Home Surveillance Robot with LPG Detection And Health Monitoring System

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Abstract— Aims to develop an automated home robot capable of efficiently identifying members, detecting LPG and monitoring health of members of family. The robot's design encompasses an integrated system comprising an embedded controller, ultrasonic sensors, image sensors, motors, drivers, other sensors, and virtual instrumentation tools. These components collectively facilitate tasks such as smoke detection, facial recognition, LPG detection and health monitoring. Employing a speed-differential control strategy, the robot adeptly adjusts its trajectory. Through a specialized turntable and sliding mechanism, the robot effectively identifies people. The robot is seamlessly controlled via a mobile app, offering motion control, real-time camera monitoring, access to sensor data, and prompt emergency alerts when necessary. The outcomes of the experiments underscore the practicality and efficacy of the proposed robotic system, offering people a valuable tool to alleviate home surveillance.

***Index Terms*—Automated home robot, LPG detection, Health monitoring, Mobile app control.**

1. Introduction

The home surveillance robot with LPG detection and health monitoring system is a comprehensive solution involving a mobile robotic platform equipped with LPG gas and health sensors, a camera module, and actuators controlled by a powerful microcontroller. The robot's software components include algorithms for LPG detection, surveillance, and health monitoring, alongside communication protocols for data transmission. Integrated with a centralized system or mobile app, the solution provides a user-friendly interface for remote control, surveillance footage viewing, and health monitoring.

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Security measures, such as data encryption and access control, ensure privacy, while a self-diagnostic system and remote operation capabilities enhance maintenance and user customization. Prioritizing safety and compliance with regulations, this system offers a sophisticated home monitoring solution with applications in security and health management.

A home security robot serves as a crucial asset in fortifying the safety of a residence by offering continuous monitoring and immediate alerts. With the ability to detect and notify homeowners or monitoring services of security threats or unusual activities, these robots provide an extra layer of defense, particularly during periods of home owner absence or nighttime hours. The option for remote monitoring, customizable security features, and integration with smart home systems enhance the adaptability and convenience of managing home security. Furthermore, the visible presence of a security robot acts as a deterrent to potential intruders, while its versatility in navigating various environments ensures comprehensive coverage. Some advanced models may also include emergency response capabilities and health monitoring features, catering to a broader range of security and well-being concerns. The user-friendly interfaces of these robots encourage active engagement and utilization, contributing to a holistic and proactive approach to home security.

One of the main attractions of this model is its micro controller. The ESP32 microcontroller is instrumental in the development of low-cost robots, offering a blend of affordability, integrated features, and community support. Its cost-effective nature stems from the affordability of the hardware itself, while the integrated Wi-Fi and Bluetooth capabilities eliminate the need for additional modules, reducing both cost and complexity. Being part of the open-source hardware community with strong community support, the ESP32 benefits from a wealth of resources and libraries, contributing to faster and more cost-effective development. Its low power consumption is advantageous for battery powered robots, promoting longer operating times and reduced powerrelated costs. The ESP32's compact size and integrated peripherals, including GPIO, I2C, SPI, and UART, further contribute to cost reduction by minimizing the need for additional components. Its ease of programming using the widely adopted Arduino IDE simplifies development, and its wireless capabilities enable cost-effective and flexible control mechanisms. The ESP32's versatility allows it to be applied in various robotic projects, making it an accessible and cost-efficient choice for hobbyists, educators, and developers working on budget-friendly robotic applications.

2. Comparison With Other Similar Robots

The hypothetical robot with LPG detection, temperature sensing, face detection, smoke detection, app control, and navigation capabilities represents a comprehensive solution for both safety and user interaction. Unlike existing robot models such as the Roomba i7+, Anki Vector, Ubtech Walker, and Boston Dynamics Spot, which excel in specific areas like vacuum cleaning, voice recognition, humanoid design, or mobility, our hypothetical robot combines a unique blend of features. With its ability to detect LPG leaks and smoke, sense temperature, recognize human faces, and navigate autonomously while offering app control, it addresses a wide range of needs from safety and environmental monitoring to user convenience and interaction.

