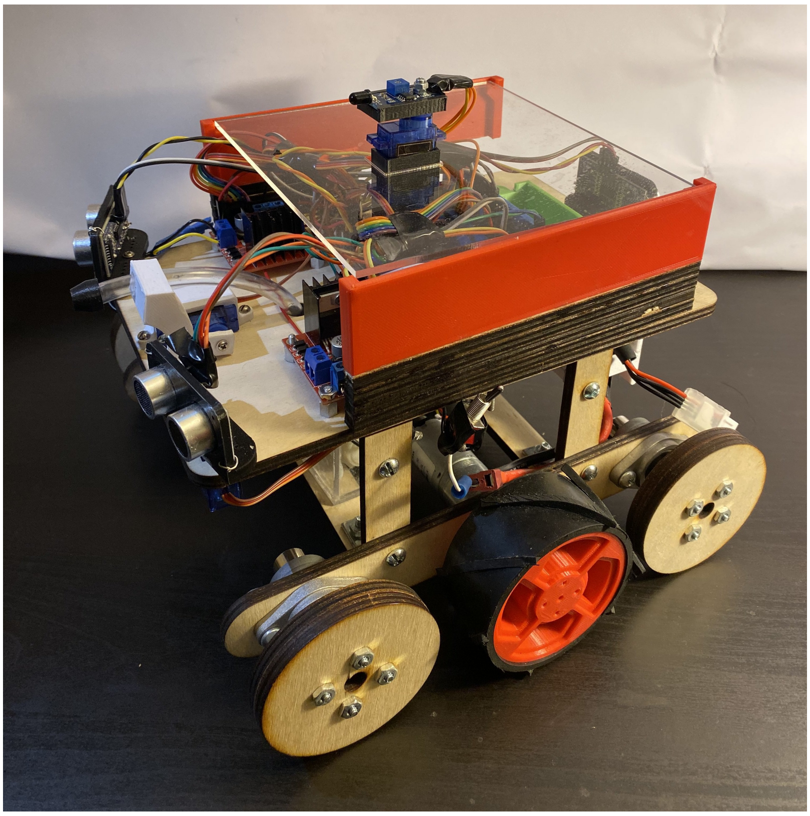
Smart Fire Fighting Robot (SFFR)

Team FIZA



Automotive fire fighting robot that can avoid obstacles while roaming to find fire and extinguish it.

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***Abstract*—For our project we made a couple of fire fighting robots. We were motivated by trying to do good in the wake of the California wildfires these past few years.**

I. Motivation

The project is motivated by the devastation that the California wildfire caused these past few years. The destructive wildfire costs California billions of US Dollars in damage and hundreds of people are suffering from this accident. The purpose of this project is to implement the prevention of wildfire to occur by locating small fire and extinguish it. The brainstorming session to solve this problem is to produce minimal invasive robots that can roam around a specified zone and will be able to assist each other when needed. The team wants the robot to be autonomous so it can independently roam around hence reducing man power needed. So, the team decided to build 2 robots that can interact with each other. These robots will be able to avoid obstacles while searching for fire and extinguish it. Large scale robots like these will prevent dangerous situations like those from occurring.

II. The Product

SFFR was made and tested to simulate a situation where the robot would be left in an area to patrol, find and take out a fire. The robot can autonomously roam around while avoiding any obstacles. The robot making use of the front two ultrasonic sensors to detect obstacles, on detecting an obstacle the sensors then spin to go down the most open route and therefore avoid the obstacle as being illustrated in Figure 2. The IR sensor which rotate detect flames and on detecting the flames, stop and pump water to put the fire out. During the demonstration, an IR LED's tower that acts as a fire simulator will shut out when water hit on specified target because of short-circuit implementation. In our simulation we aimed for the robot to detect a simulated fire from at most 20cm out, as shown in Figure **??** the robot is able to detect a candle that is more than 30cm and the pump that is set to extrude water at that distance manage to hit the target by adjusting the angle of the water hose and the pump power intensity. Our robot depicted in Figure 1 was able to successfully achieve these goals.

