FINDING MISSING PERSONS USING AI

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Abstract: Missing person cases continue to be a daunting task for law enforcement agencies around the globe. The traditional investigation methods primarily depend on manual identification procedures, witness reports, and scattered information systems, which are slowing down the time it takes to find missing persons in many cases. With the ramping up of availability of security tools like CCTV cameras and the great progress made in Artificial Intelligence (AI) facial recognition technologies can be a major game changer for enhancing the speed of finding missing persons.In this article, we put forward TraceBack, a missing person identification and case management system powered by AI for the police department. With this system, the police can create profiles of missing persons by uploading their photos along with other biometric details like name age gender, last known location, and Aadhaar number. The system simultaneously extracts a 512, dimensional facial embedding from the DeepFace ArcFace model that acts as a mathematical depiction of the person's facial traits.

Keywords- Missing Person Identification, Facial Recognition, DeepFace, ArcFace, CCTV Analysis, RetinaFace, SORT Tracking, Law Enforcement Technology

1. INTRODUCTION

Missing person cases represent a major issue not only for police officers but also for all the people around the world. Instances of missing persons are various and may concern abduction, human trafficking, mental health conditions, accidents or voluntary disappearance. It is extremely important to rapidly find these people to make sure that they remain safe and protected.

Traditional missing person investigation methods primarily rely on manual searches, witness statements, and distributed police records. While these approaches can be effective in some cases, they are often time-consuming and limited by human resources. In many situations, valuable time is lost before investigators are able to identify sightings or confirm the presence of missing individuals in public spaces.

One of the services that are most in demand in law enforcement agencies is the locating of missing persons. It has truly become the most important and impactful as well, since the time is always of essence during these situations. With the recent advancements in surveillance technologies and artificial intelligence, there are a lot of new potentials opened to enhance the work of missing person investigation. Recently, facial recognition systems have been the talk of the town due to their amazing capabilities of identifying persons in an image or a video stream merely by analyzing their faces. These state, of, the, art systems first transform a face, a picture of a person, into a set of numbers known as "face embeddings". Thus, the whole comparing process between faces becomes very efficient and speeds up the identification procedure.

Recently, deep learning models like ArcFace have made significant improvements in the accuracy of face recognition systems. With the help of deep neural networks, ArcFace generates very detailed features or embeddings that characterize a face and map it to a vector in a multidimensional space. Systems that compare these feature vectors or embeddings using some similarity measure can decide if the two sequences of features correspond to the same individual or not.With the advancement of cryptographic technologies and distributed systems, blockchain technology has emerged as a promising solution for secure data management and tamper- resistant record keeping. Blockchain is a decentralized digital ledger that records transactions in blocks linked through cryptographic hashes. Once information is recorded in the blockchain, it becomes extremely difficult to modify or delete without detection. This inherent immutability makes blockchain particularly suitable for applications that require high levels of data integrity, transparency, and trust.

Another significant factor is the widespread CCTV camera coverage in urban areas. The images recorded by these surveillance devices can reveal a lot about a person's movements and whereabouts. Unfortunately, going through such a huge amount of video footage by hand is not only very sluggish but also unfeasible.

To solve these problems, this paper suggests TraceBack, a missing person identification system and case management system powered by AI. The system combines facial recognition, video processing, and automated notifications to help the police in locating missing persons rapidly and effectively.

TraceBack is a comprehensive platform through which police officers are able to enter the information of missing persons into a shared database, carry out the matching of faces with the images they have uploaded, and even analyze CCTV tapes in an automatic way. For the facial recognition part, the system relies on DeepFace ArcFace embeddings whereas for the face detection it is RetinaFace that is used and for the continuous identification of the same person throughout the video frames, the method employed is SORT tracking

2. LITERATURE SURVEY

Recently, the locating of missing persons through digital technologies has turned into a crucial research topic. Various police departments make biometric identification systems and smart surveillance technologies their main help in crimes solving and missing persons search. As far as different biometric techniques are concerned, facial recognition is one that has gotten quite a lot of attention especially by its capability to identify people from pictures as well as videos without the need of physical presence at the time of identification. In the beginning, facial recognition was based on the use of conventional computer vision techniques such as Eigenfaces and Local Binary Patterns. However, these methods were not only dependent on changes in light, posture and facial expressions but also had poor results in natural environments [1].

