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Development of robotic hands of signbot, advanced Malaysian sign-language performing robot

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Abstract. This paper presents the development of a 3D printed humanoid robotic hands of SignBot, which can perform Malaysian Sign Language (MSL). The study is considered as the first attempt to ease the means of communication between the general community and the hearing-impaired individuals in Malaysia. The signed motions performed by the developed robot in this work can be done by two hands. The designed system, unlike previously conducted work, includes a speech recognition system that can feasibly integrate with the controlling platform of the robot. Furthermore, the design of the system takes into account the grammar of the MSL which differs from that of Malay spoken language. This reduces the redundancy and makes the design more efficient and effective. The robot hands are built with detailed finger joints. Micro servo motors, controlled by Arduino Mega, are also loaded to actuate the relevant joints of selected alphabetical and numerical signs as well as phrases for emergency contexts from MSL. A database for the selected signs is developed wherein the sequential movements of the servo motor arrays are stored. The results showed that the system performed well as the selected signs can be understood by hearing-impaired individuals.

Keywords: robotic hands; speech recognition system; Malaysian sign language; humanoid robot; servo mechanism

1. Introduction

According to statistics from United Nations, the disabled people represents around ten percent of the world population. In Malaysia in 2014, the number of people is about 30 million with approximately 530 thousand disabled individuals are registered at *Jabatan Kebajikan Masyarakat* (Office of Public Welfare) with 13% due to hearing and speech impairment (Laporan 2014). The early research highlighted the significance of interaction with robots in education and therapy

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(Robins 2004, 2005, Clavet 2000, Lave 1991, Bruner 1993). Lev in his theory (i.e., social development theory) stated that social interaction enhances the perception of children (Lev 1978). Lev also mentioned that the development and creativity of children could be enhanced by playing a game, and how it is essential for their cognition (Lev 1978). However, there is a dire need for translating speech to sign language, and the sign language robots hold promise for this issue.

Most of the recent studies focused on video databases and animation to perform different sign languages (Anuja 2009, Su n.d). Veronica Lopez et al. proposed a system to translate the Spanish spoken language to Spanish sign language (Lopez 2013). Another study was conducted for Portuguese sign language wherein the system translated the manual input items from the Portuguese language to 3D avatars (Bento 2014). A current project is also aiming for research on American Sign Language animation (Lu 2014). Although the results were appealing, the performance was through the 3D avatars, and the robotic performance of the sign language was overlooked.

Some recent studies addressed the performance of the sign language by humanoid robots. Nino is the first humanoid robot that can demonstrate sign language (Falconer 2013). Another robot named Nao-25 is a child-sized humanoid robot that, with the use of three fingers, can act as a sign language interactive game for children with hearing impairment (Kose 2011). One of the significant humanoid robots intended to perform sign language is (Aiko Chihira), a robot released by Toshiba to perform some Japanese sign language (JSL) expressions and by 2020 will be equipped with speech recognition to be fully communicating robot (Starr 2014). Guy Fierens et al. developed a sign language robot with the ability to perform the Flemish Sign Language (Fiernes 2012). A robotic hand was proposed to perform the American Sign Language by Shembade (2012). Some additional works have been conducted recently integrated the movement of the robot with the speech system as an input for the robot. Jonathan Gatti *et al.* created an automated voice to sign language robotic hand translator. They took advantage of OpenSCAD software to design the robot hand which was printed by FDM technology (Gatti 2014).

Nevertheless, there are several pitfalls in previous works considering the design and the clear description of performance. the problem still exists as all conducted research mainly focus either on the animation or on the very restricted movement of the robots used for this purpose; they also limit the number of fingers and exclude the integration of the speech system; as they do not take into account the actual necessary motion for signing, the resulted systems are mostly redundant and lack the flexible integration between the speech recognition system and the motion control platform of the robot. For example, the insufficient design of the Nao robot makes it inadequate to perform the sign language as it mainly consists of three fingers. Almost all conducted works of sign language robots lack the clarity in performance since they do not include a clear description of the movements of the robot nor did they assign the joints motion corresponding to targeted letters. Moreover, the movement of the wrist and the elbow are neglected in all proposed studies. Additionally, there are no works that highlighted the performance of Malaysian sign language by means of robotic hands.

In this paper, the design of robotic hands for SignBot, Malaysian Sign Language Performing Robot is presented. SignBot performs MSL using its two hands in response to the speech input uttered by the ordinary people. In other words, SignBot, firstly, receives vocal utterances and recognizes them as letters, numbers, and phrases using Microsoft Visual Studio speech recognition system platform, C#. The speech system platform showed a smooth integration with the controlling platform of the robot comparing to other speech platforms that implemented in MATLAB or Sphinx. Then, the uttered word is serially sent from the speech recognition system to

Arduino Uno platform wherein the sequential servo movements of every sign are stored. Finally, the robot performs the corresponding sign the uttered word.

This paper is organized as follows. Section 2 describes the overall structure of the system, starting from the speech recognition system, the mechanical design of the robot, and the right-hand kinematic model; the servo mechanism and movements of the selected signs are also presented. The results and discussion are addressed in Section 3. The conclusion is finally drawn in Section 4.

