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AI-Based Facial Recognition for Secure Prisoner Attendance Management

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Abstract -- **Accurate monitoring of the attendance of inmates within correctional institutions plays an important role in security and efficiency. Manual methods are inefficient, prone to errors, and subject to impersonation, thus calling for the use of an automated, intelligent solution. This paper seeks to introduce an automated method of efficiently and effectively monitoring the attendance of prisoners using computer-based facial recognition technology. This method will be more accurate while easing the burden on correctional officers.**
The system consists of various components that work in harmony to achieve the objectives of face detection, feature extraction, and recognition. The system is capable of detecting face landmarks such as the eyes, nose, and mouth to achieve the objectives of feature extraction. The system is capable of generating a numerical vector to represent the face characteristics of the individual. The system is capable of capturing images to achieve the objectives of identification through processing of the images to compare with the registered individuals. The system is fast, does not require a special server, is capable of preventing fraud in attendance, and is capable of serving a large number of users, ensuring security. The improvements that can be made to the system in the future include improving performance in low lighting and with visual obstructions, improving the recognition capabilities of the system through better computing facilities. The system is capable of integrating with existing prison management systems; hence, it has the potential to serve a wider number of users.

Keywords -- Facial recognition, prison attendance, biometric authentication, CNN, face-api.js, inmate monitoring, real-time AI, computer vision.

I. INTRODUCTION

Accurate inmate monitoring is a fundamental requirement in prison management systems. Conventional attendance methods based on manual counting or record maintenance are inefficient and prone to human error. Additionally, such methods are susceptible to impersontion, which poses serious security risks. Managing inmate attendance at facilities is becoming increasingly challenging for prison staff. This is because these facilities are becoming increasingly complex, and they need to monitor everything promptly. The traditional methods require a substantial amount of work from the staff, who must constantly monitor everything. They often make mistakes that can pose a security problem. Artificial intelligence and computer vision now offer innovative solutions for automating attendance tracking and identity verification. Facial recognition systems can detect, analyse, and identify inmates rapidly and accurately, streamlining attendance management and improving security. These systems leverage advanced computer models such as convolutional neural networks and pre-trained models like Tiny Face Detector, FaceLandmark68Net, and FaceRecognitionNet to locate faces, identify key features, and generate facial descriptors for recognition. By comparing video frames to a database of inmate photos, the system ca n automatically record attendance, prevent duplicate entries, and minimise human error.

It captures frames from inmate-facing cameras, ensures image quality, encodes facial features, and matches them with stored profiles using confidence scores. Attendance is marked only when identification is certain, making it reliable even for unseen faces. Running in the browser without special ML servers, it supports real-time, scalable, and secure operation in low-resource facilities. The system will also automate the attendance system and the verification of identities. This will not only ease the work of the staff but will also eliminate the problem of impersonation. Additionally, the system will enable the integration of advanced artificial intelligence capabilities in the future, such as identifying anomalies, movement tracking, and predicting inmate behavior. In the rest of this paper, we will examine the work that has been done on facial recognition and biometric authentication in security systems. We will also present an in- depth analysis of the proposed prison attendance system's architecture and source, both from technical and practical aspects. It will improve security management and operational efficiency within the facility. Additionally, the system will provide accurate and real-time attendance records, improving overall operational efficiency.

II. LITERATURE REVIEW

Facial recognition in attendance tracking and security monitoring has seen major developments in the past few years. This development is mainly because of advancements in deep learning and computer vision. Research on convolutional neural network-based models was conducted in 2018 to implement face detection and recognition in real-time in security-sensitive environments. This study showed that

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facial recognition systems, which utilise Convolutional Neural Networks (CNNs), can identify people even under challenging conditions, like when someone's face is partly covered or the light is bad. These systems showed high accuracy in identifying individuals and produced very few errors under controlled testing conditions.

Other studies examined ways to improve recognition systems in crowded or challenging environments. They experimented with tools like Single Shot Multibox Detector and Faster R-CNN to locate faces and key features such as eyes, nose, and mouth. Single Shot Multibox Detector was quicker and capable of real-time detection, making it usef ul for continuous monitoring. Faster R-CNN was more precise in pinpointing facial features, which is crucial for verifying identities.

In 2020, Hybrid approaches combining traditional feature extraction methods with deep learning techniques were explored. Techniques such as Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG) were utilised to help the systems recognise faces even when people are making expressions or their faces are partly covered. This was especially helpful in places like prisons, where it can be hard to recognise people.Transfer learning techniques were also employed to improve the system's ability to recognise faces when they initially had limited information. They utilised models that had already been trained on groups of faces and adapted them to work with the specific individuals in the prison. This approach enabled the systems to learn faster while maintaining high accuracy in person recognition.

Recently, efforts have been made to develop systems that go beyond facial recognition. Such systems integrate recognition with other data, like inmates' IDs, movement, and access data, which facilitates the creation of smart surveillance systems with the ability to monitor people and identify unusual behaviors. This makes it easy to manage the prison, thus protecting everyone involved. There are also ways of making facial recognition systems more transparent, thus more trustworthy. This is done by revealing the facial features used for recognition, thus helping people understand them better, hence improving their accuracy.

