Smart Glove for Translating Arabic Sign Language "SGTArSL"

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Abstract*—Deaf and mute people who use sign language often face serious communication problems with others. The Smart Glove for Translating Arabic Sign Language (SGTArSL) tries to address this problem by providing them with means of communications, especially with their families. SGTArSL uses small components to build a communication device to enhance the communication between deaf/mute people with others who, do not necessarily, understand their language; thus improving their independence. The system includes a smart glove that translates the Arabic Sign Language (ArSL) alphabets using only one hand by building a Printed Circuit Board (PCB) on a textile glove. The PCB uses a microcontroller and sensors to detect and classify the hand gesture, then sends the observed alphabet via Bluetooth as a text to a mobile application. In this paper, SGTArSL is successfully tested to enable people who communicate with deaf/mute users to understand their sign language alphabets.

***Keywords*— Arabic Sign Language, smart sensory glove.**

I. Introduction

Interaction between a deaf community and a hearing one is minimal and is basically concentrated around families and relatives of the deaf [1]. The SGTArSL can reduce this barrier and provide them with a means to help them to communicate with others. This is accomplished by using a smart glove to translate their Arabic sign language alphabets.

Arabic Sign Language (ArSL) is a natural language that serves as the predominant sign language of deaf communities in the Arab World. Many efforts have been made to establish the sign language used in individual arab countries, by trying to standardize the language and spread it among all society members. ArSL is still in its developmental stages, only in recent years has there been an awareness of the need of translating the arabic sign langauge. SGTArSL is designed to translate the Arabic Sign Alphabets, shown in figure 1 [2], into text using an Arduino microcontroller built on a sensory circuit borad to detect the hand gesture and translates it to a text using a mobile application.

There are several types of translating sign language to readable text systems. These types appear with many features, but nearly with the same tasks. Mainly, there are two types: translating systems that are based on sensors and systems that are based on vision.

The system in [3], was built as a real-time prototype glove equipped with 5 flex and 1 accelenometer sensors. Using a mobile application, the system translates ArSL into text and vice versa. The authors claimed that their prototype was accurate, low cost, and fast in response. Researchers in [4] proposed a system to translate ArSL gestures, they used image processing to recognize ArSL gestures. Their approach was limitted to 10 arabic sign getstures only. The accurracy dropped down when they tried to include more gestures to recognize visually.

The research in [5] investigates various visual descriptors to recognize ArSL alphabets. They used One-Versus-All Support Vector Machine (SVM). The resultant system succeeded in recognizing 63.5% of ArSL alpahbet gestures. However, an ArSL translator based on Dynamic Time Warping was introduced in [6]. Authors said that the experimental results for collected ArSL data acheieved a high recognition rate of about 95.25%. In the meanwhile, researchers in [7] tried to solve the lack of data sets for ArSL. The system was trained on "morphological fetaures of 100 samples". Then these samples were classified into 3 alpahet classes with accurracy of 73.3%. However, the researchers in [8] designed a low cost smart glove that recognized left and right hands' gestures in ArSL. The glove was desgined for words and sentences levels with 90% recogniztion rate using both voice and text.

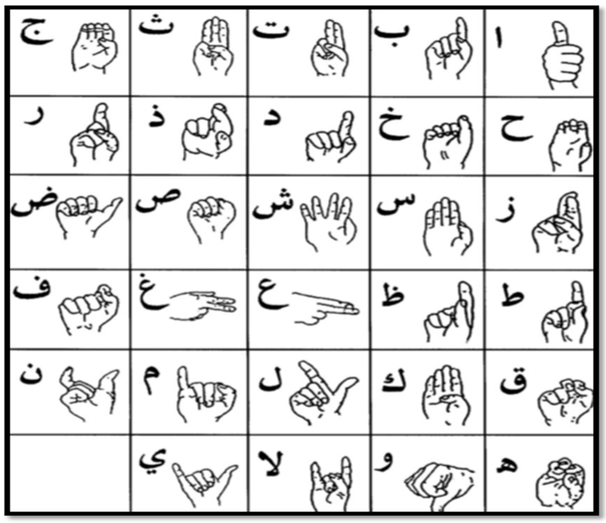

Figure 1. Arabic Sign Langauge Alphabets [2].