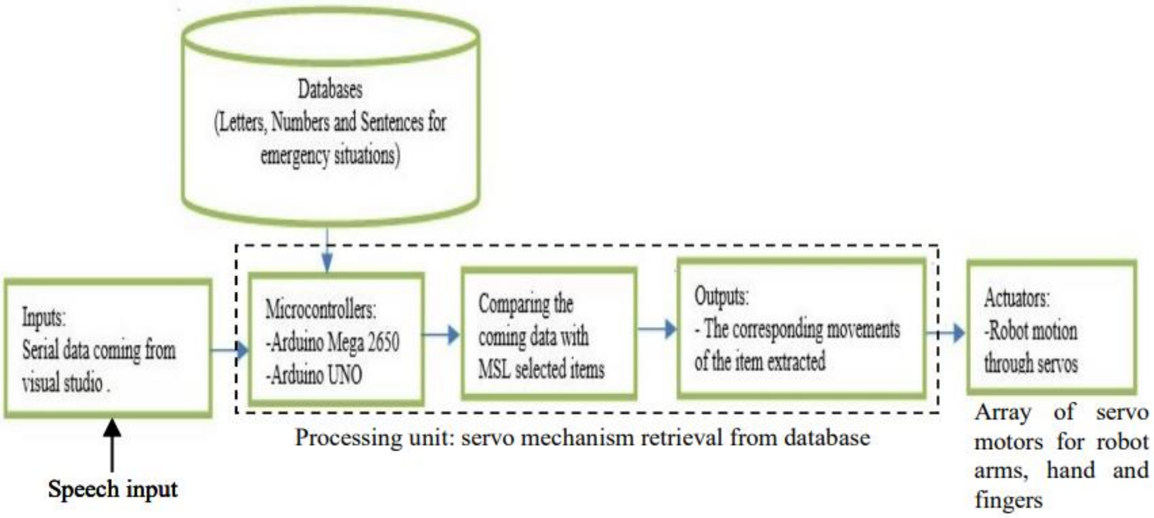


Fig. 1 The overall block diagram of the proposed system

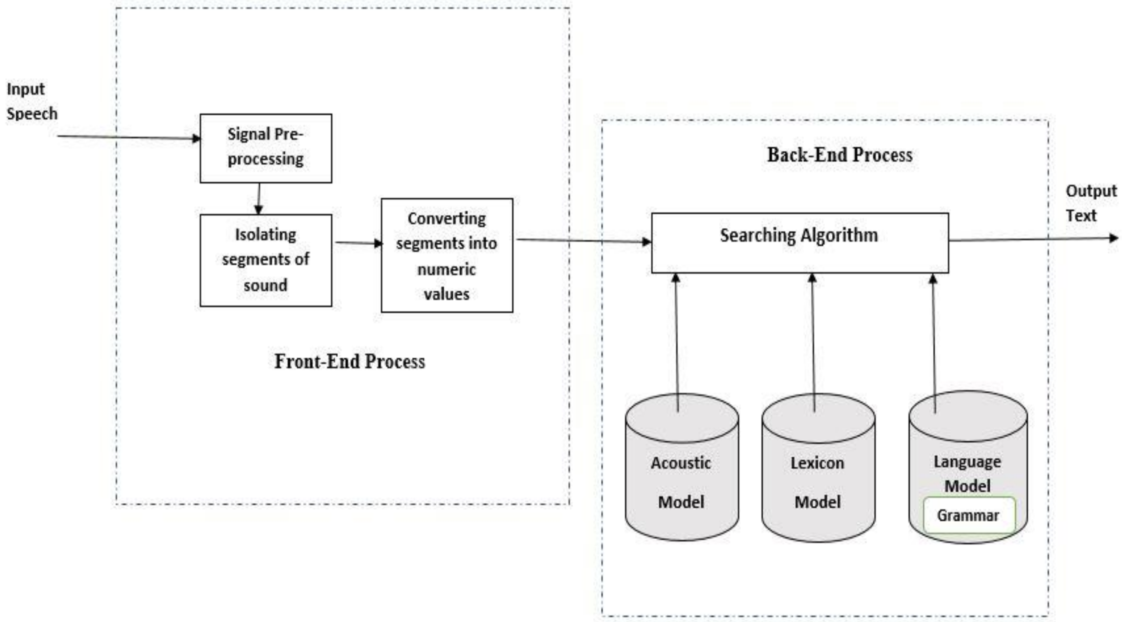


Fig. 2 Speech to text translation flowchart

2. System design and structure

The entire system comprises three main sections. The first section is at the input in which a speech processing system that recognizes the normal speech and converts it into text strings, is developed. In the second section, the processing units wherein the text strings of the recognized utterances are compared to the stored sequential movements of the selected signs in the database. The last section is the output unit which consists of twelve servo motors allocated to perform the corresponding sign of the recognized utterance in MSL; the servos are distributed throughout the right and left hands. Eight servos are assigned to the right hand while only four servos allocated for the left hand. The system uses a microphone to detect the speech signal, which then is processed using Microsoft Visual Studio platform and converted into text strings. The text is then serially sent to the Arduino Uno controller that checks whether the corresponding sign exists in the database or not. Accordingly, the sequential movement of the servos is retrieved to perform that certain sign in Malaysian Sign Language. The servo motors are referenced by numbers as later explained in more detail in Section 2.2. Fig. 1 shows the overall process of the system. At the current stage, the database includes alphabetical and numerical signs; some selected emergency words, such as “tolong” (i.e., “help”), “sakit” (i.e., “painful”), etc. are included in the database as well.

