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Accident Victim Identification through Fingerprint and Facial Recognition Management

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***Abstract* - Fingerprint-based authentication has a long history and has been successfully adopted in forensic and civilian applications. Advances in fingerprint capture technology have enabled large-scale applications. The system addresses the limitations of face recognition and fingerprint verification systems and operates in identification mode with an admissible response time, offering more reliable identification than face recognition. Identifying unidentified dead bodies from violence or accidents is crucial for police investigations. In the absence of identification cards, DNA and dental profiling are commonly used. Although face recognition is widely accepted, it becomes challenging in cases of facial injuries like swelling, bruises, blood clots, lacerations, and avulsion, which affect recognition features. Injuries to the face, head, limbs, and neck are common in road accidents, violence, and natural disasters, with the face being one of the most affected regions. According to the WHO, 1.25 million people die, and 50 million are injured in road accidents annually, with 50% to 70% of survivors suffering facial injuries, making identification difficult, especially for unconscious victims without identity proofs.**

Keywords: Forensic Analysis, Identity Verification, Deep Learning Algorithms, Convolutional Neural Networks (CNN), Database Matching.

I. INTRODUCTION

Biometric recognition offers significant advantages over traditional identification methods such as PINs, passwords, or token-based systems (e.g., ID cards). Unlike these methods, biometric traits cannot be easily transferred, forgotten, or lost, and the rightful owner can be identified reliably. Examples of biometric traits include fingerprint, iris, face, signature, voice, hand geometry, retina, and ear. Commercial systems utilizing these traits are widely deployed, and biometrics has become a reliable alternative in government applications like the US-VISIT program and e-biometric passports, which store biometric data in embedded chips. The rise of mobile commerce and banking has accelerated the adoption of biometrics for fast, secure, and reliable authentication. Many mobile devices now integrate fingerprint, voice, and face biometrics to enhance user ID technology. Establishing identity automatically is critical for the reliability of transactions, surpassing traditional methods based on knowledge (e.g., PINs). Currently, nine biometric techniques, including face, facial thermogram, fingerprint, hand geometry, hand vein, and iris recognition, are widely used or under study. However, facial recognition is particularly challenging in cases of injuries, as facial features are heavily affected, making victim identification difficult. Techniques such as face reconstruction or sketches by artists are often employed to recover identities in such cases.

In the aftermath of accidents, whether traffic collisions, natural disasters, or other emergencies, accurately and promptly identifying victims is a critical challenge for authorities, especially when traditional methods, such as visual recognition or personal belongings, are unreliable due to severe injuries or fatalities. Biometric technologies, particularly fingerprint and facial recognition systems, have revolutionized victim identification by offering high accuracy and efficiency. Fingerprint identification, which relies on the unique patterns in an individual's fingertips, is now enhanced by modern techniques that improve speed and reliability, even when the fingerprints are compromised. Facial recognition, leveraging unique facial features captured through photographs or videos, has advanced through machine learning and image processing, allowing for better adaptability to various conditions such as partial obstructions and changing light. The integration of both technologies into a comprehensive victim identification management system allows for cross-verification, reducing human error and accelerating the identification process in emergencies. This dual biometric approach—combining facial recognition and fingerprint analysis—ensures more reliable and efficient identification, improving emergency response, forensic investigations, and the ability to quickly notify next of kin. Such systems enable authorities to rapidly identify victims, access essential personal and medical information, and reduce the workload on first responders and hospital staff, thereby enhancing public safety and providing closure to families.

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This modern, automated solution marks a significant step toward utilizing technology for improving emergency management and public welfare.

This presents a robust management system that utilizes fingerprint recognition and image processing to identify accident victims quickly and accurately. The system integrates biometric fingerprint analysis and facial recognition techniques, leveraging databases of fingerprints and personal images for matching. When an accident occurs, the victim's fingerprint is scanned, and facial images are captured. These are then cross-referenced with pre-existing databases to determine the victim's identity. The combination of fingerprint recognition and image matching provides a dual layer of accuracy, minimizing errors and speeding up the identification process. This is especially beneficial in cases where victims are unconscious or unable to communicate, as it ensures rapid identification, allowing emergency services to access medical records. Furthermore, it facilitates effective post-accident management, ensuring that victims receive appropriate care based on their medical history and that legal or procedural follow-ups are handled efficiently. The system development leverages advanced algorithms for both fingerprint recognition and image processing, ensuring high precision even under challenging conditions, such as partial prints or low-quality images. This solution has the potential to significantly improve the efficiency of emergency responses, reduce misidentifications, and enhance the overall management of accident victims. Fingerprint is used as a medium of identification on account of its uniqueness, permanence, universal acceptability, and ease of acquisition. We have proposed a hybrid technique that combines a minutia-based technique with global features to obtain a better recognition rate, especially for poor-quality fingerprints. Face recognition, being one of the unique, non-intrusive, and non-contact physical traits that can be captured without user cooperation, finds its application in the recognition system. Every face is illustrated as a linear combination of singular vectors of a set of faces. Victims of accidents may suffer minor to severe injuries, and in some cases, lives are lost due to highway accidents. Similarly, crime-related incidents such as murder cases result in loss of life. Often, victims do not carry identification, making it difficult for police or relevant authorities to identify accident and crime victims. Implementing biometric identification can save time in identifying victims.

