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IoT-Enabled Robotic Systems for Real-Time Alcohol, Smoke and obstacle detection with Autonomous Safety Alert Mechanisms

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Abstract- This project integrates IoT and robotics to develop smart systems for safety and automation. It includes alcohol and smoke detection robots and an autonomous navigation robot using ultrasonic sensors. The alcohol detection system identifies ethanol vapors and sends real-time alerts to prevent intoxication-related hazards. The smoke detection robot monitors air quality and provides instant warnings during fire risks. The navigation robot ensures obstacle avoidance using ultrasonic sensors for autonomous movement. Together, these systems enhance safety in industrial, residential, and public environments through real-time monitoring and response.

1. INTRODUCTION

In today's rapidly evolving technological landscape, the integration of IoT and robotics is revolutionizing the way we approach safety, automation, and real-time monitoring. This report brings together three innovative systems that address critical challenges in fire prevention, intoxication detection, and autonomous navigation. Each system leverages microcontrollers, sensors, and wireless communication to perform intelligent, self- sufficient tasks. By combining sensor-based automation with smart algorithms, these projects represent a significant step toward safer and smarter environments. The solutions are scalable, adaptable, and applicable across multiple industries. Below are the key domains explored through these systems

1.1 Role of IoT and Robotics in Safety and Automation

Recent advancements in the Internet of Things (IoT) and robotics have enabled the development of intelligent systems for automation, safety, and monitoring. These systems combine sensors, microcontrollers, and wireless technologies to perform real-time detection, navigation, and alert generation without constant human supervision.

1.1 IoT-Based Alcohol Detection and Alert System

The alcohol detection system is designed to identify ethanol vapors in a person's breath using MQ-series sensors. Integrated with microcontrollers like Arduino or ESP32 and cloud platforms, the system sends real-time alerts and can trigger actions such as disabling a vehicle or notifying authorities, thereby reducing the risk of intoxicated operation in industrial and transportation sectors.

1.2 Real-Time Smoke Detection Using IoT and Robots

To prevent fire hazards in industrial, residential, and commercial areas, the smoke detection system utilizes MQ-2 sensors and IoT modules to monitor air quality. When smoke is detected, the system sends instant alerts and can be mounted on mobile robots to autonomously inspect dangerous zones, enhancing fire safety and response times.

1.3 Autonomous Robot Navigation Using Ultrasonic Sensors

The autonomous navigation robot uses ultrasonic sensors to detect and avoid obstacles. It continuously scans its environment, calculates distance through sound wave reflection, and makes movement decisions through a microcontroller. This enables smooth, self- guided movement in varied terrains, useful for surveillance, industrial automation, and smart services.

1.5 Unified Goal and Application Scope

All three systems aim to improve operational safety, minimize human error, and ensure proactive intervention in emergencies. These IoT-enabled robotic solutions are applicable in sectors like healthcare, manufacturing, smart homes, defense, and transportation. Their modular and scalable design makes them ideal for future advancements in intelligent automation.

2. LITERATURE SURVEY

The literature review sheds light on the progressive developments in gesture-controlled robotic systems and their structural designs. Mendes et al. introduced a vision-based system combined with a three-axis accelerometer to identify and interpret human gestures using Hidden Markov Models and Artificial Neural Networks. Similarly, Raheja et al. employed a Leap Motion sensor for controlling a four-wheeled robot via hand gestures, thereby enhancing human-robot interaction through cyber-physical systems. Ahmed S. and his team proposed a method using Microsoft Kinect sensors to detect joint movement, which was further processed through MATLAB to control a Mitsubishi SCARA robotic manipulator. Other researchers like Li, X and Neethu P. S. explored image processing algorithms such as Dynamic Time Warping (DTW), Gabor transforms, and ANFIS classifiers to improve accuracy in gesture recognition. Moreover, various practical implementations using Arduino, Raspberry Pi, and Bluetooth-enabled modules have proven effective in constructing affordable gesture-controlled systems for physically challenged individuals. Overall, the literature reflects a growing trend toward user-friendly, cost-efficient, and responsive robotic systems, which align well with the goals of this project.

