Design of an ROV for Precision Sea Floor Vehicle Mobility & Entry in the 2009 MATE International ROV Competition

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Abstract

The main goal of this project was to engineer a Remotely Operated Vehicle (ROV) to compete in the 2009 Marine Advanced Technology Education (MATE) International ROV competition. The vehicle has been designed for the efficient completion of tasks that a rescue ROV may have to perform. These tasks range from surveying the submarine, opening a hatch and inserting emergency supplies, supplying an airline, and providing a transfer skirt for rescue. Since the vast majority of the tasks can be completed while on the bottom our track system gives us the advantage of only having to work in 2D space.

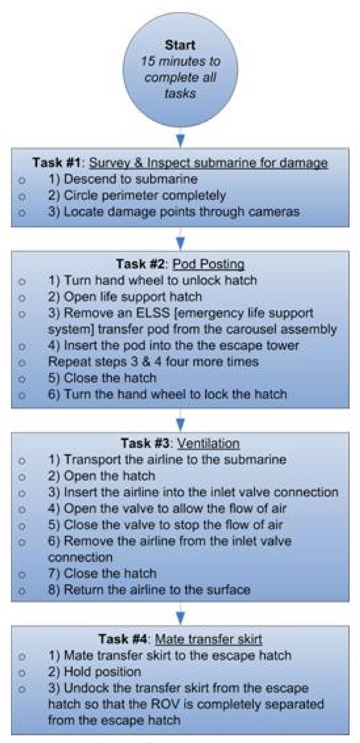

Fig 1 – Competition Task Flow Chart

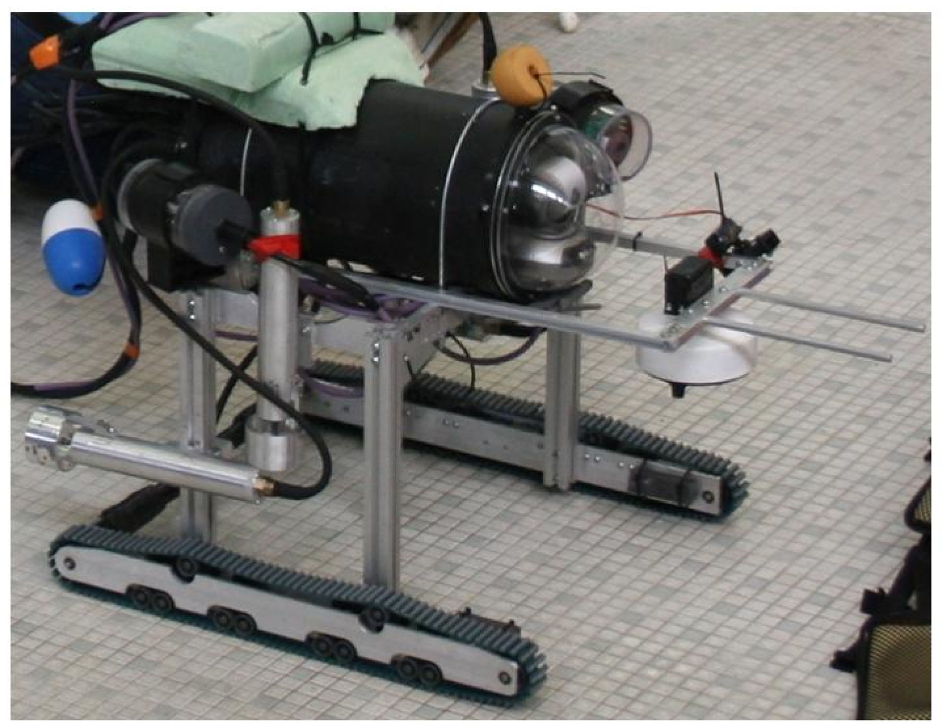

Fig. 2 – ROV pool side ready for competition

Introduction

Each year MATE has an ROV competition in which teams of students must perform specified missions based on real world scenarios [1]. This year the mission is a mock submarine rescue with 4 main tasks (Fig. 1). When working to rescue the crew of a submarine on the sea floor additional care must be taken to insure the safety of the survivors. The major goals were to design a vehicle that was more stable and can excel in tasks on the sea floor [2]. With that in mind PantheROV-V was a major redesign of its predecessor PantheROV-IV, which competed in the 2008 MATE competition [3].

