Assistive gloves for the deaf and blind

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Abstract **:**

Deaf and mute individuals face significant challenges in communication, while blind individuals encounter numerous obstacles during daily movement. This project introduces a multipurpose glove designed to assist people with these disabilities by translating finger movements into human speech and recognizing objects in their environment.

The glove incorporates bend sensors to detect finger movements and convert sign language into audible speech and text display, enabling deaf and mute individuals to communicate with others who do not understand sign language. Additionally, using an ESP32-CAM module and deep learning, the glove can identify objects for blind users, aiding them in navigating their surroundings. Other features include pothole detection, where an ultrasonic sensor detects hazards and alerts the user, and thief detection, which acts as an anti-intruder warning system.

This innovative, budget-friendly solution seeks to improve the quality of life for the deaf, mute, and blind, facilitating communication and providing safer mobility. It combines various technologies into a single, portable, and user-friendly device.

1 Introduction

Deaf and mute individuals face significant challenges in communication, while blind individuals encounter numerous obstacles during daily movement. This project introduces a multipurpose glove designed to assist people with these disabilities by translating finger movements into human speech and recognizing objects in their environment.

The glove incorporates bend sensors to detect finger movements and convert sign language into audible speech and text display, enabling deaf and mute individuals to communicate with others who do not understand sign language. Additionally, using an ESP32-CAM module and deep learning, the glove can identify objects for blind users, aiding them in navigating their surroundings. Other features include pothole detection, where an ultrasonic sensor detects hazards and alerts the user, and thief detection, which acts as an anti-intruder warning system.

This innovative, budget-friendly solution seeks to improve the quality of life for the deaf, mute, and blind, facilitating communication and providing safer mobility. It combines various technologies into a single, portable, and user-friendly device.

2 Project Overview

1. Develop a wearable device capable of interpreting sign language gestures using custom-made flex sensors.

2.Translate sign language gestures into binary commands and provide real-time audio feedback through a speaker.

3. Integrate object detection capabilities using an ESP32-CAM module to assist blind individuals in identifying objects in their surroundings.

4. Implement a path detection mechanism using ultrasonic sensors to enhance mobility and navigation for blind users.

5. Incorporate security features, including a PIR sensor, to ensure user safety and prompt response to potential threats.

6. Design the device to be user-friendly, comfortable to wear, and adaptable to individual user needs.

2.1 Sign Language Translation

The Sign Language Translation component of the Assistive Device for Deaf and Blind Individuals plays a pivotal role in facilitating effective communication for deaf users. Leveraging custom-made flex sensors integrated into wearable gloves, this component enables the device to interpret sign language gestures with precision and accuracy.

2.1.1 ***Sensor Technology*** The Sign Language Translation component relies on the use of flex sensors strategically placed within the fingertips of the gloves. These sensors are meticulously crafted using DIY techniques to ensure optimal sensitivity and responsiveness to the subtle movements and nuances inherent in sign language gestures. By detecting changes in resistance as the fingers are flexed or extended, the sensors capture the intricate patterns of hand movements associated with different signs in sign language.

2.1.2 ***Gesture Recognition Algorithm*** A sophisticated gesture recognition algorithm processes the signals captured by the flex sensors, translating them into meaningful binary commands. This algorithm is designed to analyze the patterns and sequences of finger movements characteristic of various sign language gestures. Through pattern recognition and machine learning techniques, the algorithm accurately identifies and classifies each gesture, assigning a corresponding binary code to represent it.

2.1.3 ***Binary Command Mapping*** Once the sign language gestures are translated into binary commands, they are mapped to predefined strings or messages associated with specific actions or communication prompts. For example, a binary code representing the sign for "Doctor" may be mapped to the string "Call Doctor." This mapping process enables the device to provide contextually relevant feedback and instructions to the user based on their sign language input.

2.1.4 ***Audio Feedback*** The final step in the Sign Language Translation process involves converting the mapped strings or messages into audible feedback using a built-in speaker. Upon recognizing a sign language gesture and translating it into a binary command, the device emits clear and intelligible audio cues to communicate the corresponding action or prompt to the user. This audio feedback ensures real-time communication and interaction, empowering deaf individuals to engage effectively with their surroundings.

2.1.5 ***Accuracy and Reliability*** The Sign Language Translation component is engineered to deliver high levels of accuracy, reliability, and responsiveness in interpreting sign language gestures. Through rigorous testing and optimization, the sensor technology, gesture recognition algorithm, binary command mapping, and audio feedback mechanisms work seamlessly together to provide a user-friendly and intuitive communication experience for deaf users.

2.2 Object Recognition for the Blind

The "Object Recognition for the Blind" component of the Assistive Device for Deaf and Blind Individuals is designed to empower blind users with enhanced awareness and independence through the detection and identification of objects in their surroundings. Leveraging cutting-edge technology, this component utilizes an ESP32-CAM module to capture images and recognize objects, providing real-time auditory feedback to the user.

2.2.1 ***ESP32-CAM Module*** Central to the Object Recognition component is the ESP32-CAM module, a versatile and powerful micro-controller equipped with a camera. The module is capable of capturing high-resolution images and processing them in real-time, making it ideal for object detection applications. By interfacing with the device's micro-controller, the ESP32-CAM module enables seamless integration of object recognition functionality into the assistive device.

2.2.2 ***Image Processing Algorithm*** An advanced image processing algorithm is employed to analyze the images captured by the ESP32-CAM module and identify objects within the user's vicinity. This algorithm utilizes machine learning and computer vision techniques to detect object patterns, shapes, and features, enabling accurate and reliable recognition of a wide range of objects. Through continuous refinement and optimization, the algorithm ensures robust performance in various environmental conditions and scenarios.

2.2.3 ***Auditory Feedback*** Upon detecting and identifying objects, the Object Recognition component provides real-time auditory feedback to the user, enabling them to perceive and comprehend their surroundings effectively. Using a built-in speaker, the device emits clear and intelligible audio cues corresponding to the detected objects. For example, upon recognizing a "chair," the device may emit the auditory cue "chair" to alert the user to the presence of the object.

2.2.4 ***User Interaction*** The Object Recognition component is designed to facilitate seamless interaction with the user, allowing them to access information about their environment effortlessly. Through intuitive user interfaces and feedback mechanisms, blind users can navigate their surroundings with confidence and independence, leveraging the device's object recognition capabilities to identify objects, obstacles, and landmarks in real-time.

