Technical Design Report of Matsya 6D, Autonomous Underwater Vehicle

Shubham T, Govind S, Kalp V, Sankalp B, Kaustubh C, Advait R, Shivam A, Anuj B, Anurag D, Kaushik C, Mayank B, Archit S, Nimish S, Yashas S, Aaryan D, Archit G, Sameer M, Shumail M, Suyash W, Adwai K, Akshaj A, Dhruvi M, Sparsh B, Urvi G, Anirudh J, Anshu A, Ayush P, Dey S, Siddhi D, Gokul R, Khushajh V, Yash S, Atharva M, Shivam A, Shubhi A, Aniket G, Jigar M, Om I, Shlok R, Shresth K, Akshika J, Divyanshu G, Ratan K, Jash D, Khushi T, Manit J, Anuj P, Arham S, Ayush K, Ayush L, Divya M, Manaswi G, Arush S, Avani G, Jinay V, Shivam S

Faculty Advisors: Prof. Leena Vachhani and Prof. Shashi Ranjan Kumar

***Abstract*—This year, for RoboSub 2024, Team AUV-IITB is bringing into action Mastya 6D, with new actuation systems, a reliable electrical stack and a brand-new codebase. A novel gripper was designed employing soft robotics, considering the versatility of the objects to be picked. The torpedo shooter was made simpler and easier to reload. The existing SubConn connector was replaced with our in-house connector for ease during testing and improved speeds. The power board was made smaller, and a high degree of redundancy was incorporated to ensure smooth functioning. The cameras were changed to provide a wider field of view, brighter feed, and a high data transfer rate. Most importantly, the entire software architecture was revamped to use Python instead of C++, thus making use of its extensive library support and improving readability. Finally, extensive and rigorous testing was performed on the vehicle, ensuring all functionalities were well-tested and capable.**

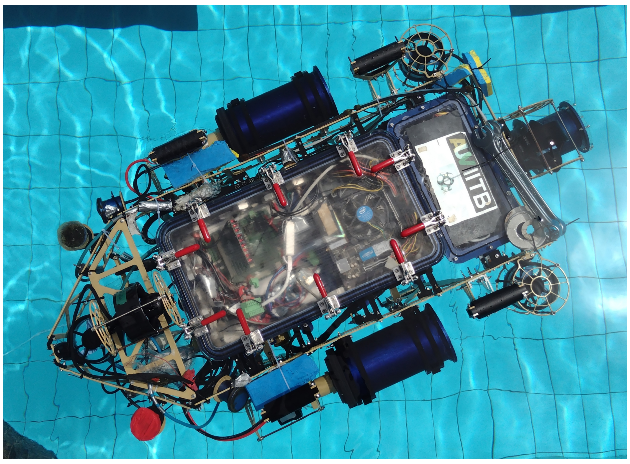

Figure 1: Matsya 6D

I. Competition Strategy

Matsya 6D is the fourth and most advanced iteration of Matsya 6, incorporating all the knowledge and experience gained from developing 6A[1], 6B[2], and 6C[3]. As we're headed to Irvine, our RoboSub 2024 strategy involves overcoming the lack of consistency in the performance of Matsya 6C. Hence, this year we have a simple yet effective strategy in mind - focusing on reliability by adjustments in the mechanical and electrical aspects of the vehicle.

A. General Strategy

Our improvements in Mastya 6D revolved around enhancing the reliability of existing features and undergoing an extensive testing process for newer ones. The team is confident in the ability of Matsya to complete all the tasks. However, given the time constraint, we shall focus on maximising our score by prioritising the highest-scoring tasks first.

B. Testing based insights

The vehicle has been tested extensively in the swimming pool, and various decisions have been made across subdivisions based on testing results. To that end, various localization methods were tested, and the most promising method was implemented. Multiple cameras were tested, and the GoPro was chosen as the front camera for its larger FoV and bright and vivid feed. We plan to use a mix of YOLOv8[4] and OpenCV2[5] for vision and decide between red and blue based on testing results. We also intend to stay with our choice for the remainder of the tasks for bonus points. Also, to increase the time for which the vehicle could be tested, we designed larger battery hulls to accommodate batteries with higher power ratings.

C. Course Strategy

- Enter the Pacific: With the two coloured plates added to the gate, detecting the obstacle has become easier. We plan on doing the coin flip and are 100% confident that we will complete this task in style.

- Hydrothermal vent: After going through the appropriate side of the gate based on the chosen color, the vehicle will hit the buoy with the torpedo and circumnavigate around it. Detection has become simple due to the single red buoy. Hence, the team is 90% confident in executing the buoy task this year.
- Ocean Temperatures: Due to the highly characteristic colors of the bin, we expect high accuracy from our vision stack. The probability of success with the open bin is estimated at 90%. After this, we would request a random pinger selection and perform either the "Mapping" task or the "Collect Samples" task based on the pinger.
- Mapping: Extensive testing and enhancements in localization have made the vehicle accurate and stable. Coupled with the bright red border, which the vehicle detects with over 80% confidence, we are 70% confident in our ability to complete this task.
- Collect Samples: Matsya would attempt to pick up three samples and place them in three different collection bins with object detection using the bottom camera. The newly introduced randomness poses a challenge to our vision stack when it comes to identifying the octagon. However, labeling each symbol as a separate entity has shown great results, and we are 85% confident of detecting it. We are focusing our efforts to pick up at least one object, primarily the Nautilus because of its large size. After completing these tasks the vehicle would resurface through the octagon.

II. Design Strategy

A. Mechanical Subsystem

The mechanical subsystem ensures the robustness of the design by performing various structural, hydrodynamic, and thermal analyses on the vehicle. Any potential design undergoes an iterative procedure involving prototyping and critical design reviews until all design requirements are met. The following sections present the work of the new actuator and connector designs.

