Krakens Auvs: Release the Baby Kraken – Robosub 2021

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***Abstract*— The Krakens team makes its first participation in Robosub, which is also its first AUV: the baby Kraken. Fruit of the effort of more than twenty engineering students from the most diverse areas, this prototype inaugurates the entry of the second Brazilian team to participate in RoboSub. The main focus in the construction of this vehicle was in its basic operability, that is, in its minimum conditions of orientation and proper motion in the pool, albeit at the cost of fully carrying out some tests. It is a first step by our newly formed team towards future more complete and more authoritative prototypes.**

I. Introduction

The Krakens AUV's is a team of students from the Federal University of Itajubá (UNIFEI), whose main objective is the construction of autonomous underwater vehicles. The team was founded in March 2019 on the university campus, is new in the RoboSub and is starting in the competition this year 2021. The idea of founding a team that works in the construction of submarines came after 8 students observed a yellow boat floating in a flood in the region. From this, the team was created, increases every year and currently has 32 members. The project is divided into 4 areas, namely: Management and Marketing, Hardware, Software and Mechanics, and our members are students from various courses at the university who deal with the responsibility of planning, building, programming and designing the vehicle. Our proposal for this year's underwater vehicle, the Baby Kraken, is designed to achieve good scores autonomously, based on the competition's basic tasks.

II. Competition Strategy

The main strategy adopted by the team is to aim for the highest score possible in the basic tasks. The team is currently in its first year of competition, so the adopted strategy is based on the knowledge already obtained from the studies, understanding the limitations due to the team's lack of experience in building a submarine and the limitations in executing the necessary missions. To this purpose, the entire project was developed with the current situation in mind, so that it can be enhanced later.

III. Design Creativity

A. *Mechanical Design*

The AUV's design was defined by all members in the mechanics division. The decisions regarding the physical shape of the AUV, the arrangement of its components and its materials were accomplished with the adopted strategy in mind, keeping operability as the most important factor.

The housing is composed of extruded aluminum profiles that can be easily assembled in various configurations, allowing easy handling and various dispositions that can be adapted to various situations. This provides not only practicality, but also a good cost-benefit ratio. The material is light and resistant, has an accessible price, an important factor for Krakens AUVs, because we are a new team that doesn't possess many resources.

The acrylic tube was chosen because it fits the group's needs. Firstly, its transparency is important due to the fact that it is possible to see through the tube, allowing the possibility to detect any possible water infiltration, cable ruptures or any other possible visible error. An important factor in the choice of the tube is its manufacture. It is splice free, despite its large diameter. The tube must be extruded to prevent imperfections from causing sealing problems and, hence, water infiltration. Unlike the initial design, where the AUV had two acrylic cylinders linked by connectors. The low voltage cylinder contained all the control boards and sensors, while the high voltage cylinder contained the batteries. Thinking about the chances of infiltration and the cost of waterproof connectors, it was decided to use only one larger cylinder, enabling better communication between the hardware components.

The tubes are attached to the housing by supports developed by the team. The choice of the color purple was made based on the main colors of the project, aiming to create a visual identity for the robot associated with Krakens AUVs. The holders were created in modeling software and, following the idea of the thrusters' holders, are manufactured in 3D printing with ABS material. The holders were developed specifically for the tubes, taking all the adopted dimensions into consideration.

Inside the tube, the hardware components are positioned in a support, which has been developed by the team, that holds all the boards and sensors. This support is located in the middle of the cylinder, dividing it in half. At the top are the low-voltage devices, which are the boards and sensors, and at the bottom are the high-voltage components, the batteries. The supports for the thrusters were developed by the team.They were modeled in software so that they could be printed in 3D printers with ABS material, which is light and very resistant, in addition to being non-corrosive, unlike metal supports. The arrangement of the thrusters was selected with the best possible mobility for the AUV in mind. The configuration chosen allows the AUV to move in all directions and allows it to rotate on axes.

