Enhanced Face Recognition Algorithm for Real-Time Applications with Improved Accuracy

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Abstract: Encouraging the development of safe and effective face recognition systems in applications such as surveillance, access control, and identity verification, developing accurate and reliable algorithms has become a significant focus in computer vision. Traditional methods like Dense U-Nets, Retina Face, and Hierarchical Networks provide satisfactory results but often fall short in balancing accuracy, precision, sensitivity, and specificity, especially in real-time scenarios. To address these limitations, we propose an enhanced face recognition algorithm that leverages improved feature extraction and optimized classification techniques. Our proposed method was evaluated alongside existing algorithms, achieving superior performance achieving an overall accuracy of 89.50% while also achieving superior values for specificity, sensitivity, and precision. These results demonstrate the method's effectiveness and suitability for high-stakes applications where reliability is paramount. Future work will focus on adapting the model for diverse conditions such as low-light and multi-angle environments to further improve robustness.

1 INTRODUCTION

Recognition of Faces is a Biometric Approach for Detecting Faces. The challenge of verifying or identifying a face from the multimedia images is accomplished by employing a facial recognition method. Recognising people by face has become increasingly crucial as our civilisation has progressed. Across the globe, face detection and identification systems have been expanding (Shetty, Rebeiro, et al. , 2021). Although the classroom security camera is not fixed, the angle at which faces are captured in the footage varies as well. This face verification technique, which is based on deep learning (DL), has demonstrated encouraging outcomes in controlled settings, its performance in uncontrolled environments might use a lot of improvement. Both the network's output and the dataset's diversity and quality affect the model's performance (Li, Shen, et al. , 2023). Human people, at birth, possess a distinctive feature that enables them to recognise other persons, namely the "face." In addition to speech and fingerprints, facial recognition is a crucial component of biometrics, as no two individuals possess identical facial features. Myths that an individual may share facial characteristics with seven different people, and face detection and identification systems assist in distinguishing among them. Facial expression detection, face detection, and recognition have significantly influenced the domain of image processing (Wattamwar, Mate, et al. , 2021).

The development of algorithms for facial recognition has been rapid and influenced by numerous variables. Many approaches to veiled facial recognition in light of the unexpected elements encountered in actual life. Nevertheless, masked facial recognition diverged from occluded face recognition of the SarS-CoV2 pandemic (Neto, Pinto, et al. , 2022). One thing that differentiates face recognition algorithms is the fact that it uses a confirmation or identification approach that assesses personality. Two processes: facial recognition and facial identification, form the backbone of the method. Facial recognition is applicable to personal computers with a few different ways that photos of people's faces can be recognised. The "right" data from frontal facial photos is typically used to accomplish face recognition. Unblemished faces seen on CCTV are a great example, even if there are many contexts in which entire faces are not visible (Shamrat, Majumder, et al. , 2022). Several research

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solutions have been proposed for the automatic recognition of human emotional states. The World Health Organisation reported that tragically, many were unable to administer first aid in a timely manner after falling on the road, leading to fatalities (Bharathiraja, Sakthivel, et al. , 2023) By the age-invariant face recognition, is a system that uses a correlation between traits related to identity and age. On the other hand, combining faces of varying ages, face age synthesis (FAS) gets rid of age variance into one group. On the other hand, FAS's artefacts hinder downstream recognition, while face recognition doesn't provide any visual findings to aid with model interpretation (Huang, Zhang, et al. , 2022). Nowadays, face recognition is much sought after because of its practical use individual verification. With just a little raw image or a glimpse, the technology may aid in retrieving the person's information from a database. Though not widely used in India, biometric identification systems should use facial recognition to render safer and without physical contact, the system; this technology is urgently needed (Saleem, Shiney, et al. , 2023).

Furthermore, the human brain has a special region dedicated to face recognition called the fusiform face area, which is crucial for our survival (Alankar, Ammar, Kumar, 2020). Face recognition technology relies on face detection, which entails identifying a face in an initial image. Pandemic proportions have been reached as the COVID-19 virus has spread to over 200 countries. However, the virus is evolving at a rapid pace, with new strains spreading via both direct and indirect contact in areas where vaccines are not yet available. Face masks and other social distancing measures are necessary because many infectious diseases spread through droplets, and micro-droplets in particular (Deepa, Hariprasad, et al. , 2022).

