Arduino-Based Recognition of Hand Gesture Using Flex Sensor

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Abstract: **This system presents an Arduino Nano based emergency notification system that utilizes hand gesture recognition to initiate real-time alerts. By integrating five flex sensors into a wearable setup, the system monitors finger movements and interprets specific gestures based on calibrated threshold values. When an emergency gesture is detected, the Arduino Nano triggers two key actions, it communicates with a GSM module to send an SMS alert to predefined contacts over long distances, and it activates an MP3 module to play a corresponding audio message, such as "Help." This dual-alert mechanism enhances both the reliability and immediacy of the response. The system documentation includes detailed hardware schematics, wiring configurations, and sample code that integrates sensor data acquisition, SMS command sequences, and audio playback control. Through rigorous calibration and testing, the system demonstrates its potential as a cost-effective solution for personal safety, assistive technology, and smart wearable applications.**

Key Words**: Arduino Nano, Hand Gesture Recognition, Emergency Notification System, Flex Sensors, GSM Module, SMS Alert, MP3 Module, Audio Playback.**

I. INTRODUCTION

In the present world it is very complicated for the deaf & dumb people to communicated with the normal people. The normal people did not understand deaf and dumb people language. One of the best method of communication between them is the sign language. Using the sign language, they can share their thoughts and knowledge with the normal people. In this technique for improving Sign Language Recognition System using glove with the flex sensor . The number of deaf- dumb People in the world are roughly calculated to be from 700,000 to 900,000 and of these 63 percent, are said to be born deaf, the others losing their hearing by different accident. Sign Language is a language of gestures and symbols that is used not only by deaf and dumb people but also by others with normal hearing to communicate with them. When deaf and dumb people communicate with each other, they commonly use a standard sign language such as American Sign Language or British Sign Language developed in USA and UK respectively.

The flex sensors are used to detect hand movements of the person and then the data from sensors are analyzed in the Arduino and then the corresponding speech output is emitted through the speaker and also the message gets displayed on the LCD screen connected to the Arduino. During emergency, a deaf- dumb person who is travelling among new people and if he/she wants to communicate with them becomes a difficult task. For the operation of the system battery powered circuit is used to power the system and to run it. The system comprises of about stored messages which will help deaf people to communicate their primary messages like "need help", For different variations of hand movement, the system reads persons hand motions.

The system consists of flex sensor, which helps in automatically activating the system whenever the person wants to speak something. the deaf person makes hand motion just impulsively, the system ensures that it does not speak. The brain of the system. i.e., Arduino processes the input sensor values which are constantly received. Now for the set of received sensor values messages are matched. From memory the message is retrieved once it is found, and through the speaker it is spoken out using text to speech process. Thus, a smart speaking system which is fully functional is useful which helps deaf people convey their messages with normal people using wearable system. Sign Language Glove which will assist those people who are suffering for any kind of speech defect to communicate through gestures i.e. with the help of single handed sign language the user will make gestures of alphabets. The glove will record all the gestures made by the user and then it will translate these gestures into visual form as well as in audio.

II. SYSTEM MODEL

Recent advancements in Arduino and sensor technologies have enabled the creation of compact, efficient systems for real-time monitoring and communication. The integration of various modules such as flex sensors for gesture recognition, GSM modules for remote communication,and MP3 modules for audio feedback has paved the way for innovative solutions in emergency response. This system builds on these advancements by employing an Arduino Nano as the core controller for a gesture based emergency notification system.

