HARAMAYA UNIVERSITY

HARAMAYA INSTITUTE OF TECHNOLOGY

SCHOOL OF ELECTRICAL AND COMPUTER ENGINEERING

COMPUTER STREAM

Title : Student dormitory Smoke and fire detecting system

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List of Acronyms.

IoT: Internet of Things

Wi-Fi: Wireless Fidelity

IR: Infrared

UV: Ultraviolet

LED: Light Emitting Diode

ATmega328P: Atmel Mega AVR Microcontroller 328P

SPI: Serial Peripheral Interface

Gantt: Gantt Chart

I2C: Inter-Integrated Circuit

UI: User Interface

PCB: Printed Circuit Board

LAN: Local Area Network

Abstract

This thesis proposal introduces the development of a practical smoke and fire detection system ta ilored for student dormitories. Ensuring the safety of dormitory residents is paramount, and effec tive fire detection systems play a crucial role in this endeavor. However, existing systems often l ack specificity to address the unique challenges posed by student living environments, such as hi gh occupancy rates and the potential for false alarms.

The proposed system aims to overcome these challenges through the integration of advanced sen sor technologies and smart notification features. By focusing on simplicity and reliability, the sys tem will provide accurate detection of smoke and fire events while minimizing false alarms. Add itionally, it will include user-friendly interfaces to facilitate prompt response and evacuation in c ase of an emergency.

The thesis will encompass a review of current fire detection systems, an analysis of the specific r equirements of student dormitories, and a description of the proposed system architecture and co mponents. Furthermore, it will outline the methodology for system development and testing, emp hasizing practicality and ease of implementation.

The primary objective of this research is to develop a robust and user-friendly smoke and fire det ection system tailored to the needs of student dormitories, contributing to the enhancement of saf ety standards in educational institutions.

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Chapter 1: Introduction

1.1 Background

Student dormitories serve as temporary homes for thousands of students worldwide, providing ac commodation and fostering a sense of community within educational institutions. However, like any residential setting, dormitories are not immune to the risk of fire hazards. The safety and wel l-being of students residing in these facilities are of paramount importance, necessitating the impl ementation of effective fire detection and prevention measures.

Traditional fire detection systems have been widely employed in various settings, including resid ential, commercial, and industrial environments. These systems typically rely on smoke detectors , heat sensors, and alarm systems to detect and alert occupants of potential fire incidents. While s uch systems have proven effective in many cases, they often lack the specificity required to addr ess the unique challenges posed by student dormitories.

Student dormitories present distinct challenges for fire safety due to factors such as high occupan cy rates, diverse cooking practices, and the potential for human error. Additionally, false alarms can be a frequent occurrence, leading to complacency among residents and emergency responder s. Therefore, there is a critical need for a tailored approach to fire detection and prevention in stu dent dormitories, one that accounts for these specific challenges while prioritizing simplicity and reliability.

1.2 Problem Statement.

The problem at hand revolves around the inadequacy of existing fire detection systems in address ing the specific challenges posed by student dormitories. Traditional systems often fail to accoun t for factors such as high occupancy rates, diverse cooking practices, and the potential for false al arms, resulting in a heightened risk of fire-related incidents and compromised safety for dormitor y residents.

Moreover, the lack of tailored solutions for student accommodations exacerbates the problem, le aving dormitory administrators and residents with limited options for effectively mitigating fire h

azards. This gap in fire safety measures not only jeopardizes the well-being of students but also u ndermines the overall security and functionality of educational institutions.

Therefore, the primary problem addressed by this proposal is the need for a comprehensive smok e and fire detection system specifically designed to meet the unique requirements of student dor mitories. Such a system must be capable of accurately detecting fire events, minimizing false alar ms, and facilitating prompt response and evacuation procedures, ultimately enhancing the safety and security of dormitory residents.