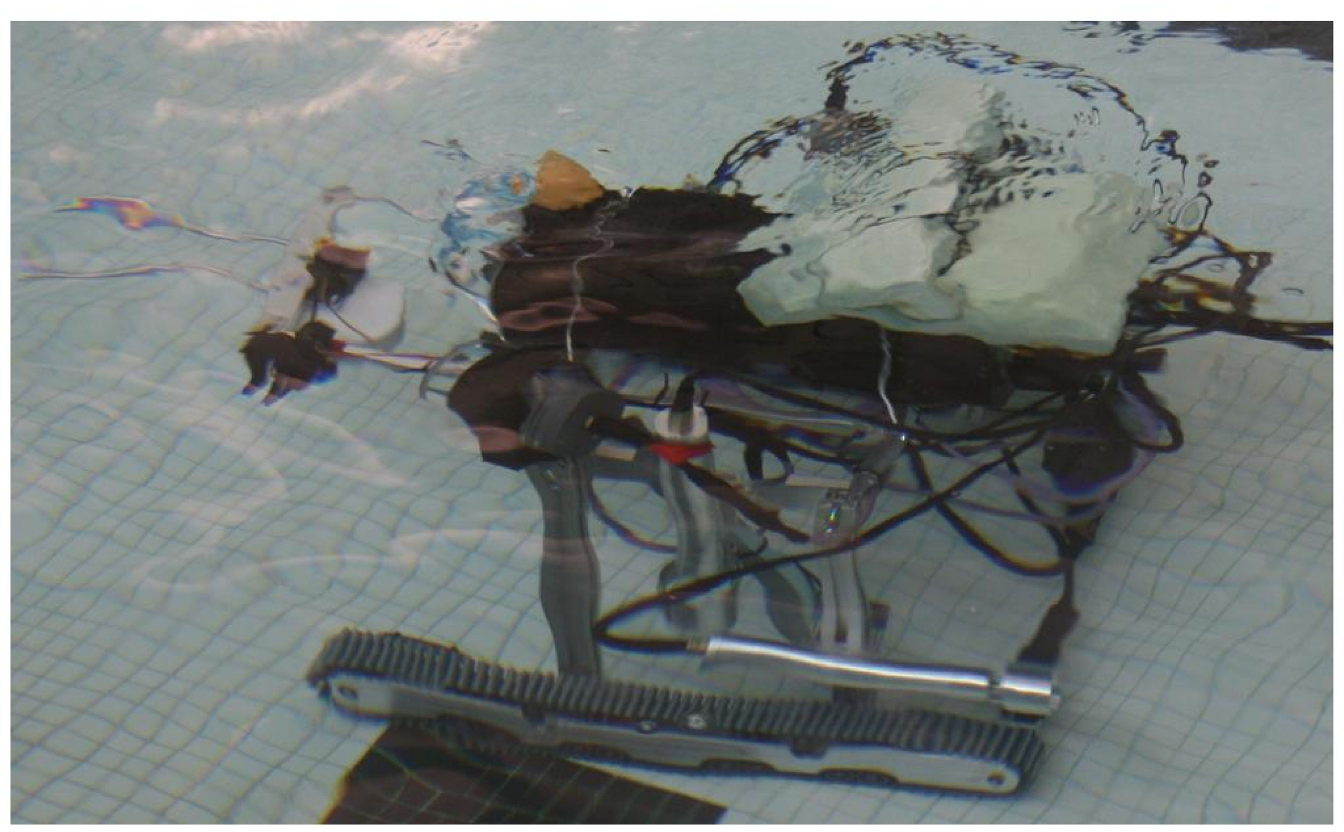

Fig 3 – Pre-mission pool test

Design Rational & Construction

PantheROV-V incorporates a versatile track system to crawl on the bottom of the sea floor to accomplish the rescue mission (Fig. 2). These tracks provide a stable platform for the vehicle to execute precision manipulations while drastically reducing positional drift when compared to a free floating vehicle. To further facilitate recovery, the tracks are wide enough so the ROV can crawl over the submarine hatch and accurately position a rescue transfer skirt. Since the rescue ROV is a hybrid crawling robot as well as a swimming robot, neutral buoyancy must be maintained. When in "tank mode" the vertical thrusters are set to a constant rate in order to keep the ROV on the bottom (Fig. 3). When on the bottom, the tracks utilize skid steering to precisely maneuver along the bottom much like an army tank would.