The rise of deep learning paved the way for convolutional neural networks (CNNs) to deeply revolutionize the accuracy and reliability of face recognition systems. The most advanced systems of facial recognition today represent faces as very high, dimensional feature vectors, also known as facial embeddings, which numerically encode each face's unique characteristics. Utilizing such embeddings one can very conveniently compare two faces by calculating their similarity using measures like cosine similarity. FaceNet model is one of the landmark deep learning models in this domain because it came up with the idea of a single embedding for the tasks of facial recognition and face clustering through the projection of face images into a small Euclidean space [1].

Inspired by the success of FaceNet, many state, of, the, art models have been put forward to raise the bar in the recognition performance. One of these models ArcFace came up with an additive angular margin loss function, a kind of trick, which enhances the discriminative ability of face embeddings. By means of this mechanism, ArcFace has been able to outperform other models on major face recognition challenges and is nowadays the go, to solution for many real, world applications like identity verification and surveillance systems [2]. Furthermore, other neural network architectures have also played their part in boosting the recognition rates such as VGG, Face and DeepFace that have been trained on very large datasets of facial images [3], [4].

Besides face recognition, pinpointing faces accurately through face detection is a very important phase for creating dependable identification systems. Face detection methods identify and separate the facial parts from images or video frames which is the prerequisite for recognition. Earlier face detection techniques like the Viola, Jones detector dominated the first generation of computer vision systems but they faced difficulties when dealing with complex scenes and obstructed faces. Latest face detection methods based on deep learning such as RetinaFace have drastically boosted detection precision by employing single, stage dense prediction networks that can spot faces under tough conditions like dim lighting, unusual angles, and partial occlusions [5].

Object tracking is another very important element of identification by surveillance, based systems. Tracking methods enable the systems to preserve the coherence of the recognized person identities over the sequential frames when a video is being analyzed. The Simple Online and Realtime Tracking (SORT) method is a popular one for real, time tracking use cases as it integrates Kalman filtering together with data association techniques to perform efficient tracking of multiple objects in video streams [6]. By tracking persons, the surveillance system can follow the individuals as they move from one camera frame to another and decrease the number of times the recognition operation needs to be repeated.

Numerous researches have looked into the possibility of combining CCTV surveillance with facial recognition ones for the purpose of automatically identifying individuals in public places. These systems perform face detection on video streams before performing a face comparison with the reference databases to identify persons whose face is similar to that in the database. Such technologies have been used for various purposes such as security surveillance, law enforcement and missing person identification [7], [8].

Research has also explored the impact of deep learning in automated video analysis for large, scale surveillance systems. Sophisticated computer vision methods enable automated frame extraction, face detection, identity recognition, and movement tracking in recorded video. Such automated methods greatly cut down the time investigators need for manual review of surveillance videos [9].

Along with automated recognition systems, many platforms have launched means of public involvement by which citizens can provide information about missing persons. Web, based reporting platforms and crowdsourced ID systems give the community an opportunity to share possible sightings photos address, etc. Such teamwork is able to enhance the success rate of finding missing people by widening the information network that investigators use.

Even with these developments, several current facial recognition and surveillance analysis systems still demand a lot of computation resources or use of specialized hardware like GPUs. As such, this could pose a challenge when implementing these technologies at smaller law enforcement agencies or areas with limited resources [11].

