Cal Poly UROV

California State Polytechnic University San Luis Obispo
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Team Members

Kerr Alan (Project and Electrical Lead), Liam Duckworth(Software Lead), Andrew Peterson(Mechanical Lead), Giovanni Malone(Electrical Team), Jonathan Lam (Mechanical Team), Evan Lee (Electrical Team)
Mentor Professor John Seng

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Project Management

The Company and Personnel

Cal Poly UROV is a six person team that is part of the California Polytechnic State University Robotics IRA(Instructionally Related Activities). We receive our funding through the College of Engineering of Cal Poly.

Kerr Alan

Kerr is a 5th year electrical engineering student who has completed their bachelors degree at Cal Poly and is continuing his education at Cal Poly to gain his masters degree in electrical engineering. Kerr is in charge of overall project direction as the project lead. He makes the major structural decision with input from the mechanical lead and software lead. Additionally as the electrical lead he makes sure that the electrical system will work and interface properly with the mechanical and software components. Finally he ensures that ROV is compliant with the electrical safety requirements and other build specifications.

Liam Duckworth

Liam Duckworth is a second year computer engineering major and the software lead for the team. He is in charge of taking the project lead's directions for how the ROV should operate and writing the code to make it work. He also provides input for what mechanical designs would be easy to code for including adding thrust vectoring for the ROV. He coordinates with the electrical and mechanical team to ensure that they all have a cohesive and feasible vision on how the ROV will work.

Andrew Peterson

Andrew is a fourth year and the mechanical lead for the team. He is in charge of designing and manufacturing all of the mechanical parts of the ROV. He is heavily involved in the idea drafting phase of the project. He provides input for any mechanical design's feasibility, reliability and ease of implementation. He works heavily with the other team leads to ensure that all ideas are possible and can be integrated seamlessly together.

Electrical Team

The electrical team is in charge of taking the project lead's ideas and implementing them into the ROV. This has included PCB design, soldering components, cable management motor and servo testing, and creating the tether. They do this with help from the electrical team lead that takes an advisory role in the development of the ROV alongside their own contributions.

Mechanical Team

The mechanical team plays a very similar role to the electrical team but for the mechanical systems in the ROV. They take directions from the mechanical lead which in turn gets their instructions from the project lead. They then disseminate what needs to be worked on how they should do it. These tasks include designing the frame, the grabber, mounting the motors, pitch control, mounting the cameras, and other mechanical systems.

Design Rationale

Engineering Design Rationale

For our ROV we have a strong rigid frame made out of HDPE with a welded aluminum box to house our control system. For waterproofing we used a gasket and clamp system to ensure a watertight seal. To route cables from the inside of the control box to the motors and camera we used drilled out bolts that were then epoxy sealed. We have 6 motors with two pointing up and the other 4 pointed at 45 degree angles. This allows us to perform thrust vectoring for more maneuverability.

Our current team is all people who are new to the MATE ROV competition as none of us have competed before. This is not true about Cal Poly as a whole. As a team we inherited a partially built ROV that we then modified and finished to perform as best as possible. This is because we were under severe time constraints due to the limited amount of time to work per week and a small team.

Innovation

After our first deep water test we discovered that we needed more pitch control. To fix this we added weights on a belt to allow for pitch control. This is a very cost effective solution with a total cost of about thirty dollars including some replacement parts. This allows us to not only use the budget on the other parts of the ROV while having replacements if it breaks.

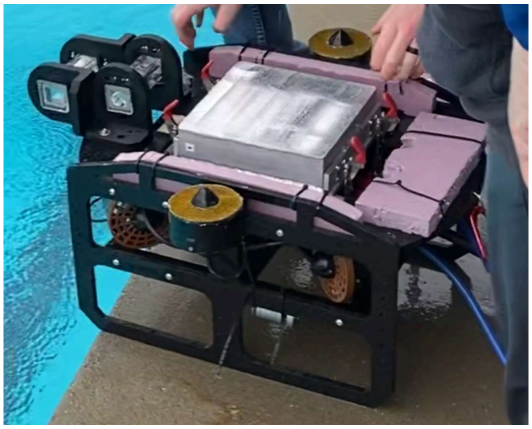
Problem Solving

When we need to brainstorm and come up with new ideas we all get together and write down any and all ideas we have. After we have a list of 5-10 ideas we research and discuss pros and cons for the ideas. After we finish doing this for all of the ideas we talk about if there is any way to combine the solutions to come together and get the most optimal solution. After we decide on what solution we will go on then we divide up the parts of the task to each of the sub teams. After each team finishes what they need to do we reconvene and discuss how they are working together and what improvements could be made. We repeat this process for every problem we encounter.