Each of the two tracks are composed of a rear driven sprocket, which is directly coupled to a geared DC motor (Fig. 4). The front sprocket spins passively with the tracks. There are 4 pairs of load bearing idler wheels in between the sprockets to evenly distribute pressure to the ground (Fig. 5).

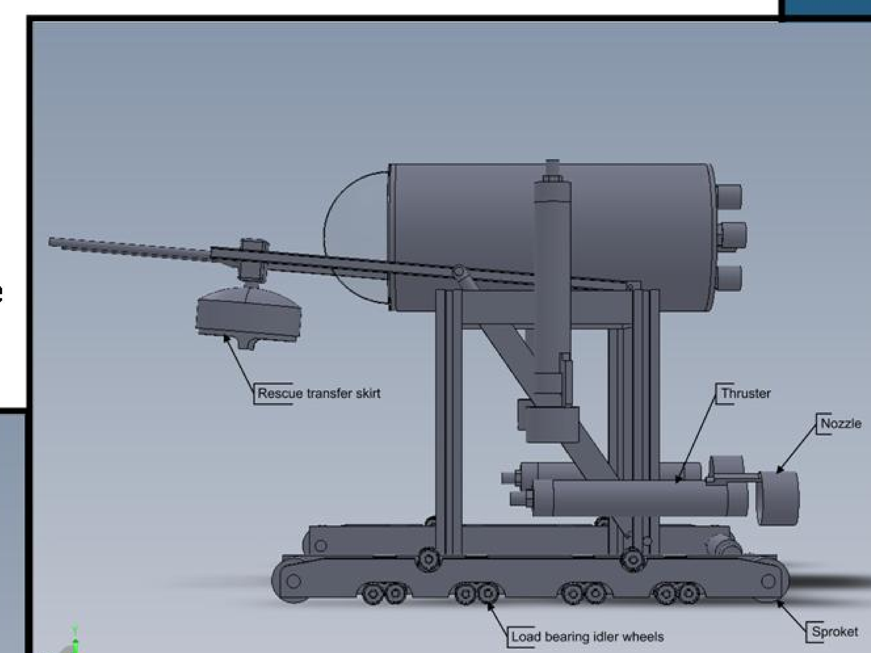

Fig. 5 – Right side view

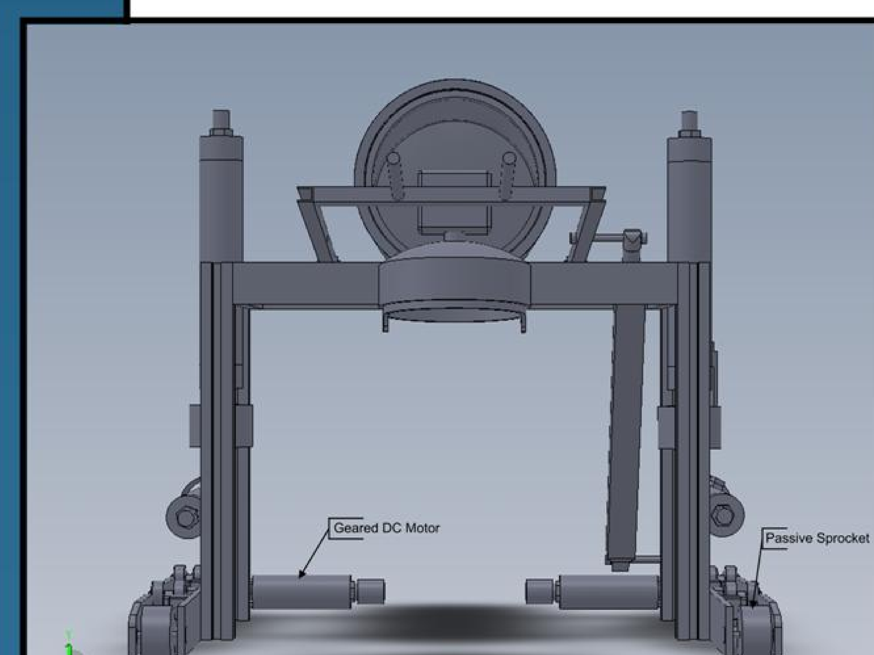

Fig. 4 – Front view of SolidWorks model

The thrusters were designed to be compact and lightweight so they can be mounted just about anywhere on the ROV. The motor used is a brushless DC motor with attached reducing gearbox, both contained in a watertight pressure canister. A nozzle is held tightly around the propeller to minimize thrust losses off the tips by directing thrust backwards.

The manipulator for PantheROV-V is a completely new design from previous years. It uses a linear actuator and a servo motor to function both as a translator and a rotator (Fig. 6). The manipulator arm was used to unlock and open the simulated hatch. To do this