

# BIOMEDICAL GLOVE SYSTEM FOR TRANSLATING HAND GESTURES INTO TEXT USING ARDUINO

Alhasan Abd Alkareem Alnaeme\*<sup>1</sup>, Abdullah Mohammed Siham<sup>2</sup>, Tabarek Akram Mohammed<sup>3</sup>,  
Yousif Jamal Hachim<sup>4</sup>

<sup>1</sup>Al-Kitab University, College of Technical Engineering, Technical Engineering of Medical Devices

<sup>2</sup>Al-Hikma University College, Medical Instruments Techniques Engineering

<sup>3,4</sup>Middle Technical University, Electrical Engineering Technical College, Medical Instruments  
Techniques Engineering

\*Email: [alhasanalnaeme1114@yahoo.com](mailto:alhasanalnaeme1114@yahoo.com)

## Abstract:

This project represents an innovative practical step toward facilitating communication for individuals with hearing and speech impairments, by designing and implementing a device that uses tilt sensors and Arduino technology to convert finger gestures into written text. The results demonstrated that the device features high response speed and an acceptable accuracy rate of approximately 90%, combined with ease of use and low cost compared to other complex systems. Despite challenges such as sensitivity to rapid movements or improper glove fitting, the prototype proved its efficiency and potential for further development. This work opens promising horizons for future improvements, including expanding the set of recognizable gestures and integrating smart features such as wireless connectivity and text-to-speech functionality. Thus, the project highlights the importance of utilizing simple technologies to serve special needs groups and reinforces the concept of human-centered innovation within scientific and engineering research.

**Keywords:** Gesture Recognition, Arduino, Tilt Sensor, Assistive Technology, Hearing and Speech Impairments

## 1. Introduction

The development of societies depends on effective communication between their members, which makes understanding the needs of special groups, such as those with hearing and spectacular disabilities, is very important. This chapter deals with a general background on the importance of developing alternative means of communication, clarifying the goal of the project, and highlighting the challenges it seeks to solve. It also reviews the importance of the project in improving the lives of beneficiaries, and establishes the general framework from which the technical study of this innovation starts.

## **1.1 Background**

Communication between people is one of the fundamental pillars of building and developing societies, as it is the means through which ideas, feelings, and information are exchanged. With the varying abilities of individuals, challenges have emerged for some groups with speech or hearing difficulties, prompting societies to seek alternative methods and approaches for communication. The deaf and mute are among the most vulnerable groups in need of assistive devices for effective communication with others.

Over the ages, methods to assist the deaf and mute have evolved, ranging from traditional sign language to the use of modern technologies aimed at improving the quality of communication and increasing the integration of this important group into society.

With significant advances in technology, programming, and electronics, there are vast opportunities to develop smart devices that facilitate communication more effectively and quickly.

Recent innovations, such as microsensors, microprocessors, and microcontrollers, have facilitated the design of technological solutions capable of capturing body signals and hand movements and converting them into understandable forms of written or spoken language. This opens new horizons for supporting and empowering people with special needs and achieving the principle of equality in human communication [1].

## **1.2 Aim of the Project**

This project aims to design and implement a smart device that helps the deaf and mute convert hand signals and finger movements into understandable text, instantly displayed on a display. This device facilitates communication between the hearing-impaired and those around them, using simple and practical technologies such as tilt sensors and the Arduino platform. It also ensures ease of use and low cost, making it a practical solution accessible to a wider range of users [1].

## **1.3 Problems Project**

Deaf and mute individuals face significant challenges in communicating effectively with those who do not master sign language, leading to difficulties communicating their needs, thoughts, and feelings. Although traditional means such as writing or hand signals exist, they are often slow or incomprehensible to all segments of society, limiting their full integration into daily life.

With rapid technological development, numerous technical solutions have emerged aimed at improving communication methods for people with special needs. However, many of these solutions still suffer from complexity, high cost, or limited performance.

Hence, the need to develop a simple and effective device based on modern technologies that can quickly and directly convert hand signals and finger movements into written text, facilitating communication and enhancing the independence of deaf and mute individuals in various social situations [1].

## **1.4 Significance of the Project**

The project's importance stems from its vital role in supporting the deaf and mute, enabling them to communicate more easily and clearly with the community. This contributes to improving their quality of life and increasing their self-reliance in daily interactions. The project also offers a low-cost technological solution compared to traditional methods or other advanced devices, and promotes the idea of integrating simple technologies with innovation to serve important humanitarian causes. Furthermore, the project represents an important step toward raising community awareness of the importance of developing practical solutions to the problems of people with special needs [2].

