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Arabian Deaf and Dumb Communication system using wireless Flexible Sensor

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Abstract. : The deaf and dumb is the most pathological case which leads to various economic and social problems. So, it is important to develop an economical tool to facilitate an efficient communication between Arabian deaf-dumb, and normal persons. As those people depend on using hand gestures to contact with others .On other hand, Arabs use expressions not alphabet in their communication .In this work, a mobile smart system based on two stages is designed. First ,creating a digital code for the hand gestures using gloves flex sensors equipped with a three-axis accelerometer and a microcontroller. The digital results are compared to the corresponding wards stored in database .Then , translation of the matching ward into both written text and voice. Second, the newly developed system allows Arabian deaf to translate words of ordinary people into gestures using a speech recognition system .The accuracy was over90 % without the need for a webcam, coloured gloves, or online translator. This protocol can be used with for android systems in addition to ordinary computer systems.

Keywords: Sign language, flexible resistance, Arab deaf, gloves sensors, and accelerometer.

1. INTRODUCTION

According to statistics, there is more than 360milliondeaf round the world[1], and it is expected to extend in the future due to the uncontrolled growth within the chronic diseases .There are more than ten percentage of Arabian population are deaf impaired where there are 23.5 %in Saudi Arabia and 16 %in Egypt .Efforts are done to solve this essential issue to facilitate communication between impaired and ordinary people[2-7]. It is noticed that most of deaf and dumb around the world are using the American Sign Language[8]. So, they must be aware of English alphabets and the corresponding signs for each letter to spell English words [9-13].

Various studies used a digital camera that placed in front of the impaired person who wear collared rings in fingers .The sign of each alphabet are detected and translated into speech[14]. A drawback of those systems that it needs ones to face the camera all time, however impaired person cannot manipulate the stored data by himself[15]. Other systems use laptop camera and capture image for the gesture of one hand at one feet distance from the camera and blank background with no object rather than the used hand. The accuracy was sensible with totally different intensity level[16].While others used video frames, detect hand gesture and use classification system[17]. Research in the field is used to overcome communication issues using smart gloves that depend on flexible resistance and detect the tilt of hand [18-20]. The sign of each alphabet in ward is collected to form and show it as a text or a voice. Wireless system for signals is is finished with the assistance of RF transceiver[21, 22]. This makes the system more comfortable than others. The sign of each letter is shipped via thirty meters wireless module to laptop where information of the signed letter stored, compared, and then letters or word are displayed[9, 23]. To avoid using cables,

image process is introduced based on image technique, hand segmentation, point, and colour matching and conversion to text [24, 25].

Other study tracks hand motion, detects the path and it scentre [1, 26-29]. Then, by comparing with the database, the sign is recognized. There are systems that used Neural Network (NN) for gesture recognition. It based on using images of hand sign for training and classification process [30-32]. NN could be combined with Fuzzy systems to get high accuracy in sign recognition and classification [33]. However, there are systems get frames from videos , extract features, hand contour then the corresponding alphabet or the mean is represented[34-36].

The data gloves with sensing element is a lot of benefits than image-based one and became a promising tool for communication [18, 37, 38]. The hand gestures will play a major role in several fields as artificial intelligence, Robotics and Automatic management[23, 39].Capacitive sensor and flexible resistance are mostly used in these applications .However, the limitation of information effects on system performance and speed. For Arab individuals, their letters are units totally different from English people alphabet as words with an equivalent letters have different meanings, pronunciations, and signatures. There is an important ought to develop a brand new system for Arabs deaf individuals.

Inspired by this, herein, a new smart mobile system for effective communication between Arabian impaired and healthy ones was designed. This was successfully achieved using flexible sensors and a three-axis accelerometer .Then, using a microcontroller to generate digital outputs for the hand gestures followed by conversion into written texts and may associated with voices .The accuracy was high and more than ninety percentage. Our new developed system is mobile application, low-cost, fast, and easy to handle without any need for special preparations. Moreover, the system promptly is able to convert the outputs into ward and text instead of separated letters. Finally, it simply permits translation of spoken communication of traditional normal person to sign language.

