

BUILDING A SMART IOT-ENABLED SURVEILLANCE CAMERA WITH LIVE STREAMING APP

Abstract

In today's world, ensuring security has become a paramount concern, prompting the exploration of various technologies to safeguard and monitor our surroundings. However, these technologies often come at a high cost, posing a challenge for domestic and small-scale businesses seeking effective yet budget-friendly security solutions. Traditional CCTV systems also demand constant human surveillance, adding to the complexity. This paper introduces an IoT-based intelligent CCTV camera system integrated with video recording capabilities, focusing on delivering live streams to authorized users via an Android application. This innovative approach empowers users to effortlessly monitor their residences through a mobile app, offering an economical and efficient security solution for households and small businesses. The system autonomously detects, monitors, and alerts users about potential intruders within the monitored premises. Upon detecting an intrusion, the camera triggers an immediate alert, sending a notification to the authorized user's mobile app. This notification includes a live video stream, providing real-time visual evidence of the incident.

Keywords: CCTV camera, video recording, live streams, android application, security solutions.

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I. INTRODUCTION

The IoT phenomenon has swept the globe, ushering in an era where commonplace devices seamlessly connect and communicate through the internet, elevating our everyday experiences to unprecedented heights. At the forefront of this technological wave lie smart cities and home automation, burgeoning fields that captivate the present moment. Within this landscape, IoT finds a vital application in the realm of smart security systems.

The evolution of Smart Security Cameras has been nothing short of remarkable, assuming a pivotal role in fortifying homes and ensuring safety. This technology transcends the domestic sphere and extends its embrace to social security. Central to this paradigm is an ingenious automated smart CCTV camera, endowed with the remarkable ability to autonomously detect, monitor, and promptly alert users to the presence of intruders within the surveilled premises.

Enabling this sophisticated system is the Arduino UNO microcomputer, an embodiment of cost-effective ingenuity catering to a myriad of applications. For those stepping into the realm of electronics and coding, the Arduino UNO stands as the most resilient and optimal platform for exploration. Built upon the ATmega328P microcontroller, it boasts 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. This all-encompassing infrastructure readily accommodates the microcontroller's demands, offering a straightforward connection via USB or powering it through an AC-to-DC adapter or battery.

In this burgeoning domain of security, a novel technology takes shape, orchestrating a secure and nurturing milieu within modest abodes. The system bears manifold objectives: the discernment of an intruder's presence, the capture of their image, and the dissemination of an alert to the property owner. Positioned at the entrance, a high-definition camera springs to life upon activation. When a human countenance enters its frame, the camera adeptly identifies and acknowledges the visitor. With its gaze fixed and recognition achieved, the camera promptly captures an image while concurrently initiating video recording. This live stream becomes instantly accessible via an intuitive Android app, offering users real-time insights into the transpiring events.

In this synergy of IoT innovation, smart security, and microcontroller mastery, a new horizon emerges—a realm where connectivity, vigilance, and convenience harmoniously coexist to shape the future of safeguarding our spaces.

II. LITERATURE REVIEW

“IoT Based Smart Surveillance System” presented by M Sri Lakshmi, C Padma et al^[1] elaborates the way of using the power of Iot in the field of Surveillance. The IoT based surveillance systems enables the user to view the activity from a remote location. It also facilitates the user to receive notifications whenever the intrusion is detected with the help of sensors connected with the surveillance cameras. This reduces the human intervention in the Surveillance monitoring and reduces the errors of manual surveillance.

“Implementation of Closed-circuit Television (CCTV) Using Wireless Internet Protocol (IP)Camera” presented by A Michael F Adaramola et al^[2]. In this paper, the

implementation of Surveillance camera using Wi-Fi based technology is presented. The live streaming of video based surveillance can be adapted for the image detection and tracking for real-time intelligent.

“Action Recognition using Surveillance system” presented by Rishabh Paunikar, Shubham Thakare, Utkarsh Anuse et al^[3]. They elaborated that Surveillance systems use CCTV cameras or other surveillance equipment continuously record the footage while they are in use. The majority of the data is idle data, meaning there is no activity taking place. When viewing a previously recorded activity, the viewer must go through all of the film to determine when and what occurred.