2.2.5 ***Impact and Benefits*** By providing blind users with enhanced awareness of their surroundings, the Object Recognition component of the assistive device promotes independence, safety, and confidence in daily activities. Whether navigating unfamiliar environments, locating objects, or identifying obstacles, blind individuals can rely on the device to provide essential auditory cues and information, empowering them to live life to the fullest.

2.3 Pothole Detection

The "Pothole Detection" component of the Assistive Device for Deaf and Blind Individuals aims to enhance safety and mobility for visually impaired individuals by detecting and alerting them to the presence of potholes and uneven surfaces in their path. Leveraging ultrasonic sensors and advanced servo motor mechanisms, this component provides real-time feedback to users, enabling them to navigate urban environments with greater confidence and safety.

2.3.1 ***Ultrasonic Sensors*** At the heart of the Pothole Detection component are ultrasonic sensors strategically integrated into the device. These sensors emit high-frequency sound waves and measure the time it takes for the waves to bounce off nearby surfaces and return. By analyzing these measurements, the device can accurately detect changes in surface elevation, such as potholes and uneven terrain, in the user's path.

2.3.2 ***Servo Motor Mechanism*** To ensure continuous and accurate path detection, the Pothole Detection component utilizes a sophisticated servo motor mechanism. This mechanism allows the ultrasonic sensors to maintain a stable scanning angle relative to the user's hand position. When the user's hand is in a downward position, the sensors remain fixed at a predetermined angle. However, as the user's hand moves upward, the servo motor adjusts the sensors to maintain their position relative to the user, ensuring consistent and reliable path detection regardless of hand movement.

2.3.3 ***Real-Time Feedbac*k** Upon detecting a pothole or uneven surface, the Pothole Detection component provides real-time feedback to the user through auditory cues or tactile vibrations. Using built-in speakers or haptic feedback mechanisms, the device alerts the user to the presence of potential hazards in their path, allowing them to take evasive action or adjust their trajectory accordingly. This real-time feedback enhances user safety and confidence while navigating urban environments.

2.3.4 ***User Interaction*** The Pothole Detection component is designed to seamlessly integrate into the user's interaction with the device, providing intuitive and responsive feedback without disrupting their mobility. Through user-friendly interfaces and feedback mechanisms, visually impaired individuals can navigate urban environments with greater ease and assurance, relying on the device to alert them to potential hazards and obstacles in their path.

2.3.5 ***Impact and Benefits*** By providing real-time detection and alerting of potholes and uneven surfaces, the Pothole Detection component enhances safety and mobility for visually impaired individuals, reducing the risk of accidents and injuries. By empowering users with greater awareness of their surroundings, the component promotes independence and confidence in navigating urban environments, ultimately improving their quality of life and well-being.

2.4 Thief Detection

Our project incorporates a "Thief Detection" feature aimed at enhancing the safety and security of our users, particularly those who are deaf or blind. This feature utilizes a Passive Infrared (PIR) sensor, functioning as a motion detector. Upon detecting movement in its vicinity, the sensor activates an alarm system, serving as an alert mechanism, especially during nighttime when vulnerability may be heightened.

What sets our implementation apart is the integration of a GSM module, allowing for immediate communication in the event of suspicious activity. When the PIR sensor registers movement while the device is not in the user's possession or when unexpected visitors are detected, a signal is transmitted. This signal enables the user to discreetly summon assistance, such as contacting law enforcement, through a simple hand gesture. Essentially, this feature functions as a personalized security system embedded within the user's gloves.

We believe that the addition of the Thief Detection feature provides an additional layer of protection and reassurance for our users, thereby augmenting the overall utility and safety of our device.

3 Components

Component List

1. Arduino Mega
2. Arduino Uno
3. Bend Sensitive Sensor
4. ESP32 Cam Module
5. ESP32-CAM W-BT Board ESP32-CAM-MB
6. GSIM900 GSM
7. Ultrasonic Sonar Sensor HC- SR04
8. Accelerometer
9. Servo Motor SG-90
10. PIR Sensor
11. 16x2 LCD Display and 16x2 LCD Display Module
12. Breadboard
13. Jumper Wires
14. 1k and 10k Resistors
15. 5V Speaker

3.1 Arduino Mega

The Arduino Mega 2560 is a powerful development board designed for projects that demand extensive input/output capabilities and processing power.It features an ATmega2560 microcontroller, offering ample flash memory, SRAM, and EEPROM for storing code and data. The board is a significant step up from the Uno in terms of specifications, making it suitable for larger and more complex projects.

Arduino Mega 2560 Specifications and Features:

1. Microcontroller: ATmega2560
2.Flash Memory: 256 KB
3.SRAM: 8 KB
4.EEPROM: 4 KB
5.Digital I/O Pins: 54

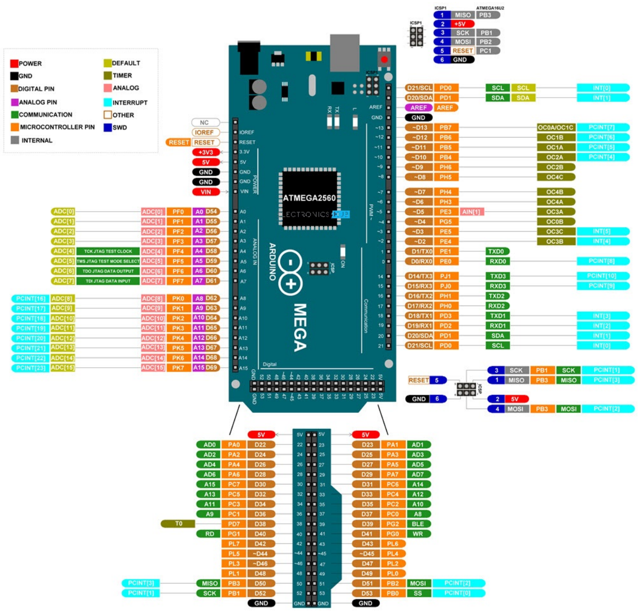

Figure 1. Arduino Mega 2560

6. PWM Outputs: 14
7.Analog Input Pins: 16
8.Clock Speed: 16 MHz
9.USB Interface: ATmega16U2
10.Power Input: USB or External (7-12V)
11.Operating Voltage: 5V
12.Compatibility: Compatible with most Arduino shields and libraries
13.Communication: UART, SPI, I2C
14.Dimensions: 101.52mm x 53.3mm

The Arduino Mega 2560 is favored for projects such as 3D printers, CNC machines, robotics, and automation systems due to its extensive I/O capabilities and processing power. Despite its advanced features, it remains beginner-friendly and widely used in the Arduino community for a variety of applications.

