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Talking Glove for Gesture Recognition with Flex Sensors

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Abstract

Deaf and dump people have difficulty communication with their surroundings, especially those who do not know sign language, which makes them relatively aloof from their communities. In addition, it is important for them to interact with others in order to live a normal life and gets jobs. This paper aims to design an embedded system using the Arduino board to get a readable text, and a voice that can be heard to help deaf and dumb people engage in society. The system consists of a talking glove consisting of five curvature sensors that sense the movement of the hand and fingers and an accelerometer, which was programmed by the Arduino Nano microcontroller, which translates the hand movements into text that appears on the LCD screen in English and also exits the corresponding sound in Arabic, as well as variable resistance to sound intensity control; This system has been applied to a number of people.

As recommended, artificial intelligence should be used to enhance system efficiency and a PCB board should be used to make the system more organized.

Keywords—Deaf and dumb, Sign Language, Arduino Nano, talking glove.

القفاز المتكلم للتعرف على الإيماءات باستخدام أجهزة استشعار مرنة

يوسف حماد، مبروكة فاضل

جامعة وادي الشاطئ

الملخص

يواجه الصم والبكم صعوبة في التواصل مع محيطهم، لا سيما أولئك الذين لا يعرفون لغة الإشارة، مما يجعلهم بعيدًا نسبيًا عن مجتمعاتهم. بالإضافة إلى ذلك، من المهم بالنسبة لهم التفاعل مع الآخرين من أجل عيش حياة طبيعية والحصول على وظائف. تهدف هذه الورقة إلى تصميم نظام مدمج باستخدام لوحة Arduino للحصول على نص مقروء، وصوت يمكن سماعه لمساعدة الصم والبكم على الانخراط في المجتمع. يتكون النظام من قفاز ناطق يتكون من خمسة مستشعرات انحناء تستشعر حركة اليد والأصابع ومقياس التسارع، التي تمت برمجتها بواسطة المتحكم

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الدقيقArduino Nano، الذي يترجم حركات اليد إلى نص يظهر على شاشةLCDباللغة الإنجليزية ويخرج أيضًا من الصوت المقابل باللغة العربية، بالإضافة إلى مقاومة متغيرة للتحكم في كثافة الصوت؛ تم تطبيق هذا النظام على عدد من الأشخاص.

كما نوصي ان يتم استخدم الذكاء الاصطناعي لتعزيز كفاءة النظام واستخدام لوحة PCB لجعل النظام أكثر تنسيقا.

الكلمات المفتاحية– الصم والبكم، لغة الإشارة، أردوينو نانو، قفاز ناطق.

Introduction

Attention to people with special needs has recently increased globally. In order to increase their numbers, by identifying their problems, trying to resolve them and reduce their severity, trying to help them communicate with community members naturally, people who don't have the ability to speak and hear need constant care, The ability to speak and hear is one of the important capabilities and senses that ALLAH Almighty has given to mankind. So hearing is one of the most important senses in human beings that helps them adapt to their surroundings[1].

In recent years, there has been a rapid increase in the number of people with hearing and speech disabilities as a result of being exposed to birth defects or sometimes as a result of a particular accident that has lost the ability to speak, so they show certain movements and expressions performed by hands, arms or facial expressions, known as sign language [2].

Millions of people in the world use sign language as their main language, which statistics strongly point to. 70 million people are severely deaf, and another 230 million are hearing impaired or can no longer speak due to conditions such as autism or stroke. Plus, 90% of deaf children are born to parents who hear and only 25% of these parents can communicate with the signal, so communication can be a big problem. According to the World Health Organization (WHO), 360 million people worldwide have hearing impairment and this number could rise to 900 million by 2025, in a study that found hearing impaired students find it difficult to adapt to their classmates and that they do not feel belonged and therefore get admitted to special education institutions while the lack of sign language interpreters in schools is one of the reasons for the frustration observed by students [3].

