IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

Gesture Based Communication Device for Speech and Text Conversion

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Abstract: *The message displayed will also help deaf people to understand their thoughts. This Sign language and facial expressions are the major means of communication for the speech flawed people. General people can understand the facial expression to an extent but cannot understand the sign language. Dumb people are unable to express their thoughts to normal humans. To reduce this gap of communication, this paper presents an electronic system which will help the mute people to exchange their ideas with the normal person in emergency situations. The system consists of a glove that can be worn by the subject which will convert the hand ges-tures to speech and prototype involves arudino as the micro-controller along with the groscopesenser.*

Keywords: Gyroscope sensor, Esp 12 E, DF Player, Arduino UNO, lcd.

I. INTRODUCTION

This project introduces an innovative system that leverages spatial orientation to provide context-aware audio feedback, creating an intuitive interaction model based on motion. The system is designed to detect the angular position of an object or user and map specific angles to predefined audio messages, enabling real-time verbal guidance. As the orientation changes, the system dynamically triggers distinct audio outputs, offering relevant information or instructions without requiring physical touch or visual focus. This approach significantly enhances user interaction, particularly in scenarios where traditional input methods like touchscreens or visual cues may not be ideal. The system's responsiveness to movement ensures that each shift in angle corresponds precisely to the intended message, providing a seamless and engaging experience. Such a solution is particularly valuable in assistive technologies, where it can aid individuals with visual impairments or other accessibility challenges. Additionally, the system has broad applications in educational environments, immersive learning experiences, interactive museum tours, and even physical therapy, where real-time feedback enhances the learning or therapeutic process.

II. RELATED WORK

Gesture-based communication devices have gained significant attention as assistive technologies for individuals with speech disabilities. Several systems have utilized wearable sensors such as accelerometers and gyroscopes to capture hand movements and interpret them into meaningful outputs. Early implementations primarily focused on static gesture recognition using flex sensors and accelerometers, converting gestures into text displayed on an LCD screen. However, these systems often lacked real-time speech output or wireless connectivity, limiting their usability.

Recent approaches have incorporated gyroscope modules like the MPU6050 and microcontrollers such as Arduino and ESP-12E to improve gesture detection accuracy and enable wireless data transmission. Some systems also employed Wi-Fi modules for sending data to cloud-based platforms, though this introduced latency and dependency on internet connectivity.

To overcome these limitations, newer designs integrate local components such as DF Player Mini for offline voice playback and LCD displays for visual feedback. These enhancements eliminate the need for external APIs, making the devices more portable, power-efficient, and reliable in real-time usage scenarios. Furthermore, the combination of gyroscope-based motion tracking with onboard audio and text output provides a practical, low-cost solution for gesture-

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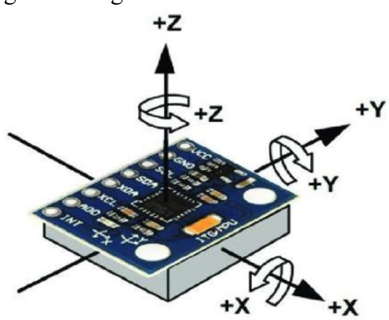
to-speech and text communication, especially beneficial in regions with limited access to advanced medical or communication facilities.

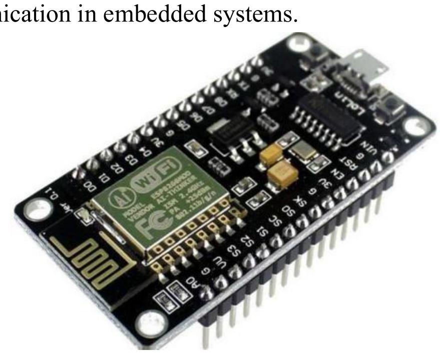
III. SPECIFICATIONS

ARDUINO: The Arduino Uno R3 is the central processing unit of the proposed system. Based on the ATmega328P microcontroller, it operates at 16 MHz and features 32 KB Flash memory and 2 KB SRAM. It is responsible for collecting data from the gyroscope sensor, interpreting gestures, and triggering appropriate actions such as playing audio and displaying text. The board supports multiple digital and analog I/O pins for interfacing with various components. Its compatibility with the Arduino IDE and wide support for libraries make it a suitable choice for rapid development and reliable control of gesture-based communication systems for speech-impaired users.

GYROSCOPE: The MPU6050 sensor module is a MEMS-based device that combines a 3-axis gyroscope and a 3-axis accelerometer in a single chip. It detects rotational motion and linear acceleration of the user’s hand, enabling accurate gesture recognition. This sensor communicates with the Arduino through the I2C protocol, ensuring efficient and synchronized data transfer. The module operates at 3.3V–5V and provides real-time orientation data, which is filtered and mapped to specific gestures. This component plays a critical role in identifying dynamic hand movements, thus allowing users to convey messages through natural gestures converted into text and audio outputs by the system.