The acrylic tube ends were developed in software from a revolution solid. The material chosen was aluminum, which is easily machined. These specifications were set to ensure adequate protection of the tube ends. The caps are designed to be removed and inserted multiple times, and for effective sealing the sealing system consists of several rubber o-rings. The back cover has slots that allow the cables that connect the hardware components to the thrusters to pass through. The front cover has a large hole where an acrylic dome was positioned, ensuring the proper functioning of the camera, allowing ample vision. The dome was chosen because it does not distort the image even when submerged, ensuring that reading and object recognition errors do not occur. Its frontal position facilitates the recognition of objectives that include displacement and makes its locomotion easier to be performed by the AUV's intelligence.

B. Hardware

With regard to the electrical part, the prototype has two main structures: one for high voltage and one for low voltage, separated by different compartments to avoid interference. In the high voltage part, a lipo 5s battery was used - enough to power the 6 thrusters - which is properly monitored by current sensors and management systems and then distributed by a dedicated board to power the other systems and acquisition of signals. This last board was developed by the team and named ADB (Acquisition and Distribution Board). Its main function is to safely transfer the energy from the batteries, as well as to turn off the power in case of humidity inside the submarine or excessively high temperatures.

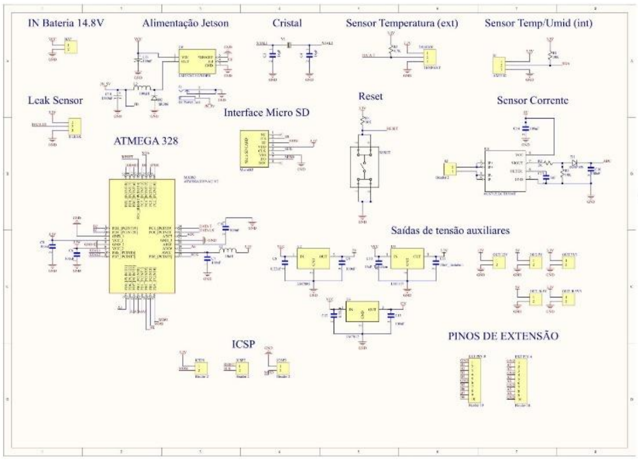

Fig. 1 ADB Schematic

In the low voltage part, the other sensors and actuators of the vehicle are arranged, including sensors to measure safety parameters, such as humidity and temperature inside the submarine, devices for the orientation of the prototype, such as IMU, barometer and camera, and, of course, the motherboard (NVIDEA Jetson Nano), intended for fine control of the submarine, which includes the codes for the automation itself.

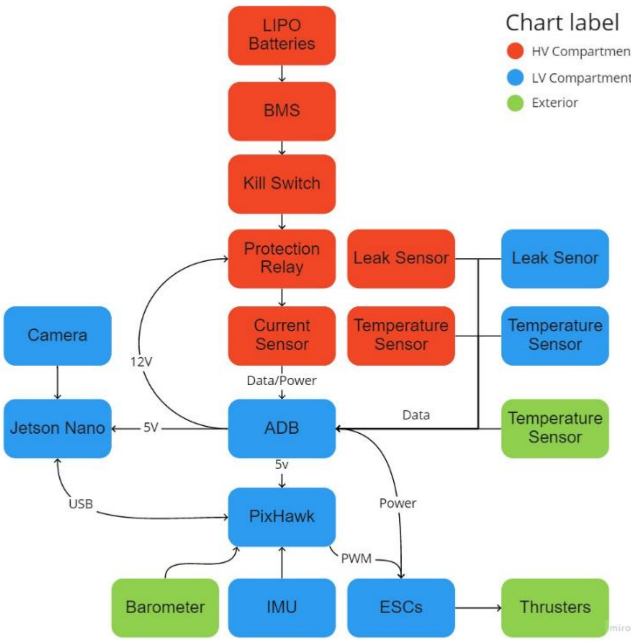

Fig. 2 Hardware Diagram

We also utilize a PixHawk as a board dedicated to controlling thrusters. This board communicates with the Jetson Nano via USB and feeds it with information about the vehicle's position in the pool. Note that the lack of a sonar element makes us rely exclusively on other sensors for guidance. This is possible thanks to the DMP (digital motion processor) functionality, which makes use of algorithms with quaternions, reducing errors related to the integration of signals. Finally, ESCs are used as LV/HV (low voltage/high voltage) interface for this controller to drive the motors.

