CS 321 Project

Smart Glove

PROJECT REPORT

Group 8

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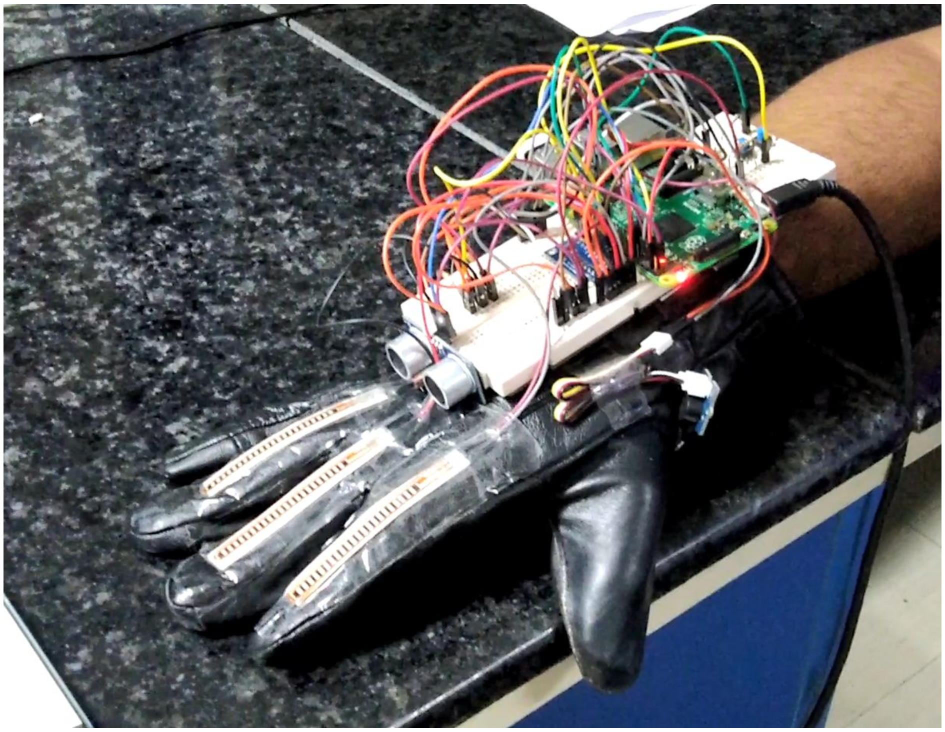
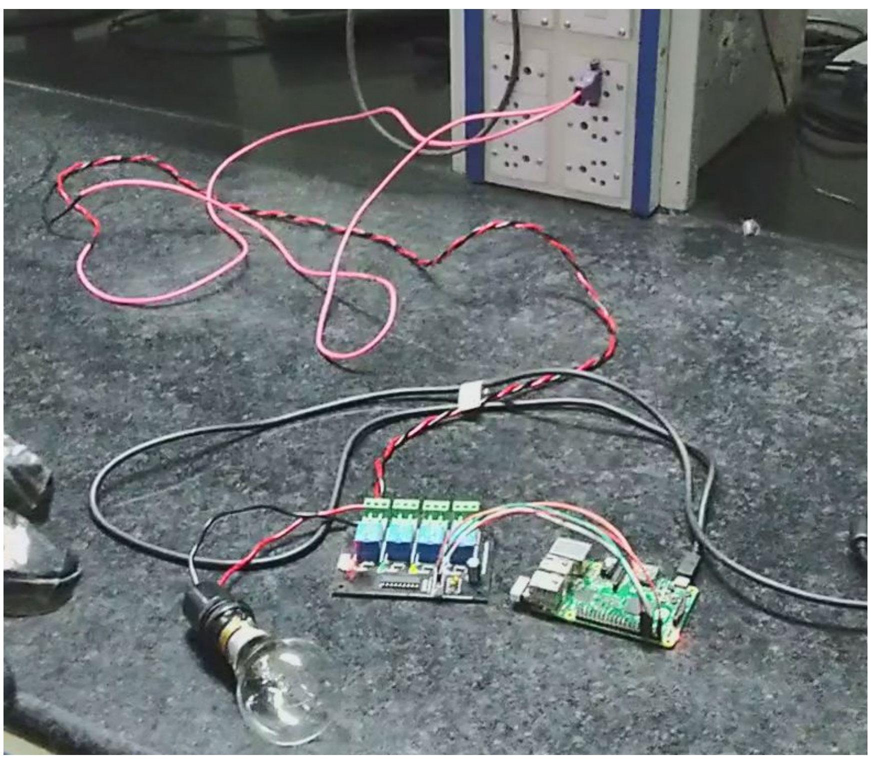


Smart Glove



Home Automation Setup

Table of Contents:

1. Features and Target Audience

1.1 Gestures to speech output

People with speech impairment find it difficult to communicate in a society where most of the people do not understand sign language. Our project focuses on this matter enabling the impaired ones to communicate needs with people using specific gestures using multiple flex sensors.The feature also targets hospitalized people which may use it to render their request to the attendant.

A start-stop mechanism is needed so that features are on only when needed. For each gesture there is an output like a specific phrase from a speaker , the phrase can be set accordingly by the user himself/herself thus providing a dynamic environment.