While robots like the Roomba i7+, Anki Vector, Ubtech Walker, and Boston Dynamics Spot each offer impressive capabilities in their respective domains, they do not match the comprehensive feature set of our hypothetical robot. These existing models may excel in specific tasks like vacuum cleaning, voice command recognition, humanoid design, or mobility, but they lack the combined functionality of LPG detection, temperature sensing, face detection, smoke detection, app control, and navigation found in our hypothetical robot. By integrating these diverse capabilities, our hypothetical robot sets itself apart as a versatile and multifunctional solution for various applications ranging from home safety to personal assistance and beyond.

3. Basic Working Principle

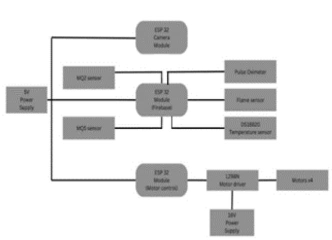

Fig.1. Flowchart of the system

The system utilizes an ESP32 microcontroller as its core processing unit and incorporates various sensors, including an MQ6 for methane gas detection, an MQ9 for carbon monoxide detection, a DS18B20 for temperature measurement, and a heart rate sensor. Additionally, an ESP32 camera enables real-time visual capture, enhancing situational awareness. The system operates through a structured workflow, wherein it checks for sensor input upon initialization. In the absence of a button press, it seamlessly interfaces with Firebase to retrieve messages, triggering the robot's navigation to designated locations. Conversely, if sensor input is detected or Firebase messages are absent despite no button press, the system transmits data to Firebase for storage and analysis. This data includes sensor readings and real-time visuals, providing comprehensive insight into the robot's operating environment. Integration with the MIT App Inventor platform enables user-friendly visualization and control through a mobile application.

In recent years, the development of robotic systems for environmental monitoring and remote operation has gained significant attention due to its potential applications in various domains such as industrial automation, healthcare, and disaster management. This paper presents an integrated robotic system designed to address these needs effectively. By leveraging advanced technologies such as the ESP32 microcontroller, multiple sensors, Firebase cloud platform, and MIT App Inventor, the system offers a comprehensive solution for environmental monitoring and remote operation.

The system architecture comprises several key components, including the ESP32 microcontroller, multiple sensors (MQ6, MQ9, DS18B20, and heart rate sensor), an ESP32 camera, Firebase cloud platform, and MIT App Inventor. The ESP32 microcontroller serves as the central processing unit, orchestrating the system's operations and facilitating communication with peripheral devices. The sensors enable the robot to monitor environmental parameters such as gas concentration, temperature, and heart rate, ensuring timely detection of potential hazards. The ESP32 camera enhances situational awareness by capturing real-time visuals of the robot's surroundings. Integration with the Firebase cloud platform enables seamless data transmission and storage, facilitating remote access and analysis. The MIT App Inventor platform provides a user-friendly interface for visualizing data and controlling the robot's functionalities via a mobile application. The system's operational workflow is structured to ensure efficient operation and responsiveness to external cues. Upon initialization, the system checks for sensor input; if no button press is detected, it interfaces with Firebase to retrieve messages. In the presence of Firebase messages, the robot navigates to the designated location, guided by predefined instructions. Conversely, if sensor input is detected or Firebase messages are absent despite no button press, the system transmits data to Firebase for storage and analysis. This data includes sensor readings and real-time visuals captured by the ESP32 camera, providing valuable insights into the robot's operating environment.

4. Simulation Of Proposed System

A. SEGMENT 1

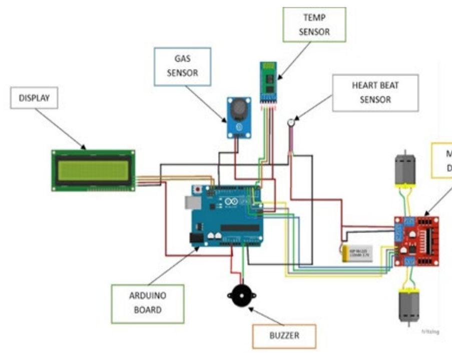

Fig.2. Simulation diagram of Proposed System

In the early stages of Arduino robot code development, leveraging Fritzing—an open-source software for electronic circuit design and simulation—is paramount. Following installation, developers access the simulation diagram via the Fritzing interface, enabling visual exploration of circuitry before physical assembly. Activating the Arduino Integrated Development Environment (IDE) within Fritzing facilitates code creation and uploading to the Arduino board. Once code is written and uploaded, the simulation commences with a click of the "Play" button, initiating virtual robot movement and execution of programmed actions. This simulated environment serves as a vital testing ground, offering insights into code functionality and performance. Iterative refinement and debugging based on simulation outcomes ensure the development of reliable and efficient code. With virtual testing complete, developers seamlessly transition to physical construction, bridging the gap between simulation and real-world implementation. This comprehensive process guarantees that the Arduino robot code under goes thorough testing and optimization for successful deployment.

