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Design and Development of IoT Device that Recognizes Hand Gestures using Sensors

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ABSTRACT

A hand gesture is a non-verbal means of communication involving the motion of fingers to convey information. Hand gestures are used in sign language and are a way of communication for deaf and mute people and also implemented to control devices too. The purpose of gesture recognition in devices has always been providing the gap between the physical world and the digital world. The way humans interact among themselves with the digital world could be implemented via gestures using algorithms. Gestures can be tracked using gyroscope, accelerometers, and more as well. So, in this project we aim to provide an electronic method for hand gesture recognition that is cost-effective, this system makes use of flex sensors, ESP32 board. A flex sensor works on the principle of change in the internal resistance to detect the angle made by the user's finger at any given time. The flexes made by hand in different combinations amount to a gesture and this gesture can be converted into signals or as a text display on the screen. A smart glove is designed which is equipped with custom-made flex sensors that detect the gestures and convert them to text and an ESP32 board, the component used to supplement the gestures detected by a flex sensor. This helps in identifying machines the human sign language and perform the task or identify a word through hand gestures and respond according to it.

KEYWORDS: Flex, resistance, Hand gesture, IoT, glove, sensor, microcontroller.

INTRODUCTION

The Internet of Things (IoT) refers to a system of interrelated, internet-connected objects that can collect and transfer data over a wireless network without human intervention [1]. Hand gesture recognition plays an important role in the field of human-computer interaction, because of its extensive applications in virtual reality, sign language recognition. To obtain a more robust hand gesture recognition, one effective way is used to capture the hand gesture and motion using sensors. The motivation of this project is to design and develop an IoT device that recognizes hand gestures using sensors that are economical and affordable. This system has been developed to aid the user to communicate efficiently with the help of gestures. The detected signal is transferred micro-controller to compute the results and to display the text or can also be connected to an application to output the voice signals and also display the text. According to a survey by the Government of India in 2012, the number of dumb people in India is around 21.12 lakhs out of which 55% or 1,121,120 people and 45% or 920,920 people suffer from speech impairments and hearing impairments. Considering worldwide statistics, as many as 1.55 billion people face challenges in communicating in daily life in which sign language is used to the information. This is not only used by mute people for communication but is used by people who need to communicate with deaf people because of their hearing impairments. the main goal of this system is to aid physically challenged people to communicate with others. The gestures can easily be expressed through a glove powered by a flex sensor.

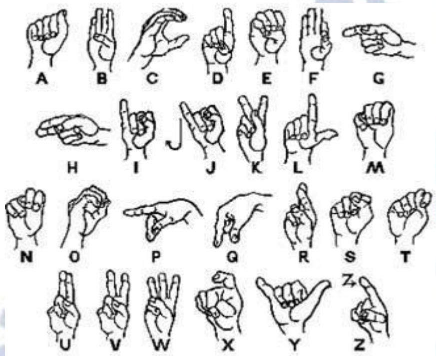

Fig.1. Standard Sign Language

LITERATURE SURVEY

A. A device named SeleCon was designed to provide a natural device selection and control method for users to interact with smart IoT devices. Users can simply point their arm towards the intended device to select it, the gesture-based system will identify which IoT device is selected by monitoring the direction of the wrist. Then people can draw a gesture in the air to give a command to the selected device. This device achieved 96% accuracy for hand gesture recognition. They also show that SeleCon is power efficient to sustain daily use by turning off when the user's wrist is stationary [2].

B.A design of a hand gesture recognition system based on ultrasonic sensor SC-04 was proposed. This sensor uses a low-power receiver to extract and classify gesture information through wireless transmissions. When a person performs a gesture with their hand, the sensors change the amplitude of the wireless signals in the air. The All See sensors then recognize unique amplitude changes created by specific gestures. During testing, 3 seconds were sufficient to recognize the gesture, where it can also be changed as per the developer's need through programming. The device can establish hand poses and also perform its tracking. It mainly used image data and depth data to detect and estimate the position of the body of the user [3].

C.In this paper hand, a gesture recognition system is implemented for the traffic light control system (TLC). A Thresholding Algorithm is used for recognition. The accelerometer sensors are used to identify the gesture made by hand using ARM. Indication of the traffic lights was done using LED. Other components like X-Bee, SD card, and Speaker were used in the transceiver [4].

D.In this System, Hand gesture recognition was identified by the method of waving the hand in the air, Alphabet was recognized by graffiti based on Palm OS. This system mainly used image and depth data to detect to estimate the hand of the user. A Kinect sensor was used which was able to recognize the gesture within 2-3 seconds. A Windows SDK was used as a development environment for the Kinect sensor as it was easy to perform the detection and estimation of the motion of the user's body from depth data [5].

IMPLEMENTATION

Working of Flex Sensor:

A variable resistor is a flex sensor. The value of resistance increases when the sensor is bent, this is the main principle of working of the flex sensors. The flex sensors have graphite coated material on both sides, when the flex sensor is flat it gives out a constant resistance value and when the flex sensor is bent this will cause the resistance value to change and when the sensor is brought back to its initial position, the resistance reverts to the initial value. The flex sensors can convert the flex angle to the resistance value and voltage divider circuit can be used to convert the resistance value into voltage in the circuit.