2.1 Building speech-to-text translation system

As it can be seen from the previously proposed work in this field that the robots intended to perform the sign languages lack the suitable speech recognition system that can easily integrate with the robot controlling platform. The few works that perform the sign language in response to the human spoken language implemented very basic techniques to translate the spoken language. They used the already stored phrases on chips with very limited phrases that cannot be extended nor edited.

As the speech recognition system is an essential part of sign language robots, the most adequate speech recognition system has to be implemented. It must be sufficient in terms of the number of items (words and phrases) included, accuracy, and the effortless integration with the controlling platform of the robot. Therefore, an extensive review conducted to implement the most suitable platform for the speech system. The Microsoft Visual Studio (MVS) platform turned out to be the best comparing to MATLAB and Sphinx platforms.

The proposed speech recognition system consists of two processes, the front-end and back-end processes. Further details can be found in (Al-Khulaidi and Akmeliawati 2017). The front-end process involves the preprocessing of the input speech signal, isolating segments of sound, and conversion of the isolated segments into numeric values. The back-end process, on the other hand, is wherein the output of the front-end is looked out across three databases including acoustic model, lexicon model, and language model as in Fig. 2. In this part, the grammatical rules of the MSL are considered. The back end, essentially, is a search engine which is specialized to take the output of front end and look out across three databases (Al-Khulaidi and Akmeliawati 2017).

1. The acoustic model which represents the language acoustic sounds; this can be trained to recognize the characteristics of a particular user’s speech patterns and acoustic environments.

2. The lexicon includes a large number of the words in the language and offers information on how to pronounce each word.

3. The language model represents the means by which the words of the language are combined.

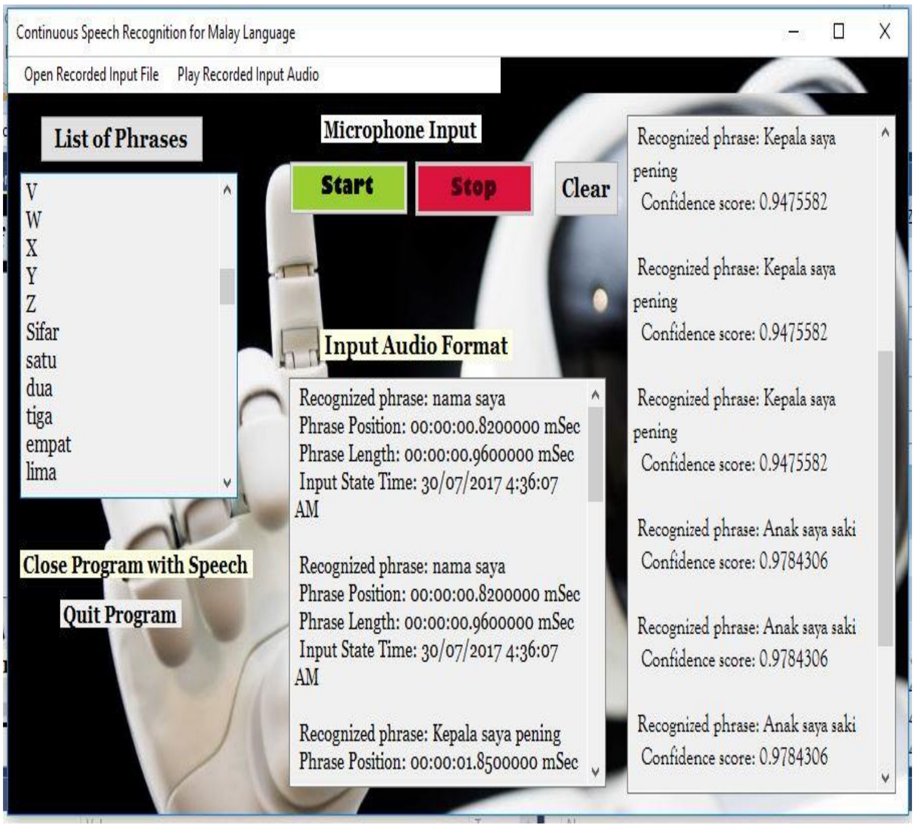


Fig. 3 GUI of the proposed speech recognition system

The algorithm starts finding the matches within the models depending on the value of the confidence factor which was set programmatically to 0.85, so the algorithm can estimate the matches and accordingly select the one with the highest confidence.

The numeric values coming from the front end are compared to the phonemes, which are the parts of the words used to produce speech, in the acoustic model. After the acoustic model finds a match in the language (word or phrase) to that values, this match is compared to the included phrases in the lexicon and language models. The lexicon and the language models in the proposed platform consists of the intended 80 Malay language items, alphabets, numbers, words and phrases.

The language model contains the grammar which is the most significant part of the speech recognition system as it limits the number of recognized words and phrases. The speech recognizer often needs to process certain utterances with specific semantic meaning to the intended application rather than using the general language model, such as everyday spoken-language. This provides several benefits to the system such as increasing the accuracy of the system, ensuring that all recognized sets are meaningful to the intended application as well as specifying the semantic values inherent in the detected text. This grammar can be authoring programmatically in the Microsoft Speech Platform SDK.

