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A New Data Glove Approach for Malaysian Sign Language Detection

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Abstract

A normal human being sees, listens, and reacts to his/her surroundings. There are some individuals who do not have this important blessing. Such individuals, mainly deaf and dumb, depend on communication via sign language to interact with others. However, communication with ordinary individuals is a major concern for them since not everyone can comprehend their sign language. Furthermore, this will cause a problem for the deaf and dumb communities to interact with others, particularly when they attempt to involve with educational, social and work environments. In this research, the objectives are to develop a sign language translation system in order to assist the hearing or speech impaired people to communicate with normal people, and also to test the accuracy of the system in interpreting the sign language. As a first step, the best method in gesture recognition was chosen after reviewing previous researches. The configuration of the data glove includes 10 tilt sensors to capture the finger flexion, an accelerometer for recognizing the motion of the hand, a microcontroller and Bluetooth module to send the interpreted information to a mobile phone. Firstly the performance of the tilt sensor was tested. Then after assembling all connections, the accuracy of the data glove in translating some selected alphabets, numbers and words from Malaysian Sign Language is performed. The result for the first experiment shows that tilt sensor need to be tilted more than 85 degree to successfully change the digital state. For the accuracy of 4 individuals who tested this device, total average accuracy for translating alphabets is 95%, numbers is 93.33% and gestures is 78.33%. The average accuracy of data glove for translating all type of gestures is 89%. This fusion of tilt sensors and accelerometer could be improved in the future by adding more training and test data as well as underlying frameworks such as Hidden Markov Model.

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Keywords: Malaysian sign language; data glove; gesture recognition; Bluetooth communication;

1. Introduction

Each individual utilize language to communicate with others. Sign language is basically used by hearing-impaired people to communicate with each other, developed by deaf communities. Communication through signing is a very organized nonverbal language using both non-manual and manual correspondence. Non-manual signals are essentially outward appearance, head movement, stance and orientation of the body. While manual signals includes movement and orientation of hand that passes on typical significance [1]. On the other hand, communication with typical individuals is a major challenge for them since not every ordinary people can comprehend their gesture-based communication.To overcome this issue, sign language recognition system is expected to assist the deaf and mute people to communicate with normal people. In Malaysia, Malaysian Sign Language (MSL)

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is the communication via gestures that is generally utilized by the deaf community. Hence, the design of the sign language recognition system will be based on the MSL, in order to accommodate local people. In this project, the technology for hand gesture recognition is the data-glove approach which use special glove-based device to extract hand posture and motion. The glove will utilize microcontroller as the processor, and tilt sensors and accelerometer as the sensors to identify hand pose that represent alphabet, number and several words from Malaysian Sign Language. The translation of the gesture will be displayed on mobile phone.

Statistic shows that around 9 billion people in this world are deaf and dumb [2]. In Malaysia, there are about 2.8 million people who have disabilities [3]. Interactions between deaf-dumb people and normal people have always been a troublesome task. This is because not every ordinary people can comprehend sign language. This increases their life difficulty as communication is one of the necessities. This will affect their integration into society. To overcome this issue, a sign language recognition system must be developed with a specific end goal to bridge the gap between the disabled and normal individuals.

The main goal of this project is to develop sign language translation system that can translate sign language into text. Since not every typical people are educated with sign language communication, this system will help them to comprehend the language of deaf and dumb people to ease their daily tasks. Section II presents some gesture recognition methods developed by other researches, Section III selects the suitable method in this research, Section IV explains the overall construction of the prototype and Section V elaborates on the experiments and results.

2. Gesture Recognition Methods

Nowadays, automatic sign language translation systems generally use two different sensor-based approaches, which are data-glove and visual-based approaches [1]. However, a new hand gesture recognition method has been introduced, called virtual button [4]. This section will clarify the detail about some common methods of gesture recognizing and the comparison between these methods.

