Vortex NTNU - RoboSub 2019

Manta
Norwegian University of Science and Technology

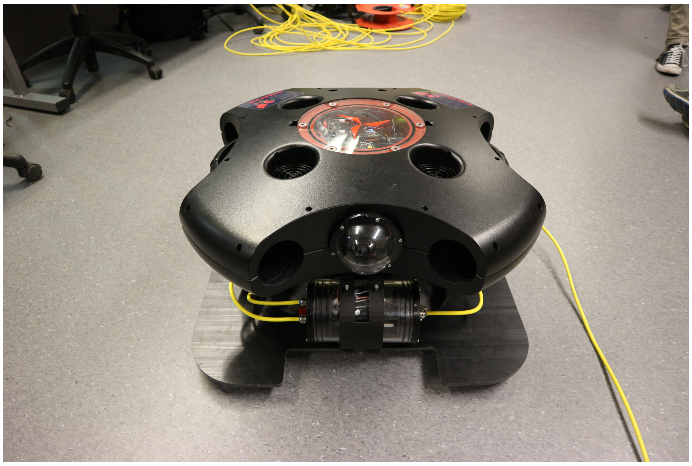

Fig. 1: Manta

***Abstract*—Vortex NTNU is an independent student organization at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway. Our team is composed of 21 students from different engineering disciplines at NTNU. The last three years we have conceived, designed, and built ROV's to compete in an international ROV competition. This year we have taken a step further made our first Autonomous Underwater Vehicle (AUV). We are newcomers to Robonation's RoboSub and are looking forward to present what we have been working on for the last year.**

I. Competition Strategy

This year we have transformed last year's ROV, Manta, into an AUV. The transition from ROV to AUV is significant and with limited time we had to prioritize our efforts. We have mainly focused the navigation tasks as well as most of the computer vision aspects of the competition. We have also started to develop an acoustic localization system but it is unfortunately not reliable enough to use in the competition yet.

Our strategy is to collect as many points as we can without the task spesific tooling as well as gather as much experience as possible so that we can come back as a contender for the top spots next year.

II. Vehicle Design

Our vehicle is consistion of two parts; the main body of Manta and it's skid. The main body includes the thrusters, motorcontrollers, batterymodules and kill switch as well as the main on-board computer, which makes it can operational by it self. On the skid we have periferals such as additional sensors, cameras, equipment and extra space for actuators. The skid is designed to be modular and easy to modify.

A. Mechanical Design

Mantas core components are centered around a cylindrical aluminum housing with a transparent acrylic lid. The water tight enclosure is surrounded by a ABS body, consisting of a top and bottom frame, securely bolted together. Each of Mantas eight vectored thrusters are integrated into the polymer frame and are not vulnerable to accidental impact. In front, Manta has an acrylic dome containing an actuated camera with full vision ahead. To get a greater field of view we have equipped Manta's skid with an extra camera pointing downwards.

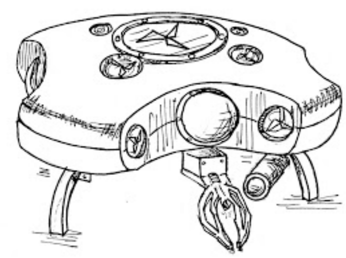

Fig. 2: Conceptual design of Manta

B. Electronical Design

1) Battery module: Manta is equiped with two 14.6V 6750mAh LiPo batteries placed in separate enclosures connected to the killswitch with wetconnectors making it possible to easily swap battery modules without much disassembly. The kill switch is triggered by removing a handle with a static magnet on the end. This removal triggers the magnetic Hall-effekt switch and a relay cuts the power from the batteries.

2) Sensors: The biggest hardware upgrades we have had on Manta this year has been it's sensors. We have been lucky to get our hands on a STIM300 Inertial Measurement Unit from Sensonor and DVL1000 Doppler Velocity Log from Nortex. Both of these measurement units are lightweight and have exceptional accuracy.

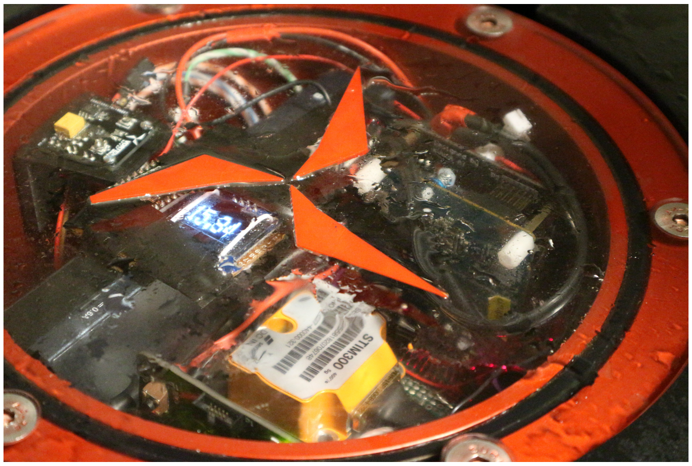

Fig. 3: Manta's main enclosure

C. *Software Design*

We have split our software members into two groups, one focusing on perception and another focusing on the control system and mission planning.

1) Perception: The perception group is responsible for Manta's observation and sensing of it's invironment trought it's sensors and cameras. The measurement from the IMU, magnetometer, pressure sensor and DVL gets filtered through a Kalman filter and the estimated position is used by the rest of the control system. A combination of classical computer vision and deep learning is used to observe the objects and tasks throughout the course.

