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Design and Implementation of Underwater Autonomous Vehicle (Uav- Varauna)

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Abstract- **VARUNA is the first autonomous underwater vehicle (AUV) design and builds by our team. Complete the AUV in a six-month design cycle, the vehicle is fully modeled using Solid works software and extensively we will simulate the structural and flow analysis with ANSYS, STARCCM+ software 's and going to manufacture almost entirely in our campus. Grid Independent studies will be carried out for the structural and flow analysis. Various Turbulence models will be select based on the literature survey for the flow analysis. Based on the Grid independent studies simulation is carried out for various speeds for 0.1-0.5 m/sec then only we can neglect the lift forces based on the wet test. During generation of the meshes, attention will be given for refining the meshes near the AUV so that the boundary layer can be resolved properly. Varuna presents a cheaper, stronger, lighter in weight of 27 kg and compact size of 0.8m*0.6m*0.6mas length, width and height of the vehicle and capable of working under 25 m depth. New advancements include full vehicle control of six degrees of freedom, a dual-hull cantilevered electronics rack and hulls, overhauled wire routing for electrical systems, and significant software for mission reliability and robustness. Varuna sensor suite comprises of inertial measurement units (IMUs), two vision cameras, and humidity sensors, water sensors for kill switches, a depth sensor and an internal pressure sensor. Returning features include a vacuum-assisted sealing system; hot-swappable battery pods, unified serial communications, and flexible mission software architecture will be install.**

Keywords- **Raspberry Pi, Stainless steel frame, Acrylic hull, Sensors, Aurdino.**

I. INTRODUCTION

Flow over submerged body has been a subject of great number of investigation mainly because of wider engineering applications. Some examples are flow over car, buildings, flight-deck of a ship, Underwater appended vessels like submarine, torpedo, automated underwater vehicle (AUV) remotely operated vehicle (ROV) etc. Autonomous Underwater Vehicles (AUV) is free swimming marine robots that require little or no human intervention. Underwater bodies are axis-symmetric or cylindrical like shapes. They are compact, self-contained, low-drag profile. The vehicle uses on-board computers, power packs and vehicle payloads for navigation, automatic control, and guidance. They are also equipped with state-of-the-art scientific sensors to measure oceanic properties, or specialized biological and chemical payloads to detect marine life when in motion.

DESIGN OF AUV

The hull of AUV houses the electrical systems and it is waterproofed. The hull, needs to have enough space for the electrical systems (for future expansion), should have a good accessibility, needs to be corrosion resistant, has to be able to withstand high impact and at the same time needs to be capable of withstanding the water pressure. A cylindrical shape is chosen for the hull because it has a favourable geometry for both pressure and dynamic reasons, at the same time it offers also enough room for the electrical systems. The hull is made out of a thick acrylic tube which keeps the hull relatively cheap, corrosion free and able to with-stand an impact. The acrylic tube is closed with aluminium plate with propylene cap at one end and another end is covered by hemispherical propylene cap. The cap consists of an aluminium ring which is permanently fixed to the hull with connectors in the aluminium plate. Sealing between the ring and the plug is ensured by a ring, Sealing is provided in the axial direction of the acrylic tube which means that water pressure will ensure more tension on the sealing area when the vehicle is submerged, since the water pressure will press the end caps against the acrylic tube. In this way a webcam, which is mounted inside the hull, can deliver an underwater view. The transparent acrylic tube is also useful to see warning lights of the central processing unit from outside the hull. The AUV has an overall length of 60cm and a maximum height and depth of 40cm.

COMPONENT PLACEMENT AND WEIGHT DISTRIBUTION:

The AUV is symmetric about the x-z plane and close to symmetric about the y-z plane. Although the AUV is not symmetric about the x-y plane it is assumed that the vehicle is symmetric about this plane, so one able to decouple the degrees of freedom. The AUV can be assumed to be symmetric about three planes since the vehicle operates at relatively low speed. The aligning moment ensures horizontal stability. The AUV remains close to horizontal in all manoeuvres and stabilizes itself, since the centre of gravitation and centre of buoyancy are correctly in right order aligned (i.e. aligning moment). This could be concluded from underwater videos made during underwater experiments. The roll and pitch movement of the AUV are passively controlled and can therefore be neglected, since the AUV stabilizes itself due to the aligning moment. Therefore, the corresponding parameters do not have to be identified.

