Journal of Ubiquitous Computing and Communication Technologies (ISSN: 2582-337X)
www.irojournals.com/jucct/

Developing a SmartRail Security System with YOLO and OpenCV

Siva Jyothis[1], Anand S Nair[2], Kirandas VR[3], Rohith M[4], Divya Visakh[5]

Department of Computer Science & Engineering, Jawharlal College of Engineering & Technology, APJ Abdul Kalam Technological University, Lakkidi, India

E-mail: [1]shivjyothisd14@gmail.com, [2]mail.anandsnair@gmail.com, [3]kirankirandas134@gmail.com, [4]rohithsmurali175@gmail.com, [5]divya3954.cse@jawaharlalcolleges.com

Abstract

SmartRail Security System is an innovative research designed to significantly enhance security and safety measures within the station. The primary objective of this research is to implement advanced surveillance technology, revolutionizing the security infrastructure of the railway station and ultimately creating a smarter and more efficient approach to protecting the station environment completely. The SmartRail security system prioritizes key features aimed at enhancing rail station security System. It incorporates state-of-the-art missing person tracking capabilities that allow rapid identification and monitoring of individuals with previous missing records within the station premises. The system's goal is to provide real-time tracking and analysis, ensuring proactive measures are taken to prevent and respond swiftly to security threats. The purpose of the SmartRail security system is to combat illegal intrusion inside the restricted area of the railway station. The aim of this system is to create a strong monitoring system by introducing smart monitoring tools. This will strengthen the defenses against unauthorized access and bolster the overall security situation of the station comprehensively. SmartRail security systems go beyond mere surveillance; they promise to redefine safety standards within the station. This smart and efficient approach is deemed essential to ensure the security of staff and the entire station environment.

Keywords: Smartrail Security System, Advanced Surveillance Technologies, Missing Tracking Capabilities. Unauthorized Access.

DOI: https://doi.org/10.36548/jucct.2024.1.003
Received: 10.03.2024, received in revised form: 07.04.2024, accepted: 18.04.2024, published: 29.04.2024
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1. Introduction

In the contemporary landscape, safeguarding public safety stands as a paramount issue. With the ever-growing complexity of urban environments and transportation systems, ensuring the security of essential infrastructures, including railways, becomes vital[7-10]. An innovative solution has emerged to cope with this situation—the SmartRail protection system. This system is designed not only to detect rail trespassing and track missing persons but also to revolutionize the landscape of railway protection and security comprehensively [11-13]. At the heart of the SmartRail security system is its ability to detect rail trespassing and track missing persons in real-time. This capability is a game-changer for railway safety, providing authorities with rapid and accurate data about unauthorized individuals on rail premises. By employing advanced surveillance technologies, the system offers a proactive approach to preventing potential security threats, enabling timely interventions and ensuring the safety of passengers, staff, and the general public[14-16]. Preventing accidents is a vital aspect of the SmartRail security system's functionality. Through real-time detection, the system acts as a surveillance system for railway safety. By continuously monitoring the rail tracks, it can identify potential risks and unauthorized intrusions, enabling immediate responses to mitigate dangers and prevent accidents. This real-time detection not only enhances safety but also contributes to the overall efficiency of railway operations, minimizing disruptions and ensuring the uninterrupted flow of transportation[17].

2. Related Work

The SmartRail security system aims to instantly detect threats at train stations and alert authorities by integrating various research studies to enhance railway safety and passenger security. Drawing on information from research sources such as Open Computer Vision Classifier Automatic Face Recognition [1], the system aims to locate missing individuals by recognizing real faces using the Haar classifier algorithm. It also incorporates a surveillance platform utilizing image processing technology [2] to detect and identify objects in train stations, providing immediate alerts to authorities.

Furthermore, the system includes enhancements in CCTV-based surveillance [3] to improve video quality and emergency alert capabilities critical to rail safety. Utilizing deep learning tools, including methods like YOLO, the system can detect intrusions in real-time and contribute to the security of smart security applications [4]. The integration of AI-

powered automatic detection for rail intrusion [5] underscores the importance of leveraging AI to analyze inspection data and address safety issues.

