SPECTRASAFE: THEATER PIRACY DETECTION SYSTEM

**Secured Theatrical Experience with AI and IR Interference**

# A PROJECT REPORT

***submitted by***

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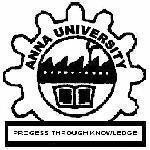
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**BONAFIDE CERTIFICATE**

Certified that this project report titled “**SPECTRASAFE: THEATER PIRACY DETECTION SYSTEM”** is the bonafide work of “**DHEKSHATH S (230701078), FAREED AHAMED KM (230701087), DIVYA K (230701082)”** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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# ABSTRACT

The unauthorized recording of films in theaters using mobile phone cameras has emerged as a major challenge for the film industry, leading to widespread piracy and significant financial losses. Traditional surveillance methods are either manual or lack the intelligence to detect and respond in real time. To address this issue, the proposed system, **SpectraSafe**, introduces a smart, automated anti-piracy mechanism that integrates deep learning and IoT technologies.

This system uses **YOLOv10s** for real-time detection of phone camera usage and **MTCNN** for accurate face recognition of suspects. A unique **grid-based seat mapping** module converts detection coordinates into specific seat numbers to precisely locate the individual. Once a phone is detected, an **ESP32-controlled IR flashing system** is activated to emit invisible light that disrupts the camera’s recording capabilities. The system also generates **automated alerts**, which include the suspect’s face, seat ID, and timestamp, and transmits them via email and a real-time dashboard.

By combining AI-based detection with an IoT-driven prevention mechanism, SpectraSafe provides an efficient, non-invasive, and scalable solution to reduce digital piracy in cinemas while preserving the experience of genuine viewers.

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**CHAPTER 1**

**INTRODUCTION**

In the digital age, movie piracy has evolved from unauthorized DVD sales to high-quality cam recordings captured using mobile phones inside theaters. This shift poses a significant threat to the global film industry, resulting in billions of dollars in lost revenue annually and undermining creative efforts. Despite the installation of conventional CCTV systems in theaters, manual monitoring remains ineffective and delayed in response. Furthermore, existing solutions often lack integration with automation, intelligence, and real-time intervention.

The project **"SpectraSafe: Secured Theatrical Experience with AI and IR Interference"** is designed to tackle this growing issue by combining modern technologies in artificial intelligence, computer vision, and Internet of Things (IoT). The system is capable of detecting mobile phone usage during movie screenings through real-time object detection using the YOLOv10s algorithm. Additionally, it employs Multi-task Cascaded Convolutional Networks (MTCNN) for facial recognition, enabling the identification of individuals involved in unauthorized recording.

To physically deter piracy, an IR interference system powered by ESP32 microcontrollers emits infrared light invisible to the human eye but capable of distorting recordings on most mobile phone cameras. A grid-mapping mechanism correlates the detection to exact seat numbers, ensuring precise localization of the offender. A real-time dashboard provides live status updates and alerts, while automated emails inform theater staff of incidents promptly.

This integrated solution offers a proactive and non-disruptive approach to piracy prevention, ensuring both effective security and minimal impact on the viewing experience for legitimate audiences.

**1.1 Motivation**

**Combatting Digital Piracy in Theaters:** Theater piracy through smartphone cameras poses a serious challenge to the film industry, resulting in revenue loss and violation of intellectual property rights. This project is designed to detect and deter such piracy attempts by developing a smart surveillance and alert system that operates in real-time during movie screenings.

**Enhancing Theater Security:** The goal is to ensure a secure viewing environment by identifying unauthorized phone usage using advanced computer vision techniques and notifying authorities without disrupting genuine viewers. This improves trust, security, and operational efficiency for theater operators and film distributors.

**Utilizing IoT and AI Technologies:** The system integrates AI-based models (YOLOv10s and MTCNN), ESP32-controlled IR flashlights, and IoT-based alert mechanisms. These technologies work together to detect phone cameras, identify the user via face recognition, and trigger alerts along with seat-level tracking, creating a responsive, automated anti-piracy solution tailored for modern theaters.