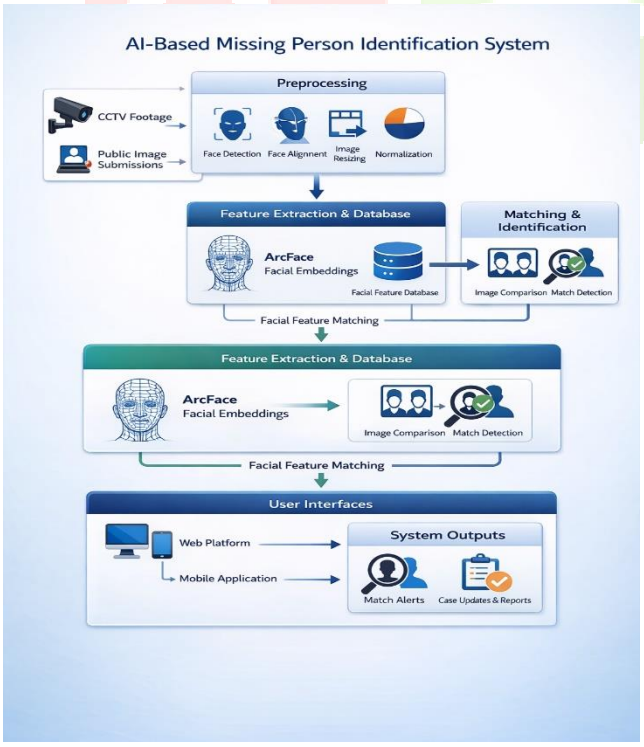
Furthermore, certain detection systems merely concentrate on recognition functions and do not come with the integrated case management tools that enable law enforcement personnel to follow missing person cases records,

.This platform, based system of theirs relies on DeepFace ArcFace embeddings for accurate face recognition, RetinaFaces for reliable face detection, and SORT for video, based identity tracking. Their approach is to use these technologies integrated with automated alerts and a public reporting portal to dramatically shorten the process of missing person identification while also being able to be deployed on stand...

3. METHODOLOGY

The planned TraceBack software will be a valuable tool for police departments who are trying to locate missing people with the help of AI, powered facial recognition and automated camera footage analysis. It combines powerful neural networks, methods of working with video data, and an online platform for managing investigations to facilitate quick detective work in cases of disappearance.
The methodology consists of the following major components:

Missing Person Registration, (B) Facial Embedding Generation, (C) Manual Face Matching, (D) CCTV Video Analysis, (E) Face Detection and Tracking, (F) Automated Match Detection and Alert System, (G) Public Submission Portal, and (H) System Workflow



The complete workflow of the proposed system is illustrated in Fig. 1 – System Architecture.

A. Missing Person Registration

The process of TraceBack starts with registering missing persons in the system database.

To do this, police officers use a secure web interface to input information about the missing person.During registration, the following information is gathered:After the information is sent, the system keeps the personal information in the centralized database. Next, the uploaded photo is analyzed for extracting the face features.

B. Facial Embedding Generation

(A) In order to perform facial recognition, the system transforms every face image submitted into a figure referred to as a facial embedding.

(B)

TraceBack utilizes the DeepFace ArcFace model for the generation of these embeddings. ArcFace is a deep convolutional neural network architecture optimized for face recognition. The model outputs a 512, dimensional vector identifying the unique aspects of a face.

This representation can be considered a mathematical fingerprint of a face and enables the rapid comparison of one face to another.

The embeddings made are in the database with the information profiles of the missing persons.

(C) Manual Face Matching

In a scenario where the police officer has to deal with an unrecognized individual, the system instantly offers a manual face matching capability. The following is the explanation of the method: The officer submits an image of the unknown person.The system recognizes the face in the submitted picture.A face embedding is created by the ArcFace model.The embedding is compared with embeddings of the missing persons retained in the system.The comparison is done using cosine similarity, which is a metric that determines how similar two vectors in high, dimensional space are.The system gives back a list of possible matches ordered by their ranks along with confidence percentages which help the officer to decide if the unidentified individual is a missing person or not.

(D) CCTV Video Analysis

Main highlight of the TraceBack system is the capability to automatically analyze CCTV surveillance footage. Uploading video by the officers is the first step. Then, the system automatically processes the video through these steps: The reason for processing a video at a lesser frame rate is to lower computation time yet keeping the accuracy of detection at a fair level.

(E) Face Detection and Tracking

After the video frames have been extracted, the face detection model based on deep learning is used by the system to identify the faces. RetinaFace is a face detection framework that is used in the system for detecting faces in each frame. It can also get the facial

landmarks and is very effective in detecting faces even under more challenging situations, such as a darker image or if the face is only partly visible. After detecting the faces the system uses also applies SORT (Simple Online and Realtime Tracking) algorithm to track the faces in the succeeding frames. SORT also gives a tracking ID for each face detected and ensures the person is moving through the video. This way of tracking ensures that the same individual is not recognized repeatedly across multiple frames.