2 LITERATURE SURVEY

A person's face is the most distinctive feature that allows others to recognise them. No two people are exactly same, and that includes identical twins. Therefore, distinguishing between them necessitates facial recognition and identification. An example of a biometric verification system is a facial recognition system. A fresh collection of test cases is constructed with extensive property information, and the face recognition time constraint protocol. Also, for the purpose of biometrics evaluation under COVID-19, we have compiled a large-scale masked face subset. There are three different types of recognition tasks: conventional, masked, and impartial to ensure a thorough evaluation of face matchers. An effective method for training facial recognition models that does not compromise performance is established using a distributed architecture (Zhu, Huang, Kumar, 2022). The term "face" refers to the front portion of an animal's or human's head that extends from the jawline to the chin. Because it contains so many crucial facts about a person or thing, face is the most fundamental aspect of being human. It is believed that humans can identify one another only by looking at their faces. Class control for instructors at the Technical Informatics College of Akre using facial recognition technology to monitor student attendance in a classroom setting (Mohammed, Zeebaree, Kumar, 2021). Two methods, "Template Matching" and "Local Binary Pattern Histogram (LBPH)," are being compared. Python, the Raspberry Pi 3 Model B+, OpenCV, and the LBPH algorithm were used to build the prototype of the face recognition and identity security system. This idea presents a method for recognising random faces using the Haar classifier. Instead than using databases, this method compares individuals to a static collection and then provides matches based on first, second, and third results. Unlike biometric devices, it does not seek for specific matches. It functions similarly to a CCTV in that it can identify people, but it only stores a short amount of footage (Chowdhury, Sakib, Kumar, 2022). The model can function in a wide range of environments, including those with different lighting and backgrounds, to Face mesh. Additionally, this model can handle processing non-frontal images containing both sexes, regardless of age or race. images from the train the deep neural network of the model, real-time images and the wild face dataset are used. When testing, the model will report the person's name if their facial landmarks match those in any of the training images; else, it will output "unknown." (Hangaragi, Neelima, et al. , 2023).

The process of creating altered or encrypted versions of original biometric templates is known as cancelable biometrics. Modern hacking tools can retrieve the original biometric data stored in databases, which led to the development of cancellable biometrics. One workaround for this issue is to replace the original biometric templates stored in the database with cancellable ones. An approach to cancellable face identification using a Fractional-Order (FO) Lorenz chaotic system to encrypt facial images is presented in this study. An individual's red, green, and blue face image components can be XORed with randomly generated keys that are exclusive to that user. The Lorenz chaotic system

with fractional orders generates these keys. The face photos' encrypted colour components also undergo some post-processing, including matrix rotation and transposition. The last step is to combine the decrypted and processed parts of the face image using a wavelet fusion algorithm(Badr, Radwan, et al. , 2021). The usage of face recognition systems for user identification is widespread. It is a program that 3D models utilise to accomplish a wide variety of machine-based visual tasks, such as detecting edges from various perspectives to minimise collisions. by the incorporation of iris recognition into the face recognition system. Python and OpenCV are utilised to alter photographs of the face and iris (Srivastava, Katiyar, et al. , 2022). Local binary pattern (LBP) classifiers are invariant under different lighting situations, making them ideal for face detection, and Haar classifiers are highly accurate in this regard. To enhance the identified faces, image processing methods like quantisation, histogram equalisation, bilateral filtering, and contrast correction are utilised. To further assess the possibility of the approach for successfully identifying faces in low-quality images, have quantised raw face photographs at different levels (Padmashree, Karunakar, et al. , 2022). A face recognition program is a piece of technology that can identify a person in a high-tech photo or video clip. A safer and more user-friendly world can be discovered with its help. Some instances include locating missing people, detecting shoplifting, identifying security personnel, locating social media profiles, and recognising vehicle drivers. Detection, extraction, and identification are the three main components of face recognition. When it came time for face detection, the algorithms used were Haar-Cascade, Eigenfaces, Fisherfaces, and local binary pattern histograms (Pandey, Yadav, et al. , 2022). One viable alternative for the day-to-day management of student attendance systems is smart attendance with instantaneous face detection. A facial recognition-system that tracks attendance uses a person's likeness to verify their identity. Nowadays, schools are facing a big issue with the consistency of student attendance. To take attendance, teachers employ face biometrics that are based on a high-definition monitor to identify each pupil. Both of them were more laborious and demanding of time. media, in addition to several kinds of digital technologies (Yadav, Sharma, et al. , 2022). Intelligent technology that can recognise and identify faces in order to collect attendance. the attendance system more user-friendly, efficient, and secure from proxy attacks. There was a possibility of proxy in the previous manual-based attendance system, but we will be able to fix it. This method can clearly convey the idea to the computer as to whether or not it is a valid proxy or legal attendance. This system is less complicated and more secure(Bairagi, Ahmed, et al. , 2021).