Actuators:

This year we have come up with entirely novel designs for the torpedo shooter and gripper employing electro-mechanical systems for better control and reliability. Instead of using linearly actuated pistons, waterproof servo motors will be used along with simple 3-D printed parts.

(a) *Marker-Dropper:* The Marker-Dropper uses a single servo motor to drop two or more markers independently. It is mounted with 3D-printed parts that are lightweight and simple to assemble.

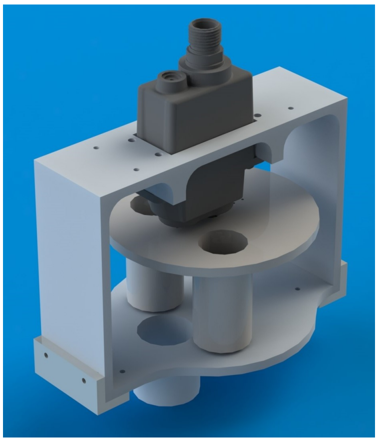

Figure 2: Marker-Dropper

(b) *Torpedo Launcher:* The improved torpedo shooting mechanism uses a simple yet elegant way to shoot two torpedoes independently using a single servo motor. To simplify the loading process, our upgraded torpedo launcher keeps the spring compressed at all times, unlike the previous version, where the spring had to be manually compressed during loading.

(c) *Gripper:* We ventured into the field of soft robotics[6] by printing our gripper claws using Thermoplastic Polyurethane (TPU). The gripper has three flexible claws with PLA inserts, providing better grip and adaptability, especially for picking up irregular objects.

Custom Connector:

A significant issue encountered during the testing of Matsya 6C was unreliable ethernet connection to the base station. To address this, we designed and manufactured a custom

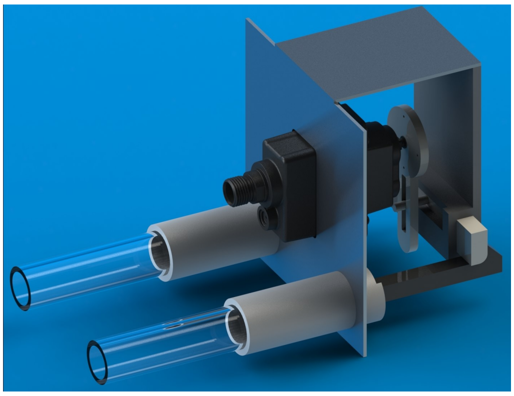

Figure 3: Torpedo Launcher

Figure 4: Gripper

waterproof connector capable of 1 Gbps data transmission, ensuring reliable access to the vehicle's SBC. Our connector is also 30 times more cost-effective than industrial alternatives.

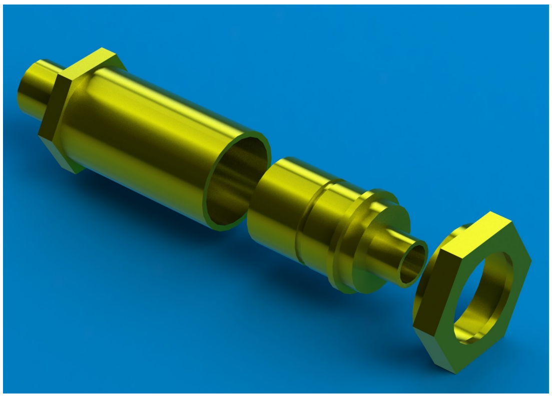

Figure 5: Custom Connector

B. Software Subsystem

The software subsystem encompasses a comprehensive stack designed to decode Matsya's environment (as captured through its various visual, acoustics, and inertial sensors) and process this information to facilitate finely tuned autonomous underwater operations.

Our source code is written primarily in Python and is organized into distinct core modules, including vision, acoustics, localization, navigator, controller, and mission control. We employ the Robot Operating System (ROS) to enable effective communication between these modules.

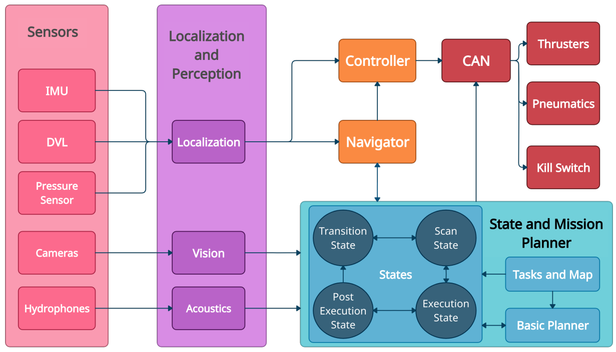

Figure 6: Software architecture of Matsya 6D depicting inter-package communication facilitated by ROS

Software Reset:

The codebase underwent a significant reconfiguration and refactoring to a more functional, minimalist, and modular design approach. Keeping in mind the rigorous tasks in Robosub 2024, we decided to shift our codebase from C++ to Python, which offers numerous advantages such as improved readability, comprehensibility, and ease of modification. Python also provides extensive library support, particularly in image processing and complex mathematical operations, which make up for any speed loss compared to C++.

Improvements in Acoustics:

We have transitioned to a new acoustics package developed in Python, moving away from the old C++ implementation. The processing pipeline involves recording 10 samples and processing each to identify the peak. We use a TDOA[7]-based algorithm to calculate the location of the pinger. Once the locations for all 10 samples are determined, we select the median to minimize the influence of outliers. We have also developed algorithms to locate the pinger using 2,3 or 4 hydrophones leading to a more robust acoustics module.