2. Material and Methods

The developed system has two stages. First, manipulates gesture of deaf individual and translates into corresponding words and voice. Flexible resistance sensors, accelerometer and mega2560 -the microcontroller based on the ATmega2560- were used to receive information and transmit them to the portable computer .Second stage; translate wards told by ordinary person into sign using speech library in c#..To design the smart gloves ,we have fixed flexible resistance and accelerometer on gloves as well as a wireless recognition system .Ten persons with age ranged from twenty to twenty two participated within the experiments at HTI. All experiments were carried out in accordance with relevant rules and guidelines.

2.1 Gloves Design

In this stage, gloves with its design are used to capture hand gesture and convert it into speech and text. Flexible sensors and accelerometer on wrist are used for motion capture. Bending degree of Finger gestures are calculated into voltage terms using voltage divider rule. The microcontroller is used for conversion of flex sensors output into digital data. Then digitized data for each hand is collected and matched to the corresponding one in stored data. Block diagram of the developed system is shown on Fig.1.

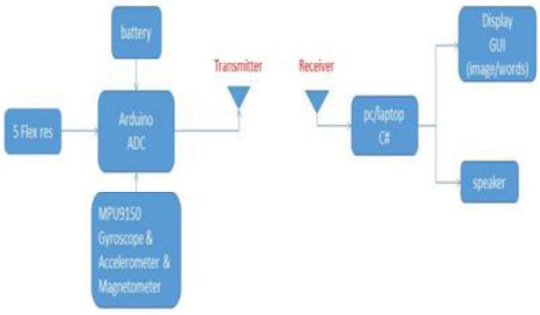

Fig.1: Block diagram of the developed system.

2.2 System components

2.2.1 Flexible Resistance

A flexible resistance was used to capture the person's fingers motion, as shown in Fig.2. It is a normal resistance with the ability to change with bending. It is approximately 22.5 k ohm without bending and approximately 75.6 k ohm with maximum bending. The output voltage is calculated for different Resistances, and a voltage divider with R2=20 k ohm is used. Flexible

Resistances were used for the five fingers in a glove and then connected them to Arduino mega analog pins.

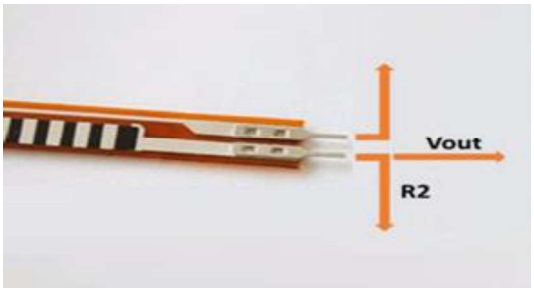

Fig.2: Flexible resistance

2.2.2 Accelerometer

The accelerometer detects the moving directions of the hand. As different orientation gives totally different mean for same sign, it is vital to detect hand tilting. Analog output is converted into digital using ArduinoInertial measurement unit (IMU) shown in Fig.3,which was used to determine orientation degree .New directions of yaw are developed to make sure that all the angles lie in the range of 0-360 for accurate detection. So, the angles range converted from -180-0 to 0-180 and from 0-180 to 180-360 (Fig.4). For accurate detection of direction and motion, the system detect motion direction as back, front, right, or left. First, the flexible resistors will capture the motions, and by using a voltage divider, the change in resistance is converted into a change in voltage .The unit shown in Fig.3 is used to determine hand's degrees of freedom. It is used to compute the following direction: YAW: angles on p surface to vary from the front, right, back and left, Pitch: angles on p surface to vary from up or down, Roll: angles on p surface to vary from twist right or twist left and Mov: to know if the body in a static or dynamic state. Angle and motion of a person's hand captured, and then the wireless connection is used for sending the data to be analysed and then gives the output in the shape of image or words

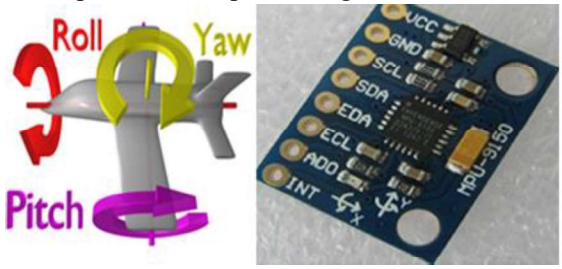

Fig. 3: IMU (Inertial measurement unit)/COMPAS).

