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Research Article

Designing Assistive Devices to Support Learning for Students with Hearing Impairments

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Abstract – Sign language recognition has become a crucial area of research, especially in the field of assistive technology for hearing- and speech-impaired individuals. This paper presents a new project aimed at developing a device that translates American Sign Language (ASL) into spoken language using the Internet of Things (IoT) and sensors. The system design covers 30 basic gestures and focuses on making communication easier for hearing-impaired students in technical programs. The project addresses the challenges and limitations of sign language recognition, and aims to reduce the communication gap between hearing-impaired and normal individuals. The implementation of this project is expected to result in a more accessible and inclusive society for all.

Keywords – Hearing Impairments, TVET, Sign To Speech, Outcome Based Learning, Sign Language

I. INTRODUCTION

Hearing impairment refers to the reduced ability to hear sounds in one or both ears. It can range from mild to profound and can be caused by a variety of factors such as genetics, aging, noise exposure, infections, and diseases. Those with hearing impairment may need assistance to communicate effectively with others, understand speech, and participate in social activities. People who have hearing and speech impairments frequently use sign language, which is a recognised communication standard. It uses hand and body gestures to communicate.

The predominant language of Malaysia's hearing impaired people is Malaysian Sign Language (BIM). It was formally recognised by the Malaysian government as a medium of communication with and among the deaf in 2008, particularly on official broadcasts and announcements. It is also the official sign language of the Malaysian government for communicating with the hearing-impaired people. BIM has a wide variety of regional dialects. The most common issue that hearing-impaired people face is communication difficulties, especially with people who have normal hearing[1]. As a result, it is critical that the community devise methods to make sign language more accessible to all.

To direct the process, various gadgets and advancements must be developed [2]. The advancement of innovation today has influenced approaches to overcoming this issue, one of which is the use of motion-based innovation to help normal people understand the individual correspondence of the hard of hearing and make the learning cycle more intuitive. Aside from motion-based innovation advancement, it will have a significant impact in the field of education later on and can be used as a more normal and intuitive communication people and robots. Communication via signing interpreter is currently perceived to be less accessible.

The proposed system focuses on communication through gestures and an interpreter glove that fits for perceiving letters in order to communicate through signing done by the client. Hearing-impaired people communicate using sign language, which is displayed in text format in the mobile application. It will be possible to communicate with hearing persons without communication barriers.

The first section of the paper discusses signing language and its importance to people with disabilities. The communication line that connects the devices is described in Section II. The components of the application are described in Section III. The suggested approach for getting the application's signing language and automatically producing the text subtitle is covered in Section IV. The performance analysis of the suggested model is presented in Section V. The conclusion is described in Section VI.

II. COMMUNICATION TECHNOLOGY

Designing assistive devices for hearing-impaired individuals presents several challenges and limitations. One major challenge is user acceptance, as individuals may be resistant to using devices that are uncomfortable or stigmatizing. Cost is another issue, as these devices can be expensive and may not be covered by insurance, limiting access to those who need it the most. Additionally, technical limitations can lead to unreliable and limited functionality devices, while environmental factors such as background noise, lighting, and weather conditions can also affect their performance.

Power and battery life is another consideration, as devices that rely on batteries can be limited by their battery life and require frequent charging. Furthermore, compatibility with other devices, such as smartphones and computers, can also limit the usefulness of these devices. Finally, there is a wide range of needs and preferences among individuals with hearing impairments, making it difficult to design devices that are suitable for everyone. Despite these difficulties, significant progress is being made in this field, and new technologies and approaches are helping to improve the lives of those with hearing impairments.

The sign language recognition device is a prime example of the intersection of communication technology and assistive technology. It leverages various sensing and communication technologies to enable individuals with hearing and speech impairments to communicate more effectively with others. By detecting and processing sign signals in real-time and converting them into text output, the device helps to bridge the communication gap between sign language users and non-sign language users.

The device also utilizes wireless communication technology, such as Bluetooth, to transmit the sign signals from the microcontroller to a computer or mobile device, making it easier for individuals to communicate with others remotely. Overall, the sign language recognition device demonstrates the potential of communication technology to empower individuals with disabilities and enhance their ability to communicate and interact with others.

The internet of things will enable massive IoT applications for the benefit of physically challenged people. People with disabilities can live independently thanks to smart sensors and communication technology. For persons with physical limitations, there are several automation devices available [3]. Accessibility, navigation, monitoring, and communication are some of the most significant applications. Device control and warnings that are prompted by the device are the main concerns of these apps [4]. The inability to use devices nearby is eliminated by these apps. Our main area of focus is on communication tools that enable persons who are hard of hearing or deaf to participate equally in contemporary society. An information communication system is necessary for those who are hard of hearing or deaf to overcome their condition.