Fig.2.Flex Sensor

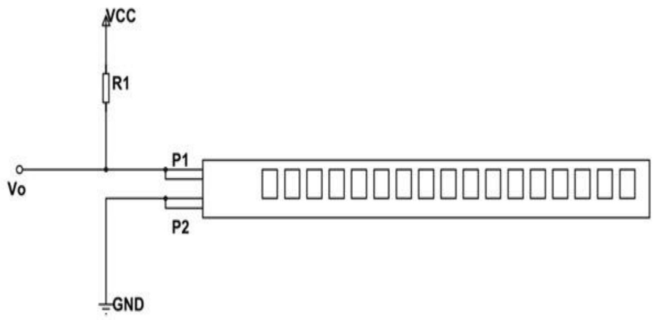

Fig.3.Voltage Circuit

The five flex sensors are connected to a voltage divider circuit. One end of the flex sensor is connected to a supply of 5V from the ESP-32 microcontroller and the other single strand wire is connected to the static resistor (1-kilo ohm's). While one end of the resistor is connected to the sensor it is also connected to the analog read pins or input pins and these act as input values that need to be computed. The other end of resistors needs to be connected to the common ground terminal of ESP-32 or to that of a ground of a battery. These flex sensors are used as gesture input.

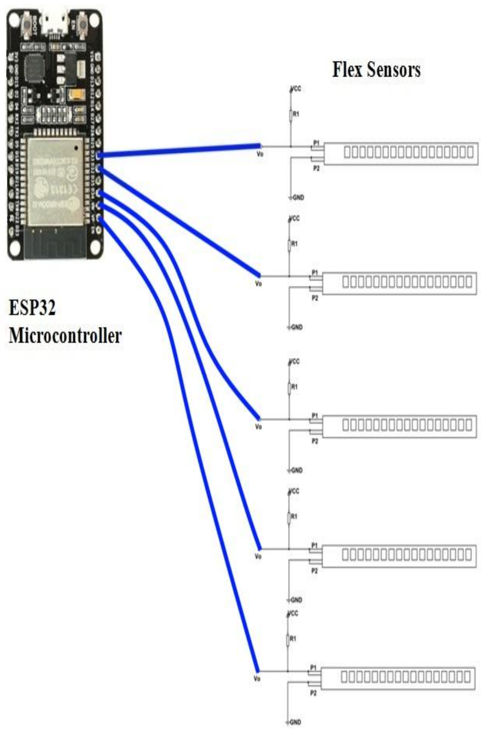

Fig.4. Sensor connected to the microcontroller

Recognition Of Gesture:

We can use a maximum of 10 flex sensors i.e., five fingers of two hands, and consider that each sensor has been calibrated to detect 3 flexes per finger i.e., when a finger is not bent when the finger is half-closed and when the finger is fully bent, now we have multiple combinations which can be defined according to the user's needs. These gestures will be recognized by the microcontroller and the flex sensors are used as gesture input.

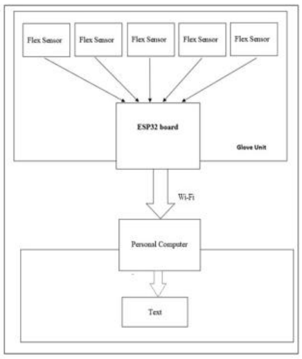

Fig.5. Block Diagram

Wireless Communication:

The flex sensors are connected to the microcontroller, ESP-32 in this case. we choose this microcontroller because of its small size, consumes less power, and availability of analog pins. This microcontroller receives voltage values from flex sensors and decodes them into angles of the bend. We have used a wireless type of communication using an inbuilt Wi-Fi module which is a wireless technology standard for exchanging data over a certain distance using radio waves. This module has a range of more than 10m. This module can be powered from 3.6 to 6 volts. The data from all the flex sensors are consolidated into a structure and is transmitted. The microcontroller receives the data and decodes it appropriately. Later it sends the data to an IoT application which reads out the words accordingly.

WORKFLOW

This proposed system is represented by the following flowchart. This flowchart explains the working of the entire system in a pictorial way.

Step 1: ESP-32 is the main microcontroller used to survey the automation. Flex sensors are connected to the controller and the output device is connected to another end of the controller.
Step 2: the microcontroller monitors each signal read concerning the change in the resistance value of the sensors that are attached to the glove when gestures are made.
Step 3: The ESP-32 board will collect data of each gesture made, computes, and processes them to identify the message associated with it.
Step 4: Once the gesture is identified, the message associated with the gesture is either displayed on the laptop or sent to an IoT application that will read out the message accordingly via Wi-Fi.