we raised up the arm and positioned it above the hatch. Then we lowered the arm and rotated it, unlocking the hatch. To open it we raised the arm, reversed and then lowered the arm all the way. The 2 slender rods were lined up with the opening under the hatch by using our tracks to carefully maneuver the vehicle into position. We proceeded to move forward and raise the arm to flip the hatch open.

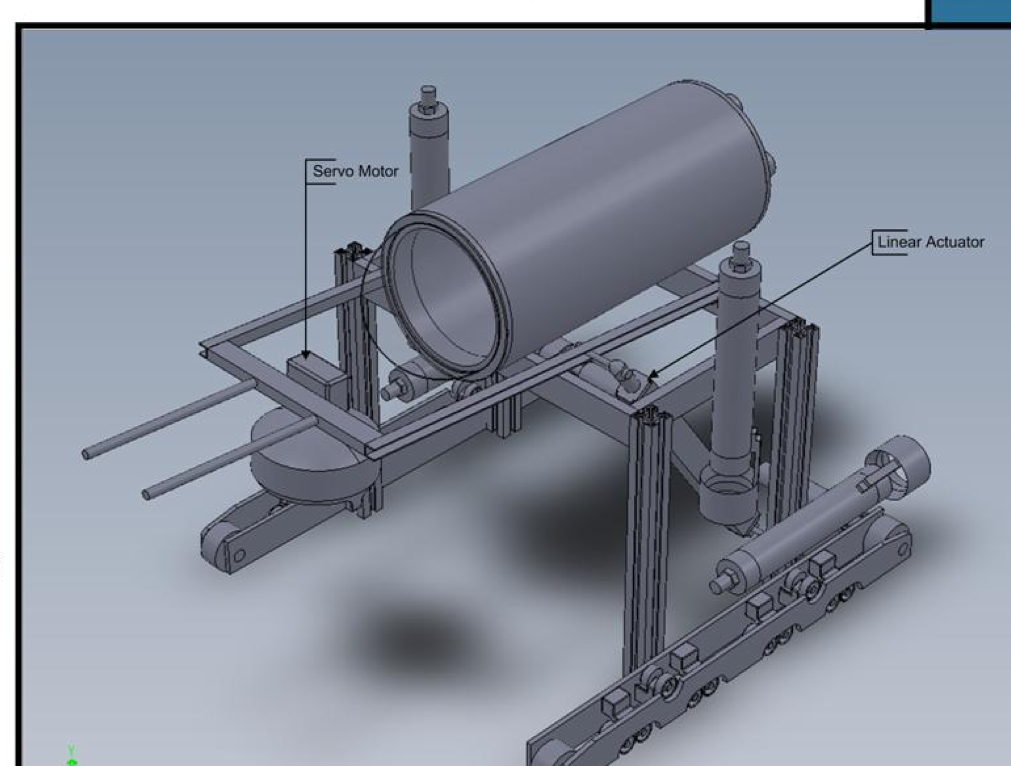

Fig. 6 - Isometric view

Control System

The vehicle control system is basically an Ethernet network with several subsurface nodes (the onboard microcontroller and the video cameras) that communicate with a surface node, a laptop computer, via the Category-5 cable in the tether (Fig 7). The onboard microcontroller (Rabbit RCM3700) receives user commands, controls the motors, reads the sensors and sends the sensor data back to the user. The surface laptop computer acts as the user interface. The pilot views video and sensor data on the computer screen and commands the vehicle via joystick or keyboard input.