(F) Automated Match Detection and Alert System

Each face found in the CCTV frames gets turned into a facial embedding via the ArcFace model. Then the embedding is matched against the database of missing person embeddings with the cosine similarity. When the similarity score is higher than the set threshold: Besides, the system is capable of instantaneously notifying the assigned officer by generating alerts. Notifications reach the officer via both email and SMS, thereby enabling a swift response.

(G) Public Submission Portal

The TraceBack system adoption includes an online portal for public reporting that enables community members to help find missing persons. Via this portal, the public can contribute All submissions enter the review process by authorized officers using an administrative dashboard. In the case where the submitted image matches a registered missing person, the system automatically conducts a facial comparison to provide support for the investigation.

4. RESULT AND DISCUSSION

The TraceBack AI, powered missing person identification system proposed has been developed and experimented upon with the aim of assessing its ability in identifying the missing persons through facial recognition and the analysis of the surveillance videos. The core of the system comprises mainly Python, based technologies such as DeepFace for facial recognition, RetinaFace for face detection, and SORT tracking for video analysis. The experimental evaluation shows that the system is capable of detecting, tracking, and identifying the persons successfully from still images as well as through CCTV videos.

A. Secure User Authentication

Logging in requires a username and password. Authorized officers use this method to enter the system. The interface only allows those with access to view case registration. They can analyze CCTV footage and manage the database. Each login step verifies user identity. Personnel must confirm credentials before accessing tools. Access is restricted to approved staff. System functions remain locked unless verified..

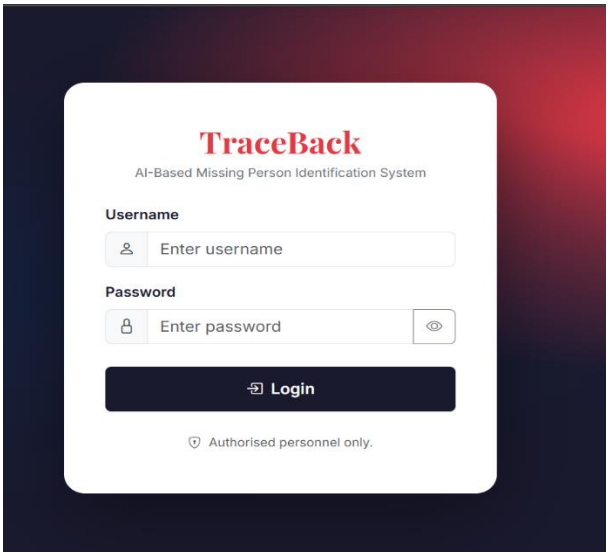


Fig. 2 – Login Interface of the Digital Evidence Locker System

B. Administrative Dashboard

After logging in, the user goes to the admin dashboard. This screen shows system stats. It lists total registered cases, missing persons now, found cases, and public reports. The data tends to be updated in real time. The numbers probably reflect the current state of the system. Users can see all key metrics at a glance.

And the dashboard includes CCTV Auto-Found Alerts, showing detected matches with confidence levels and when they were found. Does that help officers see what the AI spotted right away? For now, the alerts include scores and exact times. It lets them check possible matches fast.

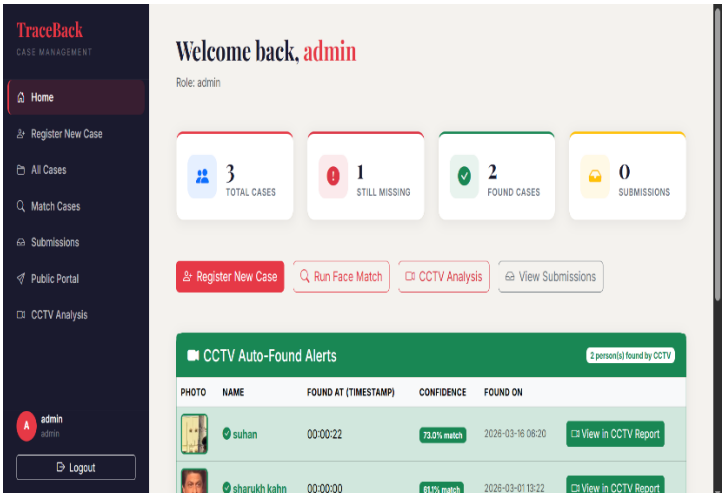


Fig. 3 – illustrates the dashboard interface displaying case statistics and CCTV detection alerts.