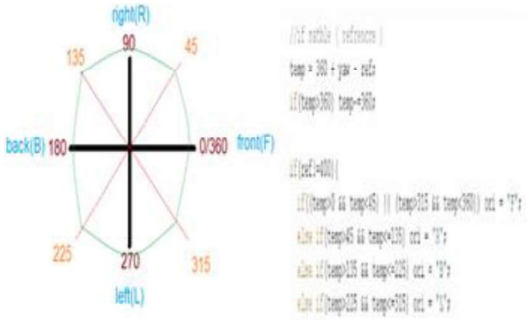

Fig. 4: Range division angle 0-360

Fig. 4: Range division angle 0-360

2.2.3 Wireless Connection

A wireless connection was used to make the person comfortable and provides an easy movement from one place to another without any impediments due to the absence of wires. Fig.5 shows the used prototype, while Fig.6 shows the wireless connection.

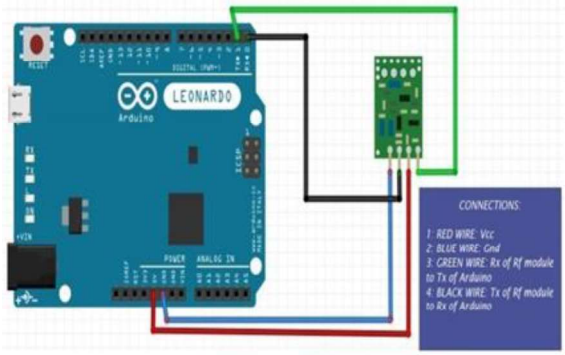

Fig. 5: A prototype 200m wireless connection used in this work

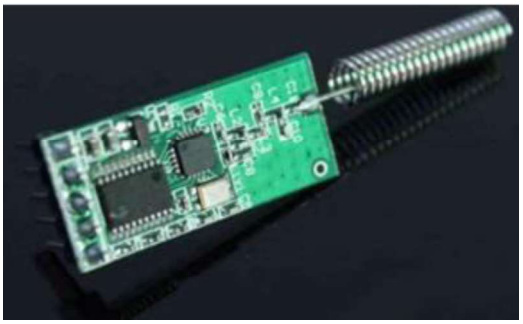

Fig. 6: 200 m wireless connection

2.2.4 Arduino mega and processing

An SQL server database was used to store signs data and process them. Arduino mega was used to receive data from flex resistors and transmit them to the laptop .The Mega 2560 that based on the ATmega2560, as known has 54 digital input/output pins, 16 analog inputs, 4 UARTs serial ports, a 16 MHz crystal oscillator, USB connection,

power jack, ICSP for programming Arduino board, and a reset button. It is simply powered by adaptor and connected to a computer with a USB cable. The board is compatible with most shields designed. [40]

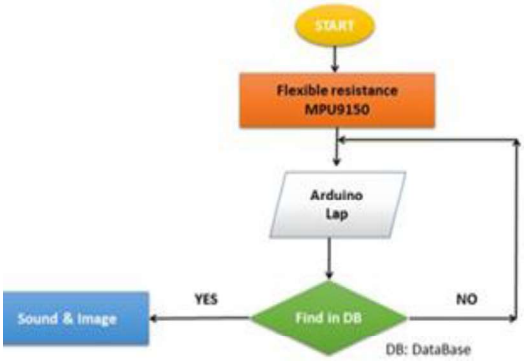

Fig. 7: Chart of First stage system.

2.3 System Description

2.3.1 First Stage

At first stage, the flex resistors capture motions then, a voltage divider used to convert the change in resistance into voltage. After that, the Arduino ADC is provided with the angle and motion of a person's hand captured by mpu9150; then the wireless send the data from both gloves via the laptop to be analysed .Finally, the output is introduced in the form of image and word .The system could be simplified in the flow chart shown in Fig.7. Flexible resistance and mpu9150 circuit shown in Fig.8. The circuit shows that the flex resistance from f1 to f5. The analog inputs takes the values of f1, f2, f3, f4, f5 to j1 while j2is the power source and reset. The wireless TX, RX connected to the j5. For interrupt connected to j9 and the Arduino TX, RX connected to j6.

