ME GY-6933 Advanced Mechatronics: Term-Project Report

Team 6:
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Mobile Fire Locator:

Abstract:

The objective of this project is to create a mobile device that orients itself toward a fire source and moves toward it. It places itself in such a way where the distance and orientation of the device depends on the location of source and intensity of the fire. Thus, it positions itself in a place where it could extinguish the fire by using an actuator which is simulated with the help of a buzzer in this project. This task is accomplished by using infrared receiver photodiodes as sensors, servo motors as tools for orientation along with a microprocessor and a microcontroller while establishing a communication between them.

Introduction and motivation:

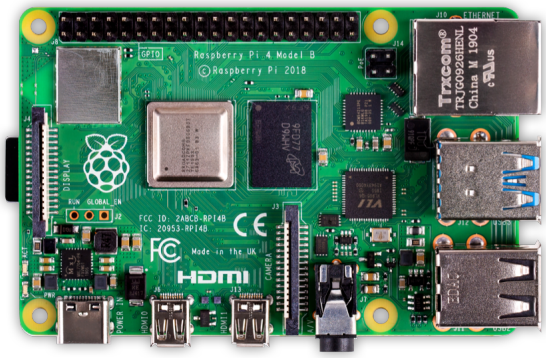
Fire has been a hazard for us for millennia. Technology has always aimed to improve the ways in which we control and react to emergencies, and fire accidents have always been a great example of such emergencies. Several different approaches have been tried to fight these emergencies in different contexts, and so we decided to try an autonomous robot firefighter.

In order to simplify the task at hand, we decided to separate it into two problems. Locating the fire in an open environment, and moving the robot towards its source. The goal is to position and orient the whole robot in such a way that, provided the equipment, it could extinguish the fire by itself.

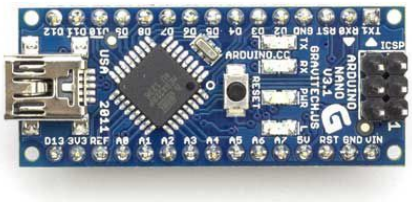
Hardware Environment :

In this project we use a Raspberry Pi and an Arduino nano to control the sensor structure and a cart that is used to carry the structure, simultaneously while communicating with each other. They are used to interface all the actuators and sensors that are used in this project. A personal computer is used to code the program.

- Microprocessor: The Raspberry pi is used in this project. It can be very useful if a prototype requires an on-board computational power without the need to be connected to a PC to reprogram. Since, the prototype is a mobile device raspberry pi was a perfect fit to run the sensor structure whilst sending the information to the microcontroller operating the mobile cart.



- Microcontroller: The arduino nano is used to run the mobile structure in this project. It is also very feasible to interface the raspberry pi and the arduino. Therefore a combination of these is implemented in the project.

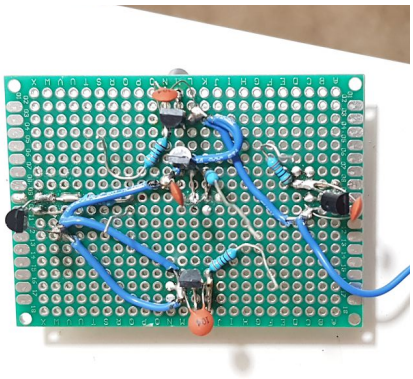


- Infrared receiver photodiodes: The current that flows through them depends on the amount of radiation they absorb from the flame. They are used because of their narrow coverage area unlike photo-resistors for greater accuracy to pinpoint the location of fire. Since they work as a variable resistor, the measurements can be easily registered with a function based on RCtime.

- Standard servo motors: Two standard metal servo motors are used for orientation. One of the servos rotates about the vertical axis and the other one rotates about the horizontal axis.The orientation depends on the input values acquired through the sensors.

- Continuous servo motors: Four continuous servos with wheels are used to move the structure that carries the sensor device toward the fire source. Two of them are attached to the front-end of the cart, while the other two are attached to the rear-end.

- PCB board: The board is used to solder all the sensors along with the RC circuit. This board along with the sensors on top, point in the direction of flame. Another board is used to solder the battery, buzzer and an arduino nano.



- Buzzer: A buzzer is used to simulate an actuator. Once the prototype reaches the required place, the buzzer goes on.

- Resistors and Capacitors: In order to use the digital pins as input pins to read the values of the sensors, the resistor-capacitor circuit and a function based RC time is used. In the project we use five resistor capacitor circuits, one for each sensor.

