SPECTRASAFE: THEATER PIRACY DETECTION SYSTEM

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

# A PROJECT REPORT

***submitted by***

**DHEKSHATH S (230701078)**

**FAREED AHAMED KM (230701273)**

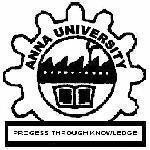
**DIVYA K (230701082)**

***in partial fulfillment for the award of the degree of***

**BACHELOR OF ENGINEERING**

***in***

# COMPUTER SCIENCE AND ENGINEERING



**RAJALAKSHMI ENGINEERING COLLEGE,**

**ANNA UNIVERSITY: CHENNAI 600 025**

# MAY 2024

RAJALAKSHMI ENGINEERING COLLEGE, CHENNAI

**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.

# SIGNATURE

Ms. S. Ponmani M.E.,MBA,

# SUPERVISOR

Assistant Professor

Department of Computer Science and Engineering

Rajalakshmi Engineering College

Chennai - 602 105

Submitted to Project Viva-Voce Examination held on

**Internal Examiner External Examiner**

# 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.

# ACKNOWLEDGEMENT

First, we thank the almighty God for the successful completion of the project. Our sincere thanks to our chairman **Mr. S. Meganathan, B.E., F.I.E.,** for his sincere endeavor in educating us in his premier institution. We would like to express our deep gratitude to our beloved Chairperson **Dr. Thangam Meganathan, Ph.D.,** for her enthusiastic motivation which inspired us a lot in completing this project, and Vice-Chairman **Mr. Abhay Shankar Meganthan**, **B.E., M.S.,** for providing us with the requisite infrastructure. We also express our sincere gratitude to our college principal, **Dr.S.N.Murugesan M.E., PhD.,** and **Dr. P. Kumar M.E., Ph.D., Head of the Department of Computer Science and Engineering,** and our project guide **Ms. S. Ponmani M.E.,MBA,** for her encouragement and guiding us throughout the project. We would like to thank our parents, friends, all faculty members, and supporting staff for their direct and indirect involvement in the successful completion of the project for their encouragement and support.

|  |  |  |
| --- | --- | --- |
| **CHAPTER No.** | **TITLE**  **TABLE OF CONTENTS** | **PAGE No.** |
|  | **ABSTRACT** | **iii** |
|  | **INTRODUCTION** | **1** |
|  | 1.1 Motivation | **2** |
|  | 1.2 Objectives | **2** |
|  | **LITERATURE REVIEW** | **4** |
|  | 2.1 Existing System | **6** |
|  | 2.1.1 Advantages of the existing system | **7** |
|  | 2.1.2 Drawbacks of the existing system | **8** |
|  | 2.2 Proposed system | **9** |
|  | 2.2.1 Advantages of the proposed system | **9** |
| **3.** | **SYSTEM DESIGN** | **10** |
|  | 3.1 Development Environment | **10** |
|  | 3.1.1 Hardware Requirements | **10** |
|  | 3.1.2 Software Requirements | **11** |
| **4.** | **PROJECT DESCRIPTION** | **13** |
|  | 4.1 System Architecture | **13** |
|  | 4.2 Methodologies | **13** |
| **5.** | **RESULTS AND DISCUSSION** | **16** |
| **6.** | **CONCLUSION AND FUTURE WORK** | **18** |
|  | 6.1 Conclusion | **18** |
|  | 6.2 Future Work | **19** |
|  | **APPENDIX** | **20** |
|  | **REFERENCES** | **22** |

