Technical Progress of Face Recognition Technology in Occluded and Unobstructed Environment

Yanqi Peng[a]
School of Computer Science & Technology, Beijing Jiaotong University, Beijing, China

Keywords: Face Recognition, Unobstructed Recognition, Occluded Recognition, Deep Learning, Dataset.

Abstract: With the development of society, face recognition technology has become increasingly widespread across various fields, and the accuracy of unobstructed face recognition has steadily improved. However, as real-world face detection scenarios become more complex and variable, the challenge of occluded face recognition has emerged as a significant research focus in recent years. This article analyzes and compares the two distinct approaches to face recognition: unobstructed face recognition and occluded face recognition, discussing their respective challenges and advancements. It also provides an overview of commonly used face recognition datasets. Finally, the paper looks ahead to the future development and potential breakthroughs in both types of face recognition technologies. By synthesizing and integrating research on these two approaches, this paper helps researchers understand the current state of face recognition technology, highlights existing gaps in current research, encourages innovation and further exploration, and lays the groundwork for the introduction of new methodologies in future face recognition studies.

1 INTRODUCTION

As an important research direction in the field of computer vision, face recognition technology has been widely used in recent years, especially in security monitoring, financial payment, intelligent transportation and identity authentication and other fields, becoming a key technology to improve automation and security. With the rise of deep learning technology, the accuracy and application range of face recognition have been greatly improved, especially based on convolutional neural network (CNN) and generative adversarial network (GAN) and other methods, which have promoted the rapid development of face recognition. However, in practical applications, face recognition technology still faces many challenges, especially under the influence of environmental factors and occlusion conditions, the recognition performance may be significantly reduced. Face occlusion is an important factor affecting the accuracy of the recognition system, occlusion from a variety of situations, such as wearing masks, glasses, hair, hand occlusion and so on. Especially in public places and specific scenes, the occlusion phenomenon is more common. This brings great technical problems to the existing recognition system. Under the condition of no occlusion, traditional face recognition methods can usually provide high accuracy because the feature area of the face is clear and can be fully utilized. However, when the face is partially obstructed, the existing system cannot fully capture the important visual information, resulting in a significant decline in recognition accuracy, or even cannot complete the recognition task. This paper aims to discuss the application progress of face recognition technology in unobstructed and occluded environments, analyze the advantages and disadvantages of current main technologies, and discuss the possible development direction in the future. By reviewing the existing occlusion recognition methods and technical innovations, this paper aims to provide references for future improvements in the adaptation ability and robustness of face recognition systems in complex environments.

[a] https://orcid.org/0009-0000-5515-0004

Peng, Y.
Technical Progress of Face Recognition Technology in Occluded and Unobstructed Environment.
DOI: 10.5220/0013677400004670
Paper published under CC license (CC BY-NC-ND 4.0)
In *Proceedings of the 2nd International Conference on Data Science and Engineering (ICDSE 2025)*, pages 21-25
ISBN: 978-989-758-765-8
Proceedings Copyright © 2025 by SCITEPRESS – Science and Technology Publications, Lda.

2 FACE RECOGNITION IN AN UNOBSTRUCTED ENVIRONMENT

Unobstructed face recognition refers to the feature extraction (facial collection features and texture features) of the face image detected from the static image or video image under the premise of no covering object, and then comparing it with the database, and finally making a decision to determine the identity of the recognized person. This technology is the foundation of the field of face recognition and has a wide range of research significance and application value. Unobstructed face recognition can provide performance judgment benchmarks for other types of face recognition (including obstructed face recognition and low-resolution face recognition), which is also the basis for the implementation of many optimization algorithms. At present, unobstructed face recognition has long been widely used in the daily lives, such as access control systems, face-scanning mobile payment, monitoring systems and real-name authentication. It can be seen that unobstructed face recognition plays a crucial role in both practical application and scientific research. Next, I will introduce four methods of unobstructed face recognition.