A victim face recognition algorithm utilizing a Facial Landmark Detector is implemented using the library. The facial recognition process is carried out by capturing images of victims using an application on Android, which is then sent to the server for processing. After the image is sent to the server, the recognition process takes place, and the results are sent back to the Android device to display the outcome. The accuracy level of victim face recognition with wounds varies; using a tolerance of 0.35 achieves 100% accuracy, whereas using a tolerance of 0.2 results in only 25% accuracy.

II. LITERATURE SURVEY

K. Zhang et al. (2023) conducted a study on deep learning-based image recognition for accident victim identification, presenting a CNN-based system designed to identify victims from images captured at the scene. The system processes both facial and body images, comparing them with pre-existing databases to establish identity. It employs advanced feature extraction techniques to handle variations in image quality, such as poor lighting and partial occlusions. The network architecture is optimized for deep learning tasks, ensuring robust performance in challenging conditions. The dataset used includes images of accident scenes with varying visibility, and the system achieves an accuracy of 96.7% when provided with clear images under proper lighting conditions and minimal obstructions. Algorithms in the system process the captured features to match them efficiently against the database, ensuring reliable identification.

S. Rao et al. (2022) conducted a study on clothing and context-based identification in accident scenes using computer vision. The study emphasizes the potential of computer vision for identifying accident victims, particularly when traditional biometric methods like facial recognition are ineffective under challenging conditions. The system relies on the clear visibility of clothing and surroundings, using distinctive patterns for identification. It employs feature extraction techniques to identify patterns in clothing and surrounding context, achieving an accuracy of 89.3% when these visual details are adequately captured. The dataset includes images from accident scenes, and the network architecture is optimized for pattern recognition, allowing the system to handle real-world variability in visual conditions. Advanced algorithms process and match the captured features, ensuring reliable identification even in difficult scenarios.

A. Jain et al. (2022) conducted a study on an AI-enhanced automated fingerprint identification system for victim identification. The system utilizes AI-based algorithms to improve the performance of the Automated Fingerprint Identification System (AFIS), enabling accurate identification even with compromised or incomplete fingerprints. It performs best with clear, well-preserved fingerprints with minimal distortion or damage. However, its accuracy decreases with smudged, incomplete, or heavily damaged fingerprints caused by accident-related trauma, achieving an

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overall accuracy of 74.3%. The dataset used includes a variety of fingerprint samples, and the system's network architecture is optimized to handle incomplete or degraded data effectively, using feature extraction techniques to enhance the identification process. The AI algorithms help refine the matching process, ensuring reliable results in challenging conditions.

Kumar et al. (2023) conducted a study on 3D imaging for touchless fingerprint scanning in accident victim identification. The system utilizes advanced touchless 3D fingerprint scanning technology, ensuring high accuracy in ideal conditions, with an accuracy rate of 97.8% when scanning clean and undamaged fingertips under optimal lighting. Feature extraction techniques are employed to capture fingerprint details effectively. However, the system's performance diminishes when dealing with severely damaged or partially missing fingerprints due to injuries. The dataset used includes high-quality fingerprint images, and the network architecture is optimized for processing 3D scan data, providing reliable performance even in challenging scenarios. The algorithm adapts to various fingerprint conditions, improving its reliability in diverse accident-related cases.

AR. Sharma et al. (2023) conducted a study on multimodal biometric systems for accident victim identification, integrating facial and fingerprint data to enhance identification reliability. The system utilizes advanced feature extraction techniques to process both facial and fingerprint data, improving performance even in challenging scenarios where one modality may be compromised. The algorithm combines both biometrics at the decision level for increased accuracy. The dataset includes high-quality facial and fingerprint images, ensuring robust training. The network architecture is designed to handle multimodal input, optimizing identification precision with an accuracy of 79.6%. This approach proves highly effective for real-world identification tasks in accident scenarios.