3.2 Arduino Uno

The Arduino Uno is a popular and versatile microcontroller board, suitable for a wide range of projects, from simple prototypes to more complex creations. It features an ATmega328P microcontroller, offering sufficient resources for many hobbyist and educational applications.

Arduino Uno Specifications and Features:

1. Microcontroller: ATmega328P
2.Flash Memory: 32 KB
3.SRAM: 2 KB
4.EEPROM: 1 KB
5.Digital I/O Pins: 14

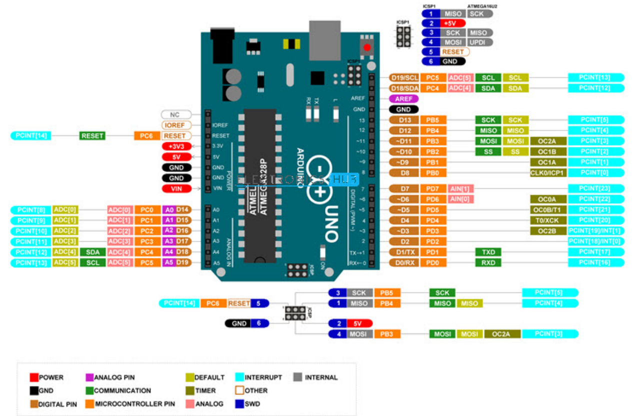

Figure 2. Arduino UNO R3

6.PWM Outputs: 6
7.Analog Input Pins: 6
8.Clock Speed: 16 MHz
9.USB Interface: ATmega16U2 or CH340G
10.Power Input: USB or External (7-12V)
11.Operating Voltage: 5V
12.Compatibility: Compatible with a wide range of shields and libraries
13.Communication: UART, SPI, I2C Dimensions: 68.6mm x 53.4mm

The Arduino Uno's compact size, ease of use, and extensive community support make it an ideal choice for beginners and experienced makers alike. It is commonly used in projects such as sensor-based applications, home automation, and educational demonstrations.

3.3 Bend-Sensitive Sensor(Flex Sensor)

The Bend-Sensitive Sensor, is a versatile and adaptable device designed to detect and measure bending or flexing in a variety of applications. This innovative sensor is constructed from materials that change their electrical resistance as they bend, allowing for precise measurement of angles, curves, or deflections in structures or objects.

Engineered to be both durable and sensitive, the Bend-Sensitive Sensor is ideal for applications where flexibility and responsiveness are critical. Its compact design and customizable length make it suitable for integration into wearable technology, robotics, medical devices, and interactive electronics.

The core principle behind the Bend-Sensitive Sensor is its ability to detect changes in resistance as it bends. As the sensor is flexed, the conductive materials within it undergo a change in electrical resistance, which can be measured and translated into meaningful data. This characteristic allows the sensor to be used in various contexts, from track-

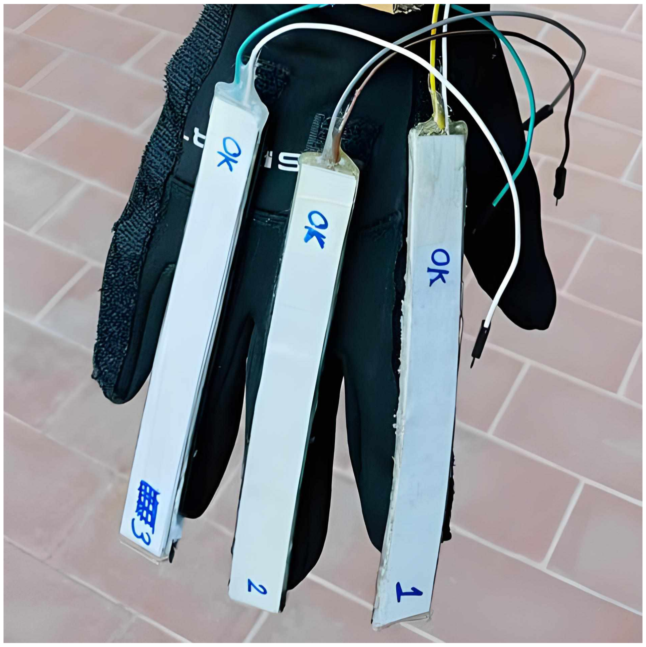

Figure 3. Self Made Bend-Sensitive Sensors(Flex Sensor)

ing joint movements in wearable health monitoring devices to detecting structural deformation in engineering projects.

3.4 ESP32 Cam Module

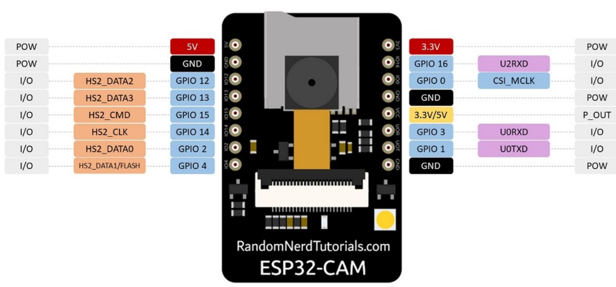

Figure 4. ESP 32-CAM

The ESP32 Cam Module is a compact and versatile development board based on the ESP32-S chip. It integrates a small camera module, making it suitable for projects requiring image and video processing capabilities. This module is commonly used in IoT applications, surveillance systems, and various other projects where visual data acquisition is essential.

ESP32 Cam Module Specifications and Features:

1.Chip: ESP32-S

2.Flash Memory: Varies depending on the module version

3.SRAM: Varies depending on the module version

4.Camera Resolution: Varies depending on the camera module used (commonly OV2640 or OV7670)

5.Digital I/O Pins: Varies depending on the ESP32 module variant

6.Analog Input Pins: Varies depending on the ESP32 module variant

7.Clock Speed: Up to 240 MHz

8.Communication: Wi-Fi (802.11 b/g/n), Bluetooth, UART, SPI, I2C

9.Power Input: Typically powered via micro USB or external power source (5V)

10.Operating Voltage: 3.3V

11.Dimensions: Varies depending on the module variant and camera module used.

The ESP32 Cam Module offers a combination of wireless connectivity, processing power, and visual data acquisition capabilities, making it suitable for a wide range of applications. With its compact size and integrated camera, it enables developers to create innovative projects involving image capture, processing, and transmission over Wi-Fi or Bluetooth connections. Additionally, its compatibility with the Arduino IDE and ESP-IDF framework provides flexibility and ease of development for both beginners and experienced users.