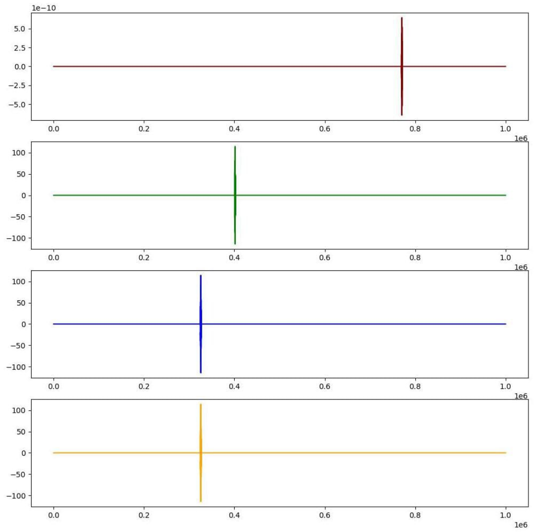

Figure 7: Detection using improved acoustic algorithms

Enhanced Control Allocation and Power Ratios:

We have built on last year's Control Efficiency Matrix (CEM)-based force allocator, which uses a pseudo-inverse of CEM to calculate thrust force given to the structure. We moved from 1 CEM to a 4 CEM-based allocator, which allows for efficient and easy tuning. To compensate for the physical effectiveness of some thrusters, we incorporated linear power coefficients for all thrusters in forward and backward directions to get better compensation accuracy.

Changes to Vision Algorithm:

Last year detections were a problem for us, hence we developed a new OpenCV2 based object detection algorithm for all tasks this year. Adding to that, we also integrated a YOLOv8-based detection algorithm for improved object recognition. To accurately predict the location of the object while performing tasks and deal with outliers, we run a linear regression post-detection using the last 10 detections.

C. Electrical Subsystem

The electrical subdivision of the team connects the software and mechanical subsystems by powering them and interfacing multiple nodes using different communication protocols. The SBC does the higher level processing such as vision, mission planner and controller. It reads/publishes data from various sensors (IMU, DVL, and pressure sensor) and the electrical stack on serial and CAN bus, respectively.

The CAN bus connects the Single Board Computer (SBC) and the electrical stack and handles the transfer of control commands and status updates.

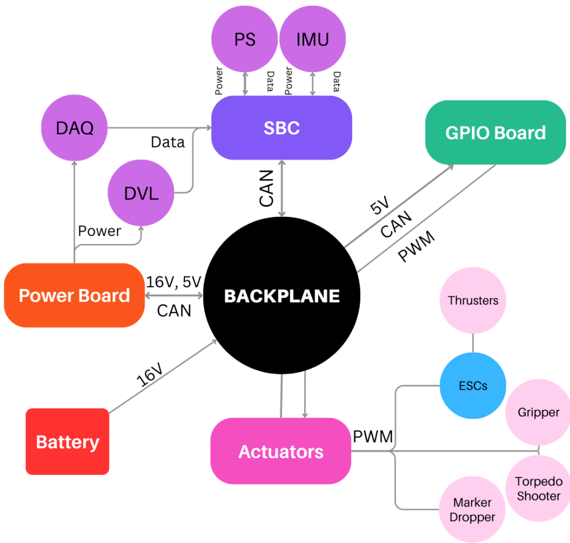

Figure 8: Electrical architecture diagram exhibiting the internal communication and power distribution

Improvements in the Electrical Stack:

The Electrical Stack serves two purposes: power distribution and general-purpose input/output. It consists of 3 PCBs, one power board for power distribution, one for GPIO, and one auxiliary backplane to facilitate easy connections with the onboard computer and peripherals.

A major issue faced while debugging is the extensive wiring and lack of space inside the main hull. Keeping this in mind, we redesigned a newer power board which is 30% smaller than the previous one. Work is in progress to further optimize the electrical stack by designing a single board that integrates the backplane, power, and GPIO boards by using the ARM-based micro-controller RP2040.

Camera:

For vision, instead of the Basler ace the vehicle was equipped with a GoPro Hero 11 Mini as the front camera. The GoPro Hero 11 Mini has better battery life and is more compact in size. Moreover, it also boasts improved FPS capabilities, wide-angle features, and plug-and-play functionality, consisting entirely of a single USB-C cable that conveniently handles power supply and data transmission.

Data Acquisition Unit:

We have replaced the NI-DAQ used in Matsya 6C for data acquisition to cDAQ-9171 as it is less bulky and has a higher compatibility with a wide range of I/O modules and software tools. The cDAQ-9171 has a USB-C port which makes it more reliable and results in faster data transmission as compared to the ethernet connection in the previously used NI-DAQ. This has resulted in easier debugging and more compact wiring.

Optimization in the ESC hull:

The ESC hull was a major point of concern from the electrical standpoint as the packed wiring due to space constraints led to issues like thruster re-initialization and faulty reception of PWM signals. To tackle this, in Matsya 6D an innovative break-out board was designed that provided a unified path for the PWM signal to go in an organized manner to the associated ESC. Power, ground, and PWM rails were integrated into the break-out board, making the wiring in the ESC hull more systematic, compact, and easier to debug.

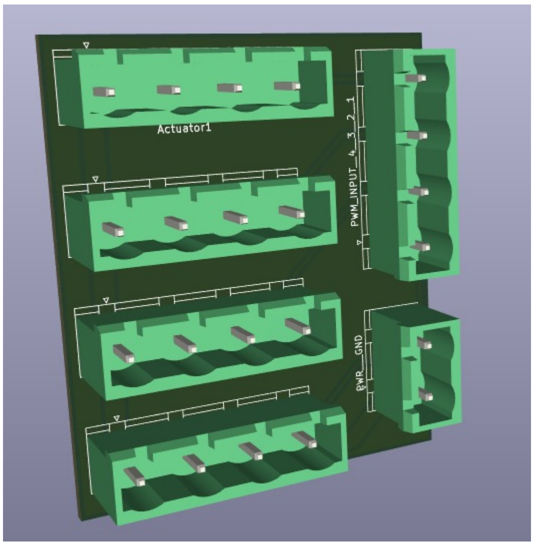

Figure 9: The break-out board in the ESC hull

III. Testing Strategy

Mastya 6D has been tested extensively for three months during the summer approaching RoboSub, as well as four months during the semester. Our summer routine started off by testing the vehicle in the pool for over seven hours across three slots. The vehicle was then taken to the lab, where maintenance and in-air testing were done. This rigorous regime refined Matsya 6D's systems to such an extent that most results are now reproducible, enabling us to meet the requirements of our fundamental target: Pre-qualification.

