All Sciences Proceedings
http://as-proceeding.com/

1st International Conference on Recent and Innovative Results in Engineering and Technology

August 16-18, 2023 : Konya, Turkey

ICRIRET
https://as-proceeding.com/index.php/icriret

Sign language voice convertor design using Raspberry pi for impaired individuals

Serhat Küçükdermenci *,1

[1]Department of Electrical and Electronics Engineering, Faculty of Engineering, Balıkesir University, 10463, Balikesir, Turkey.

*(kucukdermenci@balikesir.edu.tr) Email of the corresponding author

Abstract – In this study, a method for detecting sign language is created to help people with speech and hearing impairments communicate more effectively with each other and with people who do not know sign language. One of the applications of flexible sensors for the development of interaction/interface devices based on human gestures is the translation of sign language into audio. Resistive flexible sensors can be used in a wide variety of applications due to their light weight, compact form, flexibility, measurement efficiency and low power consumption. The design is outlined in Proteus simulation environment by connecting five flexible sensors, a switch and an LCD display to a Raspberry pi. Each finger gesture combination in the generated system represents a separate character or phrase. In digital electronics, these combinations are digital sets consisting of logic 0 and logic 1. Finger signals corresponding to the characters or sentences to be used in the study are given to the developed system. The sensor output is converted to digital form using Raspberry Pi and after processing the data, audio output is generated using gTTS. For each combination of finger movements made by the user, a character or sentence presented to the system is transferred to the LCD screen. The aim of this study is to help bridge the communication gap between sign language users and non-sign language speakers.

Keywords –Flex Sensor, Python, Raspberry Pi, Hearing Impaired, Voice Output, Sign Language;

I. INTRODUCTION

According to the World Health Organization, approximately 70 million people worldwide are deaf-mute. It is also estimated that one in four people will experience hearing loss by 2050 [1]. People with disabilities can usually communicate with each other using sign language, finger alphabet and gestures [2]. There are various sign languages around the world. Each sign language has its own gestures and terminology. The deaf community (e.g. friends and relatives of deaf people) are familiar with these sign languages. However, these sign languages are often not known outside these communities. This makes communication between deaf and hearing people difficult [3]. A mute person finds it difficult to communicate his or her message to a general audience.

Many people find it difficult to learn sign language because of the time and professional training required to become fluent in sign language. Figure 1 shows the letters and numbers represented in American Sign Language (ASL).

Today's user interface devices such as keyboards, mice and pens are inadequate for people with disabilities and require the development of alternative means of presentation and interaction. The human hand has the potential to be used as a human-computer interface input device [4].

Sensor-based gesture recognition uses flexible sensors to evaluate the angle at which fingers bend, as well as their movement, orientation, alignment and palm position. An ASL-compliant system basically needs 2 main parts, a glove and a structure that converts the input data into a visual or auditory output. In one study, the system converts hand gestures from flexible sensors and sends them over Bluetooth to a mobile application. The program recognizes the incoming input data and then converts it into text displayed on the device screen and speech generated by a text-to-speech engine [5].

Fig. 1 Letters and numbers are used in American Sign Language

In another study, a simple glove was created with multiple sensors, a small display and a mini speaker attached to the glove. Glove sensors use a "text-to-speech chip" to translate hand gestures into text on the screen and speech through the speaker. A simple glove was created with multiple sensors, a small screen and a mini speaker attached to the glove. The glove sensors use a "text-to-speech chip" to translate hand gestures into text on the screen and speech through the speaker [6].

Another glove designed to convert sign language into text and speech that can be displayed on a computer, sensors in the glove record the position of the hand. The recorded data is transmitted wirelessly via Bluetooth from the glove's Arduino controller to a second Arduino controller connected to a computer screen. If the data matches one of the gestures stored on the computer, the word related to the gesture is spoken through a speaker [7].

In another study, an Arduino circuit board was used to convert ASL to audio in a glove with flexible sensors. The device also uses Analog-to-Digital converters to display the audio on an LCD screen and convert it to text [8].

In this work, we propose a system that enables people with hearing or speech disabilities to communicate with others using hand gestures. Flexible sensors detect the gesture and an audio output unit generates audio output. Furthermore, the data stream can be managed via an LCD display. The data read from the flexible sensors can be converted into characters or words through a switch in the system. Raspberry Pi is used to process the data and provide appropriate outputs [9]. The main advantages of the sensor-based technique are high accuracy and no data processing, as the data needed for gesture recognition is obtained instantly from sensor readings.

