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A Survey of Face Recognition Methods Based on Mask Region Restoration Algorithm

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Abstract: The complex and diverse background conditions, the variability of human face and the artificial deliberate transformation have all become the problems that traditional face recognition technology can't solve, and they can't really reflect the imperceptible advantages of face recognition. After wearing masks, the most important mouth and nose areas of human face are covered by these masks with different shapes and colors, and some facial features are hidden, and the key feature points that can be extracted are greatly reduced. In this paper, the existing mask region repair algorithms at home and abroad are classified and summarized, mainly including mask occlusion face recognition based on robust occlusion, mask occlusion face recognition based on sparse representation classification and mask occlusion face recognition based on neural network. It is pointed out that partial occlusion is one of the main difficulties. The main methods and shortcomings of face recognition based on mask region repair algorithm are systematically analyzed and summarized, and the main problems and possible research ways in the future are analyzed.

Keywords: Mask occlusion; Face recognition; Neural network.

1. Introduction

Biometrics is a technology that uses human biological characteristics for identity authentication. Many biological characteristics of human body are not only unique, but also measurable, which makes it possible for computer to identify biological characteristics. Due to the prevalence of epidemic situation, face recognition with masks has become an urgent problem. In order to supervise people wearing masks in crowded public places (such as airports, stations, etc.), staff members are even specially assigned to check whether they wear masks. Complex and diverse background conditions, the variability of human face and artificial deliberate transformation have all become the problems that traditional face recognition technology can't solve, and can't really reflect the imperceptible advantages of face recognition. In response to the relevant regulations of the state on epidemic prevention and control, this paper studies the key technologies of face recognition method based on mask region repair algorithm.

2. Face recognition with mask occlusion based on occlusion robustness

This kind of method aims to help the model learn the face features that are robust to occlusion and improve the recognition rate of the model in occlusion scenes. The occlusion robust learning method based on attention mechanism helps the model refocus the key facial features through attention mechanism, which makes the extracted facial features have certain robustness in the face of mask influence, thus improving the face recognition ability of the model with mask occlusion. As shown in fig. 1, in order to improve the representation ability of the network, the document [1] proposed the SE module, which adaptively calibrated the features by modeling the dependencies between feature channels, and significantly improved the performance of the deep neural network with very low computational cost. The workflow of SE module is divided into two steps: information compression and weight activation. Compression is used to aggregate global airspace information and is realized by global average pooling.

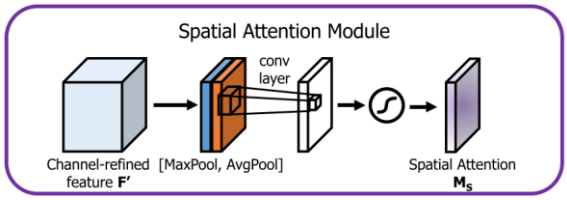

Figure 1. Workflow of SE module

The basic idea of robust estimation method is to estimate the image characteristics of the occluded part by learning from the existing unobstructed samples, so it is not affected by the size and position of the occluded area, and has been deeply studied in occluded face recognition. Reference [2] proposes to estimate the error distribution adaptively, and use semi-quadratic optimization method to get the principal component by iterative weighted least squares solution. Literature [3] proposes a new robust principal component analysis method based on low-rank constraints, which is modeled as a low-rank part plus sparse noise part. In this method, occluded face images are allowed in the training set. However, this method removes the occlusion and other discriminant information as noise at the same time. Literature [4] proposed a foreground-aware image inpainting algorithm, which obtained the foreground contour of the damaged image through the contour detection module, then predicted the complete foreground contour of the image by the contour completion module, and finally predicted the final image by the image completion module according to the completed contour and the damaged image. This method was also an advanced technology at that time.

Generally speaking, face recognition is mainly divided into three stages: face image preprocessing, face image feature extraction and classification judgment. For two-dimensional images, wavelet transform can simultaneously extract the features of images in spatial domain and frequency domain,

which provides a powerful tool for image feature extraction and expression. In reference [5], the author introduced the denoising model of wavelet transform into face recognition, modeled the illumination change as a low-frequency component, and thought that the internal feature of face was a high-frequency component. After removing the low-frequency component by wavelet transform, the feature expression of face image was obtained. Experiments show that this processing method has a good performance for face recognition under illumination change.

