Smart Patient Assistance System Using Sign Language to Speech Conversion with Flex Sensors

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Abstract—**Communication between patients with speech or hearing impairments and caregivers remains a significant challenge in healthcare environments. Traditional methods such as manual sign interpretation or written communication are often inefficient, time-consuming, and prone to misinterpretation. To address this issue, this paper presents a Smart Patient Assistance System using Sign Language to Speech Conversion with Flex Sensors.The proposed system utilizes flex sensors embedded in a glove to detect finger movements corresponding to predefined sign language gestures. These sensors measure the bending of fingers and convert the analog signals into digital data using a microcontroller. The processed signals are then mapped to specific words or phrases, which are converted into audible speech using a text-to-speech module.**

Keywords: Sign Language Recognition, Flex Sensors, Patient Assistance System, Speech Conversion, Embedded Systems, Arduino, Assistive Technology, Gesture Recognition, Text-to-Speech, Healthcare IoT.

I. INTRODUCTION

In recent years, Communication is a fundamental aspect of human interaction, especially in healthcare environments where accurate and timely exchange of information is critical. However, patients suffering from speech or hearing impairments often face significant challenges in expressing their needs and interacting with caregivers. Traditional communication methods such as writing, manual gestures, or reliance on interpreters are often inefficient, time-consuming, and may lead to misunderstandings, particularly in emergency situations.

With the rapid advancement of embedded systems and assistive technologies, there has been a growing interest in developing intelligent systems that can bridge the communication gap for differently-abled individuals. Sign language is one of the most widely used forms of communication among speech-impaired individuals. However, not all caregivers or medical staff are trained to understand sign language, which creates a barrier in effective communication.

This project presents a Smart Patient Assistance System using Sign Language to Speech Conversion with Flex **Sensors**, aimed at addressing these challenges. The system utilizes flex sensors embedded in a wearable glove to detect finger movements corresponding to specific sign language gestures. These sensors measure the bending of fingers and generate electrical signals, which are processed by a microcontroller. The processed signals are then mapped to predefined messages or commands.

The system further integrates a text-to-speech module to convert the recognized gestures into audible speech, allowing patients to communicate their needs clearly and effectively. Additionally, an LCD display is used to show the corresponding text output, ensuring better understanding for both patients and caregivers.

The proposed system is designed to be simple, cost-effective, and user-friendly, making it suitable for use in hospitals, rehabilitation centers, and home care environments. By automating the process of sign language interpretation, the system reduces dependency on human assistance and improves communication efficiency.

Overall, this project aims to enhance patient care by providing an innovative assistive solution that enables real-time communication, promotes independence, and improves the quality of life for individuals with speech impairments.

II. REVIEW LITERATURE SURVEY

Recent advancements in assistive technologies have focused on improving communication for individuals with speech and hearing impairments using embedded systems and sensor-based approaches. Traditional communication methods such as writing or manual interpretation are widely used; however, they are often slow, inconvenient, and prone to misinterpretation, especially in critical healthcare situations [1].

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To overcome these limitations, several researchers have proposed sign language recognition systems using vision-based techniques. These systems utilize cameras and image processing algorithms to capture and interpret hand gestures. Although such systems provide accurate gesture recognition, they require high computational resources, controlled environments, and are sensitive to lighting conditions, making them less practical for real-time applications [2].

In recent years, sensor-based systems using flex sensors have gained significant attention. These systems detect finger bending and convert physical gestures into electrical signals, which are then processed by microcontrollers. Compared to vision-based systems, flex sensor-based approaches are more reliable, cost-effective, and suitable for wearable applications [3].

Some studies have also integrated Arduino-based systems with text-to-speech modules to convert gestures into audible output. These systems provide real-time communication and are widely used in assistive healthcare technologies. However, many existing systems lack portability, scalability, or multi-language support [4].

Additionally, IoT-enabled solutions have been explored to enhance remote communication and monitoring, allowing data to be shared across devices. Such integrations improve accessibility and usability in smart healthcare environments.

