Proceedings of the 5th International Conference on Computing and Data Science
DOI: 10.54254/2755-2721/22/20231217

Review on the face recognition based on deep learning

Runyi Chen

Data Science and Big Data Technology, Nanjing University of Information Science & Technology, Nanjing, Jiangsu, China, 210044

wu804589@student.reading.ac.uk

Abstract. Face recognition has emerged as a new trend in the era of intelligence due to the rapid growth of artificial intelligence and other cutting-edge technologies. This paper investigates the research and application of face recognition technology based on deep learning through a comprehensive literature review and analysis. The discussion encompasses the classification and processes of facial recognition technology, the incorporation of deep learning into face recognition, and the application of face recognition across a variety of domains. Particular emphasis is placed on the use of deep belief networks (DBN) and convolutional neural networks (CNN) in face recognition. Face recognition technology, facilitated by deep learning techniques, has become pervasive in our daily lives, vastly enhancing our quality of life and productivity.

Keywords: face recognition, deep learning, convolutional neural network (CNN), deep belief network (DBN), 2D and 3D face recognition.

1. Introduction

Biometric identification is the most fundamental aspect of our daily lives. For instance, prior to the examination, the proctor examines our identification card, student ID card, campus card, and other identification documents to ensure that we are taking the exam in person and not someone else. Nonetheless, as society continues to advance and the Internet's popularity grows, these traditional identification methods are gradually facing serious challenges, and people have also put forth more stringent requirements for identification and authentication, such as greater precision and greater convenience. Therefore, biometric identification, which includes face recognition, iris recognition, and fingerprint recognition, is progressively gaining dominance in our society.

Face recognition technology is becoming increasingly prevalent in people's daily lives. For example, face recognition is used for access control based on both facial and iris characteristics. If the communication is effective, the individual is permitted to pass. In addition, face recognition is used to determine whether electric bicycle riders are donning helmets. If they are not wearing helmets, the camera will photograph them, and the police will then correspond with your ID card and send you a text message. Therefore, there is no need to station police officers at the intersection to apprehend individuals. It significantly increases the effectiveness of implementation. Face recognition technology is the most advanced and secure biometric technology, as well as the most promising technology of the 21st century.

DOI: 10.54254/2755-2721/22/20231217

Through a literature review and lineage analysis, this paper discusses the research and application of face recognition technology based on deep learning from four perspectives: the classification of face recognition technology, the process of face recognition technology, the introduction of deep learning into face recognition, and face recognition technology based on DBN deep belief network and CNN convolutional neural network. In addition, this paper summarizes the application of face recognition technology in our daily lives and explains that the technology is extensively used, which improves our quality of life and productivity at work.

2. Classification of face recognition technology

2.1. Classification by application method

Intelligent travel, access control systems, and the internet make extensive use of face recognition technology. Face recognition technology can initially be utilized in the field of intelligent travel. In subways, trains, airports, and other areas with a high flow and population density, face recognition gates can assist station managers in strengthening the management of passengers entering and exiting the station more swiftly and easily. In addition, face recognition technology can lock and monitor suspects and wrongdoers to ensure the station's safety and improve staff management efficiency. Therefore, face recognition technology has become widespread in the travel industry.

In addition, face recognition can also be utilized in access control systems. China has recently implemented face recognition access control technology by integrating people's ID cards with fingerprint recognition technology. The technology employs a split design that separates the accumulation of face and fingerprint data, as well as identity information and access control for the interior and exterior, thereby enhancing practicability and efficiency. In addition, the technology employs encrypted transmission of network information to facilitate remote control, thereby improving the convenience of people's lives. Face recognition access control has been widely implemented in schools, neighborhoods, banks, and other locations where the protection of individuals entering and exiting must be ensured.

In addition, face recognition has a vast array of Internet-related applications. In the field of e-commerce, we can use face recognition technology to assist credit card holders make secure online payments and prevent non-credit card holders from using their credit cards to make online purchases. In the past, credit card payments were typically made with passwords, and if the passwords were compromised, security could not be guaranteed. Therefore, using face recognition technology, the person's face and the card owner's face are meticulously compared, and only if they are identical is the person allowed to use the credit card, which significantly increases the security of e-commerce. Face recognition ultimately strengthens e-commerce transactions by preventing unauthorized credit card use.

2.2. Classification by material use

There are four distinct types of face recognition technologies based on the materials they employ. In the first category, there are the algorithms for recognizing faces based on their geometric structures; specifically, we have the algorithms for locating facial features (the 'face feature point detection' algorithm), identifying faces (the 'face detection' algorithm), and processing facial data (the 'face data recognition processing' algorithm). Next, we have the time-series and face-feature based face model recognition technique, which is comprised mostly of the feature extraction algorithm for facial pictures and additional model search and other techniques [1]. Then there is the third subcategory, which includes image processing techniques, artificial intelligence algorithms, and computer-aided design and is based on visual and non-visual face recognition technologies. The last group uses convolutional neural networks (CNNs) and deep belief networks (DBNs) from deep neural network methodologies [2]. In order to improve face recognition, they use deep learning methods. The efficiency of a neural network's learning is greatly increased when it is able to automatically extract and learn facial information from the source image using deep learning [3].