ESP 12E: The ESP-12E module, built on the ESP8266 chipset, is used to provide optional Wi-Fi connectivity for future system enhancements. It supports IEEE 802.11 b/g/n standards and operates in the 2.4 GHz band. With its integrated TCP/IP stack and UART communication interface, it can transmit gesture data or system status to external devices or servers. Although the current prototype functions offline, the module is included to support remote data logging or IoT applications in future iterations. It operates at 3.3V and can be programmed or controlled via AT commands, making it a flexible option for wireless communication in embedded systems.



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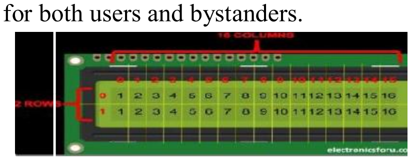
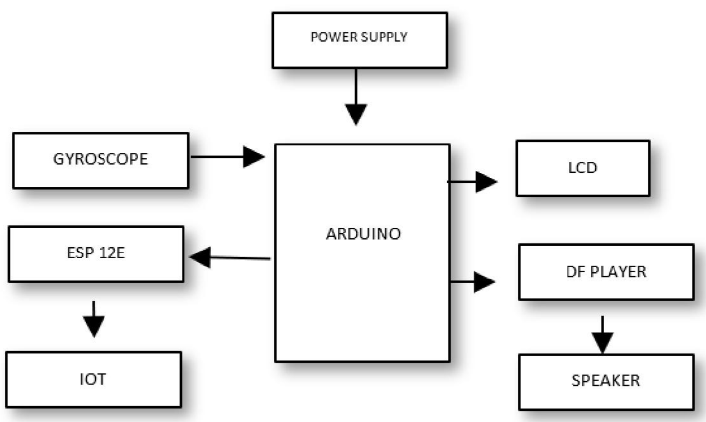
DF PLAYER: The DF Player Mini is a standalone MP3 player module capable of playing audio files stored on a microSD card. It communicates with the Arduino via UART and supports MP3 and WAV file formats. This module is crucial for converting recognized gestures into corresponding voice messages, allowing non-verbal users to "speak" using the device. The DF Player Mini features built-in DAC and supports a simple command set for audio control. It operates at 3.2V–5V and includes onboard buttons, though control is automated through the Arduino in this application. Its compact size and offline playback capability enhance device portability and usability.

LCD DISPLAY: The 16x2 LCD display is used to show the textual interpretation of recognized gestures. It can display 16 characters per line across two lines and operates on 5V. Based on the HD44780 controller, it is commonly interfaced with the Arduino via a parallel or I2C interface. The LCD enhances the user experience by providing visual feedback, helping users confirm that their gestures are correctly interpreted. It is especially helpful in noisy environments where audio output may not be effective. The display provides a secondary communication method that increases the system's accessibility and supports interaction for both users and bystanders.



IV. BLOCK DIAGRAM



V. WORKING

The system operates by detecting hand gestures using the MPU6050 gyroscope-accelerometer sensor, which continuously monitors hand movement in three axes. The sensor data is transmitted to the Arduino Uno via the I2C protocol. The Arduino processes this data to identify specific gesture patterns based on predefined threshold values. Once a gesture is recognized, it triggers the corresponding audio file to be played from the DF Player Mini, delivering speech output through the speaker. Simultaneously, the text equivalent of the gesture is displayed on the 16x2 LCD screen. This allows real-time gesture-to-speech and text communication without internet dependency.

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VI. SIMULATION

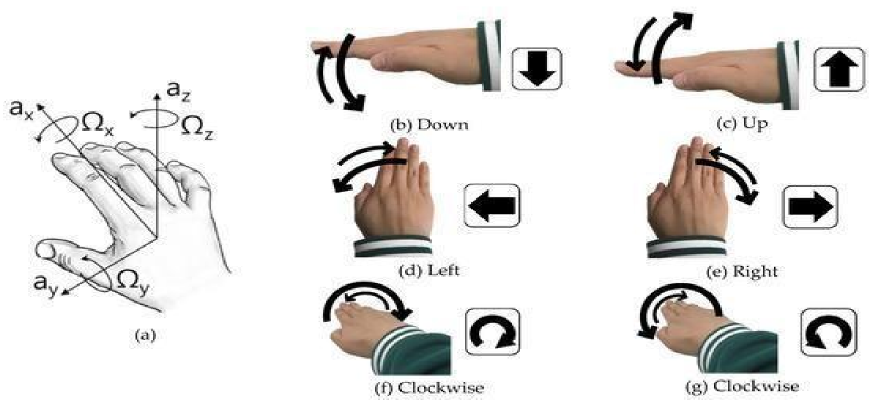
The simulation of the system was conducted using Proteus Design Suite and Arduino IDE to validate circuit functionality before hardware implementation. In Proteus, virtual models of the Arduino Uno, MPU6050 sensor, LCD, and DF Player Mini were integrated to emulate the physical setup. Gesture input was simulated by manually adjusting sensor values to represent hand movements. The Arduino code was uploaded within the simulation to verify data processing, gesture recognition logic, and output response. The LCD displayed the corresponding text output, and simulated audio triggers confirmed correct gesture-to-speech mapping. This helped identify and fix logic or wiring issues before physical testing.

