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A Deep Learning Based Real-Time Campus Student Movement Detection System

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Abstract:

The project titled *"*A Deep Learning Based Real-Time Campus Student Movement Detection System" presents an automated and intelligent solution for monitoring and tracking student activities within a campus environment. The system utilizes computer vision and deep learning techniques to detect and recognize student faces in real-time using live video feeds from surveillance cameras. Each video frame is processed to identify faces using a lightweight detection model, and recognized using a deep learning-based feature extraction model.

The recognized faces are compared with pre-stored student data in a database, allowing the system to accurately identify individuals and track their movement across different locations. The system is implemented using Python, integrating OpenCV for image processing, TensorFlow Lite for efficient model execution, and Flask for developing a web-based interface for administrators.

This approach significantly reduces manual monitoring efforts and enhances campus security by providing continuous and real-time tracking. The system is designed to be efficient, scalable, and user-friendly. Although performance may vary with lighting conditions and camera quality, it provides reliable results under standard conditions. Future enhancements may include multi-camera integration, cloud-based storage, and advanced behavioural analysis.

Keywords: Deep Learning, Computer Vision, Face Detection, Face Recognition, Student Tracking, Real-Time Monitoring, TensorFlow Lite, OpenCV, Flask, Campus Security.

I.INTRODUCTION

In recent years, ensuring campus safety and effective student monitoring has become an important concern for educational institutions. Traditional monitoring methods rely on manual observation, which is time-consuming and prone to human error. With the rapid advancement of deep learning and computer vision technologies, automated systems can now provide accurate and real-time monitoring solutions. These technologies enable systems to analyze visual data efficiently and improve the overall management of campus environments.

The Deep Learning Based Real-Time Campus Student Movement Detection System is designed to automate the process of identifying and tracking students within a campus. The system captures live video input through cameras and processes it into frames for analysis. It uses BlazeFace for fast face detection and MobileNetV3 for accurate face recognition. By comparing detected faces with stored data, the system identifies students and distinguishes unknown individuals while also tracking their movement.

This system not only improves security but also enhances administrative efficiency by reducing manual workload. It can monitor multiple students simultaneously and store important information such as identity and movement details in a database. The user-friendly interface allows administrators to easily access and manage system data. Overall, the proposed system provides a reliable, scalable, and intelligent solution for modern campus monitoring and surveillance needs.

II. LITERATURE REVIEW

[1] "BlazeFace: Sub-millisecond Neural Face Detection"

This paper introduces BlazeFace, a lightweight and fast face detection model designed for real-time applications. It focuses on achieving high-speed performance with minimal computational cost. The model is highly suitable for applications like surveillance systems where quick face detection is required.

[2] "MobileNetV3: Searching for MobileNetV3"

This research presents MobileNetV3, an efficient deep learning model optimized for mobile and embedded vision applications. It combines accuracy and speed by using advanced architecture techniques. The model is widely used in real-time systems due to its low resource consumption and high performance.

[3] "Face Recognition Using Deep Learning"

This paper explains how deep learning models are used for accurate face recognition by extracting unique facial features. It highlights the importance of feature encoding and comparison with stored data. The study shows that deep learning significantly improves recognition accuracy compared to traditional methods.

[4] "Real-Time Face Detection and Recognition System"

This study focuses on designing systems capable of detecting and recognizing faces in real-time environments. It discusses the integration of detection and recognition models for efficient processing. The system demonstrates improved performance in security and monitoring applications.

[5] "Computer Vision Applications in Smart Surveillance"

This paper explores the use of computer vision techniques in automated surveillance systems. It explains how AI-based monitoring improves security and reduces manual effort. The study highlights the importance of real-time processing in smart campus environments.

[6] "Deep Learning for Human Activity Monitoring"

This research discusses the application of deep learning models in tracking human activities and movements. It explains how real-time monitoring systems can analyze behavior patterns. The study is useful for understanding movement tracking in campus environments.

[7] "Efficient Face Recognition Using CNN Models"

This paper focuses on the use of Convolutional Neural Networks (CNNs) for accurate face recognition. It explains how CNNs extract important facial features from images. The results show that CNN-based models provide better accuracy than traditional techniques.

[8] "Real-Time Object Detection Using Deep Learning"

This study explains how deep learning models can detect multiple objects in live video streams. It highlights the importance of fast detection algorithms in real-time systems. The research supports the use of lightweight models like BlazeFace for efficient processing.