2.1. Data Glove Approach

The data-glove approach utilizes a unique assembled electronic glove, which has fabricated sensors that distinguish the hand stance. Most commercial sign language translation systems use the data-glove method, as it simple to acquire data on the bending of finger and 3D orientation of the hand using gloves [1]. The framework requires less computational force and continuous interpretation is much simpler to achieve. The data glove is outlined with ten flex sensors, two on every finger [5]. The flex sensors function as variable resistance sensor that change resistance as indicated by the sensor's flexing [6]. These sensors can recognize the bending point of every joint of the fingers and send the information to the microcontroller. It is mounted in the outer layer of the data glove, from the association joints of fingers and palm to fingertips. Furthermore, to expand the exactness in recognizing the hand pose, a 3-axis accelerometer is utilized to identify the change of acceleration of hand's movement in distinctive bearings [7]. The accelerometer is attached on the back of the data glove. The data glove is highly suitable in perceiving both fingerspelling and sign motions, which include static and movement signs. However, these data glove can be costly. While it is conceivable to create less expensive data glove, they are much more vulnerable to noise. If the number of the sensors used is reduced, it will bring about loss of important data about the hand stance. This will result in the loss of accuracy in sign language interpretation [1]. The data glove could also be less comfortable to be worn by the signer.

2.2. Visual-based Approach

With the current advancement in computer technology and software, there has been an increase in the use of visual-based methodology. Images of the signer are captured by a camera and video processing is done to perform detection of the sign language. Different from the data glove approach, the fundamental advantage of visual-based methodology is the adaptability of the framework. The recognition of facial expression and head movements additionally can be incorporated to the framework and also perform lip-perusing. This system can be separated into two strategies, which are utilization hand crafted shading gloves and in light of skin-color recognition. For the specially crafted glove, the signer is furnished with color-coded gloves. The color will give the information from the images of the signer through color segmentation. These gloves are basically a normal pair of gloves with particular shading on every fingertip and palm. In some ways or another, these gloves are less expensive compared to electronic data gloves. This system uses inexpensive equipment such as a webcam and basic (color-shaded) glove. Webcam is used to acquire images from the signer in type of still images and video streams in RGB (red-green-blue) shading.

For the recognition based on skin-color, the framework requires just a camera to capture the moving pictures of the signer with no additional gadgets needed. It turns out to be more common and helpful for constant applications. This system utilizes an uncovered hand to concentrate information required for recognition, and it is simple, where the user directly communicates with the system [2]. In order to track the position of hand, the skin color region will be fragmented using color threshold technique, and then the region of interest can be determined. The image acquisition runs constantly until the signer demonstrates a stop sign [8]. After the threshold, the segmented images are then analyzed to obtain the unique features of each sign.

These visual-based approaches are fundamentally minimizing the equipment necessities and cost. However, these systems are just suitable and viable for deciphering alphabets and numbers, as opposed to perceiving sign gestures. Signs with comparable stance to another sign can be confused reducing the precision of the system [8]. Moreover, the image acquisition process is subject to numerous ecological concerns, for example, position of the camera, background condition and lighting effects. The different height of the signer must also be considered. Adequate lighting is additionally required to have enough brightness to be seen and analyzed [1].

2.3. Virtual-based Button Approach

Function of a virtual button is to generate button events, a press and discharge, by perceiving hand motions of holding and discharging individually. This virtual button also can identify different sorts of gesture and generate proper command. The virtual button method use patterns of the wrist shape. It can perceive a squeeze movement. By using small sized IR optic sensors, the patterns of finger flexor tendons on wrist can be recognized by moving fingers. These patterns are used to perceive finger or hand movement. The IR emitter and IR optic sensor are attached on the bottom of the wrist because the area comprises of finger flexor tendons that delicately respond to finger movements. These sensors produce voltage values according to the amount of IR radiation. In the system, this sensor is used to monitor different patterns of the wrist shape resulting from the movement of finger flexor tendons in the wrist when fingers are moving [4].

