Face Image Classification Based on Deep Convolutional Neural Network Feature Extraction Method

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Abstract. The birth of face recognition technology began in the 1960s, and it has experienced a general development process: based on face structure features (1970-1990), statistical features (1991-2000), big data and complex algorithms (2001-present). Among them, the first phase of face recognition technology is mainly to establish a grayscale image model through studying facial features, and at the same time, it cannot complete the automatic recognition. In the second stage, multi-dimensional feature vectors are adopted to represent facial features, and previous empirical knowledge should be used for judgment. With the development of artificial intelligence, modern face recognitiontechnology integrates artificial intelligence, machine learning, image processing and other technologies to study the face recognition problems facing with real conditions.
This paper will summarize, analyze and discuss some traditional face recognition algorithms and current typical facial recognition technology based on artificial intelligence algorithm, and through the study on facial model building, facial feature representation, algorithm accuracy and other influencing factors, the advantages and disadvantages of each face recognition algorithm when applied to various fields will be analyzed, and then these algorithms will be evaluated and prospected.

Keywords: Image recognition; Face recognition; Artificial intelligence; Convolutional neural network; Deep learning

I. Introduction

Nowadays, with the development of biometric identification technology, face recognition technology is becoming more and more mature. In daily life, face recognition is widely used in a number of fields, such as politics, military, economy, culture. For example, we can use your mobile phone to "recognize our face" to pay for shopping and get to the station, and find the criminals through face recognition in the crowd. Therefore, facerecognition technology has been integrated into every aspect ofpeople's daily life and become one of the driving forces of human civilization, and human beings have entered the era of "face recognition".

Face recognition means that the face image in the database is compared with static or dynamic image between the samplesfor confirmation. Similar to human fingerprints and iris, humanface also has the independence, and it can carry out identity authentification of people like modern fingerprint recognition, iris recognition, DNA recognition and so on. Compared with fingerprint recognition and DNA recognition, face recognition technology has a lot of advantages, for example, the sampling and operation are simple, and it does not need to process or contact target samples, so it improves the efficiency of identity recognition and has greater development and application potential [1]. However, if analyzing from another perspective, face recognition will inevitably encounter the interference of external conditions such as illumination, expression and color in practical applications. It is an important research topic in thefield of face recognition that the algorithm can eliminate interference and efficiently realize face recognition.

II. Traditional face recognition technology

There are many types of traditional face recognition techniques. In this paper, face recognition based on geometric feature algorithm and face recognition based on principal component analysis algorithm were introduced. Then they wereevaluated and compared with the artificial intelligence algorithm below, so as to analyze its advantages and disadvantages.

Traditional face recognition technical process (based on geometric feature algorithm)

(1) Face detection

In face detection, the system needs to judge whether there isa face in the image. If so, calculate the coordinate position andarea of the face in the image.

(2) Feature extraction

The location of facial feature points (human facial features)can be determined by detecting and locating the feature points of facial organs. Meanwhile, the specific description information of facial shape and organs can be determined by the algorithm, and the description of facial features can be obtainedby the algorithm based on these information.

(3) Face recognition

The face feature description information obtained in the previous steps is compared with the face information in the database for face recognition. The process of one-to-many face matching and one-to-one authentication is mainly carried out. [2]

A. Anoverview of face recognition algorithms based on geometric features

In the early stage of face recognition research (1964-1990),face recognition research was mainly conducted by studying thefeatures of face geometric structure. With the development of science and technology, this algorithm has been gradually improved.

Human face is made up of eyes, nose, ears and mouth. Thefacial features of different people have different shapes. However, due to the regularity of human genetic and

physiological characteristics, its structure can be used as an indicator for face recognition. [3] In the early stage of this algorithm (such as the face recognition method based on geometric features proposed by Bledsoe), on the basis of manually locating the feature points, the factors such as ratio distance of facial feature points were used as features for face recognition, so as to realize face recognition semi-automatic sense. With the development of the times, Brunelli and Poggio developed the previous achievements and described human face by extracting the structural feature vectors such as the location of facial features and the shape of the face, and then used the traditional Bayesian classifier for face recognition. [3]

1) Algorithm analysis

Face recognition method based on geometric features has relatively high precision, and it is also characterized by straightforward method, quick speed, less steps, small computational overhead, etc, but the algorithm principle is to carry out mathematical linear simplification on facial features, facial expressions and forms, so the human face cannot be described with a high precision. In the face of special cases, for example, facial expressions and shape changing will lead to the robustness low, and it is prone to have errors.