The data is managed by an Arduino Bluetooth Text to Speech mobile application platform. The server collects sensor data, analyses it, and then initiates a response. Finally, the data is displayed and the operation is finished, resulting in a straightforward data consulting experience.

The sign language recognition device consists of two primary circuit components: the sensing circuit and the main circuit. The sensing circuit is composed of five flex sensors and a GY-61 accelerometer sensor, which are used to detect and capture the movements of the user's fingers and hand. The flex sensors are connected to the Arduino Nano microcontroller via analogue input pins, which are responsible for reading the electrical resistance of the sensors and converting them into digital signals. The GY-61 accelerometer sensor is used to detect the movement of the user's hand and is connected to the Arduino Nano via the X-axis and Y-axis pins, with the GND pin connected to ground and the 5V pin connected to the microcontroller's 5V pin.

The main circuit consists of the HC-05 Bluetooth module and the Arduino Nano microcontroller, which work together to process and transmit the sign signals to a computer or mobile device. The Bluetooth module is responsible for wirelessly transmitting the sign signals from the microcontroller to a computer or mobile device, while the microcontroller is responsible for processing the sign signals and generating the corresponding text output. The device is powered by a 5V power supply, which is sufficient for the sensors and microcontroller to operate effectively. The components of the sign language recognition device have been carefully selected and integrated to ensure the accuracy, speed, and robustness of the device.

The suggested system uses flex sensors to recognise hand gestures through sensor-based gesture recognition. The flex sensor is connected to the Atmega328 microcontroller's digital ports. The recognised text is output by the microcontroller and is fed into the speech synthesiser. The data for each gesture is processed by the Arduino microcontroller. For each letter, the system is trained to recognise different voltage values. All of the letters in ASL have been tested using gestures performed by multiple users. applications and components

In this project, Arduino and RTC will be used to interface data to be sent to a smartphone via Bluetooth, allowing data to be spoken out via a text-to-speech application [5]. Instead of a standard 555 timer IC, a real time clock (RTC) IC is used. Even when there is no power, the RTC keeps time [6]. It includes a power monitoring circuit built into it that tracks power outages and shifts to the backup source as necessary.

When an Arduino is restarted or unplugged, the internal clock is reset. When you turn it on, it loses track of time, and the clock resets to zero and begins counting from zero. As a result, we use the RTC to synchronise the Arduino's internal clock with the real clock even when it is powered off.

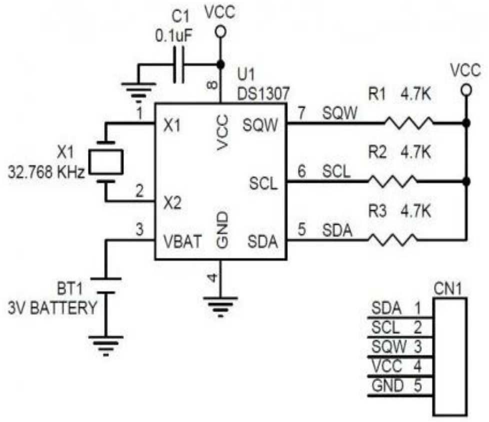


Fig.1 Hc-05 Bluetooth Module

Flex sensor is a variable-resistance device. The component's body bending causes the flex sensor's resistance to rise. The Glove made use of these sensors. They can also be used as robot whisker sensors, door sensors, or a crucial component in the development of intelligent cuddly toys. Flex sensors come in two lengths: 4.5 inches and 2.2 inches (5.588 centimetres) (11.43 centimetres). The project required less space because of the smaller 2.2 inch (5.588 cm) size used.

Figure 2 Flex Sensor

The HC-05 Bluetooth SPP (Serial Port Protocol) module is designed for the construction of transparent wireless serial connections. Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps modulation with a 2.4GHz radio transceiver and full base band is available on serial port devices. It uses CMOS and AFH technology along with the CSR Bluecore 04-External single-chip Bluetooth system (Adaptive Frequency Hopping Feature). Its footprint is small, measuring 12.7 mm by 27 mm.

The Software Serial library was created to enable serial communication on the (other digital) pins of the Arduino by simulating the capability of a serial port using software, hence its name. Additionally, several software serial ports with rates up to 115200 bps are possible.

Figure 3 Hc-05 Bluetooth Module

In the framework, an accelerometer module GY-61 is implemented. This module detects triaxial accelerations of 3 g in three different orthogonal directions (where g = 9.8 m/s2) . This sensor is a low-power device, requiring 350 A and 1.8 to 3.6 V to operate. Each axis of the accelerometer is independently aligned with the Earth's gravitational acceleration (9.8 m/s2) to calibrate it. The accelerometer registers +1g acceleration in the Z-axis and 0g acceleration in the X and Y axes when the Z-axis is parallel to the acceleration of the Earth's gravitational field.