## **2. Literature Review**

The review of previous studies is a scientific basis for understanding the research path related to the development of deaf and dumb devices. This chapter reviews the most prominent innovations that relied on sensor, computer vision and artificial intelligence techniques, explaining the strengths and palaces in each study. These efforts are also compared to the current project to highlight aspects of excellence and innovation in the proposed design.

### **2.1 Previous studies**

The development of assistive devices for the hearing impaired has witnessed significant progress in recent years. One of the most notable projects is the "Talking Glove," developed by researcher T.K.

Bhattacharyya and colleagues in 2014 [3]. Flexible sensors (flex sensors) were attached to the fingers to measure the curvature of each finger. After processing the data using a microcontroller, the signals were converted into spoken words via an audio module. This project represented an important step in facilitating communication for people with special needs, but its high cost and complex construction limited its potential for widespread adoption.

Another study conducted by researcher S. Starner and colleagues in 1998 [4] relied on computer vision techniques, where hand movements were captured and analyzed using machine learning algorithms to convert them into understandable text. This method achieved accurate results, but required controlled lighting and specific shooting angles, as well as high-performance computing devices, which limited its practical use in everyday life. In a 2002 study, researcher J. Kadous developed a smart glove that used curvature sensors connected to an Arduino platform to read finger movements and convert them into digital codes displayed on a small display.

This glove was simple and affordable, but its effectiveness was limited to a limited number of signals, and the sensors required high precision to avoid misreading movements.

In 2016 [5], researcher H. Kadry and his team developed a smart glove that uses Bluetooth technology to send finger movement data to a smartphone app, where the data is processed and translated text is displayed. This type of project added wireless connectivity, but relying on a phone connection can lead to problems in weak connectivity environments or application glitches.

Other studies have also relied on accelerometers, such as the 2012 [6] study by researcher C. Wilson, which used accelerometers to monitor hand movements in space and convert directions and speeds into text signals. The method was effective with large hand movements, but it was not accurate enough to distinguish subtle signals from finger movements.

In 2015 [7], researcher O. Koller and colleagues presented a project using artificial intelligence to analyze videos of sign language movements and convert them directly into text by training neural networks. Despite the high accuracy achieved by the system, the need for large databases and powerful hardware made this method unsuitable for simple or personal use [4].

## **2.2 Comparison Between previous & Current Studies**

Previous studies utilized advanced technologies such as flexible sensors, computer vision, and accelerometers, as well as artificial intelligence to process signal data. However, most of these projects faced challenges such as high cost, the need for ideal operating environments, and the complexity of design and use.

In contrast, the current project relies on a simpler and less expensive architecture using tilt sensors and an Arduino platform to convert signals into direct text displayed on an LCD screen. This design allows for ease of use, reduces cost, and makes the device practical for serving people with special needs effectively without the need for complex technologies or special operating environments. [8].

## **2.3 Summary of Previous Studies**

A review of previous studies has shown significant and ongoing efforts in developing technological communication tools for the hearing impaired, whether through the use of smart gloves based on curvature sensors, computer vision technologies, or artificial intelligence systems. Researchers have sought to achieve high accuracy in recognizing signals and converting them into understandable text or voice. However, most of these studies have faced challenges related to high manufacturing costs, complex system design, and the need for special operating environments or advanced hardware. From this perspective, the current project offers an alternative solution that focuses on simplicity and effectiveness by utilizing simple tilt sensors with an Arduino microcontroller and an LCD display. This provides an easy and low-cost way to convert hand gestures into text, helping improve communication for the hearing and visually impaired with their surroundings in a practical and effective manner [9], [10].

## **3. Components & Methodology**

To achieve the goals of the project, it was necessary to choose appropriate electronic components and determine the methodology of linking them and programming in a way that ensures the accuracy of performance and operation efficiency. This chapter reviews the basic elements of the system, such as sensors, control and screen unit, with an explanation of the connection and operation mechanism. The

software structure approved to achieve the immediate interaction between the movement of the hand and the display of texts, which achieves an ideal integration between technical simplicity and the human function.

