Wireless Data Gloves Malay Sign Language Recognition System

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Abstract*— This paper describes the structure and algorithm of the whole Wireless Bluetooth Data Gloves Sign Language Recognition System, which is defined as a Human-Computer Interaction (HCI) system. This project is based on the need of developing an electronic device that can translate sign language into speech (sound) in order to make the communication take place between the mute & deaf community with the general public possible. Hence, the main objective of this project is to develop a system that can convert sign language into speech so that deaf people are able to communicate efficiently with normal people. This Human-Computer Interaction system is able to recognize 25 common words signing in Bahasa Isyarat Malaysia (BIM) by using Hidden Markov Models (HMM) methods. Both hands are involved in performing the BIM with all the sensor connecting wirelessly to PC with Bluetooth module. In the future, the system can be shrunk to become a stand alone system without any interaction with PC.
Keywords—*component, formatting, style, styling, insert* (key words)

I. Introduction

Sign language is a communication skill that uses gestures instead of sound to convey meaning - simultaneously combining hand shapes, orientation and movement of the hands, arms or body, and facial expressions to express fluidly a speaker's thoughts [1][2]. Sign languages are commonly developed in deaf communities, which can include interpreters and friends and families of deaf people as well as people who are deaf or have difficulty hearing themselves. [3]

In Malaysia, Bahasa Isyarat Malaysia (BIM) is the sign language that is commonly used by the deaf community [4]. Therefore the design of the sign language recognition system will be based on the BIM, in order to suit the local people best as well as to benefit them.

II. System Designed and Implementation

In this project, a pair of data gloves is implemented to capture the movement or gesture of a user's fingers as it has been used by previous researchers for sign language recognition. Since the sign language gestures also involve the movement of wrists, elbows, and shoulders, accelerometers are put at those location to capture the gestures. When the user performs sign languages with the data gloves, all the sensors will provide measurements of hand gestures in analogue signals. The analogue signals are then fed to the PIC microcontroller for analogue to digital signal conversion. At the same time, the PIC also collects all gesture data and sends it wirelessly to PC via Bluetooth.

A. Structure of the System

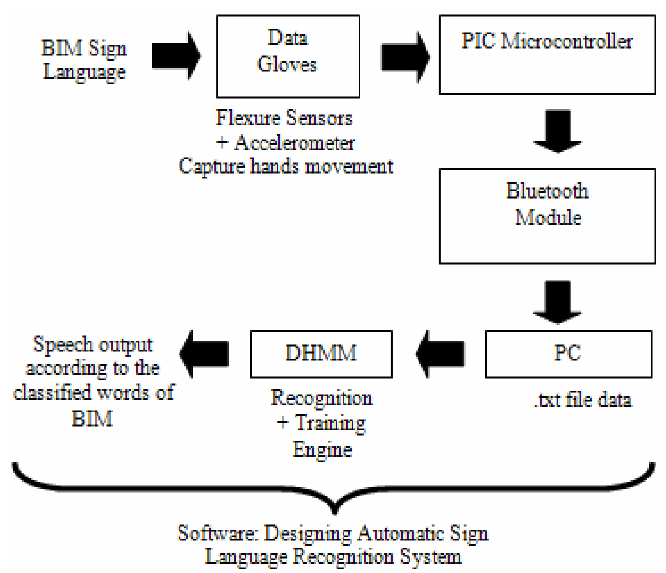

Figure 1: Block Diagram of *Wireless Bluetooth Data Gloves Sign Language Recognition System*

B. Flexure Sensors and Accelerometer

There are altogether 5 flexure sensors and 3 accelerometers on each hand as shown in Figure 2. The flexure sensors function as variable resistance sensors that change resistance according to the sensor's bending. Each sensor has resistance ranging from 10kΩ to 30kΩ. 10kΩ means fully stretched and 30kΩ means fully bent. By using the voltage divider concept, the output voltage range is from 1.35 volt to 2.5 volt.

Meanwhile, accelerometer is a small (18mm x 18mm), low power device to measure the static acceleration of gravity in the tilt sensing application. The 3-axis accelerometer is used at wrist for full capture of the waist movement changes while 2 axis accelerometers are attached at elbow and shoulder. The output voltage range is from 1 volt to 2.2volt.

Figure 2: Diagram of flexure sensors and accelerometers

C. *Microcontroller and Bluetooth*

All output signals generated from flexure sensors and accelerometers are in analogue form. These signals need to be digitized before they can be transmitted to computer. Therefore, microcontroller PIC18F4550 is used as the main controller to the hardware and at the same time digitizes all analogue signals from the sensors. There are 12 sensor outputs on each hand connected to PIC18F4550. PIC18F4550 will only start to convert the input signal once it gets starting signal from the PC. When the conversion is done, it will send the data to the computer via Bluetooth module. The digitized signal will then be stored in a text file (.txt) (as shown in Figure 3 below).

