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Raspberry PI Based Vision System for Bedridden Patients Using Eye Blink and Gesture Detection

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ABSTRACT

Bedridden and paralyzed patients may experience difficulty communicating basic needs when speech or voluntary movement is limited. This paper presents a Raspberry Pi 5-based assistive prototype using camera-based eye-blink detection and hand-gesture recognition. Predefined requests are displayed on a monitor and selected through visual input. The selected request is shown, announced using text-to-speech, and sent to a caregiver through GSM-based SMS. Heartbeat, temperature and SpO2 sensing support basic observation, while an H-bridge and DC motor demonstrate bed-position control. The prototype integrates communication, monitoring, notification and actuator functions in one embedded platform.

Keywords: Raspberry Pi 5, assistive communication, eye-blink detection, hand-gesture recognition, OpenCV, GSM, health monitoring, bed control.

I. INTRODUCTION

Communication is an essential part of daily care. Patients affected by paralysis or long-term immobility may have difficulty expressing needs such as requesting food, water, restroom assistance or a change in bed position. Conventional communication methods may depend on speech, physical switches, touchscreens or the continuous presence of a caregiver. These methods may not be accessible to patients with severe movement limitations, and delays in communicating a need can affect comfort and care.

Computer vision provides a non-contact means of interpreting visible actions. Eye blinks can be used as intentional input when eye movement is available, while hand gestures provide an additional channel for users who retain some upper-limb movement. Embedded platforms such as the Raspberry Pi can perform local processing and interface with peripherals.

This project develops a vision-based assistive prototype using eye-blink and hand-gesture inputs. It combines request selection with visual confirmation, audible feedback and GSM notification. Heartbeat, temperature and SpO2 sensing are included for basic observation, while an H-bridge and DC motor demonstrate bed-position adjustment. The objectives are to provide a camera-based multimodal input interface, communicate selected requests through display, voice and configured SMS, integrate basic vital-parameter monitoring, and demonstrate motorized bed-position control.

II. LITERATURE SURVEY

Prior work has explored communication support and healthcare monitoring for people affected by paralysis. Pandey and Nayak describe communication and healthcare monitoring functions with GSM-based alerts, providing context for integrating patient communication and caregiver notification [1]. Lamb and Madhe investigate gesture-based bed-position control, showing the relevance of hand gestures for assistive bed operation [2]. Nookhao et al. describe heartbeat and body-temperature monitoring using connected sensors [3].

Embedded eye-blink detection has also been explored, including machine-learning approaches for identifying blink events [4]. Gesture-sensor-based communication with GSM integration is another related direction [5], while image-processing and deep-learning methods have been studied for sign-language gesture recognition [6]. Recent works address health surveillance and connected monitoring for paralyzed patients [7], [8], and eye-blink-based alert interfaces [9], [12]. Eye-blink characteristics have been examined for interactive input, supporting the need to distinguish intentional selections from spontaneous blinking [10]. Computer-vision-based communication systems have also used eye interaction to select predefined messages [11]. Gesture and voice-based home automation approaches provide further context for accessible interaction [14].

The proposed prototype combines two visual input modes with display-based request selection, voice feedback, configured



GSM notifications, sensor monitoring and motor-control demonstration. Its emphasis is system integration rather than claiming a new blink-detection algorithm or clinically validated performance.

III. METHODOLOGY / APPROACH

A. System Architecture

The system uses Raspberry Pi 5 as the central controller. A camera supplies image frames for eye-blink and hand-gesture processing. The monitor presents predefined requests. When an accepted input is detected, the selected request is displayed and announced through a speaker. A GSM module supports SMS communication to a configured caregiver. Heartbeat, temperature and SpO2 sensors provide readings to the controller. An H-bridge driver receives control signals and drives the DC motor for the bed-position demonstration. The power supply provides the operating power required by the connected modules.