1.2 Home automation control

The smart glove can also be used to control home appliances including light bulbs, fans, audio system, door etc. Each of the appliance is mapped to their corresponding gesture when the user form the gesture while the home automation state is true the appliance can be turned on or off. The switching from gesture to audio mode to home automation control is done through a push button present on the glove.

1.3 Medicine Scheduler

Alarms can be set corresponding to the scheduled time of medicine intake using the app, our glove serves as a reminder triggering the buzzer on the set time. Proper intake is ensured by listening via MQTT to smart locker system opening which symbolises medicine intake. This feature is intended for hospitalized people however can be used for general purpose also.

1.4 Obstacle detection for navigation

The smart glove can be used by normal people to navigate in dark or by blind people to move around . The smart glove uses ultrasonic sensor to calculate the distance from the upcoming object and actuate the buzzer when the distance is less or equal to 50 cm , the frequency of the buzzer is inversely proportional to the distance i.e it increases as the distance decreases.

1.5 Fall Detection

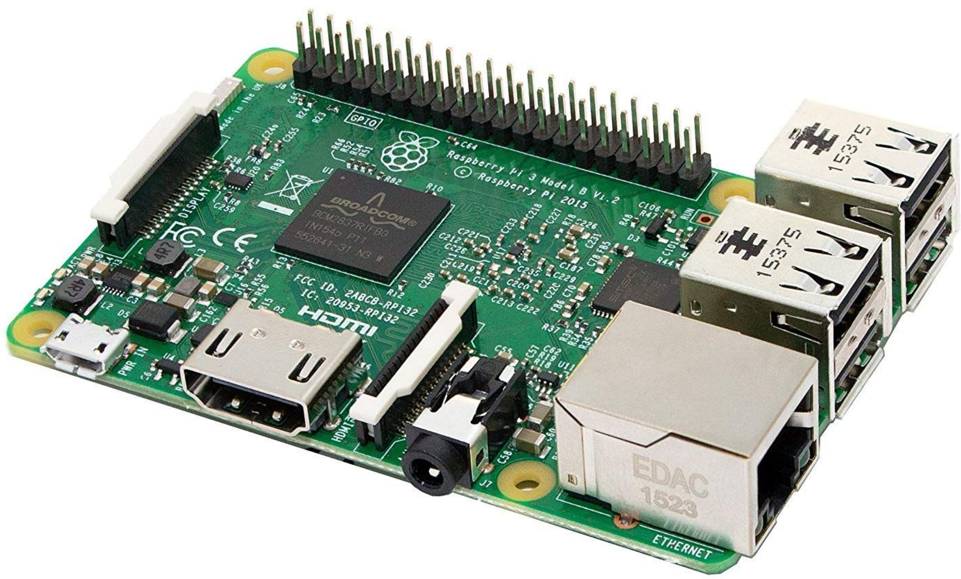
The smart glove detects fall by sensing abrupt change in acceleration and sends message to emergency contact number relaying the crisis situation . The emergency contact number can be saved using the mobile app and the emergency message can also be recorded beforehand.

2. Hardware Modules

There are two parts two this project, the Smart Glove itself and the setup for demonstrating home automation. The components used in each part are described below:

2.1 Smart Glove

2.1.1 Raspberry Pi 2 (x1)



Description:

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

Why did we use it?

Due to its excellent networking support via Plug and Play Wifi-dongle, we went with the Pi. This was required because the glove relied on MQTT to communicate with the companion app and home automation server.

Only serial communication was possible through XBee on Arduino which has limited range as it doesn't utilize the internet infrastructure. We would also have to use a self-defined protocol for communicating to and fro. These are already handled efficiently via MQTT.

2.1.2 Ultrasonic Sensor (x1)

Description:

Ultrasonic ranging module HC-SR04 provides 2 - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

1. Using IO trigger for at least 10 µs high level signal,
2. The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
3. IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