Moreover, the system incorporates advancements in human detection for aerial video sequences and object detection using YOLO networks [6], crucial for train surveillance and operational safety. By amalgamating these insights, the SmartRail security system aims to utilize technology to enhance surveillance, address threats, and ensure the security of passenger carriages across all railways, with a specific focus on locating missing persons and denying access to ensure safety

3. Proposed Work

SmartRail security system represents a software solution designed to solve the important safety and security problem in railway facilities. This sophisticated system utilizes advanced technology, including the YOLO algorithm, to detect individuals with missing information through facial recognition and to identify people entering restricted areas of a train station (including railway tracks). The primary aim of this system is to enhance overall security and ensure prompt incident response. In case of a match with an individual with missing information, the system issues a warning and promptly notifies the authorities. This approach enables security personnel to intervene quickly and reduce security threats at train stations. The figure.1 below shows the architecture of the proposed system.

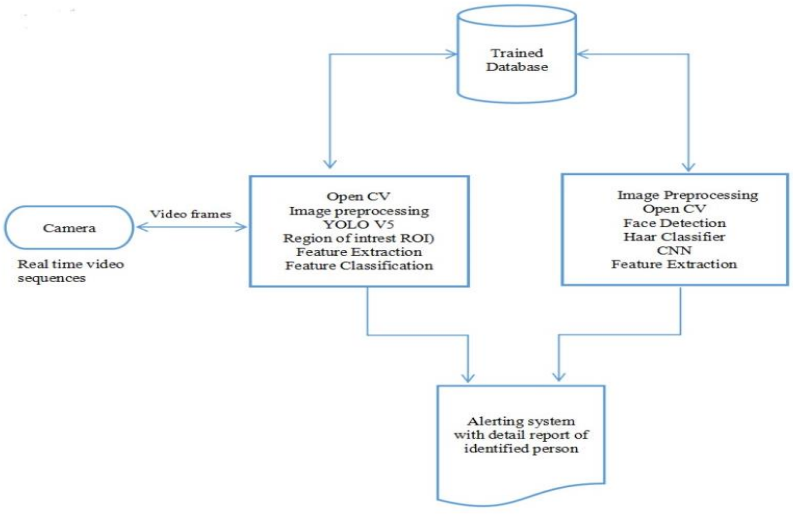

Figure 1. System Architecture

When individuals with missing person records or unauthorized trespassers are detected, the system initiates an alert that is seamlessly transmitted to the relevant authorities. This ensures that security personnel can respond swiftly to potential threats, preventing missing person activities and avoiding accidents on railway tracks.

3.1 Facial Recognition for Missing Record Detection

The primary functionality of the system revolves around facial identification to recognize individuals, particularly those suggested as missing persons. As video feeds from surveillance cameras are processed by the system, the YOLO algorithm meticulously analyzes each frame to detect faces. Subsequently, a facial recognition module comes into play, comparing the detected faces against extensive databases containing records of missing individuals.

The missing person detection system is a comprehensive framework that seamlessly integrates advanced facial recognition technology to ensure the rapid identification and location of individuals reported as missing within railway station premises. Initially, the system takes live video feeds from surveillance cameras as input, which undergo preprocessing steps. The figure.2 below illustrates the system flow diagram for the missing person detection feature