For our system, it uses flex sensors, accelerometer, and pushbutons with an Arduino Nano microcontroller to sense the right hand gesture for the Arabic Sign Language Alphabets. It then, sends the processed data to the mobile application as a text. The system uses a cheap and simple components to detect the hand gesture. The use of the mobile application increases the system usability and simplicity.

The rest of the paper is organized as follows: the next section introduces the methodology and design of the system. Section 3 explained the implementation while section 4 discusses the system testing and the experiemntal results. Finally, the conclusion and future work is introduced.

II. SGArSL Methodology And Design

SGTArSL is based on wearing a glove by a deaf in his right hand and then makes an Arabic sign language signal, as shown in figure 2. The glove is built of two main parts, as shown in figure 2.

The first part is the sensory cuicuit which consists of the flex sensors and pushbuttons. It gives a certain reading value that reflects the states of the whole hand and each finger. In addition, we put an accelerometer to distinguish letters with the same movements of fingers but with different directions of the hand.

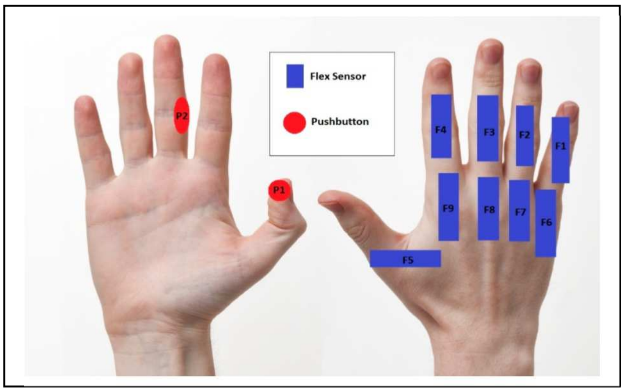

Figure 2: Distribution of all the sensors and pushbuttons on the glove

Because the outputs of the flex sensors and accelerometer are analog values, they were conveted to digital signals. The second part consists of smart phone and Bluetooth module. These two parts are connected to ArduinoNano microcontroller.

The smart glove converts ArSL alphabets into letters in Arabic languag, where nine of flex sensors will be put on the glove, nine sensors on finger joints and two pushbuttons, as shown in figure 3. We have studied the Arabic Sign Languae and classify the value of each sensor in case of each alphabet. The resultant values are shown in table 1. When the system observes the obtained sensoy data, it compares it with the values stored in table 1. As a result, the system will decide the correct signal and send it as a readable text through Bluetooth module to the mobile application and display it on the screen. To explain the flow of the system, figure 3 shows the structural model of the SGArSL.