*Test distance = (high level time * velocity of sound (340m/s))/ 2*

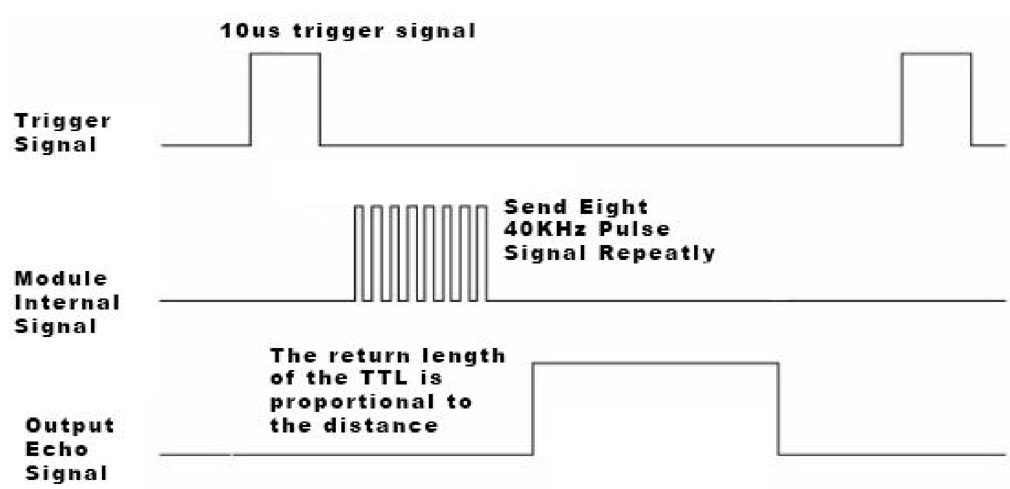
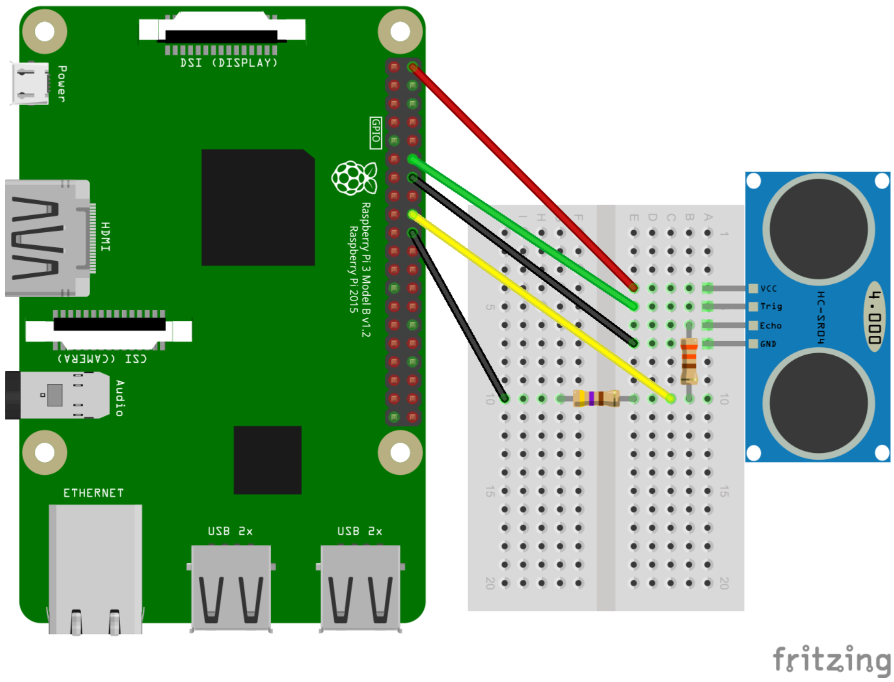


Fig.- Timing Diagram of HC-SR04

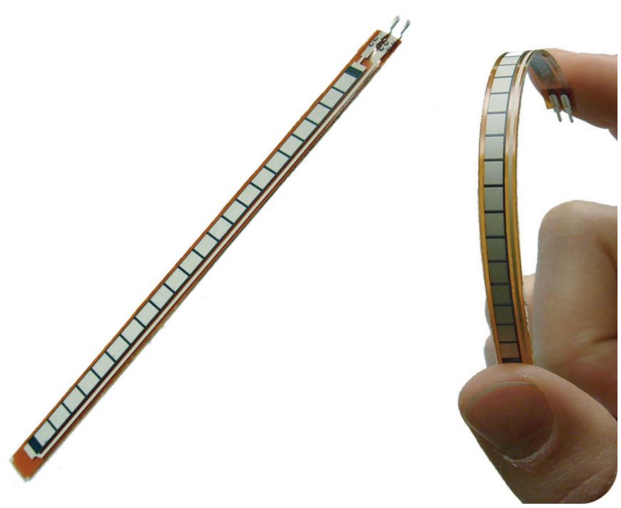
Why did we use it?

Continuous obstacle detection while navigation is done using this sensor. It is mounted on the wrist enabling the blind person to get information about the surroundings by lifting his/her hand and pointing it in the desired direction.

Circuit Diagram:



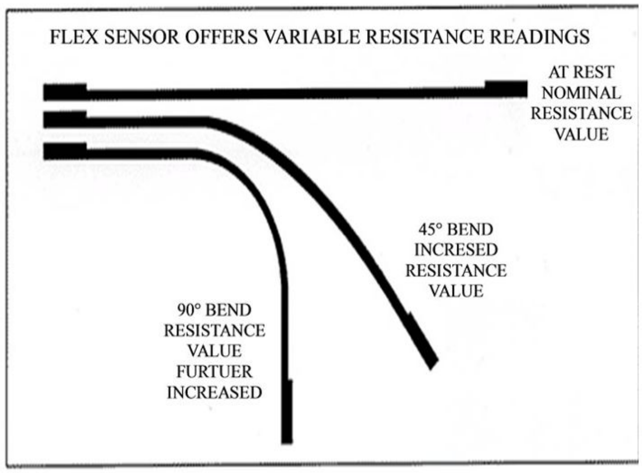
2.1.3 Flex Sensors (x3)



Description:

The Flex Sensor patented technology is based on resistive carbon elements. As a variable printed resistor, the Flex Sensor achieves great form-factor on a thin flexible substrate. When the substrate is bent, the sensor produces a resistance output correlated to the bend radius—the smaller the radius, the higher the resistance value.