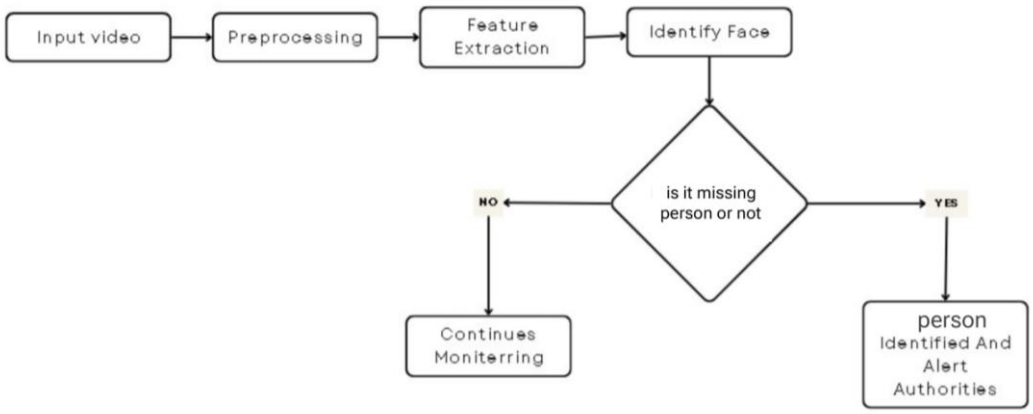

Figure 2. Missing Person Detection Flowchart

The pre-processing likely involves resizing the video, reducing noise, and converting it to grayscale to enhance clarity and reduce computational load. Subsequently, features are extracted from the pre-processed video, focusing on key facial landmarks such as the eyes, nose, and mouth. These features serve as crucial identifiers for subsequent analysis. Following

feature extraction, the system diligently attempts to detect faces within the video stream. Leveraging state-of-the-art algorithms, it compares the extracted facial features against extensive databases containing data of missing individuals. In the event of a positive match, indicating the presence of a missing person, the system promptly outputs an "identified" signal. Additionally, it can initiate immediate actions such as intensified monitoring or alerting relevant authorities, ensuring swift intervention and assistance.

Conversely, if no match is found, signifying that the individual in question is not the missing person, the system outputs a "not the individual" signal. Through this intricate process, the system fortifies security measures within railway station environments and serves as a beacon of safety, providing reassurance to passengers and employees alike. Its ability to rapidly and accurately identify missing persons underscores its paramount importance in safeguarding public welfare and ensuring the integrity of railway station operations. Upon a match with a known missing person, the system triggers an alert, providing real-time information to authorities.

3.2 Trespassing Detection in Restricted Areas

Trespassing detection in restricted areas represents a crucial application in security technology, particularly leveraging advanced video surveillance. In this state-of-the-art paradigm, real-time analysis of video feeds is performed by sophisticated algorithms capable of identifying and responding to unauthorized access within specific zones. Using a grid-based framework, these systems intricately map out restricted areas, triggering immediate alerts and responses when individuals or objects breach predetermined boundaries. This allows for a nuanced understanding of dynamic environments. The machine learning algorithms underpinning these systems continuously adapt and learn from various situations. The figure.3 below illustrates the system flow diagram for Trespassing Detection in Restricted Areas feature.