DOI: 10.54254/2755-2721/22/20231217

3. The Process of face recognition technology

3.1. 2D and 3D face recognition process

The 2D face recognition process entails gathering face images with a standard camera, adjusting image brightness, denoising, and conducting meticulous image preprocessing to improve recognition accuracy as shown in figure 1. This method extracts facial characteristics from a single photograph to generate a two-dimensional representation.

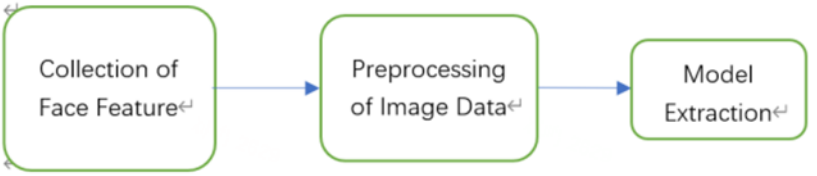

Figure 1. Face recognition process (original).

The process of 3D face recognition can be completed using either conventional methods or deep neural networks. In the conventional method, 3D face features are extracted, preprocessed, and utilized to construct models. During the phase of testing, target images are preprocessed. The respective models are then extracted for comparison [4].

3.2. Comparison between 2D and 3D face recognition process

Data gathering, extraction methodologies, and accuracy are all different between 2D and 3D face recognition processes, with the latter providing higher results.

First and foremost, the visual data acquired by 2D and 3D face recognition technologies is fundamentally different. When a face is recognized in 2D, a flat image is acquired, whereas in 3D, a three-dimensional image is acquired. Second, they are extracted in various ways. However, 3D obtains a three-dimensional image and gathers tens of thousands of acquisition points for faces, but 2D can only detect and compare them under bright light. Thus, this technique can identify and compare facial features whenever, whenever, and regardless of lighting conditions. Last but not least, the precision of these two approaches differs, with 3D face recognition yielding more accurate findings than 2D.

4. Introduction of deep learning techniques in face recognition

4.1. Overview of deep learning

In their paper "Reducing the dimensionality of data with neural networks" [5], G. E. Hinton and R. R. Salakhutdinov of the University of Toronto, Canada, introduced the concept of deep learning in 2006. They explained that deep learning networks use an unsupervised training approach with neural networks to mimic the human brain, which uses its many layers of abstract thought to abstract real-world data like speech, text, and images. To achieve optimal results from deep learning, feature extraction should be carried out with as little human interaction as possible [6].

When applied to face recognition methods, deep learning outperforms more conventional forms of machine learning. Due to its reliance on unsupervised learning, deep learning is able to automatically learn the data extracted from face recognition, construct appropriate models for it, transform people's facial features multiple times, and then restore the essential features of face recognition data. After that, models that are appropriate for the situation are constructed using these features. Multilayer neural networks are often used models in deep learning because of their ability to extract features from exceedingly complicated data in a layer-by-layer fashion. Once the model has been constructed, it must be fed the original data in order to learn and analyze it further, yielding a highly expressive feature representation appropriate for subsequent categorization [7]. For data or datasets with imperfect categorization or no labeled data, the standard supervised learning method is employed. The data is too complex for typical machine learning techniques. Unsupervised deep learning is the only

DOI: 10.54254/2755-2721/22/20231217

method we have for autonomously learning and modeling these unclassified and unlabeled datasets with multilayer neural networks.

Deep learning is now also employed in computer vision, natural language processing, image and pattern recognition, and facial recognition technology. Deep learning has received extensive research and is frequently applied in several scientific domains.

4.2. Integration of deep learning theory and face recognition technology

With deep learning, data in face recognition can be automatically learned and modeled in a way that mimics the human brain's neural system, without the need for human intervention. When compared to traditional machine learning, this method is superior when it comes to solving difficult problems in face recognition. First, deep learning's ability to process massive amounts of data has allowed multilayer neural network-based face recognition technology to make accurate, widespread comparisons of facial features. Second, deep learning algorithms are exceptionally powerful and accessible computationally, and they have unique characteristics. With the help of deep learning, facial traits with unique characteristics can be learned straight from source photographs, allowing for more rapid and precise identity verification in subsequent face comparisons.

CNN-based (Convolutional Neural Network) and DBN-based (Deep Belief Network) face recognition technologies dominate the current state of deep learning in face recognition research and application.