A. Mechanical Verification:

The first step for safe and successful testing was to validate the vehicle's waterproofing. This was done by removing all the components inside the hulls and keeping them overnight in the swimming pool at a depth of 2.5 meters for more than 12 hours. Moisture would be detected by foam stuck on the inner walls of the hulls and chalk marks around the penetrators.

B. Controller Calibration:

The next step was to tune the controller so that our vehicle would be capable of performing the tasks. Floats were added to the vehicle's frame to enhance its stability and achieve a favorable center of buoyancy and center of gravity alignment. Through extensive controller testing, we observed that certain navigation plans were more suited to longer distances, while simultaneous control of all degrees of freedom offered efficient solutions for smaller position adjustments. Post-tuning, the vehicle reached set-points of up to 20m.

C. Vehicle localization:

In the course of testing, we observed a 15% drift in position calculated using the DVL solely. By instead integrating the velocity provided by our DVL and using the IMU's orientation readings for the transformation, we were able to decrease the drift to 0.5%-2%, allowing us to localize the vehicle more robustly.

D. Vision Detections:

With two months until RoboSub, we shifted our focus to perfecting vision after fine-tuning the vehicle's motion in water. We tested the vision stack by training the YOLOv8 model on a dataset of prop images taken in our swimming pool. CV-based detection yielded excellent results for simple objects like buoys and bins, leading us to base our vision code on a combination of YOLOv8 and OpenCV2. However, detection became difficult later in the day due to reduced lighting in the pool.

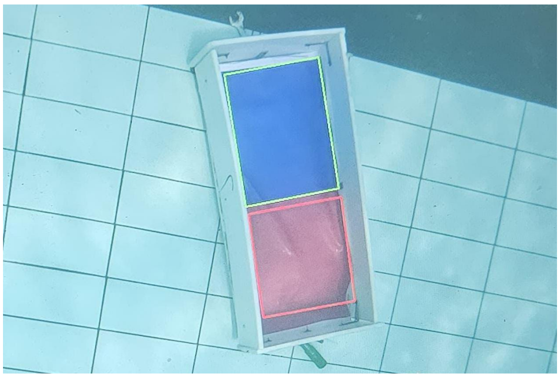

Figure 10: Accurate detection of the bin by Mastya 6D

E. **Hardware Reliability:**

Most of the road bumps faced during testing were due to hardware failures, such as loose connections or an IC overheating in the electrical stack. To debug these issues, in-air testing of the vehicle was done regularly. This consisted of checking the electrical stack using a power supply, running the thrusters individually to check for smooth operation, analyzing the PWM signals sent to the ESCs using an oscilloscope, and performing continuity check of the Gigabit CAT6 LAN cable used for testing.

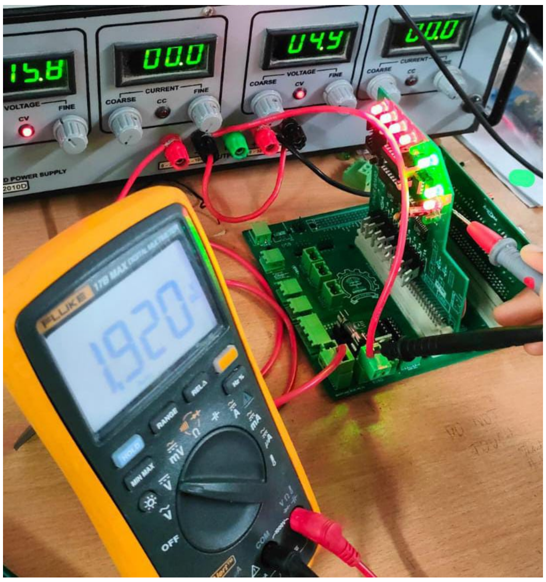

Figure 11: In air-testing of the electrical stack

IV. Acknowledgements

The team would like to extend its heartfelt gratitude to the Industrial Research and Consultancy Centre (IRCC) of IIT Bombay for their exemplary administrative and monetary support throughout the project. Their unwavering assistance was instrumental in enabling our participation in RoboSub 2024. Furthermore, we express our sincere appreciation to the Dean of Research and Development's office, whose guidance was pivotal in the successful execution of our project. We are deeply thankful for the generous support from our esteemed sponsors. Their contributions have been essential to the success of our project. We would like to offer special thanks to Blue Robotics and Teledyne RDI for their outstanding assistance in resolving technical issues. Their swift and expert support was crucial in helping us meet our goals while staying within our budget constraints. We are profoundly appreciative of their dedication and partnership, which have been vital to our progress and achievements.