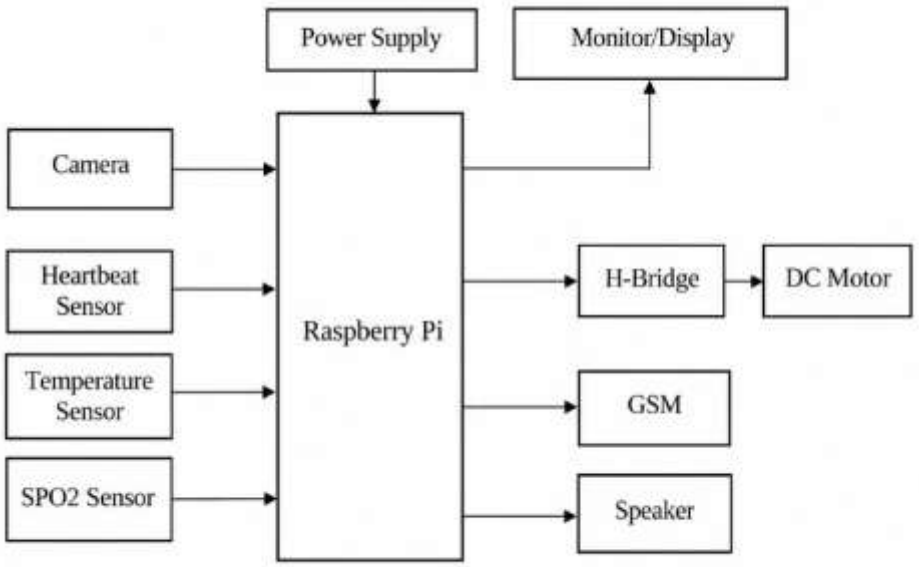


Fig. 1. Block diagram of the proposed assistive system.

The camera and vision-processing module form the primary input interface. The Raspberry Pi processes the input and maps it to a menu command. Display and speaker provide local feedback, GSM supports caregiver notification, the sensors provide basic health-related readings, and the H-bridge/DC-motor path demonstrates bed-position control. The motor is powered through a suitable driver and supply rather than directly from Raspberry Pi GPIO pins.

B. Hardware Connections

The camera, sensors, monitor interface, GSM module, speaker, motor driver and power-supply circuitry are interfaced with the Raspberry Pi 5 as illustrated in Fig. 2. Electrical connections and operating voltages follow the specifications of the individual modules. The motor receives power through the H-bridge driver, which controls direction based on the Raspberry Pi command signals.

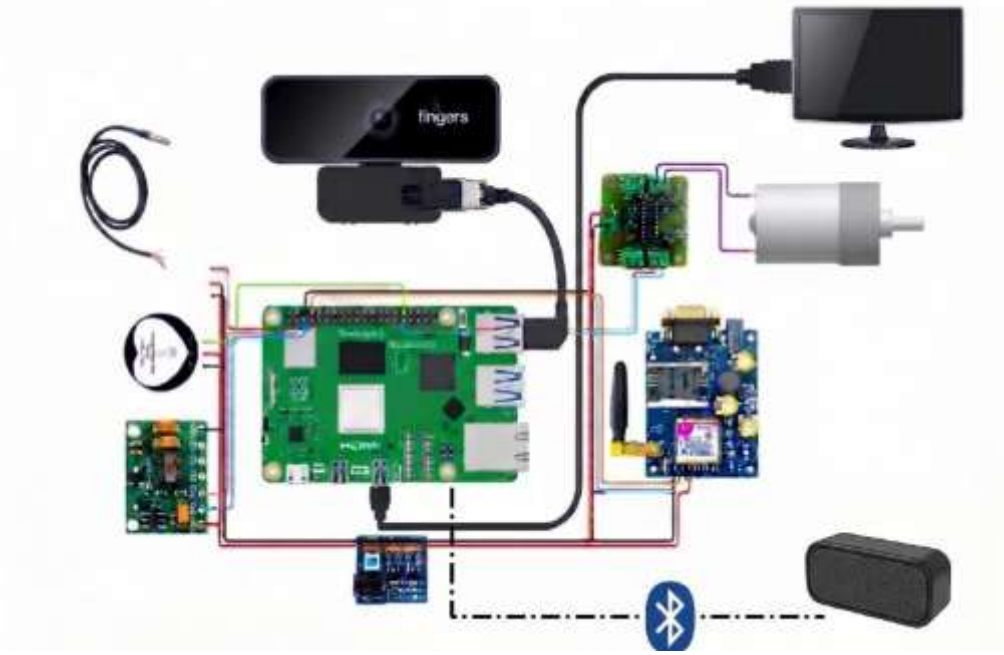


Fig. 2. Hardware connection arrangement of the proposed system using Raspberry Pi 5.