Table 1. The codes for the sensors that represent each alphabet

Alphabets	F1	F6	F2	F7	F3	F8	P1	F4	F9	P2	F5	Decimal Codes
‘ا’ & ‘ض’	1	1	1	1	1	1	1	1	1	0	0	2044
‘ب’ & ‘ل’	1	1	1	1	0	1	1	0	0	0	0	1968
	1	1	1	1	0	1	1	0	1	0	0	1972
‘ت’ & ‘ع’	1	1	1	0	1	0	0	0	0	0	0	1856
	1	1	1	0	1	0	0	0	1	0	0	1860
‘ث’	1	1	0	0	1	0	0	0	0	0	0	1600
	1	1	0	0	1	0	0	0	1	0	0	1604
‘ج’	1	1	1	0	1	1	0	1	0	0	1	1897
	1	0	1	0	1	1	0	1	0	0	1	1385
‘ح’	1	1	1	0	1	1	0	1	0	0	0	1896
	1	0	1	0	1	1	0	1	0	0	0	1384
‘خ’	0	1	0	1	1	0	1	0	1	0	0	724
	0	1	0	1	1	0	0	0	1	0	0	708
‘د’ & ‘ن’	1	1	1	1	0	1	0	1	0	0	0	1960
	1	1	1	1	0	1	1	1	0	0	0	1976
‘ذ’	1	1	0	1	0	0	0	0	1	0	0	1668
	1	1	0	1	0	1	0	0	1	0	0	1700
‘ر’	1	1	1	1	0	1	1	1	0	1	1	1979
	1	1	1	1	0	1	0	1	0	1	1	1963
‘ز’	1	1	0	0	0	1	0	0	1	1	1	1575
	1	1	0	1	0	1	0	0	1	1	1	1703
‘س’	0	0	0	0	1	0	0	0	0	0	0	64
‘ش’	0	0	0	0	0	0	0	0	0	0	0	0
‘ص’	1	1	1	1	1	1	1	1	1	0	1	2045
‘ض’	1	1	1	1	1	1	1	1	1	0	0	2044
‘ط’	1	1	0	1	0	0	0	0	0	1	0	1666
‘ظ’	1	1	0	1	0	1	0	0	0	0	0	1696
	1	1	0	1	0	0	0	0	0	0	0	1664
‘غ’	1	1	0	0	0	0	0	0	0	0	0	1536
‘ف’	1	1	1	1	0	1	1	0	1	1	0	1974
‘ق’	1	1	0	0	1	0	0	0	1	1	0	1606
	1	1	0	1	1	0	0	0	1	1	0	1734
‘ك’	0	0	0	0	1	0	0	0	0	0	1	65
‘م’	0	0	1	0	1	1	0	1	1	0	0	364
‘ه’	0	1	0	0	1	0	1	0	1	0	0	596
‘و’	1	1	1	0	1	1	0	1	1	0	0	1900
	0	1	1	0	1	1	0	1	1	0	0	876
‘ي’	0	0	1	0	1	0	1	0	1	0	0	212
	0	1	1	1	1	0	1	0	1	0	0	468

III. SGArLT Implementation

Arduino Nano V3.0 is connected to Bluetooth Module CH-06, to send the alphabet to an android application. It is connected to nine Flex Sensors located on the joints of fingers using analog pins in the microcontroller to control the bend degree of each sensor. The micrcontroller is connected to two pushbuttons one of them is located on the thumb of the smart glove and the other is located between index finger and middle finger using digital pins. Afterthat, Arduino Nano is connected to MCP3008 chip to increase the number of analog pins to be used in the system. The accelerometer is connected, too, using analog pins through the MCP3008 so that we can differentiate between some letters. The accelerometer is connected, too, using analog pins through the MCP3008 so that we can differentiate between some letters. The accelerometer sensor gives the changes in the coordinates of the three axes (x,y, and z). Based on these changes, the character is determined.

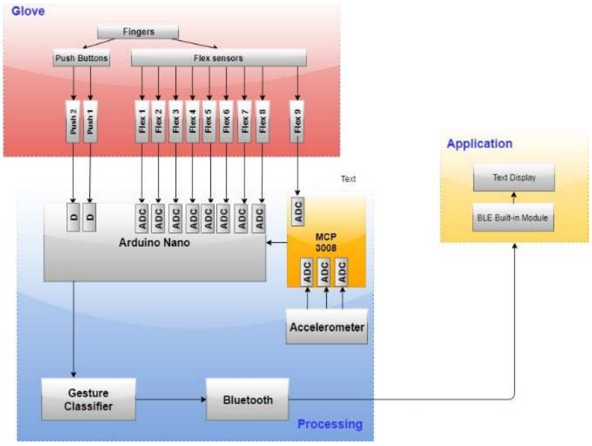

Figure 3: The structural model of the SGArSL

(a). backside of the glove	(b) frontside of the glove

Figure 4: Smart glove implementation

For example: the 'ا' and 'ض' have the same reading on each sensor but the hand orientation is different, for example in 'ا'the hand position is vertical but 'ض' is horizontal. Two Lithium (Lipo) batteries each one is 3.7v, is used to power the circuit. USB link is welded with it to be connected to Arduino and charge the battery.