C. Software

The entire system base was built using ROS and Ardusub. ROS is a tool that provides a middleware with the intention of a broader control with greater ease when performing the tasks, because it is possible to use high-level algorithms during the process. Ardusub is the support for the control systems construction, providing us with a safe and solid base for the ROS to act on the vehicle and the sensors. Integration between the two is possible using the mavros package, where we manage to integrate ardusub communication with ROS.

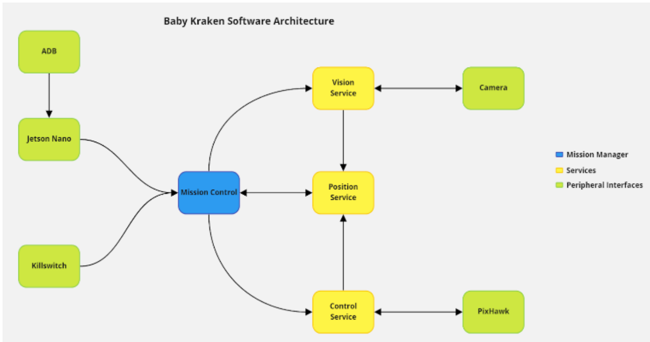

Fig. 3 Software Architecture

The system is based on a Mission Control, our main state machine where the current Baby Kraken location is defined and which the actual task . Having adjacent services where are settled the necessary engines to control all Baby Krakens functions used to complete each mission task.

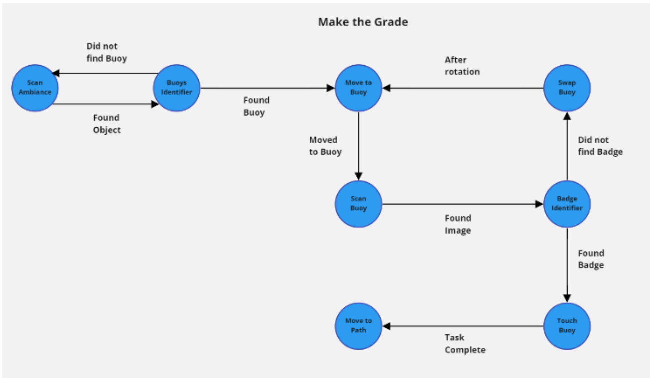

Fig. 4 Make the Grade – State Machine

1) Vision Service: Responsible for obtaining the camera data and processing them in order to identify the objects that are in Baby Kraken neighborhood, and send the appropriate information to Position Service. For the computer vision service we use the framework darknet, and YOLOv4 was chosen as a pre-training model, to serve as a base for transferring learning when training our model to the mission.

2) Control Service: Responsible for managing all the movements that will be performed by Baby Kraken, in addition to carrying out the necessary new data acquisitions to be processed on Position Service. In this service, the integration between ROS and Ardusub is located.

3) Position Service: Its function is to group the information obtained from Baby Kraken peripheral devices, perform the necessary calculations and obtain the current vehicle position, sending this information to Mission Control.

IV. Experimental Results

The first structural calculations performed for the design of the AUV refer to the final weight of the prototype and its relation to buoyancy.

A. *Frame:*

The frame structure has extruded structural aluminum profiles, which were chosen for their versatility, strength, easy handling and assembly, aiming for agility in moments where time is the most important element.