However, this method is not effective for interpreting sign language because it requires more intricate stance of fingers. Also, sign language gestures utilize more than a finger movement and wrist shape. Thus, this method is not practical for perceiving communication via gestures motions.

Table 1: Comparison of different approached for sign language detection

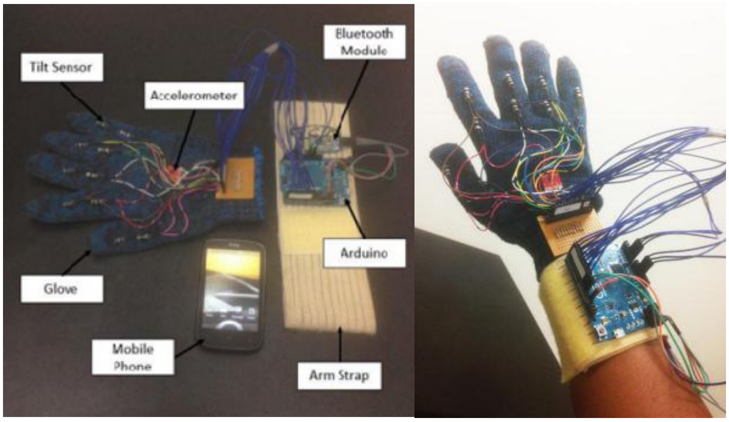
Method	**Device/ components**	**Gestures**	**Environment**	**Accuracy**
Data-glove approach [2,4,5,7]	Flex sensor, Accelerometer, Microcontroller.	Fingerspelling (alphabets and numbers), sign gestures.	Practical, no environmental concern.	Higher accuracy if use more sensors.
Visual-based approach [1,3,7]	Custom-made glove, computer's webcam.	Effective for fingerspelling only (alphabets and numbers)	position of the camera, background condition and lighting sensitivity	can be misinterpreted
Virtual button [6]	IR optic sensor	Finger and hand movement, not suitable for gestures	no environmental concern.	Overall correctness 88.82% [6]

2.4. Selection of Approach

Based on the study summarized in Table 1, the data-glove approach is chosen because it is the most suitable strategy for perceiving gesture of sign language. This is because the system can recognize both fingerspelling and sign gestures, which makes it suitable for deciphering Malaysian Sign Language. Malaysian Sign Language uses similar alphabet database than the English sign language, but the gestures are different due to the language difference, hence spelling might take longer time to recognize than showing a gesture. The data glove approach is more practical and not affected by any environmental factors such as lighting. Furthermore, this method is deemed to have higher accuracy over visual-based approaches.

3. System Construction

The system consists of the components shown in Figure 1. This is the first application of the tilt sensor in sign language detection, to the best of the authors' knowledge. The microcontroller used is Arduino, which interprets the information received from the sensors (tilt and accelerometer) to be sent to the Bluetooth module, and then the module sends the interpreted sign/gesture to the Bluetooth-enabled mobile phone.

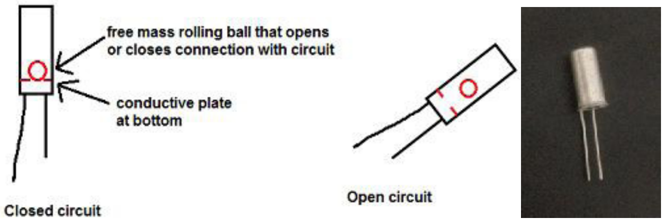


(a) (b)