3.5 ESP32-CAM W-BT Board ESP32-CAM-MB

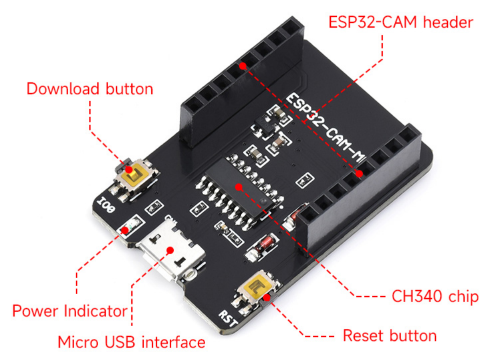

Figure 5. ESP32-CAM W-BT Board (ESP32-CAM-MB)

The ESP32-CAM W-BT Board (ESP32-CAM-MB) is a versatile development board based on the ESP32 chip. It integrates Wi-Fi (802.11 b/g/n) and Bluetooth capabilities, making it suitable for projects requiring wireless communication. Additionally, it features a camera module for visual data processing. The camera resolution varies depending on the module used, and it offers varying flash memory and SRAM capacities depending on the module version. With its digital and analog I/O pins, the board provides flexibility for interfacing with external devices. It operates at a clock speed of up to 240 MHz and supports communication protocols such as UART, SPI, and I2C. Typically powered via micro USB or an external 5V source, it operates at an operating voltage of 3.3V. The dimensions of the board vary depending on the module variant, offering flexibility for different project requirements.

3.6 SIM900 GSM Module

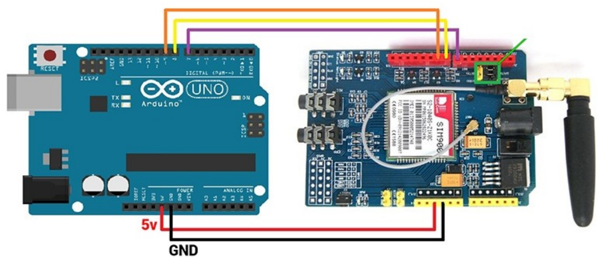

Figure 6. SIM900 GSM Module

The SIM900 GSM Module is a versatile communication module designed for cellular connectivity in various embedded systems and IoT applications. It enables devices to send and receive SMS messages, make voice calls, and establish GPRS data connections over the GSM network.

SIM900 GSM Module Specifications and Features:

1.Chip: SIM900
2.Frequency Bands: GSM 850/900/1800/1900 MHz
3.SIM Card Interface: Standard SIM card slot
4.Antenna Connector: SMA connector for external GSM antenna
5.Communication: GSM/GPRS
6.Interfaces: UART, GPIO
7.Power Supply: Typically powered via external power source (typically 5V)

Key Functions:

1.SMS Communication: The SIM900 module allows devices to send and receive SMS messages, enabling remote monitoring, control, and notifications.
2.Voice Calls: It supports voice call functionality, allowing devices to make and receive calls over the GSM network.
3.GPRS Data Connection: The module enables devices to establish GPRS data connections for internet access and remote data transfer.
4.AT Command Interface: Communication with the module is typically done through AT commands, providing a standardized interface for controlling its functions.

The SIM900 GSM Module provides a reliable and cost-effective solution for adding cellular connectivity to embedded systems and IoT devices. Additionally, its wide frequency band support ensures global compatibility across different regions and networks.

3.7 Ultrasonic Sonar Sensor HC- SR04

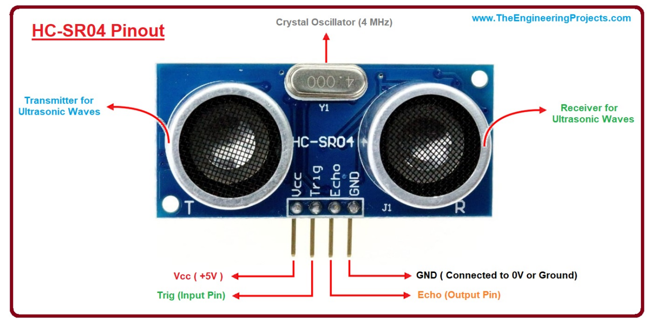

Figure 7. Ultrasonic Sensor HC-SR04

The HC-SR04 Ultrasonic Sonar Sensor is a compact and affordable module used for non-contact distance measurement. Operating at 5V DC, it offers a detection range of 2cm to 400cm with high accuracy and low power consumption. With a simple 4-pin interface, it integrates easily with microcontrollers like Arduino. Its versatility makes it suitable for various applications including obstacle detection, object tracking, and liquid level sensing. Measuring just around 45mm x 20mm x 15mm, it's compatible with a wide range of environments (-10°C to +70°C). This sensor provides reliable distance data, enabling precise and efficient sensing in robotics, automation, and IoT projects.

3.8 Accelerometer

Accelerometers are essential devices used to measure acceleration forces, whether caused by motion, gravity, or vibration. They consist of a proof mass suspended in a housing structure, which moves in response to acceleration, generating an electrical signal proportional to the force experienced. These devices come in various types, including piezoelectric, piezoresistive, capacitive, and MEMS accelerometers, each tailored for specific applications. MEMS accelerometers, with their small size, low cost, and low power consumption, have become ubiquitous in portable electronics like smartphones and fitness trackers. They enable features such as screen rotation, step counting, and gesture recognition, enhancing user experience and functionality. With advancements in technology, accelerometers continue to evolve, driving innovation across industries and contributing to safer, more efficient, and more convenient systems and devices.

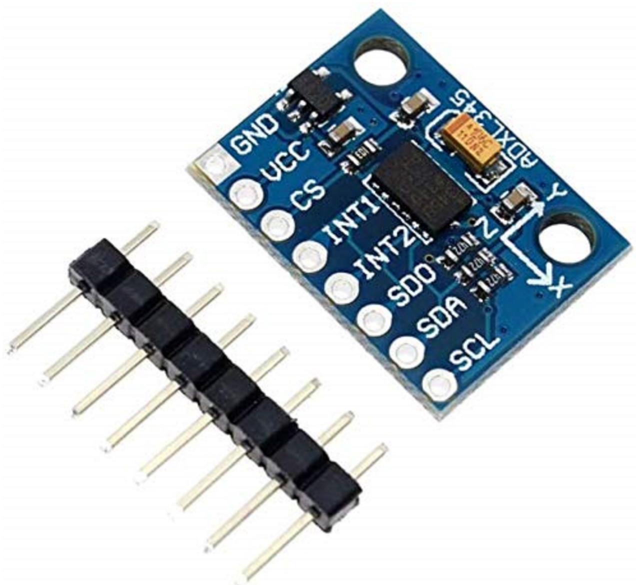

Figure 8. Accelerometer

3.9 Servo Motor SG-90

The SG-90 Servo Motor is a compact and lightweight motor commonly used for precise control in robotics and automation projects. Operating on low voltage, it offers precise angular movement within a limited range, typically 0 to 180 degrees. With its small size and affordability, it's widely utilized in hobbyist projects, RC vehicles, and small-scale automation systems.