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Appendix A: Component Specifications

Component	**Vendor**	**Model/Type**	**Specs**	**Custom/ Purchased**	**Cost USD**	**Year of Purchase**
Buoyancy Control	Designed In-House	Dead Weights & Foam	-	Custom	-	-
Frame	Designed In-House	Aluminium & Delrin	4 kg	Custom	800	2022
ASV Hull Form/ Platform	Designed In-House	Aluminium Hulls w/ Acrylic Endcap	8 Hulls weighing 22 kg Depth Rating : 70 ft	Custom	1800	2022
Waterproof Connectors	Designed In-House	Aluminium	24 connectors weighing 1.5 kg in total	Custom	150	2022
Propulsion	Blue Robotics	T200	11 and 9.5 kgf forward and backwards	Purchased	1600	2022
Motor Control	Blue Robotics	Basic R3 Version	30A PWM controlled brushless motor speed controller	Purchased	200	2022
High Level Control	Microchip Technology	Atmega 328P and 32M	Low Power CMOS 8-bit RISC Microcontroller	Purchased	15	2022
Actuators	BlueTrail Engineering	SER-110X	29.0 Kgf-cm of torque, 140 degrees range	Purchased	340	2023
Battery	SkyCell	LiPo Battery	4 Cell and 16000mAh x 2	Purchased	400	2022
Converter	Texas Instruments	TPS5430DDA	Wide Input Range, Step-Down Converter	Purchased	4	2022

FPGA	Xilinx	Zybo Z7-20	Programmable logic equivalent to Artix-7 FGPA, DDR3L memory controller with 8 DMA channels and 4 High Performance AXI3 Slave ports, 667 MHz dual-core Cortex-A9 processor	-	300	-
Regulator	Mini-Box	M4ATX	High efficiency 250W output, $< 1.25mA$ standby current	Purchased	80	2022
CPU	AMD	Ryzen 3400G (4C8T)	4 Cores (4.2GHz), 8GB RAM	Purchased	-	2022
GPU	Nvidia	GeForce GTX 1660ti	GDDR5, 6GB, 120W	Purchased	300	2022
Internal Comm Network	Microchip Technology, CAN USB	MCP 2515, MCP 2551, CAN USB	1 MB's operation limit	Purchased	150	-
External Comm Interface	-	Ethernet	10-100 Mb/s	Purchased	-	-
Inertial Measurement Unit (IMU)	Microstrain	GX5	-	Purchased	-	2022
Doppler Velocity Log (DVL)	Waterlinked	A50	-	Purchased	-	2022
Cameras	GoPro	Hero-11 Mini	-	Purchased	-	2023
Hydrophones	Teledyne	RESON Underwater TC 4013	-	Purchased	-	2022
Algorithms: Vision	YOLO v8	-	Parallel and Sequential processing, lens formula	-	-	-
Algorithms: Acoustics	FFTW	Time difference of arrival	Filtering in frequency & time domain	-	-	-

Algorithms: Localization and Mapping	Orocos BFL	Extended Kalman Filter	EKF applied on position found by integration of DVL velocity	-	-	-
Algorithms: Autonomy	-	State Machine & Mission Planner	Probabilistic (or Finite) state machine for mission planner, designed in-house	-	-	-
Open Source Software	OpenCV, Eigen, ROS, YOLO v8	-	-	-	-	-

Appendix B: Testing Box

Electrical Equipments

- Solder Gun
- Solder Stand
- Solder Wire
- Wire Stripper (Both normal and AWGfancy stripper)
- Ethernet Cable
- HDMI Cable
- Micro USB for screen
- Screen
- LAN Spool
- Multimeter
- Batteries (spare and charged)
- Battery Chargers
- Extension cords
- Screw Drivers
- USB extenders
- Scissors
- USB ASP
- Glue Gun and Glue Sticks
- Arduino Uno boards
- Arduino Cable
- Spare Atmegas and CAN ICs
- Duct Tape/Insulation Tape
- Jumpers
- Single Strand Wire
- AWG wire
- Mouse
- Keyboard

Mechanical Equipments

- Allen key and spanner box
- PSD
- Drill bits
- epoxy
- cups
- cardboard piece
- tissue
- chalk
- duct tape
- zip ties
- rope
- nuts, bolts, washers
- floats
- mini hacksaw
- scissors
- pvc pipe

Appendix C: Testing Procedure

Controller

Required Equipment

- Matsya AUV
- AUV ethernet tether
- 2 Batteries
- Operator laptop with ethernet connector
- A pool with minimum size of 10m x 10m x 4m (L x W x D)

Steps

1) Connect batteries to the AUV and power on the onboard SBC in the AUV
2) Connect ethernet tether between AUV and the operator laptop
3) Power the laptop on and open SBC terminals using ssh and go to `matsya` directory
4) Run the `driver_run.py` script (all sensor drivers)
5) Check the ROS topics running using the command `rostopic list` to ensure all the sensors are giving data.
6) If all the sensor drivers are publishing the data, launch the localisation package using the command `roslaunch auv_localisation localisation.launch`
7) To view the location data, run the command `rostopic echo /localisation/pose` on a new terminal
8) Reset the origin of localisation data using a service call
9) Unkill all the thrusters using a ROS service call
10) Launch controller package using the command `roslaunch auv_controller controller.launch`
11) If the vehicle is unstable or moving in an undesirable manner then perform the following checks and tuning in the specified order:
    - Check thruster mapping and direction by giving individual PWM values to each thruster using `can_driver.py`.
    - Tune the CEM values (yaml files) for all directions in the order - heave, surge, sway, roll, pitch & yaw by giving global force in the script `allocator.py` until the vehicle moves desirably for a given global force
    - Tune the PID values (`pid_constants.yaml`) for all directions in the order - Kp, Kd, Ki to make the AUV stable at origin after running steps 1-10
    - Give a setpoint to AUV by publishing a setpoint to the ROS topic `/controller/setpoint` using the command - rostopic pub /controller/setpoint auv_msgs/msg/Setpoint \<setpoint>"
    - Observe the movement of the AUV using the localisation data (step 7)
    - Observe how fast does the AUV reach the setpoint or overshoots from the setpoint and accordingly change the Kp, Kd, Ki values of that degree of freedom
12) Ultimately, all the CEM values and PID constants (controller config) should be tuned such that the AUV reaches a given setpoint as desired