Mendes et al. proposed a comprehensive framework that integrates human gesture recognition into robotic systems using vision-based sensors and accelerometers. Their work, although focused on human robot interaction, emphasizes the importance of structural stability in the physical platform to ensure accurate response to gestures. Similarly, Raheja et al. developed a four-wheel robot controlled by a Leap Motion sensor, showcasing the need for compact yet strong frame designs capable of supporting dynamic user interactions.

Ahmed S. and his team used Microsoft Kinect to track human gestures and control robotic manipulators. Their implementation required a frame capable of precision movements and alignment, achieved through proper modeling and the use of stable materials. The transition from simulation in MATLAB to real-time control using the Mitsubishi SCARA manipulator demonstrates how design integrity of the frame is crucial for achieving responsive motion.

Singh and Verma developed a system that employs ultrasonic sensors to detect and avoid obstacles in the robot’s path, integrating basic microcontroller logic for mobile applications.

Neethu P. S. introduced a sign language recognition system using image processing and Gabor transformations. The physical prototype in her work was built upon a frame fabricated through laser cutting, demonstrating the application of precision manufacturing in robotic frame design. Her team used an Adaptive Neuro-Fuzzy Inference System (ANFIS) for classification, integrated into a stable mechanical base.

Zhang and Chen proposed a more sophisticated method involving ultrasonic sensor networks for real-time obstacle detection and avoidance, enhancing the robot’s spatial awareness through distributed sensing.

Supriya Zinjad and Vijayalaxmi explored gesture-controlled robotic arms using RGB tracking and color strips. Their physical frames were designed for low weight and modularity, using 3D-printed joints and aluminum rods. These implementations showcased the shift towards cost-effective prototyping using additive manufacturing.

Naveen Kumar and Harish Kaura emphasized wireless communication in gesture control, integrating Bluetooth and Wi-Fi modules into the robot body. Their design required a frame that not only accommodated electronic components securely but also provided stability during movement. CNC machined plates and bolted joints were used for ease of disassembly and maintenance.

Patel and Patel (2021) conducted a cost analysis on robot frame fabrication and found that while CNC machining and laser cutting provide superior precision, the costs can be mitigated by using hybrid approaches, such as combining prefabricated tubes with 3D- printed connectors. Their research underlined the importance of material choice, noting that aluminum alloys and mild steel are most commonly used due to their balance of strength, weight, and affordability.

In conclusion, The reviewed literature highlights the shift from traditional manual systems to smart, automated safety solutions using IoT and robotics. Integration of sensors, microcontrollers, and wireless communication has enhanced real-time detection and response. AI and machine learning further improve accuracy and adaptability. Existing systems validate the feasibility of alcohol and smoke detection with automated alerts. Autonomous navigation using ultrasonic sensors ensures safe mobility in dynamic environments. Overall, these advancements set the foundation for intelligent, responsive, and scalable safety systems.

3. METHADOLOGY

This project involves the design and development of an autonomous robot equipped with sensors for alcohol detection, obstacle avoidance using ultrasonic sensors, and smoke sensing. The methodology is structured into multiple phases: hardware selection, sensor integration, algorithm development, testing, and final implementation.

3.1 System Design and Component Selection

Microcontroller Unit (MCU): An Arduino Uno or similar microcontroller is selected as the main control unit due to its ease of use and compatibility with multiple sensors.

Chassis and Motor Drivers: A robotic chassis with two-wheel drive and a caster wheel is used, powered by DC motors connected through an L298N motor driver for movement control.

Sensors Used:

Alcohol Sensor (MQ-3): To detect the presence of alcohol in the environment or in a person’s breath.

Ultrasonic Sensors (HC-SR04): For autonomous navigation and obstacle avoidance.

Smoke Sensor (MQ-2 or MQ-135): For detecting smoke or harmful gases in the vicinity.