“Automation in Surveillance” presented by Prajakta Jadhav, Shweta Suryawanshi, Mr. Devendra Jadhav et al^[4]. In this paper, the authors discussed the approaches in the automation and how to make it possible. It also mentions the storing the data in a minimal space. Most of the idle data where no event takes place occupies the storage and also the operator has to go through the entire footage to identify the particular incident. So, by using Smart surveillance systems, this time-consuming task can be reduced. This automation in surveillance can be achieved through Smart surveillance monitoring system.

“IoT Based Facial Recognition Security System” presented by Prashanth Balraj Balla, K.T. Jadhao et al.^[5]. The main purpose of this paper is to set as an alert for home visitors and provide information about the visitors in a dynamic website and phone application. The alerts are sent based on the data acquisition using sensors and the alerts of intrusion or thefts, will be sent to the registered user along with the picture of the incident using a camera module.

“Design and Implementation of Home Automation System” presented by A. Alheraish, Member^[6]. Explained that IEEE remote control system is designed and implemented using the GSM cellular connection network. This design incorporates the controlled device, the microcontroller, and the GSM Module, allowing it to be used in a variety of applications. Instead of a microcontroller, the proposed M2M system in this study uses a PC as the terminal user.

“Design and Implementation of UPnP-Based Surveillance Camera System for Home Security”. This paper is presented by Yi Gu, Myoungjin Kim Division of Internet & Multimedia Engineering, Konkuk University, Seoul, South Korea^[7]. The main focus of this article is on the rapid development of mobile devices and Internet services, and how these devices and services might be used to manage home security. They proposed the UPnP based Security Camera System (USCS), which uses UPnP technology to search, operate, and administer IP-based cameras, to broaden the range of usability of traditional home surveillance cameras

III. PROPOSED METHOD

In this innovative system design, we are introducing a Smart CCTV Camera enriched with a sophisticated face recognition module. Complementing this technology is a seamless notification mechanism that ensures immediate user awareness through an Android app installed on their mobile device.

The core functionality of this system centers on the detection and recognition of human faces within the camera's visual range. Upon successfully identifying a human face, the system triggers a sequence of intelligent actions. These actions encompass the instantaneous dispatch of notifications to the user's designated mobile phone, promptly alerting them to the presence of a visitor. Concurrently, the camera seamlessly transitions into an active mode, capturing a still image of the visitor for future reference.

In scenarios where a human face is detected and identified, the system's capabilities expand further. The camera seamlessly transitions into video recording mode, capturing real-time events as they unfold. This dynamic video stream is carefully channeled, granting users direct access through a dedicated Android application. This interface empowers users with the ability to observe live events remotely, facilitating enhanced situational awareness and responsiveness.

A pivotal feature of this system is its selective notification strategy. In instances where the camera's scrutiny reveals an absence of human facial presence within its frame, no notification is issued to the property owner. This prudent approach ensures that users are only alerted when relevant and significant events occur, thereby mitigating unnecessary interruptions and preserving the user's peace of mind.

In essence, the proposed Smart CCTV Camera, coupled with an advanced face recognition module and an intelligently synchronized notification system, heralds a new era in security and surveillance. By seamlessly integrating cutting-edge technologies, this system empowers users with a comprehensive and tailored approach to monitoring, ensuring that they remain informed and in control of their surroundings.

IV. METHODOLOGY

IOT based smart CC Tv camera with video Recording is focused on authorized user can get live stream in android application. So, can easily track his home using that app. This mechanism is to provide user with cost efficient but effective monitoring system.



Figure 1

The mobile application will communicate with the server to access the images and live stream. The server will receive the images sent by the ESP32 camera module and store them in a database. The mobile application will then request the images from the server and display them in the app. To ensure security, the system will require a login for access to the mobile application. Users will need to provide valid credentials to access the images and live stream. If the credentials are invalid, the system will deny access.