A. SYSTEM SETUP

The system setup consists of several interconnected components. The Arduino Uno is the central unit, responsible for processing input from the MPU6050 gyroscope and accelerometer sensor. The sensor is placed in a suitable position for detecting hand movements and gestures. The Arduino communicates with the DF Player Mini for audio output and with the LCD display for visual output. Power is supplied either via USB or a battery pack. The ESP-12E module, though not essential for basic operation, provides potential for future wireless communication. The system is housed in a portable casing, ensuring ease of use for the user.

B. PROCESS FLOW

The process flow begins with the user performing a gesture, detected by the MPU6050 sensor, which tracks hand movements and orientation. The sensor transmits this data to the Arduino Uno, where it is processed using predefined gesture recognition algorithms. The Arduino compares the sensor data to a set of gestures stored in memory and identifies the appropriate gesture. Once recognized, the system triggers the corresponding audio file stored in the DF Player Mini for speech output and displays the text equivalent on the LCD. This process occurs in real-time, providing seamless communication feedback to the user.



S.no	angle	Gyroscope Reading (°/s)	Detected Output	Accuracy
1	Hand tilt up	Pitch: +150, Yaw: ~0, Roll: ~0	"Hello"	✓
2	Swipe right	Yaw: +200, Pitch: ~0	"Yes"	✓
3	Swipe left	Yaw: -190, Pitch: ~0	"No"	✓
4	Circular motion	Yaw/Pitch fluctuating continuously >150	"Help"	✓
5	Ambiguous movement	Inconclusive	None	✗

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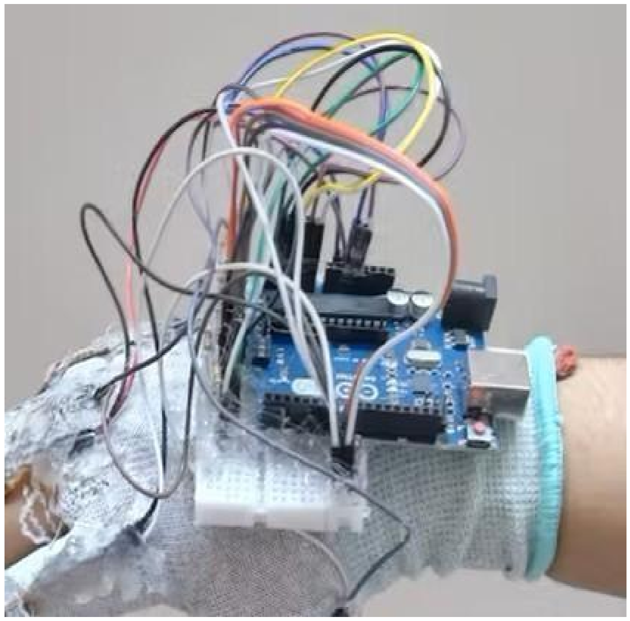
IMPLICATIONS AND APPLICATIONS: Discuss the implications of the project findings for various applications and domains, such as assistive technology, human-computer interaction, and immersive experiences. Highlight potential use cases and future directions for research and development. Table 1. Comparison of displacement of all 4 cases



VII. CONCLUSION

This gesture-based communication device effectively converts hand gestures into speech and text, providing a practical solution for speech-impaired individuals. Using cost-effective components such as the Arduino Uno, MPU6050 gyroscope, DF Player Mini, and LCD, the system enables real-time interaction without relying on external devices or internet connectivity. The integration of gesture recognition, text display, and audio feedback ensures a comprehensive communication method. The device offers portability, ease of use, and reliability, with potential for further improvements in gesture recognition accuracy and additional language support. Future developments could focus on enhancing wireless capabilities and improving real-time performance.

FUTURE ENHANCEMENT

Future developments of the gesture-based communication device can include several improvements for increased functionality and user experience. The integration of more advanced sensors, such as 3D accelerometers or machine learning-based models, could enhance gesture recognition accuracy and allow for more complex gestures. Incorporating cloud connectivity through the ESP-12E module could enable real-time data storage and remote updates. Expanding the text-to-speech capabilities to support multiple languages and dialects would broaden its accessibility. Additionally, enhancing the battery life and optimizing the system for wearable applications would increase its portability, making it suitable for continuous use in daily activities.

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DOI: 10.48175/IJARSCT-26750