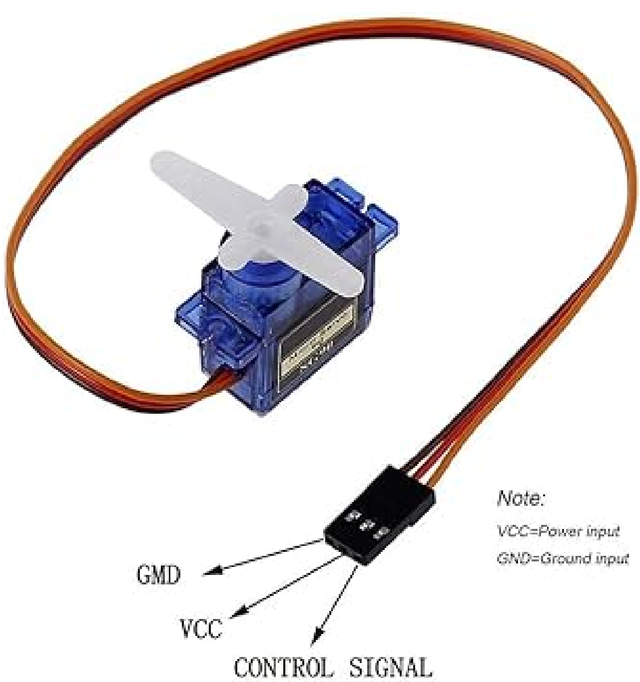

Figure 9. Servo Motor SG-90

Servo Motor SG-90 Specifications and Features:

1.Operating Voltage: 4.8V - 6V
2,Torque: Varies depending on the voltage and model, typically around 1.5 - 2.5 kg/cm
3.Speed: Varies depending on the voltage and load, typically around 0.1 - 0.2 sec/60°
4.Control Interface: PWM (Pulse Width Modulation)
5.Rotation Range: Typically 0 to 180 degrees
6.Dimensions: Compact size, commonly around 23mm x 12mm x 29mm
7.Weight: Lightweight, typically around 9 grams
8.Compatibility: Compatible with most microcontrollers and servo control boards

The SG-90 Servo Motor provides precise and reliable angular movement, making it suitable for various applications requiring controlled motion. Its compatibility with PWM control allows for easy integration with microcontrollers like Arduino, Raspberry Pi, and others. Whether used for robotic arms, pan-tilt mechanisms, or remote-controlled vehicles, the SG-90 servo offers a cost-effective solution for achieving precise motion control in small-scale projects.

3.10 PIR Sensor

The Passive Infrared (PIR) Sensor detects motion by sensing changes in infrared radiation emitted by moving objects within its field of view.

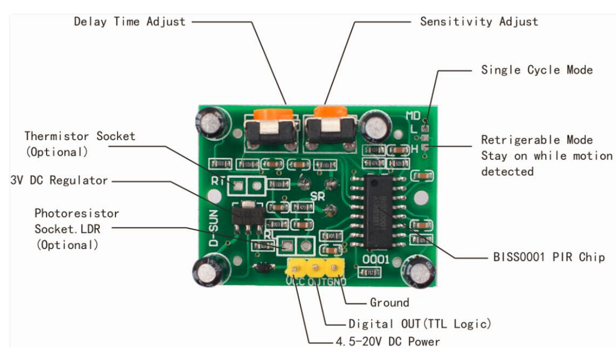

Figure 10. PIR Motion Sensor

Specifications and Features:

1.Detection Method: Passive Infrared (PIR)
2.Operating Voltage: Typically 5V - 12V DC
3.Detection Range: Up to 5 meters or more
4.Field of View: Approximately 110 degrees horizontally and 90 degrees vertically
5.Sensitivity Adjustment: Allows fine-tuning of detection levels
6.Output Signal: Digital output (HIGH when motion is detected, LOW otherwise)

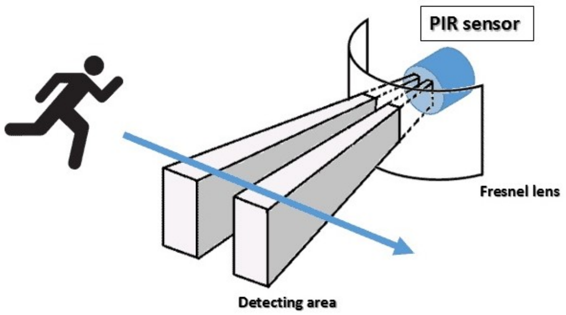

Figure 11. PIR working process

7.Response Time: Rapid, typically within a few milliseconds
8.Dimensions: Compact, around 32mm x 24mm x 24mm
9.Mounting: Easily mountable on walls, ceilings, or fixtures

The PIR Sensor offers reliable motion detection for security, lighting control, and automation projects. It integrates seamlessly with microcontrollers like Arduino and is widely used for enhancing security systems, triggering lighting, and automating various tasks.

3.11 16x2 LCD Display and 16x2 LCD display module

The 16x2 LCD Display is widely used in electronic projects, offering a simple way to show text and numbers.

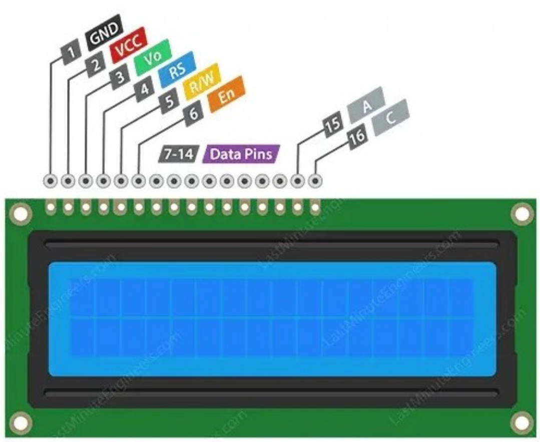

Figure 12. 16x2 LCD Display

Specifications and Features:

1.Display Type: 16x2 characters
2.Backlight: Some models have adjustable backlighting
3.Interface: Parallel or serial communication
4.Operating Voltage: Typically 5V DC
5.Dimensions: Compact, around 80mm x 36mm x 12mm

Figure 13. 16x2 LCD Display Module

3.12 Breadboard

A breadboard is a versatile prototyping tool used in electronics to quickly and easily connect electronic components without soldering. It consists of a grid of holes into which components and wires can be inserted to create circuits for testing and experimentation. It's a valuable tool for beginners and professionals alike due to its ease of use and reusable nature.