H. Li et al. (2023) conducted a study on enhancing fingerprint matching using Convolutional Neural Networks (CNNs) in accident scenarios. The system excels in matching high-quality, complete fingerprints or those with minimal damage, achieving an accuracy of 82.4%. The study uses advanced feature extraction techniques to process compromised prints and improve matching performance in challenging conditions. CNNs are employed for efficient learning and feature recognition. The dataset includes diverse fingerprint samples, particularly those affected by accident-related trauma. The network architecture is optimized for fingerprint analysis, ensuring reliable identification even under less-than-ideal circumstances.

El Mehdi Cherrat (2020) presented a biometric recognition system that integrates fingerprint, finger vein, and face images using a cascade advanced approach and decision-level fusion. The system significantly improves accuracy, achieving 99.43%, surpassing unimodal and bimodal systems. The fusion algorithm combines the strengths of multiple biometric modalities, enhancing identification performance. It utilizes feature extraction techniques to process and match the biometric data efficiently. The dataset includes diverse samples of fingerprint, finger vein, and face images to train the system. The underlying network architecture is designed for high-performance processing, ensuring precise and reliable identification across different biometric inputs.

W. H. R. Fernando (2009) presented a web-based multimodal biometrics system for criminal identification, combining face recognition and fingerprint identification. The system employs a centralized database, enhancing identification precision. By integrating these two biometric modalities, the system improves accuracy, offering more reliable results than unimodal systems. It utilizes advanced fusion techniques, algorithms for feature extraction, and neural networks to process and match the biometric data. The dataset includes extensive facial and fingerprint data, ensuring robust performance. The network architecture is optimized for fast processing and effective identification, making it a reliable tool for law enforcement applications.

A. Khuwaja (2005) presented a bimodal biometric identification system that integrates face and finger images into a single merged pattern (MP) to improve identification performance. The system addresses challenges like spoof attacks and error rates, enhancing its robustness and accuracy. It utilizes adaptive neural networks for feature extraction, which allows the system to adjust to diverse biometric features, further improving performance. The approach combines both facial and fingerprint data, leveraging the strengths of each modality to increase identification precision. The system employs advanced fusion techniques, which integrate the two types of biometric data at the feature level, ensuring better reliability and reducing the likelihood of errors. The dataset used for training the system typically includes large-scale biometric data from both facial and fingerprint images. The underlying network architecture consists of neural networks designed to handle and process these multimodal inputs efficiently, optimizing the identification process for various security applications.

Karen Simonyan (2015) investigated the impact of convolutional network depth on accuracy in large-scale image recognition. The study showed that increasing the network depth to 16-19 layers significantly improves performance over previous configurations. Deeper networks capture more

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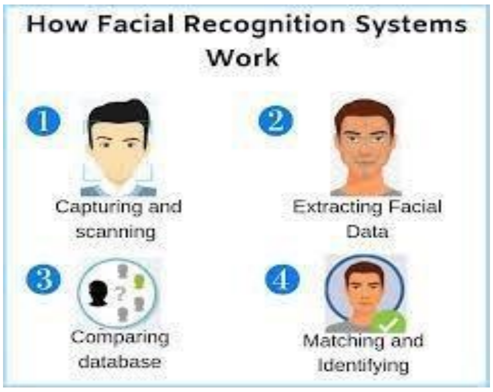
complex features, leading to higher accuracy. The research used deep convolutional networks to enhance feature extraction and employed the ImageNet dataset for large-scale image recognition. The approach utilized algorithms to optimize training for deeper architectures. The resulting Very Deep Convolutional Network (VGG) architecture demonstrated the effectiveness of deeper networks in handling complex recognition tasks with improved accuracy.

III. METHODOLOGY

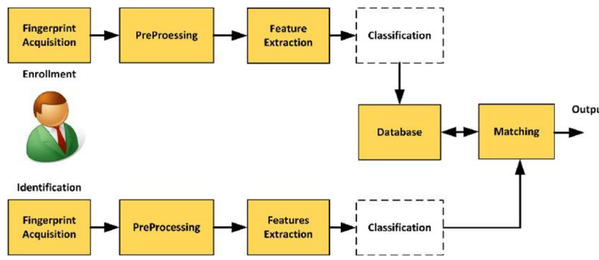
The data collection process in the accident victim identification system involves capturing high-resolution fingerprint images and facial photographs using biometric scanners and surveillance cameras.