III. Mechanical Design

The robot that is made from scratch is estimated to weigh no more than 1.5 kg. Upon searching the correct spec of encoder motor required, calculation of the torque needed by the motor to move the vehicle at 30 cm/s is made based upon the weight of the vehicle and tyre size used. Figure 4 depicts the two low cost ball bearing that are used for each tyre to minimize rotation of the tyre and also reduce the wiggling part of the ball bearing. Shaft collar is installed to prevent translational movement and flange shaft coupling connector is used to connect the tyre and the shaft. The body of the robot shown in Figure 1 and Figure 5 is designed to be manufactured from laser cut plywood and the enclosure is made from 3D print and laser cut acrylic. Battery enclosure illustrated in Figure 6 that is made from 3D printer was designed to implement snap fit design on the enclosure to be easily removable for future maintenance. The application of 6 tyres shown in Figure 8, with the center drive rubber tyre supported by front and back wheel can improve control of the vehicle and stability of the vehicle.

IV. Electrical Design

PSoC microcontroller was used to control the robot due to the fact that it could do tasks in real time and do actual multitasking. As shown in Figure 12, the PSoC microcontroller that has a lot of pins and also can be manually configured is suitable for this project that involves a lot of sensors and actuators. Several Ultrasonic sensors were used for obstacle avoidance and an IR sensor for flame detection. Motors with incremental encoders was used to improve the control of the robot to travel in a straight path and made precise turns. Water pump was used to extinguish fire with water and water nozzle was installed on servo motor to adjust the angle when needed. The 3 Ultrasonic sensors and the IR sensors were mounted on servo motors in order for the Ultrasonic sensors to rotate and scan the area for obstacles and the IR sensors can rotate to scan the fire around. Figure 9 shows all the sensor positions, Figure 7 shows the encoder mounted on the motors and Figure 10 shows the position of the pump. Switch was installed to for safety mechanism if force power shut off is required.

V. Software

C language was utilized to do all of the coding for the microcontroller. As illustrated in Figure 11, it depicts the state transition diagram that prioritized finding the fire. Upon finding this fire, the robot would stop, turn on the servo motor to adjust the angle of the nozzle and utilize the pump to shoot water at the fire. If fire was not detected, the robot would check the surroundings for obstacles, upon finding an obstacle, the servo motor that is installed with ultrasonic sensors would then rotate around and find ideal path to go upon and avoid the obstacles. Throughout the entire process the servo motor installed with the IR sensor would be rotating so as to maximize the search for the fire. Interrupts was used for the ultrasonic sensor and the encoder on the DC motor to avoid chances of data loss since there are too many devices to check. A Proportional Integrator controller was used on the encoder to accurately determine the location of the robot. Implementation of pwm function on the code is to ensure the motor to rotate accordingly without the power supplied affects the performance of the motor.

VI. Lesson Learned Advice for Future Students

The most successful part of the project was perhaps the team's good communication. Frequent message exchanges and meeting at least once a week throughout the semester are the keys for a good team experience. A problem encountered in this project was perhaps not managing time well and delaying certain tasks to later as the coding process can only be done after the robot was completely built by which time there were only a few weeks left until the deadline. Other than that, it is important to set early goals and try to meet them. Specifying role for each task is an organised way to complete the project. Picks project that is in favor of the majority since passion helps motivate the team.

