**Midterm PROJECT PROPOSAL MAE6291: IoT for Engineers**

**Spring 2025, Instructor: Prof. Kartik Bulusu (MAE Department, GWU)**

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| **Midterm PROJECT TITLE** | Smart Seat Occupancy and Safety System (Grad Student Perfector) | **Category: Circle One** | | **Grad**  **Undergrad** |
| **Full NAME(S)** | Eliot Hunter | | **DATE** | 2/13/2025 |

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| 1. **INTRODUCTION** Central problem being addressed; Topic of study related to problem **[1.0 Points]** |
| This project aims to design an IoT-based Smart Seat Occupancy and Safety System that detects when a person sits in a seat, recognizes their face, and triggers actions based on identity verification and environmental safety. Using a vibration switch, the system detects seating events. A camera module performs facial recognition, checking the person’s identity against a pre-existing database. If the individual is not recognized, a relay module activates, exercising an electrical response system (ERS). Additionally, an MQ2 gas sensor placed in the seat, with the vibrometer, continuously monitors the air for hazardous gas concentrations. If the gas level surpasses a certain threshold, the relay is again activated, as is the ERS. In both cases, a red LED will flash for five seconds before triggering the relay. An email with details will be sent in any recognition case. This project has applications in security access control, varying seat reservation environments, and air quality monitoring in confined spaces. |
| 1. **BACKGROUND AND SIGNIFICANCE** Problem details; Rationale; Problems addressed; Research methods and sources. **[1.0 Points]** |
| Unauthorized seating in restricted areas and poor air quality in enclosed spaces are growing concerns. This system integrates occupancy detection, facial recognition, and environmental sensing to improve security and safety. Potential applications include the restriction of unauthorized seating in office and publicly accessible settings, hazard detection for the toxic gas accumulation in enclosed spaces, event seating enforcement to ensure reserved seating rules are followed, and industrial worker monitoring that confirm personnel identity/presence in restricted zones while ensuring safe air quality. Traditional solutions rely on manual checks or passive surveillance, which are slow and inefficient. This IoT-based system automates monitoring, enhances security, and provides real-time alerts. |
| 1. **LITERATURE REVIEW** Cite, Compare, Contrast, Critique, Connect **[2.0 Points]** |
| The integration of artificial intelligence in facial recognition systems has significantly improved security measures in various applications, including access control and monitoring [1]. The proposed IoT-based Smart Seat Occupancy and Safety System leverages this technology to verify user identity before granting access. Santoso et al. (2024) highlights the effectiveness of AI-driven facial recognition in software security, demonstrating its potential for real-time authentication and unauthorized access prevention [1]. This supports the project’s approach of using a camera module for identity verification.  In addition to facial recognition, environmental hazard detection plays a crucial role in ensuring safety. Kodali et al. (2018) explore the use of IoT-enabled gas sensors for detecting hazardous gas leaks in industrial environments, showcasing the importance of real-time monitoring for safety applications [2]. The implementation of an MQ2 gas sensor in this project aligns with these findings, as it continuously assesses air quality and triggers alerts when gas concentrations exceed safe thresholds.  Furthermore, the effectiveness of occupancy detection systems has been demonstrated in smart building applications. Dong et al. (2019) reviews various sensing technologies used for indoor environmental control, including vibration-based detection mechanisms [3]. Their findings support the use of a vibration switch in the proposed system, ensuring accurate seat occupancy detection. By integrating these technologies, the Smart Seat Occupancy and Safety System enhances both security and safety, offering an automated, real-time solution to access control and environmental monitoring challenges. |
| 1. **PROJECT DESIGN AND METHODS** Figure out what you need for the project; Think about potential obstacles **[1.5 Points]** |
| System Components:  **Vibration Switch** – Detects when a person sits down | **Camera Module** – Captures and processes facial images for identity verification | **Relay Module** – Controls external devices (e.g., alarms, door locks) upon unauthorized access or hazardous gas detection | **MQ2 Gas Sensor** – Continuously monitors air quality for harmful gases | **LED Indicator** – Warns the user before activating the relay.  Workflow:   1. Seat Detection: The vibration switch registers when someone sits down. 2. Facial Recognition: The camera captures an image, checking against a database of approved users. If the person is not recognized, the red LED flashes for 5 seconds, and the relay closes for one second. Then, an email is sent. If the person is recognized, an email is sent as well. 3. Gas Monitoring: The MQ2 sensor continuously measures gas levels. If the threshold is exceeded, the LED flashes for 5 seconds, then the relay closes for one second, and an email is sent.   Potential Obstacles:  Facial Recognition Accuracy: Poor lighting or occlusions can reduce identification performance.  Gas Sensor Calibration: Requires precise calibration to avoid false positives.  Power Management: Continuous sensing and image processing can drain power in battery-operated systems. |
| 1. **PRELIMINARY SUPPOSITIONS AND IMPLICATIONS** Task division; identify who is doing what if you are in a team of two **[2.0 Points]** |
| Since this is an individual project, I will be responsible for all aspects of hardware integration, software development, system testing, and documentation. The project will be divided into the following key tasks:  1. Hardware Integration   * Assemble and wire the vibration switch, MQ2 gas sensor, camera module, relay module, and LED indicator. * Ensure proper connectivity with the Raspberry Pi.   2. Software Development   * Develop a Python script to handle sensor data processing and facial recognition. * Implement a database system to store and match facial images. * Code the relay control logic to trigger actions based on detection conditions.   3. System Testing and Calibration   * Test vibration detection accuracy by simulating different seating scenarios. * Fine-tune the gas sensor threshold to ensure reliable readings. * Validate the facial recognition system under various lighting conditions.   4. Final Integration and Optimization   * Optimize power consumption and real-time processing efficiency. * Conduct multiple test runs to ensure the system operates reliably under different environmental conditions. |
| 1. **SUMMARY** Why is this problem worth addressing; Why is it unique and how does it advance existing knowledge **[1.0 Points]** |
| This project integrates vibration-based seat detection, AI-powered facial recognition, and real-time gas sensing to enhance security and safety in enclosed spaces. The system ensures only authorized users can sit in specific areas while also monitoring air quality for safety. The use of IoT automation makes this an efficient, scalable, and adaptable solution for multiple industries. The addition of email notifications also ensures the function of the system without any direct human intervention. |
| 1. **REFERENCES** References; Bibliography **[1.5 Points]** |
| 1. Santoso, Widi & Safitri, Rahayu & Samidi, Samidi. (2024). Integration of Artificial Intelligence in Facial Recognition Systems for Software Security. sinkron. 8. 1208-1214. 10.33395/sinkron.v8i2.13612. 2. R. K. Kodali, R. N. V. Greeshma, K. P. Nimmanapalli and Y. K. Y. Borra, "IOT Based Industrial Plant Safety Gas Leakage Detection System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), Greater Noida, India, 2018, pp. 1-5, doi: 10.1109/CCAA.2018.8777463. 3. [1]Dong, B., Prakash, V., Feng, F., and O'Neill, Z., “A review of smart building sensing system for better indoor environment control”, Energy and Buildings, vol. 199, pp. 29–46, 2019. doi:10.1016/j.enbuild.2019.06.025. |