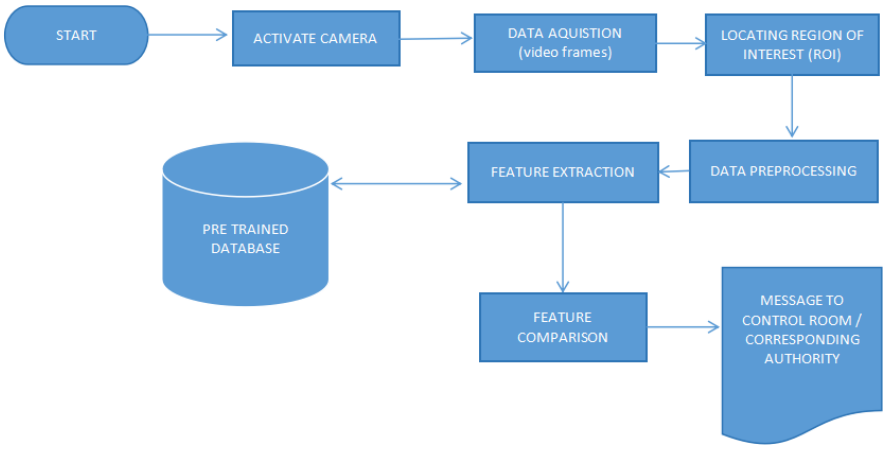

Figure 3. Trespassing Detection in Restricted Areas

To achieve this, the YOLO algorithm is configured to recognize the distinct features of a railway track and its surroundings. The system employs a region of interest (ROI) mechanism to focus on specific areas prone to unauthorized access. As surveillance cameras capture video streams, [6] the YOLO algorithm processes the frames to identify and track individuals entering restricted zones. The ROI is dynamically adjusted based on the evolving scenarios in the surveillance footage, ensuring a robust and adaptable trespassing detection mechanism. Once an unauthorized presence is detected, the system triggers an immediate alert, notifying the authorities in real-time.

4. Results and Discussion

The use of the SmartRail security system has yielded excellent results in enhancing security measures at railway stations. By integrating YOLOv5, OpenCV, Python, ROI analysis, and other evaluation technologies, as shown in figure 4-6, the system has achieved remarkable results in missing person tracking, The red rectangular box in the figure indicates when a person is identified as missing. The system promptly reports missing persons and identifies individuals engaged in suspicious activities at the station. The use of YOLOv5 and Python streamlines the detection of objects, enabling authorities to intervene quickly to prevent security threats. Additionally, the system triggers emergency alerts to prompt immediate action, thus minimizing risks and ensuring passenger safety. This facilitates the early detection of potential incidents, such as fires or hazardous behavior, allowing for timely intervention to prevent harm and enhance overall security.

Figure 4. Trespassing Detection

Figure 5. Missing Person Identification

Figure 6. Dashboard for Recorded Events

5. Conclusion

The integration of Smartrail security systems in railway stations marks a transformative leap forward in bolstering safety and security within these vital transportation hubs. The system's core emphasis is on missing detection. and the prevention of unauthorized access to railway tracks directly targets longstanding issues that have posed significant challenges in these environments. Crucially, the SmartRail system's capacity to detect and thwart trespassing on railway tracks is instrumental in mitigating accidents and upholding the safety of individuals within and around railway stations. This proactive approach aligns with the overarching objective of fostering a secure environment by addressing key vulnerabilities. An adaptive and flexible nature is a hallmark of the SmartRail Security System, allowing it to effectively respond to emerging challenges within the dynamic landscape of railway security. This adaptability ensures that the system remains at the forefront of safeguarding railway stations, adapting to evolving threats and vulnerabilities. The real- time alert capabilities of the system further contribute to its efficacy. By providing instantaneous alerts, the SmartRail system facilitates swift responses to potential security breaches, thereby enhancing public safety. The strength of the system lies not only in its technological sophistication but also in its practical application, actively contributing to the overall well-being of passengers, staff, and the general public frequenting railway stations.

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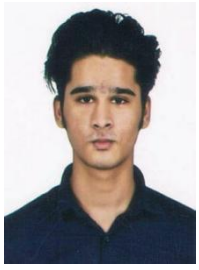
Author's biography



Siva Jyothis, pursing B. Tech in Computer Science and Engineering at APJ Abdul Kalam Technological University, Kerala, India. He has been dedicated to this project for one year, focusing on machine learning & AI which is his area of expertise.

Anand S Nair, pursing B. Tech in Computer Science and Engineering at APJ Abdul Kalam Technological University, Kerala, India. He has been working on this project for one year. His area of interest is Machine learning & Image processing.

Kirandas VR, is currently pursing B. Tech in Computer Science and Engineering at APJ Abdul Kalam Technological University, Kerala, India. He has been dedicated to her project for the past year. His area of interest is Deep Learning and Image Processing.

Rohith M, pursing B. Tech in Computer Science and Engineering at APJ Abdul Kalam Technological University, Kerala, India. He has been working on this project for a year and his area of interest is Deep Learning

Divya Visakh, is an Assistant Professor at Jawaharlal College of Engineering and Technology, Kerala, India. She has completed M.Tech in Computational Linguistics from Government Engineering College, Sreekrishnapuram, Palakkad.