Researchers are working on developing techniques to make face recognition technology better over time. This is done using techniques like reinforcement learning, which enables face recognition technology to adapt to various images, lighting conditions, and different camera angles. Enhances face recognition robustness. The research indicates that facial recognition systems leveraging machine learning and related methods are highly effective at identifying individuals and can contribute to enhancing safety and efficiency in prisons. These systems are the basis for the facial recognition attendance system that is being proposed. Facial recognition systems continue to improve in accuracy and robustness with advancements in deep learning techniques.

III. ANALYSIS OF THE EXISTING MODELS

Traditional attendance systems in prisons are not very flexible. They rely on manual headcount and record-keeping methods, which take time and can have mistakes. Someone could also pretend to be someone. To improve accuracy, they started using things like fingerprints and special cards. These require physical contact and can still be used in the wrong way.

The modern systems use computational models for facial recognition. This is done with computer programs like Convolutional Neural Networks. These computer models are very effective in face detection and identifying who they are. Some examples of these programs are MTCNN, SSD and Faster R-CNN. These models are very effective in face recognition as well as identification.. Then there are programs like FaceNet and ResNet that are effective in recognising faces by extracting unique facial features by looking at what makes them special.

The problem with most of these systems is that they need a computer somewhere else to work. This makes them expensive and slow. They also need to be connected to the internet all the time. There are smaller programs like TinyFaceDetector, FaceLandmark68Net that can work faster and in real time on the computer that is right there. With these improvements, there are still problems. If the lighting is poor or obstacles are present, the computer might not be able to recognise a face. Prisons are also secure places, and these systems are not presentable to them. Prison attendance systems, like these, need to be improved for prisons.

IV. METHODOLOGY

This system aims to thoroughly address the challenges in prison attendance monitoring using facial recognition. It takes a picture from the video footage of the inmates, examines the image, and ensures it is clear and in good quality. It then uses advanced technology to compare the facial details of the inmate with the existing ones on file. The software is sure of the accuracy of the image, so it is highly confident when it declares the inmate is present. Therefore, even when the image is partially hidden or unclear, the software works effectively. The software uses a web browser, which means it does not require any computers, thus making it operational instantly, able to support a large number of inmates, and secure even in a low- tech environment. The developers are knowledgeable in the design of facial recognition software and attendance, which means they have addressed problems like inadequate lighting, improper alignment of cameras, and large numbers of inmates, thus making the software work effectively.

A. System Architecture

The client performs the primary processing tasks, while the server handles data management and system operations. The client side operates as a web-based interface accessible through a browser. It uses the face-api.js library to recognise faces.

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This system uses three models to make it work. These models are called TinyFaceDetector, FaceLandmark68Net and FaceRecognitionNet. They help the system to processes video streams in real time to detect and identify faces. The client side captures video input from the camera device. It detects faces and analyses them for recognition. It then analyses the detected faces and matches them with stored profiles. All of this happens in your browser. The server side manages data processing and system operations. It utilises Node.js and Express to manage all information about the people in the system, including their arrival and departure times. The server also ensures that only authorised personnel can access the system. It uses a method called JSON Web Token (JWT) for authentication and security.The system stores all the information in a database called MongoDB. This functions as a structured database for storing inmate records and facial data that holds all the information about the people in the system, like their pictures and where they are. This system is designed to work seamlessly, so it can update everything in real time and be efficient and user-friendly. This system facilitates efficient tracking of inmate location and attendance records.

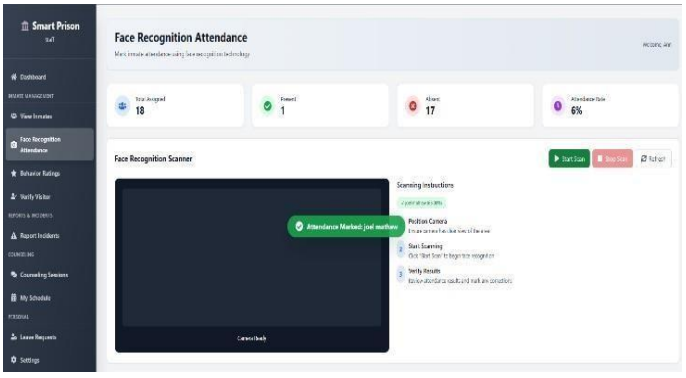

Fig 1: UI of Face Recognition Attendance

Importance of AI-Powered Face Recognition: AI face recognition helps identify people accurately and reduces manual errors. It works quickly, so attendance can be marked in real time. The system can tell small differences between faces, which helps prevent impersonation. It is efficient to use and works with normal cameras, so staff do not need special technical knowledge. Challenges in Face Detection: Face detection can be difficult when a person turns their head or covers part of their face. Poor lighting or shadows can also affect accuracy. Age differences and facial features require the system to be well-trained.