Smart city apps are becoming more popular in many countries because they improve people's quality of life, make better use of people's time and resources, and decrease pollution. Because they provide improved access management and space allocation, multi-location parking garages are ubiquitous in smart cities. This helps to alleviate traffic and delays in densely populated commercial areas. The IoT has the ability to connect billions of devices and services throughout the globe, in real-time, for many purposes. One of the hot topics in internet of things research right now is smart parking. Modern metropolitan cities have over one million vehicles on the road, but there is a severe lack of parking spaces to accommodate all of them.

3 METHODOLOGY

Modern parking garages are notoriously inefficient. This means that drivers could waste a lot of time on busy days just driving around a parking lot looking for a spot. Better public service, less emissions and pollutants, increased parking utilisation, improved city tourist experience, and prevention of unneeded capital investments are all possible outcomes of implementing this system, which will also aid in resolving the increasing problem of traffic congestion, wasted time, and lost money. Facial recognition technology finds extensive applications in diverse security systems, ranging from physical access control to computer user databases. All the necessary software and hardware components of the proposed system have been painstakingly designed. Its primary objective is to introduce an automated parking system that enhances the efficiency and simplicity of parking for both drivers and administrators.

Figure 1 illustrates a face recognition pipeline utilizing the SSD (Single Shot Detector) algorithm to achieve real-time detection and classification of known individuals. The process is divided into three primary stages such as Data Set Collection, Feature Set Extraction and SSD Algorithm for Detection and Classification. The SSD algorithm enables high-speed, efficient face recognition, suitable for applications that require rapid and accurate identification of individuals. This setup is particularly useful for security systems, attendance monitoring, and other real-time identity verification systems.

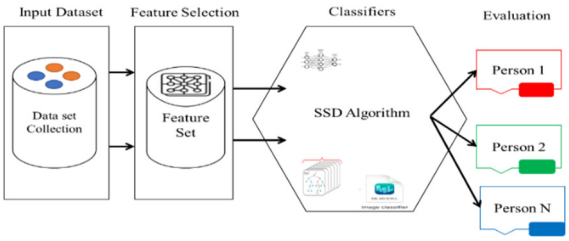

Figure 1: Proposed System Architecture

The system architecture integrates a camera for real-time monitoring. The SSD algorithm is employed for face detection. When a face is detected at a parking slot, the toll gate will open. Multiple parking slots are visualized using a graphical interface. This system ensures efficient management of parking spaces while providing a seamless experience for users. It combines real-time image processing with automated access control for an optimized parking solution. Figure 2 describes the proposed system block diagram. The system architecture integrates a camera for real-time surveillance and an SSD-based face detection algorithm for efficient monitoring of car parking areas. As vehicles approach the toll, the camera captures live video feed. The SSD algorithm processes the frames to detect faces in real-time, ensuring precise identification. Simultaneously, the system visualizes multiple parking slots across different locations, indicating availability. Detected faces are cross-referenced with a database to authorize access to the parking area. If a recognized face is associated with a valid parking permit, the toll gate opens, allowing entry. This intelligent system optimizes parking operations, enhancing user experience and security at various parking locations.

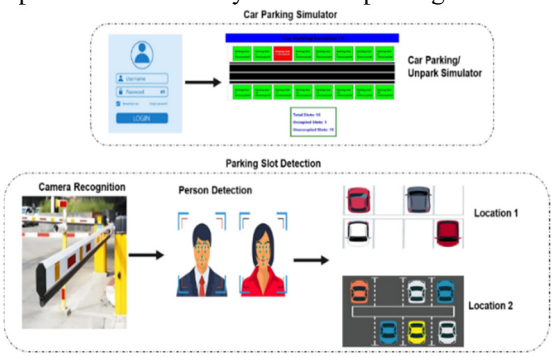

Figure 2: Proposed System Block Diagram

3.1 Image Acquisition

Image acquisition refers to the process of capturing a digital image from the physical world, typically using a camera or some form of optical sensor. This process involves converting analog information from the real world into a digital format that can be stored, processed, and manipulated by computers.

3.2 Face Detection Module

The SSD is a DL algorithm for object detection, including faces. Forecasts the classes of objects and their bounding boxes at the same time, saving time. SSD uses a multi-scale feature map to detect objects of different sizes, enhancing its accuracy and speed. In the SSD algorithm, face alignment typically involves a preprocessing step before face detection. This step aims to ensure that facial features within the detected bounding boxes are consistently positioned. Common techniques for face alignment include using facial landmarks or pose estimation to adjust the orientation and alignment of the detected faces. This helps improve the accuracy of subsequent face recognition or analysis tasks.