### 3.1 Components

In our current project we used the following components:

#### 1) Arduino Uno

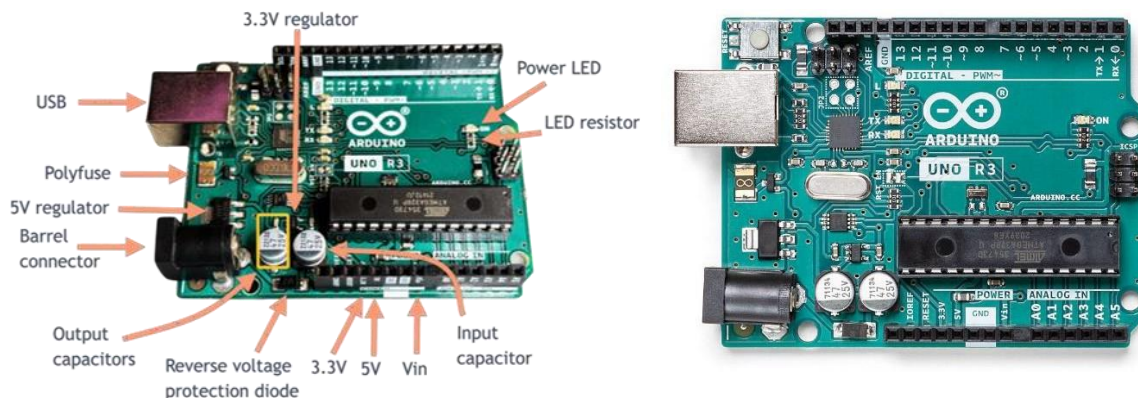
The Arduino Uno is a series of open-source microcontroller board based on a diverse range of microcontrollers (MCU). It was initially developed and released by Arduino company in 2010. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable.

It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery. It has the same microcontroller as the Arduino Nano board, and the same headers as the Leonardo board.

Arduino Uno is a smart electronic plate that works as a "brain" of the device. His mission is:

- Receive the signals coming from the inclination sensors.
- Read any move and any sensor send a signal.
- Translating this reference to a suitable word according to a specific programming within the device.
- Send the floor to the display screen for the user or others.

Arduino is easy to program with a computer, supports connecting several devices and receiving many signals at the same time, making it ideal for building practical models such as this project.



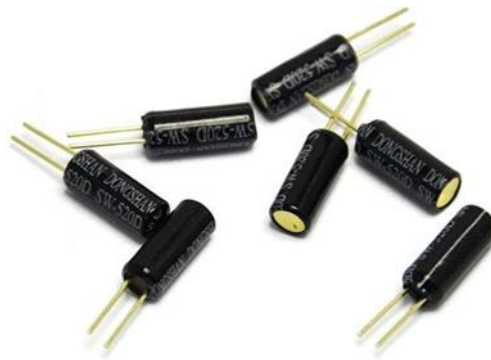
**Figure 1.** Arduino Uno.

#### 2) Tile Ball Switch sensor

The tile sensor is a very simple device, similar to a small ball placed inside a tube. When the sensor is in a specific position (fixed or straight), the electrical circuit is open (i.e. not passing the current) and when it is tilted or moved due to the movement of the finger or the hand, the metal ball moves inside the tube and closes the electrical circuit, sending a signal to the controller (Arduino).

In this project, 8 sensors were installed on the glove so that each sensor is responsible for monitoring a specific finger movement. Moreover, based on any finger that moves, the right word is determined to display on the screen.

The main advantage of this type of sensors is that it is simple, fast to respond and is materially expensive.



**Figure 2.** Tile Ball Switch sensor.

### 3) Electrical Resistance (Resistor 10 K $\Omega$ )

The electrical resistance is an electronic component used to control the amount of electrical current that passes in the circuit. In this project, 10 km resistance was placed in parallel with each mile sensor. Her role here is very important:

- It protects the circle from sudden high currents.
- It ensures that the electrical signal is stable and accurate.
- It prevents vibration or cut signals from the sensor movement.
- Consequently, the presence of resistors makes reading movements across Arduino more reliable and without errors.



**Figure 3.** Electrical Resistance.

### 4) LCD Liquid Crystal Display I2C

The display is the part that shows the words of the user.

The screen works with the i2C, which means that it only needs two wires to connect with the Arduino (instead of several wires), which reduces the complexity of the circle and provides the space.