It is here that assistive technology, which rehabilitates and adapts by designing devices for persons with disabilities, promotes independence by empowering people with special.

abilities to perform tasks that they were previously unable to accomplish, by providing different ways of interacting with innovative technology needed to accomplish such tasks. Speaking gloves are an example of auxiliary technology that turns sign language into words. A glove can transform sign language into spoken language, providing deaf people with a new way to address language barriers [4].

The system's working principle is to convert sign language to a voice signal by an accelerometer and five flex sensors that fixed on the glove for each finger and generate different voltages depending on the degree of finger curvature based on the change of the resistance. These voltages then translated into digital signals received by the microcontroller, who selects one of the sounds stored inside the memory to be exported via a speaker, and the word matches with sound via the LCD screen

Some previous inventions

Hand gestures have the potential to revolutionize communication by providing a more intuitive and interactive way for people to interact with technology and each other [5]. Hand gestures are embedded in a variety of applications, including gaming control systems, human-robot interactions, and vision-based recognition systems [6]. Wearable sensors are typically used by researchers to record hand movements. After that, the data are processed using any method for hand gesture recognition [5]. There are primarily two methods in the literature: vision-based and sensor-based[7]The vision-based method uses machine learning and deep learning techniques to recognize gestures while processing digital images and videos. Reference presented a real-time hand gesture detection system based on convolutional neural networks (CNNs) DarkNet-53 and You Only Look Once (YOLO) v3 [8]. A labeled dataset of hand gesture photos in both Pascal VOC and YOLO format is used to assess the system, and a 97.68% accuracy rate was achieved. An automatic hybrid method was developed to interpret sign language to both text and speech [9]. The system recognizes, interprets, expresses, and converts the hand gesture images to voice in 10 different languages using CNN, natural language processing, language translation, and text-to-speech algorithms. Based on an existing American Sign Language (ASL) dataset, the system achieved 99.63% accuracy. To predict the emergency signs in Indian Sign Language (ISL), a hand gesture detection system was created [10]. The system detects hand gestures using a three-dimensional convolutional neural network (3D CNN), long short-term memory, and the YOLO v3 method in conjunction with a pre-trained CNN (VGG-16). The system achieved 99.6% mean average precision for hand gesture detection, based on an ISL dataset video [11]. Taking images or videos of the hand movements is necessary for the vision-based technique, and cameras are typically found on cellphones. The primary disadvantage of this technique, which is exacerbated by illumination and background noise, is the complex and time-consuming processing needed to identify hand gestures, even with the inexpensive cameras. The process of sensor-based gesture recognition includes measuring the bending angle, palm position, finger orientations, and alignments using sensors like flex sensors. These measurements are then used to identify the gestures. A research team created a system named "Quad Squad" that consists of two components: gloves

and a mobile application that runs on Windows mobile (Windows 7 and 8) [12]. A simple glove containing multiple sensors, a small screen, and a speaker fixed to the glove was created. Using a "text-to-speech chip," the glove sensors would convert the hand motions

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into text that would show on the screen and voice that would be delivered by the speaker [13]. Another glove called Sign Aloud was created to convert sign language to text and speech that could be shown on a computer [14], [15] A number of sensors on the glove would record the hand positions. The Arduino controller on the glove would wirelessly transmit the captured data to the Arduino controller connected to the computer screen via Bluetooth. A speaker would utter the term linked with the gesture if the data matched one of the motions stored in the computer [14], [15]. Raja Pandian et al. designed a glove with flex sensors attached that uses an Arduino circuit board to translate ASL to audio [16]. Additionally, the device would use analog-to-digital converters (ADC) to convert the audio to text so that it could be seen on the LCD screen [16]. Similarly, a glove with an LCD, an Arduino board, and flex sensors was created in reference [17]. The sensors would convey the sign language to the Arduino board, which would use a microprocessor to process the data entered and relay the results to the LCD for display [11]. The primary benefits of the sensor-based technique are its high accuracy and the fact that it does not require data processing because the information required for gesture identification is immediately derived from the sensors' readings. However, the sensors may be slightly more expensive than cameras. Since communication speed between deaf-mutes and non-deaf-mutes is an important factor, the accuracy and speed of processing advantages of the sensor-based approach compensate for the increase in cost. Hence, rather than opting for a vision-based gesture, the authors of this study used a sensor-based one.