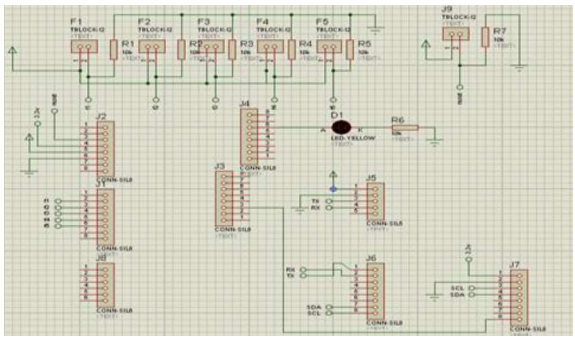

Fig. 8: Flexible resistance and mpu 9150 circuit connection

2.3.2 Second stage: Transferring voice into text

As normal people speak, the voice is processed and translated into text, and the corresponding sign is retrieved from database. So, deaf people can read .This stage was done using the system speech library to c#. A speech recognition is performed through creating speech recognition grammar, loading and then handle the speech voice for recognition stage .The equivalent mean in the form of sign picture is appeared.

3. Results and Conclusion

The designed system aims to aid Arab deaf and dump people to easy communicate with other those who cannot express and write what they need. The system does not need for camera or wires. It just uses flexible resistance fixed on gloves and embedded accelerometer for detection of direction as shown in Fig.9. The signal is transmitted and received by system loaded on mobile or computer. The system was designed to pick up Arabic sign language and translate it into equivalent ward that displayed as written ward and sound .The ward is written in both Arabic and English. So, they could communicate with foreign person also. The gestures were picked from both hands as many wards used the two hands and depend on relation between them and state of all ten fingers.

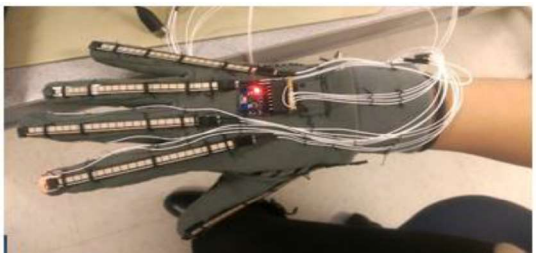

Fig. 9: System prototype shows the flexible resistance and glove design.

In order to allow normal person to communicate deaf people without the need to use sign language, second stage was used .Normal person talk and the voice is recognized by speech recognition system .The equivalent picture for the ward is appeared as the example shown in Fig.10.The word is displayed in both Arabic and English. A database contained all the words recognized by the program in Arabic and English words is used. We can summary the process as shown in Fig.11. The gesture from glove design and voice of normal person are assigned to the probable inputs. While, the equivalent sound for deaf sign,

ward displayed in letter on PC or mobile and corresponding sign for input voice are outputs.

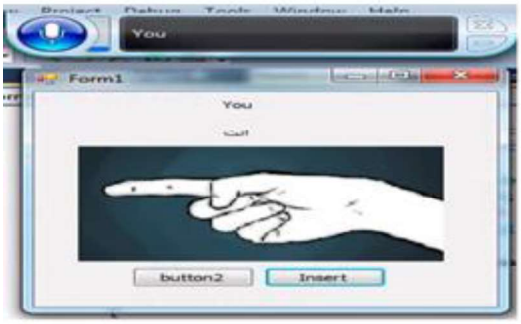

Fig. 10: An Image for the picture that appeared after applying voice recognition

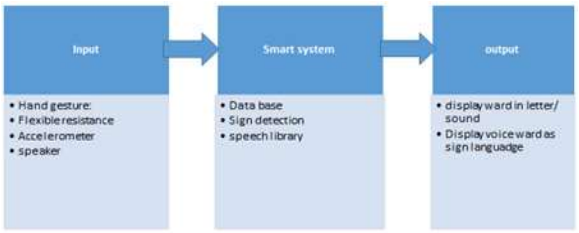

Fig. 11: Summary of inputs and outputs of the proposed system

The system also allows the user to add new words as a binary sign code. A notepad is shown in Fig.12 displays the code for some words. As one means that this finger is flatted and used while zero means that it does not use this one. B for back, F for forward, R for right and L for left. Fig.13 shows the insert window to add new words as function of shape of fingers, yaw, pitch, roll, move with text, image box address