Since speed is an important factor in communication between deaf-mutes and non-deaf-mutes, the advantages of accuracy and fast processing of the sensor-based approach are outweighed. As a result, sensor-based design is preferred over image-based design in this study due to the aforementioned advantages.

II. Materials and Method

The proposed system uses five flexible sensors representing the fingers of a hand and a switch as input elements. The Raspberry Pi converts the data from the flexible sensors into numeric data. The switch allows the user to choose whether the input will be converted into characters or sentences. When the switch is off, inputs are converted to characters; when the switch is on, inputs are converted to sentences. The Raspberry Pi transmits the selection to the LCD panel and uses gTTS to generate audio output. Figure 2 shows the block diagram of the system and Figure 3 shows the flowchart of the system. Proteus simulation was used to create the design. In this way, the design is more usable thanks to its flexible structure that is open to modification and tuning. Once the design is customized according to the user, it can be easily implemented in real life.

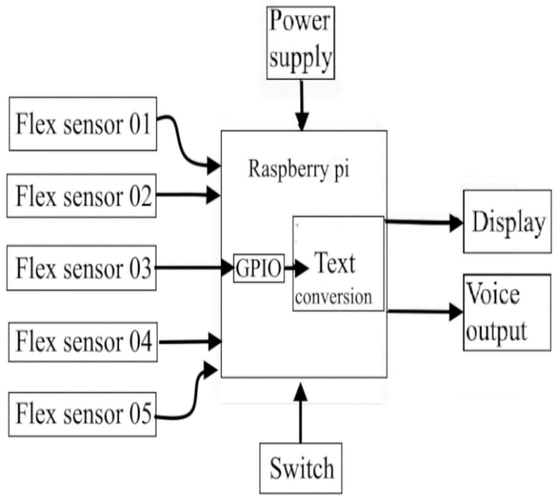

Fig. 2 Block diagram of the system

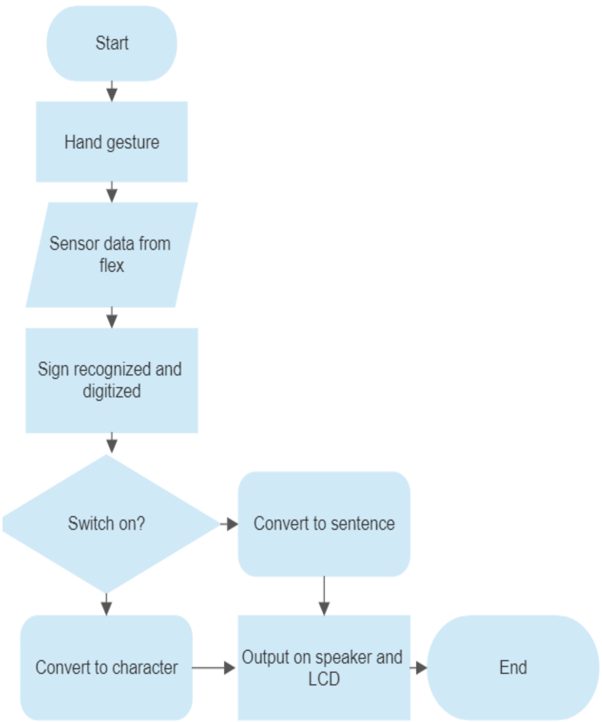

Fig. 3 Flow chart of the system

A. *Analog and Digital Flex Sensors*

The flexible sensor is a thin, light and flexible strip with a resistance proportional to its bending. Its operating range is from 0° to 180°. An analog signal is generated by the flexible sensor. The carbon surface is designed on a strip with an operating voltage of 0 V to 5 V and an operating temperature of -45°C to +80°C. The flexible sensor is activated when the plastic strip is bent. The resistance value of the flexible sensor at 0° and 90° is 40910.20 ohms and 93697.67 ohms respectively.

Figure 4 shows a flexible sensor attached to each finger of the data glove.