The primary goals of all the aforementioned IT interventions were to facilitate communication and help the deaf and silent get heard. The vision-based method, which makes use of deep learning and machine learning algorithms, requires more time for detection and has a sophisticated processing structure, which could slow down communication between deaf-mute people and those who are not. Furthermore, when using dynamic images as input, the vision-based approach necessitates the difficult task of developing an appropriate model to distinguish hand gestures [9]. For sign language translation systems, the sensory technique is thought to be the most accurate method of gathering input data, despite its higher cost. When gathering hand gesture data, sensors are unaffected by the surrounding environment, which improves recognition accuracy. This work provides a sensor-based glove prototype so that deaf and mute can translate sign language and also create their own gestures and translate them into audible and readable words and thus increase the speed of communication with healthy people.

Figure (1) shows the block diagram of the talking glove methodology.

The system was applied in several stages, where initially all the hardware components were tested to ensure their safety and performance of the required function. Figure (2) shows electronic components used in system design.

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Hardware Components

1. Power unit

The electrical power supply is the cornerstone when designing any electronic system, as the electronic units that contain active elements in their design need continuous feeding with specific values that must be provided directly, without which no electronic circuit will work. The supply to the system is provided by a charging device that can be recharged.

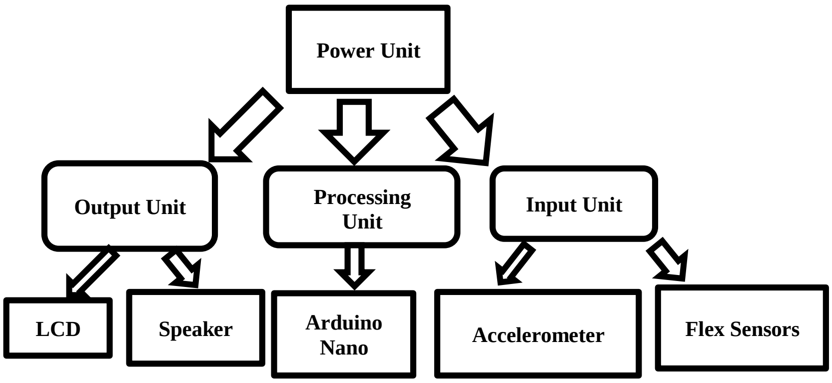

Fig. 1. Talking glove system architecture

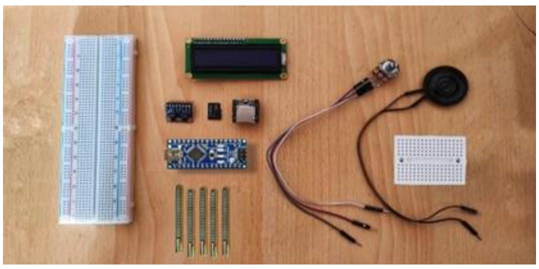

Fig. 2 electronic components in system design.

2. Input units

This unit includes the flex sensors and an accelerometer responsible for providing the analogue voltages that are processed in the processing unit, in order to obtain the digital signals corresponding to those voltages and thus output the required sounds and written text via the output units.

- ***Curvature (flex) sensors 2.2cm Spectra Symbol Company:***

It is the main sensor in this work, which was relied upon to determine the state of each finger of the hand (clenching or extending).

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The sensor is flexible (it extends over each finger) and has only two legs and is not polarized because it is resistive. Figure (3.1) shows the flex sensor, Figure (3.2) depicts the work principle of the flex sensor. Fig (3.1) flex sensor Fig (3.2) work principle of flex sensor