V. SYSTEM IMPLEMENTATION

Main Components:

- 1. Arduino UNO R3:** The Arduino UNO R3 stands as a cornerstone within the Arduino microcontroller board family, revered for its widespread usage and versatility. Debuting as the third iteration of the Arduino board lineage, it was introduced in 2011, marking a significant advancement in microcontroller technology. One of its standout features is its modifiability; should errors arise, the microcontroller on the board can be readily replaced, offering an element of flexibility uncommon in other platforms.

The heart of the Arduino UNO R3 lies in its ATmega328 microcontroller, which serves as a computational nucleus for various applications. This board boasts an array of 14 digital input/output pins, including 6 outputs capable of generating Pulse Width Modulation (PWM) signals. Furthermore, it is endowed with 6 analog inputs, facilitating the integration of analog sensors and data acquisition. A 16 MHz ceramic resonator provides the clocking mechanism, enabling precise timing for the microcontroller's operations.

The board's physical connectivity is equally notable. A USB connection serves as the conduit for data exchange with external devices, while a power jack accommodates alternative power sources. An In-Circuit Serial Programming (ICSP) header and a reset button augment the board's utility, contributing to its versatile design.

Integral to the Uno's appeal is its holistic package, which includes all the essential components needed to embark on a microcontroller journey. Simply connect the board to a computer using a USB cable or power it using an AC-to-DC adapter or battery, and you're poised to delve into the world of microcontroller programming and experimentation.

The name "uno" holds significance, translating to "one" in Italian, and heralds the dawn of the future Arduino 1.0 release. The Uno, along with version 1.0, takes on the mantle of being the reference standards within the Arduino ecosystem. It represents a culmination of refinements and innovations, solidifying its position as the platform's contemporary benchmark.

- 2. R3 ESP32 Camera Module:** The ESP32 Camera stands as a compact and energy-efficient camera module, rooted in the potent capabilities of the ESP32 microcontroller. Anchored by the OV2640 camera sensor, this module emerges as a formidable contender in the realm of imaging and visual data processing. An integral facet of its design is the inclusion of a dedicated TF card slot, a feature that adds an extra layer of functionality.

Central to the ESP32 Camera's prowess is its onboard 4MB PSRAM. This dynamic component serves as a buffer, orchestrating the seamless flow of images from the camera to diverse applications, such as real-time video streaming. This enables the module to handle higher image quality without overburdening the ESP32 microcontroller, preserving stability and performance.

The ESP32-CAM development board encompasses an ESP32-S processor, an OV2640 camera, a microSD card slot, and an assortment of GPIO pins catering to peripheral connections. Beyond its camera capabilities and GPIO versatility, the board is further equipped with a microSD slot, facilitating the storage of captured photographs and data.

A notable embodiment of this technology is the AI-Thinker ESP32-CAM, a manifestation of the ESP32 Camera's capabilities. The AI-Thinker ESP32-CAM amalgamates the ESP32's computational prowess with the OV2640's imaging finesse, unveiling a compact yet robust solution for a spectrum of applications.

VI. ALGORITHM USED

- 1. Haar Cascade Classifier:** The Haar Cascade Classifier algorithm stands as a significant breakthrough in computer vision, rooted in the pioneering work of Viola and Jones. This method harnesses the power of edge detection to achieve object detection and recognition, as elucidated in their seminal research paper.

At its core, the Haar Cascade Classifier adopts a machine learning paradigm. It involves the meticulous training of a cascade function using a diverse dataset comprising both positive and negative images. This process equips the classifier with the ability to discern between desired objects (positives) and non-relevant elements (negatives). Once trained, the cascade function is employed to identify objects within new, unprocessed images.

Integral to this algorithm is the concept of Haar-like features. These features serve as the building blocks for object detection. Each Haar-like feature consists of both dark and light regions, organized in a specific pattern. The algorithm capitalizes on the differences in intensity between these regions to generate a single numerical value. This value, derived from the contrast between dark and light regions, constitutes a fundamental element that contributes to the identification of an object.

Through this intricate interplay of machine learning, feature extraction, and contrast analysis, the Haar Cascade Classifier achieves a nuanced understanding of objects within images. This multifaceted approach empowers the algorithm to detect and recognize a wide range of objects, with applications spanning from facial recognition to object tracking in real-world scenarios.