C. System Operation

At startup, the Raspberry Pi initializes the camera, display, sensors, GSM interface, audio output and motor-control interface. The user selects or operates the eye-blink mode for users with very limited movement or hand-gesture mode for users who can move their hands. The camera captures the face or hand according to the selected mode. In eye-blink mode, a deliberate closure of approximately one second selects a command, while closure longer than two seconds activates sleep mode. In gesture mode, a closed fist selects a command and an open palm does not select.

The monitor cycles through predefined patient requests—Need food, Need water, Need restroom assistance, Bed up and Bed down—at the implemented display interval. When a command is selected, the request is displayed, announced through the speaker using text-to-speech and sent as an SMS to the caregiver through GSM. The heartbeat, temperature and SpO2 sensors are read during operation. When a configured alert condition is reached, the system announces the alert and sends a caregiver SMS. The monitoring and command-display cycle then repeats.

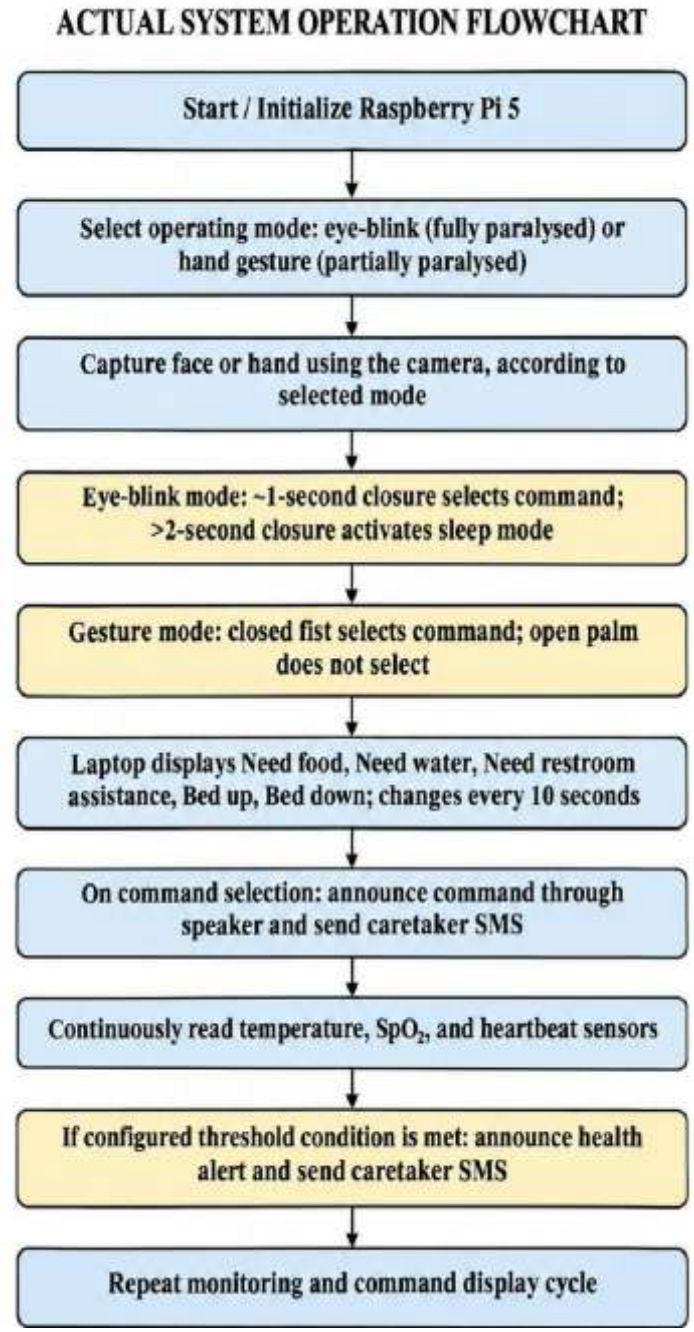


Fig. 3. Flow chart of system operation.