B. Overview of Principal Component Analysis algorithm

Nowadays, feature extraction method is an important part of face recognition field. Principle Component Analysis (PCA) is one of the most widely used methods in feature extraction. As an important statistical method, PCA has been widely used in image processing, signal processing and other fields. The principle of principal component analysis is to separate the principal elements of the original spatial data and ignore the redundant data, so that the extracted data can be processed in afeature space with reduced dimension, so as to solve the practical application problem.

Eigenface is widely used in face recognition algorithms based on principal component analysis. In application, the image region containing face can be regarded as a random vector, and the feature face can be obtained after transformation. During the recognition, the face map is mapped to the vector subspace constituted by the feature vector, and then the location of the face map to be recognized in the feature space is compared.

The specific steps of this algorithm are as follows:

Obtain the training set of facial graph and obtain the characteristic face, and then obtain the vector subspace constituted by the characteristic face, and wait for the test.

Import the new image to be tested, map it into the vector subspace constituted by the feature face, and obtain the face feature data of the face map to be tested.

Judge the distance from the image to be tested to the vector subspace constituted by the feature face to judge whether thereis a face in the image to be tested (If there is, judge whether it is an object in the database according to the weight, and makea specific judgment. This step doesn't affect the algorithm andcan be ignored.)

1) Algorithm analysis

The face recognition method based on principal component analysis can carry out the dimension reduction process of the data very well. In practical application, PCA algorithm has a relatively high robustness to face expression changes, so as to improve the accuracy of face recognition. But at the same time,the accuracy of PCA algorithm will be reduced when the illumination and expression under real conditions change simultaneously. At this point, if an algorithm (such as LDA algorithm) that resists light changes can integrate the two, the system can have a high face recognition rate [4].

To sum up, among the traditional face recognition methods,they often require artificial auxiliary, so that the system can extract useful characteristic data from the original image. In theera of big data and intelligence times, if traditional face recognition method isn't improved, the deficiencies will be exposed greatly.

III. Overview of artificial intelligence algorithm

A. Neural Network

Since the 1980s, along with the progress of science and technology, artificial intelligence (AI) gradually entered the public view, and brought a tremendous progress to the society,and the Artificial Neural Network (ANN, also known as Artificial Neural Network or Neural Network), under the field of artificial intelligence also got a further development with therise of Artificial Intelligence.

As the name suggests, the artificial neural network is an abstract model of the operation mode of human brain neural network, and its operation mode is: some mutually connected "neurons" (nodes) represent a particular output function, and it also refers to the activation function (also known as the excitation function) and inputs and maps the nodes to the outputend. The "memory" of artificial neural network consists of the weighted values of connection signals between nodes. The output of the algorithm is often determined by its own signal weighting value, activation function and connection mode of "neurons" .

Along with the increasing maturity of artificial neural network, it has been widely extended in many fields, such as pattern recognition, biology, robotics, medicine, etc. And solved many practical application problems which cannot be solved by ordinary computer in life, showed its sophistication and efficiency and many other excellent properties. In today's face recognition field, artificial neural network also plays an indispensable role, and many of its extended algorithms (such as convolutional neural network) plays a significant role in promoting and contributing to the field of face recognition. In this paper, face recognition algorithms based on artificial neuralnetwork such as DeepFace and DeepID were introduced, their advantages and disadvantages were compared with other face recognition methods, and then their future development trend was prospected.

B. Convolutional Neural Network

Convolution Neural Network consists of several hierarchical structure, and it consists of input layer, convolutional layer, pooling layer, fully connected layer and output layer [5]. Its basic structure is shown in Figure.1 As shown in the figure, the network mostly uses a combination of

convolutional layer and pooling layer.

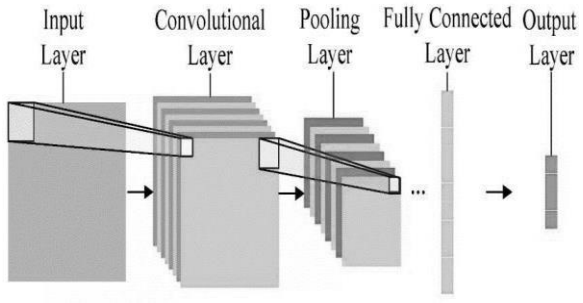

Figure.1. Basic structure of convolutional neural network.