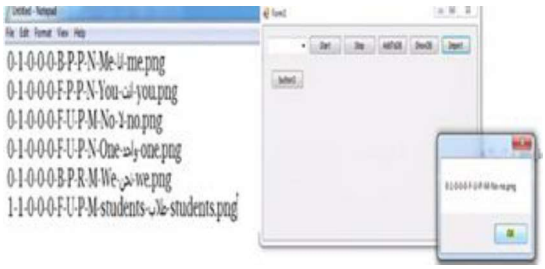

Fig. 12: Inserted notepad file and interface of the program.

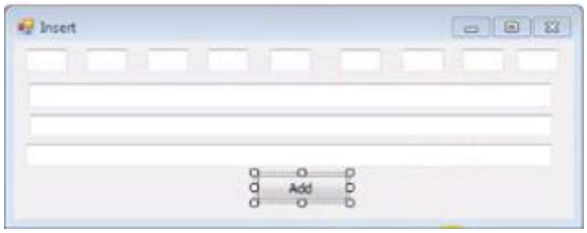

Fig. 13: User Insert window to add new words as function of shape of fingers, yaw, pitch, roll, move with text , image box address

Fig.14, shows an example of wards in addition to its stored code .Ten persons with different hand size and different pitches performed sign language. They started the experiment for words then sentences .The detection accuracy was 71 to 82 %, while it was 82 to 92 % for persons with big hand size. It is recognized that as gloves were good fitted and suitable to hand size, the error decreased. Accuracy for transferring the signs into voice and text was 89% on average .So, as the speech recognition and translation into the sign was high accuracy.

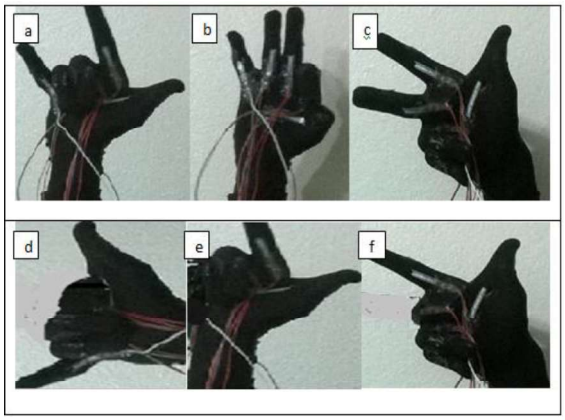

Fig. 14:example of wards and its stored data:a) ward of يطير or fly with code 1-1-0-0-1-p- u-p- M b) ward of Excellent or ممتاز with code of 0-0-1-1-1- p- u-p- N c) ward of Wednesday: in case of one hand with code 1-1-1-0-0- B- p-R- N and Uniform or زى for use of two hands with same pattern , move down and code 1-1-1-0-0-B-D-R/L-M d) telephone- هاتفwith code 1-0-0-0-1-p-p-p-N e)smile- ابتسم with code1-1-0-0-0-F-p-p-N [N/ M means static or move of hand, u for up and D for down].

The accuracy was relatively high; the accuracy was92% forepersons who used good fitted gloves .Others with the good preparation had accuracy ranged from 75% to87%. The system showed high performance and fast response with result below one second after each gesture. By increasing training and dataset, the results could be better .Hybrid of methods may enhance the performance .The system has advantage over other systems that depend on alphabet sign converter .This system depends onward sign translation. It is easy for the user seven the deaf and dumb to build their dataset with different signs .The user is able to detect his sign, specify position of each finger and store it in database through data entry .The system is prepared for mobile application .It could be used to improve life quality and communication method for this category of people.

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