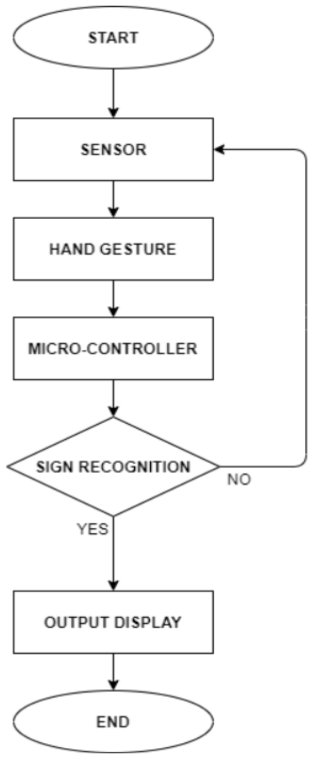

Fig.5. Flow Chart

RESULTS

The experimental setup contains a wearable data glove on which the flex sensors are placed. They can be either be powered by a battery or from a voltage source. A new way for recognition is formed by the new methods of using hardware components with small-sized hardware. Consequently, a smart glove with flex sensors has been used to make communication more efficient which provides higher accuracy when compared to few other methods. Moreover, this device is power efficient and can be easily carried. Fig. 7 shows the design of the glove along with the circuitry. Each flex sensor is connected to the breadboard and then to the ESP-32. The WIFI module is also connected and even more, connections can be made into a Printed Circuit Board (PCB) for stability and compactness which will eventually lead to a lightweight glove module. Fig. 9 shows the configuration of flex sensors and ESP-32 that can be done using simple conditional statements. As the resistance of the flex sensors changes on bending, certain values are established. The resistance readings are sent to the ESP-32. Accordingly, the control statements given to gesture will provide the necessary output. When the user performs a gesture, signals coming from the sensors are captured by the ESP-32. The microcontroller will decode the detected gesture and compares it with the database. The decoded instruction is transmitted to the smartphone via a WIFI module. The smartphone uses an app that converts text messages to a voice output or text can also be displayed in the output device. when the device starts, the sensor senses the hand gestures and sends its data to ESP-32. If the board successfully recognizes the sign with the help of the, then the receiving side will get voice output or displaying a text. If ESP-32 fails to recognize the sign then it will enter delay mode and the device again starts from the initial stage.

Fig.7. Smart Glove

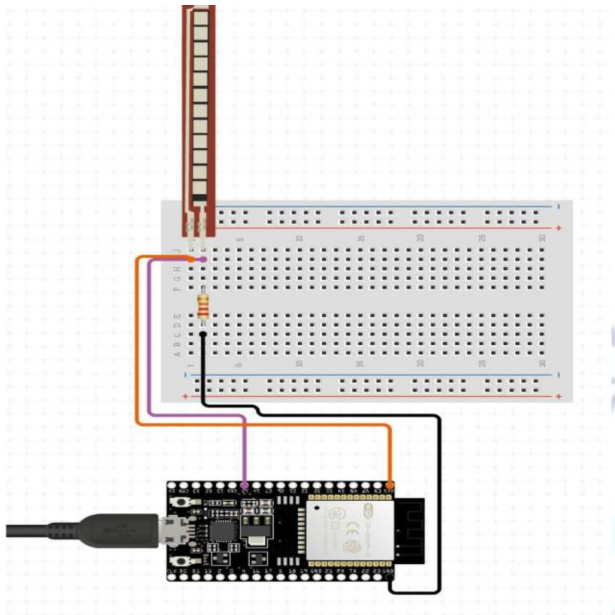

Fig. 8. Circuit Diagram

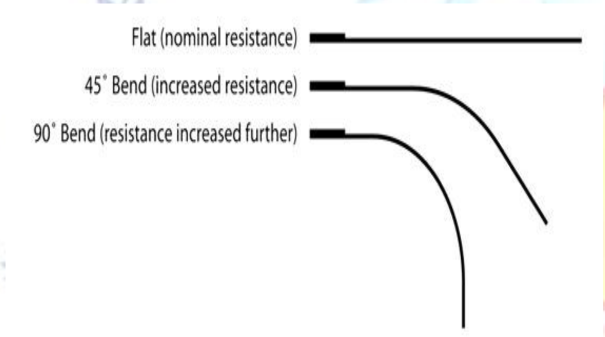

Fig.9. Working of the flex sensor

CONCLUSION

we efficiently designed and built an excellent and smart wearable device for hand gesture recognition. This device is based on IoT that provides a stable system by utilizing its quick functionality and ease of access. An IoT-based mobile application is used to identify the gesture produced using a glove. The mobile application contains text to speech module to have an audible output for easy communication. The developed system can be implemented in several areas. The main advantage of this system is it does not require any human intervention to perform its process of hand gesture recognition. The components that are used in this system are cost-effective and have a long life when compared to other devices, the projected arrangement is compact and portable. The hand gesture recognition system enables us to perform complex gestures and simulations with the usage of sensors attached to gloves in engineering applications. The system can be further enhanced by considering the following: The system can be used with RFID tags which will be placed on the glove and this data can be sent along with the gesture interpretation for multiple users. An LCD screen can be attached near to the microcontroller itself for ease of use and displaying notifications. The system can be made more efficient and accurate, allowing easy access to control household devices.

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