D. Vision-Based Input and Command Mapping

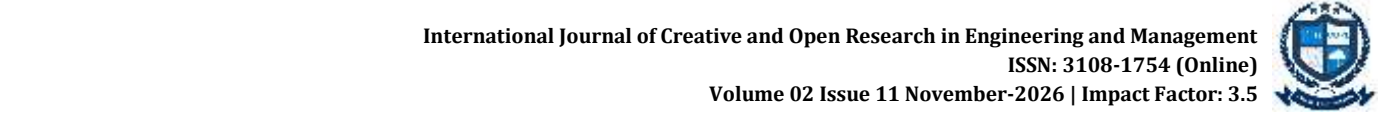
The camera supports two interaction modes. Eye-blink mode uses a detected closure as a selection event; hand-gesture mode uses a recognized hand state for selection. The predefined requests provide a simple interface for expressing basic assistance needs. The input is mapped to a request, and the request is passed to the display, audio and SMS output functions. The selection logic is implemented within the Raspberry Pi application.

E. Health Monitoring and Caregiver Notification

Heartbeat, temperature and SpO2 sensors are interfaced with the Raspberry Pi for basic readings. The system checks the available sensor values against configured alert conditions. On an alert, the speaker provides audible feedback and GSM sends a message to the configured caregiver number. Sensor values may be affected by sensor placement, motion, contact and signal quality; the prototype is intended for basic observation and not clinical diagnosis.

F. Bed-Position Demonstration

A selected bed-position command is converted into direction-control signals for the H-bridge. The H-bridge drives the DC motor in the required direction for the demonstration. A suitable motor power supply and driver are used so that the motor current is not drawn directly from Raspberry Pi GPIO. A real patient-support mechanism would require mechanical safeguards, limit switches or position feedback and an independent emergency stop.



IV. RESULTS AND DISCUSSION

The assembled prototype integrates camera-based patient interaction, vital-parameter sensing, caregiver notification and motor control on a Raspberry Pi 5 platform. The hardware prototype is shown in Fig. 4. The assembly provides a common platform for the communication, monitoring and control functions of the system.

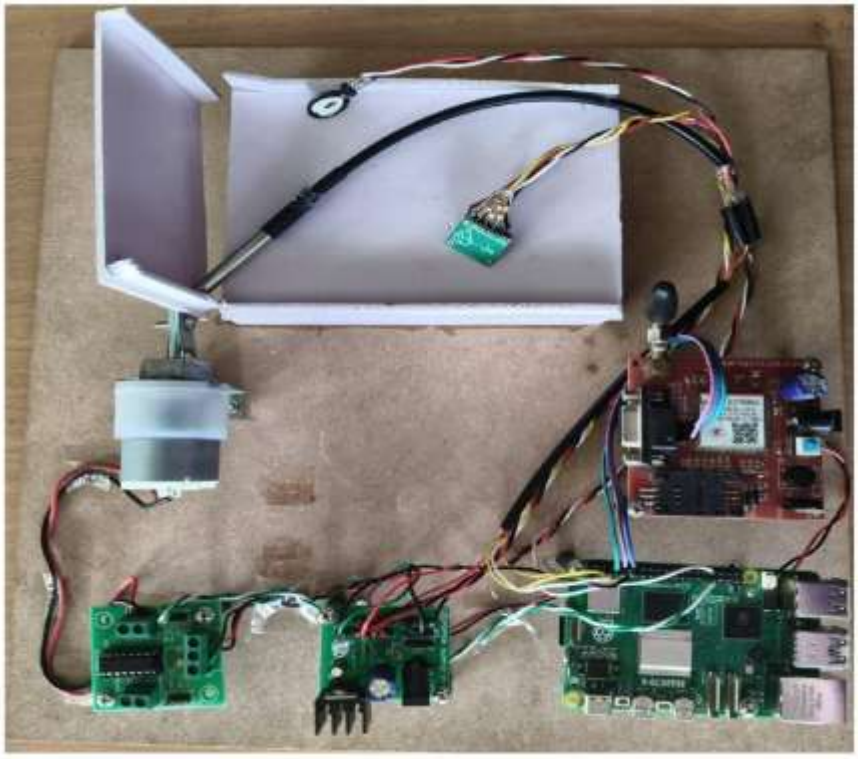


Fig. 4. Hardware prototype of the Raspberry Pi-based assistive system.