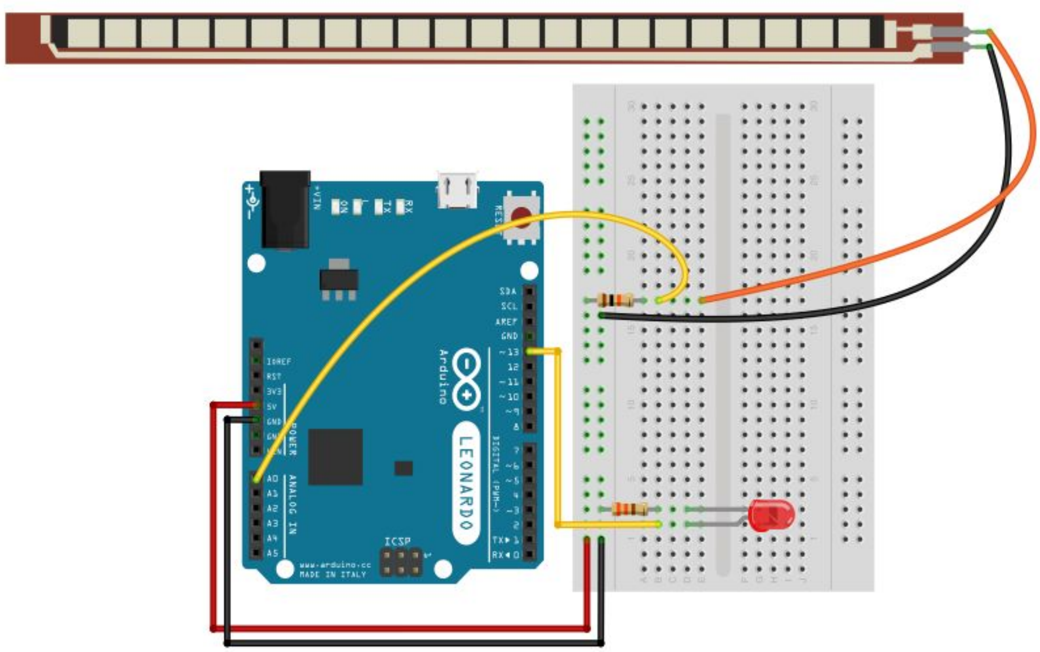
This changing resistance is used in a voltage divider circuit. The divided voltage is proportional to the resistance of the flex sensor and serves as a analog input.



Why did we use it?

The flex sensors are used to measure the degree of bending of the fingers . Different degree of bending correspond to different state of the finger and the combination of all the fingers result in a specific gesture.

Circuit Diagram:

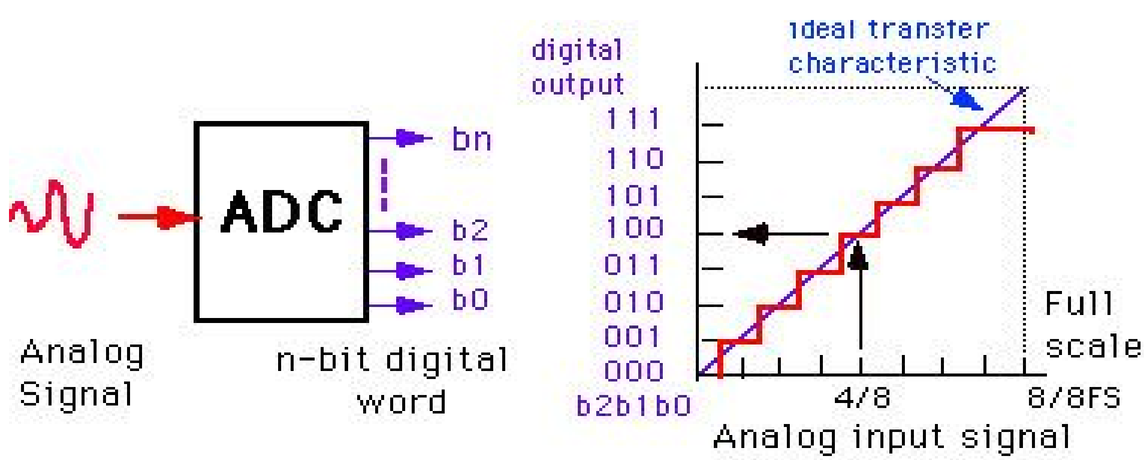


In our product we have interfaced 3 flex sensors with Raspberry Pi using ADC.

2.1.4 Analog-to-Digital Converter ADS1115 (x1)

Description:

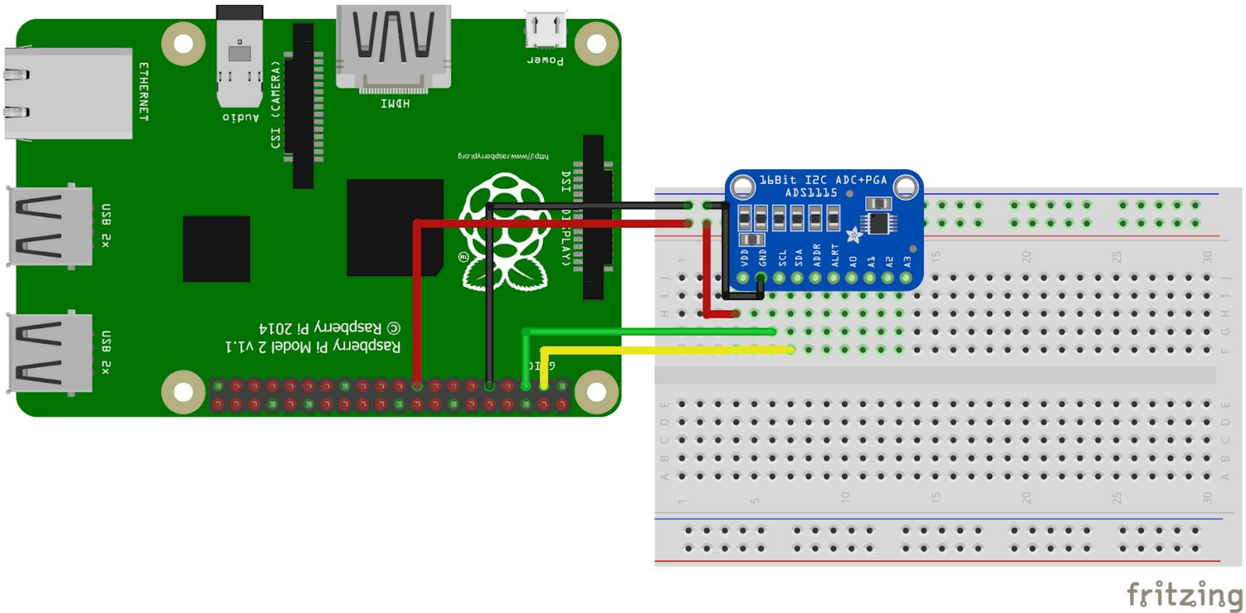
ADC samples the analog signal on each falling or rising edge of sample clock. In each cycle, the ADC gets of the analog signal, measures and converts it into a digital value. The ADC converts the output data into a series of digital values by approximates the signal with fixed precision.In ADCs, two factors determine the accuracy of the digital value that captures the original analog signal. These are quantization level or bit rate and sampling rate.



Why did we use it?

The signal from flex sensors are analog in nature and had to be converted into digital to be fed into raspberry pi, therefore analog to digital converters were required.

Circuit Diagram:



2.1.5 Accelerometer from MPU9150 (x1)

Description:

The MPU-9150 is a 9-axis Motion Tracking device that combines a 3-axis MEMS gyroscope, a 3-axis MEMS accelerometer, a 3-axis MEMS magnetometer and a Digital Motion Processor™ (DMP™) hardware accelerator engine. The MPU-9150 features three 16-bit analog-to-digital converters (ADCs) for digitizing the gyroscope outputs, three 16-bit ADCs for digitizing the accelerometer outputs, and three 13-bit ADCs for digitizing the magnetometer outputs. Communication with all registers of the device is performed using I2C at 400kHz.

Why did we use it?

Since the glove is targeted towards blind or hospitalised people, we have implemented fall detection for safety. The algorithm captures the momentary free fall followed by an impact on hitting the ground. Note that only an accelerometer was needed but due to unavailability of a discrete unit we used the IMU.

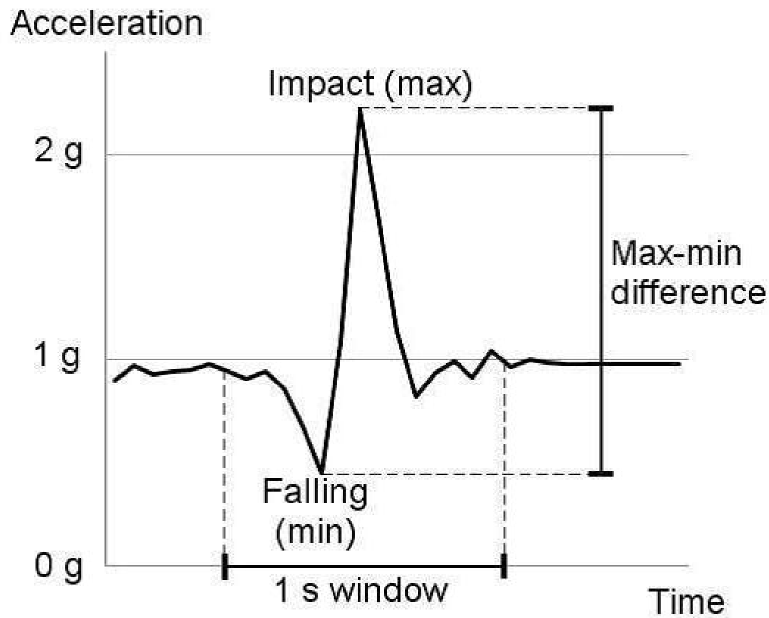


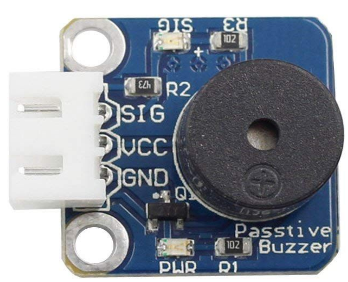
Fig.- Acceleration vs Time Graph while falling

Connections:

The GND and VCC pins of the MPU9150 were connected to the GROUND and 3.3v pins on the Raspberry Pi 2.

SDA (Serial Data) and SCL (Serial Control) pins of the IMU were connected to the GPIO0 (Physical Pin 27) and GPIO1(Physical Pin 28) of the Pi for communication using its I^2C Bus 0.