Based on the reviewed literature, it is evident that a combination of flex sensors, microcontroller-based processing, and speech output systems provides an efficient, reliable, and cost-effective solution for assisting speech-impaired individuals. The proposed system builds upon these approaches to deliver an improved real-time communication solution for patient care.

III. RESEARCH METHODOLOGY

The proposed system is designed to assist patients in communicating their needs using sign language gestures, which are converted into speech using embedded system components

A. System Design

The system consists of a glove embedded with flex sensors, a microcontroller (Arduino), an LCD display, and a text-to-speech module. The sensors detect finger movements and send signals to the microcontroller.

B. Data Acquisition

Flex sensors continuously monitor the bending of fingers. The variation in resistance due to finger movement is converted into analog signals.

C. Data Processing

The Arduino reads the sensor values, processes the signals, and maps them to predefined gestures stored in the system.

D. Display Unit

An I2C LCD display is used to show the recognized text corresponding to the gesture for better understanding.

E. Alert Mechanism

The processed text is converted into speech using a text-to-speech module, enabling verbal communication.

IV. PROPOSED METHODOLOGY

The proposed Smart Patient Assistance System is designed to provide an efficient and user-friendly communication interface for speech-impaired patients using gesture recognition technology. The system integrates flex sensors, a microcontroller (Arduino), an LCD display, and a text-to-speech module to enable real-time conversion of sign language gestures into audible speech.

In this methodology, a wearable glove embedded with multiple flex sensors is used to capture finger movements. Each flex sensor detects the degree of bending of individual fingers and produces corresponding analog signals. These signals vary based on the gesture performed and are transmitted to the Arduino microcontroller.

The Arduino acts as the central processing unit of the system. It continuously reads the analog signals from the flex sensors and converts them into digital values using its built-in Analog-to-Digital Converter (ADC). These values are then compared with predefined threshold ranges stored in the system to identify specific gestures.

A database of predefined gestures is created, where each gesture corresponds to a specific message or command such as “Need water,” “Call doctor,” “I am in pain,” or “Help me.” Once the system identifies a gesture, it retrieves the corresponding message.

The system then performs two simultaneous operations:

1. The recognized message is displayed on an LCD screen for visual confirmation.
2. The message is converted into speech using a text-to-speech module, enabling audible communication.

The system operates in real time, ensuring immediate response and interaction. It is designed to be lightweight,

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portable, and cost-effective, making it suitable for hospital environments as well as home care applications. The simplicity of the system allows patients to use it easily without requiring technical knowledge.

V. WORKING PRINCIPLE

The working principle of the proposed system is based on gesture detection, signal processing, pattern recognition, and speech generation.

Initially, the user wears a glove embedded with flex sensors. When the user performs a hand gesture, the flex sensors detect the bending of each finger. The bending causes a change in the resistance of the sensors, which is converted into analog voltage signals.

These analog signals are sent to the Arduino microcontroller, where they are converted into digital values using the ADC. The microcontroller continuously monitors these values and compares them with predefined threshold values corresponding to specific gestures.

Once a gesture is recognized, the system maps it to a predefined message stored in memory. For example, a particular combination of finger bends may correspond to "Need help" or "Call nurse."

After identifying the gesture, the system displays the message on the LCD screen, providing visual feedback. At the same time, the text-to-speech module converts the message into an audible voice output, allowing caregivers to understand the patient's needs instantly.

To ensure accuracy and reliability, the system continuously processes incoming sensor data and updates outputs in real time. The process is repeated in a loop, enabling uninterrupted communication.

This working mechanism ensures that the system provides fast response, high accuracy, and efficient communication, making it highly effective for assistive healthcare applications.