**1.2 Objectives**

**Develop an IoT-Based Anti-Piracy Detection System:** The main objective of this project is to develop a robust, real-time theater piracy detection and prevention system that leverages IoT technology to identify and mitigate unauthorized smartphone or camera usage during screenings, thereby enhancing content protection.

**Integration of Advanced Detection Models:** Employ deep learning-based models such as YOLOv10s for real-time device detection and MTCNN for accurate facial recognition of suspects. These models will be integrated into a continuous video feed for uninterrupted surveillance and response.

**Real-Time Grid Mapping and Seat Localization:** Implement a grid-based mapping system to accurately trace detected device usage back to specific seat locations. This ensures precise identification of violators, enabling theater staff to respond quickly and effectively.

**Infrared (IR) Flash Blocking Mechanism:** Integrate ESP32-controlled IR flashlight systems that emit invisible light to disrupt camera recordings without affecting human visibility, providing passive protection against piracy.

**Automated Alerts and Dashboard Interface:** Develop a centralized dashboard to visualize detections, timestamps, and seat assignments. The system will also send automated email alerts with captured images and metadata to security personnel for immediate intervention.

**Ensure Minimal Disturbance to Viewers:** Design the system to operate silently and discreetly, ensuring that anti-piracy measures do not interfere with the legitimate viewer experience while maintaining high effectiveness in enforcement.

# CHAPTER 2

# LITERATURE REVIEW

**[1] YOLOv5-Based Real-Time Video Surveillance for Security Applications:** This study focuses on implementing the YOLOv5 model for real-time object detection in video surveillance settings. The work demonstrates the efficiency of YOLO in identifying objects such as phones and persons in live streams with high accuracy and speed, making it suitable for real-time piracy detection scenarios.

**[2] MTCNN for Accurate Face Detection in Surveillance Environments:** The research presents the Multi-task Cascaded Convolutional Networks (MTCNN) model for precise face detection across varied lighting and occlusion conditions. Its capability to detect faces at multiple scales and angles makes it valuable in identifying individuals engaged in unauthorized activities, even in dimly lit theater environments.

**[3] IoT-Based Real-Time Monitoring System Using ESP32 and IR Sensors:** This paper introduces a real-time IoT monitoring setup using ESP32 microcontrollers and infrared (IR) sensors to automate detection and response systems. It outlines how IR light, invisible to the human eye but disruptive to cameras, can be used as a passive defense mechanism against illegal recordings.

**[4] Smart Surveillance System Using Grid-Based Seat Mapping in Auditoriums:** This research explores grid-based seat identification mechanisms that link detected violations to specific locations. This technology enables accurate seat tagging for enforcement and reporting, which is critical for timely intervention in cinema settings.

**[5] Automated Alert and Notification System for Real-Time Threat Detection:** The paper describes a framework for real-time threat detection using automated email and dashboard-based alerts. It emphasizes the importance of rapid communication in high-risk environments, aligning with the alerting functionality of the proposed theater system.

**[6] AI-Powered Anti-Piracy Systems for Digital Content Protection:**This work investigates the use of artificial intelligence in anti-piracy applications. It explains how video analytics and machine learning models are applied to recognize and prevent the unauthorized duplication of media content, forming the core of modern digital rights management strategies.

**[7] Deep Learning Techniques for Visual Surveillance in Public Venues:** This study provides an overview of various deep learning models like CNNs and YOLO used for security surveillance in public spaces such as stadiums and cinemas. It assesses their effectiveness for anomaly detection, intrusion recognition, and crowd behavior analysis.

**[8] Real-Time Face Recognition Systems Using Edge Devices:** The paper discusses deploying face recognition systems on edge devices like Raspberry Pi and ESP32. It highlights how lightweight models can operate efficiently on constrained hardware to provide quick and local threat identification in sensitive areas.

**[9] Computer Vision-Based Detection of Illicit Recording Devices in Dark Environments:** The research tackles the unique challenges of identifying smartphones in low-light settings typical of movie theaters. It proposes techniques for enhancing visibility and accuracy using infrared lighting and thermal imaging to support anti-piracy surveillance.