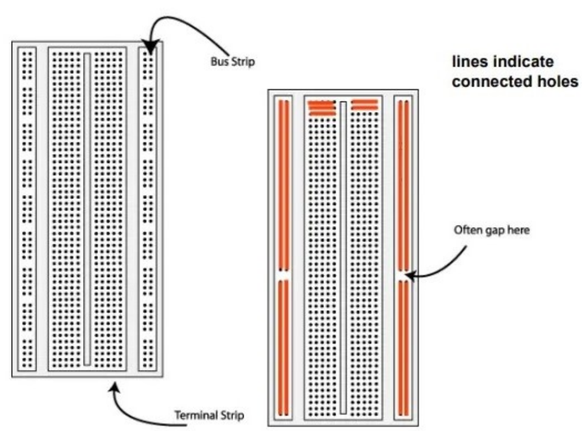

Figure 14. Bread Board

3.13 Jumper Wires

Jumper wires are flexible wires with pins or connectors at each end used to connect components on a breadboard or between different points on a circuit. They provide a quick and convenient way to establish connections without the need for soldering, allowing for easy prototyping and experimentation in electronics projects.

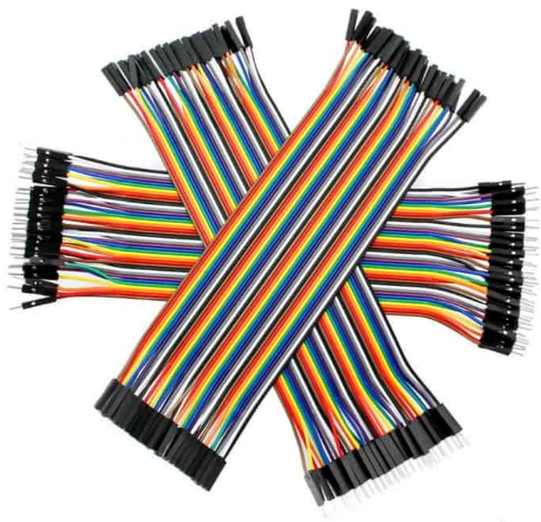

Figure 15. Jumper Wire

Figure 16. 1k and 10k Resistors

3.14 1k and 10k Resistors

1k and 10k resistors are common types of resistors used in electronics. The "1k" stands for 1000 ohms, while "10k" stands for 10,000 ohms.

1k resistors limit the flow of electric current in a circuit to 1/1000th of an ampere. They're commonly used in LED circuits and as pull-up or pull-down resistors in digital circuits.

10k resistors limit the flow of electric current to 1/10,000th of an ampere. They're frequently used in voltage dividers, sensor circuits, and as pull-up or pull-down resistors in digital circuits.

These resistors are essential components for controlling the flow of current and voltage levels in electronic circuits, making them indispensable in a wide range of applications.

3.15 5V speaker

A 5V speaker is a type of audio transducer designed to produce sound when connected to a 5V power source. It typically features a built-in amplifier and is commonly used in electronic projects where low-voltage audio output is required, such as in small-scale music players, alarm systems, and electronic gadgets. The speaker converts electrical signals into audible sound waves, providing an essential component for audio playback in various applications.

Figure 17. 5V Speaker

4 Implementation

4.1 Implementation of Bend Sensitive Sensor

After creating 30+ prototypes we have come up with our very own bend sensitive sensors that work perfectly for our project. In order to do that we have tested several materials and components with different building approaches that helped us to perfect our sensors.

Figure 18. Assistive gloves prototype

Materials used to build the sensors:

1.Graphite Paper : The core and the most important material of our sensor is a dense sheet of graphite paper. We took A4 size paper and shaped it according to our sensors and put a dense layer of graphite with the help of a 6B pencil. (Denser the layer, better the value)

2.Plastic Laminated Paper : In order to make a strong but bendable shell for our sensors we had to choose between materials like cardboard, plastic sheet, aluminum cans etc. As we did not get the perfect bend, we used 4 layers of plastic laminated A4 size papers and combined it to get the perfect bend and flexibility.

3.Aluminum Foil : For conductivity we attached 2 sheets of aluminum foil 1 on each side of our graphite paper and attached jumper wires with the sheets to connect it with the arduino.

At last we combined all the materials and formed our bend sensitive sensors.

How it works : Our sensors work based on the theory of resistance being proportional to the amount of bend. Our graphite paper sticks to the shell of aluminum coated plastic laminated papers and the more the shell bends the more the resistance increases. This happens because of the distance between the conductive particles of the shell. Bending the sensor causes the particles to move further from each other which causes the change of resistance in our sensors.

Based on this formula we have created 4 flex sensors for each finger except the thumb and attached them to a thermal glove. Using binary representation where each digit represents a finger we chose 16 different commands to implement with our flex sensors which are as follows:

0000 - Help
0001 -Water
0010 -Food
0011 -Bathroom/Toilet
0100 -Doctor
0101 -Pain
0110 -Thank you
0111 -Sorry
1000 -Yes
1001 -No
1010 -Name
1011 -Police
1100 -Money
1101 -Lost
1110 -Home
1111 -Idle

Our microcontroller reads the input from the sensors and passes the necessary signals to a speaker where the commands are expressed as audio output and shown on a 16x2 LCD Display. We have also attached a GSM Module with our glove which reads the signals from the sensors and contacts a family member through call or text message in case of an emergency.

4.2 ESP32-CAM Module

The ESP32-CAM module,powered with the ESP32-CAM MB, significantly enhances the object detection capabilities of our assistive device. Below is a simplified breakdown of how we implemented this module:

1.Data Collection: Our first step involved collecting data on various objects such as calculators, boxes, chairs, laptops, spoons, and stairs. We amassed around 3700 images of these objects using the ESP32-CAM module in conjunction with the ESP32-CAM MB. The module's built-in functionality streamlined the image capture process.