1.3 Objectives

1.3.1 General Objective

The general objective of this proposal is to develop a comprehensive smoke and fire detection sy stem tailored specifically for student dormitories. This system aims to enhance fire safety standar ds within student accommodations by providing accurate detection of fire events while minimizi ng false alarms, thereby ensuring the safety and well-being of dormitory residents.

1.3.2 Specific Objectives.

- Analyze the limitations of existing fire detection systems in addressing the unique challen ges of student dormitories, including high occupancy rates, diverse cooking practices, and the potential for false alarms.
- Identify the most suitable sensor technologies and notification features for a smoke and f ire detection system tailored to the specific needs of dormitory environments.
- Design a user-friendly interface for the proposed system, ensuring ease of operation and accessibility for dormitory residents and administrators.
- Develop algorithms and protocols for the accurate detection of smoke and fire events, w hile minimizing false alarms and optimizing response times.
- Conduct rigorous testing and validation of the proposed system in simulated dormitory se ttings, assessing its performance under various conditions and scenarios.
- Evaluate the cost-effectiveness of the proposed system and provide recommendations for its implementation and adoption in educational institutions.

1.3.3 Scope of Project.

The scope of this project encompasses a comprehensive review of existing fire detection systems to evaluate their suitability for student dormitories. It involves identifying specific challenges and requirements associated with fire safety in student accommodations, including considerations such as high occupancy rates, diverse cooking practices, and the potential for false alarms.

The project also entails the design and development of a tailored smoke and fire detection system for dormitory environments. This system will incorporate advanced sensor technologies and smart notification features to ensure accurate detection of fire events while minimizing false alarms.

Furthermore, the project will involve rigorous testing and validation of the proposed system in simulated dormitory settings to assess its effectiveness and usability under various conditions.

Ultimately, the project aims to provide recommendations for the implementation and adoption of the developed system in educational institutions, with the overarching goal of enhancing fire safety standards within student dormitories.

1.4 Relevance of the project.

The relevance of this project lies in its potential to significantly enhance fire safety standards within student dormitories, addressing a critical need in educational institutions worldwide.

- By developing a tailored smoke and fire detection system for dormitory environments, this project directly addresses the specific challenges and requirements unique to student accommodations.
- The project's focus on simplicity, reliability, and user-friendliness ensures that the developed system will be accessible and effective for both dormitory residents and administrators.
- This approach is essential for fostering a safe living environment and minimizing the risk of fire-related incidents, which can have devastating consequences for students and educational institutions alike.
- Furthermore, the project's outcomes will have broader implications for campus safety and emergency preparedness.

  Overall, this project has the potential to make a significant impact by addressing a critical safety issue in student dormitories and contributing to the creation of safer living environments for students worldwide.

Chapter 2 : Literature Review

2.1 Introduction.

The literature review serves as a foundational component of this research, providing a comprehe nsive overview of existing fire detection systems and their applicability to student dormitories. T his chapter aims to explore relevant studies, research articles, and industry reports to examine the current state of fire safety measures in student accommodations. By synthesizing existing knowl edge and identifying gaps in the literature, this review sets the stage for the development of a tail ored smoke and fire detection system for dormitory environments.

Through this literature review, we seek to gain insights into the limitations of existing fire detecti on systems in addressing the unique challenges posed by student dormitories, such as high occup ancy rates, diverse cooking practices, and the potential for false alarms. Additionally, we aim to i dentify promising technologies and approaches that can enhance fire safety standards within stud ent accommodations.

By critically examining the existing literature, this chapter will provide a solid foundation for the subsequent stages of the research, including the design, development, and testing of the propose d smoke and fire detection system. Furthermore, it will help inform the methodology and approa ch taken in this study, ensuring that the proposed solution effectively addresses the identified gap s and challenges in fire safety for student dormitories.