The quality of the speech recognizer is detected by how good the recognizer at sanitizing its search, removing the weak matches, and choosing the more similar matches. This entirely depends on the quality of the language and acoustic models of the recognizer and the effectiveness of the algorithm, for the processing of input sound and the searching across its models.

The GUI of the proposed speech system as showed in Fig. 3 includes all necessary functions to start, hold and quit the recognition. Once the user press “Start” button, the system starts working waiting for any item to be uttered by the speaker. Then, it converts it to text and serially sends it to the Arduino to be performed as a sign language by the robot.

After building the speech recognition system using MVS, the result was very satisfactory as it resulted in an accuracy of 93% of 80 tested phrases. It also integrated smoothly with the Arduino to which the data serially was sent. Moreover, unlike other speech platforms, the items in the platform can be easily edited and more items can be added in the future if more advanced designs involved in performing the sign language.

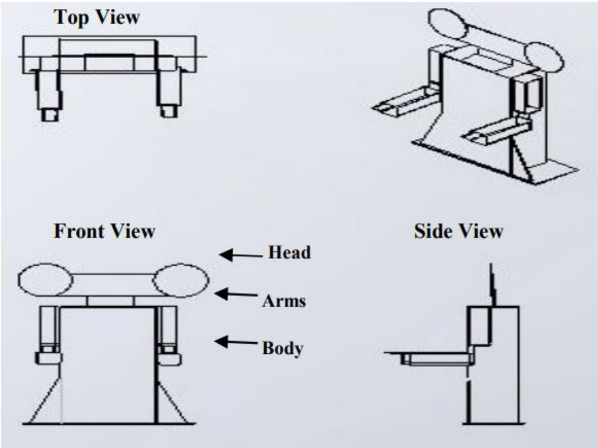


Fig. 4 Mechanical design

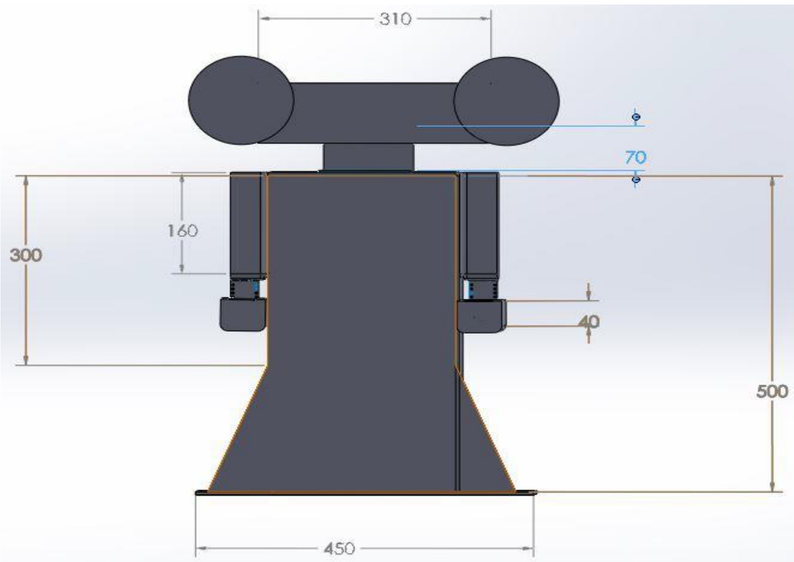


Fig. 5 The dimension of the robot

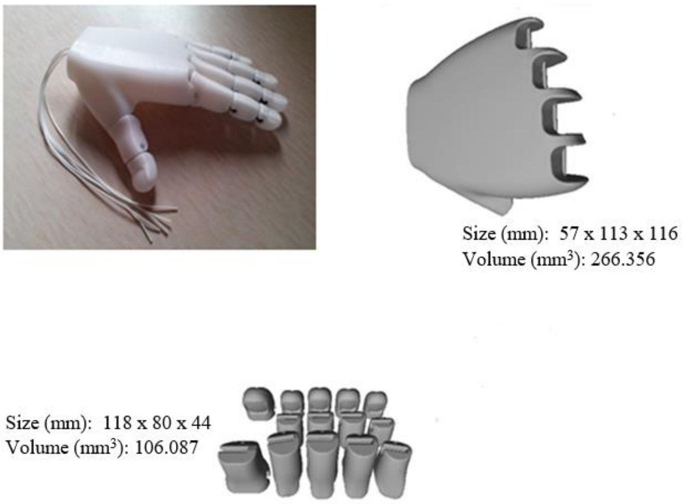


Fig. 6 The mechanical structure of the robot right hand (Gyrobot 2014)

Table 1 Specifications of the hand fingers

Finger	Part	Length (mm)
Thumb	IP	29.17
	TMC	33. 54
Index	DIP	25.30
	PIP	26.6
	MCP	41.31
Middle	DIP	26.85
	PIP	28.50
	MCP	44.20
Ring	DIP	26.9
	PIP	26.7
	MCP	42.8
Little	DIP	23.70
	PIP	20
	MCP	36

2.2 Mechanical design of signbot

The structure of the system comprises two main parts: the body along with head represents the stationary part and the hands which are the focal point of the study. Every part is made up of different materials. The material of the hand is ABS and it is printed by a 3D printer. Both the body and head are made from Perspex and constructed manually. Moreover, we have designed the head and the body while the robot hands design is obtained from an open source design retrieved from Thingiverse website (Gyrobot 2014). The mechanical structure of the body and head are shown in Fig. 4 and Fig. 5; Fig. 6 provides the design of the hand and fingers.