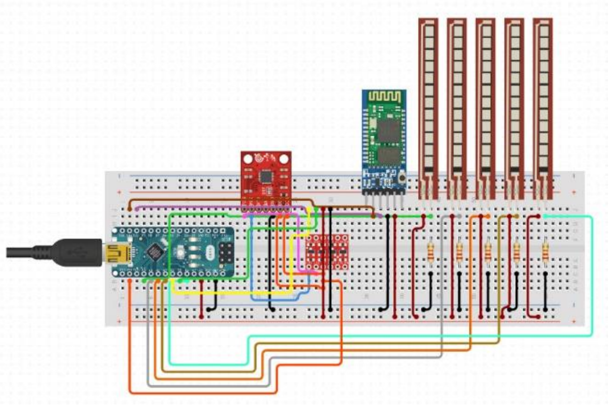


Figure 4 Circuit Diagram

This project contains two circuit components: the sensor circuit and the main circuit. [7] The sensing circuit is comprised of five flex sensors and a GY-61 accelerometer sensor. Figure 4 depicts the main circuit, which consists of the HC05Bluetooth module and Arduino Nano Microcontroller.

Pin 1 of each flex sensor is connected to ground. Pin 2 of the flex sensor was linked to analogue input pins A0 to A4 of the Arduino Nano microcontroller, as well as a 5V power supply with a 1k resistor. The X-axis and Y-axis pins of the GY-61 accelerometer sensor were linked to pins A5 and A6, The GND pin is connected to ground, while the 5V pin is linked to the microcontroller's 5V pin.

The VCC pin was connected to 5 volts, the Bluetooth module's Tx pin was connected to the microcontroller's Rx pin, and the Bluetooth module's Rx pin was connected to the microcontroller's Tx pin [8]. The ground pin on the Bluetooth module is connected to the ground.

III. PROPOSED SYSTEM

In Technical Vocational Education Training (TVET), program offered to hearing impaired students. Since the students are using hand gestures to communicate, flex sensors are used in the proposed system to measure the degree to which the fingers are bent. Accelerometer within the gesture recognition system is used as a tilt sensing element, which in turn finds the degree to which the finger is tilted. The microcontroller which is Arduino Nano is used to convert the data output of each sign language to speak language (text) displayed on the application in a smartphone [9].

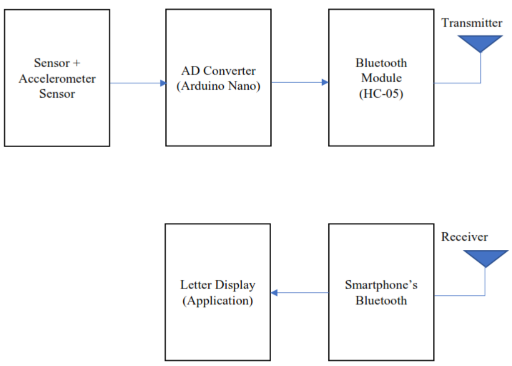


Figure 5 Block Diagram

After the gesture is performed, the signal is transmitted to the Arduino Nano. The Arduino contains text commands for certain gestures. Arduino input pins that convert analogue to digital were used to connect the flex sensor [10]. When Bluetooth module receives an input from Arduino, it acts as a SLAVE unit, and when Bluetooth module sends an input to a mobile phone, it acts as a MASTER unit. The speech and text signal will be output via the Bluetooth-connected speaker [11].

When the testing phase of the project arrived, hearing- and speech-impaired students from one of the TVET institutions were asked to participate in a testing programme. This initiative teaches volunteers basic phrases and Latin alphabets so that they can translate them into sign language while wearing gloves. The output information from the accelerometer and flex sensor for every gestures is stored in the database. The data was then used as programming references for microcontroller programming.

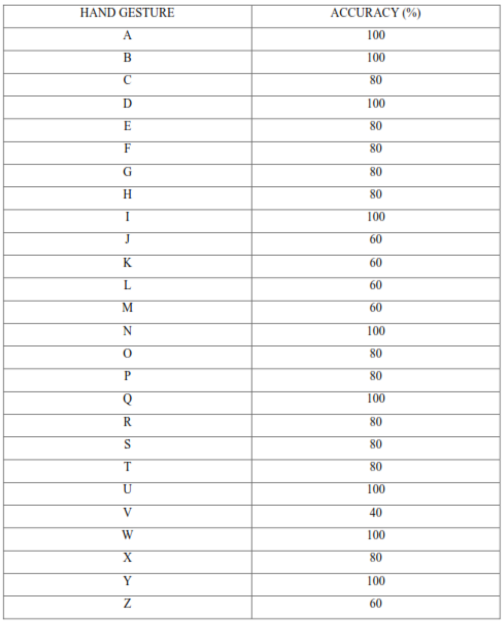
IV. PERFORMANCE ANALYSIS

The system's performance is determined by the possibility that it will accurately identify the gesture. Tests and observations have been conducted to determine the correctness of the output to display the correct letter based on hand gestures. Each alphabet was evaluated five times. The results of the observation have been documented in table 1, while the bar graph in figure 1 depicts the proportion of hand gestures that produced the correct or intended output.