[9] "Automated Attendance System Using Face Recognition"

This paper presents a system that uses face recognition technology to automate attendance in educational institutions. It reduces manual effort and improves accuracy. The system demonstrates the practical application of face recognition in real-world scenarios.

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[10] "AI-Based Smart Campus Monitoring Systems"

This research focuses on the use of artificial intelligence in campus monitoring systems. It explains how AI can improve security and automate surveillance tasks. The study highlights the future potential of deep learning in smart campus environments.

III. METHODOLOGY

3.1 Face Detection Algorithm (BlazeFace)

BlazeFace is a lightweight, sub-millisecond face detection model optimised for mobile GPU inference. It employs a modified single-shot detector (SSD) architecture with a custom encoder specifically designed for facial feature extraction. The model processes each video frame through a series of depthwise-separable convolutions that balance detection speed and accuracy. BlazeFace outputs bounding box coordinates and confidence scores for all detected faces within a frame, supporting simultaneous multi-face detection. Its computational efficiency — achieving detection in under 1 ms on mobile hardware — makes it ideal for real-time video stream processing.

3.2 Face Recognition Algorithm (MobileNetV3)

MobileNetV3 is a highly efficient deep neural network architecture optimised for mobile and edge inference. It uses hard-swish activation functions, squeeze-and-excitation modules, and neural architecture search techniques to achieve high accuracy at reduced computational cost. In the proposed system, MobileNetV3 extracts 512-dimensional facial feature embeddings from each detected face region. These embeddings are compared against stored encodings in the student database using Euclidean distance. A match is confirmed when the computed distance falls below a predefined threshold.

3.3 Student Tracking and Database Management

Once a student is identified, the tracking module assigns a unique identity token and monitors their position across successive video frames. Detection timestamps, duration at location, and movement trajectory are logged to the database. The student database stores registered details including student ID, name, department, and pre-computed facial encodings. Each recognition event generates a log entry with student ID, detection timestamp, camera location, and confidence score.

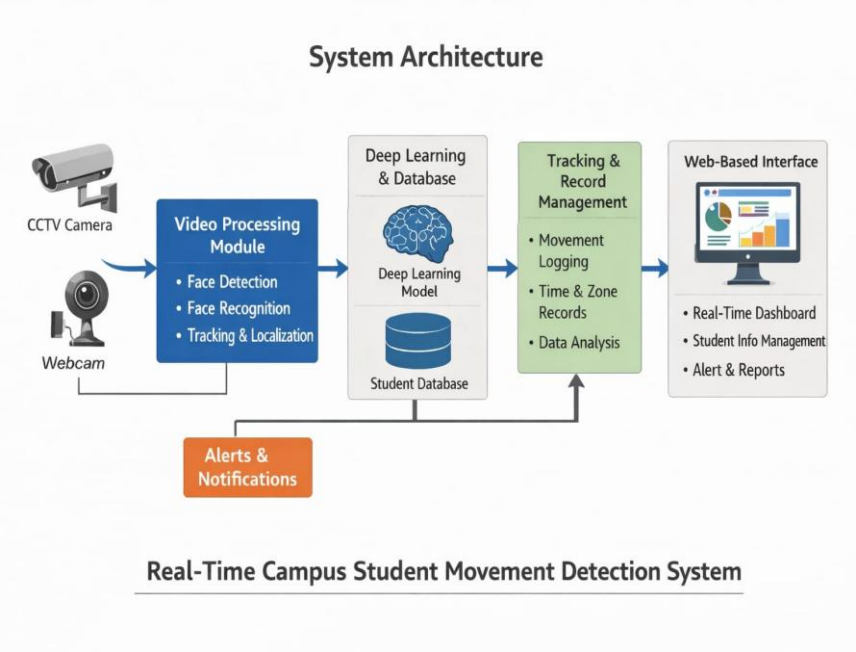

Fig-1: System Architecture

IV. ANALYSIS

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The analysis of the Deep Learning Based Real-Time Campus Student Movement Detection System focuses on evaluating the performance of face detection, recognition, and tracking modules under different conditions. The system processes real-time video input and uses BlazeFace for fast and efficient face detection, while MobileNetV3 is used for feature extraction and recognition. The system was tested with multiple users, varying lighting conditions, and different camera angles to ensure reliability and consistency in real-world scenarios.