When the user moves his finger in a certain way, the device recognizes this movement and the right word appears on the screen clearly.

The screen is characterized by being small, easy to read, and consumes low energy, which makes it perfect for this type of portable project.



**Figure 4.** LCD Liquid Crystal Display I2C.

### 5) Battery 9 V

The battery is the power source that operates all parts of the device.

Using a 9 -volt battery, the device can work completely independently without having to connect it to

an electric socket.

The battery provides a fixed and strong current to operate the Arduino, the sensors and the display together, and allows the device to carry and use it easily anywhere.



**Figure 5.** Battery 9 V.

#### 6) Hand Gloves

Glove is the physical structure that carries all ingredients related to fingers.

The inclination sensors are installed above the glove, specifically at the places of the fingers, so that they capture accurately any small movement.

The glove is a crucial part to ensure the stability of the sensors during the natural movement of the hand, which gives accurate and comfortable results to the user without feeling heavy or discomfort.



**Figure 6.** Hand Gloves.

#### 7) Electrical Wires

The wires here are the mediator that transfers electricity and signals between all components of the device.

Each mile sensor has two wires: one to connect with Arduino and the second is to connect with resistance or ground.

Wires are also used to connect the display screen with Arduino, as well as connect the battery to feed the circuit with electricity.

Flexible and light wires are chosen in order not to hinder the movement of the glove, and until the device remains comfortable when long use.

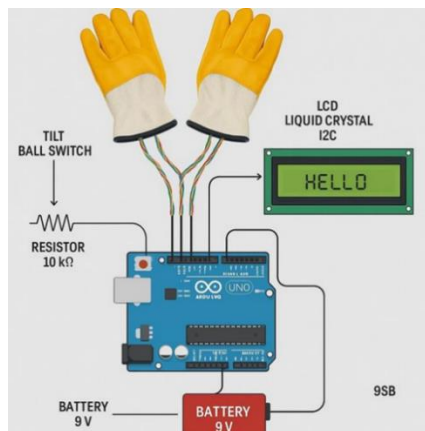


**Figure 7.** Electrical Wires.

### 3.2 Methodology

The methodology of linking the components of the device depends on the principle of integration between sensors, the treatment unit, and the output unit, in order to achieve the required performance accurately and efficiently. Initially, the tunnel sensors are installed on the glove at suitable locations over the joints of the fingers, so that each sensor can sensitize a specific finger movement. Each sensor is connected directly to the Arduino UNO panel through flexible electrical wires, with the addition of an electrical resistance of 10 km to each signal line to increase signal stability and prevent electrical

noise. The wires secure the connection between inclination sensors and the digital Arduino inputs, so that any movement is monitored immediately. As for the liquid crystal display (LCD i2C), it is connected to the Serial Communication Ports (SCL and SDA) on the Arduino plate using the i2C protocol, which reduces the number of wires required for delivery, provides accuracy and speed in sending data to the screen. The circuit is fully fed with a 9-volt battery, where it is reached to the power entrance in the Arduino UNO to provide enough effort to operate all ingredients continuously. This method of linking ensures that the signals resulting from the movement of the fingers are transferred smoothly to the processor (Arduino), which it analyzes immediately according to the program stored inside it, then sends the opposite word to the LCD screen to display it clearly and quickly. This arrangement and linking the components were carefully chosen to be lightweight, comfortable, and fast to respond to movements, to serve the primary goal of the project, which is to improve the communication of people with hearing and spectacular needs with their surroundings in an easy and effective way.



**Figure 8.** Connection diagram.

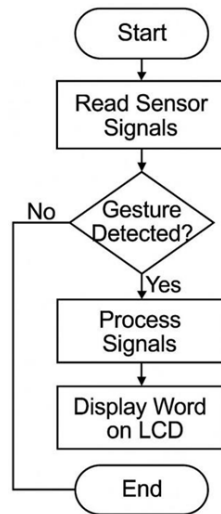
### 3.3 Device operating system

The device depends on a simple built-in operating system based on the ARDUINO UNO control plate using the Arduino Ide environment. The idea of the operating system is to read the signals coming from the inclination sensors (Tilt Ball Switches) on gloves, and analyze these signals to determine the type of movement or signal from the user's hand. When moving a specific finger, the sensor installed on it sends an electrical signal to the Arduino via the connected wires and resistors. The previously stored programming inside the Arduino processes these signals using the IF-LESE Statements, where any active sensor is currently verified and the movement matches with the pre-defined word.