Appendix A
Figures

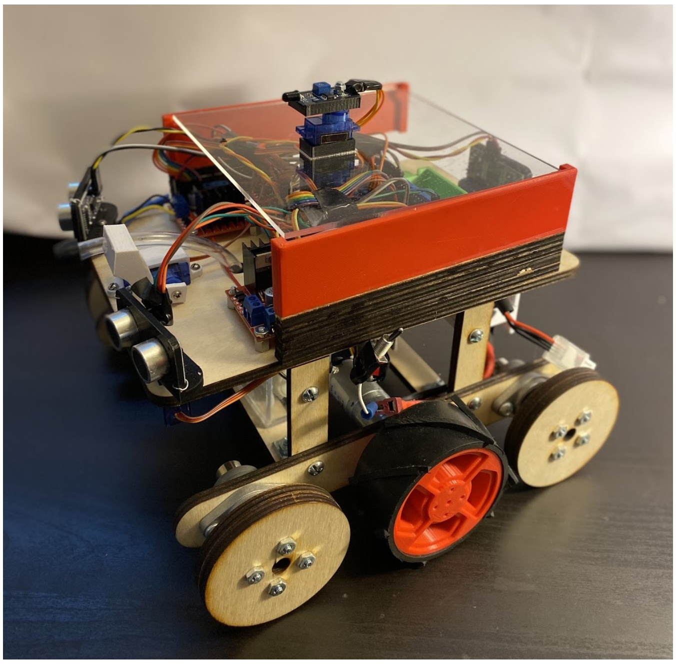

Fig. 1. Final Product

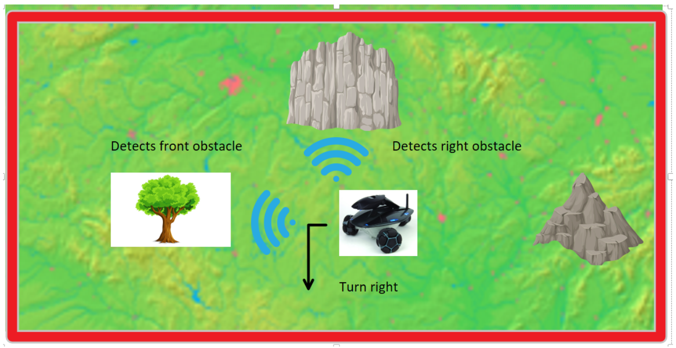

Fig. 2. Illustration of Obstacle Avoidance

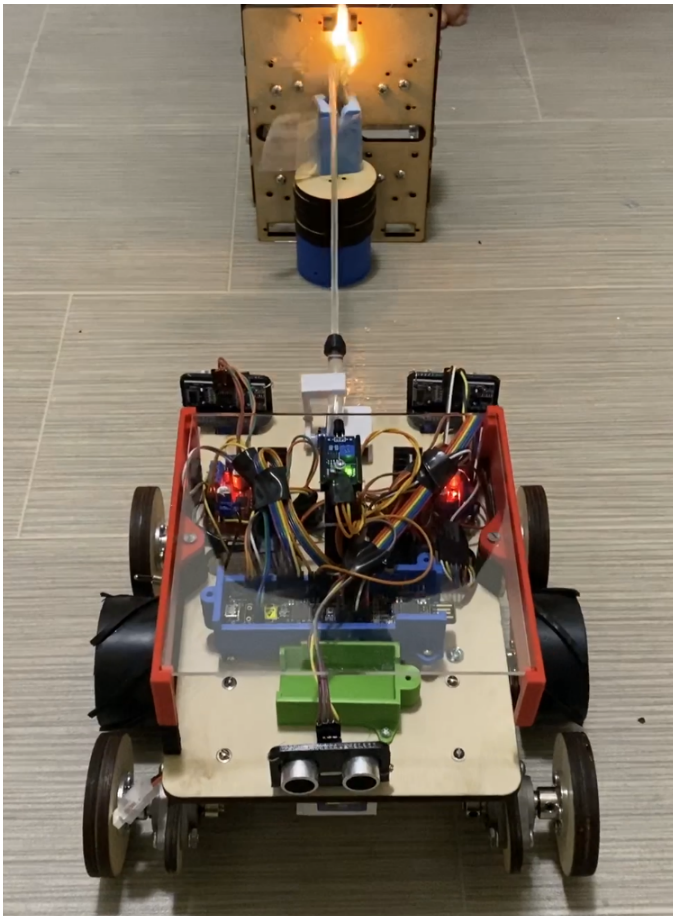

Fig. 3. SFFR Putting out Fire

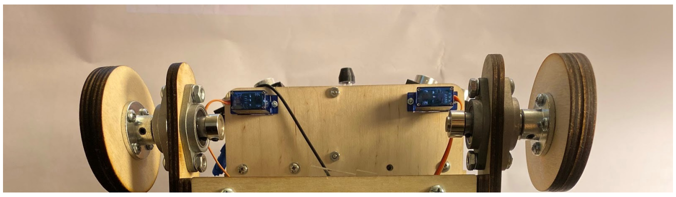

Fig. 4. Connection Between Tyre and Robot

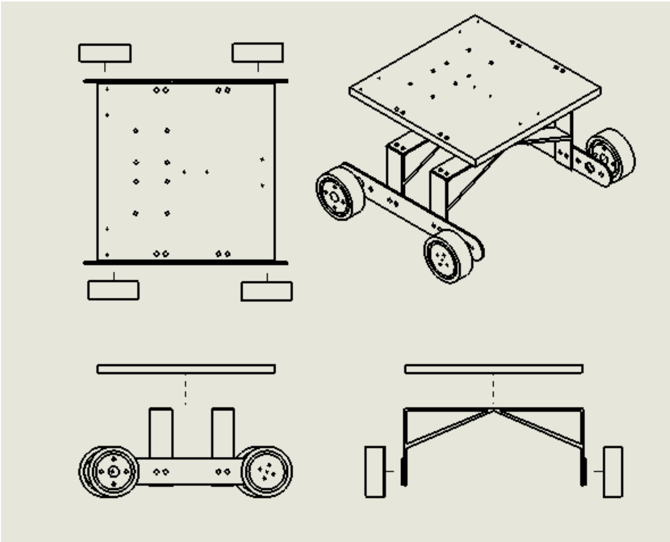

Fig. 5. Assembly Drawing

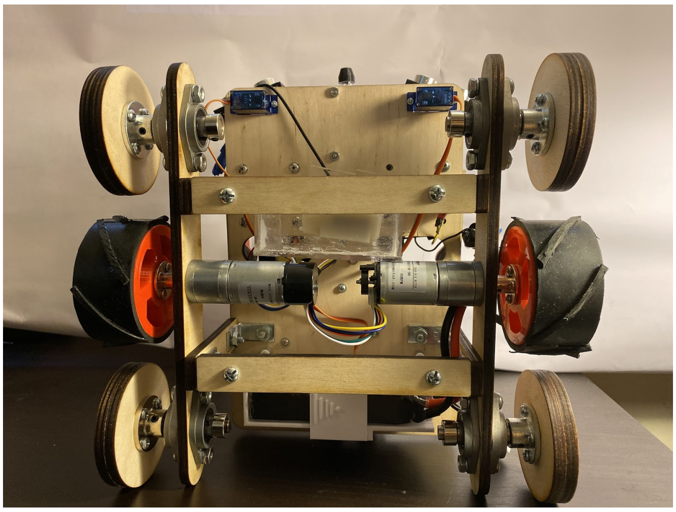