Bill Of Materials:

Manufacturer	Part name	Part type	Quantity	Description	Price
Raspberry Pi foundation	Single-board computer	Raspberry Pi 4	1	1.4GHz 64-bit quad core processor with wireless LAN	$40.00
Arduino	Microcontroller	Arduino nano	1	ATmega328 operating at clock speed of 16MHz	$21.00
Adafruit	Continuous servo motors	FS90R	4	Operating Voltage: 4.8 to 6 VDC Communication: Pulse-width modulation	$27.99
TowerPro	Standard Servo motor	MG-995	2	Operating Voltage: 4.8 to 6 VDC Communication: Pulse-width modulation is ~1–2 ms high pulse, 20 ms intervals	$11.59
Uxcell	Infrared Sensor	IR Receiver photodiode	5	Operating Voltage: 1.2V DC Wavelength: 940nm	$1.50
-	PCB board	-	2	Solderable board	$2.00
				Total:	$104.08

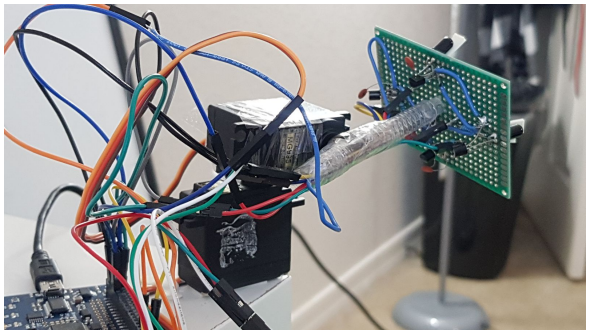
Design Parameters:

The design is divided into two parts controlled by two different microcontrollers.

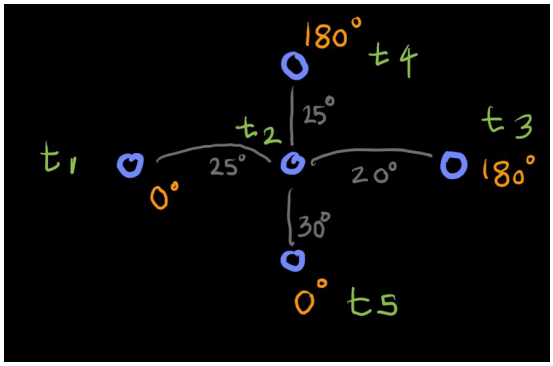
1) Sensor Head
2) Mobile cart

Sensor Head:

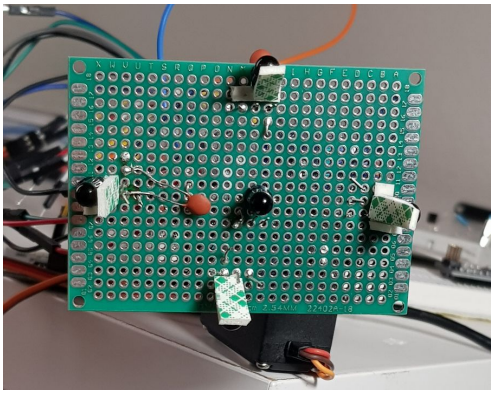
The idea is to make a structure that points toward the direction of fire. Two metal gear servos that are used are aligned one above the other. The one below rotates about a vertical axis. The other servo is attached to it and it rotates about a horizontal axis. The PCB board is fixed to this servo using a rod like structure.



To it PCB board with sensors is soldered to it. The sensors are oriented in such a way that there are three in each axis.

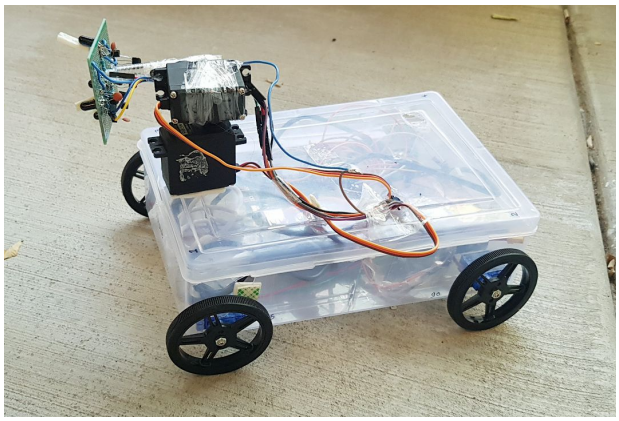


The whole board setup is oriented in the direction where the flame is present. Partitions are used to separate the sensors for accuracy while detecting the location of the fire.

