VOL. 17, NO. 21, NOVEMBER 2022 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DEVELOPMENT OF SMART GLOVE WITH MOBILE APP THAT HELPS NORMAL PEOPLE TO SELF-LEARN MALAYSIAN SIGN LANGUAGE

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ABSTRACT

Sign language was used as a means of communicating many centuries ago. Learning sign language can be problematic and confusing for ordinary people, where most of them do not have the basics of the word. This paper aims to create a smart glove, which consists of a hardware-based glove complemented by a mobile application to help regular people learn Malaysian Sign Language (MSL) themselves. This differentiates this project compares to most other literature that focuses on translating MSL. The glove uses a microcontroller such as Arduino as a processor and an accelerometer as a sensor to recognize hand gestures defined by alphabet, number, and several Malaysian Sign Language words. The hand gesture data will be sent to the mobile application via Bluetooth communication. The mobile application built using MIT App Inventor will provide suitable questions and provide feedback to the user. In the result and discussion, the accuracy of the prototype is discussed. The effectiveness of the prototype as a learning tool is not discussed in this paper as the paper tries to fit within the scope of the journal. Having said that, the potential of the prototype for further improvement and a more detailed study from the perspective of learning theory needs to be studied to gauge accurately the effectiveness of the prototype as a learning tool.

Keywords: Malaysian sign language, gesture recognition, flex sensor, accelerometer sensor, mobile application, educational tool.

1. INTRODUCTION

According to the World Health Organization, about 5% of the world's population suffers from an impairment like deaf and blind even though 5% may seem low, over 360 million worldwide (World Health Organisation, [1]).

In Malaysia, the deaf community adopts a version of signs, Malaysian Sign Language (MSL), derived from the American Sign Language (ASL). The plurality of people in this group considers sign language as their primary medium of communication.

The language of a sign was used by man as a communication medium many centuries ago, which means the movements of body motion, and facial expressions concurrently converge to convey the meaning of the speaker. However, few people understand sign language. Those with disabilities may find it difficult to communicate or even express their thoughts to others using sign language as their daily communication tool.

Books are commonly used in Malaysia as the primary learning tool for sign language; however, it is not as effective for most people as recently. Therefore, it lacks creativity and interactivity for regular people to learn sign language. Apart from books, videos on sign language are also available, but it also lacks interactivity (Mokhtar *et al.,*[2]).

Inspired by great progress in the electronic-based educational tool as part of a self-learning tool (Faseh *et al.,* [3]-Azahar *et al.,* [14]), this paper aims to provide an alternative learning tool which seems more interactive. Although the contribution might sound toward the field of education, this paper aims to address all the technical issues in developing and building the prototype. Addressed the system's problem for understanding sign language, which is expected to help people with disabilities interact with ordinary people. This glove uses Arduino as a processor and accelerometer to recognize hand gestures defined by alphabets, numbers and a combination of words. The hand gesture's data output is connected to the Bluetooth module, and the text and speech to the mobile learning application are presented.

2. RELATED WORK

The related literature on sensor gloves-based gesture recognition that serves the deaf-mute people has been done. This project attempts to combine the hardware built by Lee B. G. and Lee S. M. [16] and the learning application by Hafit*et al.,* [21]. Thus, this project's novelty is that no attempt to create an educational kit using a data glove to capture the information of the hand gesture.

2.1 Data Glove Approach

The data glove approach usually uses an electronic, mounted glove with a manufactured sensor to discern a hand's movement. Firstly, the system proposed a data glove design with five flex sensors, five resistors of 10Ω, the Arduino Lilypad, a Bluetooth module and the battery.

Akthem M. [15]proposed a low-cost glove device for MSL. The recognition process is carried out by applying Linear Discriminant Analysis (LDA) to the input signal. The system evaluated 24 letters of Malaysian Sign Language (MSL) and has a good accuracy reaching up to 86.36%.

In another article by Lee B. G. and Lee S. M. [16], the authors proposed a method to detect ASL signals using five flex sensors and two pressure sensors and one motion sensor. Precision for flex sensors and motion sensors was only 65.7%, but by adding pressure sensors, it was 98.2 percent. This paper aims to adapt the proposed method in building the hardware prototype.