5. Research and application of deep learning in face recognition technology

Input, two convolutional layers, two downsampling layers, a fully connected layer, and an output layer make up what is formally known as a Convolutional Neural Network (CNN). To extract features from the input layer, the convolutional layer is used as the feature extraction layer (C layer)[8]. All of the feature maps in a convolutional layer are the same size because they correspond to the same convolutional kernel. By combining and analyzing neighboring regions, the downsampling layer brings the dimensionality of the feature maps down. The Sigmoid function is used by the output layer to relay information from the fully connected layer, also known as the classifier layer[9]. Radial Basis Function (RBF) output unit, Sigmoid function output unit, and Softmax regression classifier output unit are all included.

Using a Deep Belief Network (DBN) for facial recognition requires multiple operations. To begin, images of faces are processed in low-contrast settings to reduce the impact of lighting on the recognition process. Next, complementary information is integrated by fusing texture characteristics derived using TPLBP (Three-Patch Local Binary Patterns) with structure features extracted using HOG (Histogram of Oriented Gradients)[10]. The fused features are first reduced using an appropriate algorithm, and then the optimal data for the DBN model parameters is dynamically searched for and determined using a trained DBN model. The trained DBN is then put to use for the purpose of face recognition.

6. Application of face recognition technology in our everyday life

Face recognition technology has acquired significant traction in people's daily lives as a result of technological and social advancements. Face recognition has distinct advantages over other biometric recognition methods, such as fingerprint and iris recognition, in terms of security and accessibility. In the first place, face recognition technology enables non-contact acquisition, ensuring that no bodily damage is caused during data collection. This characteristic makes it more acceptable to individuals than iris recognition technology. Secondly, the image collection apparatus for face recognition technology is more interactive and cost-effective, aligning well with people's daily routines. In addition, the technology can be utilized covertly, for example, to check whether cyclists are wearing helmets by capturing images through monitoring and conducting facial comparisons without the riders' knowledge. Face recognition technology possesses quick, convenient, and comprehensive post-event tracking capabilities, thereby enhancing productivity.

DOI: 10.54254/2755-2721/22/20231217

In recent years, 3D face recognition technology has made significant advancements in its ability to capture facial expressions and postures in greater detail. This technology provides multiple methods for reconstructing 3D visage models. However, obstacles remain, such as integrating 2D face recognition results with 3D face recognition results and enhancing facial feature selection and extraction algorithms.

The integration of face recognition technology with human-computer interaction, computer vision, and deep learning is an active area of research. The development of face recognition technology will significantly contribute to the study and research of face and facial expression recognition, identity verification, video surveillance, and related fields, thereby enhancing the effectiveness of daily life and business operations.

7. Conclusion

This paper provides an in-depth examination of the research and applications of face recognition technology based on deep learning, focusing on four key aspects: classification of face recognition technology, face recognition process, integration of deep learning in face recognition, and face recognition technology based on CNN and DBN. The paper also discusses the practical applications of face recognition technology. It is essential to observe that this article is a review of existing research and that some arguments lack experimental evidence. In addition, CNN and DBN face recognition techniques are better suited for large datasets due to their reduced accuracy with a limited number of samples. However, future research seeks to improve the precision of CNN- and DBN-based face recognition methods.

In conclusion, large-scale, intelligent, personalized, and secure applications will continue to emerge from the combination of deep learning and face recognition technology. This development will result in more convenient lives and enhanced work productivity.

References

[1] Lee S Y，Ham Y K，Park R H. Recognition of human front faces using knowledge-based feature extraction and neuron fuzzy algorithm, 1996.

[2] Fleming M.K., Cottrell G.W. Categorization of faces using unsupervised feature extraction, 1996.

[3] Yuandong Zhao. The Research on Face Recognition Method Based on Deep neural network. Shenyang University of Technology, 2019.

[4] Lianjing Ding，Guangshuai Liu，Xurui Li，et al. Face recognition that combines weighted Information Entropy with improved local binary pattern. Computer Application Journal, 2019.

[5] G. E. Hinton，R. R. Salakhutdinov. Reducing the dimensionality of data with neural networks. Science, 2006.

[6] Xiaoyan Yin. Study of Face Recognition Based on Deep Learning. Tianjin University，2014.

[7] Lingli Li. Overview of face recognition technology application based on deep learning theory. Guangzhou: Guangdong Vocational College of Judicial Police, 2021.

[8] Bouvrie J. Notes on convolutional neural networks. Neural nets,2006.

[9] Xiuping Zhu, Xueyi Wu, Wenfeng Liu. Review and Prospect of Face Recognition Technology[J]. Computer and Information Technology, 2008.

[10] Lianjing Ding，Guangshuai Liu，Xurui Li, et al. Face recognition combining weighted Information Entropy with enhanced Local Binary Pattern [J]. Journal of Computer Applications, 2019.