To make a connection between the Arduino and the mobile, we use Bluetooth module CH-06. A mobile application is developed using MIT App inventor. The application enables the user to connect the mobile to the glove and then receives the translated sign langauge alphabet to be displayed on the mobile screen. To start the system, the user should make sure that the required pairing process between the two Bluetooth modules is done before sending messages. By the end of the implementation process, the smart glove (shown in figure 4) was constructed. (Figure 4- a) shows the back side of the glove, on which the flex and accelerometer sensors are fixed. The pushbuttons and lithium battery are fixed on the inner part (Figure 4-b). The sequence of the system operations is explained in the flow chart which is shown in figure 5.

IV. System Testing and Experimental Results

In this section, the testing of the system components and the experimental results are discussed.

A. *Setup Testing*

The overall system was tested. This includes ensuring that all system components are working as required: Arduino Nano with MCP3008 and flex sensor, Arduino Nano and MCP3008 with ADXL335. The Bluetooth connection is established between mobile and Bluetooth module CH-06. The mobile application validity to receive a character, and the application validity to receive a character from the smart glove is tested. Finally, the system prints it as a text message.

B. *Eperimental Results*

After we tried all the letters of the Arabic sign language several times, we averaged the error rate every ten of attempts for each letter, as shown in the table 2. Equation 1 is applied on these data to calculate the error rate of the system.

Error rate for all the system is:

$$= \frac{\sum_{i=0}^{n-1} error\ rate\ for\ each\ alphabet}{n} \qquad \text{Equation 1}$$

$$= \frac{(0.3+0.1+0.2+0.3+0.2+0.1+\cdots+0.2+0.0)}{28} = \frac{3.3}{28}$$

Form the calculations above, the error rate = 0.1178571428571429. which implies that the success rate is 88.21%.

Table 2. Experimental data

Alphabets	Decimal codes	Error Rate
'ا'	2044	3/10
'ب'	1968 | 972	1/10
'ت'	1856 | 1860	2/10
'ث'	1600 | 1604	3/10
'ج'	1897 | 1385	2/10
'ح'	1896 | 1384	1/10
'خ'	724 | 708	3/10
'د'	1960 | 1976	1/10
'ذ'	1668 | 1700	2/10
'ر'	1979 | 1963	0/10
'ز'	1575 | 1703	2/10
'س'	64	0/10
'ش'	0	2/10
'ص'	2045	0/10
'ض'	2044	0/10
'ط'	1666	1/10
'ظ'	1696 | 1664	0/10
'ع'	1856 | 1860	2/10
'غ'	1536	0/10

‘ف’	1974	2/10
‘ق’	1606 | 1734	0/10
‘ك’	65	1/10
‘ل’	1968 | 972	1/10
‘م’	364	1/10
‘ن’	1960 | 1976	1/10
‘ه’	569	0/10
‘و’	1900 | 876	2/10
‘ي’	212 | 468	0/10