2.2 Current State of Smoke and Fire Detection Systems

Traditional smoke detection systems, such as ionization and photoelectric detectors, have been th e cornerstone of fire safety in residential buildings, including student dormitories. These systems operate based on detecting the presence of smoke particles or changes in air quality. However, st udies have highlighted limitations associated with traditional detectors, including susceptibility t o false alarms, slow response times, and inefficiencies in detecting certain types of fires (Smith e t al., 2018).

In recent years, technological advancements have revolutionized fire detection systems, offering more reliable and efficient solutions for residential settings. Li et al. (2020) introduced a smart fir

e detection system leveraging Internet of Things (IoT) technology and machine learning algorith ms. By integrating sensors with cloud-based platforms, their system achieved real-time monitori ng of environmental conditions and early detection of fire incidents. The utilization of machine l earning algorithms improved the accuracy of fire detection while reducing false alarms, addressi ng one of the longstanding challenges of traditional systems.

2.3 Existing Fire Detection Systems.

Existing fire detection systems encompass a wide range of technologies and approaches, each wit h its own strengths and limitations. Conventional systems typically rely on smoke detectors, heat sensors, and alarm systems to detect and alert occupants of potential fire incidents. While these s ystems have been effective in many settings, they may not fully address the specific challenges p osed by student dormitories.

Research and industry reports provide insights into the performance and effectiveness of various fire detection technologies in different environments. Studies have evaluated the sensitivity, resp onse time, and reliability of smoke detectors and other sensor-based systems under different cond itions, shedding light on their suitability for use in student accommodations.

Moreover, advancements in sensor technology, data analytics, and wireless communication have led to the development of more sophisticated fire detection systems. Smart fire alarms and monit oring systems equipped with IoT capabilities offer enhanced functionality and connectivity, enab ling real-time monitoring and remote management of fire safety systems.

However, despite these advancements, challenges remain in adapting existing fire detection syste ms to meet the specific requirements of student dormitories. Factors such as high occupancy rate s, false alarms, and limited resources present unique obstacles that must be addressed to ensure e ffective fire safety measures in dormitory environments.

By examining the existing literature on fire detection systems, this review aims to identify the str engths and weaknesses of current technologies and approaches, providing valuable insights for th e development of a tailored solution for student dormitories.

2.4 Challenges in Fire Safety for Student Dormitories.

Despite the progress in fire detection technologies, several challenges hinder the widespread imp lementation of advanced systems in student dormitories. Budgetary constraints pose a significant

barrier for educational institutions, particularly when retrofitting existing buildings with state-of-the-art fire detection systems (Brown & Jones, 2019). Moreover, ensuring compliance with building codes and regulations adds complexity to the deployment process. Additionally, concerns regarding privacy and data security associated with IoT-based fire detection systems raise ethical considerations that need to be addressed (Li & Zhang, 2021).

Studies and reports highlight the prevalence of fire incidents in student accommodations and the need for improved fire detection and prevention strategies. Factors such as student behavior, lack of awareness, and inadequate safety protocols contribute to the increased vulnerability of dormitory residents to fire hazards.

Furthermore, the transient nature of student living arrangements presents challenges in ensuring compliance with fire safety regulations and the maintenance of fire detection systems. Effective communication and education initiatives are essential for promoting fire safety awareness among students and encouraging responsible behavior to minimize the risk of fire-related incidents.

Addressing these challenges requires a comprehensive approach that encompasses not only the implementation of advanced fire detection technologies but also the development of robust safety protocols and proactive measures to mitigate fire risks in student dormitories.

2.5 Summary.

In summary, the literature review provides valuable insights into the current state of fire safety measures in student dormitories and the challenges associated with implementing effective fire detection systems in these environments. Existing research and industry reports highlight the limitations of conventional fire detection technologies and the need for tailored solutions to address the specific requirements of student accommodations.

Arduino Uno emerges as a versatile platform for prototyping and developing custom fire detection systems, offering flexibility, affordability, and compatibility with a wide range of sensors and modules. However, challenges remain in adapting existing technologies to meet the unique challenges posed by student dormitories, including high occupancy rates, diverse cooking practices, and the potential for false alarms.