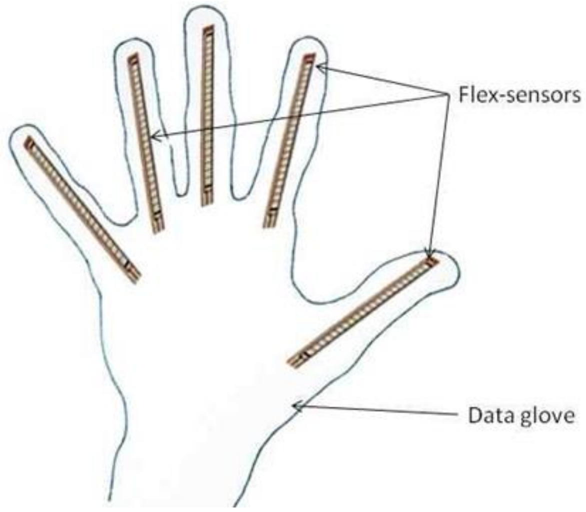

Fig. 4 Flex-sensors based data input glove

The electrical equivalent of a flexible sensor can be likened to a voltage divider circuit. A resistor, say 10 K, is connected in series with the flexible sensor to detect changes in resistance. The purpose of the additional resistor is to create a voltage divider V0 between the flexible sensor and the additional resistor from the 5 V supply voltage. Figure 5 shows the flexible sensor pin-out layout.

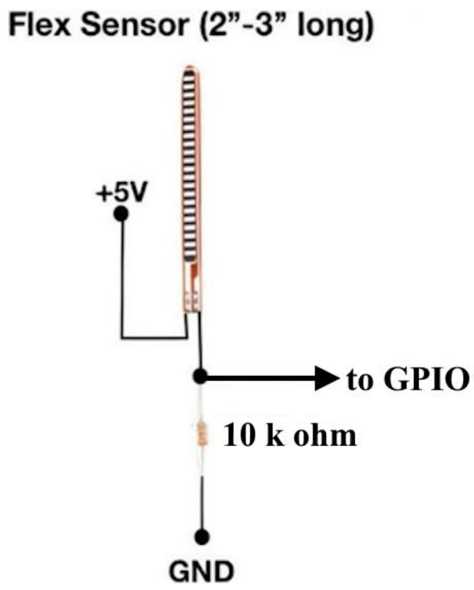

Fig. 5 Pinout configuration of flex sensor

As a result, the V_0 value can be calculated using equation 1. Here R1 is the resistance value of the flexible sensor that changes when it is bent [10].

$$V_0 = 5 \times \left(\frac{10K}{R_1 + 10K} \right) \quad (1)$$

Assume that the resistance of the flexible sensor is 10 K when bent 0o and 40 K when bent 90o. Thus, the maximum voltage, V_{max}, and the minimum voltage, V_{min}, are 2.5 V and 1.0 V respectively for a series resistance of 10 K. These voltage values can be used to configure the Raspberry Pi's range of signal recognition margins. When the flexible sensors on all five fingers are flexed to correspond to an American Sign Language (ASL) sign, different V0 values result. These data values are then converted into digital format through a quantization process on the Raspberry Pi.

Proteus analog flexible sensor library: Bending causes a change in the resistance of the analog sensor. When placed in the Proteus workspace, this sensor has four pins as shown in Figure 6a. G is the first pin and is the ground pin that will be connected to the ground voltage. The second pin is the OUT pin which provides the flex sensor value and indicates whether the sensor detects the flex value or not. The third pin is the voltage supply pin which receives 5V to power the sensor. TestPin is the fourth pin and we only need it for the Proteus simulation. This pin is not present in the real sensor. When this pin is HIGH it gives the bend value and when it is LOW it gives no bend value.

Proteus digital flex sensor library: Since this Flex Sensor works with digital logic, not analog, it only detects whether the sensor is up or down, rather than how much the sensor is bent. There are four pins on the sensor. The first is V_{cc}, which is needed to provide 5V, the second is GND, which is needed to provide ground. The third pin is OUT, which can be HIGH or LOW depending on the Test Pin. If the Test Pin is HIGH, OUT will also be HIGH, otherwise OUT will be LOW. Figures 6b and 6c [11] show both flat and bent cases for the digital flex sensor.