B. Image Analysis Process

Image analysis in the system occurs continuously, with frames captured from the live camera feed approximately every 1.2 seconds. The user interface captures these images and converts them into a suitable format for processing. The system processes each image to detect and identify faces using a feature extraction technique. This is achieved through face detection and feature extraction algorithms, then finding parts of the face and generating a numerical representation of the face. If initial detection fails, the system reprocesses the input using optimized parameters to enhance accuracy. This way, the system can handle it if the room is bright or dark or if someone is standing at an angle.

When the system finds a face, it compares it to the faces of registered individuals to see if it is a match. A high confidence threshold is required for the person before it says they are present. The system can do all of this quickly, so it can look at many faces at the same time without needing special equipment. This makes it an effective solution for resource- constrained environments.

C. Feature Extraction and Recognition

The system extracts features using a combination of deep learning models to capture both global and local characteristics of each face. It detects and localises faces using bounding boxes. The FaceLandmark68Net works out where the eyes, nose, mouth, and jawline are. The FaceRecognitionNet produces a feature embedding that is used for matching up identities. These feature vectors are created for the images of inmates that we already have, as well as the images that we take when we scan a person. When we try to identify a person, the extracted feature vectors are compared with the ones we have, which tells us if there are any identity matches. We only say it is a match if the lists of numbers are very similar, and we know who the person is supposed to be. The TinyFaceDetector, FaceLandmark68Net, and FaceRecognitionNet work together to make sure that we get the person, even if we have not seen them before or if they look different. This ensures that we accurately identify people, which means there are not a lot of mistakes. The FaceRecognitionNet is a very important part of the program, as it allows us to make sure that we are looking at the right person.

D. Analysis and Attendance Tracking

Once the face is recognised, the attendance record is updated in real time, and a detailed analysis is offered, which includes the identity of the inmate, the degree of recognition, the time taken to scan, and the attendance status. The system keeps a record of people already marked, so they are not marked again. It keeps a record of faces already seen, so people can check them. The system displays the total number of inmates, the total number of inmates present, the total number of inmates absent, and the attendance rate. The information is always updated. The system is designed to be accurate, efficient, and easy to use, so attendance can be checked easily by the staff without having to manually record it. The attendance is checked by a web browser, which is safe, efficient, and convenient to use anywhere. It is also safe to use with a server, making it even better. The attendance is checked by a computer and a database, making it a practical solution to automatically monitor attendance in prisons. The system is reliable in automatically monitoring attendance in prisons.

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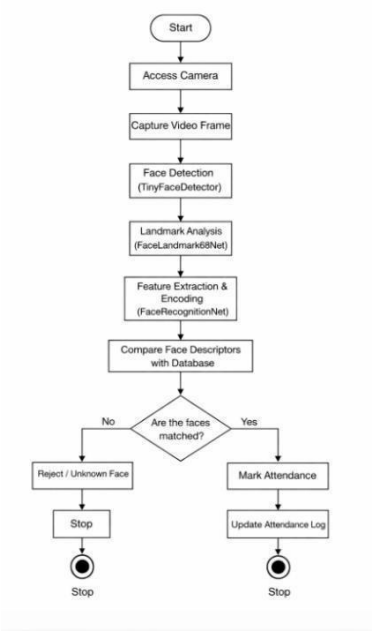

Fig 2: Workflow Of System

V. RESULT

The main features that are part of this system are a live camera interface that captures images of inmates' faces, verifies video, and processes images. This system allows for images to be displayed to inmates as they are being scanned, showing results that are structured, such as inmate name, ID, and attendance. This makes the process easy to use, as face detection, feature extraction, face matching, and attendance are all done automatically.

The system was also tested with different images of inmates with different lighting conditions and angles of capture. This also helped in evaluating the performance of the recognition system. The performance of the system was also evaluated based on the accuracy of the recognition, precision, recall, and reliability of marking attendance. The system has shown high accuracy in identifying inmates with clear face images. However, a few difficulties have also been observed in images with poor lighting conditions and partially occluded images. The system has shown high accuracy in identifying inmates compared to face detection. Thus, the effectiveness of the system in combining different computer vision techniques to recognize inmates is clear. The system also shows potential to extend to a large scale in real-world environments.

This was confirmed through case testing, which showed the system's potential in accurately identifying enrolled inmates and recording attendance in real-time. Although there are challenges when the faces of inmates are partially covered, turned away, or under harsh lighting, the AI- powered system has been seen as an efficient tool in monitoring attendance in prison facilities, using a combination of different computer vision techniques.

VI. CONCLUSION

The current study looked at a facial recognition system that utilises artificial intelligence for automated inmate attendance management. The system ensures high accuracy in attenda nce monitoring. It enhances prison security by reducing manual workload and minimising human errors. The system achieves low latency by operating on the client side.

Using this system for taking attendance makes the management of records easy, which improves efficiency. This system has helped in the efficient management of routine tasks. The study has proven that using technology for taking attendance is efficient, as it is easy to manage. This has helped improve the process, making it simple and accurate. This has helped improve accountability for attendance management, improving efficiency and prison management. The facial recognition system has proven that technology has helped improve efficiency, as seen with the intelligent attendance management system. This has improved the reliability of attendance management for inmates. The system has been found efficient for use in prisons, as it has intelligent attendance management. The system has played a critical role in efficient prison management.

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