Fig. 8. Bottom of Robot

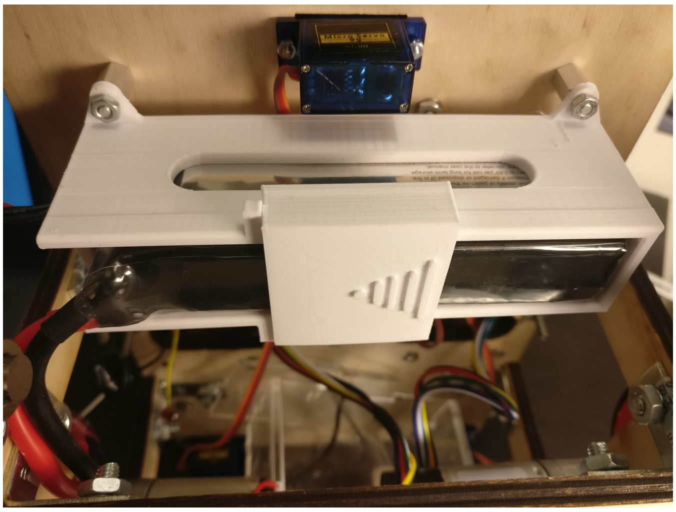

Fig. 6. Battery Holder

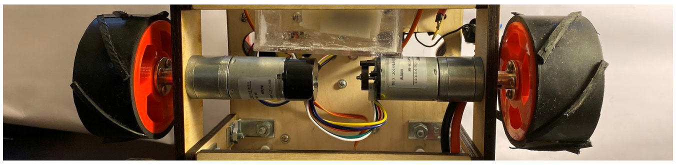

Fig. 7. Encoder Position

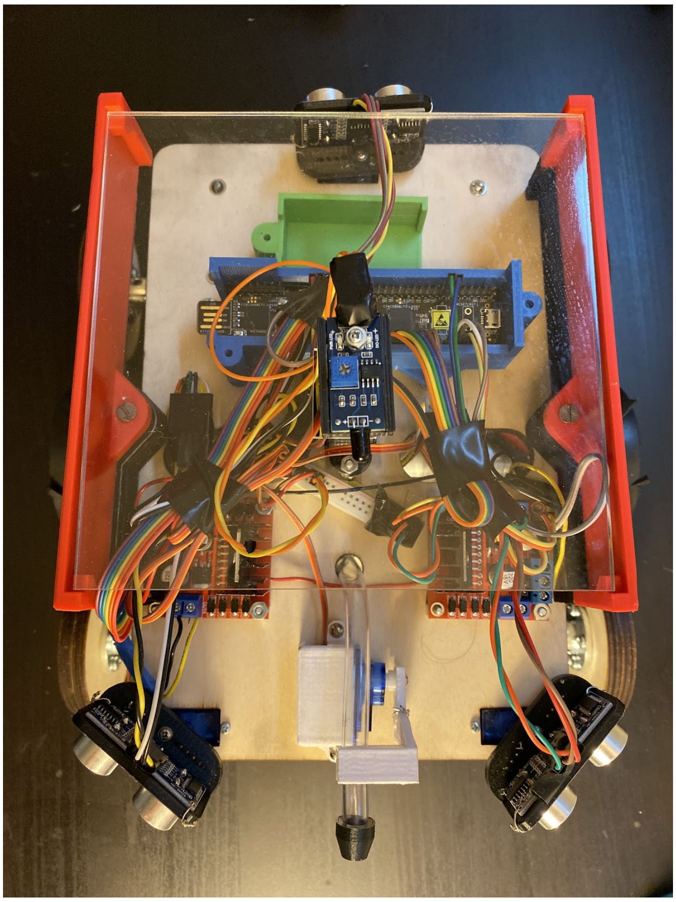

Fig. 9. Sensor Positions

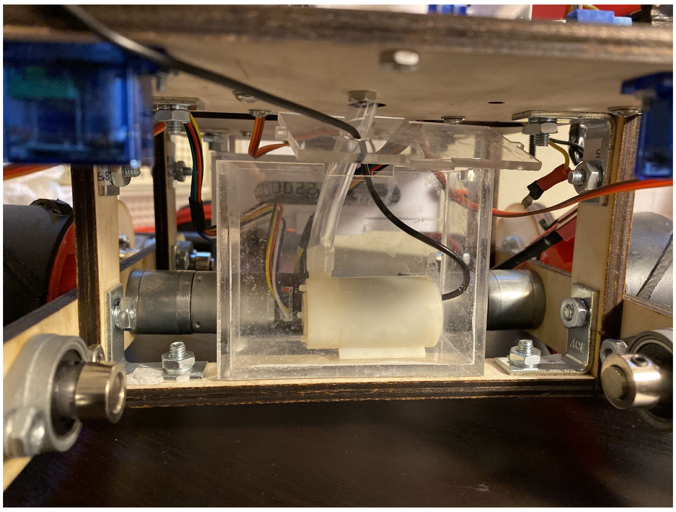

Fig. 10. Pump Position

Fig. 13. Tower with IR Led to Simulate Fire

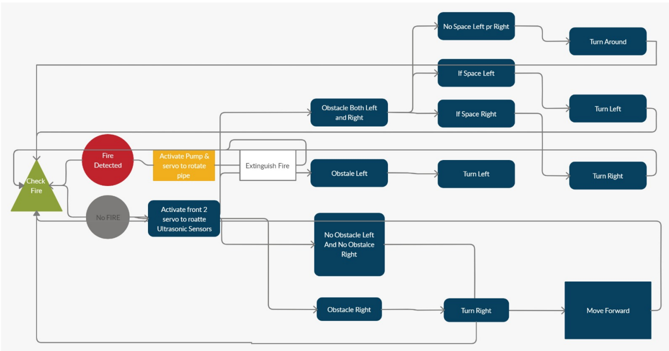

Fig. 11. State Transition