Fig. 1(a) Overall System Components and (b) the device worn on user's hand

3.1. Tilt sensor

A flex sensor is used to detect the flexion of finger. Flex sensor which is also known as bend sensor is a sensor that changes its resistance according to amount of bend on the sensor. It is a passive resistance device fabricated by laying strips of carbon resistive elements within a thin flexible substrate. The flex sensor can be read as a potentiometer with a resistance output or across a voltage divider to get voltage output that is proportional to the bend applied [9]. However, constructing the data glove with flex sensors can be quite costly because the price for flex sensor is quite expensive. Also, the reading of flex sensor is not very stable and sensitive to noise. However, another type of sensor that can replace the flex sensor for detecting finger flexion, is the tilt sensor. A tilt sensor or inclinometer detects the angle between a sensing axis and a reference vector such as gravity or the Earth's magnetic field. It has been used in various industrial areas related to aerospace, automobiles, and entertainment. In health sciences, tilt sensors have been mainly used in occupational medicine research [10]. Since a tilt sensor measures the tilt of its axis with respect to a fixed reference, the joint angle of limbs or other body parts can be measured with pairs of sensors placed on either side of a joint [11]. Furthermore, tilt sensor is cheaper than flex sensor. Tilt sensors are applied in many fields, such as communication, consumer electronic products, toy, electronic equipment, and also in automobiles, tanks, ships, robots and stabilization system of radar and missiles [12]. For the data glove, tilt sensor can be used to detect the bending of a finger. Figure 2 illustrates on how the tilt sensor works and the actual picture of a tilt sensor.



(a) (b)

Fig. 2 (a) The operation of a tilt sensor, (b) actual picture of a tilt sensor

3.2. Accelerometer

Since the sign language gestures also involve the movement of wrist and hand, those gestures also need to take into account. Therefore, an accelerometer is used to capture the gestures. In this research, a 3-axis accelerometer is used to complete the gesture recognition. This accelerometer provides the variations in acceleration along each axis, called roll, pitch and yaw [13]. Each sign gesture entails a change in acceleration along each axis. Gestures are then detected by measuring the accelerometer reading, based on a threshold value. Researchers in [14] applied the accelerometer for a Traffic Light control system which is said to be user friendly

3.3. Sign Language Detection Algorithm

The algorithm used to ensure continuous detection of the sign language is simpleSigner wears the data glove and turns ON the power supply. Then the connection between glove and mobile phone is set up. When signer performs sign language, tilt sensor (open or closed circuit connection, which is read as digital inputs) and accelerometer inputs are compared with the memory stored in the microcontroller(for the few set data) which then users can immediately see the translated text output of the sign language on their mobile phone. The flowchart is shown in Figure 3. The algorithm is a fusion between tilt sensors and accelerometer. The accelerometer is required to detect gesture motion by setting a threshold in the axis of motion (x, y or z) since it is placed in the palm of the glove.