Javed S. [17] proposed a digital wireless glove capable of converting sign language into text and voice output. The result is shown in the GLCD module's text, and the prototype consists of a flex sensor and an IMU to detect the movements. It incorporated 20 words and 15 sentences and tested it with four different users to check the Analogue to Digital Conversion (ADC) values.

Choudhary*et al.,* [18] proposed a novel braille translation glove that helps communication of deaf-blind individuals. The system translates the Braille alphabet and displays the output to a remote contact via SMS. Capacitive touch sensors are located on the palm side of the glove and sense mini-vibratory vibration motors by touch patterns on the glove's dorsal side.

2.2 Visual Based Approach

Asri *et al.,* [19] proposed a system consisting of a laptop and a single board machine, and a camera is visual-based pattern recognition of movements. Signs are drawn in front of a camera that primarily uses different techniques to reach the desired output, including computer vision processing. An MSL real-time detection based on Convolution Neural Network technology using You Only Look Once (YOLO) v3 algorithm. This experiment's main objective is to identify or detect the object's position in the class belonging to the item. This device has been trained and tested on the Darknet frame. This system achieved 63% accuracy with learning saturation at 7000 iterations. Sutarman *et al.,* [20] proposed the use of MATLAB software and computer to recognize Dynamic Malaysian Sign Language as a back propagation neural network (BNN). In the first step, skeletal data tracking with eight joint positions are taken from the Kinect sensor. In the second phase, the skeleton extracts the X, Y and Z coordinates' values, and in the third phase, the classification processes are performed by BNN. The system for recognizing 15 dynamic signs with a precision of 80.54%.

2.3 Sign Language Learning Application

Hafit *et al.,* [21] proposed the development of apps with learning tools to track the sign language and visualize the phone camera image in sign sense. This application aims to help the public learn MSL efficiently by selecting a type of sign that the user wants to know and test with the Quiz module. The software includes four features to detect signals using a phone camera, learning by type, playing quizzes and providing feedback. HTML, Typescript and Ionic frame use the Angular Firebase application. The only difference is that it uses image processing to read the hand gesture of the learner. This can be rather slow compared to our proposed approach.

3. METHODOLOGY

3.1 Block Diagram of the System

According to the block diagram in Figure-1, Arduino Nano's primary input is the flex sensor values and accelerometer. When the hand is present in a specific gesture, the readings from flex sensors and accelerometers are in sign language. The resistance transition is transformed into a voltage after the ADC and then interpreted by the microcontroller. A particular sign's specific value is used to detect the letter or word in the range defined for the sign. The alphabet is wirelessly processed to and interpreted on the Android application when the match is found in the build-in database.

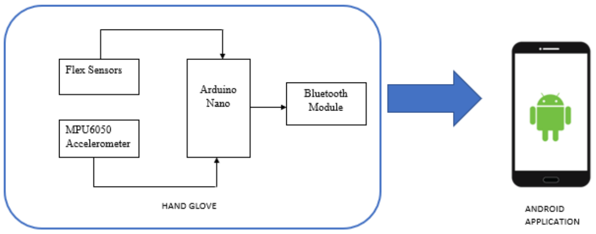

Figure-1. Block diagram of the system.

3.2 System Hardware Design

Figure-2 shows the circuit diagram for this project. The design of the motion glove plays a vital role in the identification of the alphabet. The flex sensor is a sensor type that changes resistance when pitched at a single degree. The sensors are integrated with the Arduino Nano Microcontroller Digital Converter Analog (ADC). This project conjointly uses the GY-61 ADXL335 accelerometer mounted on the top of the hand to observe inclination and acceleration.

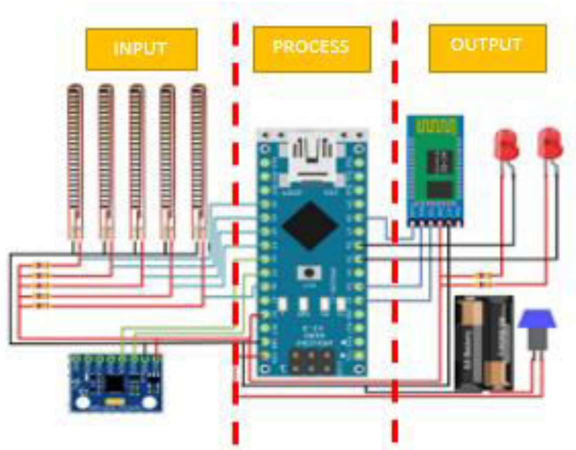

Figure-2. Circuit diagram.