Vision

Camera Operations

1) The cameras require the following script to be running at all times: `python3 cam_main_gopro.py`
2) The script is located at: `~/catkin_ws/src/matsya/auv_drivers/scripts/cam/`
3) Toggle cameras using:
   - `rosservice call /cam/front`
   - `rosservice call /cam/bottom`
   - `rosservice call /cam/stop`
4) For viewing live feed from a camera, use:
   - `rosrun image_view image_view image:=/cam_front/raw_image`
   - `rosrun image_view image_view image:=/cam_bottom/raw_image`
5) If the live feed is unresponsive due to poor ethernet connection, use:
   - `rostopic echo /cam_front/raw_image`
   - `rostopic echo /cam_bottom/raw_image`
6) Launch the `auv_vision` package for detections: `roslaunch auv_vision scam_vision.launch`
7) Setpoint of the detections can be read:
   - Using the output in the terminal running `auv_vision` package
   - Using the topic `/vision/setpoints`

Tuning

- Tune HSV values & min_area values in `constants.py` located at: texttt˜/catkin_ws/src/matsya/auv_vision/scripts/cv/

Troubleshooting

- If the camera driver script `python3 cam_main_gopro.py` does not recognize the camera, check if the device recognizes the camera using `lsusb`
- To check IP addresses: `hostname -I`
- To check the accuracy of detections:
  - View images in folders: `raw_imgs`, `bbox` at `~/catkin_ws/src/matsya/auv_vision_scripts/`
  - Copy images using secure copy command: texttscp -r auv@192.168.198.45:˜/catkin_ws/src/matsya/auv_vision/scripts/raw_imgs/* .

Mission Control

Scripts and Configuration

- The scripts have function calls in the following order: `main.py` → `perform_task.py` → `matsya.py`
- A sequence of tasks can be set in `rs24_mission.yaml` located at: `~/catkin_ws/arc/matsya/auv_mission_control/config/`
- Every task is described by a name, timeout period (seconds) and a list of navigator actions with its own set of subparameters.- Sample:
  Mission_control:
  plan: → describes the list of tasks to be performed in the autonomous run
  num_tasks: 1 → describes the number of tasks in the autonomous run
  mission:
  - *main: "Bin"* → the same task name ought to be used below
  backup: ""
  Bin:
  task_timeout: -1 → a task is aborted midway on exceeding task_timeout; when set to *-1*, mission control waits for all navigator actions to either in turn exceed timeout or complete successfully
  actions:
  - *name: "align_continuous"* → only actions described in auv_navigator package are permissible
  scan_type: "horizontal_spiral" → a subparameter of navigator action; alternatives here are *vertical_spiral*
  camera: "bottom"
  align_displacement: → a subparameter of navigator action; describes the relative setpoint
  x: 0
  y: 0
  z: -30
  roll: 0
  pitch: 0
  yaw: 0
  align_pos_tolerance: 10.0 → a subparameter of navigator action; that describes the permissible limit for x, y & z localization coordinates in centimetres to confirm that the action has been successfully completed
  align_angle_tolerance: 5.0 → a subparameter of navigator action; that describes the permissible limit for roll, pitch & yaw localization coordinates in degrees to confirm that the action has been successfully completed
  timeout: -1 → a subparameter of navigator action; describes the time after which an action is considered unsuccessful and the *perform_task.py* script can move to the next navigator action
  - *name: "scan_align"*
  scan_name: "hover"
  align_displacement:
  x: 0
  y: 0
  z: 20
  roll: 0
  pitch: 0
  yaw: 0
  scan_timeout: -1
  align_timeout: -1

verify_timeout: -1
align_pos_tolerance: 1
align_angle_tolerance: 1
verify_pos_tolerance: 1

- Every task has an approximate setpoint described by 6 coordinates (x, y, z, roll, pitch & yaw)set by the user before an autonomous run by AUV Matsya in the following file *~/catkin_ws/src/matsya/auv_mission_control/config/map.yaml*