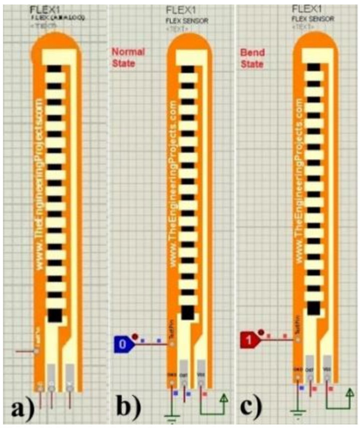

Fig. 6 Analog and digital flex sensors

B. Raspberry pi

The Raspberry Pi Foundation has unveiled a series of credit card-sized single-board computers in the UK to support the teaching of basic computer science in schools and developing countries. In February 2012, the first generation (Pi 1) was released as the basic model A and the higher specification model B. A year later the A+ and B+ models were released. In February 2015, the Raspberry Pi 2 model B was released, followed by the Raspberry Pi 3 model B in February 2016. The prices of these boards range from 20 to 35 dollars. A scaled-down "compute" model was introduced in April 2014, and in November 2015 a smaller Pi Zero with limited I/O and general purpose I/O (GPIO) was released for US$5.

All variants include a Broadcom system-on-a-chip (SoC) with an ARM-compatible central processing unit (CPU) and on-board graphics processing unit (GPU, Video Core IV). The Pi 3's CPU speed ranges from 700 MHz to 1.2 GHz, while on-board memory ranges from 256 MB to 1 GB of RAM. Secure Digital SD cards, available in SDHC and Micro SDHC capacities, are used to store the operating system and program memory. Most cards have one to four USB ports, HDMI and composite video output, and a 3.5mm telephone connector for audio. A number of GPIO pins support standard protocols such as I^2C and provide lower level output. Some models have the 8P8C Ethernet interface, while the Pi 3 has Wi-Fi 802.11n and Bluetooth (see Figure 7).

Fig. 7 Raspberry pi 3

The Foundation makes Debian and Arch Linux ARM variants available for download and promotes Python as the primary programming language.