2.Data Labeling and Training: Subsequently, we labeled each collected image according to its respective object. This labeling process was facilitated by a platform, ensuring accurate association of each image with the correct object name. With the labeled datasets in hand, we proceeded to train the ESP32-CAM module using the Faster Object More Object (FOMO) model. This training enabled the module to effectively recognize and identify objects.

3.Creation of Arduino Zip Library: Once the datasets were trained, we compiled them into an Arduino zip library. This library served as a reference for the ESP32-CAM module to perform real-time object detection.

4.Coding: In the coding phase, we leveraged the built-in example code provided in the Arduino IDE. This example code was accessible via the following sequence:

Arduino Software -> File -> Example -> [Trained Data Zip Library] -> ESP32 Camera.

The example code provided a foundational framework for object detection using the ESP32-CAM module in conjunction with the ESP32-CAM MB. Upon execution, it initiated the object detection process.

5.Integration with Assistive Device: With the ESP32-CAM module fully configured, we seamlessly integrated it into our assistive device. The module, along with the ESP32-CAM MB, was strategically positioned in the lower middle part of the user's hand, ensuring optimal visibility of the surroundings.

When users sensed objects in their vicinity, they simply raised their hand, prompting the ESP32-CAM module to perform real-time object detection.

Upon detecting an object, the module triggered auditory cues through a connected speaker, providing valuable feedback to blind users. Deaf users could visually perceive the detected objects in real-time.

4.3 5-Volt Speaker

In our project, the integration of a 5-volt speaker serves a crucial role in providing auditory feedback based on user interactions. Here's how we implemented the speaker setup:

1.Selection of Arduino Uno for Speaker Handling: While most components are controlled by an Arduino Mega, we opted for an Arduino Uno specifically to power the speaker and manage sound playback. The Arduino Uno offers sufficient power and memory capacity to handle the speaker's requirements effectively.

2.Amplification with BC547 Amplifier: To ensure clear and audible sound output, we incorporated a BC547 amplifier into the speaker setup. This amplifier boosts the audio signals generated by the Arduino Uno, enhancing the overall sound quality.

3.Sound Recording and Encoding: We recorded sounds corresponding to the various commands detectable by the bending sensors. Each command has a unique sound associated with it. After recording, we encoded these sounds using an encoder, preparing them for playback through the speaker.

4.Utilization of PCM Library: To streamline sound playback and management, we leveraged the PCM library code. This library enables seamless interaction with encoded sound data, allowing us to control playback based on input commands received from the bending sensors.

5.Command-Activated Sound Playback: By implementing conditional statements in our code, we ensured that each command detected by the bending sensors triggers the playback of the corresponding sound through the speaker. This real-time auditory feedback enhances user interaction and usability.

4.4 SIM900 GSM module

Incorporating the SIM900 GSM module into the project significantly enhances its communication and safety features. The module, powered by a 5V battery and connected to the Arduino Mega, facilitates seamless communication through calls and SMS.

During the implementation phase, specific functionalities were programmed to handle emergency situations effectively. When the user triggers predefined emergency commands, such as "police" or "doctor," via hand gestures detected by the bend sensors, the system responds promptly. It automatically initiates a call to the corresponding emergency number, typically 999, ensuring immediate assistance.

Moreover, in critical scenarios, the GSM module can send SMS alerts to predefined contacts or relatives of the user. This feature serves as an additional layer of safety, providing reassurance and support during emergencies. By integrating the SIM900 GSM module, the project not only enables direct communication with emergency services but also establishes a reliable mechanism for reaching out to trusted contacts in times of need. This implementation enhances the overall safety and security of the users, aligning with the project's goal of providing assistance and support to individuals with sensory impairments.

4.5 Servo Motor with Accelerometer

We begin by attaching an ultrasonic sensor to the user's hand, ideally in a central position for optimal detection range. This sensor is connected to an Arduino Mega board, serving as the device's main controller.

Next, we integrate a servo motor into the setup, allowing controlled movement of the sensor. The servo motor is mounted to the ultrasonic sensor assembly, enabling adjustments to its angle.

An accelerometer, also known as an "Accelerometer," is incorporated into the device. This accelerometer detects changes in hand position, particularly vertical movement.

We program the accelerometer to interpret hand movements and communicate with the servo motor. When the hand is downward, the sensor remains at a stable 60-degree angle. If the hand moves upward, the servo motor adjusts the sensor to its previous angle, ensuring consistent path detection.

Feedback mechanisms are implemented to ensure the accuracy of servo motor adjustments. Calibration tests are conducted to verify the responsiveness and reliability of the system in various hand positions.

By combining the servo motor's movement control with the accelerometer's orientation detection, this implementation enables dynamic adaptation of the ultrasonic sensor to the user's hand movements. Consequently, blind individuals can maintain reliable path detection, enhancing their mobility and safety.

4.6 PIR Sensor

We have connected the PIR sensor to an Arduino Mega, which can be controlled by a switch. When the person desires, they can activate the sensor for security purposes. If the blind person is asleep, the sensor will detect the motion of a thief and will play sound on Speaker.

4.7 16x2 LCD Display

The LCD display will exhibit every action's output. Its primary function is to exhibit signals from the flex sensor initially, followed by indicating whether the user of the gloves is signaling to call someone or if a thief is detected upon sensing any motion.

4.8 UltraSonic Sensor

We are utilizing an ultrasonic sensor for detecting potholes. We will establish a threshold value. If the obtained value exceeds this threshold, it will indicate the presence of a pothole in front of the person. Conversely, if the value is below the threshold, it will announce that there is no pothole.

5 Reference

1. https://store.roboticsbd.com
2. https://www.electronics.com.bd
3. https://www.electronicshub.org
4. https://www.electronicshub.org
5. https://randomnerdtutorials.com
6. https://kazi.nihat.aus.component.org
7. https://mytectutor.com
8. https://www.theengineeringprojects.com
9. https://iesedmonton.org
10. https://grobotronics.com
11.https://www.quora.com

6 Conclusion

Our assistive device for the mute and blind is on prototype stage right now and we aim to upgrade our prototype and turn it into a complete sign language to audio converter. Our device is currently limited with 16 commands but our goal is to make it capable of translating traditional sign language used by the mute so that it can be used by any mute person with efficiency. We aim to train our cam module farther to track more real life obstacles that a blind person faces and make it more capable of detecting objects. We want to use a better microcontroller and cam module in future that will help us to improve our data set even further. We are very optimistic about our assistive device for the mute and blind and hope to improve the lives of the blind and the mute.