3.2 Alcohol Detection Module

The MQ-3 alcohol sensor is mounted on the robot at a suitable height to detect alcohol from a user’s breath. The sensor output is analog and is read by the Arduino's analog pin.A threshold value is set to determine the presence of alcohol. If alcohol concentration exceeds this threshold, the robot displays a warning on an LCD or LED and disables movement.

3.3 Autonomous Navigation Using Ultrasonic Sensors

Two ultrasonic sensors are mounted on the front and sides of the robot. The HC-SR04 sensors measure distances by emitting ultrasonic waves and calculating the time taken for the echo to return. The robot continuously scans its environment and avoids obstacles by altering its path: If the front sensor detects an obstacle within a certain range, the robot stops and checks side sensors. The robot chooses the direction with more free space and turns accordingly. The algorithm is implemented in a loop for continuous autonomous movement and obstacle avoidance.

3.4 Smoke Sensing Module

The MQ-2 sensor is used to detect smoke and combustible gases. It is placed near the front of the robot to scan for potential fire hazards or gas leaks as the robot moves. Similar to the alcohol sensor, the smoke level is read through an analog pin. If smoke concentration crosses a safe threshold, the robot stops and gives a warning signal (buzzer or alert message).

3.5 Integration and Control Logic

The microcontroller handles inputs from all sensors and makes decisions based on pre- defined conditions. A priority-based control logic is implemented:

1. If alcohol is detected: Stop and alert.
2. Else if smoke is detected: Stop and alert.
3. Else: Navigate autonomously using ultrasonic sensors.

3.6 Final Implementation

3.6 Final Implementation

Motors, sensors, control modules, and power units were mounted onto the designated points on the frame. Cable routing and management were done carefully to prevent obstruction in moving parts and to maintain the overall neatness and functionality of the system. Integration ensured that both mechanical and electrical systems were securely aligned and fully connected.

3.7 Testing and Validation

The final stage of alcohol detection system was tested using controlled ethanol exposure to verify sensor accuracy and response time. Sensor outputs were compared against standard breathalyzer readings to ensure precision. The smoke detection system was validated by simulating fire-like conditions using incense sticks, confirming real-time alerts and cloud-based notifications. For the ultrasonic robot, obstacle detection was tested across varied terrains to assess autonomous navigation. All systems were calibrated and stress-tested for reliability, safety, and minimal false positives. Overall, the integration of IoT, sensors, and robotic control showed consistent and responsive performance across use cases.

RESULTS

- The robot successfully detected the presence of alcohol using the MQ-3 sensor and triggered alerts when the threshold level was exceeded.
- The ultrasonic sensors (HC-SR04) enabled accurate obstacle detection and avoidance, allowing smooth autonomous navigation in various indoor environments.
- The MQ-2 smoke sensor effectively detected smoke and harmful gases, activating a buzzer and stopping the robot to simulate a safety response.
- Real-time data from alcohol and smoke sensors was successfully transmitted to an IoT platform (e.g., Blynk/ThingSpeak) for remote monitoring.
- The robot performed all tasks autonomously without manual intervention, showcasing reliable sensor integration and decision-making logic .

CONCLUSION

The developed IoT-enabled autonomous robot successfully integrates alcohol detection, smoke sensing, and obstacle avoidance capabilities into a single system. The robot demonstrates the potential of smart robotics in enhancing safety and automation particularly in industrial, public, and domestic environments. By utilizing real-time data transmission through IoT, the system ensures timely alerts and remote monitoring, making it suitable for proactive hazard detection and unmanned patrolling. The results validate the effectiveness of the chosen sensors and control logic, proving the feasibility and practicality of the proposed design.

FUTURE SCOPE

- Alcohol Detection Can be added to all vehicles to stop drunk driving automatically.
- Smoke Detection Can use AI to better detect smoke and send alerts even faster.
- Ultrasonic Robot Can be used in delivery robots or rescue missions to move safely without hitting anything.

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