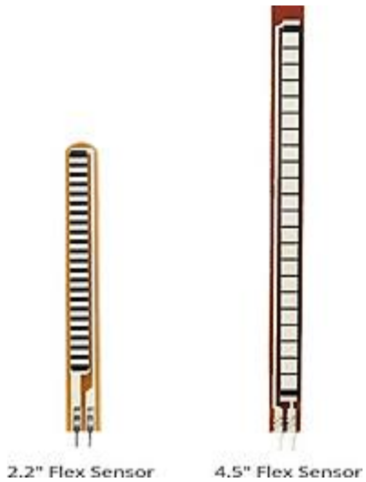

Fig. 3.1 flex sensor

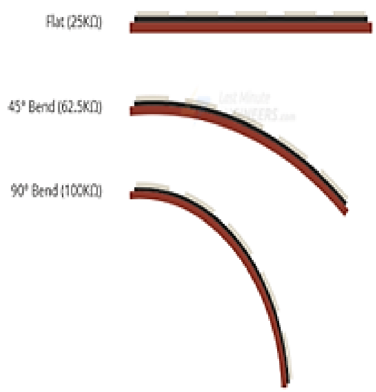

Fig. 3.2 the work principle of the flex sensor.

- ***Accelerometer "MPU6050":***

This sensor uses the tilt angle more accurately. SDA (Serial data), which is the line for data transfer. SCL (Serial clock): It is the line for clock pulses. Figure (4) shows the MPU6050 accelerometer.

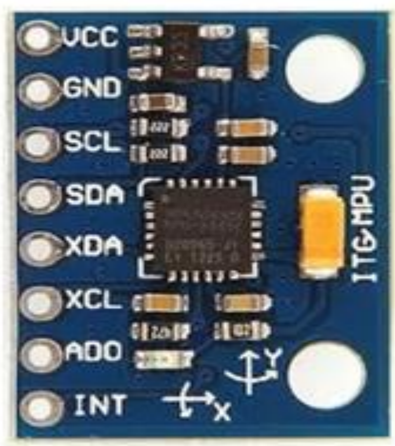

Fig. (4) MPU6050 accelerometer.

3. processing unit

In this work, the Arduino board was used to process the input data via the input modules and the output is displayed via the output modules.

- ***Arduino***

It is an electronic development board consisting of an open-source electronic circuit with a computer-programmed microcontroller, designed to facilitate the use of interactive electronics in multidisciplinary projects. The microcontroller on the board is programmed using the Arduino Programming language and the Arduino IDE. Arduino projects can be integrated, with the Arduino connected only to its sensors and electronic parts, or the Arduino can be connected to programs on the computer, such as MATLAB. Figure (5) represents the structure of the Arduino Nano.

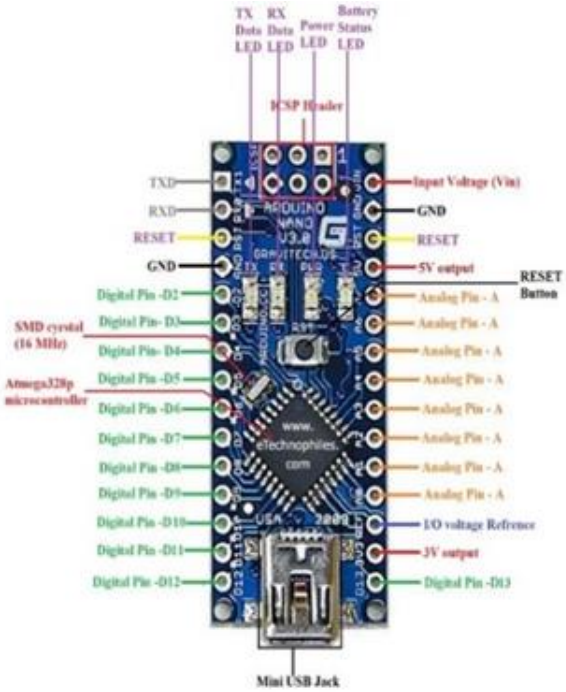

Figure (5) Arduino Nano structure.

4. Output units

- ***Audio Player "DFPlayer":***

The player outputs an audio clip stored on an external memory. Figure (6) shows the DFP structure.