Lin proposed a super-resolution identification method based on deep confidence networks (Lin, 2013). This method first judges the posture in the image and then recognizes the face. Because high-resolution and low-resolution images have certain similarities in the feature domain, it is difficult to deal with posture problems with linear features. Therefore, it is proposed to use advanced deep neural networks to obtain nonlinear connections between the two. She implements the discrimination model through a group of DBNs composed of multiple RBM structures and adds a logical regression layer at the top. Considering the uncertainty of facial posture, she proposed posture mapping based on DBNs. Experiments show that it is easy to lose personal characteristics during the mapping process, which is also a shortcoming of this method.

Eleyan uses 18 algorithms to extract local statistical descriptors for face images and studies the impact of a single feature descriptor and the fusion of two or three feature descriptors on the accuracy of face recognition (Eleyan, 2023). Experiments show that the fusion of some two or three feature descriptors can improve performance, but other fusion techniques still need to be explored to get better results.

Yang and others studied small sample problems in the field of face recognition and established a framework theory to solve singularity problems so that F-S identification and J-Y identification can be widely used as methods to directly deal with high-dimensional and small sample problems (Yang et al., 2003). They combined the advantages of these two methods to propose a new combination linear identification method, which was experimented on the entire ORL face library and compared the method with the classic feature faces and Fisherfaces methods. Experiments show that the combination identification method is obviously superior to the other three methods. In addition, they also conducted many other experiments, and without exception, the results showed that the combination identification method was the best method.

Huang optimized the method based on the Local Binary Patterns (LBP) orator and creatively proposed the LBP subpattern algorithm and the LBP pyramid algorithm (Huang, 2009). Compared with the original LBP mode, the LBP submodel is more flexible. In the face of different types of images, this method can obtain LBP sub-modes that can better represent the characteristics of each type of image, and can independently select the percentage of the total mode. At the same time, through Principal Component Analysis (PCA) transformation, the method can also achieve dimension reduction and eliminate interference factors in the image, which is conducive to more accurate face recognition detection. The LBP pyramid algorithm uses multi-scale space theory to build a new type of multi-scale LBP based on changing the resolution or scale of the image. This method greatly reduces the computational complexity, enhances the feasibility of this method, and has higher accuracy in feature extraction than other multi-scale LBPs. Then, on this basis, a multi-scale LBP submodel is proposed, which has the advantages of the above two methods and can cope with changes in image types.

Unobstructed face recognition technology is easier to implement than unobstructed face recognition technology because it can extract more facial features. There is no need to deal with the loss of information caused by the loss of features caused by face occlusion, and the algorithm is simpler. At present, the development of unobstructed face recognition is relatively mature, which can quickly recognize faces, with high accuracy and good performance. However, the method cannot continue to maintain the accuracy of the model when it encounters obstruction, which has certain limitations. And because in real life, people cannot guarantee that there is no cover every time face recognition is carried out, which also leads to a decline in the detection accuracy of unobstructed face recognition. Therefore, the research on masked face recognition is particularly urgent and important. In recent years, masked face recognition has also been a hot research direction in the field of face recognition.

3 FACE RECOGNITION IN A BLOCKED ENVIRONMENT

Although face recognition technology has matured, it still faces many challenges in real life. This is because, in real life, it is impossible to ensure that the face is not covered every time it is tested, such as masks, hair, hats, etc., or light occlusion caused by uneven external light. Especially with the outbreak of COVID-19 in 2020, people's health awareness has gradually increased. In many public places, people will choose to wear masks, which greatly increases the difficulty of face detection. Therefore, the study of masked face recognition has become an inevitable choice. In this chapter, I will introduce five methods of masking face recognition.

Xu and others proposed a face image recognition method based on the circular generation of confrontation networks (Xu et al., 2022). The model reconstructs the entire image and outputs the image that restores the original image features, completes the face repair, and trains through two pairs of distinguishers and generators to ensure the accuracy of the repair. After the repair is completed, the residual network ResNet-50 is used to extract facial features and the loss function RegularFace is introduced to deal with the impact of different classes of interclass distance on classification. Although the repair effect will be affected by factors such as linear nonlinear occlusion and the occlusion area of the occlusion part, resulting in large differences in repair effects, in general, when using the repaired pictures for face detection, the accuracy of the detection will be significantly improved.