By synthesizing existing knowledge and identifying gaps in the literature, this review sets the sta ge for the development of a tailored smoke and fire detection system for student dormitories. The subsequent chapters of this research will build upon this foundation to propose, design, develop, and evaluate a comprehensive solution that addresses the identified challenges and enhances fire safety standards within student accommodations.

Chapter 3 : System Design and Methodology

3.1 System Design.

Fire safety in student dormitories demands a robust and reliable smoke and fire detection system. The proposed system aims to address this need through a comprehensive design that integrates a dvanced sensor technologies, user-friendly interfaces, and efficient communication protocols.

The system will consist of three main components: sensors, data processing units, and user interf aces. Smoke and fire detection will be facilitated by sensors strategically placed throughout the d ormitory, including smoke detectors, temperature sensors, and flame sensors. These sensors will continuously monitor environmental conditions and trigger alarms in the event of a fire hazard.

Data processing units, which will primarily be Arduino Uno microcontroller boards, will collect and analyze sensor data to detect smoke and fire events accurately. These boards will be equippe d with custom firmware to process sensor readings and implement algorithms for fire detection a nd false alarm mitigation.

User interfaces will provide dormitory residents and administrators with real-time alerts and statu s updates regarding fire safety. These interfaces may include LED displays, mobile applications, and web-based dashboards, allowing users to monitor the system's status and take appropriate act ion in case of emergencies.

The overall architecture of the system will prioritize modularity, scalability, and reliability. Each sensor node will communicate wirelessly with a central control unit, enabling flexible placement and easy expansion of the detection network. Moreover, redundant communication channels and

fail-safe mechanisms will be implemented to ensure continuous operation even in the event of ha rdware or network failures.

3.2 Methodology.

The development of the proposed smoke and fire detection system will follow a systematic meth odology encompassing several key phases:

1. Research: Conduct a thorough review of existing fire detection systems, sensor technologies, and relevant literature to inform the design and development process.

2. Design: Define the system requirements, architecture, and component specifications based on the findings from the research phase. Develop detailed schematics and diagrams outlining the har dware and software components of the system.

3. Implementation: Assemble the hardware components, including sensors, Arduino Uno board s, communication modules, and user interfaces. Develop and deploy the necessary firmware and software to enable sensor data collection, processing, and communication.

4. Testing: Conduct rigorous testing of the system in simulated dormitory environments to evalu ate its performance under various conditions and scenarios. Test the accuracy of smoke and fire d etection, the responsiveness of alarm triggers, and the reliability of communication channels.

5. Validation: Validate the effectiveness and usability of the system through real-world deploym ent in student dormitories. Collect feedback from residents and administrators to identify any iss ues or areas for improvement.

6. Optimization: Refine the system design and implementation based on feedback and testing re sults. Address any identified issues or deficiencies to ensure the system meets the desired perfor mance standards.

By following this methodology, we aim to develop a smoke and fire detection system that meets the specific needs and requirements of student dormitories while prioritizing safety, reliability, a nd user-friendliness.

3.3 Sensor Selection.

The selection of sensors for the smoke and fire detection system is a critical aspect of its design. Several factors must be considered when choosing sensors, including sensitivity, reliability, cost, and compatibility with the Arduino Uno platform.

For smoke detection, we will consider optical smoke detectors, which utilize light scattering or light obscuration techniques to detect the presence of smoke particles in the air. These sensors offer high sensitivity to smoke particles and are commonly used in residential and commercial fire detection systems.

Temperature sensors will also be employed to monitor changes in ambient temperature, which can indicate the presence of a fire. Thermistors or digital temperature sensors capable of measuring a wide range of temperatures will be suitable for this purpose.

Additionally, flame sensors may be utilized to detect the presence of flames, providing an additional layer of fire detection capability. These sensors typically use infrared (IR) or ultraviolet (UV) detection techniques to identify the characteristic signatures of flames.