Appendix D: FLOWCHARTS AND ALGORITHMS

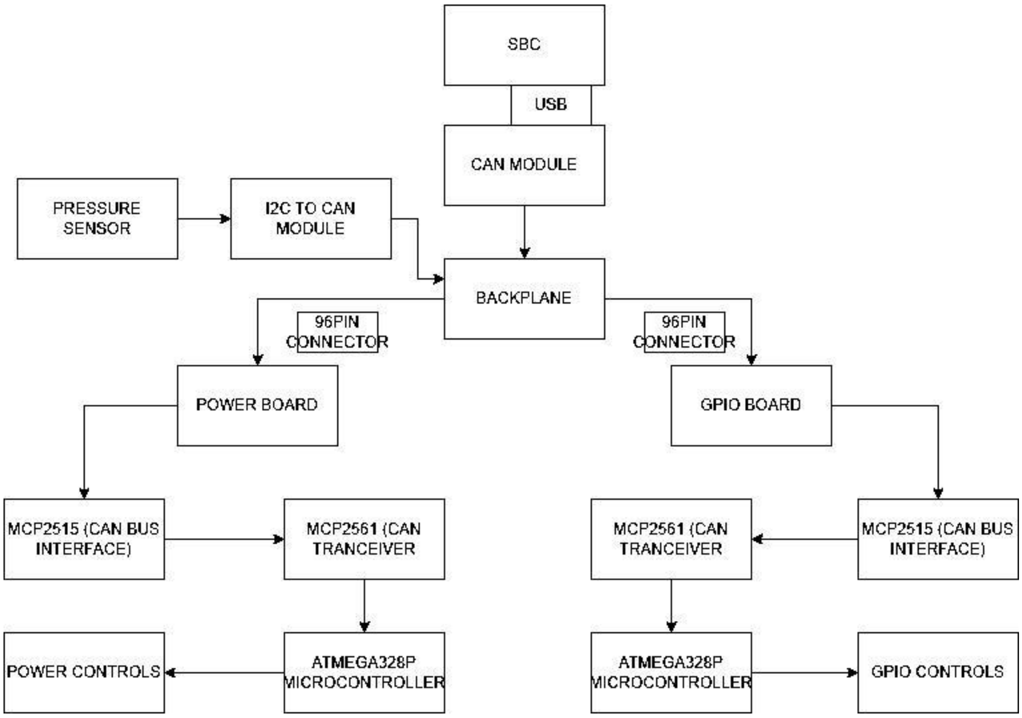


Figure 12: Communication via CAN

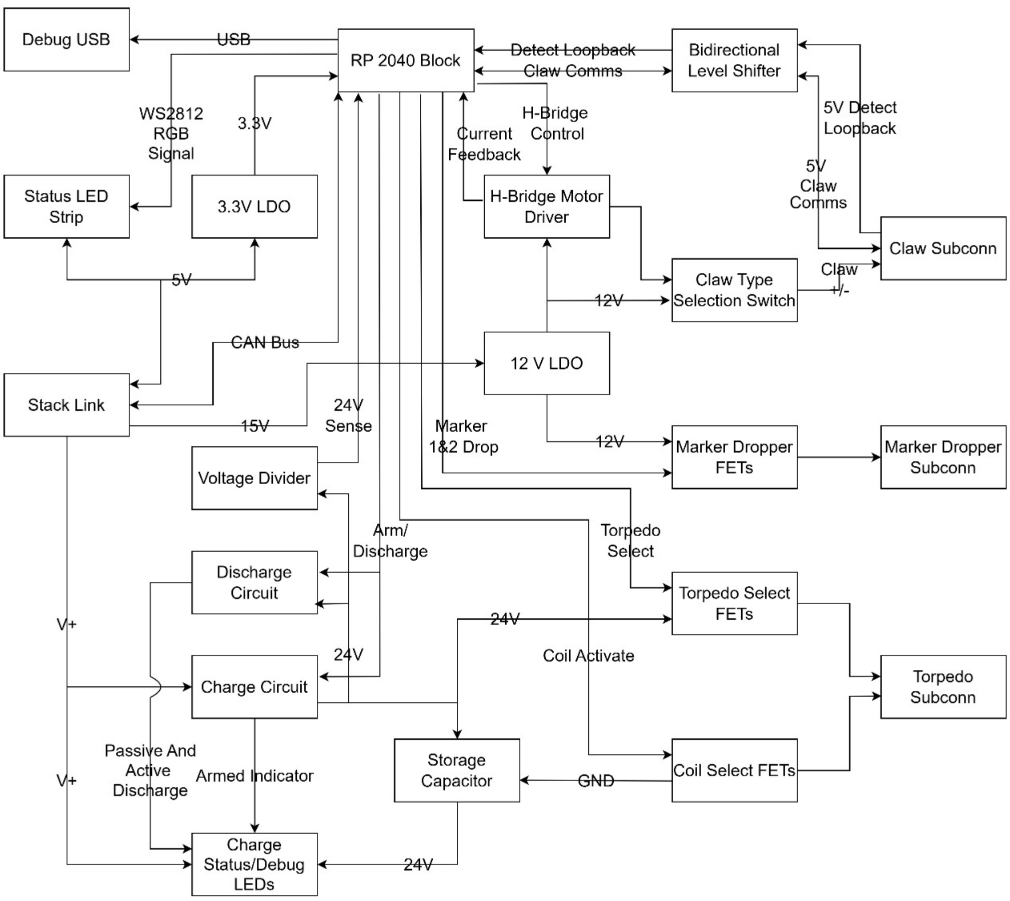


Figure 13: Power board

Figure 14: Mission Controller

Appendix E: Outreach Activities

Community Engagement and Outreach

The AUV-IITB Team actively engages with the community through various workshops and exhibitions each year. These events serve as platforms to inspire young students from schools and high schools to explore the field of robotics. During these exhibits, the team showcases the functionality of their AUV, followed by a detailed seminar and a QA session to enhance students' understanding and interest in AUVs and robotics.

Figure 15: Displaying the vehicle to students at an exhibition

Recognition and Interaction with Prime Minister

Notably, Prime Minister of India, Shri. Narendra Modi, interacted with Matsya 4 at IIT Bombay, underscoring the significance of our work.

WISE: Empowering Future Women in Science and Engineering

Figure 16: An interactive session with the WISE community

The Women in Science and Engineering (WISE) program invites 150 high school girls to campus for a few days of immersive exposure to cutting-edge technologies and scientific exploration. As part of this initiative, the AUV-IITB Team had the honour of presenting our autonomous underwater vehicle (AUV) to these aspiring young scientists. Our AUV presentation inspired these talented young women to envision their futures as leaders in science and engineering. Through WISE, we proudly contribute to empowering the next generation of female innovators.

Participation in MTS TECHSYM

In 2020, we participated in the MTS TECHSYM Students' Technical Symposium on Advances in Engineering and Technology at IIT Madras. This event provided an opportunity to interact with professors and students nationwide who are dedicated to maritime technologies. Our poster presentation, which highlighted the advancements in Matsya, received a special mention, aiming to inspire other AUV teams in their endeavors.

Workshops and Training

We also conducted a week-long workshop for the student technical team from Bannari Amman Institute of Technology, Tamil Nadu, focusing on the design and manufacturing of AUVs.