The performance of the system is measured based on detection accuracy, recognition accuracy, and response time. The system successfully detects multiple faces simultaneously and identifies registered students with high accuracy under normal conditions. The response time is minimal, allowing real-time processing without noticeable delay. However, factors such as low lighting, occlusions, and poor camera quality can slightly affect recognition performance. Despite these challenges, the system maintains stable performance and delivers reliable results for campus monitoring.

Overall, the analysis shows that the integration of BlazeFace and MobileNetV3 provides an efficient and scalable solution for real-time student tracking. The system effectively reduces manual effort and enhances monitoring efficiency. With further improvements in hardware and model optimization, the system performance can be enhanced to handle more complex environments and large-scale deployments.

V. RESULTS

The results of the system demonstrate successful real-time face detection, recognition, and student tracking. The system accurately identifies registered students and marks unknown individuals. It also tracks student movement and records important details such as time and identity.

The system performs efficiently with minimal delay and supports multiple face detection. The results are displayed on the user interface, providing useful information for monitoring and analysis. The system improves accuracy and efficiency compared to manual monitoring systems.

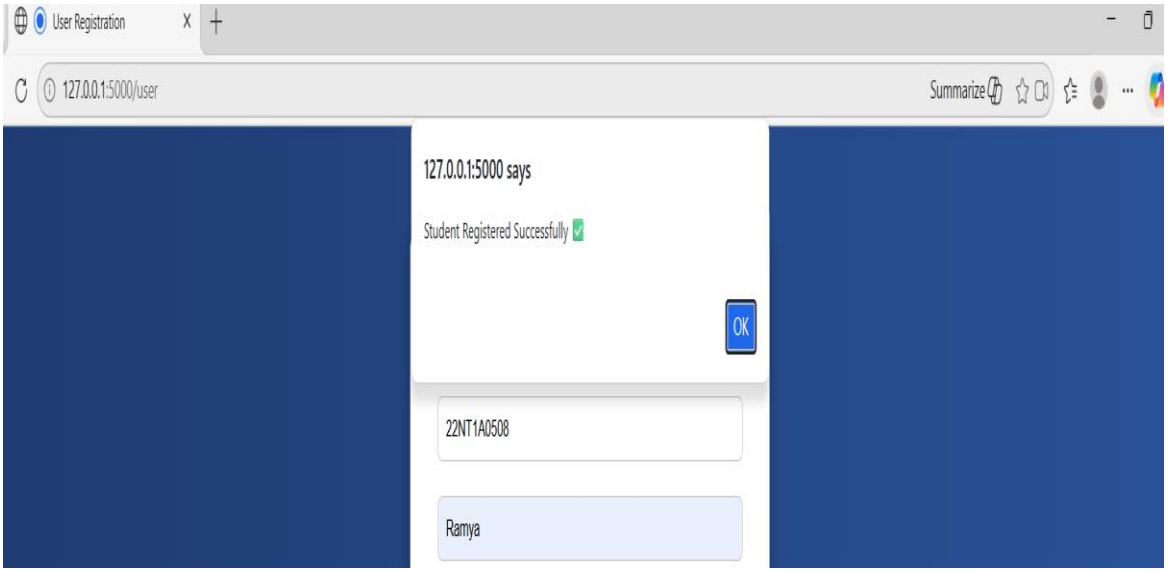

Fig-2: Student Registration – Successful Registration Confirmation

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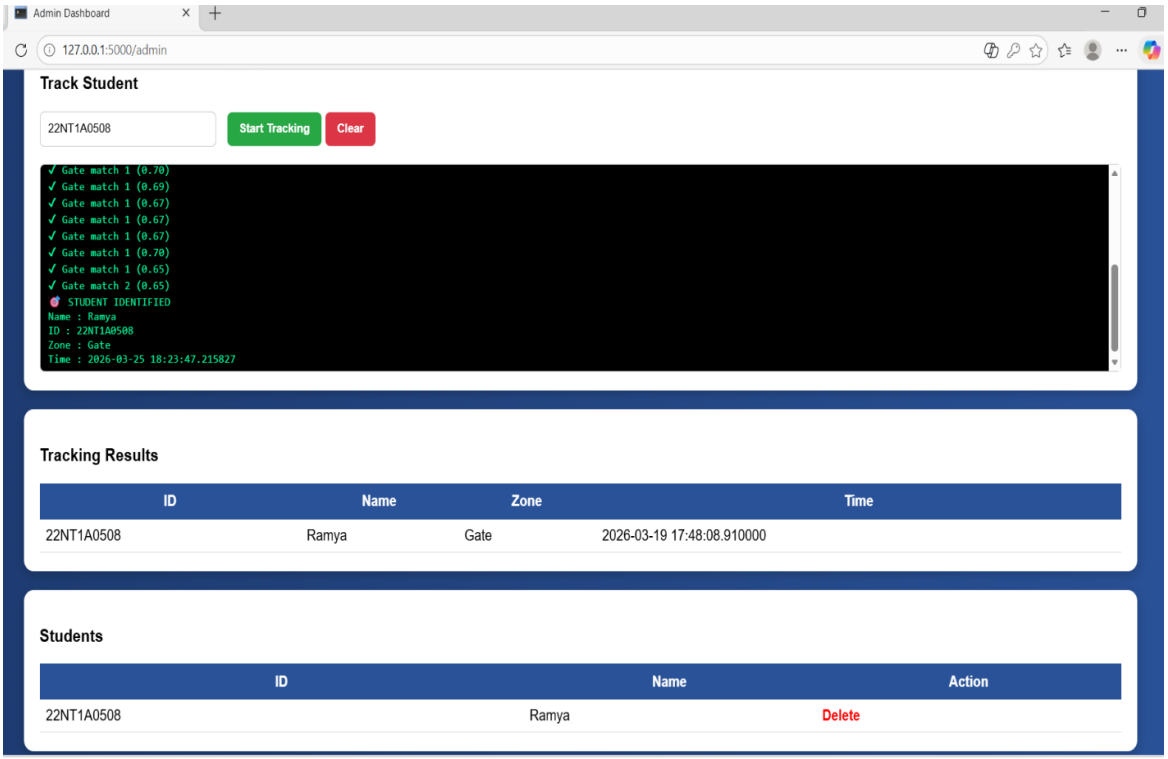

Fig-3: Admin Dashboard – Live Student Tracking and Identification Output

VI. CONCLUSION

The Deep Learning Based Real-Time Campus Student Movement Detection System has been successfully developed and implemented to provide an automated solution for monitoring and tracking students within a campus environment. The system integrates deep learning and computer vision techniques to perform face detection, recognition, and real-time tracking. It reduces the need for manual monitoring and improves the efficiency and accuracy of campus surveillance. The system demonstrated reliable performance in detecting and recognizing students using live video input and was capable of handling multiple faces simultaneously.

