SENIOR DESIGN 1

PROJECT ALL TERRAIN FIND

Department of Electrical Engineering and Computer Science

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Initial Project Document

Divide and Conquer

Group 11

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Project Narrative

According to a survey published by Mozy.com, the average human loses 9 items every single day and spends up to 10 minutes daily to locate lost items. Project All Terrain Find will develop and produce a solution to this frustrating and fatiguing dilemma that we each encounter every single day. Not only will this robotic vehicle be able to locate an item indoors, but it will also be able to scour different outdoor terrains including adverse terrestrial conditions and non-submersible aquatic environments in a constrained area.

Our robotic vehicle will utilize robotic vision to accomplish search and rescue missions in an autonomous fashion with minimal human interaction. The most significant feature that will be incorporated in our robotic system is robotic vision through the use of a smart vision sensor which will be programmed to find and locate a specific object autonomously by utilizing a search algorithm to effectively locate an item. This vehicle will be equipped with sensors in order to efficiently dodge present obstacles. What makes this product especially unique is that it will be amphibious allowing it to locate lost items on both land and non-submersible aquatic environments. This product will contain both an autonomous mode and a manual mode, which will allow the user to manually control the robot in case human interaction is required. Its compact design will allow the robot to efficiently traverse through difficult terrain The robot will also contain a sensor to detect if it has flipped upside down during a difficult obstacle and will be able to flip itself back to normal position.

Our search and rescue robot will also contain a multitude of different photonics features. We will incorporate an IR rangefinder, night vision, and a thermal sensor. The rangefinder will be able to monitor how far away the specified object is from the vehicle. We will be able to achieve this through the use of an ultrasonic sensor. The robot will also be equipped with night vision to allow it to successfully traverse through different terrains in the dark. This task will be challenging due to the fact that we will have to create a dataset of a specific object by taking a large number of night-time photos in order to successfully train our robot during the robotic vision programming stage. Lastly, we will incorporate a thermal sensor which will be able to log the temperature of the specified object. This is an important feature in which we will be able to identify if an object is within a safe temperature range to handle.

This product will appeal to all different sorts of target audiences. Not only can this product be used by a typical household to locate missing items, but it can also be used in both military and search and rescue settings to locate missing people. Suppose an area is tragically impacted by a natural disaster introducing an abundance of unsafe conditions for a human to safely travel across in order to locate a missing item or person. This robot will be able to navigate its way around difficult obstacles such as flooded entryways and be able to identify a specific object, and then return to the user and display whether or not the specific item was located on an LCD screen.

Due to the fact that this vehicle will be used in both rough terrains and aquatic environments, it is essential that this product will be durable, lightweight, and waterproof to allow it to travel efficiently through the different mentioned environments. It is also critical that this project will be cost efficient to be able to meet the defined project requirements and specifications. By undergoing a detailed research and development phase, achieving these design requirements will be achievable.

Project Specifications

The robot must be able to maintain its balance while crossing a flat surface, climb difficult terrain, and tread water as well. For now, we will not aim to make the robot completely waterproof, but to build the bottom of the robot like the bottom of a boat, and focus on waterproofing the underside of the robot. Since we want this robot to be able to float when in aquatic environments and tread water, we have to manage the weight of the robot to prevent it from sinking. So one major constraint when building this robot is that we must keep in mind the volume and size of the robot so that it floats when in water.

We aim to make this robot on the smaller side as well, so that it will have an easier time maintaining its stability when ascending or descending inclines. We will try to place the weight towards the center of the robot for better balancing. We aim through testing to try to account for as many balance issues as we can test for, but will also implement an algorithm for it to be able to right itself if knocked over, or turned over.

We aim to have the robot self guide itself when placed in an environment, but initially we will focus on controlling the robot with a remote device. We want to create a search algorithm, so that when placed in a small area, it can effectively search the area until it finds the target ball. We also will have sufficient memory installed so that the robot can record the path it took to reach the target ball, and use it to return back to the user to provide the location of the found target. These requirements and more can be seen in table 1.