7 Codes:

```
include <Wire.h>
include <Servo.h>
include <LiquidCrystal_I2C.h >
include <Servo.h>
include <SoftwareSerial.h>
Servo servo1;
int trigPin = 9;
int echoPin = 8;
int motion;
long distance;
long duration;
const int flexPin1 = A0;
const int flexPin2 = A2;
const int flexPin3 = A4;
const int flexPin4 = A5;
const int pir = 3;
LiquidCrystal_I2Clcd(0x27, 16, 2);
SoftwareSerial SIM900(16, 17);
void setup() {
lcd.begin();
lcd.backlight();
Serial.begin(9600);
pinMode(flexPin1, INPUT);
```

```
pinMode(flexPin2, INPUT);
pinMode(flexPin3, INPUT);
pinMode(flexPin4, INPUT);
pinMode(pir, INPUT);
servo1.attach(7);
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
SIM900.begin(19200);
delay(20000);
}
void loop() {
motion = digitalRead(pir);
if (motion) {
Serial.println("Motion Deteced");
}
int flexValue1, flexValue2, flexValue3, flexValue4;
int f1_1, f1_2, f1_3, f1_4;
int f2_1, f2_2, f2_3, f2_4;
int f3_1, f3_2, f3_3, f3_4;
int f4_1, f4_2, f4_3, f4_4;
int o1, o2, o3, o4;
f1_1 = analogRead(flexPin1);
f1_2 = analogRead(flexPin1);
f1_3 = analogRead(flexPin1);
f1_4 = analogRead(flexPin1);
f2_1 = analogRead(flexPin2);
f2_2 = analogRead(flexPin2);
f2_3 = analogRead(flexPin2);
f2_4 = analogRead(flexPin2);
f3_1 = analogRead(flexPin3);
f3_2 = analogRead(flexPin3);
f3_3 = analogRead(flexPin3);
f3_4 = analogRead(flexPin3);
f4_1 = analogRead(flexPin4);
f4_2 = analogRead(flexPin4);
f4_3 = analogRead(flexPin4);
f4_4 = analogRead(flexPin4);
if (f1_1 <= 800 && f1_2 <= 800 && f1_3 <= 800 && f1_4
<= 800) {
o1 = 0;
} else if (f1_1 > 800 && f1_2 > 800 && f1_3 > 800 &&
f1_4 > 800){
o1 = 1;
}
if (f2_1 <= 550 && f2_2 <= 550 && f2_3 <= 550 && f2_4
<= 550) {
o2 = 0;
} else if (f2_1 > 700 && f2_2 > 700 && f2_3 > 700 &&
f2_4 > 700){
o2 = 1;
}
if (f3_1 <= 750 && f3_2 <= 750 && f3_3 <= 750 && f3_4
<= 750) {
o3 = 0;
} else if (f3_1 > 800 && f3_2 > 800 && f3_3 > 800 &&
f3_4 > 800){
o3 = 1;
}
if (f4_1 <= 1010 && f4_2 <= 1010 && f4_3 <= 1010 &&
f4_4 <= 1010){
o4 = 0;
} else if (f4_1 > 1010 && f4_2 > 1010 && f4_3 > 1010 &&
f4_4 > 1010){
o4 = 1;
}
int binary = o1 * 8 + o2 * 4 + o3 * 2 + o4;
String word = binaryToWord(binary);
if (binary == 8) {
//SMS codes
sendSMS();
delay(500);
callSomeone();
}
Serial.print("Binary: ");
//Serial.print(binary);
Serial.print(o1);
//Serial.print(binary);
Serial.print(o2);
Serial.print(o3);
Serial.print(o4);
Serial.print(" -> Word: ");
Serial.println(word);
lcd.print(word);
//cout « "Binary: " « o1 « o2 « o3 « o4 « " ->
Word: " « word « endl;
ultra();
servo1.write(0);
if (distance <= 10) {
servo1.write(120);
Serial.print("Distance : ");
Serial.println(distance);
}
delay(200);
}
void ultra() {
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);
distance = duration * 0.034 / 2;
}
void callSomeone() {
SIM900.println("ATD + +8801909699925;");
delay(100);
SIM900.println();
delay(30000);
```

```
SIM900.println("ATH"); // hang up
}
void sendSMS() {
SIM900.print("AT+CMGF=1");
delay(100);
SIM900.println("AT+CMGS=+8801909699925");
delay(100);
SIM900.println("Save me!!!!!");
delay(100);
SIM900.println((char)26);
delay(100);
SIM900.println();
delay(5000); }
String binaryToWord(int binary) {
String word;
switch (binary) {
case 0: word = "Help "; break;
case 1: word = "Water "; break;
case 2: word = "Food "; break;
case 3: word = "Bathroom/Toilet ";
break; case 4: word = "YES "; break;
case 5: word = "Pain "; break;
case 6: word = "Thank you "; break;
case 7: word = "Sorry "; break;
case 8: word = "Doctor "; break;
case 9: word = "No "; break;
case 10: word = "Name "; break;
case 11: word = "Police "; break;
case 12: word = "Money "; break;
case 13: word = "Lost "; break;
case 14: word = "Home "; break;
case 15: word = "Idle "; break;
default: word = "Invalid ";
}
return word;
}
```

7.1 code for sound

```
include<PCM.h>
int signal ;
const unsigned char
pani_Khabo[]PROGMEM
= {
126,127,120,127,.... ..
};
const unsigned char
shahajjo_korun[]
PROGMEM = {
127,120,122,128,....
..
};
const unsigned char
dhonnobad[] PROGMEM =
{
128,126,120,129,....
..
};
const unsigned char
doctor_dakun[]
PROGMEM = {
127,126,120,128,....
..
};
const unsigned char
khuda_peyeche[]
PROGMEM = {
128,127,120,129,....
..
};
void setup() {
}
void loop() {
if(signal == 0 ) {
startPlayback(shahajjo
_korun, sizeof(shahajjo
_korun));
delay(1500);
}
else if(signal == 1) {
startPlayback(pani_k
habo,sizeof(pani_kha
bo));
delay(1500);
}
else if(signal == 2) {
startPlayback(khuda
peyeche,sizeof(khuda
_peyeche));
delay(1500);
}
else if(signal == 6)
startPlayback(dhonno
bad,sizeof(dhonnobad
));
delay(1500);
}
else if(signal == 8) {
startPlayback(doctor
_dakun, sizeof(doctor
_dakun));
delay(1500);
}
}
```


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