Similar to the physique of the real fingers, the index, middle, ring and little fingers each contains three parts reflecting the anatomical structure of MCP (Metacarpophalangeal), PIP (Proximal Interphalangeal) and DIP (Distal Interphalangeal) joints. Every joint has 1 DOF enables it to flex and extend to a range of 90. Each finger has holes to insert a fishing thread for the actuation. The thumb, on the other hand, has 2 DOF. It could be unnecessarily sophisticated if we managed to use the same replica of the real thumb. Nonetheless, the design of the thumb makes it very capable of reaching all the required positions of MSL entries. With a parallel axis to the palm and other fingers, the TMC (Trapezoimetacarpal) and IP (Interphalangeal) joints of the thumb can flex and extend appropriately toward the axis of the other fingers. Thus, the thumb is able to apparently imitate the movement of the real thumb while performing MSL. Further specifications of the fingers are in Table 1.

2.3 Right hand direct kinematic model

The direct kinematics of the fingers and the thumb is solved separately as they have different structures. As the index, middle, ring, and little fingers have the same structure, the direct kinematics of the index will be solved. Thus, two kinematics configurations are presented; one is for the index finger and the other is for the thumb as shown in Fig. 7.
Denavit-Hartenberg (D-H) parameters are used to calculate the equations. The final direct

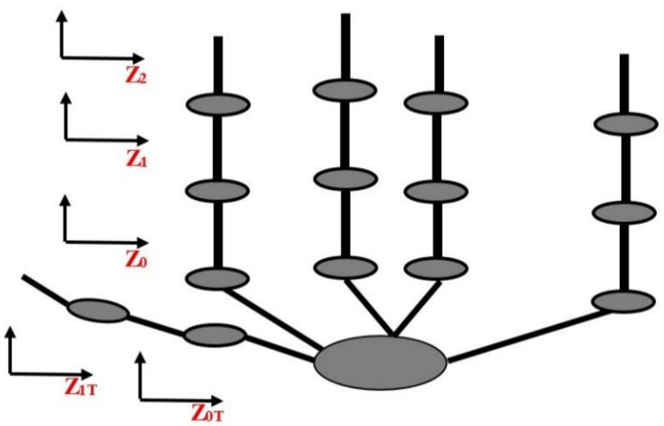


Fig. 7 Kinematic configurations of the index and thumb fingers

Table 2 DH parameters of the index, middle, ring and little fingers

Joint	Θ_n	d_n	a_n	α_n
1	Θ_1	0	L_1	0
2	Θ_2	0	L_2	0
3	Θ_3	0	L_3	0

Table 3 D-H parameters of the thumb finger

Joint	Θ_{nT}	d_{nT}	a_{nT}	α_{nT}
1	Θ_{1T}	0	L_{1T}	0
2	Θ_T	0	L_{2T}	0

kinematic solution can be solved from Eq. (1); the general transformation matrix at the certain joint is shown by Eq. (2).

$$T_0^n = \begin{bmatrix} n_x & s_x & a_x & p_x \\ n_y & s_y & a_y & p_y \\ n_z & s_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{1}$$

$$A_n = \begin{bmatrix} Cos\theta_n & -Sin\theta_n Cos\alpha_n & Sin\theta_n Sin\alpha_n & a_n Cos\theta_n \\ Sin\theta_n & Cos\theta_n Cos\alpha_n & -Cos\theta_n Sin\alpha_n & a_n Sin\theta_n \\ 0 & Sin\alpha_n & Cos\alpha_n & d_n \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{2}$$

By substituting the values of D-H parameters, θ_n, d_n, a_n and α_n from Table 2 into Eq. (2), the transformation matrices for each joint respectively are as follows.

$$A_1 = \begin{bmatrix} C\theta_1 & -S\theta_1 & 0 & L_1C\theta_1 \\ S\theta_1 & C\theta_1 & 0 & L_1S\theta 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$A_2 = \begin{bmatrix} C\theta_2 & -S\theta_2 & 0 & L_2C\theta_2 \\ S\theta_2 & C\theta_2 & 0 & L_2S\theta_2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{4}$$

$$A_3 = \begin{bmatrix} C\theta_3 & -S\theta_3 & 0 & L_3C\theta_3 \\ S\theta_3 & C\theta_3 & 0 & L_3S\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{5}$$