B. SEGMENT 2

Face detection, a critical aspect of computer vision technology, involves identifying and localizing human faces within digital images or video frames. Its significance spans numerous applications, from photography and video surveillance to facial recognition and human-computer interaction. The core objective of face detection algorithms is to pinpoint and distinguish facial features like eyes, nose, and mouth within visual inputs. Methods for face detection vary, encompassing traditional techniques such as Haar cascades and more sophisticated approaches like deep learning-based convolutional neural networks (CNNs). These advancements have substantially enhanced the accuracy and efficiency of face detection systems, facilitating their widespread adoption across diverse domains, including security, entertainment, and human-computer interface design. Notably, face detection is pivotal in applications like automatic photo tagging, video analysis, emotion recognition, and authentication systems.

The process of achieving face detection involves a series of algorithmic steps tailored to different scenarios.

For instance, in model training, the procedure entails importing necessary libraries, setting dataset paths, extracting facial features using recognition algorithms, and training classifiers like K-Nearest Neighbors. Similarly, for real-time video feed detection, steps involve loading trained models, initializing Haarcascade classifiers, processing video frames, and performing face recognition for each detected face. These algorithms are essential components in the development of systems like home surveillance robots with LPG detection and health monitoring capabilities, emphasizing the critical role of face detection in enhancing security and enabling advanced functionalities in robotics and automation.

5. Hardware

The hardware of the robot is implemented mainly using three micro controllers. Among these ones is for realizing the robotic motion, one for providing live camera feed and other for controlling the sensors. The robot used three micro controllers that are ESP32 developer module, ESP32 camera module and ESP8266.These three are used for realizing different function blocks. By designating each controller for particular block complexity and delay in operation can be reduced. ESP32 Developer Module: This module is specifically dedicated to realize the robotic motion. It controls the four motor and makes the motion as per input from user. This module consists of inbuilt bluetooth. The bluetooth functionality is being utilized to communicate with app. The user input from app is communicated with the module via bluetooth and as per the input the movement occur. ESP32 Camera Module: Camera module is utilized to get the live feed from robot. The module comes with a camera and inbuilt Wi-Fi. The Wi-Fi of the module is paired to the hotspot in the user's smartphone in which the app is installed. The live feed is transfered via the communication line and the footage can be viewed in the app's interface. An LED light is provided near camera to improve the footage visuals in low light. Various camera parameters can also be adjusted in the app.

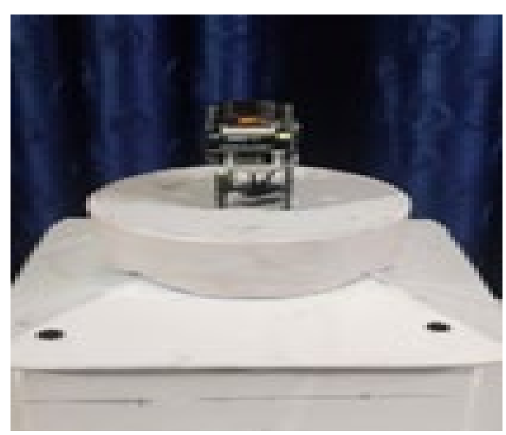

Fig.3. Camera module on robot

Fig.4. Temperature sensor on robot

Fig.5. Heart beat sensor on robot

ESP8266: For sensor integration the ESP8266 module is used. This module has inbuilt Wi-Fi functionality. The module's Wi-Fi is paired to the hotspot in the user's smartphone in which the app is installed. This establishes a communication path that can be used is data exchange. In the robot all the sensors are connected to this module and the module passes the data to the user's smartphone. The sensor data are first stored in a cloud so that the data are secured. The network of smartphone is used to exchange data to cloud. From cloud the data are accessed by the app.