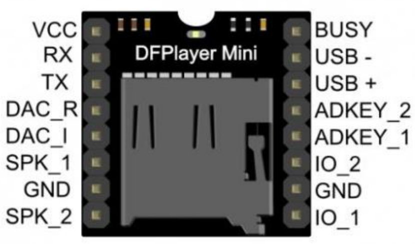

Fig. (6) DFP structure

- ***MicroSD memory unit***

It is a flash-based storage device that is available in a compact and lightweight form. Figure (7) shows the memory unit.

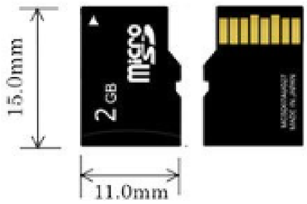

Fig (7). Memory unit

- ***speaker***

It is a device that converts electrical signals into mechanical waves (audible sounds). Figure (8) shows a speaker.

Fig. (8). Speaker

- ***Variable resistance (Rheostat)***

Variable resistance is one of the types of resistors that control the change in the flow of current by presenting a different set of values. Figure (9) shows the variable resistance.

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Figure (9) variable resistance

- ***LCD screen***

An LCD (Liquid Crystal Display) screen is an electronic display unit that is a very basic unit and is commonly used in various devices and circuits. Figure (10) present the LCD display screen.

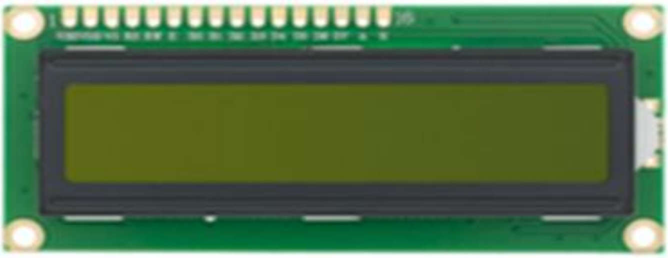

Fig (10) LCD display screen.

A. Software Components

Arduino IDE is an open-source software, designed by Arduino.cc and mainly used for writing, compiling & uploading code to almost all Arduino Modules. The IDE environment mainly contains two basic parts: Editor and Compiler where former is used for writing the required code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages [18].

SYSTEM IMPLEMENTATION

Step1:

Connecting the five curvature sensors and installing them on the glove, and installing the accelerometer so that it is directly above the glove in order to take the angle values with better accuracy, as in the figure (11) below.

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Figure (11) the installation of a flex sensor and accelerometer on the glove

Step2:

Connecting system components with each other, figure (12) shows the final shape of the system. Figure (12a) the final shape of the system.

Figure (12a) the final shape of the system.

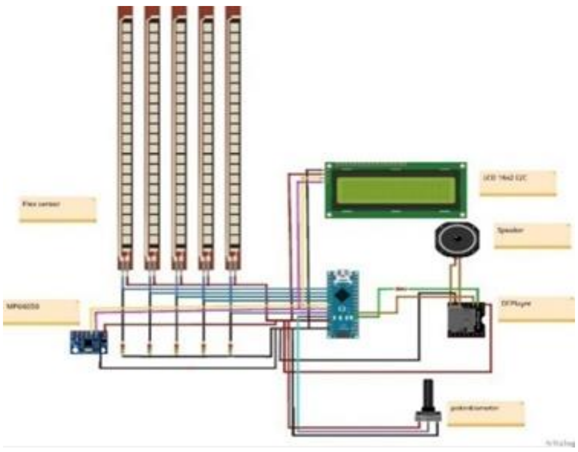

Figure (12b) Final connection of the system in Fritzing software.

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Step 3: Insert sentences and words

In this system, 22 sentences and 8 words were selected to be displayed in audio on the speaker and in text via the LCD screen. Sentences and words appear on the speaker in Arabic while the text appears in English, Table 1 shows the sentences and words that were included in the system.

Table (1) sentences & words included in the system.