Attached to the front of the robot will be an RGB camera, which will continuously capture images of its surrounding environment, and using our vision recognition algorithm will identify and then reach the target ball. To not impede movement speed, we will code it to take a couple photos every second, so that the movement is as fluid as if it was analyzing video, but with simpler code. We will implement machine learning to improve the robot's recognition time of target objects. We also hope that if time allows, that we can code it to search for more than one target object. The goal with our algorithm is to recognize the target ball in 5 seconds or less. We shall use a raspberry pi to implement the computer vision algorithm and sensors on our PCB layout board for sensors.

Engineering Requirements Summarized:

Marketing Requirements	Engineering Requirements	Specifications
1	Cost	Less than $500
4	Weight	Less than 10 kg
4	Dimensions (Volume)	Less than 20 liters ($0.02m^3$) *
1, 5	Power Consumption	Less than 15 Watts *
2, 5	Object Detection Accuracy	Greater than 90% accuracy *
2, 5	Sensor Accuracy	Error less than 10% of actual value
5	Battery Run Time	At least 1 hour
3	Response Time	Less than 100 ms
5	Autonomous Area of Operation	Within 200 m^2
Marketing Requirements 1. The system must be affordable. 2. The system must be accurate. 3. The system must be quick. 4. The system must be agile. 5. The system must be reliable.		
Specifications marked (*) are demonstrable to review panel		

Table 1: Engineering requirements

House of Quality Diagram:

Figure 1 is a House of Quality Diagram relating our engineering and user requirements, and their correlation to each other.

Relationship	
Positive	+
Negative	-
No Correlation	

Cost	Weight	Dimensions	Power Consumption	Algorithm Accuracy	Sensor Accuracy	Implementation Time	Battery Run Time	Response Time
				-				
				-	-			
		-	-			+		
				-	-		-	

User Requirements		Cost	Weight	Dimensions	Power Consumption	Algorithm Accuracy	Sensor Accuracy	Implementation Time	Battery Run Time	Response Time
		▼	▼	▼	▼	▲	▲	▼	▲	▼
Cost	▼	• •		▽	▽	• •	▽ ▽		▽	▽ ▽
Ease of Use	▲					• •	•			
Robot Speed	▲	▽	•	•	▽ ▽	•	•	▽	▽ ▽	• •
Object Dectection Accuracy	▲	▽			▽ ▽	• •	• •	▽ ▽	▽	▽ ▽
Size / Dimensions	▼	▽	•	• •		•	▽		▽	
Battery Life	▲	▽ ▽	▽	▽ ▽	• •				▽	▽
Responsiveness	▲	▽	▽ ▽	•	▽ ▽	•	• •	▽	• •	•
User Interface	▲	▽			▽			▽		•
		< \$500	< 10 kg	< 0.020m^3	< 15W	> 90% accuracy	Within 10% of actual value	< 12 weeks	At least 1 hour	< 100ms latency

Correlation	
Very Positive	• •
Positive	•
Negative	▽
Strong Negative	▽ ▽
Direction of Improvement	
Maximize	▲
Target	□
Minimize	▼

Figure 1: House of Quality Diagram

Block Diagrams

Figure 2 breaks down the responsibilities between group members for the hardware necessary for this system. Figure 3 breaks down the software we plan to implement into a simplified block diagram.

Hardware Diagram:

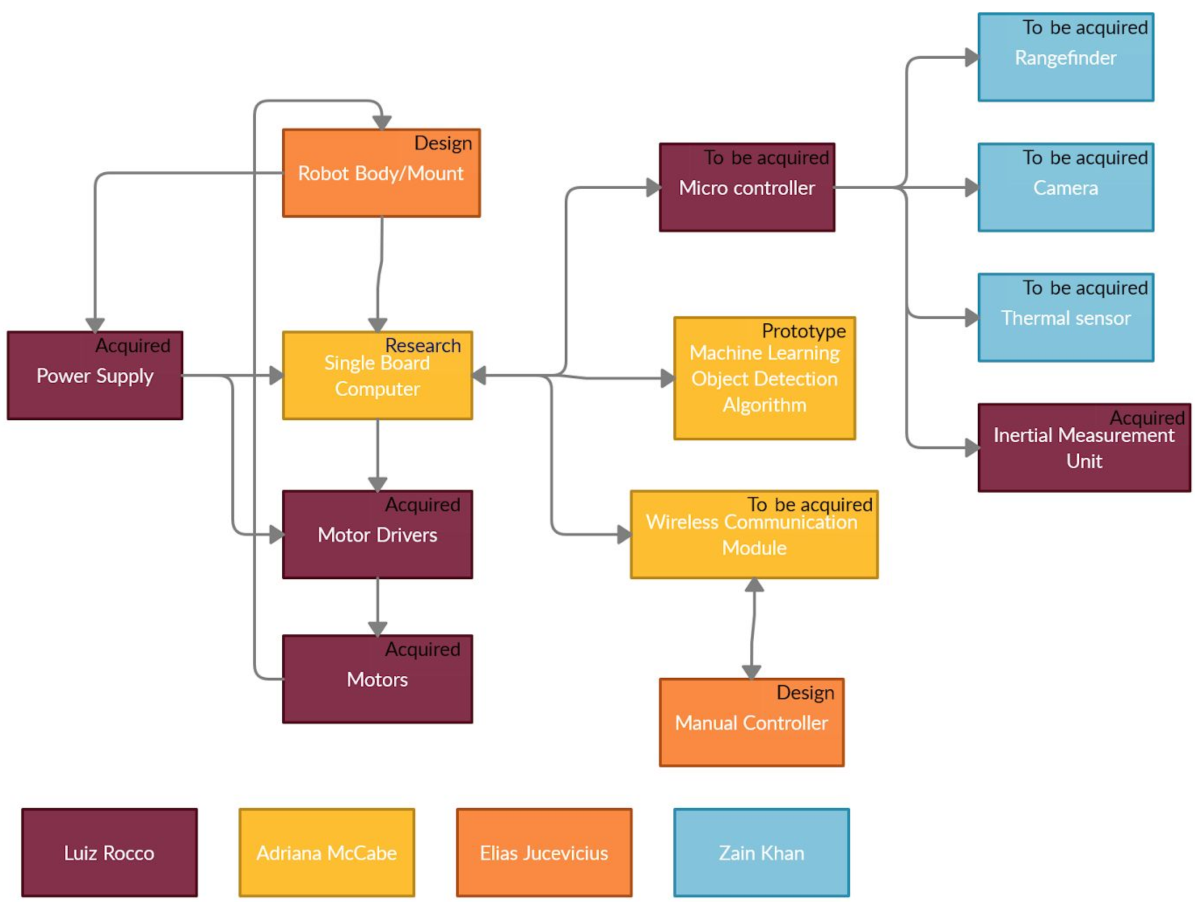

Figure 2: Hardware Block Diagram

Software Diagram:

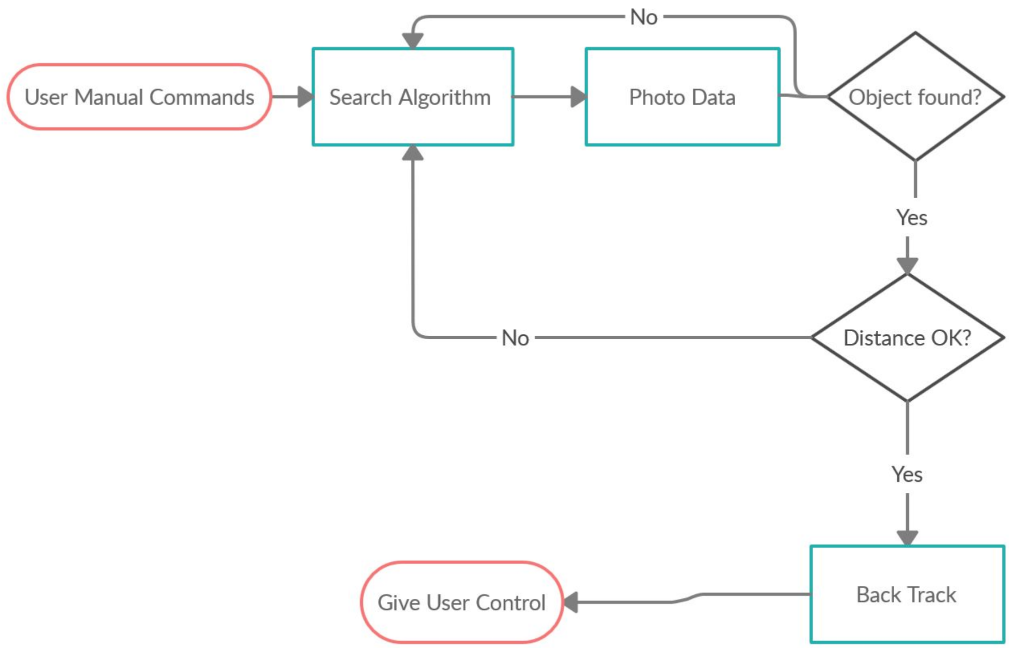

Figure 3: Software Block Diagram

Estimated Project Budget and Financing

As of currently, our project will be self-funded. From completing previous robotics projects, we already have a large amount of components that we will be able to utilize for our project which will significantly help with the budget for our project. The total amount predicted to be spent on our project is $454.50, broken down in Table 2.

ITEM	QUANTITY	TOTAL PRICE
Raspberry Pi 2GB	1	$50
Smart Vision Sensor	1	$60
Robot Chassis	1	$100
LCD Display	1	$10
PCB	5	$50 - $100
Tamiya Battery Long Plug Set (*)	1	$6
Elenco Electronics Hook-Up 3 Colors Wire Kit (*)	1	$17
6-Cell NiMH Battery Packs (*)	2	$36
S.S. Set Screw Shaft Coupler (*)	1	$27
12-Pack Plated Brass Dura-Collar (*)	1	$7.50
100-Pack Female Crimp Pins (*)	1	$6
25-Pack Crimp Connector Housing (*)	1	$1
830-Point Breadboard for Testing Purposes (*)	1	$5
Break Away Headers – Straight (*)	2	$3
Resistor Kit – 1/4W (*)	1	$8
Break Away Headers – Long (*)	1	$3

Items marked (*) are items that are already purchased

Table 2: Estimated Project Budget

Project Milestones

For the next two semesters, Table 3 presents a rough draft of our plan to complete our robotic system in a timely manner.

Task	Start Date	End Date
Senior Design I		
Initial Divide and Conquer Paper	9/11/2020	9/18/2020
Meet with Professor	9/23/2020	9/23/2020
Updated Divide and Conquer Paper	9/23/2020	10/2/2020
Start Coding Vision Processing Algorithm	10/7/2020	March 2021
Start Coding Search Algorithm	10/7/2020	March 2021
Complete 60 page Paper	10/10/2020	11/13/2020
Complete 100 page Paper	11/14/2020	11/27/2020
Senior Design I Paper	11/28/2020	12/8/2020
Senior Design II		
Order Parts	1/15/2021	2/1/2021
Start Building the Robot	3/1/2021	3/21/2021
Waterproof the Bottom of the Robot	3/4/2021	3/10/2021
Set up the Remote Control	3/7/2021	3/14/2021
Test Functionality on Land and in Water	3/15/2021	3/20/2021
Testing Camera Functionality	3/15/2021	3/20/2021
Test Autonomous Mode	3/20/2021	3/25/2021
Have Search Algorithm Work on Attached Camera	3/25/2021	3/30/2021
Finish Debugging	3/25/2021	4/7/2021
Senior Design II Paper	4/8/2021	4/25/2021

Table 3: Estimated Project Milestones

Resources

https://www.computersciencezone.org/virtual-lost-found/

http://www.robotoid.com/appnotes/construction-managing-weight-of-robot.html

https://app.creately.com/