VI. BLOCK DIAGRAM

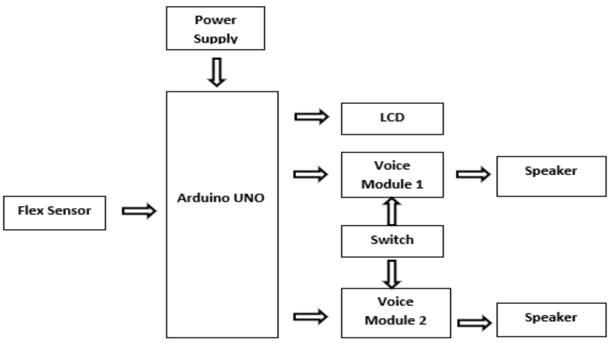

Fig. 6.2. Block Diagram

VII. RESULTS AND OUTCOMES

The proposed Smart Patient Assistance System was successfully designed and implemented using flex sensors, Arduino, LCD, and a text-to-speech module.

Fig. 1. The system accurately detected hand gestures based on finger movements and successfully converted them into corresponding text and speech outputs. The LCD displayed messages clearly, while the speech module produced understandable audio output.

Fig. 2. During testing, the system responded quickly to gestures and demonstrated reliable performance under different conditions. The accuracy of gesture recognition was found to be high, with minimal errors.

Fig. 3. The system significantly reduced communication barriers between patients and caregivers. It improved response time in emergency situations and minimized dependency on manual assistance or interpreters.

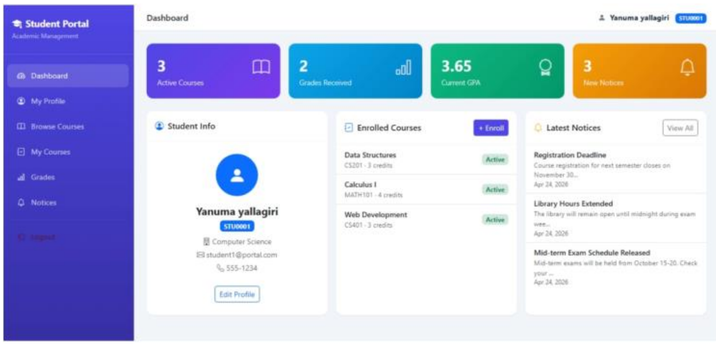

Fig. 7.1. Output1

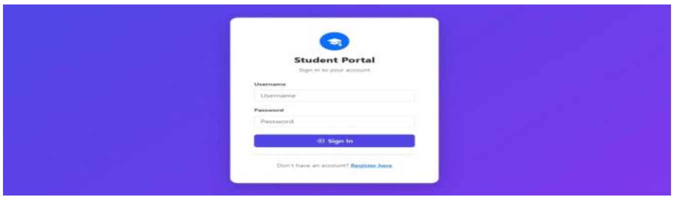

Fig. 7.2. Output2

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Overall, the results demonstrate that the proposed system is accurate, reliable, and efficient in converting sign language gestures into both text and speech. The outcomes highlight its potential as a practical assistive technology that enhances patient independence, improves interaction, and contributes to better healthcare support systems.

VIII.CONCLUSION

The Smart Patient Assistance System using Sign Language to Speech Conversion with Flex Sensors has been successfully designed and implemented as an assistive solution for individuals with speech impairments. The system effectively bridges the communication gap between patients and caregivers by translating hand gestures into both text and speech outputs in real time.

One of the major advantages of the system is its simplicity and ease of use. The use of flex sensors allows accurate detection of finger movements, while the Arduino microcontroller efficiently processes the data and identifies gestures. The integration of LCD and text-to-speech modules ensures both visual and audible communication, enhancing clarity and usability.

The system significantly reduces dependency on manual communication methods and interpreters, thereby improving response time in critical situations. It enhances patient independence and provides a reliable communication medium in healthcare environments.

Additionally, the system is cost-effective, portable, and easy to implement, making it suitable for hospitals, rehabilitation centers, and home care settings. The real-time operation and minimal hardware requirements further contribute to its practicality.

In conclusion, the proposed system demonstrates the effective use of embedded systems and assistive technologies to improve the quality of life for speech-impaired individuals. It serves as a valuable contribution toward inclusive healthcare solutions and highlights the potential of technology in addressing real-world communication challenges.

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