Values of flex sensors per finger					Angle values for accelerometer				
Thumb	Index	middle	Fault	Pinky	X	Y	Z	movements	num
253	125	90	169	150	25	78	45	ALsalam Ealaykum	1
175	155	95	215	190	240	90	276	Mabrouka Fadil	2
230	160	98	230	206	240	140	280	To help Deaf and Dumb	4
300	205	90	185	170	310	309	225	where do I register for the flight?	5
235	184	97	230	205	330	18	254	When will the plane take off	6
251	188	98	167	155	274	145	284	How long to wait?	7
255	128	83	235	207	340	82	340	Can I book an appointment at the clinic?	8
266	170	103	168	340	330	75	290	May I know how much there is before me?	9
250	123	94	182	174	50	30	80	Is the doctor now in the clinic?	10
285	110	88	166	150	60	344	120	Yousuf hammad	11

Step4:

Calculating the angle values of the accelerometer in the three axes (x, y, z), and resistance values resulting from five flex sensors installed on each of the right fingers. 11 sentences have been selected to clarify how the movements were quoted, which applies to the rest of the sentences and words as shown in Table 2.

Table (2) values of accelerometer and flex sensors

English words	Arabic words
ALsalam Ealaykum	السلام عليكم
Introduce my self	أعرفك بنفسي
My name is	أسمي هو
This system is designed	تم تصميم هذا المشروع
To help	لمساعدة
Deaf and dumb	الصم والبكم
Mabrouka fadil	مبروكة فضل
Please	من فضلك
I Want to Help	أريد المساعدة
I have some questions	لدي بعض الأسئلة
Where do I register for the flight?	أين أسجل حضوري للرحلة
Where is the gate	أين هي البوابة

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How long to wait	كم مدة الانتظار
When will the plane take off	متى ستقلع الطائرة
Where do put my bags	أين أضع حقائبي
Thank you	شكرا لك
An Appointment withIn The Clinic	هل يمكن أن أحجز موعدا عند الطبيب
Is the doctor now in the clinic	هل الطبيب موجود الأن في العيادة
How many cases before me	هل لي أن أعرف كم توجد حالة قبلي
Welcome	مرحبا
Good job	عمل جيد
No	لا
Yes	نعم
I want	أريد
Happy	سعيد

Values as illustrated in Table 2, were the values through which words were shown as a sound and text. Where flex sensor resistance values are determined based on finger bending and then sentences are determined, each finger value is taken so that the value is confined between its lower values and greater values, and these values are displayed on the Arduino serial screen. Figure (13).

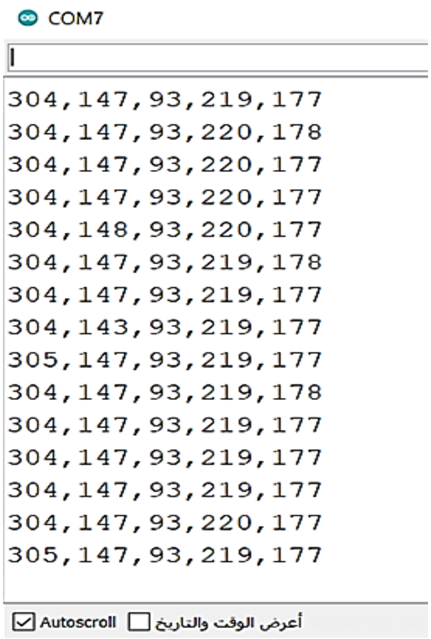

Figure 13. Arduino serial screen

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Figure (13) Flex sensor values per finger.

As illustrated in figure (13), the state of the hand is in the form of a "total stretch", here each value has been taken separately and confined between a lower value and a larger one; for example, at the far left of the figure, the value is equal to (304) and represents the state of the thumb finger and is placed under the following condition:

If ((flex1>220 && flex1<360) && (flex2>100 && flex2<200) && (flex3>40 && flex3<180) && (flex4>190 && flex4<250) && (flex5>140 && flex5<250))

As is clear, the value (304) is confined between (360, 220); where flex1 symbolizes the thumb finger, and so for the rest of the fingers, "flex2" represents the index finger, "flex3" represents the middle finger, "flex4" represents the ring finger, and flex5 represents the pinky finger. The angles of the accelerometer were then measured and displayed on the LCD screen to determine the value of the angle that is in line with the sign language movement, as shown in figure (14).