2) Control: The control group is responsible for Manta's control system and missionplanning. We are using ROS as framework and all of the control code is written inhouse. Gazebo has been used to simulate manta in an underwater environment and test the control system and mission planner through the mission course.

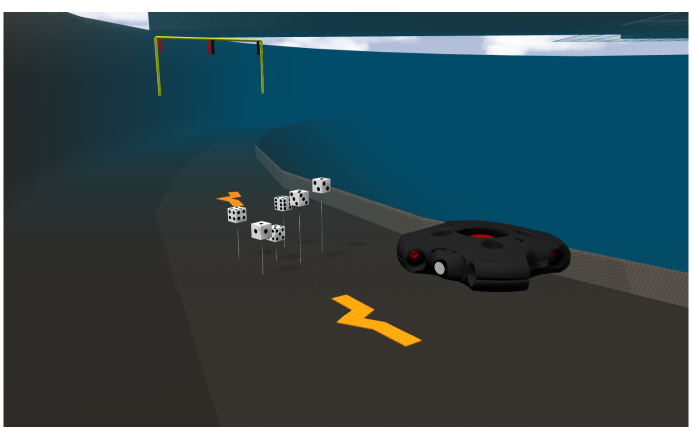

Fig. 4: Simulator in Gazebo

III. Experimental Results

Most of our software testing has been happening in our Gazebo simulator. Unfortunatly we did not have time to get the in-water testing hours we wanted, but each module on Manta has been tested separately.

IV. Acknowledgements

Vortex NTNU would like to thank the following contributors for their support and guidance in the development and production of Manta, and making our journey to the 2019 RoboSub competition possible:

- Robonation: For hosting Robosub.
- Equinor: Our main collaborator. Funding most of our components, and technical guidance.
- NTNU Department of cybernetics and Department of Marine Technology: Providing offices, labs and workshop areas. Funding of lab equipment, components and pool facilities.
- Water Linked AS: Supporting us with one of their acoustic SBL systems and technical guidance.
- FFU: Financial support and the opportunity to write for Norways largest news magazine for subsea technology and underwater robotics, DYP.
- Nortek AS: Providing one of their high quality DVL1000 - Doppler Velocity Logs.
- Sensonor AS: Providing a STIM300, a small, tactical grade, low weight, high performance non-GPS aided Inertial Measurement Unit (IMU).
- Mechman AS: Machining and production of Manta's top boyancy hull.
- Blueye AS: Providing us with Blue Robotics T200 thrusters and valuable knowledge in development of underwater.

APPENDIX A

Subjective Measures			
	Maximum Points	Expected Points	Points Scored
Utility of team website	50	40	
Technical Merit	150	90	
Written Style	50	5	
Capability for Autonomous Behavior	100	70	
Creativity In System Design	100	60	
Team Uniform	10	10	
Team Video	50	25	
Pre-Qualifying Video	100	100	
Discretionary points	40	0	
Total	650	400	
Performance Measures			
	Maximum Points	Expected Points	Points Scored
Weight	See Table 1 / Vehicle	15	
Marker	−1000	0	
Gate: Pass through	100	100	
Gate: Maintain fixed heading	150	150	
Gate: Coin Flip	300	300	
Gate: Pass through 60 percent section	200	-	
Gate: Pass through 40 percent section	400	400	
Gate: Style	800	400	
Collect Pickup: Crucifix, Garlic		-	
Follow the "Path"(2 total)	100 / segment & 200	200	
Slay Vampires: Any, Called	300, 600 & 300	300	
Drop Garlic: Open, Closed	700, 1000 / marker (2 + pickup)	-	
Drop Garlic: Move Arm	400	-	
Stake through Heart: Open Oval, Cover Oval, Sm Heart	800, 1000, 1200 / torpedo (max 2)	-	
Stake through Heart: Move lever	400	-	
Stake through Heart: Bonus - Cover Oval, Sm Heart	500	-	
Expose to Sunlight: Surface In Area	1000	1000	
Expose to Sunlight: Surface with object	400/ object	-	
Expose to Sunlight: Open coffin	400	-	
Expose to Sunlight: Drop Pickup	200 / object (Crucifix only)	-	
Random Pinger first task	500	-	
Random Pinger second task	1500	-	
Inter-vehicle Communication	1000	-	
Finish the mission with T minutes (whole + factional)	Tx100	-	

APPENDIX B

Component	Vendor	Model/Type	Specs	Value(if new)
Buoyancy Control	Mechman AS			-
Frame	3A Prototype			-
Waterproof Housing	Machined inhouse + bluerobotics			
Waterproof Connectors	-			
Thrusters	Bluerobotics	T200		8*170$
Motor Control				
High Level Control				
Actuators				
Propellers				
Battery				
Converter				
Regulator				
CPU	ODROIDXU4 + NVIDIA TX2			
Internal Comm Network	Ethernet			
External Comm Interface	Ethernet			
Programming Language 1	C++			
Programming Language 2	Python			
Compass				
Inertial Measurement Unit (IMU)	Sensonor	STIM300		
Doppler Velocity Log (DVL)	Nortek	DVL1000		
Hydrophones	Water linked as	A1		
Manipulator	-			
Algorithms: vision	Yolo v3 tiny			
Algorithms: acoustics	-			
Algorithms: localization and mapping	Orb-slam			
Algorithms: autonomy	Smach			
Open source software:	ROS			
Team size(number of people)	21 members			
HW/SW expertise ratio	1/3			
Testing time: simulation	100 hours			
Testing time: in-water	20 hours			