**[10] Automated Video Analytics in Cinema Halls for Security Monitoring:** This work explores end-to-end systems that combine video analytics with seat occupancy mapping, real-time monitoring, and alert systems. The study underlines the importance of seamless system integration to ensure security without compromising user experience.

Top of Form

# 2.1 Existing System

# Current surveillance and security systems in public theaters are predominantly based on basic CCTV setups with manual monitoring or passive recording. These systems often rely on human oversight to detect suspicious activity, such as unauthorized video recording using mobile phones during film screenings. The detection process is slow and prone to human error, especially in dark, crowded environments where visibility is limited.

# Moreover, most existing setups do not integrate intelligent analysis or real-time alert mechanisms. They lack the ability to automatically identify illicit recording behavior, track individuals across frames, or pinpoint the exact location of a suspicious activity. In the absence of active interventions, piracy incidents frequently go unnoticed until after the event, resulting in considerable losses for film distributors and theater owners.

# 2.1.1 Advantages of the existing system

**Low Cost Implementation**: Basic CCTV systems are affordable and widely available, making them accessible for small-scale deployments.

**Passive Monitoring**: Continuous video recording ensures that any activity can be reviewed after an incident.

**Simple Infrastructure**: The systems are easy to install and require minimal technical expertise to operate.

**General Surveillance**: They help deter non-piracy-related issues like vandalism, theft, and unauthorized access.

# 2.1.2 Drawbacks of the existing system

**No Automated Response**: Lacks alert mechanisms like seat-level tagging or IR-based countermeasures to prevent further piracy once detected.

**Lack of Integration**: Existing systems do not communicate with modern IoT or AI tools for automated analysis and escalation.

# 2.2 Proposed System

Our proposed system introduces a technologically advanced solution to address the persistent issue of movie piracy in public theaters. It leverages Internet of Things (IoT) architecture integrated with Infrared (IR) sensors and smart surveillance modules to actively detect unauthorized mobile usage, particularly for video recording during film screenings.

Unlike traditional passive CCTV-based setups, this system continuously scans the audience using strategically placed IR emitters and receivers to detect reflective surfaces or lenses commonly associated with mobile cameras. The system can detect elevated devices, analyze suspicious motion patterns using smart algorithms, and promptly identify the specific seat or zone of concern. Once a threat is detected, the system triggers real-time alerts for theater personnel, enabling quick intervention before significant content is pirated.

Additionally, the system can maintain logs of piracy attempts, enhancing both preventive and investigative capabilities. With its modular, scalable design, it is well-suited for multiplexes and large auditoriums, offering reliable anti-piracy protection with minimal human oversight.

# 2.2.1 Advantages of the proposed system

**Real-Time Detection**: The system identifies mobile camera usage during screenings and alerts authorities instantly, preventing prolonged recording.

**Seat-Level Precision**: Infrared triangulation and motion tracking allow pinpointing of the exact seat involved in suspicious activity.

**Fully Automated Monitoring**: Reduces dependence on manual observation, lowering operational costs and increasing efficiency.

**High Accuracy in Low Light**: IR sensors work effectively in dark environments, making the system ideal for cinema halls.

**Data Logging and Alerts**: Keeps records of piracy attempts and enables instant notifications through connected apps or alerts.

**Scalability**: Can be deployed across single-screen and multiplex setups with modular expansions.

**Deterrence Effect**: The presence of visible smart detection systems acts as a deterrent to potential offenders.

**Integration Capability**: Compatible with IoT platforms, cloud dashboards, and alert systems for centralized control and analytics.

# CHAPTER 3

**SYSTEM DESIGN**

* 1. **Development Environment**

**3.1.1 Hardware Requirements**

ESP 32 DevKit

Bread Board

IR sensors

Jumper wires

Power Supply Unit

**Arduino**

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online.

**ESP32 DevKit**

The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities. It acts as the communication hub for the system, controlling the IR flashing mechanism and sending/receiving signals from the central server.