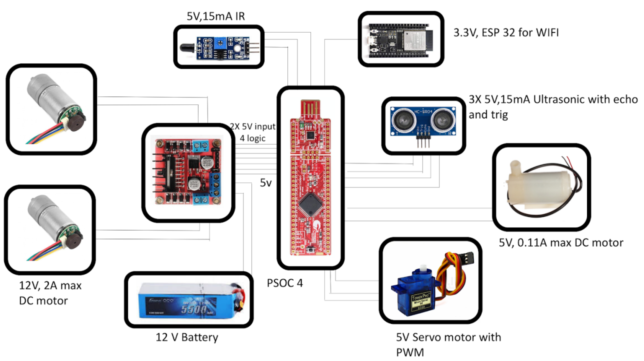

Fig. 12. Connections

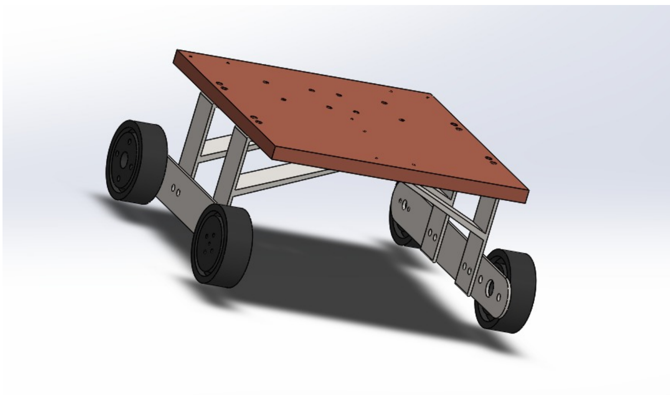

Fig. 14. 3D Assembly of Car

with label.PNG

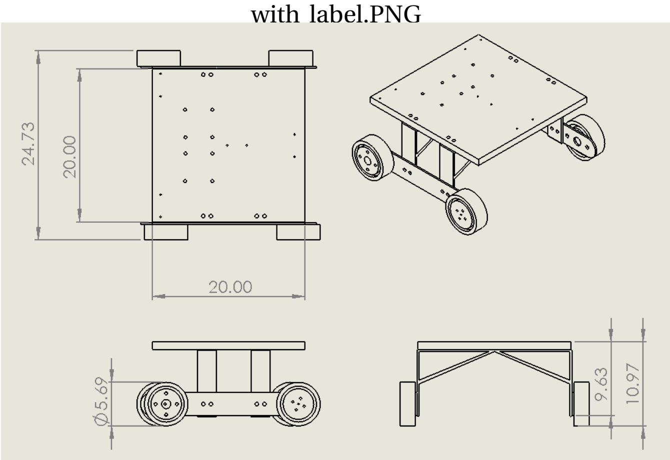

Fig. 15. Assembly Drawing of Car

APPENDIX B
BILL OF MATERIALS FOR FINAL PROTOTYPE

Material	**Quantity**	**Price**
Wood	1/4x30x12in	$1.12
Acrylic	1/8x30x12in	$8.40
Clear PVC Pipe	0.22”-0.32”x 20 in	$1.50
Ultrasonic Sensor	3 units	$2.40
Infrared Sensor	1 units	$1.40
Micro Servo Motor	5 units	$8.0
DC Geared Motor with Encoder	2 units	$36.88
PSOC	1 units	$10.25
Pump Motor	1 units	$8.45
Motor Driver	2 units	$4.80
L-Brackets	8 units (1 x 1/2 in)	$ 5.50
Bearings	8 units (8mm)	$18.98
Flange shaft coupling connector	4 units (8mm)+2 units (4mm)	$29.58
Shaft	2 units (7.9mm x 330 mm)	$4.52
Shaft Collar	4 units (8mm)	$4.79
Battery	1 unit	$17.99
	Total	$164.56