By substituting the values of L_1, L_2, and L_3 (in mm) by the values of MCP, IP, and DIP, respectively, from Table 1, and by multiplying all the matrices of the successive joints A_1, A_2, and A_3, the overall transformation matrix that relates the frame at the wrist and the frame at the fingertip of any of the four fingers can be calculated as

$$T_0^3 = A_1A_2A_3 = \begin{bmatrix} n_x & s_x & a_x & p_x \\ n_y & s_y & a_y & p_y \\ n_z & s_z & a_z & p_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{6}$$

where

$$n_x=C_{12}C_3-S_{12}S_3 \quad n_y=S_{12}C_3+C_{12}S_3 \quad n_z=0$$

$$s_x=-(S_{12}C_3+C_{12}S_3) \quad s_y= C_{12}C_3-S_{12}S_3 \quad s_z=0$$

$$a_x=0 \qquad a_y=0 \qquad a_z=1$$

$$p_x=(25.3)(C_{12}C_3-S_{12}S_3)+(26.6)C_{12}+(41.31)C_1$$

$$p_y=(25.3)(S_{12}C_3+C_{12}S_3)+(26.6)S_{12}+(41.31)S_1$$

By substituting the values of D-H parameters, θ_n, d_n, a_n, and α_n from Table 3 into Eq. (2), the transformation matrices for each joint, respectively, can be obtained as

$$A_{1T} = \begin{bmatrix} C\theta_{1T} & -S\theta_{1T} & 0 & L_{1T}C\theta_{1T} \\ S\theta_{1T} & C\theta_{1T} & 0 & L_{1T}S\theta_{1T} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{7}$$

$$A_{2T} = \begin{bmatrix} C\theta_{2T} & -S\theta_{2T} & 0 & L_{2T}C\theta_{2T} \\ S\theta_{2T} & C\theta_{2T} & 0 & L_{2T}S\theta_{2T} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{8}$$

By substituting the values of L_{1T} and L_{2T} (in mm) by the values of MCP, IP, and DIP, respectively, from Table 1, and by multiplying all the matrices of the successive joints A_1 and A_2, the overall transformation matrix that relates the frame at the wrist and the frame at the fingertip of the thumb can be obtained as

$$T_0^2 = A_{1T}A_{2T} = \begin{bmatrix} n_{xT} & s_{xT} & a_{xT} & p_{xT} \\ n_{yT} & s_{yT} & a_{yT} & p_{yT} \\ n_{zT} & s_{zT} & a_{zT} & p_{zT} \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{9}$$

where

$$n_{xT}=C_{12T} \quad n_{yT}=S_{12T} \quad n_{zt}=0$$

$$s_{XT}=-S_{12T} \quad s_{yT}=C_{12T} \quad s_{zT}=0$$

$$a_{xT}=0 \qquad a_{yT}=0 \quad a_{zT}=1$$

$$p_{xT}=(29.17)C_{12T}+(33.54)C_{1T}$$

$$p_{yT}=(29.17)S_{2T}+(33.54)S_T$$

2.4 Servo mechanism

The system is mainly consisted of two phases: the speech system as an input phase and the servo motors as an output one. Using C# language in Microsoft visual studio environment, the