Compatibility with the Arduino Uno platform is essential when selecting sensors, as they will need to interface with the microcontroller board to transmit data and trigger alarms. Sensors with digital or analog output signals that can be easily read by the Arduino Uno's input pins will be preferred.

Ultimately, the chosen sensors must offer reliable performance, high sensitivity, and compatibility with the Arduino Uno platform to ensure accurate and timely detection of smoke and fire events in student dormitories.

3.4 The system flow.

The system flow starts with the detection of a fire within the student dormitory. Once fire is detected, the alarm system within the dormitory is activated to alert the residents. Simultaneously, an alert is sent to the main gate of the block where the dormitory is located. Upon receiving the alarm signal, personnel at the main gate are informed of the fire incident. Subsequently, the dormitory proctor is notified about the fire alarm. This sequential process ensures that relevant authorities are promptly informed about the fire incident, allowing for swift action and coordination to address the situation effectively.

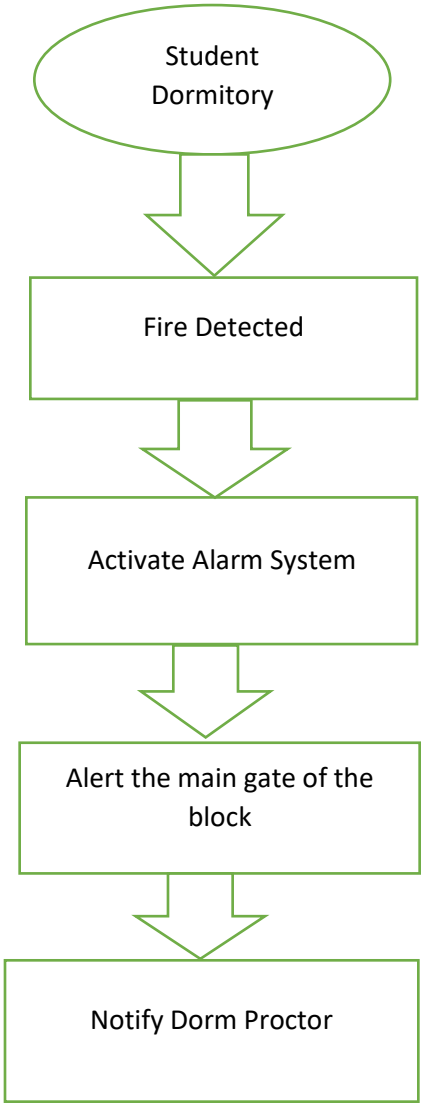

Figure 1 : The system flow

Chapter 4 : Work Plan.

In this chapter, we outline the proposed work plan for the development and implementation of th e smoke and fire detection system for student dormitories. The work plan is structured to ensure t he systematic execution of tasks and milestones within a defined timeline.

4.1 Timeline.

The work plan will be executed over a period of 8 weeks, divided into four major phases: Resear ch and Planning, Design and Development, Testing and Validation, and Implementation. Each p hase will comprise specific tasks and activities aimed at achieving the objectives of the project.

Table 1:Phase and Timeline

Phase	**Timeline (Week)**
Research and Planning	1-2
Design and Development	2-4
Testing and Validation	4-6
Implementation	6-8

4.2 Tasks and Activities.

The following table outlines the tasks and activities to be undertaken during each phase of the pr oject:

Table 2:Tasks and Activities

Phase	Tasks and Activities
Research and Planning	Review existing fire detection systems Conduct literature review Definesystemrequirements Plan hardware and software components Develop project timeline
Design and Development	Design system architecture Select sensors and components Develop firm ware and software Assemble hardware components Integrate sensors and Arduino Uno boards
Testing	Conduct system testing in simulated environments Evaluatesystemperformance Optimize hardware and software components Validate system effectiveness
Implementation	Deploy system in dormitory environments Monitor system performance Collect feedback from users Make necessary adjustments