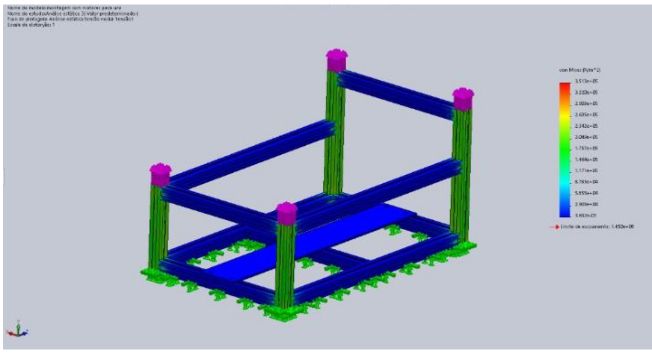

Fig. 5 Representation of the test in the frame

B. *Main Tube:*

The acrylic tube allows visualization of the internal components for monitoring them, it has considerable resistance to compression, impact and temperature. The tube will hold the Hardware components as well as the batteries in order to save space, connectors and improve its stability. The 5mm wall thickness is sufficient to withstand the pressure without reaching its yield point.

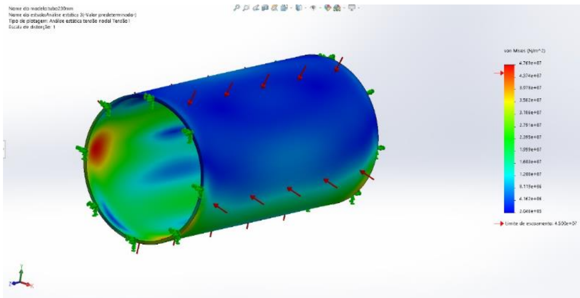

Fig. 6 Representation of the flow in the capless tube

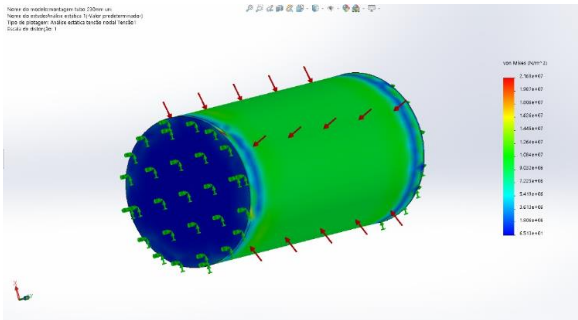

Fig. 7 Representation of the flow in the capped tube

Acknowledgment

Currently, the team has a room located inside the University. The space was provided by the college, and the team has a coordinating professor who helps in bureaucratic terms, in the acquisition of resources and materials inside the institution and technical knowledge.The room has tools and equipment that allow the development of the project.

The purchase of the materials that make up the AUV are possible through contracts with sponsors that provide everything from resources to simulation software licenses and scholarships in language courses, in order to prepare the team for times that need these specific skills, participation in fundraising events, raffle sales with a raffle of products donated by people related to the team members, and by the existence of an incentive program offered by the university.

Appendix A: Component Specifications:

Component	Vendor	Model;Type	Specs	Cost (US$)
Buoyancy Control	-	-	-	-
Frame	Perfil Estrutural em Alumínio	X	25mm x 25mm	1x $ 55.00
Waterproof Housing	Casa dos Acílicos	Acrilic Tube	430mm x 230mm	1x $ 121.00
Waterproof Connectors	DIY YOU	SP16-L	2p, 3p and 4p	12x $ 7.73
Thrusters	Blue Robotics	T200	102 mm x 100mm	6x $169.00
Motor Control	Blue Robotics	PixHawk	v1	1x $118.06
High Level Control				
Propellers	Blue Robotics	Includes w/ T200 thrusters		
Battery	HobbyKing	4S 12C Lipo Pack	1600mAh	2x $156.61
Converter	N/A			
Regulator	DigiKey	IC REG Lin DDPAK	DC DC 12V/3V3/5V	9x $0.83
CPU	NVIDEA	Jetson Nano		1x $99.00
Internal Comm Network				
External Comm Interface				
Compass	InvenSense	Includes w/ MPU-6050 IMU		
Inertial measurement Unit (IMU)	InvenSense	MPU-6050		1x $2.73
Vision	WITHROBOT Inc.	oCam-5CRO-U-M	2592x1944@15fps	1x $54.00
Algorithms: vision				