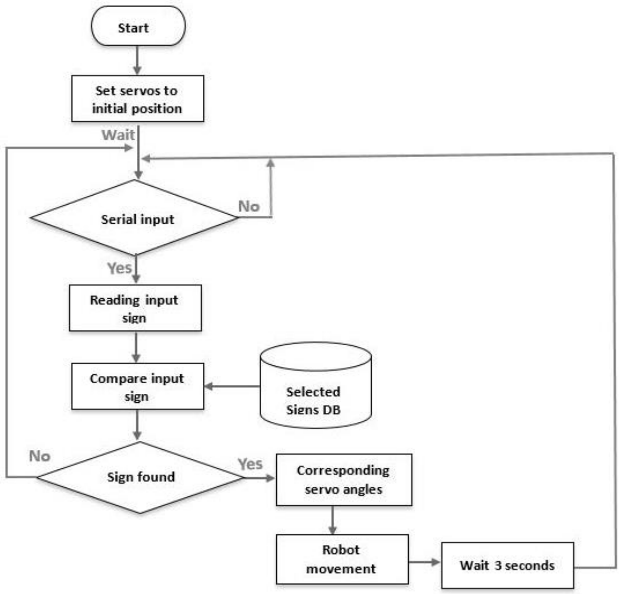


Fig. 8 Flowchart of the signs performance

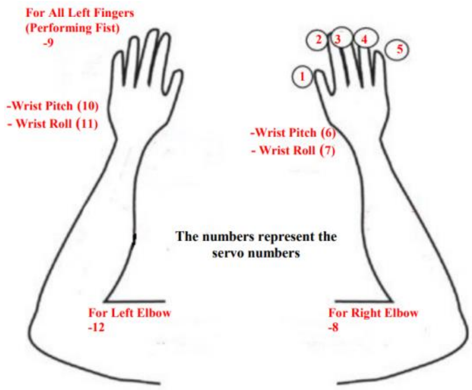


Fig. 9 Servo distribution for both hands

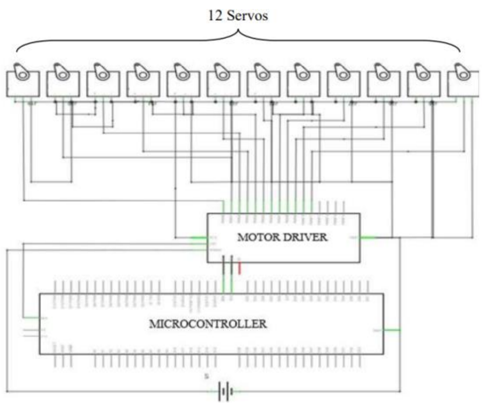
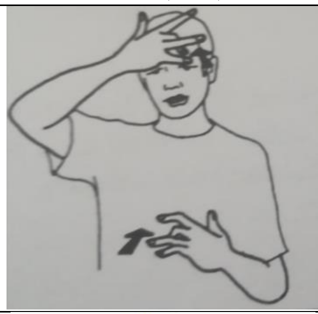
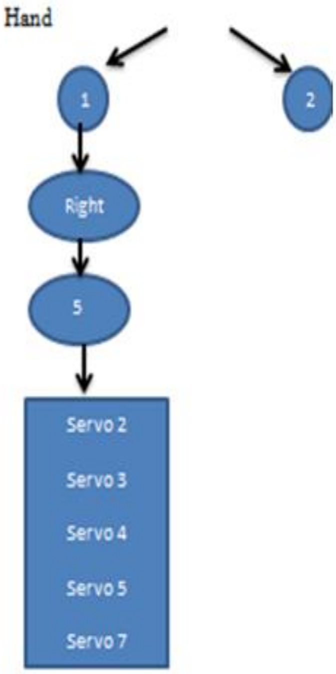
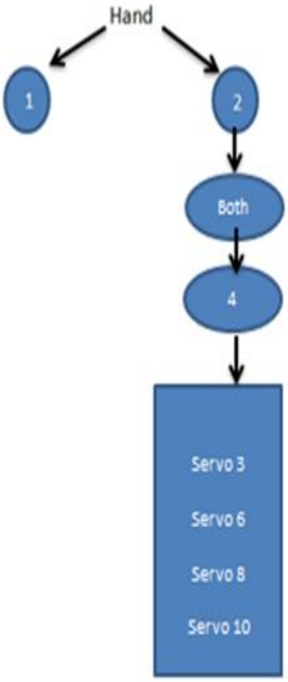


Fig. 10 Schematic circuit diagram for servo arrays

Table 4 A sample of the word signs stored in the database

<table>
<tr><th>Command</th><th>Awak (You)</th><th>Sakit (Sick)</th></tr>
<tr><td>Picture</td><td></td><td></td></tr>
<tr><td>Number of hands</td><td rowspan="4">
</td><td rowspan="4">
</td></tr>
<tr><td>The hand used</td></tr>
<tr><td>Number of servos</td></tr>
<tr><td>Sequence of servos</td></tr>
</table>

speech system is implemented. The process starts by recognizing the utterances of a Malay language speaker, and then the recognized utterance is converted to text strings. Next, the string is serially sent to the Arduino Uno controller. Each received string is assigned to one sign of the selected alphabets, numbers and/or the emergency phrases. For instance, when the sound of "A" is pronounced and recognized, the corresponding mechanical movements in MSL of this particular alphabet will be performed by the robot after its retrieval from the database. The process flowchart is shown in Fig. 8.

The system is actuated by an array of twelve servo motors. The right-hand side has eight servos while the left-hand one only has four servos as shown in Fig. 9; the servo motors are enumerated from 1 to 12 for reference. Each right-hand finger is assigned with a servo motor, and the remaining three servos represent the pitch and roll movements of the wrist and the flexion/extension movement of the elbow. The left side, on the other hand, consists of only four servos; one servo is assigned for all left-hand fingers as the hand is only needed to form a fist during the performance of the emergency signs. Like the right part, three servos are allocated to the wrist and elbow movements. There is no need to move the left-hand in the full degree of freedom since all the alphabetical and the numerical signs in MSL can be performed using the right hand. An array of four servos for the left hand is sufficient enough to perform the selected essential words/phrases at this stage. Fig. 10 shows the circuit diagram of the twelve servos.

2.5 Robot hands' movements

The hand movement of the robot is adjusted according to the standard MSL. Each sign (letter, number or phrase) has been studied meticulously by appointing the servos of each joint to ensure the exact sequence of motion. Samples of the detailed description of the sequential movements of the servos for alphabets, numbers and the emergency phrase are shown in Tables 4, 5, 6 and 7. That is, the sequential movements, corresponding to every sign, of the servo motor arrays for both hands are stored in the database.

Table 5 Selected MSL letters

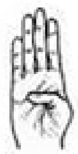
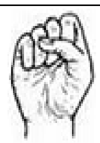
Letter	Features	Servo number used	Sequences of servos
A		2,3,4,5	Simultaneously 2,34,5
B		1	1
H		1,4,5,6,7	Simultaneously 1,4,5 then 6 & 7
I		1,2,3,4	Simultaneously 1,2,3,4
L		3,4,5	Simultaneously 3,4,5
S		1,2,3,4,5	Simultaneously 1,2,3,4,5

Table 5 Continued

Letter	Features	Servo number used	Sequences of servos
U		1,4,5	Simultaneously 1,4,5

Table 6 Selected MSL numbers

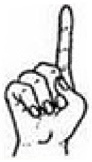
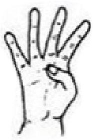
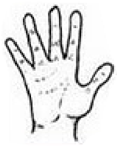
Numbers	Features	Servo number used	Sequences of servos
1		1,3,4,5	Simultaneously 1,3,4 & 5
2		3,4,5	Simultaneously 3,4 & 5
3		4,5	Simultaneously 4 & 5
4		1	1
5		none	None