The monitor interface presents the available patient needs and displays the command selected through eye-blink or gesture input. The selected option provides visual confirmation of the request. Fig. 5 shows the hand-gesture and eye-blink communication interfaces used in the prototype.



Fig. 5. Hand-gesture and eye-blink communication interfaces.

When a configured request or alert is generated, the Raspberry Pi communicates with the GSM module to send an SMS to the stored caregiver number. The message identifies the request or alert and provides a remote notification. An example of the SMS output is shown in Fig. 6.

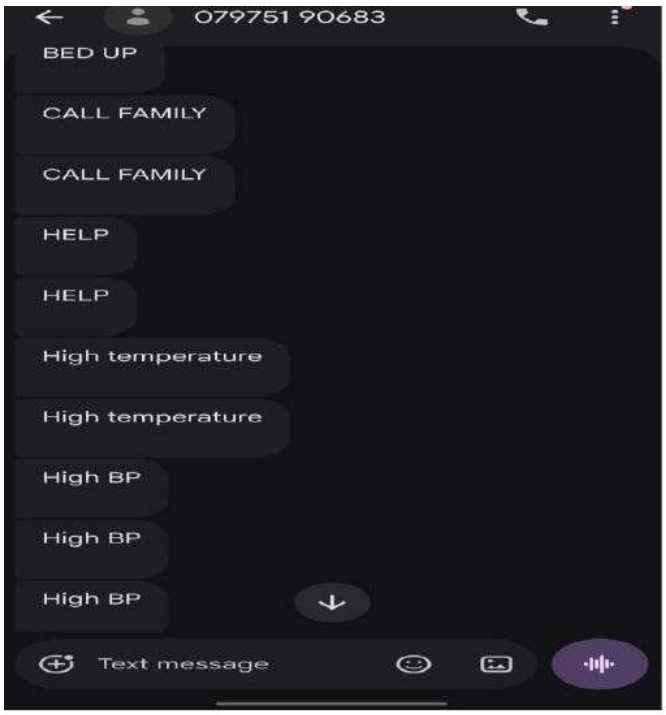


Fig. 6. SMS notifications generated by the assistive prototype.

These observations describe functional integration and demonstration. The project report does not provide a structured quantitative evaluation of eye-blink or gesture-recognition accuracy, end-to-end response time, SMS delivery latency, sensor error against reference instruments, or motor-control reliability. Numerical performance metrics are therefore not claimed. A future evaluation should record repeated trials for each input, correct selections, false activations, missed detections, notification success, timing and sensor comparison with reference equipment.

The prototype combines several assistive functions in a single platform. Its use of two visual input modes may provide flexibility depending on the user's movement capability. Display and audio feedback make the selected request observable, while GSM provides a remote notification channel. The monitoring and actuator modules broaden the prototype beyond communication alone. However, performance is dependent on camera positioning and lighting, input detection, sensor quality, cellular coverage and safe actuator design.

V. CONCLUSION AND FUTURE SCOPE

A Raspberry Pi 5-based assistive prototype combining eye-blink detection and hand-gesture recognition has been presented. The system displays predefined patient requests, confirms selections visually, provides voice feedback and supports caregiver SMS notification through GSM. Heartbeat, temperature and SpO2 sensing provide basic monitoring inputs, while an H-bridge and DC motor demonstrate bed-position control. The integrated architecture brings communication, monitoring, notification and actuator functions into one embedded platform.

Future work includes improving vision-based input under varying lighting and orientation, adding gaze-based navigation and customizable requests, supporting multilingual voice output, and providing a secure caregiver dashboard. Sensor readings should be evaluated against suitable reference equipment. Structured tests should quantify recognition performance, false selections, response time and communication success. Bed-control development should include a load-rated mechanism, limit switches, position feedback, fault handling and an independent emergency stop. Usability and safety evaluation would be necessary before real-world patient-care deployment.

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