Figure (14) Accelerometer values on LCD screen

These values change based on the movement and direction of the hand. The values and direction of the hand are determined by the bending sensors. The value displayed on the screen is confined between fewer values and greater than the following:

(x>290 && x<350) && (y>15 && y<60) && (z>270 && z<350)
The value (x = 325) is confined between 290 and 250.

When the requirement is applied by bending sensors and an accelerometer, the word is shown in sound and text. If these conditions are met, sentences and words will appear on the basis of the gesture chosen.

RESULTS AND DISCUSSION

The talking glove system has been applied to four people, two of whom are deaf and dumb, and the others are healthy people with different ages and different hand sizes.

The sentences displayed using the glove as a sound and text are as follows:

1. The phrase "ALsalam Ealaykum" is displayed under the following condition:

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```
//السلام عليكم
if ( (flex1>200 && flex1<300) && (flex2>60 && flex2<170) && (flex3>30 && flex3<140) && (flex4>100 && flex4<210)

&& (flex5>90 && flex5<200)&& (x>18 && x<70) && ( y>50 && y<90)&& ( z>1 && z<60))
```

Figure (15) shows the display of the sentence "ALsalam Ealaykum" on the LCD screen as text, and sound on the speaker.

Figure (15) Display the phrase "ALsalam Ealaykum."

1. The display of the sentence "deaf and dumb" according to the condition:

```
//الصم و البكم
if ( (flex1>175 && flex1<280) && (flex2>110 && flex2<210) && (flex3>40 && flex3<150) && (flex4>180 && flex4<280)

&& (flex5>155 && flex5<255)&& (x>235 && x<255) && ( y>135 && y<160)&& ( z>280 && z<300))
```

Figure 16. The presentation of a "deaf and dumb" sentence on the LCD screen shows a text, and a sound on the speaker according to the sign language gesture.

Figure (16) displays "Deaf and Dumb" sentence

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1. Display the phrase, "When will the plane take off?" According to the requirement:

```
//متى ستقلع الطائرة
{
 if ( (flex1>180 && flex1<280) && (flex2>120 && flex2<230) && (flex3>40 && flex3<140) && (flex4>180 && flex4<280)

&& (flex5>150 && flex5<250)&& (x>290 && x<350) && ( y>10 && y<30)&& ( z>275 && z<300))
```

Figure (17) shows the presentation of the phrase "When will the plane take off?" as a voice and text.

Figure (17) displays "When will the plane take off?"

Thus, all the sentences and words saved on the memory card were displayed as text on the LCD screen and as audio on the speaker. We note from the results obtained that this sensory technique based on sign language translation is more accurate and fast compared to computer vision-based techniques in terms of collecting input data, despite its high cost. We found that when gathering hand gesture data, sensors are not affected by the surrounding environment, which improved the accuracy of gesture recognition and translation.

CONCLUSION

Deaf and dumb people are known to use communication via sign language gestures to communicate with others, and often many do not understand the movements of this language, and thus this work has been done to break the communication gap between deaf society and the standard world. The methodology implemented translates sign language into speech (voice and text). The system improves persons with disabilities' time difficulties and their efficiency, and is relatively effective and easy to conceive. One of the most important features of this research is that gesture recognition may be an independent system, i.e., deaf and dumb can create their own gesture and translate it using this system. This technology transforms language into sound that can be easily heard by the blind and the public, and also translates language into text displayed on the digital display screen to allow deaf people to read it. In world applications, this design is very useful for those dumb and deaf among us who cannot communicate with ordinary people.

Under this glove, communication between the deaf and dumb person and the normal person becomes real. This system eliminates the need for an interpreter and avoids miscommunication. Thus, the final system will not be too expensive, making it accessible to everyone. It is an added advantage for patients with speech impairment and paralysis, meaning those who cannot speak properly. Thus, the price of the glove is inexpensive, and the items used are available, making it suitable for different groups of society. The glove is also comfortable in use and far from technical complexity, as well as its light weight, as it does not place any burden on the deaf person during use. Our main goal is to find a model that can soslve or reduce the problem of communication for people with disabilities.

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