If the flex sensor has a reasonable value (not an inclination) of 25k ohm resistance, bending it will have a maximum resistance value of 100k ohm when bent, since only one degree is free; each finger requires only a flex sensor. As suggested by Lee B. G. and Lee S. M. [16], in

VOL. 17, NO. 21, NOVEMBER 2022 ISSN 1819-6608
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the ADC, the sensor component includes LEDs (light emissions diode) and the two batteries of the voltage supply as an accurate description.

3.3 Flowchart of the System

Figure-3 shows the system flow developed in this paper. First, the accelerometer is converted to voltage via the flex sensor using the voltage divider, which is already stored in the required format. The flex sensor shows the variable resistance value when bending to the fingers and is then processed to filter out unnecessary fluctuations. This event provides the microcontroller with only useful data. After several experiments in the scenarios, the two sensors' values are evaluated by comparing them to a defined set of data.

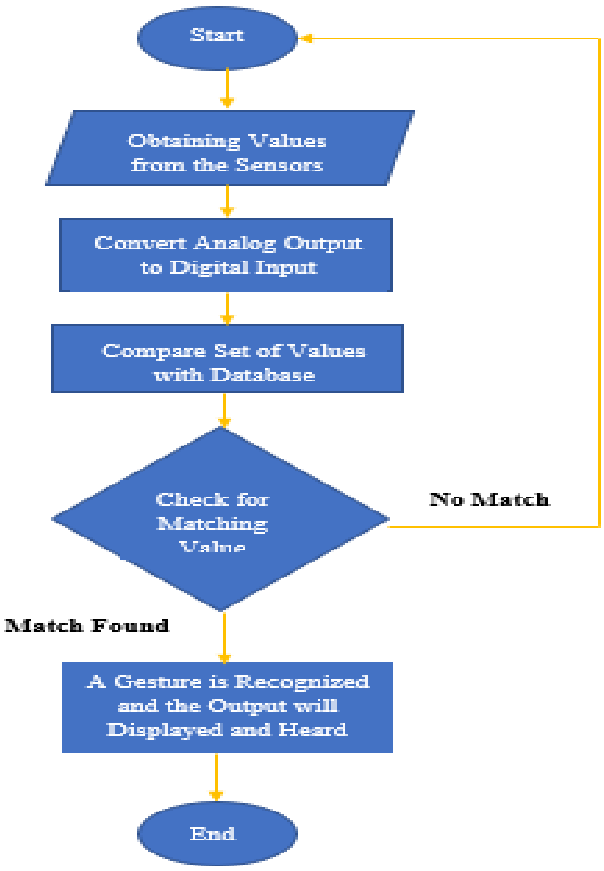
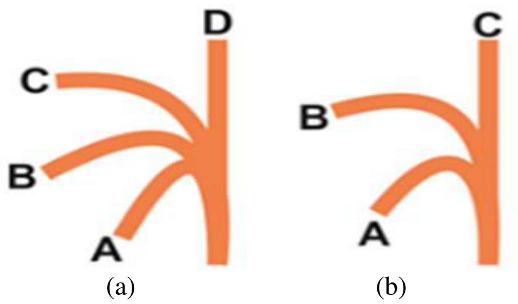


Figure-3. Flowchart of the system.

The next part is to compile in Arduino Nano all sensor values, including the accelerometer GY-61 ADXL335 module. These are tested by binary digits and active sensors on-site for comparison in the algorithm. If the microprocessor recognizes the signs, it can find the alphabet. With the Bluetooth module's help, the data-glove can wirelessly transmit the signal to the Android device using the mobile android app called "iSignM," which displays an alphabet or word and turns the performance to speech as well. This user-friendly mobile application increases the project's scale in terms of audio/visual output, portability and cost-effectiveness.