2.1.5 Buzzer (x1)



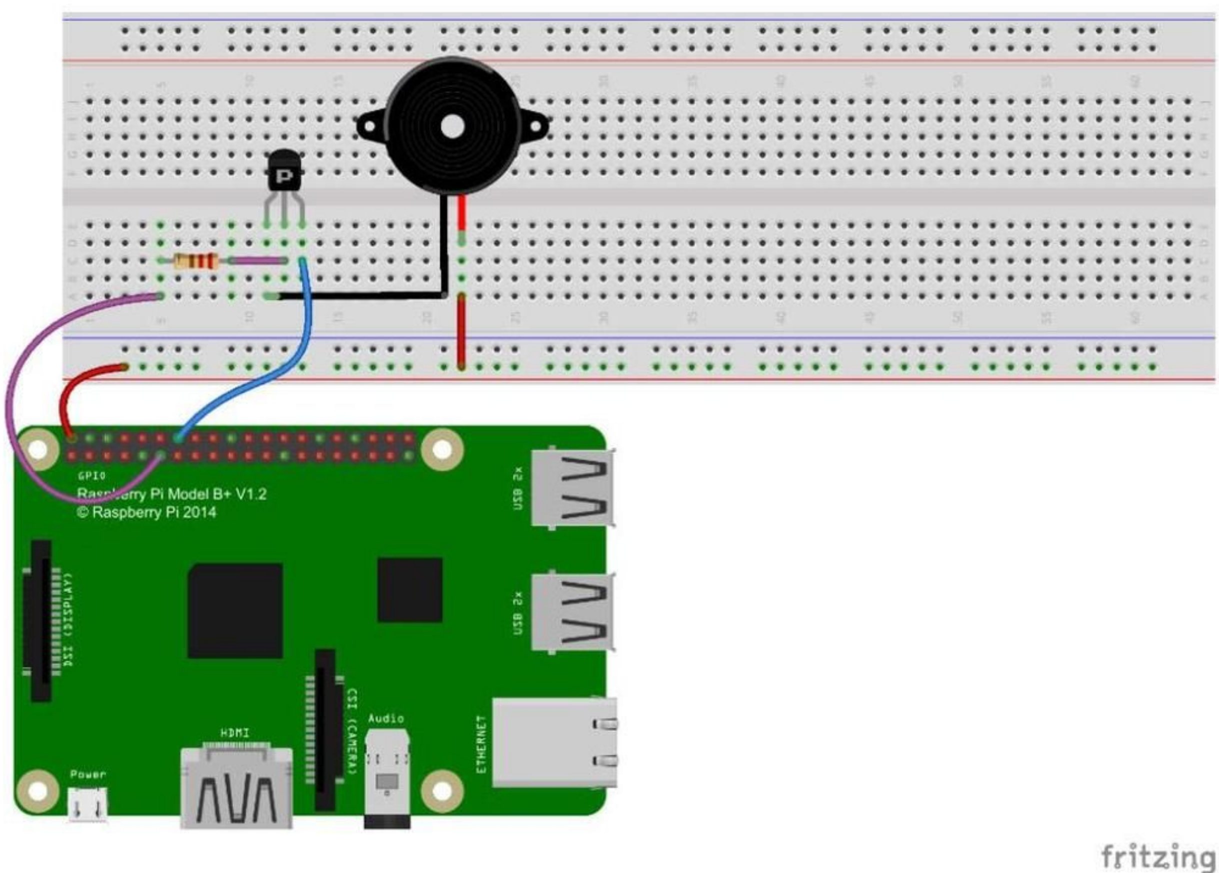
Description:

A buzzer or beeper is an audio signalling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. Grove - Buzzer module has a piezo buzzer as the main component. The piezo can be connected to digital outputs, and will emit a tone when the output is HIGH.

Why did we use it?

Alert when an obstacle is detected is given using the the Grove - Buzzer. The frequency of the the beeping linearly increases as the distance from obstacle decreases. It is also used to trigger alarm when a medicine reminder is set.

Circuit Diagram:



2.2 Home Automation

A Raspberry Pi was used as the server for this module. We have already described it above.