Firstly, the input data of text file will be plotted on graph for screening purpose in the filtering stage. Then the start and end point of the data will be detected to locate the important information of the 24 channel input signal.

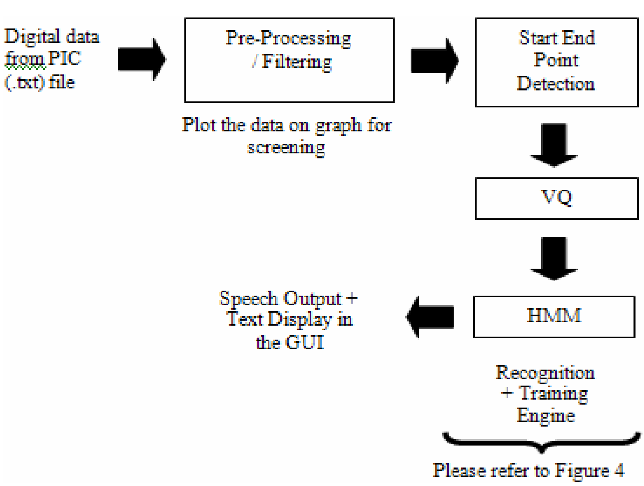

Figure 3: Block Diagram of Software Part

III. HMM Recognition and Training Engine

A. *Vector Quantization (VQ)*

As there are 24 input signals from the sensor, the system will require high computation time to process all the signals simultaneously. Thus, a data compression technique, vector quantization (VQ) is used to reduce transmission and storage cost while the quality is preserved. Vector Quantization (VQ) has been shown to be very useful in compressing data for many applications [5]. Data compression using VQ has received considerable attention due to its compression ratio and rather simple structure [6]. In the VQ process, a codebook is usually trained to minimize the quantization error for data from an individual speaker [7]. The input vectors are then individually quantized to the closest codewords in the codebook built. Compression is gained by using the indices of codewords for transmission and storage [8].

In this project, a codebook with size of 128 is built to represent all the training signals. For every signals, the indices of the codewords will be used as the input to the HMMs.

B. *Hidden Markov Models (HMMs)*

HMMs can be defined by :

- $\{s\}$ – a set of states sequence including an initial state S_I and a final state S_f
- $\{\pi\}$ – a set probability of the first state
- $\{a_{ij}\}$ – a set of transitions where a_{ij} is the probability of taking a transition from state *i* to state *j*
- $\{b_{ij}(k)\}$ – the output probability matrix; the probability of emitting symbol *k* when taking a transition from state *i* to state *j*

The compact notation for hidden Markov model is $\lambda=(a,b,\pi)$.

The forward-backward and Baum-Welch algorithm is used to estimate *a* and *b*. They adjust *a* and *b* iteratively, in order to optimize the model. For each iteration, the estimates from the previous iteration are used to count how frequently each symbol is observed for each transition, and how frequently each transition is taken from each state. Finally, the best state sequence found using Viterbi algorithm [9][10].

The property of HMMs to compensate time and amplitude variances has been proven for speech and character recognition. Due to these characteristics, HMMs appear as an ideal approach to sign language recognition.

Several HMM-based sign language recognition systems have been proven to be successful in demonstration. For example, Liang and Ouhyoung's work in Taiwanese Sign Language [11] shows very encouraging results with a glove-based recognizer. The HMM-based system recognizes 51 postures, 8 orientations and 8 motion primitives. When combined, these constituents can form a lexicon of 250 words which can be continuously recognized in real-time with 90.5 percent accuracy.

The topology HMM model used in this project is a five state HMM as shown in figure 4. This topology of five states was considered sufficient for the most complex signs in BIM. In our approach, each sign is modeled with one HMM.

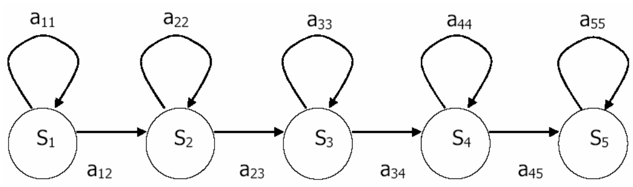

Figure 4 : The 5-state HMM used for recognition

C. *Training / Learning Phase*

The main purpose of learning phase is to create database for the recognition engine. 20 samples of each BIM sign are collected. For this project, only one signer is used for creating signer dependent system. Signer dependent system usually offers higher accuracy compare to signer independent system. This is because 25 BIM signs has been used in this project to make 25 HMM models by using (25 signs x 20 samples) 500 files. By using the training software developed by the Centre of Biomedical Engineering (CBE), the input data can be trained to produce the HMM models. In the training state, 128 codewords are built. The input data is clustered to 128 classes by using VQ [12]. VQ is used to produce closest codeword from the codebook for each gesture observation. VQ is required to map each continuous observation vector into a discrete codebook index. [13]