System Approach

To ensure that we have a cohesive functional ROV at the end of the design process we have weekly check in on the progress of the ROv to ensure that everything will continue to function together. Additionally all of the work is done in one room so if one subteam has a question about integration with another subteam the team culture allows for free questions to ensure a unified understanding of the ROV.

Vehicle Structure



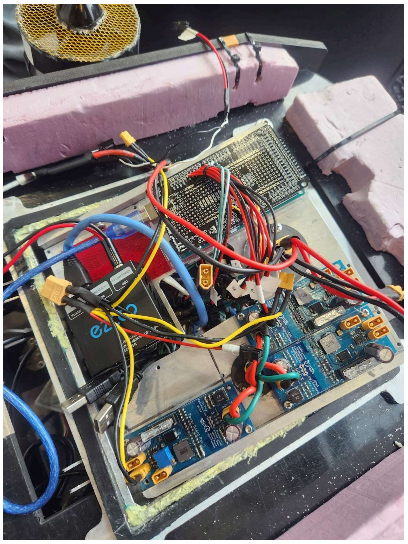
For our vehicle structure we chose a size that made it easy to mount all of the motors and other modules to interact with the environment around us. This size and having mostly empty space for our ROV means that we are well under the maximum weight threshold for maximum weight points. Additionally this lack of filled volume allows us to not need as buoyancy adjustments as we might have otherwise. Cost was not that major of a factor as manufacturing was done by the team allowing for only base material costs to be incurred. This allowed us to spend our money on the more expensive positions of the ROV like the motors.

Vehicle Systems

We selected HDPE as the main frame for our ROV as it is a good mix between density and durability. A density not much more than water allows us to be much less negatively buoyant allowing for less materials to be added to counteract the negative buoyancy. We used an aluminum dry box as we had the materials already and we could weld it closed and watertight. With the aluminum dry box it was easier to manufacture than other options and less dense. It also has enough durability so we do not need to worry about a puncture breaking our watertight seal.

The design evolved by adding additional modules to complete each task for the competition. One example is how we are going to open the sprinkler. Our grabber claw is fragile to exert that much torque and changing it to be more robust would be difficult and lose other functionality. Our solution was to create a custom fit attachment to a DC motor allowing it to grip around the sprinkler turn valve and apply enough torque to turn it quickly and efficiently.

Control/Electrical System



For the electrical system we revive 120 volts ac from an external 120 volt plug. This then goes into a 48 volt supply, the computer monitors and a 12 and 5 volt power supply. From the 48 volt power supply it goes through a fuse and current sensors. When we then toggle the contactor it supplies the 48 volts down the tether. Additionally all of the commands sent from the jetson nano are sent down the tether through ethernet.Once it reaches the ROV it converts it into 24 volts. This goes across another fuse to a 24 volt to 12 volt converter the escs and 24v to 5 volt converter. The ESCs go to the propellers. The 12 volts goes to a set of h bridges that control our actuator DC motors. The 12 volts also goes to a servo. The 5 volts powers a usb converter that connects the arduino and cameras with the jetson nano.

To control the ROV we use a controller attached to the jetson nano. The jetson nano interprets the direction it is supposed to go or other commands then it sends that down to the arduino. The ROV also sends camera feed back up to the jetson nano.This allows us to control the ROV and complete the tasks.

Propulsion

The propulsion of our ROV consists of 6 t200 blue robotics motors. There are two motors for vertical control and 4 motors for rotation and lateral movement. This is done by the motors at the front being pointed 45 degrees towards the center and the motors at the back being pointed 45 degrees out. This allows for much more versatility in movement.

Buoyancy and Ballast

For buoyancy we used foam and washers to make our ROV's not less buoyant on one side and tip. We tested the buoyancy in a pool adjusting until it was both balanced and slightly positively buoyant. We chose to be positively buoyant as during lifting tasks we will be weighted down. This buoyancy allows us to have an easier time maneuvering while holding objects in return for less unburdened maneuverability.

Payload and Tools

We have two cameras for our ROV. The first camera points out so we can see where we are driving. Our second camera points down to where our grabber is. This is so we can precisely position the ROV to grab task objectives. We have designed a grabber for grabbing task components and transporting them. We have also designed a metal claw that is shaped to go around the sprinkler valve to turn with greater torque than the claw is able to withstand. We have a temperature and water sensor to monitor the inside ROV health to be informed about overheating and water intrusion.