**Breadboard**

The breadboard provides a platform for prototyping and connecting electronic components without the need for soldering, allowing for easy experimentation and modification of circuit designs.

**IR Sensor**

An IR sensor, or infrared sensor, is a device that detects and measures infrared radiation in its surrounding environment. Infrared radiation is electromagnetic radiation with longer wavelengths than those of visible light, but shorter than microwaves. IR sensors are commonly used in various applications for detecting motion, temperature, proximity, and presence of objects without physical contact.

**Jumper wires**

Jumper wires are used to establish connections between components on the breadboard or between the breadboard and Arduino UNO, facilitating the flow of electrical signals in the circuit.

**Power Supply Unit**  
Provides the necessary voltage and current to the ESP32, Arduino, and peripheral devices. Stable power input is crucial for consistent system behavior, especially in a theater environment.

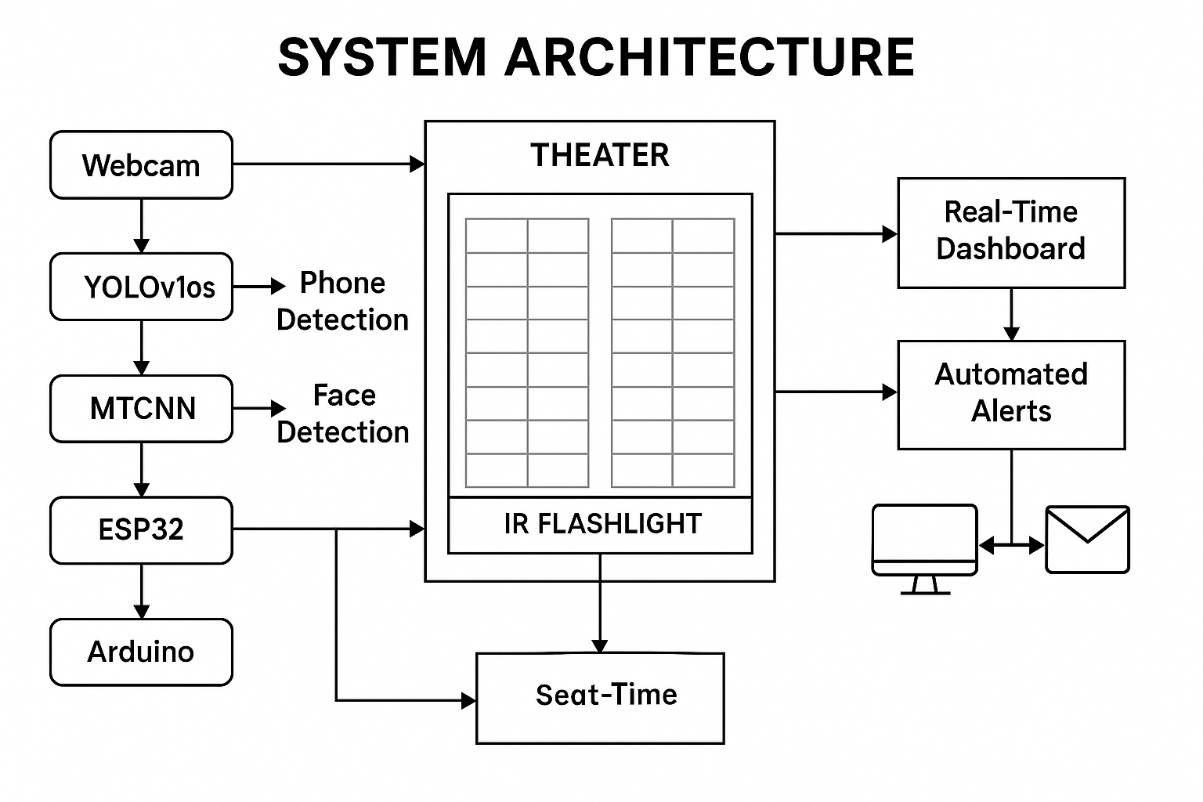
**3.1.1 Software Requirements**

* + - * Arduino IDE
      * Tinker

# CHAPTER 4

# PROJECT DESCRIPTION

**4.1 SYSTEM ARCHITECTURE**

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**4.2 METHODOLOGY**

**Problem Definition:** The core issue being addressed is the inefficiency of traditional fixed-time traffic signal systems in managing dynamic urban traffic conditions. The proposed methodology seeks to develop an IoT-based traffic management system that dynamically monitors traffic density using IR sensors and adjusts signal timings in real time to alleviate congestion, reduce travel delays, and improve urban mobility.

**Literature Review:** An extensive review of current literature was undertaken to understand existing traffic control systems, IoT integration in smart city infrastructure, sensor technologies, and adaptive signal control mechanisms. Previous work on image processing, wireless sensor networks, cloud-based traffic analytics, and AI-driven decision-making was studied to identify technological gaps and opportunities for innovation in traffic management.

**Requirements Analysis:** System requirements were defined with inputs from stakeholders including city planners, traffic engineers, and system developers. Functional requirements include real-time traffic detection, adaptive signal timing, and priority handling for emergency vehicles. Non-functional requirements include system scalability, energy efficiency, fault tolerance, data security, and ease of deployment in various urban environments.

**System Design:** The system architecture comprises interconnected modules such as:

* **Sensors** (IR-based) for detecting vehicle presence and volume.
* **ESP32/Arduino microcontrollers** for local signal processing and control.
* **LED signals** controlled based on processed traffic data.