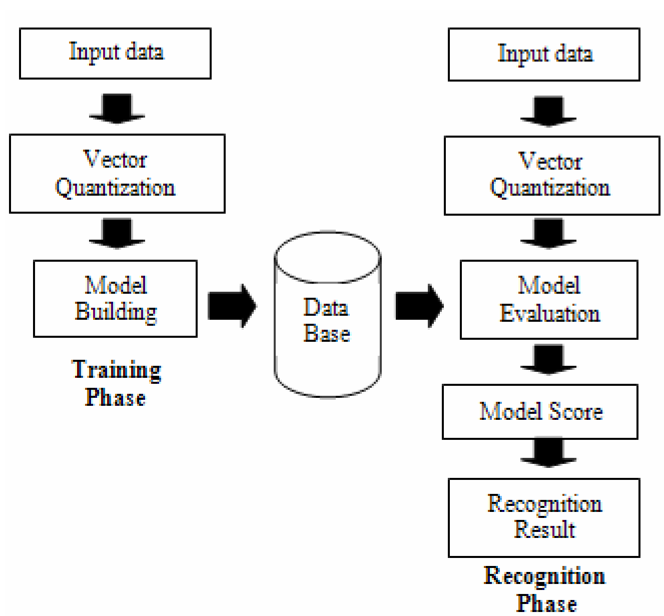

Figure 4: Block Diagram of HMM Recognition and Training Engine

D. *Real-time Recognition Phase*

The real time recognition takes place when the user wearing data glove perform a certain sign and it is able the get the output speech immediately.

The system is quite similar with the learning phase. When the user performs a sign language, it will only go through the same process of training phase without creating the database. After the model evaluation, the system will get the model score as the output of evaluation. Once the score is matched then the result of that particular BIM sign will appear as output in text form in the GUI with speech. The speech of each BIM sign is pre-recorded and will only play out if the score of that sign is matched.

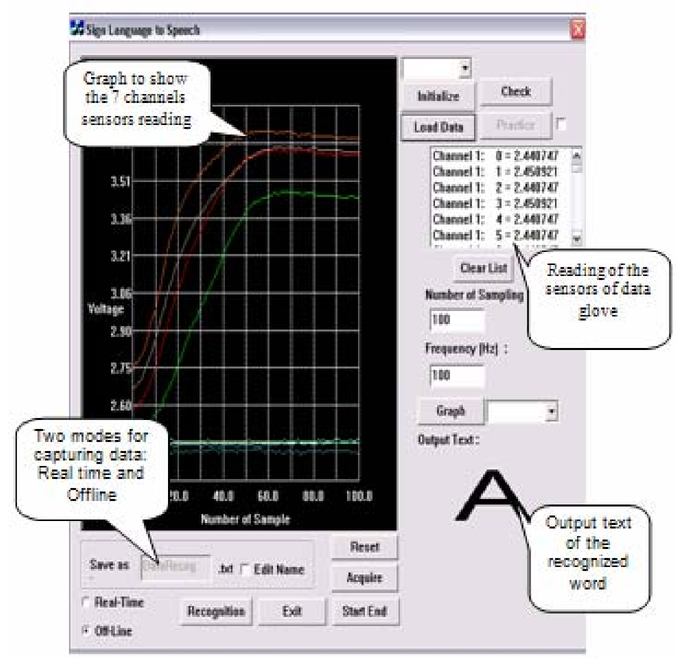

Figure 4: The GUI of Malay Sign Language to Speech

IV. Conclusions

Sign Language is a useful tool to ease the communication between the deaf, mute community and even the normal people who understand the language. Yet there is a communication barrier between these communities with the normal people as most of them do not learn or know the language. Therefore there is a need to develop an electronic device that can translate the sign language into speech (sound) in order to make the communication take place. With this project, the deaf or mute people can use the gloves to perform BIM sign language and it will be converted into speech so that normal people can understand their expression.

This project is the first version of BIM Sign Language to Speech Machine that has the capability in verifying approximately 25 words using 2 data gloves plus accelerometers. Users can utilize it as learning and training tool to learn BIM Sign Language. The sign recognizer engine is still in computer-based as a real sign language to speech machine needs a standalone system which is applicable in daily life.

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