In reference [6], the author uses wavelet transform to analyze the face image with multi-resolution, so as to find wavelet subbands insensitive to expression and illumination changes, and then fuses the wavelet subband features or discriminant results of the extracted face image to get the final discriminant classification result, thus further improving the correct rate of face recognition, especially in the case of illumination changes.

3. Face recognition with mask occlusion based on sparse representation classification

In the process of face recognition, how to effectively extract and describe the features of each person's face image to distinguish it from others is one of the key issues in related research. However, the personalized features of human face are largely restricted by the changes of expression, posture, illumination and distance. Therefore, it is the goal pursued by researchers to establish a stable and quotient robust face recognition algorithm.

Although the face image has a high dimension, it may be located in a low-dimensional subspace or manifold. Therefore, scholars at home and abroad have put forward many subspace learning methods to extract the features of face images, and use nearest neighbor classifier or support vector machine to recognize face images [7]. Sparse representation is applied to the field of face recognition, and good recognition results are obtained when the face image is polluted by noise or partially occluded. Since then, face recognition methods based on sparse representation of images have attracted much attention.

Sparse representation represents images linearly by constructing or learning a complete dictionary. It uses less data to describe the characteristic information of the object of interest. It is a concise and efficient image representation method and provides a good solution for dealing with external interference factors such as illumination, occlusion, noise, corrosion and misalignment. The flow of face recognition method based on sparse representation is shown in Figure 2.

Sparse representation expands a new direction of image representation. Its basic idea is: to use the sparsity of an image to build a mathematical model, and to reflect the internal structure and essential genus of an image through a small number of non-zero representation coefficients, so as to obtain the most concise expression of an image in an over-complete dictionary. A typical application of sparse representation in face recognition field is classification based on sparse representation. Using sparse representation theory to deal with the problem of face recognition, a classification method based on sparse representation is proposed, which provides a new research perspective and solution for the study of face recognition. Many studies have proved that the sparse representation based on dictionary learning has obvious advantages over the sparse representation based on analytic dictionary, and has obtained ideal results in many image processing applications [8].

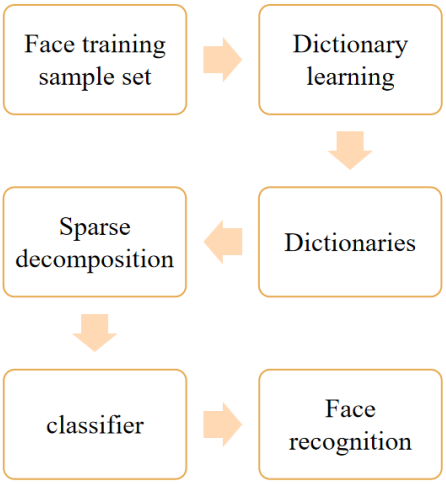

Figure 2. Face recognition method flow based on sparse representation

Dictionary design is an important research content in sparse representation classification face recognition method, and whether the face image can be sparsely represented depends on the performance of the dictionary. Literature [8] puts forward a double sparse dictionary learning algorithm, which assumes that dictionary atoms themselves contain certain structural information, so they can also be sparsely represented by a known base dictionary, thus obtaining a more adaptive dictionary. Literature [9] improves the discriminant power of dictionaries by introducing discriminant reconstruction constraints into dictionary learning models. Subsequently, they put forward a supervised dictionary learning method and applied it to digital recognition and texture classification. Some scholars have further considered the discrimination of sparse coding of face images, and thus designed a classifier with better classification effect [10].

4. Face recognition with mask occlusion based on neural network

With the development of important science and technology related to machine learning, deep learning has gradually been widely used in many fields such as computer vision, pattern recognition and image processing. Through multi-layer learning, deep learning will build a neural network structure model similar to the human brain, and obtain an expression suitable for the input data characteristics of the target. Deep learning has also achieved great success in many fields, especially in the field of face recognition. Various face recognition algorithms based on CNN (Convolutional Neural Networks) have far exceeded the recognition rate of other kinds of machine algorithms in related database tests [11]. CNN refers to DNN (Deep neural network) with convolution as the calculation method, which plays an important role in the field of computer vision. CNN structure is shown in Figure 3:

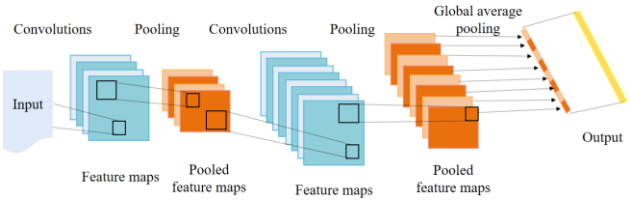

Figure 3. CNN structure

In the process of collecting face images, face images will always be affected by various obstructions, and the diversity of obstructions will lead to the inconsistency of application modeling of face recognition, making it a difficult point to deal with face recognition technology under occlusion conditions. Literature [12] In order to reduce the influence of local occlusion, a method of blocking face images is proposed, and features are extracted by using self-organizing mapping neural network. Literature [13] proposes a method of face recognition after the occlusion image is segmented. The limitation of this method is that there is a big difference in gray value between the required occlusion and the unobstructed face image, otherwise the performance will be unsatisfactory.

YOLO has really pushed the target detection to a large-scale landing application with its powerful real-time detection performance. YOLO series didn't give consideration to both detection accuracy and speed until YOLOv3 version, and it really matured. YOLOv4 adopts a series of optimization and training techniques to improve the detection performance and reduce the application cost of the model. YOLOv5, on the other hand, is more flexible, compact and easy to deploy. While maintaining high detection accuracy, it further accelerates the reasoning speed of the model and takes less time, thus achieving the best balance between speed and performance of the current series. Literature [14] expands the pyramid structure of 3×3 to 4×4, and adds a new prediction branch to the shallow feature extraction part, which improves the detection accuracy of the model for small targets by 7.2 percentage points. The mask wearing detection based on YOLOv4 is easy to be disturbed by complex illumination, which leads to poor results. Literature [15] improved the simplified model of residual structure to achieve real-time detection, increased multi-scale output structure, enhanced the expression of low-level feature layers, reduced the missed detection rate of small targets, and adopted multi-level cross-fusion structure to improve the feature utilization rate. The improved algorithm model was only 5.8 MB and the mAP value increased by 5.3%. Literature [16] proposed an improved lightweight mask detection algorithm based on YOLOv4-tiny. Document [17] proposed a mask wearing detection and embedded implementation method based on YOLOv4 block weight pruning. Literature [18] proposed an improved YOLOv3 multi-scale network. In the end, the accuracy of this algorithm in face mask detection reached 93.66%, which was 5.61% higher than the original algorithm. However, its model became more complicated and the network parameters increased, so the detection efficiency decreased.

In order to generate the face edge of the mask area, it is necessary to locate the mask and obtain the missing face map of the mask area. The position and shape of the mask are preliminarily obtained by using the key point information of the face and combining with prior knowledge. Literature [19] introduces perceptual loss and style loss, and the weighted sum of identity consistency loss and spatial weighted confrontation loss designed in this paper as the total loss function to train the regional filling network. Literature [20] applied CNN to facial expression recognition with partial occlusion. Experiments show that facial expression recognition based on CNN has high recognition rate and good robustness. Literature [21] improved a kind of CNN for face recognition, mainly combining the attention mechanism with CNN effectively, focusing on the area above the nose and mouth, reducing the dependence on other areas, and effectively improving the accuracy of face recognition. Document [22] proposed GAN (Generative Adversarial Network), which can continuously improve the generation ability through game learning, and its classic application is to generate natural images. Literature [23] proposed to use depth generation model to restore occluded face. Specifically, it generates random square occlusion on the face image. After the encoder maps the occluded face to a high-order representation, the decoder fills in the face occlusion and outputs it.

5. Conclusions

Face recognition technology is to judge whether there is face information in the input video stream or digital image, and further track the position and size of the face in each frame of the digital image or video to realize identity recognition. Due to the prevalence of epidemic situation, face recognition with masks has become an urgent problem. In order to supervise people wearing masks in crowded public places, staff members are even specially assigned to check whether they wear masks. In the practical application of face recognition method based on mask region repair algorithm, it is necessary to further optimize the actual performance of the equipment and the external environment, and it is necessary to focus on the portability of general equipment in order to deploy face recognition algorithm on a large scale to improve the efficiency of face recognition in the current complex environment.

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