Inspiring Young Minds

The joy and enthusiasm we witness, especially from young students like those at Witty International School, are incredibly rewarding and drive us to strive for further innovations.

A. Research and Development

Academic Contributions

Our research has significantly contributed to several students' academic projects, including Masters and BTech dissertations on topics such as Control of Overactuated Nonlinear Systems, Navigation of Unmanned Vehicles, Design of a 2-Link Gripping Mechanism, and Sunlight Flicker Removal. This academic impact further motivates us to push boundaries and deliver outstanding results.

Mentorship and Guidance

Moreover, we mentor various aspiring AUV teams across India, including those from IEM Kolkata, KJ Somaiya College of Engineering, Mumbai, Sahyadri College, NIT Rourkela, IIT Kanpur, and VIT Pune. Our guidance covers the entire process of building an AUV, emphasizing the importance of communication, documentation, and securing funding.

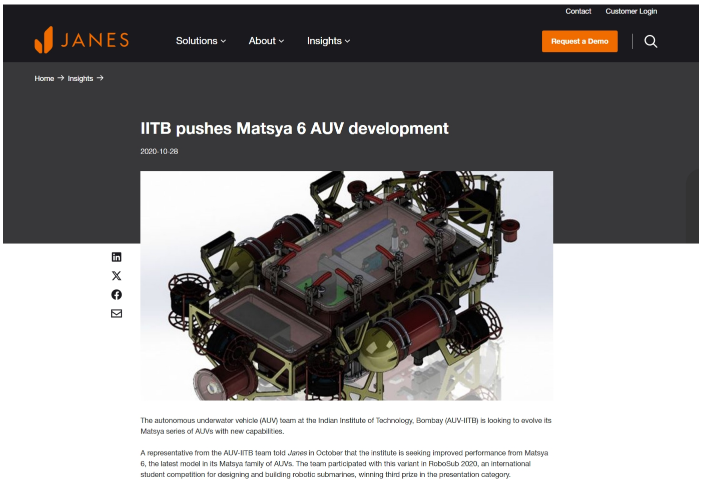
Design of Battery Management System for AUVs

The research paper "Design of Battery Management System for an Autonomous Underwater Vehicle" was presented by Team AUV-IITB at the Oceans Conference Exposition Chennai 2021. This paper focuses on optimally utilizing battery capacity and implementing essential protections.

B. Competitions and Recognitions

IEEE OES Young Researchers' Prize

Team AUV-IITB is the recipient of the prestigious Young Researchers' Prize awarded by IEEE OES (Ocean Engineering Society) at the Underwater Technology Competition 2021, organized by the University of Tokyo, Japan. We presented a 15-minute long video highlighting our journey so far, including the development of six underwater vehicles and various research projects the team has undertaken over the years.



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IITB pushes Matsya 6 AUV development

2020-10-28

The autonomous underwater vehicle (AUV) team at the Indian Institute of Technology, Bombay (AUV-IITB) is looking to evolve its Matsya series of AUVs with new capabilities.

A representative from the AUV-IITB team told *Janes* in October that the institute is seeking improved performance from Matsya 6, the latest model in its Matsya family of AUVs. The team participated with this variant in RoboSub 2020, an international student competition for designing and building robotic submarines, winning third prize in the presentation category.

Figure 17: Article published in the Janes Magazine

Janes Feature

The research and development of Matsya 6C got featured in Janes, an international-level defense-related magazine. AUV-IITB is amongst the first student teams from India to be recognized at this level.

Engineer's Conclave at Inter-IIT Tech Meet

Team AUV-IITB participated in the Engineer's Conclave as part of the contingent of IIT Bombay at the inter-IIT Tech Meet 2021 held virtually. The team presented a poster demonstrating the working methodology and capabilities of Matsya. The event helped in increasing the team's outreach amongst like-minded tech enthusiasts from various IITs. The progress made by the team was acknowledged and appreciated by all the participants.

Tech Expo at Abhiyantriki 2020

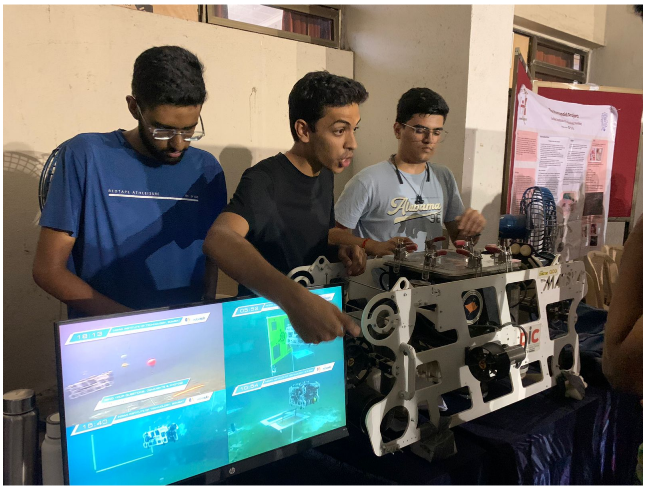

Figure 18: AUV-IITB Info Booth

Last year, the team participated in the Tech Expo event of Abhiyantriki 2020, the Annual Technical Festival of KJ Somaiya College of Engineering, Mumbai. The team presented the history of Matsya from 2011 to 2020 to a large number of technocrats, enthusiasts, and students. This expo had exhibits from major organizations like DRDO, BARC, IMD, and DAE.

INEST India 2020

Team AUV-IITB was invited to present a research paper at the prestigious International Conference INEST India 2020, INS Shivaji, Lonavala before the Chief of Navy and international marine specialists. Unfortunately, the event was called off due to Covid-related circumstances.

The collective efforts and the recognition we receive, fuel our passion and commitment to advancing AUV technology and inspiring the next generation of engineers and innovators.