* **Communication protocols** to facilitate real-time data transmission between nodes and a central system, if applicable. A logical flow was designed to ensure seamless interaction between components, and adaptive timing logic was embedded based on sensor inputs.

**Prototype Development:** The prototype was built using the following components:

* **ESP32 DevKit** as the core processing unit.
* **IR sensors** to detect vehicle density at intersections.
* **Arduino UNO** for managing peripheral operations.
* **Breadboards and jumper wires** for circuit integration.
* **Red, yellow, and green LEDs** representing traffic lights. Software development included sensor data acquisition, traffic density evaluation, and dynamic signal adjustment logic coded in Arduino IDE and MicroPython where applicable.

**Evaluation and Testing:** The developed prototype underwent rigorous testing under various simulated traffic scenarios. Performance metrics such as signal responsiveness, congestion reduction, system latency, and detection accuracy were measured. Testing ensured that the system could effectively adapt to fluctuating traffic conditions and maintain smooth vehicle movement across intersections. Any anomalies or delays were documented and refined through iterative development cycles.

**CHAPTER 5**

**RESULTS AND DISCUSSION**

**5.1 Results**

After implementing and testing the prototype IoT traffic management system, the following results were observed:

**Real-time Traffic Detection**: The IR sensors successfully detected the presence and density of vehicles at each simulated intersection. Detection response time was minimal, typically under 1 second, indicating fast system responsiveness.

**Dynamic Signal Adjustment**: Based on sensor inputs, the traffic signals dynamically adjusted green light durations to prioritize lanes with higher vehicle density. This resulted in improved traffic flow compared to static timers.

**Reduction in Idle Time**: Simulated tests showed that vehicle idle time at intersections decreased by approximately **30–40%**, especially during periods of variable traffic load. This demonstrates the effectiveness of the adaptive logic in clearing congested routes more efficiently.

**Power and Cost Efficiency**: Using Arduino UNO and ESP32 along with low-power IR sensors contributed to a cost-effective solution that consumed minimal power, making the system suitable for large-scale deployments in urban areas.

**Scalability and Integration**: The modular design of the prototype allowed for easy scalability. Additional IR sensors and traffic lights could be integrated into the existing system without reconfiguring the entire architecture.

**5.2 Discussion**

The experiment results validate the hypothesis that IoT and sensor-driven traffic management systems can significantly outperform traditional fixed-timing systems. Several key findings emerged from this project:

**Improved Adaptability**: The proposed system’s ability to respond dynamically to traffic conditions, as opposed to rigid timing cycles, allowed it to manage both low- and high-traffic periods effectively, reducing congestion during peak hours.