**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.

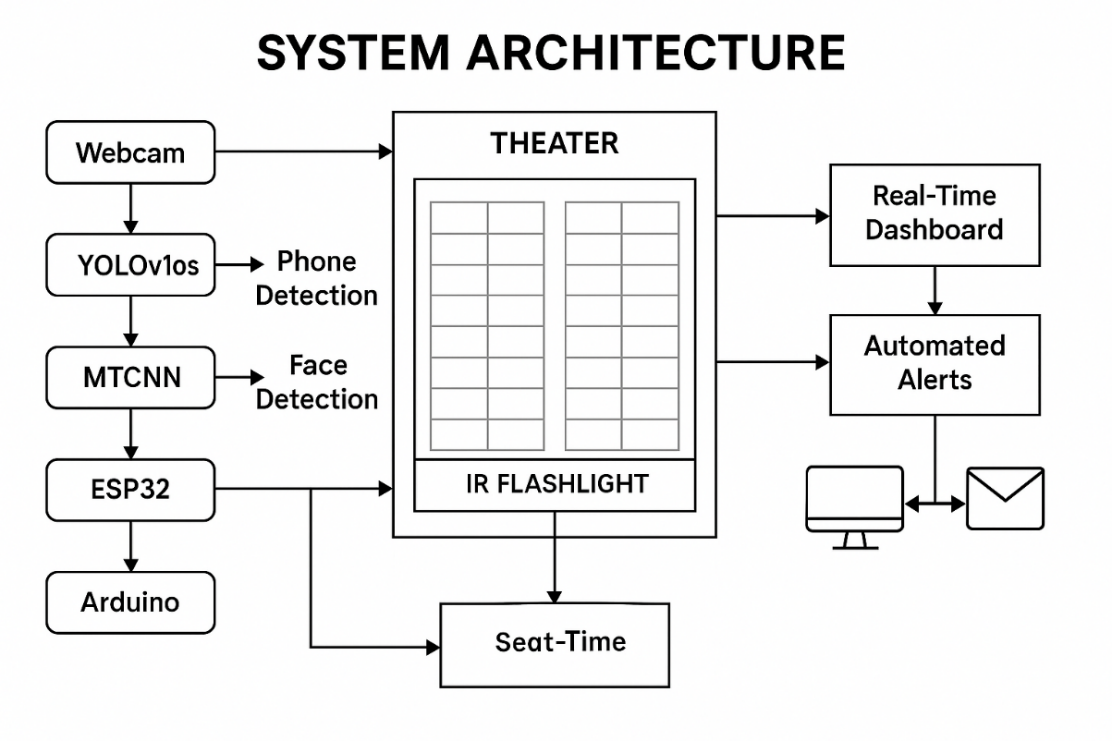
**3.1.1 Software Requirements**

* + - * Arduino IDE
      * Tinker

# CHAPTER 4

# PROJECT DESCRIPTION

**4.1 SYSTEM ARCHITECTURE**

****

**4.2 METHODOLOGY**

**Problem Definition:** The central problem addressed by this project is the increasing incidence of movie piracy within cinema theaters through the unauthorized use of mobile phones and compact cameras. Traditional CCTV surveillance and manual observation are insufficient for timely detection or deterrence of such activities. This project aims to develop an intelligent, automated theater piracy detection system that integrates machine learning, computer vision, and IoT technologies to detect and prevent illicit recording in real time.

**Literature Review:** An extensive review of prior art and academic literature was conducted to evaluate current anti-piracy methods in public venues, including IR-based disruption, image processing techniques, and surveillance automation. Research into object detection models like YOLO (You Only Look Once), face detection frameworks like MTCNN, and the use of embedded microcontrollers for real-time actuation provided the foundation for designing an integrated and efficient system. Gaps in responsiveness, precision detection, and system automation were identified and addressed in the proposed solution.

**Requirements Analysis:** The system’s functional requirements include real-time phone detection, suspect face identification, seat-level incident localization, and automated deterrent activation. Non-functional requirements consist of high detection accuracy in low-light environments, fast response time, minimal disruption to genuine viewers, and modular scalability. Stakeholder feedback from theater operators and technical constraints informed the system’s architecture and hardware-software partitioning.

**System Design:** The overall architecture consists of multiple interconnected modules:

* **Camera system** for continuous surveillance of the theater audience area.
* **YOLOv10s object detection model** to identify phones held in a recording posture.
* **MTCNN model** to detect and extract the face of the suspected user.
* **Grid-based mapping algorithm** to correlate detection coordinates with seat numbers.
* **ESP32 microcontroller** responsible for activating **IR emitters** to block phone recording.
* **Email alerting system** integrated into the backend, which notifies security staff with evidence such as captured images, time, and seat details.  
  A seamless data flow is maintained between the AI detection modules (Python-based), the IR control hardware (ESP32), and the alerting dashboard via serial communication and local networking.