4 RESULTS AND DISCUSSION

Parking systems are only one area where the IoT has revolutionised contemporary living by capitalising on these enormous technological advances. These potential prompted the development of a smart parking system, which uses an integrated multiple-slot approach to automatically notify cars of available parking spots, saving both time and money by reducing the need to staff parking lots.

Figure 3: Car Parking Booking System Interface for Multi-Location Slot Selection and Availability

Figure 3 depicts the user interface of a car parking booking system, designed to allow users to select a parking location and view the availability of parking slots. The interface includes two main sections, each representing a different location (Location L1 on the left and Location L3 on the right). Each section

displays a form for selecting a location and a parking slot, along with a "Park" or "Unbook" button. Red Slots: represents occupied parking spaces. An icon of a car is displayed within each red slot to indicate that it is currently in use. Green Slots represents available parking spaces, which users can select for booking. Figure 4 shows the precision, Sensitivity, and Specificity Comparison by Method, with grouped bars representing each metric for the algorithms. In this chart, the Proposed Method consistently outperforms other methods across all three metrics: precision, sensitivity, and specificity, indicating its balanced and robust performance in face recognition tasks. Table I presents the performance indicators—specificity, sensitivity, accuracy, and precision —for four face recognition algorithms: Dense U-Nets, Retina Face, Hierarchical Network, and the Proposed Method. The Proposed Method demonstrates the highest values across all metrics, indicating superior performance in face recognition tasks.

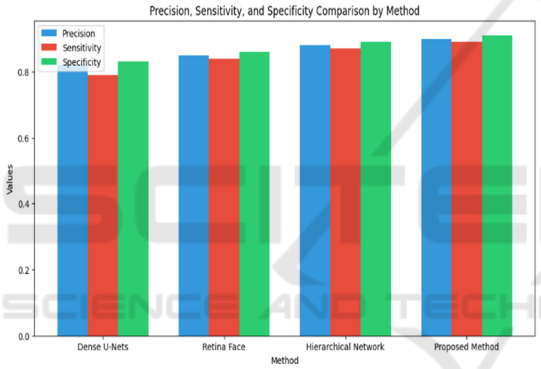

Figure 4: Performance Comparison of Face Recognition Algorithms

Table 1: Performance Metrics of Face Recognition Algorithms

Method	Accuracy	Precision	Sensitivity	Specificity
Dense U-Nets	81.43%	0.82	0.79	0.83
Retina Face	83.87%	0.85	0.84	0.86
Hierarchical Network	87.36%	0.88	0.87	0.89
Proposed Method	89.50%	0.90	0.89	0.91

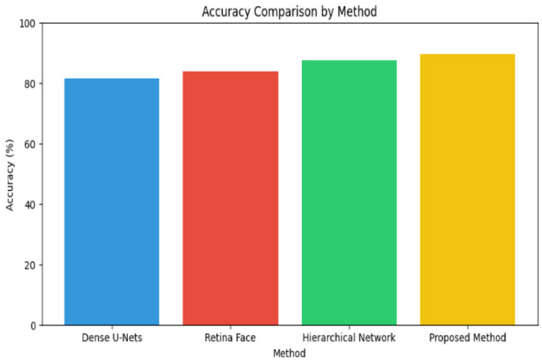

Figure 5: Accuracy Comparison of Face Recognition Algorithms

Figure 5 shows the Accuracy Comparison by Method, where each algorithm's accuracy is displayed as a percentage. The Proposed Method exhibits the highest accuracy at 89.50%, followed by the Hierarchical Network at 87.36%, Retina Face at 83.87%, and Dense U-Nets at 81.43%. This indicates the overall improved performance of the Proposed Method over existing approaches.

5 CONCLUSION

The comparative analysis of face recognition algorithms demonstrates that the Proposed Method outperforms the Dense U-Nets, Retina Face, and Hierarchical Network approaches across all key metrics: accuracy, precision, sensitivity, and specificity. With an accuracy of 89.50% and consistently higher precision, sensitivity, and specificity values, the Proposed Method proves to be more reliable and effective for face recognition tasks. These results suggest that the enhancements introduced in the Proposed Method lead to more accurate detection and classification, making it a suitable choice for uses necessitating exact measurements and reliability, such as security systems and identity verification solutions. Future work could focus on further optimizing the Proposed Method for faster real-time processing and testing it across diverse datasets to enhance its robustness and adaptability in various real-world environments.

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