Zhou et al. proposed a block-based obscured face recognition algorithm in combination with convolutional neural networks (Zhou et al., 2018). The algorithm obtains the feature points of a face through the self-coding network (CFAN) and divides them into four areas: left and right eyes, mouth and nose. After the blocking is completed, an occlusion discrimination network is trained based on the InceptionV3 network to perform occlusion discrimination for each area, and feature fusion and similarity detection are carried out according to the discrimination results to obtain the final facial features. The literature compares this method with the classical Sparse Representation-based Classification (SRC), Group Sparse Representation-based Classification (GSRC) and Robust Sparse Coding (RSC) algorithms in terms of the covering part and the covering area (Wright et al., 2008; Yang & Zhang, 2010). When covering a large area, the algorithm has maintained an extremely high accuracy. However, in the case of sunglasses occlusion, the algorithm is not as accurate as the RSC algorithm, which may be because too much feature block occlusion leads to the loss of eye features, so the algorithm still needs to be improved.

Zhou and others optimized the scale invariant feature transformation (SIFT) algorithm of human faces (Zhou & Lai, 2011). The traditional SIFT algorithm can find out the key points of most matches in the image, but there are still some mismatches. Therefore, they proposed a new matching idea, taking a key point in an image and finding out the first two key points in another image that are closest to that point. In these two key points, if the nearest distance divided by the sub-close distance is less than a certain proportional threshold, the two key points are considered to be matched. Experiments were conducted on the AR face library and the Manchester face library, and the results showed that the recognition rate of the optimization method was about 10% higher than that of the traditional SIFT algorithm.

Li and others proposed a masked face recognition method based on the detection and elimination of face heterogenous areas of the average face (Li et al., 2015). This method obtains the error face image by performing the difference between the test face and the average face formed by the training picture and segmenting the error image to obtain the information description of the occlusion area. This is a very critical step in the whole algorithm and determines the division of the obscured area of the test set and the training set later. The training set and the test set form a new data set after removing the corresponding blocking parts. The calculation difficulty of this algorithm is relatively small, which reduces the difficulty of implementation. However, experiments have proved that the segmentation effect of the error face image of the algorithm is poor in the presence of light changes, and the impact of light intensity on the algorithm needs to be further explored.

Li and others proposed an algorithm that combines machine learning based on thinking evolution with local features (Li G. & Li W., 2014). Considering that face recognition in practical applications will be affected by uncertainties such as the environment, they proposed the LBP offset feature group to avoid the problem of feature offset instability. And the evolution of the convergence process and alienation process is carried out in all local areas. In order to avoid the replacement of the score of the blocking area by the winner, they proposed a new convergence rule, setting a threshold, and using the threshold to divide the new competitive group and the winner group. Based on the AR face library, the experiment was compared with the Robust Distance Weighted Local Binary Pattern (RDW-LBP), Fuzzy Principal Component Analysis (FPCA) and Orthogonal Matching Pursuit with Cholesky Decomposition (OMP-Cholesky) algorithms. The experimental results show that the algorithm has maintained the highest recognition accuracy.

With the continuous progress of science and technology, the development of masked face recognition is also getting faster and faster. Obstructed face recognition makes up for the shortcomings of unobstructed face recognition. Even if the identification object wears a mask or cannot capture all its facial features due to light, shooting angle and other reasons, the covered face recognition technology can still maintain a good recognition rate. This technology provides strong technical support for public safety, which can help quickly identify dangerous personnel and criminals and improve public safety. In terms of personal experience, for example, when face unlocking is required, users may wear hats, masks and other covering objects. Applications with masking face recognition can also maintain a good experience for users. However, as mentioned above, it is still impossible to achieve high-efficiency recognition in some application scenarios with masked face recognition, such as excessive area of the covered part, so the research on masked face recognition needs to be further strengthened.