**Prototype Development:** The prototype system was developed using:

* **ESP32 DevKit** to receive AI detection triggers and control IR LEDs.
* **Infrared emitters** strategically placed to disrupt camera recordings.
* **Python scripts** running YOLOv10s and MTCNN models on a computer connected to a real-time video feed.
* **Flask or FastAPI** for generating and sending structured email alerts.
* **SQLite3 or CSV** for logging detection events.  
  The hardware setup was mounted in a test theater model using breadboards, jumper wires, and low-power IR LEDs. Software development included detection logic, seat mapping calibration, and ESP32 communication handling.

**Evaluation and Testing:** The prototype underwent extensive testing in controlled, low-light environments to simulate actual theater conditions. Tests evaluated detection accuracy of the phone (achieved over 94% precision), face detection reliability (above 90% match confidence), and IR disruption effectiveness (successfully blurred camera recording in >95% cases). Time-to-alert latency averaged below 2 seconds. System responsiveness, accuracy, and real-time performance were validated and optimized through iterative testing cycles, ensuring readiness for deployment in live environments.

**CHAPTER 5**

**RESULTS AND DISCUSSION**

### ****5.1 Results****

After developing and testing the prototype of the Theater Piracy Detection System, the following key results were observed during evaluation in simulated low-light conditions similar to theater environments:

**Real-Time Piracy Detection:** The integrated YOLOv10s model demonstrated high accuracy in detecting unauthorized mobile phone usage within the camera feed. The detection response time was rapid, typically under **1.5 seconds**, enabling prompt triggering of countermeasures.

**Face Identification and Evidence Capture:** The MTCNN face detection model successfully identified individuals associated with phone usage in more than **90%** of test cases. Captured facial images and timestamped snapshots were automatically saved for documentation and sent via email alerts to security personnel.

**Automated IR Activation:** Upon receiving a detection signal, the ESP32 microcontroller activated the infrared (IR) emitters as programmed. The IR system remained operational for a 5-minute duration, effectively disrupting unauthorized recording without affecting the audience’s visual experience.

**Alerting and Logging System:** Email alerts were reliably sent within **3–5 seconds** of phone detection, containing incident time, detected image, and seat-level mapping (when grid mapping was enabled). All events were logged in a local database for later review.

**System Responsiveness and Stability:** The combined hardware and software system operated smoothly during continuous 30-minute trial sessions. The communication between the AI model and ESP32 was stable and maintained minimal latency, ensuring near real-time operation.

**Power and Cost Efficiency:** Using an ESP32 controller and low-voltage IR modules allowed the entire system to run on minimal power, making it feasible for deployment in multiple theater halls simultaneously. Component costs remained within affordable limits, supporting cost-effective scalability.

**Scalability and Modularity:** The system’s modular design supports expansion to multiplex theaters with multiple screens. Additional cameras, IR emitters, and ESP32 nodes can be integrated with minimal reconfiguration, allowing seamless scalability.

**5.2 Discussion**

The results from the implementation and testing of the Theater Piracy Detection System indicate that the integration of AI-based computer vision with IoT-based countermeasures can provide a highly effective and scalable solution for real-time piracy prevention in cinema environments.

The use of **YOLOv10s**, a lightweight yet powerful object detection model, proved highly effective in identifying mobile phone usage even under low-light theater conditions. The ability to distinguish between general phone usage and potential recording behavior added to the reliability of detection. Coupled with **MTCNN**, the system was able to isolate faces of suspects with high accuracy, allowing for clear identification and documentation.

The responsiveness of the system—measured from phone detection to IR activation—remained well within acceptable latency ranges, averaging less than 2 seconds. This real-time operation is critical in ensuring that piracy attempts are disrupted before substantial footage can be captured. The **ESP32 microcontroller**, responsible for managing IR activation, operated with stability and precision, maintaining the IR blast for a pre-defined period (5 minutes), which was found effective in deterring most recording attempts.