C. Missing Person Registration

The system has a case registration module so officers can log new missing person reports. Officers upload a photo and enter details like name, age, Aadhaar number, and last seen place. This process ensures accurate documentation for follow-up actions. The information helps track the persons status after registration.

After the photo is uploaded, the system identifies facial details and creates a 512-dimensional face embedding with the ArcFace model. The data is kept in the database for later use in matching faces during CCTV reviews or person searches. Is that how it works? The process is simple and reliable. A single image can trigger a full comparison. This allows security teams to find matches quickly and efficiently.

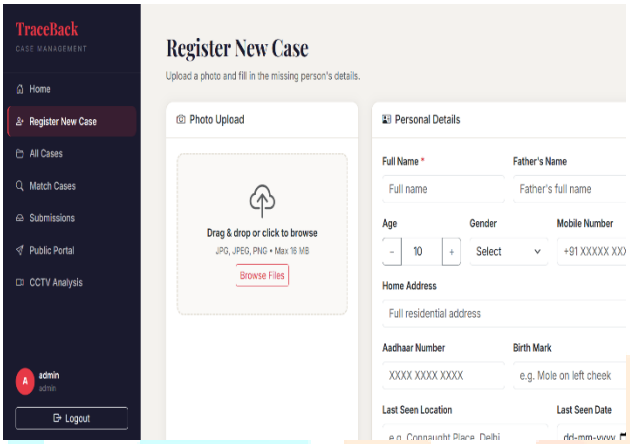


Fig. 4 – shows the missing person registration interface used to add new cases.

D. Public Submission Portal

TraceBack features a public portal where anyone can report possible sightings of missing people. People can share photos and list their contact info via a straightforward form. No login is needed to submit information. The system lets users post details quickly and easily. Anyone can participate without registration. Submissions go directly to the review team. The process is simple and accessible for all. Public input helps track missing individuals. Information stays available for officials to review.

After processing the image submitted, the system orders the checking through the missing person embeddings in the database. If there is a possible match, the system logs the submission and informs the investigators to verify.

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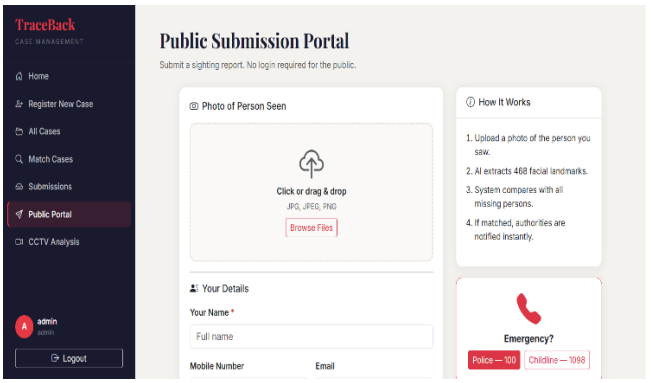

Fig. 5 – presents the public submission portal interface where citizens can report sightings.

E. CCTV Video Analysis Module

What stands out about TraceBack is its ability to handle video through a built-in review tool that police can use to submit camera recordings for machine-assisted examination. Running at two images each second, it scans for facial patterns using RetinaFace instead of manual spotting. Movement between scenes gets mapped by linking detections frame after frame with help from the SORT method. Processing happens automatically once files are loaded into the workflow.

For each face the system spots, it creates a facial embedding and checks it against all stored missing person embeddings using cosine similarity. Does the match ever truly meet the required standard? When the score goes above the set limit, the system logs the match with the time stamp and confidence level. Thing is, these details stay in the records for future review. It seems hard to ignore how consistent the process is.