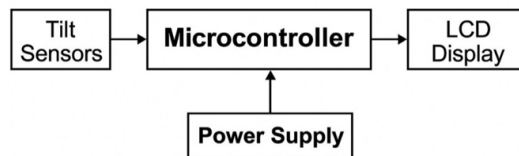
Once the corresponding word is determined, the Arduino sends this word via the Serial Communication Protocol (i2C) to the LCD screen to display the user immediately. The device is completely operated by a 9-volt battery, allowing it to work independently without the need for a permanent connection with an external electrical source. The device's operating system is characterized by simplicity, speed in processing, and high accuracy in the interpretation of motor signals, with the possibility of expanding later to add more movements and words as needed.

- Flowchart

A flowchart is a diagram that visually depicts the sequence of steps a device takes, from receiving finger movement signals via sensors, through processing them within the Arduino, to displaying the appropriate text on the screen. This type of diagram is used to simplify understanding of how a system works, using standard symbols such as arrows, rectangles, and diamonds.



**Figure 9.** Flowchart of Device.



**Figure 10.** Block diagram of Device.



**Figure 11.** Final form of the device.

#### 4. Performance Evaluation

This chapter represents the summary of the experimental stages of the project, where the achieved results are presented and the effectiveness of the device is analyzed in achieving its goals. It also discusses the advantages of the final model and the challenges that have emerged during implementation, while submitting proposals for future development. The study concludes with scientific conclusions that enhance the importance of research and open up prospects for more innovation in the field of supporting people with special needs.

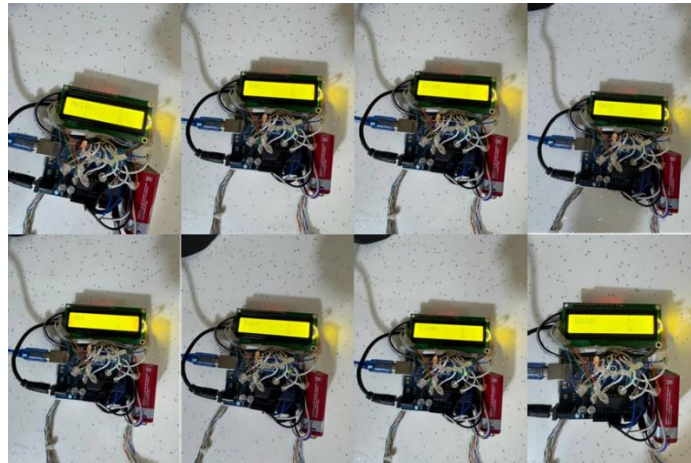
##### 4.1 Results

After the successful implementation and design of the device, test results showed that the electronic glove was able to convert finger movement signals into text displayed accurately on an LCD screen. The device featured a high response speed, with the conversion process taking less than one second. The displayed text also displayed good clarity and was easy to read without noticeable delay. The device was found to achieve a motion recognition accuracy rate of approximately 90% under normal

operating conditions, allowing it to be used effectively to communicate with surrounding people. Furthermore, the device proved its reliability during repeated tests, achieving stable performance in 45 out of 50 successful tests. In terms of power, the device operated on a 9-volt battery for up to three hours of continuous operation.

However, it was noted that very fast movements or violent glove movement may affect the sensing accuracy, and that gloves that are not properly sized may reduce performance, necessitating adjustment of these factors to obtain better results.

- Right palm from the little finger
  - 1 Hot
  - 2 Cold
  - 3 Pain
  - 4 Sleep
- Left palm from the little finger
  - 1 Eat
  - 2 Drink
  - 3 Help
  - 4 Hello



**Figure 12.** Experimental results.

#### **4.2 Advantages Project**

1. High response speed to finger movement signals.
2. Signal-to-text conversion accuracy of approximately 90%.
3. Ease of use without the need for complex training.
4. Low manufacturing cost compared to other systems.
5. Low power consumption allows for long-term operation using a 9-volt battery.\
6. Portable and mobile use of the device, independent of fixed power sources.

#### **4.3 Disadvantages Project**

1. Reading accuracy is affected by very rapid movements or violent vibrations.
2. Performance is reduced if the user wears an inappropriate glove.
3. Limited number of movements or signals that can be distinguished.
4. Sensors need to be periodically reset to ensure accuracy.
5. The device is designed for simple movements and does not support complex or sequential signals.