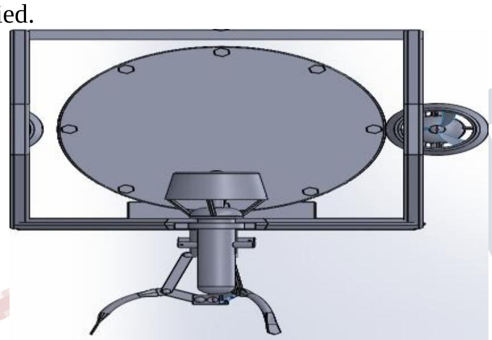

Fig. Rear View of the AUV

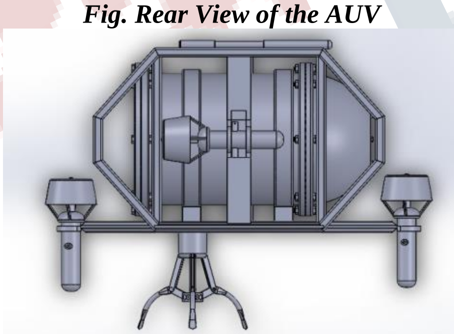

Fig. Side View of the AUV

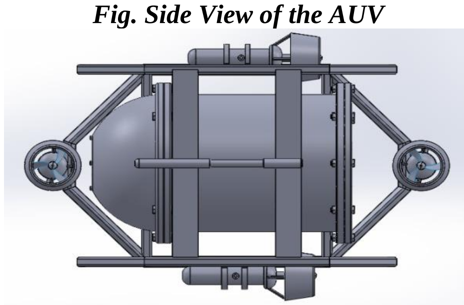

Fig. Top View of the AUV

Fig. Isomeric view of the AUV

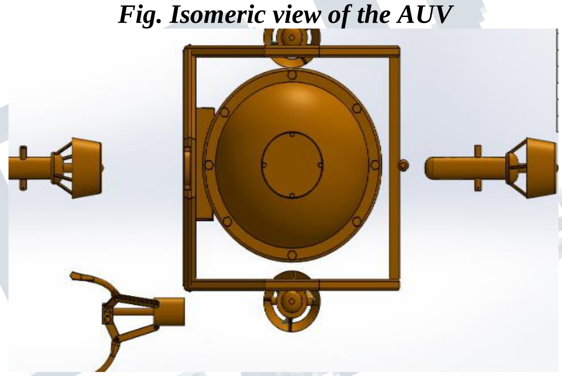

Fig. Exploded front view of the AUV

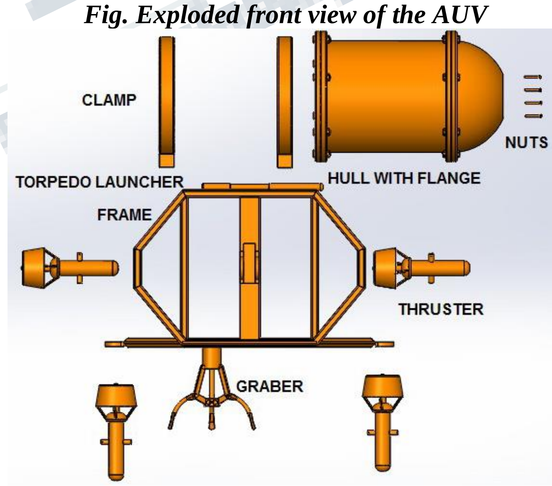

Fig. Exploded Side view of the AUV

VEHICLE SPEED

Relative low speed, so lift forces can be neglected. The AUV operates at relative low speed, i.e. max.0.5 m/s, which means that lift forces can be neglected. The low speed was verified experiments (wet tests).

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ELECTRICAL SYSTEM

VARUNA's electrical system provides the power and an interface between the on board computer and the other electronic devices. Nearly all boards are custom designed and populated in house. We designed a back panel which allows us to improve wire management for electrical interfaces between boards inside the hull.