The Haar Cascade Classifier encapsulates the fusion of theory and application, driving the advancement of computer vision by furnishing a powerful tool for object detection and identification. The Haar Cascade Classifier operates through a well-defined sequence of four stages, each playing a crucial role in the process of object detection and recognition:

- 2. Haar-Feature Selection:** Haar-like features are designed to capture specific patterns of light and dark regions within an image. These features are defined by rectangles of various sizes and positions, with dark and light regions. A Haar-like feature generates a single value by computing the difference between the sum of intensities within the dark

regions and the sum within the light regions. These calculated values serve as discriminative characteristics that aid in identifying objects.

- 3. Creation of Integral Images:** Integral images are calculated by summing up the pixel values in a cumulative manner. For each pixel in the integral image, the value is the sum of all pixel values to its left and above. Integral images facilitate efficient calculation of Haar-like features, reducing computational time for feature extraction.
- 4. AdaBoost Training:** AdaBoost (Adaptive Boosting) is a machine learning algorithm that selects the most relevant Haar-like features for object detection. It trains a series of "weak classifiers," where each weak classifier focuses on a specific Haar-like feature. The algorithm assigns higher weights to misclassified samples and iteratively adjusts the weights to improve accuracy. AdaBoost combines the outputs of these weak classifiers to form a "strong classifier," which provides an aggregate decision.
- 5. Cascade Classifier:** The Cascade Classifier is designed to efficiently discard non-relevant regions of an image, saving computational resources. It employs a cascading structure, where each stage comprises multiple weak classifiers. The cascade operates in a way that negative regions (background or non-object regions) are quickly rejected, reducing the computational burden. As the cascade progresses, the complexity of the classifiers increases, ensuring that only promising regions continue through subsequent stages.

This staged filtering allows the system to focus computational effort on regions more likely to contain the object of interest, optimizing processing time. Collectively, these four stages constitute the foundation of the Haar Cascade Classifier. Through the careful selection of discriminative features, the utilization of integral images for efficiency, the power of AdaBoost for feature combination, and the strategic use of a cascade structure for rapid rejection of non-relevant regions, the classifier achieves robust and efficient object detection and recognition.

VII. CASE STUDIES

- 1. Case Study 1: Residential Security Enhancement:** This case study showcases the deployment of the IoT-enabled surveillance camera system in a residential setting. The study outlines the hardware and software components used, including camera selection, IoT modules, and cloud integration. It delves into the installation process, user setup, and app interface. The case study emphasizes how the live streaming app empowers homeowners to remotely monitor their residences, receive intrusion alerts, and access real-time video evidence, thus enhancing overall security.
- 2. Case Study 2: Small Business Surveillance Solution:** In this case study, the IoT-enabled surveillance system is applied to a small-scale business environment. The study details the customization of the system to cater to business-specific requirements, such as extended coverage areas and multi-camera integration. It explores how the system aids business owners in cost-effectively safeguarding their premises, reducing the need for on-site security personnel, and responding proactively to potential threats.

- 3. Case Study 3: Remote Property Monitoring:** This case study presents a scenario where the IoT-enabled surveillance system is utilized for remote property monitoring, such as vacation homes or isolated sites. The study discusses the challenges of remote surveillance and how the system's live streaming capabilities coupled with intrusion alerts provide real-time awareness and control to property owners, ultimately deterring unauthorized access.

VIII. EXPERIMENTAL RESULT

This system utilizes the ESP32 Camera Module to detect human faces, capture images, and send them to the owner via our custom-built Android application. Only the owner can view the captured images, videos and also, he can access live streams through the app

IX. CONCLUSION

This System underscores the significance of an IoT-driven smart surveillance camera system coupled with a live streaming application. By intelligently amalgamating cutting-edge technologies, it addresses the challenge of providing cost-effective yet robust security solutions for homes and small businesses. The integration of autonomous monitoring, instant alerts, and live video streaming epitomizes a comprehensive and effective approach to modern security concerns, ultimately contributing to a safer and more secure environment for all.

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