The vision system of the PantheROV-V consists of Ethernet-enabled web cameras, which allow all video from the vehicle to be transferred topside using a single Cat-5 cable. In contrast analog cameras require a separate coaxial cable for each camera, our design connects all of the cameras to a single Ethernet switch within the hull of the ROV and a single shielded Cat-5 cable is sent to the surface (Fig. 7). This system greatly reduces the size of the tether permitting greater maneuverability of the vehicle.

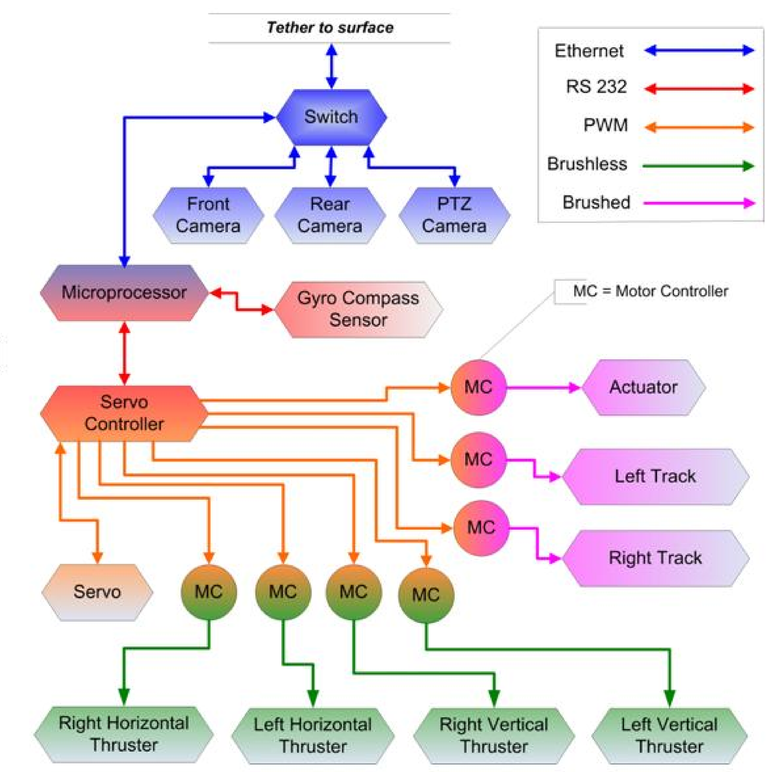

Fig 7 - Internal ROV Signal Diagram

Performance

Prior to the first mission at the competition, a pool test of the vehicle was done. Each of the vehicle's subsystems were tested and seemed to be working properly. However shortly into the first mission we encountered issues controlling the vehicle. After it was determined one of the thrusters leaked and one of the tracks sprockets was slipping. We quickly fixed them before our next attempt. During the second attempt after examining the entire submarine, the vehicle's main pan-tilt camera shut off. It seemed the vehicle had encountered a power issue. Upon post mission examination, it was found that there were no leaks; however, a motor controller appeared to be severely fried, it was concluded that the newly replaced controller was faulty and created a short. This was a difficult lesson learned but improvements to protect against these faults and others are already being worked on for next year.

Future Use

This hybrid tracked and swimming ROV has many other advantages and applications beyond simulated submarine rescue. Track propulsion makes benthic studies possible including high resolution bottom sensing, bottom sampling and instrument servicing. In the presence of heavy currents or turbulence the ROV can protect itself by sitting on the bottom and resume its mission after the disturbance subsides. Being able to choose whether to use thrusters or tracks allows the advantages of both to be utilized such as precise crawling on the bottom, while being able to swim over obstacles.

Acknowledgments

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[2] S. Bingham, T. Erdmann, J Ringstad, M. Matson, S. Laehn, "PantheROV-V Technical Report", M.A.T.E. 8th ROV Competition, Buzzards Bay, MA, June 2009

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