Fig.6. Cross sectional view of the robot

The robot's base is made of a mixture by utilizing both PVC foam board and multiwood. The flexibility of PVC foam board and strength of multiwood is utilized. The body of the robot is mainly made up of foam board. By using foam boards considerable weight of body can be reduced. Also, the flexibility of foam board reduces the complexity of the work. 3-D printing is also used for making some parts they include the sensor and controller holders, joints and other parts which are to be of precise size and shape.

Fig.7. Full view of the robot

Here cloud storage is used to store the sensor data. Here Firebase is used as a cloud server. This facilitates the data to be stored and can be accessed whenever required. The sensor data is pushed to the cloud from ESP8266 through user's smartphone by utilizing the Wi-fi communication line and the phone network. The app can later on access the data and the user can read it.

An app has been developed for controlling the robot, getting the sensor data and seeing the live camera feed. App was developed using MIT app inventor software. The app can be installed in a smart phone. The app contains two interfaces for controlling the robotic motion and for reading the sensor data. The live feed from robot is also available in the motion control interface. For motion control, four arrow shaped buttons are given. Each button represents each direction that are forward, backward, right and left. By pressing the required button, the robotic motion can be controlled. An option is provided in the same interface to access the live feed camera footage. By pressing that button, the live feed from camera in robot can be accessed. To go to the sensor data interface a button named 'Sensor Data' is provided at the top of motion control interface. By pressing that button, the second interface pops up showing the sensor data from various sensors. A bluetooth icon is also provided at the top, so that the bluetooth pairing between smartphone and ESP 32 developer module can be established.

6. Results And Discussion

The motion testing of the robot prototype demonstrated its ability to maintain balance and move according to user input, highlighting the effectiveness of its mechanical design and control system. Furthermore, the successful implementation of automatic movement towards the door upon detecting an unknown face underscores the system's responsiveness to external stimuli, enhancing its utility in security and navigation applications. Face detection functionality, validated during the simulation phase, proved reliable in real-world scenarios, ensuring accurate identification of individuals within the robot's vicinity. The seamless integration of live camera footage through the accompanying app provides users with real-time visual feedback, enhancing situational awareness and facilitating remote monitoring capabilities.

Moreover, rigorous testing of LPG and smoke detection functionalities in controlled environments confirmed the sensors' effectiveness in detecting hazardous gases, with timely alerts transmitted to users' smartphones via the app. This capability enhances safety measures, particularly in environments prone to gas leaks or fire hazards. Additionally, the successful testing of sensors intended for patient monitoring underscores the robot's versatility in healthcare applications. By storing monitoring data in the cloud and providing access through the app, healthcare professionals can remotely monitor patients' vital signs, enabling timely intervention when necessary. Overall, these results demonstrate the robustness and efficacy of the proposed robotic system, positioning it as a versatile and reliable solution for a range of practical applications, including security, environmental monitoring, and healthcare.

7. Conclusion

In conclusion, the development of a home surveillance robot, equipped with LPG detection and health monitoring capabilities, presents an innovative solution for enhancing security and well-being in residential settings. The integration of advanced hardware, such as LPG and health sensors, a camera module, and microcontroller-driven actuators, establishes a comprehensive and intelligent robotic platform. Coupled with software components featuring algorithms for LPG detection, surveillance, and health monitoring, along with efficient communication protocols, the system enables real-time remote control and monitoring through a user-friendly interface via a centralized system or mobile app. Emphasizing security measures like data encryption and access control ensures privacy, while a self-diagnostic system and remote operation capabilities enhance maintenance efficiency and user customization. By prioritizing safety and regulatory compliance, this system surpasses expectations as a sophisticated home monitoring solution. Its practical applications include continuous monitoring, immediate alerts for security threats, remote accessibility, customizable security features, and integration with smart home systems, enhancing adaptability and convenience. The robot's visible presence acts as a deterrent, and its versatility in navigation ensures comprehensive coverage, with potential features like emergency response and health monitoring expanding its contributions to security and well-being. The user-friendly interfaces promote active engagement, fostering a holistic and proactive approach to home security and ushering in a new era of intelligent and integrated home monitoring systems.

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