POWER MANAGEMENT SYSTEM

The power management system of VARUNA has been designed intelligently to run for more than40 minutes. Four thrusters and all other electronics equipment used in VARUNA is powered by 5number of 7.4V 10000mAh 25C LiPo battery. 4batteries are used as power to the four thrusters where another 1 battery powers other electrical peripherals. The current and voltage across batteries, thrusters and other electrical peripherals are regularly monitored through adequate sensors and the data is stored in the storage disk. All incoming power to the vehicle is routed through the merge board, which combines up to two power sources to provide single power rail for the vehicle. The merge board draws from all batteries equally to ensure they are discharged evenly.

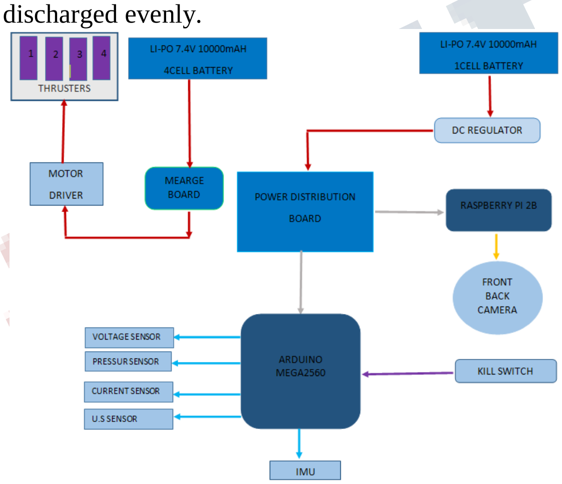

Fig: Power distribution diagram

VARUNA power management system is well equipped with a kill switch. The microcontroller is connected with all the sensors and it will off the entire power source to the AUV by measuring any fault in the system.

ELECTRONIC SYSTEM

Electronics are required in the AUV to make it capable of solving the mission tasks autonomously and effectively. The architecture has been designed to be modular enough to integrate different sensors and devices according to the specific requirements.

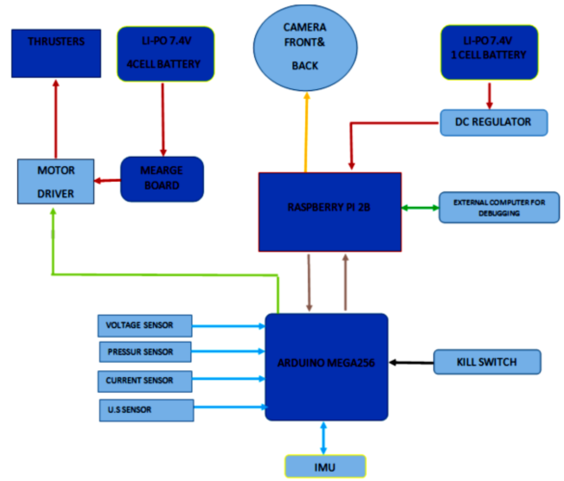

Fig: Electronics system communication Diagram

SINGLE BOARD COMPUTER: Raspberry pi

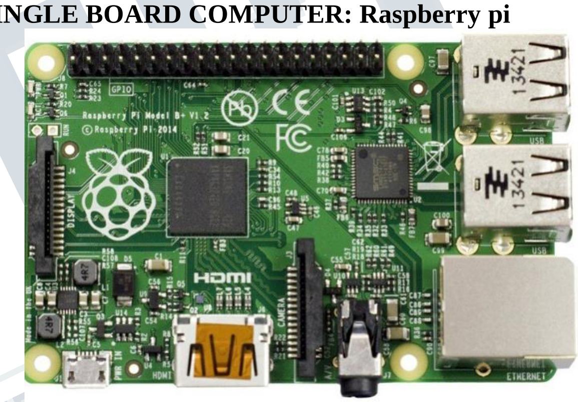

Fig. Raspberry Pi 2

We are using Raspberry Pi 2 as our single-board computer (SBC). It is a complete pocket size computer built on a single circuit board, with microprocessor(s), memory, input/output and other features required of a functional computer.

Arduino Mega 2560:

The Aurdino Mega2560 is the main microcontroller used in VARUNA. This board is connected with the main computer via USB cable. Being directed by the main on-board computer it takes logic inputs from IMU, pressure sensor and other peripherals, executes the code and hence accordingly controls the thrusters. This enables the main computer to focus on extensively image processing and mission tasks. It is engaged in accomplishing tasks in real time receiving and controlling operation units, computing controlling and stabilizing regulators, controlling thrusters as well as monitoring temperature, pressure, water leak and other parameters inside the main hull. Selection of Aurdino

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Mega2560 is determined by its good processing speed energy saving and plentiful peripherals needed to handle sensors and thrusters.