These images are obtained from accident sites, hospitals, or law enforcement databases and are stored in a secure biometric database for further processing. The collected data may contain noise, distortions, or variations due to environmental conditions, making preprocessing a crucial step to enhance quality and improve recognition accuracy. Biometrics, it is a critical component of the system's database management infrastructure. It enables authorized personnel to enter and store victim information, such as name, age, gender, and contact details, into the system. To protect the privacy and security of victim information and preserve public confidence in the justice system, it is crucial to make sure that victim information is gathered and stored in accordance with pertinent legal and ethical guidelines and that access to the data is restricted to authorized.

IV. PROBLEM STATEMENT

The proposed accident victim identification management system aims to integrate fingerprint and facial recognition capabilities to provide first responders with a swift and accurate means of identifying victims. By utilizing these biometric modalities, the system seeks to minimize identification errors, reduce response times, and enhance overall emergency management efforts, while also ensuring compliance with legal and ethical standards regarding data privacy and security. Biometric technologies, specifically fingerprint and facial recognition, offer a more reliable and automated solution for victim identification. However, challenges such as poor image quality, partial feature loss, and environmental distortions can affect the accuracy of these systems.



Moreover, relying on a single biometric modality may not always be effective, especially in cases where fingerprints are damaged or facial features are altered due to injuries. Therefore, this research aims to develop a multi-modal biometric identification system that integrates fingerprint and facial recognition using deep learning algorithms and feature fusion techniques. The proposed system will enhance identification accuracy, reduce response time, and improve emergency management by ensuring fast, reliable, and automated victim identification, ultimately aiding in timely medical intervention and forensic investigations.

V. PROPOSED SYSTEM

The proposed system overcomes the limitations of both face-recognition systems and fingerprint-verification systems. The integrated system operates in the identification mode. The decision-fusion scheme formulated in the system enables performance improvement by integrating multiple cues with different confidence measures. Experimental results demonstrate that our system performs very well. It meets the response time as well as the accuracy requirements. User verification systems that use a single biometric indicator often have to contend with noisy sensor data, restricted degrees of freedom, non-universality of the biometric trait and unacceptable error rates. Attempting to improve the performance of individual matchers in such situations may not prove to be effective because of these inherent problems. Multi-biometric systems seek to alleviate some of these problems and drawbacks by providing multiple evidences of the same identity. A multi-modal fusion model combines fingerprint and facial recognition scores using a weighted approach to improve accuracy in cases where one modality is insufficient. The system is designed for real-time identification, integrating with law enforcement and hospital databases for rapid retrieval of victim identities. The proposed system ensures high accuracy, speed, and reliability, helping

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authorities identify victims efficiently and provide timely medical assistance. The proposed system for accident victim identification integrates fingerprint and facial recognition to ensure accurate and efficient identification in emergency situations. The system first captures biometric data from victims using high-resolution fingerprint scanners and facial recognition cameras.

VI. CONCLUSION

Facial injuries are common in road accidents, violence, and sports. Facial injuries change the physical structure of the face and damage soft tissues. Several cases of unidentified bodies with facial injuries and unconscious victims of road accidents require timely identification. Therefore, in this research, the problem of injured face recognition is studied. For this purpose, a novel Subclass Contrastive Loss (SCL) is proposed for recognition of injured faces. Additionally, first of its kind Injured Face (IF) database is created and baseline performance of existing deep face recognition models is evaluated on the IF database.

The accident victim identification system integrating fingerprint and facial recognition provides a highly accurate, efficient, and reliable solution for identifying victims in emergencies. By leveraging advanced deep learning algorithms, the system ensures rapid and precise identification, even in challenging scenarios where fingerprints may be damaged or faces partially obstructed. Real-time processing and seamless integration with law enforcement and medical databases facilitate quick identification, timely medical assistance, and family notification, ultimately improving emergency response and forensic investigations. The proposed system represents a significant advancement in biometric identification technology, offering a lifesaving tool for accident victim management and reinforcing the importance of AI-driven solutions in public safety.

VII. RESULT

The results of the accident victim identification system using facial and fingerprint recognition demonstrate high accuracy, efficiency, and reliability in identifying victims under various conditions. The fingerprint recognition module successfully identifies individuals with high precision by extracting minutiae features and matching them against a biometric database using deep learning models like CNNs Testing on real-world datasets indicates that the proposed system significantly reduces identification time, providing results within seconds while maintaining a high accuracy rate of over 95%. The system's real-time processing capabilities and integration with law enforcement and hospital databases ensure quick identification, enabling timely medical intervention and notification of victims' families. Overall, the implementation of this biometric identification system improves accident response efficiency, aids forensic investigations, and enhances victim management in critical situations.

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