3.4 Tracking Hand Movement

The mapping of finger status was performed in previous research to improve the number of alphabets recognized by the system (Haq*et al.,* [22]). Based on the index research, centre, small, and ring fingers are divided into four levels as shown in Figure-4, i.e., A is shown for maximum bending, B is indicated 3⁄4 for maximum bending of the fingers, C is shown as 1⁄4 for maximum bending and D is shown as the minimum bend of the finger (right). For thumb-finger mapping in three levels, A is indicated for the finger's maximum bend, B is indicated 1⁄2 for the maximum bend of the finger, and C for the finger's minimum bend is indicated (straight).



(a) (b)

Figure-4. Mapping Finger Condition- (a) The Index, the Middle, Little, the Ring Fingers, (b) The Thumb Finger.

4. RESULT AND DISCUSSIONS

4.1 Hardware and Implementation

Flex sensors are used for measuring the bend in the finger for gesture recognition. The data obtained from the sensors are as follows: 1) the degree of bending the thumb Finger-2) the degree of bending the index Finger-3) the degree of bending the middle Finger-4) the degree of bending the little Finger-5) the degree of bending of the ring Finger-6) hand movement to the axis x, axis y and axis z as shown in Figure-5.

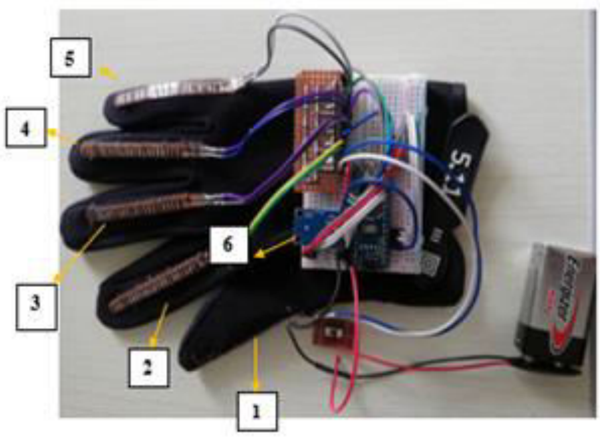


Figure-5. Flex and accelerometer positioning.

4.2 Coding Design on Arduino IDE

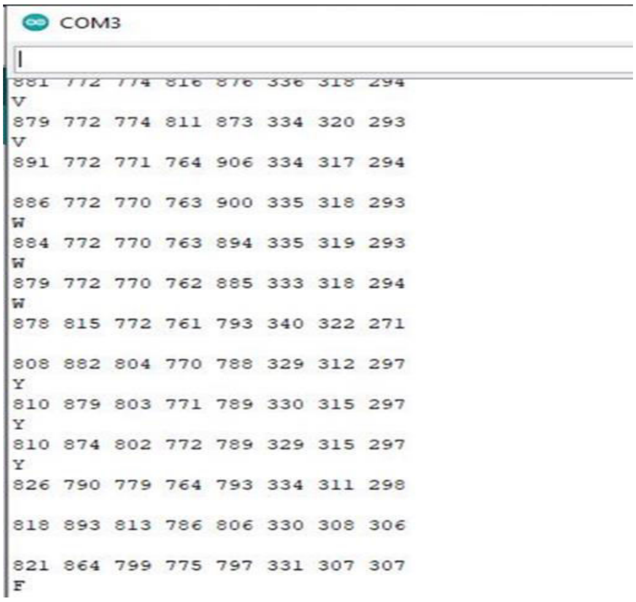


Figure-6. The outcome of gesture form of flex sensor and accelerometer reading.

In the previous section, where the hardware implementation shows the Arduino Nano will compile all the sensor data and accelerometer as its converts into voltage using the voltage divider formula and Figure-6 shows the outcome of coding for this system. The outcome of this gesture is based on the average of how much the value of the flex sensor during the straight resistance and bent resistance make the difference in each alphabet. Each must follow the criteria to make the alphabet appear and the signal of each alphabet will then transmit to the mobile application. The 10 samples of alphabets are chosen because this alphabet has the most accuracy due to how the gesture can be effective from the movement in tilting, up and down, side to side and accelerometer value also will increase by value.