Fig. Aurdino Mega 2560

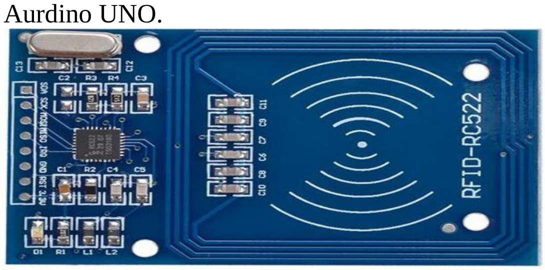
Aurdino UNO:

The Uno is a microcontroller board based on the Atmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and are set 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. This microcontroller is connected with RFID sensor.

Fig. Aurdino UNO

Main switch:

RFID: For switch on the AUV we are using RFID RC-522 with RF IC card sensor module. This system is connected with Aurdino UNO.



CAMERA: CMUcam5 Pixy

For making image processing based control, we used two Pixy CMU Cam5 cameras. These 2 cameras are place inside the hull, one camera placed in front of the hull and another one place down side of the hull. Pixy processes an entire 640x400image frame every 1/50 of a second (20milliseconds). So we get a complete update of all detected objects positions every 20ms. The 2 pixy's are connected with Raspberry pi board. This pixy camera can detect color.

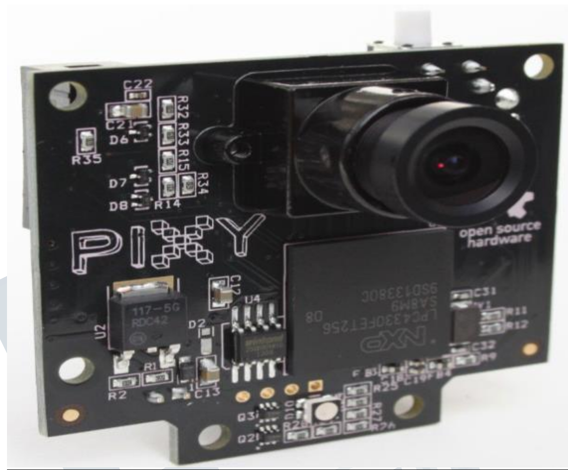


Fig. Pixy camera

MOVEMENT CONTROL:

VARUNA consists of four KZ-720B underwater thrusters. These thrusters are responsible for underwater and movement.

Thrusters:

The AUV is propelled by 4 KZ-720B underwater thrusters brush DC motor. The thrusters run on 6Vdc supply, consuming maximum continuous current of 7A. They can produce 0.72KG of maximum thrust. One thruster placed in front of AUV and another one back of the AUV to keep the AUV under the water. Another two thrusters two side of the AUV is to move the vehicle forward and reverse as well as right and left too.

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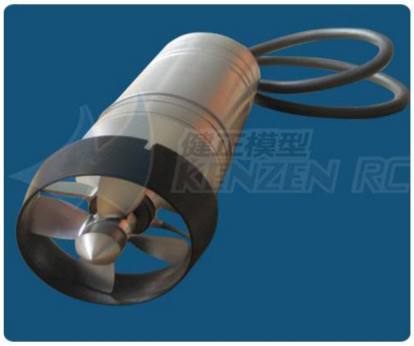


Fig. KZ-720B thruster

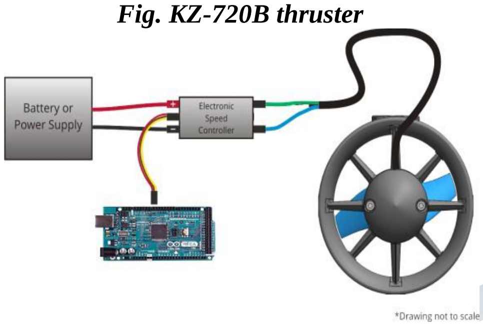


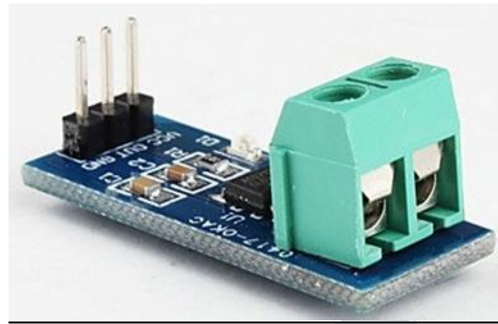
Fig. Aurdino with thruster control

SENSORS
VARUNA is well equipped with different sensors and 2pixy cameras. The following sensors provide feedback to the microcontroller.