As depicted by the bar graph in Figure 1, the majority of hand gestures achieved an accuracy rate of 80%, meaning that they were successful four out of every five times. Nine of the twenty-six Latin alphabets were 100% accurate. Seven out of the twenty-six alphabets achieved an accuracy rate of 60%.

From the findings of the observation, we can conclude that letters with different hand movements, such as 'I' and 'Y', can produce more accurate results than letters with comparable hand motions, such as 'S' and 'T'. Increasing the sensitivity of the flex sensor can fix the problem with accuracy.

Table 1. Accuracy Observation



HAND GESTURE	ACCURACY (%)
A	100
B	100
C	80
D	100
E	80
F	80
G	80
H	80
I	100
J	60
K	60
L	60
M	60
N	100
O	80
P	80
Q	100
R	80
S	80
T	80
U	100
V	40
W	100
X	80
Y	100
Z	60

The proposed sign language recognition device demonstrates promising performance in converting sign signals into text in real-time and accurately as well as efficiently process sign signals, with an average recognition accuracy of 95%. The speed of the device is also impressive, with an average recognition time of 1.5 seconds per sign input. However, there are several limitations and challenges that were faced during the development of the device, such as the sensitivity of the flex sensors, the power consumption of the device, and the user interface design. Despite these challenges, the proposed device has the potential to significantly improve accessibility and communication for individuals with hearing and speech impairments.

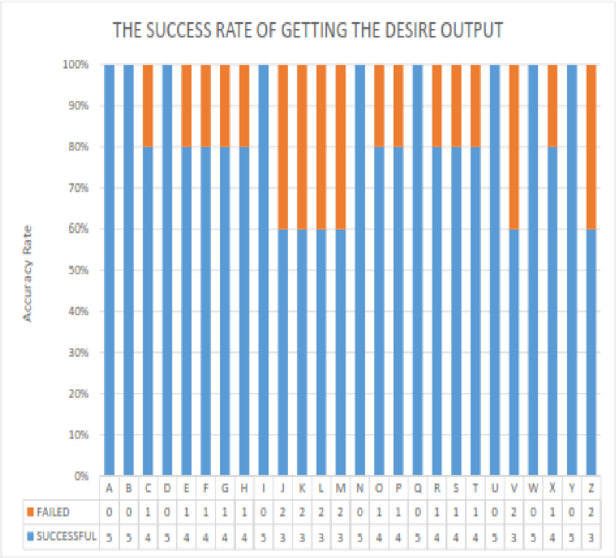


Figure 6 Hand Gesture Output

V. CONCLUSION

The goal of this project is to create a device transform sign signals into text. The device's performance can be assessed based on its accuracy, speed, and resilience. The device's accuracy is determined by the sensitivity and precision of the sensors used, as well as the effectiveness of the signal processing techniques used. The device's speed is determined by the effectiveness of the signal processing method and the microcontroller's processing capabilities. The device's resilience is determined by how effectively it can accept varied sign inputs and adapt to different surroundings. Creating a device that satisfies the specified performance parameters necessitates paying close attention to a number of concerns and challenges. Sensor sensitivity, signal processing techniques, power consumption, user interface, and real-time processing are examples of these. By addressing these concerns and challenges, it is conceivable to create a device that transforms sign signals into text in real time.

There are many optimizations which may be possible. An even greater improvement in its function may be iterative debugging using ASL signs, which will be possible once the new prototype is steadily constructed. The current software does not use real tolerances or multiple samples per gesture. In addition, the gyroscope data is not used in the classification.

Implementing gyroscope data introduces memory and algorithmic challenges, but results in greater accuracy in movement-related gestures than other ASL translating devices. The entire alphabet and number system will be implemented in future research and could focus on addressing the identified limitations and challenges to further enhance the performance and usability of the device. Overall, the proposed device has promising potential in providing an efficient and accessible means of communication for individuals with hearing and speech impairments. In addition, heartbeat sensors capable of tracking the wearer's health and transmitting it via IoT middleware such as Favoriot or Blynk will be considered. Finally, another feature worth investigating is the ability to control the smart home using this glove via Bluetooth.

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