4.3 Building Dataset

After mounting the five-flex sensor and the analogue values obtained from the gesture glove, it is converted into digital Mapping Finger-Condition values using the map method as in Zakaria*et al.,* [4]. Each sensor value is represented by a level indication of the letter "A," "B," "C," and "D." The level is obtained from each of the fingers. A manual-training model from the sensor represents each letter of the Malaysian Sign Language alphabet and numbers while the user is gesturing. The conflicts due to identical result values are recognized, and the correct letter is identified. The level and accelerometer set point values corresponding to each alphabet, and number are illustrated in Table-1.

Table-1. Alphabets recognition parameter.

Alphabets	Fingers Level					Gyroscope(*100)		
	1	2	3	4	5	X	Y	Z
A	C	A	A	A	A	3.3-3.7	2.8-3.3	2.7-3.2
B	A	D	D	D	D	3.3-37	2.9-3.2	2.6-3
D	B	D	B	B	B	3.3-3.5	3-3.2	2.7-3
F	C	A	D	D	D	3.2-3.5	2.7-3	2.8-3
I	A	A	A	A	D	3.3-3.5	2.8-3	2.8-3
L	C	D	A	A	A	3.3-3.5	2.8-3	2.8-3
S	A	A	A	A	C	3.3-3.7	2.7-3	2.7-3
V	B	D	D	A	A	3.3-3.7	2.8-3.2	2.8-3
W	A	D	D	D	A	3.3-3.7	2.8-3.2	2.8-3
Y	C	A	A	A	D	3.3-3.7	3-3.3	3-3.3

This system is tested in the testing model about ten times using the parameter that has been stored in the Arduino IDE program. In performing the test, the data are taken consisting of 10 Alphabet. The condition does not require gestures but also requires moving the hands or other parts of the hand. The results gesture recognition stated Yes-“Y" and No-"N" for the results that had been achieved.

Table-2. Alphabets recognition results.

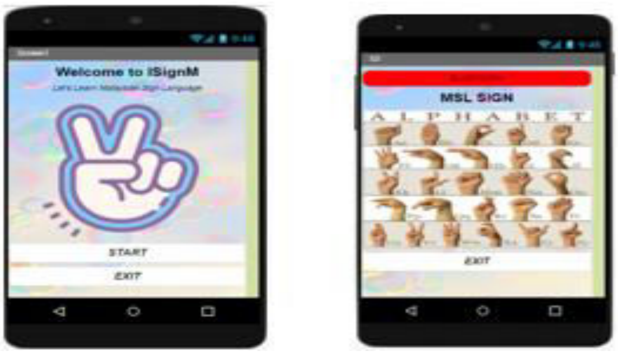
Alphabets	Number of Trials										Total	
	1	2	3	4	5	6	7	8	9	10	TRUE	FALSE
A	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	9	1
B	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
D	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
F	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
I	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
L	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
S	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	9	1
V	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
W	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0
Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	10	0

Table-2 shows the gesture recognition in Malaysian Sign Language (MSL) if the glove works well. Alphabets such as "J", "Z", "N" and "M", "K," and also "U," and "V," can be difficult to compare due to their same movement and tilting.

Comparing the sensors' values such as the flex sensor, gyroscope and accelerometer that implement in the cotton glove and found that the generated value is almost similar. The cause of this can be due to having a similar form of fingers curve and shifting glove. In the worst-case scenario, the glove produced poor results by generating random values or unstable output.

4.4 Software Results

The MIT App Invertor has been used as the inventor in creating the mobile application of ‘ISignM’ where each of the blocks will show the function.



(a) (b)

Figure-7. The interface of Mobile app 'ISignM'.

Figure-7(a) shows the MIT-blocks for listing all the available Bluetooth devices. If the user selects one of them, then the connection occurs, and the word "connected" is displayed or otherwise "not connected" is displayed.

Figure-7(b) above shows the communication's establishment, the application starts receiving the data, and the recognition process starts. The recognition process occurs, and lastly, the generation of the output in the text and audio form.

5. CONCLUSIONS

This paper presents the technical part of developing an electronic educational tool for self-learning MSL. Based on the research and the work done, a user-friendly glove was developed based on past literature that can translate sign language gestures into letters with a high level of accuracy in recognizing gestures.

ACKNOWLEDGEMENT

This paper was supported by the Faculty of Electrical and Electronics Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM) under Centre of Research and Innovation Management (CRIM) Publication Incentives.

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