In the field of face recognition, the traditional face recognition algorithm based on face feature vectors introducedpreviously needs to extract face features, select features and select classifier in operation, which requires tedious operation, and the features extracted by the algorithm cannot fully expressthe target. However, the convolutional neural network can make up for such shortcomings, extract the high-level features of human face and improve the expression ability of the features, so as to effectively improve the accuracy and efficiency of facerecognition.

C. DeepFace algorithm

Deepface was proposed by facebook in 2014. It is an optimized face recognition network structure based on deep learning algorithm, and its steps can be roughly divided into detect -- align -- represent -- classify. Its network structure is shown in Figure.2.

Figure.2. Deepface's network structure.

In the detection step, Deepface used the fiducial point detector based on the detection points, and first found six reference points (the center of the eyes, the nose and the mouth) on the face. The reference points were obtained through relevant learning (e.g., using SVR via LBP feature).

In the alignment step (as shown in Figure.3), a 3D model was used to process 2D face into 3D face, and the face model was triangulated. Then the triangulated face was carried out with 3D treatment and deflected, and finally a face was obtained[6].

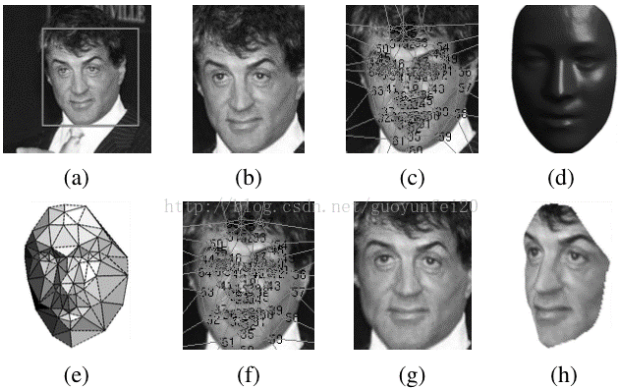

Figure.3. Deepface alignment steps.

In the face representation, the above aligned image was sentto the Convolutional Neural Networks (CNN) for processing, and the feature vectors of the face images were obtained and finally classified. In application, this algorithm can generate relatively compact and sparse descriptors and greatly improve its recognition accuracy. In the test of face recognition test database (LFW), and the accuracy of this algorithm reached 97.35%, reducing the error of existing technology by 27%[6]. However, the disadvantage is that the model needs to be alignedto extract specific features. If it isn't aligned, the recognition accuracy can only reach 87.9% in the test. In addition, in the process of training the model, the loss function was constructedby the classifier result. In other words, when using the model, its classifier and characteristics were in the binding state, and the classes divided by the classifier were bound to the size of the input data class simultaneously, and different training was required to ensure the accuracy when entering different data.

D. DeepID algorithm

DeepID is one of the mainstream face recognition algorithms based on convolutional neural network proposed byprofessor Tang Xiaoou of the Chinese University of Hong Kongin 2014. It uses three-layer convolution and three-layer maximum pooling, and the final fully connected layer is connected with the third and fourth convolutional layers [7]. Itsstructure is shown in Figure.4.

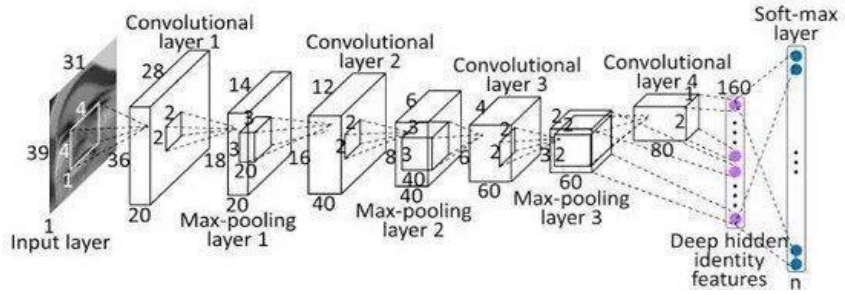

Figure.4. Structure diagram of DeepID.