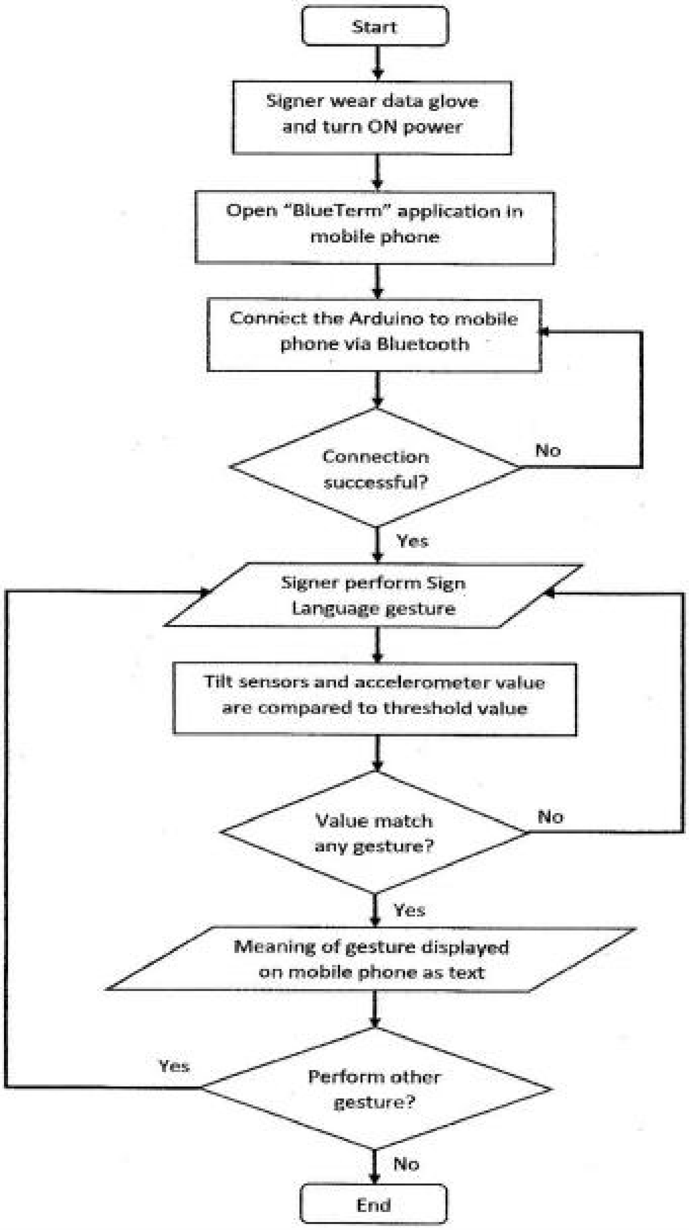


Fig. 3 The general algorithm used for the data-glove continuous sign language detection system

4. Experiments and Results

4.1. Tilt sensor test

The initial experiment done was to test the ability of the tilt sensor in detection a flexor motion, which is later interpreted as a bending posture. To do this, the tilt sensor is arranged in vertical position (with 0 degrees assumed as the vertical axis). Then, the tilt sensor is bent every five degrees, and the output is shown by a Light Emitting Diode (LED) which lights up when the free mass rolling ball inside the tilt sensor is in open circuit from the conductive plate. In closed connection, the current will flow to the LED. When open (tilt sensor bent), current will not flow to the LED, turning it off. Figure 4(a) shows the tilt sensor at upright (vertical) position and Figure 4(b) shows the tilt sensor bent at 50 degrees.

(a) (b) (c)

Fig.4(a) at vertical position (0 degrees), (b) at 55 degrees and (c) at 85 degrees

As seen in Figure 4(c), the LED is turned off when the bending angle is around 85 degrees. This shows that the sensor effectively detects the bend and can be used in detecting the bend of a finger (if bent around 90 degrees). One finger will use two tilt sensors, totaling up to 10 tilt sensors for a hand.

4.2. Overall system test

After successful test of the tilt sensor, 10 tilt sensors were fitted on the data glove, 2 for every finger. In addition, an accelerometer is also attached to the glove to detect gestures. From the standard database of Malaysian Sign Language, the alphabets set for the test were A, B, and C. The numbers to be detected were 1, 2, and 3. For the gestures, three set of gestures tested were ‘Saya’, ‘Makan’ and ‘Apa’. This is illustrated in Figure 5.

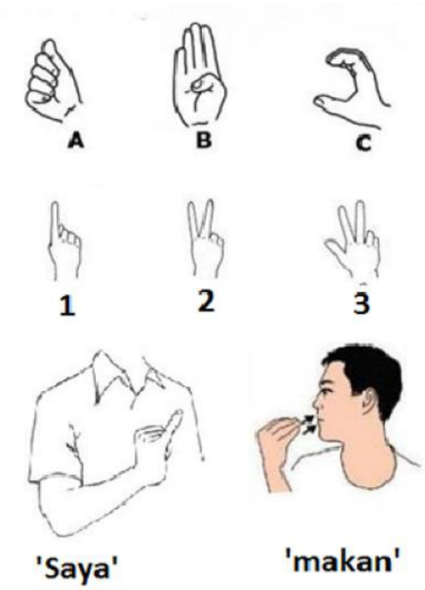


Fig. 5 The gestures used for the system test

Four candidates were tested (as shown in Figure 6, each wearing the data glove and perform the sign language and gestures for a number of 10 attempts for each alphabet/number/word.Figure 7 shows a continuous sign language test displayed on a smartphone.