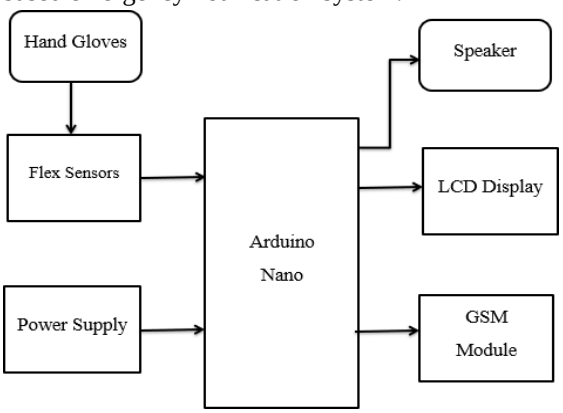


Fig.1: Block Diagram

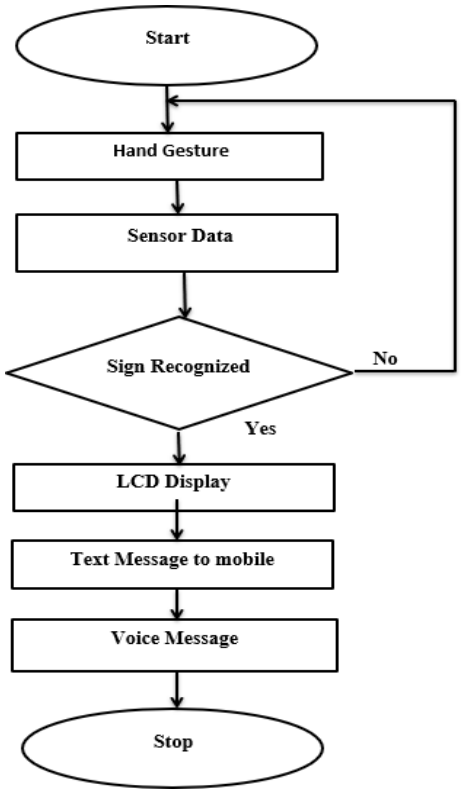


Fig.2: Flow Chart

Start & Initialization:- The system begins by powering up the Arduino Nano, initializing communication with the GSM and MP3 modules, and calibrating the flex sensors to set proper threshold values.

Data Acquisition:- The Arduino continuously reads analog values from the five flex sensors, which are mounted on a wearable device (e.g., glove).

Data Processing:- The sensor values are compared to the preset thresholds. If the values indicate a bend that corresponds to an emergency gesture, the system decides to initiate alerts.

Alert Trigger:- Upon detecting an emergency gesture, the system simultaneously:

1. Sends an SMS alert through the GSM module.
2. Plays an audio message (e.g., "Help") via the MP3 module.

Debounce and Loop:- A delay is applied to prevent multiple triggers from a single gesture, then the system loops back to continuously monitor sensor inputs.

1) Arduino Nano

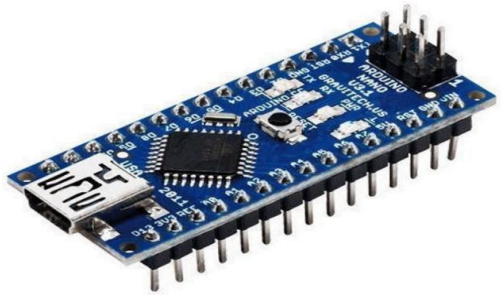


Fig.3: Arduino Nano

The Arduino Nano is a compact development board ideal for fast prototyping, based on the ATmega328 microcontroller running at 16 MHz. It features 14 digital pins (for input/output) and 8 Analog pins (for voltage measurement from 0V to 5V). Functions like pin Mode(), digital Write(), and analog Read() control pin operations. The board operates at 5V and is perfect for breadboard-friendly applications..

2) Flex sensor

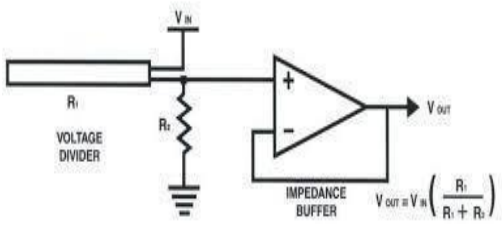


Fig. 2.1: Circuit diagram of flex sensor

A component mounted on the human hand, operates as a variable resistance device, undergoing changes in resistance when bent. This resistance alteration is directly linked to the degree of bending, with a higher bend angle resulting in increased resistance. Functionally, flex sensors also known as analog resistors, function as variable analog dividers within their structure. They contain carbon resistance elements embedded within a flexible substrate, where a higher concentration of carbon leads to reduced resistance. When the substrate is subjected to bending, the flex sensor generates a resistance output proportional to the bend radius. In essence, the flex sensors resistance dynamically adjusts in response to the hand's movements, providing valuable input for controlling the Arduino based recognition of hand gesture using flex sensor.

Fig.2.2: Flex sensor

3) GSM Module

Fig.3: GSM Module

The A7670 series uses an LGA form factor and is compatible with SIM7000/SIM7070 (NB/Cat M) and SIM800A/SIM800F (2G) modules, enabling easy migration to LTE Cat 1. It supports built-in network protocols, drivers for Windows, Linux, and Android, and uses AT commands compatible with SIM7500/SIM7600 series. It offers multiple interfaces (UART, USB, I2C, GPIO) for IoT applications like telematics, POS, surveillance, and remote diagnostic to use the A7670C modem, connect via a USB-to-RS232 TTL converter, find the correct COM port, and open a terminal (e.g., PuTTY) at 115200 baud rate. Send AT commands (e.g., "AT") and receive res ponses like "OK".

4) MP3 SD Card Module with Serial Port

Fig.4: MP3 SD Card Module with Serial Port

MP3-TF-16P MP3 Disk TF Card Module Serial Port is a compact and inexpensive MP3 module that can be connected directly to the speaker. Module with battery power supply, speaker, the keypad can be used alone, or through the serial port control, as the Arduino with a serial port module. The module itself perfectly integrated hardware decode MP3, WAV, WMA. While the software supports TF card driver to support FAT16, FAT32 file system It can be done by simple serial command plays the specified music, as well as how to play music and other functions, without low level, easy to use, stable and reliable. The MP3-TF- 16P MP3 module is a compact and affordable solution for adding MP3 playback. This module is designed to be versatile and easy to use, allowing for seamless integration with a variety of applications. With its built-in hardware decoder, the module can play MP3, WAV, and WMA file formats, providing high- quality audio output. The module supports TF cards (micro-SD cards) with FAT16 and FAT32 file systems, making it easy to store and play music files.