Table 7 Selected emergency phrases

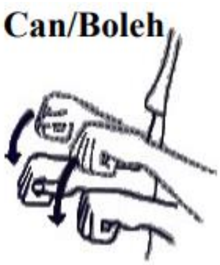
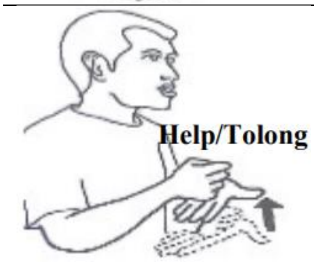
Sentences	Features	Servo number used	Sequences of servos
1) Can I help you? *Boleh saya tolong awak?*		2,3,4,5,6	Simultaneously for both hands 2,3,4,5, then 6

Table 7 Continued

Sentences	Features	Servo number used	Sequences of servos
		1,2,3,4,7	1,2,3,4 then 7
1) Can I help you? *Boleh saya tolong awak?*		1,2,3,4,5,6,7,8,10 ,11,12	Simultaneously for both hands 1,2,3,4,5 then 6, 7, 8, 10 then 11, 12
		2,3,4,5,6,7	2,3,4,5 then 6, 7

3. Result and discussion

To ensure the most authentic results, testing SignBot performance was held in front of hearing-impaired individuals. The process commenced by uttering the sound of the selected signs by a normal individual. Then, when the uttered sign exists in the database, the Green LED of the microcontroller is turned on showing that certain sign has been identified. Accordingly, the command continues to the performance of the intended sign (after extracting it from the database) by executing its own code based on Table 1-4 (in Section 2.3); after the assigned servos for the recognized sign is determined as shown in the tables, the corresponding movement in MSL will be performed as in the feature column of the tables so that it can be understood by the hearing-impaired individuals. When the letter “A” is uttered by the speaker, the servos number 2, 3, 4 and 5 are actuated concurrently. The performance of the robot is represented in Fig. 11. SignBot showed the capability to perform seven alphabetical signs (A, B, H, I, L, S, U), the numbers from 1 to 5, and “Boleh saya tolong awak?” Malay interrogative sentence that is equivalent to “Can I help you?” in English.

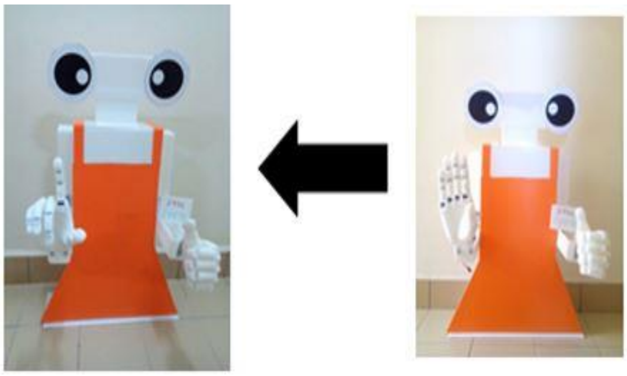


Fig. 11 Testing the performance of SignBot

SignBot is considered the first robot that can perform Malaysian sign language in response to the spoken language. Its movement is based on the detailed sequential movements of the array of 12 servos. The tests were conducted in a real-life situation in the presence of hearing-impaired individuals. The results showed that SignBot has proved that the robot is capable of performing Malaysian sign language as its performance can be comprehended by the hearing-impaired community. The experimental results showed the smooth integration between both the speech system platform and the robot performance of the sign language while testing the overall system as a single entity. The developed speech system platform can be used as a universal platform for any sign language performing robot in the future as it can be integrated with any advanced robot in this field with only a few adjustments.

However, up to this point, SignBot still has two limitations. First, the number of alphabetical and numerical signs and the selected phrases implemented in the database is restricted at this stage. A second issue regarding the motion of the robot as it lacks the movement of the shoulder and the yaw movement of the wrist. Therefore, the arm does not move in full range comparing to the actual human signers. However, these limitations do not mean that the signs performed are less understood since the majority of the signs in MSL require less movement of arm and elbow.

4. Conclusions

In this paper, a sign language performing robot, SignBot, is presented. The result shows that the robot can perform some alphabetical and numerical signs as well as some signs in emergency contexts selected from Malaysian Sign Language (MSL). The study intended to help ease the means of communication between mainstream Malaysians and speech/hearing-impaired individuals. The humanoid robot has a friendly look with its design so that it might depict the real human signer. Unlike other works, the robot is equipped with a very reliable speech recognition system that has a smooth integration with the robot controlling platform; it can recognize the utterances from the regular people and send it serially to the robot platform wherein the corresponding movement is retrieved from the database and performed mechanically by the robot. The speech platform can be used as a general platform for any sign language robots as it can be easily adapted to any future adjustments. Despite the performance of the targeted signs, some additional signs including more emergency phrases. Nonetheless, SignBot is the only work that intends to perform Malaysian sign language. Implementing some adequate, dexterous design that is sufficient to employ more signs will enhance the performance in the future.

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