In face recognition, the illumination, angle, age, expression and other factors of the face in the image to be detected will obviously affect the recognition accuracy, and even a greater recognition accuracy will appear in the same picture. Many traditional face recognition algorithms cannot accurately recognize face models due to their own algorithms or other reasons when dealing with the above practical problems. For such problems, based on the particularity of DeepID structure, the fully connected layer is connected to the 3rd and 4th convolutional layers. This special property has the advantages, which enable the model network to recognize more scale features, and avoid the information missing in the convolution layer at the end due to continuous sampling, thus improving the information integration. In the end, DeepID will output a high-density, internally validated and 160-degree vector that can be directly used for face recognition [6][12].

In an actual combat environment, when using the CeleFace dataset as a training model, DeepID obtained an accuracy of 97.45% in LFW under weak alignment conditions, which was only 0.05% lower than that of human eyes (97.50%) [6].

E. DeepID2 algorithm and DeepID2+ algorithm

After the above DeepID achieved a greater face recognition accuracy, in the year when DeepID appeared, DeepID2 also appeared. Compared with DeepID, DeepID2 made some improvements in adding face verification signals and face recognition signals into the network structure by studying the impact of recognition and verification signals on the neural network [6][13][14]. By adding these two signals, the difference between the same face and different picture sources can be reduced. The existence of these two signals can not only reduce the difference between different face image samples but also improve the diversity of different samples.

In practical application, DeepID2 achieved an accuracy of 99.15% in the LFW, increasing by 67% compared with the previous DeepID. [8]

DeepID2+, a face recognition algorithm based on DeepID2, was still proposed by professor tang xiaoou's team in 2015. In this algorithm, more sampling layers are added to the full connection layer of the network to accurately collect more local features, and the dimension of the full connection layer is increased to 512 layers. In the LFW test, it can obtain 99.47% recognition accuracy [6] [9], which exceeds the recognition accuracy of human eyes.

F. Fecenet algorithm

Different DeepID series algorithms with improved network structure. Facenet is a face recognition system put forward by Google in 2015, and the system improved the loss function in the neural network, proposed new loss function based on Euclidean facial similarity measurement, directly abandoned the traditional softmax classification and used Triplet Loss as the loss function [8]. A triplet was constructed to make the distance of the nearest negative sample be greater than the distance of the positive sample (the farthest), so that the 128- dimensional vector distance output by the vector of the penultimate second layer in the structure only needed to be calculated for face recognition.

The appearance of Facenet brings a new loss function, indicating that the feature dimension can scattered to 128 dimensions. In practical application, facenet also achieved outstanding results, and it achieved a high face recognition accuracy of 99.63% on the LFW in 2015. Therefore, it surpassed the best performance of face recognition in LFW [5][10][11].

IV. Summary and prospect

Face recognition technology has been existed for more thanten years until now, and it generally experienced four stages, including the theory, semi-automatic, automatic, intelligent stages. With the progress of the times, more new and efficient algorithms emerge one after another. From the previous description of face recognition technology in this paper, we can know that, compared with intelligent algorithms, traditional face recognition is vulnerable to be interfered by more external malignant conditions, and the recognition accuracy isn't high. However, if multiple algorithms are combined (such as principal component analysis algorithm and LDA algorithm mentioned above), a better face recognition accuracy can be achieved. For the traditional face recognition algorithm, the face recognition algorithm based on deep learning and neural network is characterized by high robustness, high automation and high recognition accuracy. Some algorithms, such as the Facenet algorithm, even have a better face recognition ability than human eyes. However, there is still a great room for improvement in intelligent face recognition algorithms, such asthe improvement of neural network structure (DeepID) mentioned above, and the improvement of loss algorithm (Facenet). Nowadays, face recognition still has many development paths, such as strengthening the theoretical exploration of deep learning algorithm, strengthening the research of semi-supervised learning and unsupervised learning,

etc. [1]. In terms of application, the author believes that face recognition is popular in the field of security. Of course, face recognition has been widely used in many fields, such as electronic payment, transportation. But the author believes that, with the development of face recognition technology and the deepening of interdisciplinary cooperation between disciplines as well as the growth of social demand, face recognition technology will have a new breakthrough in theory and set footon a new discipline level, and in terms of application, it will beintegrated into more and more social fields, and become a fieldand the mainstay of an industry. At the same time, it will be more deeply and widely integrated into the daily life of humanbeings to improve the living standard of human beings and become the driving force of civilization development.

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