#### **5. Conclusion**

Concluding this research, we were able to design and implement a practical device based on simple and accessible technologies to convert finger gestures into written text using Arduino. The results demonstrated that the device effectively facilitates communication for people with hearing and speech disabilities, enhancing their integration into society and achieving greater independence. Despite the technical challenges facing the project, such as the need to improve the accuracy of

sensing and responding to rapid movements, the prototype proved its efficiency in terms of speed, accuracy, and low cost.

This project opens up vast horizons for future development, whether by increasing the number of recognized signals or by integrating new technologies such as wireless control and automated text pronunciation. In conclusion, we emphasize that innovation in the service of humanity, especially those with special needs, is one of the noblest goals of scientific and engineering research, and that this project represents a promising first step towards more smart solutions that serve society.

### **Suggestions & Recommendations**

1. Developing the software to add more signals and words.
2. Using more precise types of sensors, such as flex sensors.
3. Integrating wireless connectivity (Bluetooth or Wi-Fi) to display results on other devices, such as smartphones.
4. Improving the glove design to be more comfortable and compatible with different hand sizes.
5. Adding a voice pronunciation feature for displayed texts to further support people with special needs.
6. Improving the system's resistance to noise and random movements by improving the software algorithms.
7. Developing the power source using rechargeable batteries to increase operating time.

### **References**

- [1] R. Kaur and P. Vig, "Assistive Technology for Communication Disorders: A Review of Sign Language Recognition Systems," *International Journal of Computer Applications*, vol. 178, no. 43, 2019. doi: 10.5120/ijca2019918805 (<https://doi.org/10.5120/ijca2019918805>).
- [2] T.K. Bhattacharyya, A. Sharma, and P. Saha, "Talking Glove for Speech Impaired," *International Journal of Engineering Research and General Science*, vol. 2, no. 1, pp. 196–202, Jan 2014.
- [3] S. Starner, J. Weaver, and A. Pentland, "Real-Time American Sign Language Recognition Using Desk and Wearable Computer-Based Video," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 20, no. 12, pp. 1371–1375, Dec. 1998. doi: 10.1109/34.735811 (<https://doi.org/10.1109/34.735811>).
- [4] J. Kadous, "Machine Recognition of Auslan Signs Using PowerGloves: Towards Large-Lexicon Recognition of Sign Language," *Proceedings of the Workshop on the Integration of Gesture in Language and Speech*, pp. 165–174, 1998.
- [5] O. Koller, H. Ney, and R. Bowden, "Deep Learning of Mouth Shapes for Sign Language," *Proceedings of the IEEE International Conference on Computer Vision Workshops (ICCVW)*, 2015. doi: 10.1109/ICCVW.2015.120 (<https://doi.org/10.1109/ICCVW.2015.120>).
- [6] C. Wilson and M. Bobick, "Recognition and Interpretation of Parametric Gesture," *Proceedings of the IEEE International Conference on Computer Vision*, pp. 329–336, 1995. doi: 10.1109/ICCV.1995.466892 (<https://doi.org/10.1109/ICCV.1995.466892>).
- [7] H. Kadry, A. Ezzat, and M. R. Mokhtar, "Smart Glove for Sign Language Recognition Using Flex Sensors," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 7, no. 12, pp. 369–374, 2016. Doi 10.14569/IJACSA.2016.071250 (<https://doi.org/10.14569/IJACSA.2016.071250>).
- [8] A. M. Zadeh, T. Baltrušaitis, and L.-P. Morency, "Convolutional Experts Constrained Local Model for 3D Facial Landmark Detection," *Proceedings of the IEEE International Conference on Computer Vision Workshops (ICCVW)*, 2017. doi: 10.1109/ICCVW.2017.152 (<https://doi.org/10.1109/ICCVW.2017.152>).
- [9] Arduino Official Website, "Arduino Uno Rev3," [Online]. Available: <https://store.arduino.cc/products/arduino-uno-rev3>. [Accessed: 25-Apr- 2025].
- [10] M. AlZain and A. Al-Harbi, "Survey on Sign Language Recognition Using Machine Learning Techniques," *International Journal of Computer Applications*, vol. 182, no. 24, 2019. doi: 10.5120/ijca2019918717 (<https://doi.org/10.5120/ijca2019918717>).