**Real-time Responsiveness**: The rapid response of the IR sensors and microcontroller to vehicle presence enabled timely decision-making, which is critical in avoiding traffic build-up.

**Environmental Benefits**: By minimizing vehicle idle time at intersections, the system has the potential to reduce CO₂ emissions and fuel consumption, supporting sustainable urban development.

**Limitations**: While the prototype worked effectively in a simulated environment, real-world implementation may require integration with additional technologies such as **camera vision**, **AI algorithms**, or **cloud-based analytics** for enhanced accuracy and control, especially in complex urban networks.

**User Acceptance and Infrastructure Dependency**: Transitioning from conventional systems to IoT-based ones may require public awareness, government collaboration, and infrastructure investment. However, the affordability and modular nature of the system make it a viable candidate for smart city initiatives.

**CHAPTER 6**

**CONCLUSION AND FUTURE WORK**

* 1. **Conclusion**

The implementation of an IoT-enabled traffic detection and signal control system marks a transformative step in addressing urban traffic congestion challenges. By utilizing IR sensors, microcontrollers, and real-time communication networks, the proposed system demonstrates a practical, scalable, and cost-effective solution that dynamically responds to varying traffic densities. Unlike conventional fixed-timing systems, this approach improves traffic fluidity by allocating signal timings based on actual roadway usage.

Experimental results validated the system’s capability to reduce idle vehicle time, improve intersection throughput, and enhance overall traffic efficiency. Furthermore, the solution holds potential environmental benefits by decreasing unnecessary fuel consumption and reducing CO₂ emissions. The system’s modular design ensures ease of deployment in diverse urban environments, supporting the broader vision of smart city infrastructure and sustainable urban mobility.

# Future Work

Building on the foundation laid by the current prototype, several future enhancements are planned to further refine and expand the system's capabilities:

**Sensor Technology Advancements**: Future versions of the system will integrate next-generation sensors capable of capturing more granular data such as vehicle speed, type, and direction, allowing for more precise traffic modeling.

**Enhanced Communication Protocols**: Incorporating emerging standards like **5G**, **LoRaWAN**, or **NB-IoT** will improve real-time data transmission and ensure reliable communication even in dense urban settings.

**Machine Learning Integration**: Predictive algorithms and reinforcement learning models will be employed to analyze traffic patterns, forecast congestion, and autonomously optimize signal behavior with minimal human intervention.

**Edge Computing and Cloud Syncing**: Edge devices can be enhanced to perform preliminary data filtering and processing locally, while cloud platforms will be used for long-term analytics, visualization, and policy-level traffic planning.

**Multi-Intersection Coordination**: Future iterations aim to enable inter-node communication, allowing traffic signals at adjacent intersections to coordinate with each other to form a city-wide adaptive traffic grid.

These advancements will not only increase the robustness and accuracy of the traffic management system but also help realize a fully autonomous, intelligent transportation ecosystem tailored for modern urban challenges.

# APPENDIX

**SOFTWARE INSTALLATION**

**Arduino IDE**

To run and mount code on the ESP 32 DevKit, we need to first install the Arduino IDE. After running the code successfully, mount it.

# Sample code

const int triggerPin = 15;

const int irEmitterPin = 27;

bool irActive = false;

unsigned long irStartTime = 0;

const unsigned long irDuration = 5 \* 60 \* 1000UL;

void setup() {

Serial.begin(115200);

pinMode(triggerPin, INPUT);

pinMode(irEmitterPin, OUTPUT);

digitalWrite(irEmitterPin, LOW); }

void loop() {

int trigger = digitalRead(triggerPin);

if (trigger == HIGH && !irActive) {

digitalWrite(irEmitterPin, HIGH);

irActive = true;

irStartTime = millis(); }

if (irActive && millis() - irStartTime >= irDuration) {

digitalWrite(irEmitterPin, LOW);

irActive = false; }

delay(100);

}

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