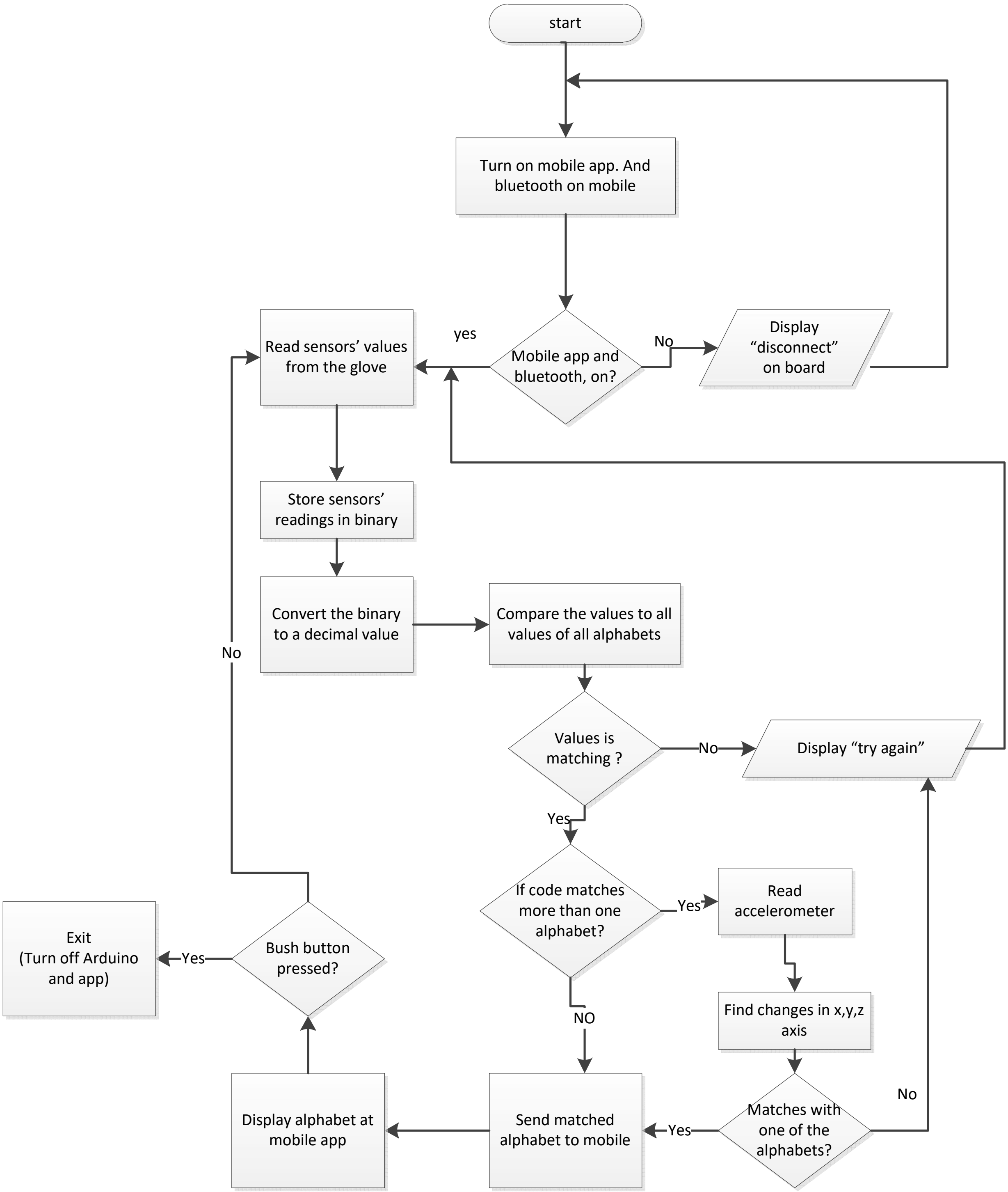

Figure 5: Flow Chart of the system.

V. CONCLUSION AND FUTURE WORK

We succeded to design a smart sensory glove for translating ArSL alphabets and build a mobile application that enables normal people to understand mute people. The glove also enabled the user to communicate with people who have no idea about ArSL. It captures the hand gestures representing a specific arabic alphabet by the flex and accelerometer sensors. Then, it logs the obtained sensory data to the Arduino Nano micrcontroller to process the data. A table for codes of the the sensor readings was introduced.

The analyzed sensory data compared to the values stored in table1. The resultant character is sent as a text to the mobile application by the bluetooth module. The system's success rate was about 88.21%.

SGTArSL can be enhanced by using more accurate sensors. The user of the glove is a critical factor in increasing the success rate. To get better results, the user should be practiced better. This is because that different users may perform different degree of orientations and different degree of finger bendings. This is of course, can affect the accurracy of the system and the success rate.

Ultimately, we aim to develop and enhance the system to support sending a word and/or full sentences instead of a single letter. We are working, now, on a developed version of the system that enables translating Arabic sign alphabets, numbers, words and sentences to both a text and voice messages by smart gloves put on both hands with and without using the mobile application.

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