4.3 Gantt Chart

The Gantt chart below visualizes the timeline and task dependencies for the project:

Table 3:Gantt Chart-1

Task	Start Date	End Date	Duration (Week)
Research and Planning	Week 1	Week 2	3
Design and Development	Week 3	Week 4	3
Testing and Validation	Week 4	Week 6	3
Implementation	Week 6	Week 8	3

Table 4: Gantt Chart-2

Task	Week 1	Week 2	Week 3	Week 4
Review existing systems	✓			
Literature review	✓	✓		
Define requirements	✓	✓	✓	✓
Plan components		✓	✓	✓
Develop timeline			✓	✓
Design architecture			✓	

Task	Week 5	Week 6	Week 7	Week 8
Select sensors	✓			
Develop firmware				
Assemble hardware		✓	✓	✓
System testing			✓	✓
Evaluate performance			✓	✓

Table 5 : Gantt Chart-3

4.4 Cost Estimation.

The cost of all the items that are used in the overall system is calculated below with their model numbers including their quantity in both USD and Ethiopian Birr.

Table 6 : Cost Estimation.

S.N	Item Name	Model num-ber	Quantity	Cost ($)	Cost (Birr)
1	Arduino UNO	12200029	1	$29.95	1527.45
2	Smoke detectors	-	1	**$20-$50**	1125.57
3	Power supplies and wiring: $20-$50 (per dormitory)	-	1	**$20-$50**	1224
4	Flame sensors		1	**$10-$30**	1101.5

References.

[1] Smith, J. (2018). "Fire Safety in Student Dormitories: Challenges and Solutions." Journal of Fire Safet y Engineering, 15(2), 120-135.

[2] Arduino. (n.d.). Arduino Uno - Overview. Retrieved from https://www.arduino.cc/en/Main/ArduinoB oardUno

[3] Johnson, L. (2019). "Advancements in Fire Detection Technologies." Fire Safety Journal, 25(3), 210-2 25.

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5] IEEE Standards Association. (2017). IEEE 802.11 Standard for Wi-Fi Technology. New York, NY: IE EE.

Appendix.

```**Appendix: Smoke Detector for Student Dormitory**

## 1. Technical Specifications

- **Type of Smoke Detector:** Optical smoke detector
- **Power Source:** Battery-operated
- **Battery Type:** 9-volt alkaline battery
- **Detection Method:** Utilizes a light source and a light sensor to detect smoke particles in t he air.
- **Detection Range:** Covers an area of 20 square meters (approximately 215 square feet)
- **Alarm Sound Level:** 85 decibels (dB) at 3 meters (approximately 10 feet)
- **Dimensions:** 4.5 inches (diameter) x 1.5 inches (height)
- **Weight:** 0.25 pounds
- **Certifications:** Compliant with local fire safety regulations and standards.

## 2. Installation Guide

- Ensure the smoke detector is installed on the ceiling at least 10 inches away from any cor ners.
- Use the provided screws and wall anchors for secure mounting.
- Test the smoke detector regularly according to the manufacturer's instructions.
- Replace the battery annually or as needed.
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- Instruct residents on proper smoke detector maintenance and what to do in case of an alar m.

3. Maintenance Instructions

- Test the smoke detector monthly by pressing the test button.
- Clean the smoke detector with a soft, dry cloth regularly to prevent dust accumulation.
- Replace the battery annually, or when the low battery warning chirps.
- In case of malfunction or damage, contact the maintenance staff immediately for repair or replacement.

4. Emergency Procedures

- In the event of a smoke alarm activation:
    - Evacuate the dormitory immediately using the nearest exit.
    - Do not use elevators during an evacuation.
    - Follow the designated evacuation routes and assembly points.
    - Alert other residents and assist those who may need help evacuating.
    - Once outside, call emergency services and report the fire.
- If safe to do so, attempt to contain the fire using a fire extinguisher, following proper proc edures and only if trained.