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Assistive Gesture Recognition System for Patients with Real-Time Notifications and Alerts via Raspberry Pi

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Abstract: In recent years, Gesture recognition and health monitoring technologies enhance human-machine interaction and support proactive healthcare. This system uses a camera to capture hand gestures, processed through image segmentation and classified using machine learning for touchless control of devices. It also includes sensors to monitor heart rate, body temperature, SpO2, and movement. Data is sent via a microcontroller to a cloud or mobile app for real-time analysis. Alerts are triggered for abnormal readings to ensure quick response. The system is portable, energy-efficient, and works in various environments, making it ideal for smart homes, assistive applications, and remote health monitoring.

I. INTRODUCTION

With the increasing need for assistive technologies, particularly in healthcare and communication, innovations combining IoT, machine learning, and embedded systems are gaining prominence. People with hearing and speech impairments face barriers in communication, while elderly or immobilized patients face challenges in health tracking and emergency signaling. This work proposes a dual-functional assistive system: A gesture-to-speech and text conversion system using Raspberry Pi and a deep learning model. A health monitoring module using Xiao ESP32-C3 and biomedical sensors with cloudbased alert transmission. The integration of both systems through a Telegram interface facilitates remote monitoring and quick response in emergencies, making it an ideal solution for smart healthcare environments.

II. LITERATURE SURVEY

Gesture recognition and health monitoring systems have been key areas of interest in assistive technology research. Pavithra et al. [1] proposed a real-time gesture recognition system using computer vision and convolutional neural networks (CNNs) to aid individuals with speech impairments. Their system effectively translated hand gestures into text, demonstrating improved communication efficiency. In the field of health monitoring, Kumar et al. [2] introduced a wearable device using the ESP32 microcontroller equipped with sensors to measure heart rate and body temperature. Their solution transmitted data to cloud servers in real time and proved beneficial in remote health diagnostics .Singh et al. [3] further advanced this approach by integrating fall detection sensors with gesture recognition, creating an emergency response system for elderly users that alerts caregivers via mobile notifications. Although these systems have achieved notable outcomes individually, they often address only single objectives. The present work combines gesture-to-speech conversion with real-time health monitoring using Raspberry Pi and XIAO ESP32-C3. This dual-functional approach supports speech-impaired individuals while also ensuring timely alerts during medical emergencies, thus enhancing user safety and communication.

III. IMPLEMENTATION AND METHODOLOGY

A. Sign Language to Speech/Text Conversion

1. Image Acquisition: Raspberry Pi Camera captures real-time hand gestures.
2. Preprocessing: OpenCV filters noise and enhances contours.

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3. Classification: A pre-trained CNN model classifies gestures into alphabets or predefined words.
4. TTS Engine: gTTS converts recognized text to speech output.
5. Data Transmission: Text and speech files are sent to caregivers via bylikIoT.

Figure:1 shows the gesture recognition system using raspberry pi camera module.

Figure:1 Gesture recognition system

B. Health Monitoring Subsystem

1. Sensor Input:- MAX30102 for heart rate, SpO_2, and body temperature, MPU6050 for motion and fall detection.
2.Microcontroller: Xiao ESP32-C3 handles data processing and Wi-Fi communication.
3. Alerts: Telegram bot sends real-time notifications and activates a buzzer in emergencies.
4.Power System: Operates on a rechargeable lithium-ion battery for portability.

Figure:2 Shows health monitoring system using sensors.

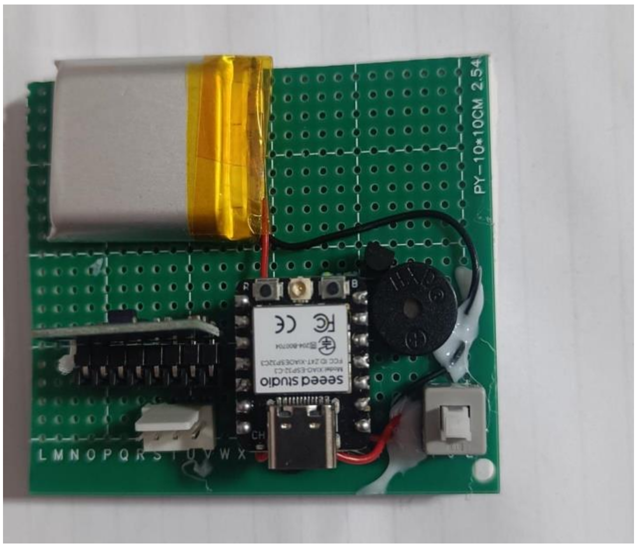

Figure:2 Health monitoring system

C. Integration

Both systems transmit data to the cloud. A mobile interface via Telegram allows caregivers to receive updates and speech-translated gestures on the go.
Figure:3 Shows result of the capturing signs and convert into text

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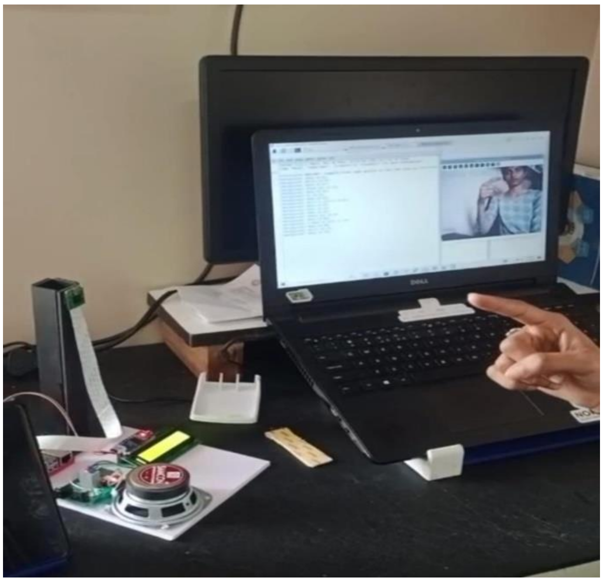

Figure:3 Result of capturing signs

IV. RESULTS AND ANALYSIS

Component	Metric	Result
Gesture Recognition	Accuracy	~90% under normal light
TTS Output	Clarity & Latency	Clear, <1 sec delay
Health Monitoring	Heart Rate/SpO_2 Accuracy	±2% error margin
Fall Detection	Sensitivity	Triggered correctly in >85% tests
Communication	Transmission Delay	1-3 seconds via Mobile.

V. CONCLUSION

The proposed assistive system effectively combines gesture-based communication and remote health monitoring into a single, IoT-enabled platform. The integration of AI, embedded systems, and cloud communication enhances both accessibility and safety for differently-abled users.

VI. FUTURE SCOPE

- Integration of 3D gesture recognition
- Multi-language speech output
- Offline functionality for rural deployment

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