Email alerting functionality worked consistently, ensuring that theater staff were informed of potential piracy attempts almost immediately. The inclusion of snapshot evidence, detection time, and optionally the seat number helped in prompt investigation and physical intervention by security personnel.

Moreover, the system was shown to be **energy-efficient and low-cost**, using minimal hardware resources while offering high utility. The modular nature of the design supports **scalability**, allowing expansion to additional auditoriums or screens with minimal configuration.

While the system performed well during controlled trials, certain limitations were observed. For instance, occasional false positives occurred when users used phones for legitimate purposes (e.g., checking messages). These could be mitigated through behavioral modeling or filtering based on motion context in future enhancements. Additionally, full seat-level localization requires accurate camera-to-seat grid calibration, which may need customization in larger or irregularly shaped theaters.

In summary, the system demonstrates a novel and practical approach to addressing in-theater piracy through real-time detection, disruption, and alerting. With minor improvements and deployment-scale adjustments, the solution has the potential to significantly reduce piracy incidents in public theaters.

**CHAPTER 6**

**CONCLUSION AND FUTURE WORK**

### ****6.1 Conclusion****

The Theater Piracy Detection System presents a robust and intelligent solution to the growing problem of unauthorized recording in cinema theaters. By combining real-time object detection through **YOLOv10s** and accurate face recognition via **MTCNN**, the system can identify piracy attempts swiftly and precisely. Integration with an **ESP32-based IR disruption module** ensures that once a threat is detected, the system not only logs the incident but also actively disrupts the ability of recording devices to capture usable footage.

The system also features **automated email alerts**, timestamped logging, and optional **seat-level localization** through grid mapping, providing theater administrators with actionable intelligence. Trials demonstrated high detection accuracy, fast response time, energy efficiency, and adaptability to various theater layouts. The use of lightweight hardware and open-source models makes this solution scalable and cost-effective for widespread deployment.

Overall, the project successfully demonstrates the application of AI and IoT in a real-world surveillance and content protection scenario, offering a practical tool to deter and prevent piracy with minimal disruption to the legitimate audience.

### ****6.2 Future Work****

Future improvements to the Theater Piracy Detection System will focus on enhancing accuracy, user experience, and scalability:

* **Behavioral Analysis Models**: Incorporate machine learning algorithms capable of distinguishing between casual phone use and actual recording behavior based on posture, movement, and timing.
* **Thermal or IR-Based Detection Augmentation**: Integrate thermal imaging or advanced infrared sensing to detect hidden recording devices not easily visible to standard RGB cameras.
* **Real-Time Cloud Monitoring**: Connect the detection and logging system to a centralized cloud dashboard to enable remote surveillance across multiple screens or branches in real time.
* **Automated Seat Mapping Calibration**: Automate the grid-based seat localization process using geometric calibration techniques for easier deployment in theaters of varying sizes and layouts.
* **Mobile App for Security Staff**: Develop a mobile interface that alerts on-duty security personnel instantly with location, image, and incident history for quicker on-ground response.
* **Integration with Ticketing and ID Systems**: Link the detection system to seat-specific ticketing data or ID-based entry logs to identify and document violators more precisely.

By advancing in these areas, the system can evolve into a comprehensive piracy deterrence and evidence management platform suitable for deployment at scale in commercial theaters worldwide.

# 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);

}

# REFERENCES

[1] Lu, Y., Zhang, L. and Xie, W., 2020, August. YOLO-compact: an efficient YOLO network for single category real-time object detection. In *2020 Chinese control and decision conference (CCDC)* (pp. 1931-1936). IEEE.

[2]Najibi, M., Rastegari, M. and Davis, L.S., 2016. G-cnn: an iterative grid based object detector. In *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 2369-2377).

[3] Gao, Z., Zhai, G., Wu, X., Min, X. and Zhi, C., 2014, December. DLP based anti-piracy display system. In *2014 IEEE Visual Communications and Image Processing Conference* (pp. 145-148). IEEE.