicker acquisition of GPS satellites. GPS module is powered by USB port of the PC.

4.3 Inertial Measurement Unit (IMU)



This 9 Degrees of Freedom (DOF) Inertial Measurement Unit (IMU) is used for tracking and sensing motion of any mechanical platform and is an ideal sensor system for motion control of aerial autonomous systems like multi-rotors, model airplanes, helicopters etc., and other systems that require to control the pitch, roll and yaw. An internal processor acquires data from a gyro, an accelerometer and a magnetometer to calculate the pitch, roll and absolute heading (yaw). This is known as AHRS (Attitude Heading Reference System) that is used for boat control.

This IMU, with and AHRS system outputs the pitch roll and absolute heading (yaw) of the system on a TTL/CMOS compatible serial UART line.

4.4 Weather Resistant (MB7066) Sonar Range Finder

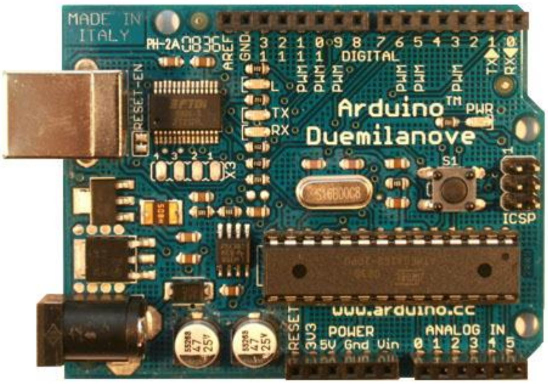
This sensor provides very short to long-range detection and ranging, in a compact, robust PVC housing, designed to meet IP67 water intrusion, and matches standard electrical ¾” PCV pipe fittings. The low power 3.0V to 5.5V operation detects objects from 0-cm to 1068-cm (35 feet) and provides sonar range information from 20-cm out to 1068-cm with 1-cm resolution. Objects from 0-cm to 20-cm range as 20-cm. The interface output formats included are pulse width output (MB7066), real-time analog voltage envelope (MB7076), analog voltage output, and serial digital output.

4.5 USB to Serial TLL/CMOS Logic Module

This USB to serial converter is based on FT232 from FTDI. It gives out all 8 pins of the serial port at user selectable 3.3 or 5V logic levels. It has Transmit and Receive indicator data LEDs. It is most suitable for serial communication where data flow control is important. Since all the pins of the module are available at 5V / 3V3 and TTL / CMOS levels.

4.6 Arduino Board

The Arduino Duemilanove ("2009") is a microcontroller board based on the ATmega168 (datasheet) or ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.



All the electrical components are placed inside the deck. Separate clips are made for Laptop, GPS module and other components. A detachable lid is made which can be opened for any modifications. ICs, namely, GPS Module, Inertial measurement unit, motor driver, USB to Serial converter, arduino development board was placed inside a plastic box to protect it from moisture. Servo Motor used to control the ultrasonic range finder and logitech webcam was mounted in the front of the boat. The router is placed inside the boat for wireless communication and emergency stop.

5. Software

5.1 Design Technique

Software is designed in labview. It is designed into modules, where each module interfaces with each of separate hardware thereby detecting and debugging hardware specific problems separately. Each labview module is grouped using a project and intercommunication between different modules is achieved using a set of global variables.

5.2 Blender

This 3-D designing software is used to create the three dimensional model of the boat. It gives us a rough idea of the placement of buoys as well as placement of various electronics and mechanical systems on the boat.

6. Operations

The ASV operations were drafted after a detailed and meticulous analysis of the mission requirements and the final outcomes expected. The key considerations were:

1. **Safety**: Of the boat frame and its systems.

2. **Portability**: The entire system had to be made capable of being quickly and efficiently set up out of a single container.

3. **Set Up time**: The setup of the entire system (Dock Control Station and the boat) had to be done under the allotted time.

The entire ASV mission has been divided into the following stages and further planning has been done based on that.

1. **M1**: Collection of required equipment before leaving for the mission.
2. **M2**: Setup of the DCS and the boat frame.
3. **M3**: Testing of the all the systems and communications.
4. **M4**: Operations during test run
5. **M5**: Post run operations

7. Wireless Access / Tethering

The SBC present inside the ASV is the client to which the offshore client connects remotely through a server. It is achieved by using Windows Remote Desktop Connection application which establishes a wireless Ethernet (802.11g) connection. A router is configured as a TCP server. This router is connected to the ASV operating below through a long Ethernet cable. This router leases out private IP addresses to offshore clients that connect to it. Remote access helps in parallel code development, debugging and data logging. It plays a key role in testing of the vehicle. By viewing the real-time sensor data, we can tune most aspects of the boat's intelligence and control. In addition, the main control program can be remotely modified and recompiled.

8. Conclusion

The entire procedure that has been devised has been improved and updated after all the test runs carried out so far. Further analysis also revealed the key components required for the mission and a back-up for the same has always been in place. The mission operations also helped us to better understand the failures that could occur during its entire course. The team has handled emergencies like over-run by the boat and over heating of the motor driver. This helped us to come up with a fall-back plan in almost all kinds of imaginable scenarios. At the time of writing the journal, the team had performed a total of 4 boat tests.

9. Acknowledgements

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• Prof. P.B Sharma (Vice Chancellor, DTU)
• Dr. Rishu Chaujar (Faculty Advisor)

10. References

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2. www.**blender.com** - Design Software