Build vs. Buy, New vs. Used

We have built the majority of the components used in ROV. The main components that we have not made were servos, motors, usb hub, arduino, ESCs, contactors, current sensor, water sensor, temperature sensor, and heatsink fins. This is because the complexity of the items were too hard to manufacture with our limited resources. We built everything we could to keep the costs as low as possible. Most of our ROV is used as the previous team built up the skeleton of the ROV and was unable to make it work. We fixed all of the previous team's issues and made it function.

Testing and Troubleshooting

To test the ROV we started in a kiddie pool as we did not have access to a pool. During this test we had sodium acrylate and a water sensor to test for any leaks in the ROV. We then went through every function testing if it worked. When things did not work we first checked the software then the wiring of the ROV. For example the motors were not working and the thrust vectoring was wrong. We checked the software and there were no visible errors so we checked the wiring. As the wiring was correct we went back to the software and made the values negative for the motors that were going the wrong direction. We continued testing until the motors worked and then moved onto the next function.

Accounting

Catagory	Item Name	Item Description	Cost Per	Quantity	Total Cost
ROV					
	Plastic Frame	HDPE Sheet	$52.96	1	$52.96
	Drive Motors	Blue Robotics T200-Thruster	$200.00	6	$1,200.00
	ESCs	Used to drive the drive motors	$38.00	6	$228.00
	Power Distributers	Distributes power from tether to electronics and motors inside the ROV	$21.00	4	$84.00
	Arduino	Sends signals from topside to motors	$24.00	1	$24.00
	Servo Motors	Used for grabber	$139.00	1	$139.00
	DC Motors	Used for turning the sprinker valve and adjusting the rov tilt	$60.00	2	$120.00
	DC Motor Drivers	Drives the motors from the arduino	$2.00	1	$2.00
	Eszooo	Converts ethernet signal from topside to arduino from inside the ROV	$57.00	1	$57.00
	Cameras	Vision for the ROV	$19.95	2	$39.90
	PETG Filament	Used for mounting cameras, and to make the grabber	$25.00	1	$25.00
	Tilt Adjuster System	Controls the Tile of the ROV	$50.00	1	$50.00
	Aluminum Bar	Used for case walls of the electronics case	$430.00	1	$430.00
	Aluminum Plate	Used for flanges and top and bottom of electroinics case	$340.00	1	$340.00
	Gasket	Used to seal the top and bottom fo the electronics case together	$9.40	1	$9.40
	Foam	Used for buoyancy	$1.20	1	$1.20
	Assorted small connectors	Used for internal wiring	$13.00	1	$13.00
	Case Connectors	Connects power, ethernet and motors to the inside of the ROV	$501.00	1	$501.00
				Subtotal:	**$3,316.46**
Tether					
	Power Cable	Powers ROV	$56.00	1	$56.00
	Ethernet Cable	Connects ROV to Topside	$151.00	2	$302.00
	Tether Wrap	Holds tether cables together	$31.00	1	$31.00
	Strain Relief	Provides Strain Relief	$25.00	2	$50.00
				Subtotal:	**$439.00**
Topside Case					
	Monitors	Used for Displaying Camera feedback from ROB	$24.00	2	$48.00
	Mouse and Keyboard	Used to navigate code feedback	$30.00	1	$30.00
	XBox Controller	Used to control the ROV	$23.00	1	$23.00
	Jetson Nano	Controls the ROV from the topside case	$159.00	1	$159.00
	Contactor	Turns Rov on and off	$35	1	$35.00
	Voltage Sensor	Allows for voltage monitoring	$15.00	1	$15.00
	Current Sensor	Allows for current monitoring	$19.00	1	$19.00
	Power Strip	For distributing 120 volts	$11.00	1	$11.00
	AC switch	Allows for turning things on	$11.00	1	$11.00
				Subtotal:	**$329.00**
Travel					
	Housing	For 6/17 through 6/22	$587.30	1	$587.30
	Flights	Leave 6/17 return 6/22	$1,879.00	1	$1,879.00
	UBER	To and from airport to Kingsport	$240.00	1	$240.00
				Subtotal:	**$2,706.30**
				Total:	$6,790.76
				Tax @ 7.5%	$509.31
				Grand Total:	**$7,300.07**

Acknowledgments

We give thanks to the Shoptech group at California Polytechnic State University, San Luis Obispo, for their manufacturing expertise, which ensured the successful completion of the UROV manufacturing process.