III. METHODOLOGY

1. MODELING AND ANALYSIS

1) Human Hand-Glove

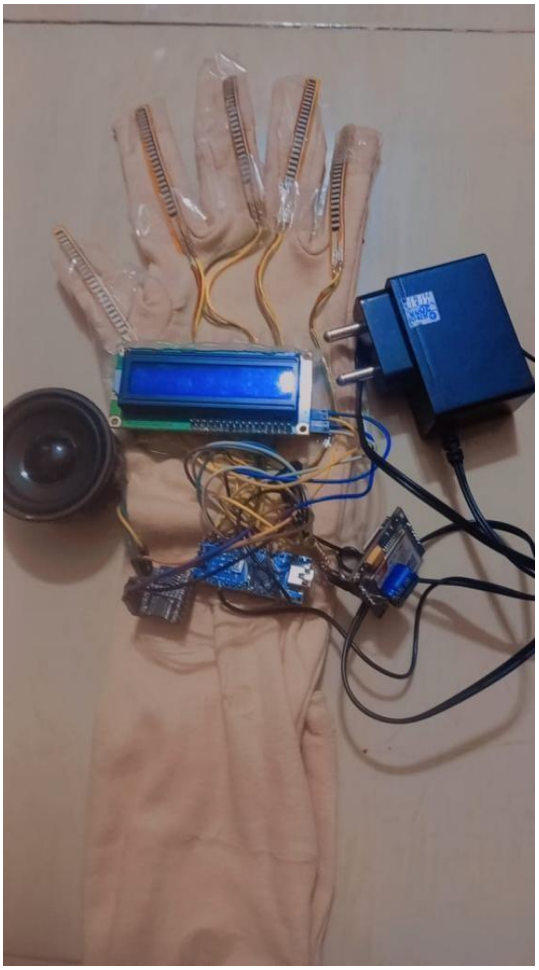
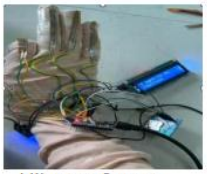


Fig 3.1: Human Hand-Glove connection

In this system Flex sensors are placed on gloves which can be easily operated by the user by making gestures. According to the gesture made by the user the resistance values will change and sensor produces voltage correspondingly.The output voltage of flex sensors is in the analog form which is converted into digital form by using inbuilt ADC of Atmega328P. Predefined gestures with corresponding messages are stored in the database of the Arduino in different languages.Arduino matches the motion with the database and produces the speech signal using Auto Playback Recorder. The output is given out through the LCD and speaker, GSM module is used to send text messages. performing and recognizing.

IV. RESULT

The successful detection of various hand gestures based on finger bending.

Sr.no	Performing and Recognizing Gesture	Output
1.	 Index Finger	 I Want togo Restroom
2.	 Middel Finger	 I Need Rest
3.	 Ring Finger	 I Need Some Money
4.	 Pinky Finger	 Please Help Me
5.	 Thumb Finger	 Give Me some Food
6.	 Pinky & Ring Finger	 I'm Not Feeling Well
7.	 Index and Middel Finger	 I Need Medicine

Power supply is given to the flex sensors which gives maximum five volt. Here 10 k ohm's resistor is in parallel with flex sensor which again has the resistance of 10 k ohm. On bending it changes its resistance. It has LCD which is in parallel to voice processor and in series with LCD so that board is taking response or not. Now, in Arduino have an inbuilt ADC which is directly connected to flex

sensor. This LCD is wired to digital pins of Arduino Nano voice processor connected to analog pin of the Arduino. It has a reset button which is only used to execute the program from the starting .There is GSM module which is connected to the Arduino. It plays the recorded voice corresponding to the code given to the Arduino. Figure 1 shows that the identified gesture is 'I Want to go Restroom' and displays the message on LCD. Similarly Figure 2, 3, 4, 5, 6, and 7 conveys that the identified gesture is "I Need Medicine", "I Need Some Money", "Please Help Me", "Give Me Some Food", "I Need Rest" and "I'm Not Feeling Well". respectively and displays the same on LCD.

V CONCLUSION

The Arduino-based hand gesture recognition system using flex sensors, GSM, LCD, and a speaker provides an effective solution for communication gap between Deaf-Dumb and normal People individuals. By translating hand gestures into speech and text, the system enhances accessibility and ease of interaction. The integration of GSM enables remote communication, making it more versatile. The LCD display ensures clear message visibility, while the speaker provides audible output. Overall, this portable and user-friendly system significantly improves communication for Deaf-Dumb individuals, offering them a more inclusive and independent way to express.

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