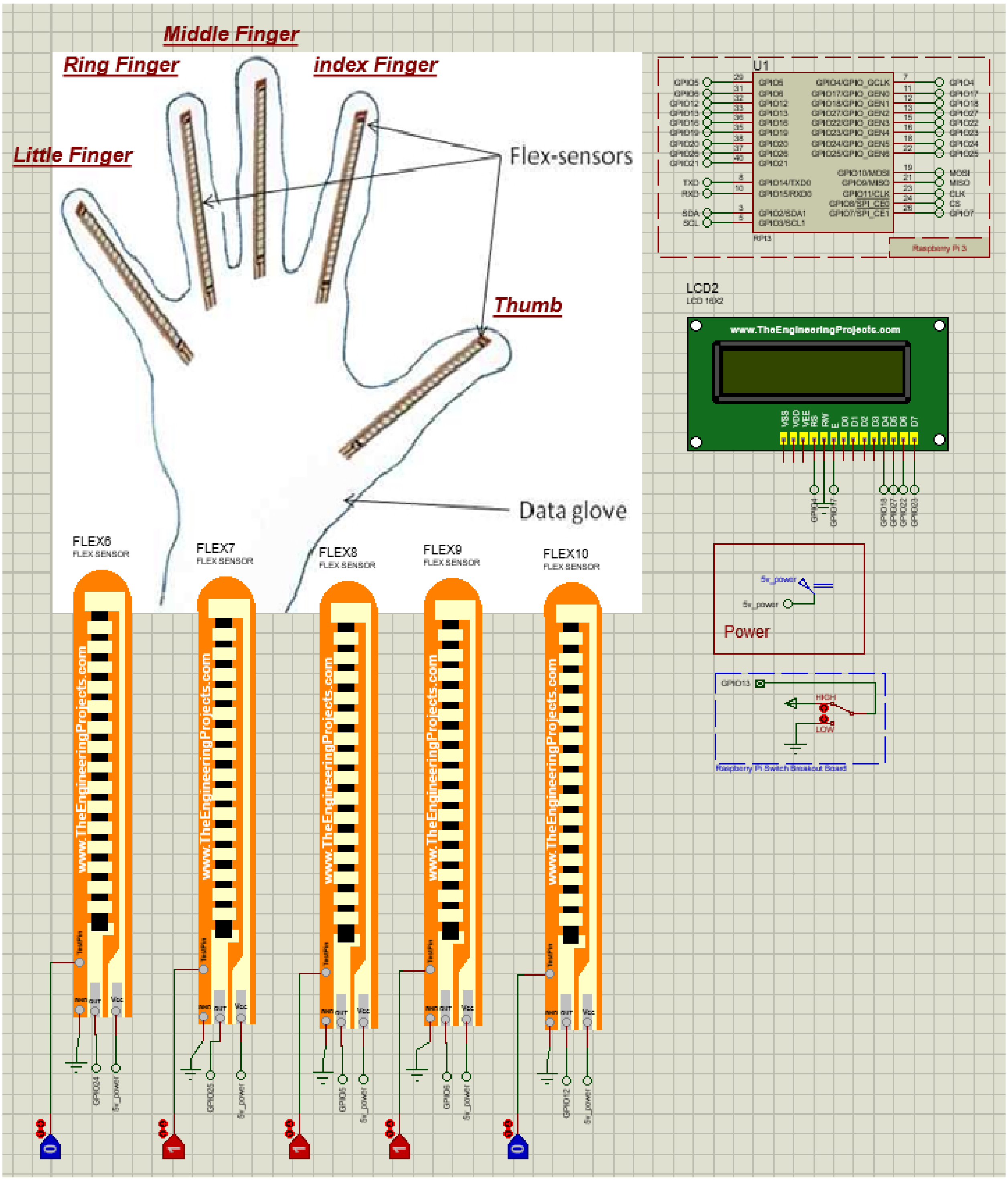

Fig. 8 Screenshot of the Proteus simulation environment

C. *gTTS*

gTTS (Google Text-to-Speech) is a Python library and command line interface for interfacing with Google Translates' text-to-speech API. This API accepts text as input and outputs an audio file. The audio file is then stored in .mp3 or .m4a format or some other format. This .mp3 audio file is then played using a music player.

D. *Stages of system operation*

As shown in the Figure 8, the one-handed glove system simulated using Proteus software includes five flexible sensors, a switch, an LCD display and a Raspberry Pi 3.

The Raspberry Pi recognizes the user's flexible sensor and switch inputs and optionally displays either letters or sentences as output. Table 1 shows the ASL letter outputs generated in response to specific inputs. In this study, the digital flexible sensor was chosen as the flexible sensor type due to its ease of use. Fingers in the open state represent digital 0 data, while fingers in the closed state represent digital 1 data. Numbers can also be assigned instead of characters if required. Depending on the conditions, if analog sensors are used, not only 1 and 0 values can be assigned, but also new output assignments can be made according to the voltage levels of the intermediate values.

When the key is opened, sentences are assigned instead of characters as indicated in Table 2. Sentence groupings can be customized according to the user's preferences and requirements. Input data is converted to audio using gTTS and the converted input data can be displayed on the LCD panel. After the design is finalized in the proteus simulation environment, the project can be realized and customized.

The phrase set of the system can be organized according to the most frequently used sentences in daily life or the most basic requests. Possible sentences that could be added to the system are as follows: Hello, How are you, Take a note, I need water, Can you please help me, Do you have a pen, I'm hungry, I can do it, Thank you. Turn off the lights, I'm tired, I'm satisfied, Where can I find the toilet, Let's go, etc.

Table 1. Examples of input and output containing letters.

Input	Output
[1,1,1,1,0]	a
[0,0,0,0,0]	b
[1,1,1,0,1]	d
[0,0,0,1,0]	f
[0,1,1,1,0]	i
[1,1,1,0,0]	l
[1,1,1,1,1]	s

Table 2. Examples of input and output containing sentences.

Input	Output
[1,1,1,1,0]	I require food.
[0,0,0,0,0]	I need to sleep.
[1,1,1,0,1]	I require water.
[0,0,0,1,0]	Hello, my name is...
[0,1,1,1,0]	I am from...
[1,1,1,0,0]	I require medication.
[1,1,1,1,1]	Please open the window.