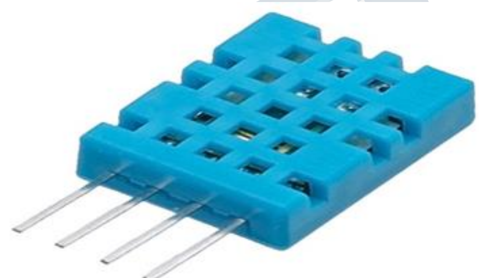
Voltage sensor:

Ultrasonic sensor:

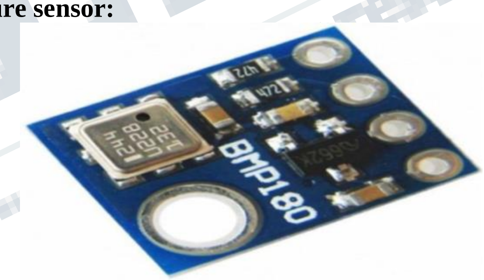
Current sensor:



Moisture sensor:



Pressure sensor:



SOFTWARE
VARUNA's software architecture is designed by the software team. The software on the vehicle is powered by a Raspberry pi 2 900MHz quad-core ARM Cortex-A7 CPU processor with 1GB RAM and along with an 16GB class 10 micro SD card. With the help of Open V-Python (Open Source Computer Vision) the coding is done in raspberry pi 2 board. Open CV-Python is a library of Python bindings designed to solve computer vision problems. Python is a general purpose programming language very popular mainly because of its simplicity and code readability. It enables us to express ideas in fewer lines of code without reducing readability.

Compared to languages like C/C++, Python is slower. Python can be easily extended with C/C++, which allows us to write computationally intensive code in C/C++ and create

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Python wrappers that can be used as Python modules. This gives us two advantages: first, the code is as fast as the original C/C++ code (since it is the actual C++ code working in background) and second, it easier to code in Python than C/C++. Open CVPython is a Python wrapper for the original Open CV C++ implementation. The software system is implemented as one stack with different packages representing various modules like vision, navigation and mission planning. The modules are entirely independent of the internal implementations of each other.

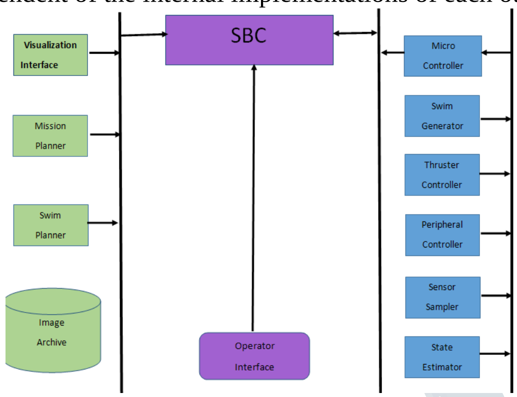

Fig. Software Architecture

ADVANTAGES

- High stable.
- Excellent navigational algorithm for providing accurate target location.
- It has low deployment costs as it does not require bulky and complex support equipment.
- High reliability.
- Improves the data quality.
- It reduces operational errors and high costs associated in employing a women operator.

FUTURE SCOPE

- Octagon Resurfacing.
- Torpedo Launching.
- Recovery Algorithm.
- Kill switch/Recovery.

II. CONCLUSION

In this project, analysis is carried out for POSEIDON model of AUV with commercial code STAR-CCM+. Both Structural and Flow Analysis is carried out for bare AUV propeller interaction for various drift an0067les. In the analysis, AKN k-ε model (buffer layer turbulence models is used for the CFD analysis The Drag co-efficient, the FOS, stress, strain, etc. are presented.

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