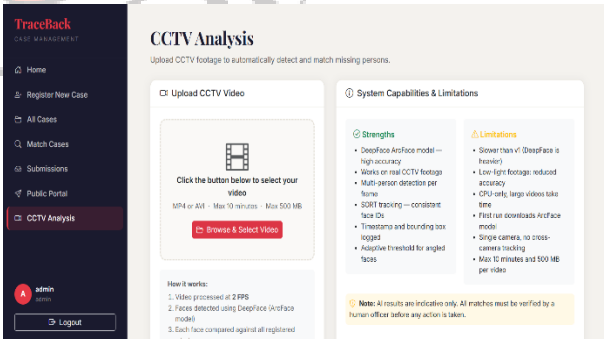

Fig. 6 – shows the CCTV analysis interface where surveillance footage can be uploaded and processed.

F. CCTV Detection Result

The CCTV report module produces the final TraceBack output. It shows detailed results from matches found in uploaded surveillance footage. After analyzing video frames, the system finds possible links between detected faces and missing person files. ArcFace facial embeddings and cosine similarity are used to compare faces. The comparison checks how similar each face is to registered

records. This process detects potential matches between people in the footage and missing persons. The results are displayed clearly in the module. Detection accuracy depends on facial image quality. The system flags matches that need further review. A match may appear when features align closely. Each detection uses standardized embedding models for consistency. Processing speed varies based on video resolution and frame count. Multiple frames are reviewed for accuracy and reliability. Results are updated automatically after each new upload. The entire workflow runs in real time without delay.

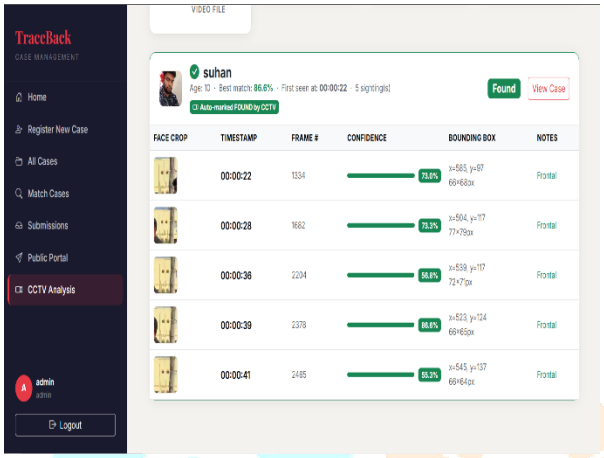

Fig. 7 – CCTV Detection Report Showing Identified Missing Person

5. CONCLUSION

Tracking missing persons becomes faster with TraceBack, an AI-driven system for law enforcement. Instead of relying on manual efforts and scattered records, the new approach connects facial recognition, CCTV reviews, and case tracking in one place. Agencies gain quicker access to information during investigations. Identifying individuals no longer depends on slow, isolated processes. Case details are managed centrally to reduce confusion. The tool supports faster recovery by improving data flow across departments. Real-time updates keep teams informed during active searches.

The system can register missing persons, match faces manually, review CCTV, and spot possible links with confidence scoresthough at least in theory, this works well. It also gives timestamps, frame numbers, box positions, and cropped images from the footage. Investigators can check those details quickly and be sure what theyre seeing is accurate. This helps them confirm findings without confusion.

The system uses DeepFace with the ArcFace model to create 512-dimensional facial embeddings that capture unique features of registered people. These embeddings are saved in a central database and checked when identifying individuals. For surveillance, the system watches CCTV by finding faces with RetinaFace and following people across frames using SORT. Faces are matched against the database using cosine similarity to spot possible matchesthis helps confirm if a person is known. The accuracy of these matches is key to reliable identification.

Thing is, the system can register missing person reports, do manual face matching, check CCTV footage, and find possible matches with confidence scores that can be measured. It also gives out timestamps, frame numbers, box coordinates, and cropped images from the video clips. Investigators can use that data to double-check the findings. For now, the detection method works well in theory. The report lets users review the evidence directly. The results are stored so they can be reexamined later.

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