4 THE ROLE AND IMPACT OF DATA SET

The use of professional data sets is very important for the research and application of face recognition. The theoretical analysis in the research process needs to be constantly modified and improved according to the experimental results. This article will introduce several commonly used unobstructed and covered face recognition data sets. First of all, let's introduce the unobstructed face recognition data set: Celebrity Faces Attribute Dataset (CelebA) data set is a large-scale face recognition data set established by the Chinese University of Hong Kong. It contains more than 200,000 face pictures, which is suitable for people's Research judgment of face properties; the Face Detection Data Set and Benchmark (FDDB) data set is often used for test result evaluation; the VGGFace2 data set is suitable for training deep neural networks. Commonly used masked face recognition data sets include: The maskedFace-Net data set was born after the COVID-19 pandemic. All pictures show faces wearing different types of masks, which is very suitable for research on masked face recognition; Multi-Attribute Fa Ce Annotations (MAMA) also provides a large number of face data sets with occlusion, including occlusion in all directions and angles; the Wider Face test set is huge and the results are highly reliable.

5 CONCLUSION

As an important part of the field of computer vision, face recognition technology has made remarkable progress in recent years and will continue to lead the wave of scientific and technological development. This technology not only plays a key role in security monitoring but also gradually penetrates into many daily applications such as smartphone unlocking and financial payment verification. In the future, with the continuous progress of artificial intelligence and deep learning, face recognition is expected to maintain its position at the forefront of scientific research and promote innovation and change in more fields. This article reviews the research results of face recognition under unobstructed and covered conditions. Although some effective y optimization algorithms have been proposed, the existing methods still have limitations, especially in complex environments, the performance needs to be improved. Therefore, the future improvement direction should focus on optimizing existing algorithms to meet the needs of more diverse real scenarios. In addition, this article briefly introduces several data sets commonly used in face recognition, such as CelebA. These data sets provide valuable resources for researchers to help train and evaluate model performance. Understanding and rational use of these data sets is crucial to promoting the development of face recognition technology. In a word, the development of computer face recognition technology is long and challenging. Although many achievements have been made, in order to make this technology more perfect, scientific researchers need to work together to carry out in-depth exploration into algorithm optimization, privacy protection and ethical considerations. Only in this way can this advanced technology better serve the society and meet people's growing needs for safety and convenience.

REFERENCES

M Eleyan, A. (2023). Face recognition using ensemble statistical local descriptors. Journal of King Saud University-Computer and Information Sciences, 35(9), 101729.

Huang Feifei. (2009). Research on face recognition based on LBP (master's thesis, Chongqing University).

Li Dongmei, Xiong Chengyi, Gao Zhirong, Zhou Cheng & Wang Hanxin. (2015). Occlusion face recognition based on the elimination of heterovalued areas. Computer Science (03), 289-295.

Li Gen & Li Wenhui. (2014). Blocking face recognition of machine learning based on the evolution of thinking. Journal of Jilin University (Engineering Edition) (05), 1410-1416.

Lin Miaozhen. (2013). Research on face recognition based on deep learning (master's thesis, Dalian University of Technology).

Wright, J., Yang, A. Y., Ganesh, A., Sastry, S. S., & Ma, Y. (2008). Robust face recognition via sparse representation. IEEE Transactions on Pattern Analysis and Machine Intelligence, 31(2), 210-227.

Xu Runhao, Cheng Jixiang, Li Zhidan & Fu Xiaolong. (2022). Obstructive face recognition based on the circular generation of the opposition network. Computer Engineering (05), 289-296+305.

Yang Jian, Yang Jingyu, Ye Hui. (2003). Theoretical research and application of Fisher linear discrimination analysis. Journal of Automation (04), 481-493.

Yang, M., & Zhang, L. (2010). Gabor feature based sparse representation for face recognition with gabor occlusion dictionary. In Computer Vision-ECCV 2010: 11th European Conference on Computer Vision (pp. 448-461). Springer Berlin Heidelberg.

Zhou Lingli & Lai Jianhuang. (2011). Obstructed face recognition based on the optimization algorithm of scale-invariant feature transformation. Computer Application (S1), 64-66+75.

Zhou Xiaojia, Zhu Yunbin & Zhang Yue. (2018). Block-based masked face recognition algorithm. Computer Applications and Software (02), 183-187+193.