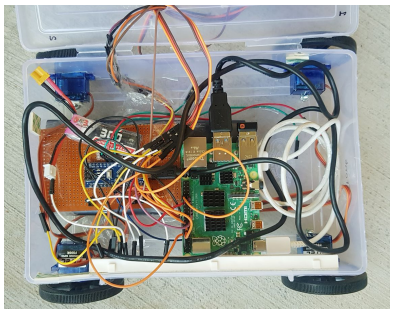


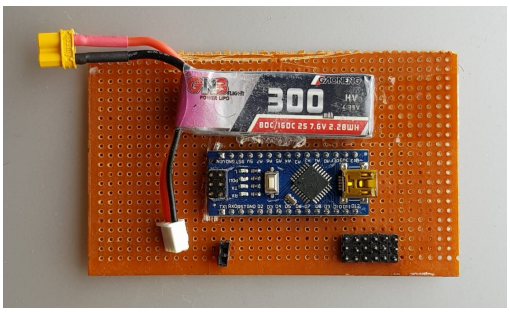
Mobile cart:

A box with four continuous servos along with wheels attached to it acts like a cart is used to move around.



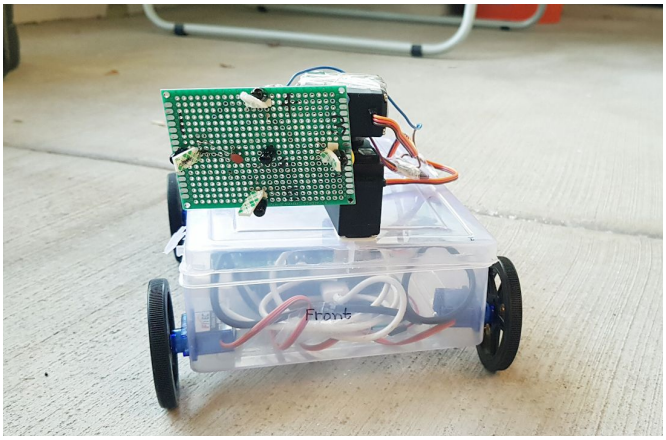
A PCB board with a battery, arduino nano, buzzer soldered to it along with the Raspberry Pi with all the required connections is placed inside the box. The whole setup is powered by a power bank which is also placed inside the box.





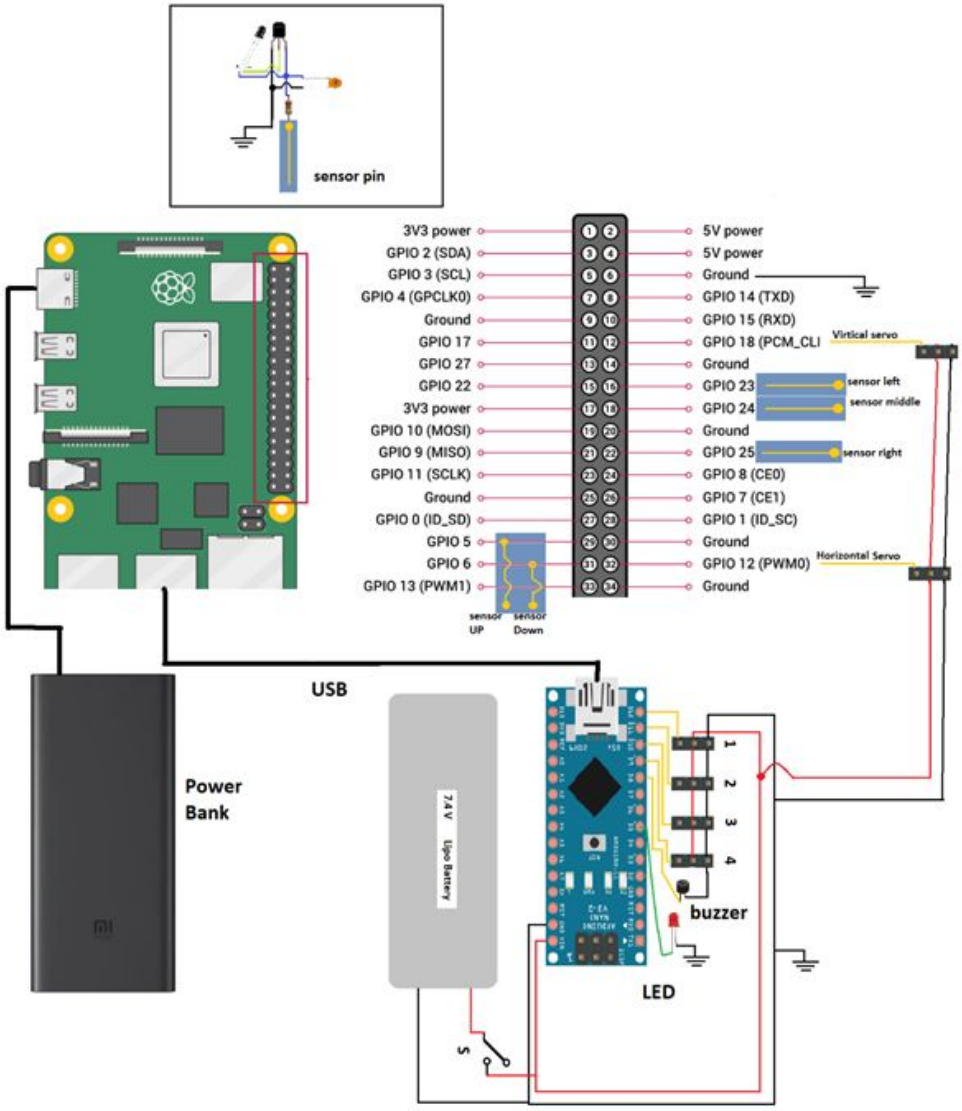
Assembly:

The sensor head and the mobile cart are assembled together. The head structure is fixed on top of the cart which carries it around. Thus making the whole setup a mobile fire locating structure.



Circuit Diagram:

Connection between Raspberry pi and Arduino is established by connecting both of them through a usb cable. Transistors are used with the sensors in order to amplify the current flowing through the sensors. The five sensors along with a RC circuit are connected through pins 5 different GPIO pins of the Raspberrypi. The two standard servos are connected to PWM GPIO pins of the same. The continuous servos are connected to PWM pins of the Arduino.



Communication:

Universal asynchronous receiver/transmitter (UART) communication is used in this project.

It is a simplex type of communication i.e. Communication takes place in one direction. The frequency at which the transmitter sends, the receiver receives. It is one of the simplest forms of communication to implement because all we need is a USB cable and same data transmission rate on the devices that are used. Raspberry pi being a single board computer can just be connected to an Arduino with the help of a USB cable which will replicate the connection used between the PC and the arduino.

The Arduino has a USB-to-UART bridge that converts signals of USB interface to the UART interface making it feasible to implement. Since the requirement is to send information from the Raspberry Pi to the Arduino, there is no need for receiving and transmitting information simultaneously back and forth, therefore the serial communication is a perfect fit.

Program:

The code is divided in two modules: the sensor head and the cart. The sensor head is controlled by a raspberry pi, while the cart section is controlled by an arduino board, considering the data that the sensor head provides.

Sensor head:

The microcontroller executes an RCtime algorithm to get an analogue input from each of the IR sensors, and therefore determines the source of the fire. If the highest value recorded in one of the lines corresponds to one of the sensors on the edge, the corresponding servo will reorient the sensor head towards it. If the highest value corresponds to the middle sensor, the orientation is considered accurate and the servo stops.

The two variables sent from the Raspberry Pi to the Arduino are the current position of the horizontal servo and the measurement of the central sensor.

Cart:

The Arduino receives the position of the horizontal servo, interpreting it as the direction of the fire source with respect to itself. Considering this information, a difference is assigned to the left and right wheels, allowing the cart to turn in the desired direction. The intensity measured in the middle sensor helps the cart determine a safe distance from the fire, moving closer if it’s too far

in order to position itself at an ideal distance to extinguish it. Once the threshold is crossed, the cart stops and activates an actuator (in this case a buzzer) that simulates an extinguishing system such as a fire extintor.

Future steps and possible improvements:

In order to make the prototype more accurate, instead of using only infrared receiver diodes as sensors, temperature and light sensors can be used in order to have a more robust reading of the environment, ruling out noise from background light or the sun, for example. A thermal camera can be interfaced with the Raspberry Pi and OpenCv can be used for better understanding of the environment. Obstacle avoidance can be incorporated as well. A water hose or a fire extinguisher can be mounted to the structure which can be automatically turned on to extinguish fire when reached.