2.2.1 Relay Switch (x1)

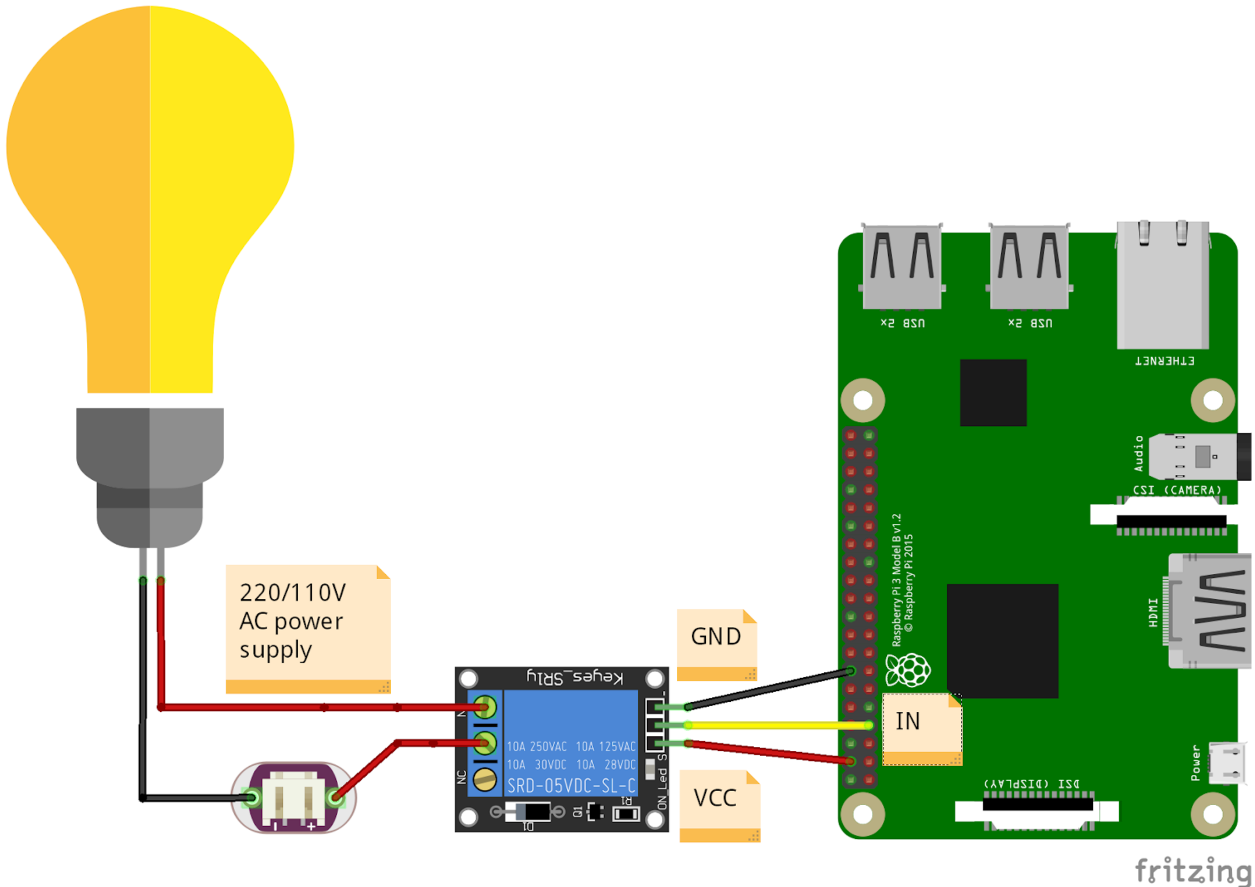
Description:

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. The heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). A relay can be thought as a kind of electric lever: switch it on with a tiny current and it switches on ("leverages") another appliance using a much bigger current. It is useful with sensors that are incredibly sensitive pieces of electronic equipment and produce only small electric currents but need to drive bigger pieces of apparatus that use bigger currents. Relays bridge the gap, making it possible for small currents to activate larger ones. Relays can work either as switches (turning things on and off) or as amplifiers (converting small currents into larger ones).

Why did we use it ?

The relay switch was used in our product to control the home appliance connected to our home automation system. The relay was controlled using a raspberry pi which received signal using MQTT depending on which appliances were turned on/off.

Circuit Diagram:

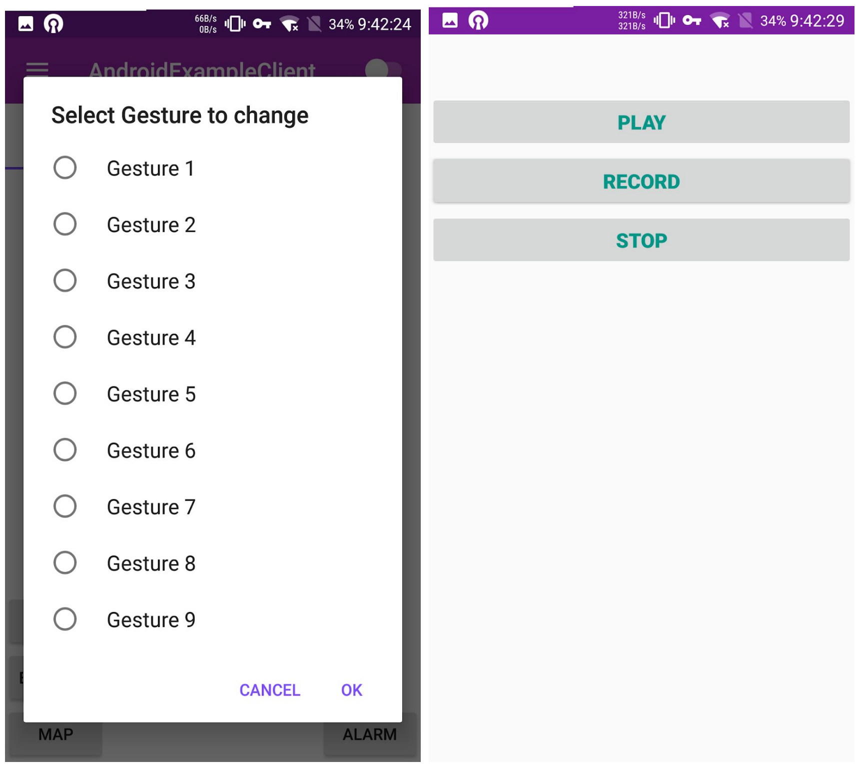


3. Companion App

3.1 Gesture to Audio Output:

Each gesture can be mapped to any audio output. The audio can be recorded via the app. After recording, whenever that gesture is formed, then corresponding sound is played. This feature can be employed in two different scenarios as has been mentioned below:

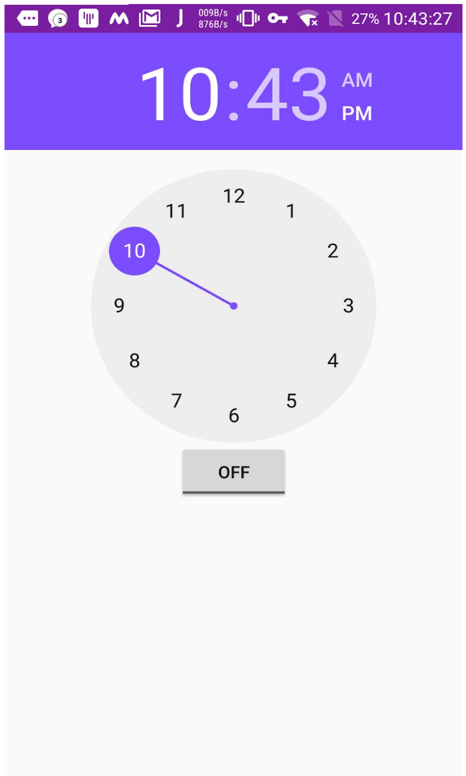
1. When used for the patient the attendant should be the one receiving the audio and
2. When it is used by mute people the user should be the one carrying the smartphone with the app to be able to communicate with others.



3.2 Medicine Scheduler:

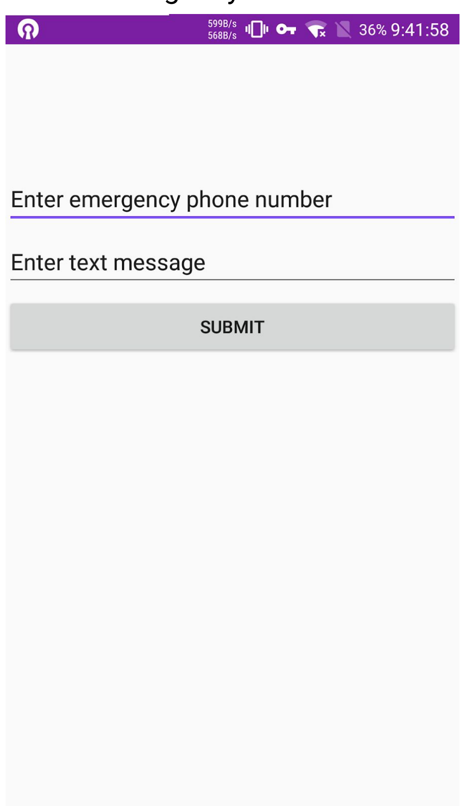
An alarm can be set via app which triggers at a specific time. The buzzer starts buzzing when scheduled which acts as a reminder for taking medicine. The alarm is automatically turned off when the connected locker (in which medicine is kept) is opened.

The alarm can be set by attendant and when the buzzer activates the attendant can turn the alarm off by delivering the medicine from the locker to the patient.



3.3 Emergency Contact:

One can also set emergency contact and emergency message in the app. Whenever a fall is detected in the glove, an SMS is sent to the emergency contact.



4. Implementation Highlights

4.1 Threading using Python

Fall detection requires very frequent polling of the accelerometer which is not required for other sensors nor does every sensor support such high frequency polling. Thus a single main loop would be relatively less stable, reliable and energy-consuming.

Our solution is to make a separate thread for the accelerometer which iterates much faster compared to the main thread.

4.2 Communication via MQTT

MQTT (Message Queueing Telemetry Transport) is the lifeline of all communication done in this project. We believe that gestures can be used as a controller for a wide variety of cases. MQTT is a standardised IoT protocol which will make interfacing with other system easier.

For example, a more robust home automation system can be hooked with the glove.

5. Limitations

5.1 Number of gestures

Currently one flex sensor is just to determine if the corresponding finger is bent or not. This yields 23 = 8 gestures, one of which is rest state. Thus, bumping each flex sensor into 3-states and using Euler angles for orientation from IMU will increase gesture count manifold.

5.2 Mandatory presence of phone nearby for audio output

The phone might be in pocket hindering the voice output. A miniature speaker mounted with the raspberry pi will be ideal.

6. Scope for Improvement

6.1 Use Gestures instead of Push Buttons

As pointed out in the demonstration, a start-stop mechanism is needed so that features are on only used when needed. Also, instead of using push buttons it is more meaningful to use a gesture as a master control for cycling between modes and turning the glove on/off.

6.2 Endorsement by the attendant in Medicine Scheduler

Opening the smart locker containing medicine is not a full-proof assurance that the patient has taken the medicine. As such, a final endorsement in the app to be done by the attendant will be more practical. Additionally, the scheduler data may then be published in the doctor’s channel.

6.3 Haptic feedback instead of Buzzer

A constantly beeping buzzer is obtrusive to other people in proximity to the glove.

Thus, a vibrating motor providing feedback to the bearer will be more practical.