Fig. 6. Some of the candidates testing the system

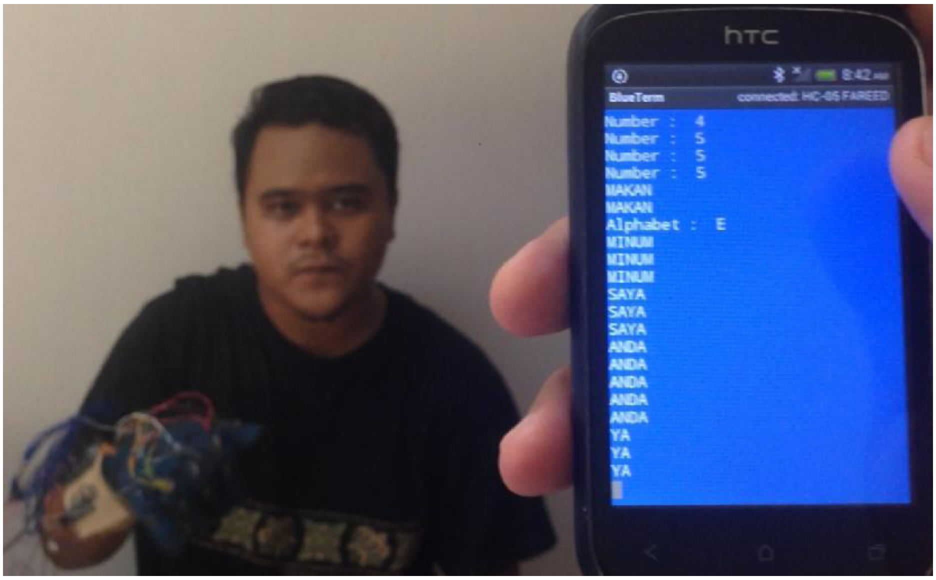


Fig. 7. Continuous Sign language test displayed on a Bluetooth-enabled smartphone

Table 2: Accuracy test of Sign Language Detection System

Candidate	Number of successful attempt per 10 attempts								
	Alphabets			Numbers			Words		
	A	B	C	1	2	3	Saya	Makan	Apa
A	10	10	9	10	10	8	7	8	7
B	9	10	9	10	10	7	7	9	7
C	10	9	9	10	10	9	8	8	8
D	10	10	9	10	10	8	8	9	8

Based on the results shown in Table 2, the accuracy for all the tests is quite high. In the number of 10 attempts tested for each sign, at least 7 trials were successful. The alphabet/number has higher accuracy due to the usage of tilt sensors. The words have lower accuracy because the words involve motion which needs to be detected by the accelerometer. Overall, the accuracies range from 78.33 % to 95 %, which is reasonably high, even though the algorithm is a straightforward fusion between almost-digital output from tilt sensor and threshold-based value of the accelerometer in the direction of motion.

5. Conclusions

The results of the tests conducted shows that the system successfully detects the alphabets/numbers/words tested. The bend of the tilt sensor helps in detecting the alphabets/numbers and the accelerometer assists in detecting words/gestures. The total number of alphabets/numbers/words tested was 12 and future work can be done in adding the database of other stance/gestures of the Malaysian Sign Language. It should be noted that by increasing the number of signs, more combinations of sensor range/values needs to be added to the microcontroller. In future, an underlying framework would be useful in differentiating between more set of alphabets and gestures from the database of Malaysian Sign Language.It is hoped that this research helps in assisting the disabled in communicating effectively using their own sign language with the community at large.

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