The system provided accurate identification results under normal conditions, and the tracking module successfully recorded student movement details such as time and identity. This data was stored in the database for further analysis, and the user-friendly interface allowed administrators to easily manage and monitor system activities. Although the system performed well, certain limitations were observed under challenging conditions such as poor lighting and partial face occlusions. Despite these issues, the overall performance of the system was satisfactory and met the project objectives.

In conclusion, the proposed system offers an efficient, accurate, and intelligent solution for real-time student monitoring and tracking. It has significant potential for use in educational institutions to improve security and automation. Furthermore, the system provides a strong foundation for future advancements, where additional features such as behavior analysis, alert systems, and cloud-based storage can enhance its capabilities and make it more scalable and effective.

VII. FUTURE SCOPE

The Deep Learning Based Real-Time Campus Student Movement Detection System can be further enhanced by integrating advanced technologies and improving its performance under different environmental conditions. Future improvements can focus on increasing detection and recognition accuracy by using more powerful deep learning models and high-resolution cameras. The system can also be extended to support multi-camera setups for covering larger campus areas and providing continuous monitoring.

In addition, the system can be upgraded with smart features such as real-time alerts, cloud-based data storage, and mobile application support. These enhancements will make the system more scalable, efficient, and suitable for modern smart campus environments. Integration with other institutional systems can further improve automation and management.

Future Scope – Key Points

- Integration with multiple CCTV cameras for wide-area coverage
- Use of advanced deep learning models for higher accuracy
- Implementation of real-time alert and notification system
- Cloud-based storage for large-scale data management
- Development of mobile application for remote monitoring
- Integration with college ERP and attendance systems
- Improvement in low-light and occlusion handling
- Addition of behavior analysis and activity detection
- Enhanced data security and privacy mechanisms
- Expansion to smart campus and smart city applications

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