III. RESULTS AND DISCUSSION

Creating a glove-based sign language interpreter can greatly improve communication between a hearing person and a deaf/mute person. The main advantage here is that the sensors provide the flexion value directly to the glove and the output can be obtained in a very short time. Also, other gestures can be added to the code to create different characters or words. The proposed system is very easy to develop as the basic components are a Raspberry Pi and an LCD display. A deaf and mute person does not need pen or paper to convey his/her message. This makes communication extremely easy and practical.

In this study, a practical method of recognizing sign language gestures using sensory gloves is proposed. In this system, which can recognize ASL characters or and display sentences, the number of gestures can be increased by using two gloves in the next stages. As a result, sensors or cameras can be incorporated into the system to capture facial expressions. By adding different sensors to the system, eye and lip movements can be added to the database and the scope of the project can be expanded in the future.

IV. CONCLUSION

The presented Raspberry Pi based sign-to-speech conversion system converts sign language into audio through flexible sensors, a switch, an LCD display and gTTS. By converting sign language into audio output, it is aimed to facilitate communication between normal and deaf-mute people in a practical way. A framework similar to the one in this project could be created using different sets of letters (e.g. the Turkish alphabet) to suit different societies.

REFERENCES

[1] A. Babour *et al.*, "Intelligent gloves: An IT intervention for deaf-mute people," *J. Intell. Syst.*, vol. 32, no. 1, Feb. 2023, doi: 10.1515/jisys-2022-0076.

[2] A. Núñez-Marcos, O. Perez-de-Viñaspre, and G. Labaka, "A survey on Sign Language machine translation," *Expert Syst. Appl.*, vol. 213, p. 118993, Mar. 2023, doi: 10.1016/j.eswa.2022.118993.

[3] E. Pontecorvo, M. Higgins, J. Mora, A. M. Lieberman, J. Pyers, and N. K. Caselli, "Learning a Sign Language Does Not Hinder Acquisition of a Spoken Language," *J. Speech, Lang. Hear. Res.*, vol. 66, no. 4, pp. 1291–1308, Apr. 2023, doi: 10.1044/2022_JSLHR-22-00505.

[4] O. Szczepaniak and D. Sawicki, "Gesture controlled

human–computer interface for the disabled," *Med. Pr.*, vol. 68, no. 1, pp. 11–21, Feb. 2017, doi: 10.13075/mp.5893.00529.

[5] J. Bukhari, M. Rehman, S. I. Malik, A. M. Kamboh, and A. Salman, "American Sign Language Translation through Sensory Glove; SignSpeak," *Int. J. u- e-Service, Sci. Technol.*, vol. 8, no. 1, pp. 131–142, Jan. 2015, doi: 10.14257/ijunesst.2015.8.1.12.

[6] K. Gurbanova, "GESTURE LANGUAGE: HISTORY, DEVELOPMENT STAGES AND CURRENT STATE," *Probl. Inf. Soc.*, vol. 09, no. 1, pp. 94–99, Jul. 2018, doi: 10.25045/jpis.v09.i1.10.

[7] K. Shenoy, T. Dastane, V. Rao, and D. Vyavaharkar, "Real-time Indian Sign Language (ISL) Recognition," in *2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, Jul. 2018, pp. 1–9, doi: 10.1109/ICCCNT.2018.8493808.

[8] D. Cotoros, A. Stanciu, and A. Hutini, "Continuously Variable Transmission Vehicle Modeling and Control Algorithm Considering Fuel Efficiency and Driveline Efficiency," *Int. J. Model. Optim.*, pp. 53–57, May 2021, doi: 10.7763/IJMO.2021.V11.777.

[9] A. M. Abd-Elrahim, A. Abu-Assal, A. A. A.-A. Mohammad, A.-I. M. Al-Imam, A.-H. A. Hassan, and M.-A. M. Muhi-Aldeen, "Design and Implementation of Raspberry Pi based Cell phone," in *2020 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE)*, Feb. 2021, pp. 1–6, doi: 10.1109/ICCCEEE49695.2021.9429601.

[10] M. Tiboni, A. Filippini, C. Amici, and D. Vetturi, "Test-Bench for the Characterization of Flexion Sensors Used in Biomechanics," *Electronics*, vol. 10, no. 23, p. 2994, Dec. 2021, doi: 10.3390/electronics10232994.

[11] "Analog and digital flex sensor library for Proteus," *Online: 01 Aug 2023*. https://www.theengineeringprojects.com.