International Core Journal of Engineering Volume 7 Issue 7, 2021
ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0038

A Survey of Research on Deep Face Recognition based on Gabor Features

Tiantian Chen[1,2], Hongjie Zhang[1,2], Hongrong Jing[1,2]

[1]Artificial Intelligence Key Laboratory of Sichuan Province, Zigong 643000, China;

[2]School of Automation & Information Engineering, Sichuan University of Science & Engineering, Zigong 643000, China.

Abstract

The visual stimulus response of human visual cells is similar to Gabor wavelet. Gabor wavelet has a good representation of spatial locality and selective characteristics of orientation. This paper reviews the biometric field of deep face recognition based on Gabor features, expounds the characteristics of Gabor wavelet, the method of face feature extraction and the basic structure of deep learning.

Keywords

Gabor Transform; Face Recognition; Deep Learning.

1. Introduction

Face recognition is a biometric recognition technology, which uses computer technology to process and analyze face images, and extract effective identification information from face images to identify the identity [1]. With the continuous development of science and technology, face recognition technology has achieved unprecedented development, and it can be seen everywhere in daily life, such as access control systems, mobile phone lock screen systems, and so on. In the field of face recognition, feature extraction has always been in a key position, and a hot research topic in the field of pattern recognition is how feature extraction can be performed effectively.

Since Gabor features are robust to poses, illuminations, and expressions, they can describe the texture features of images well [2]. Deep learning is a popular learning method in recent years, and it is widely used in the mining of facial feature information. Deep learning makes it possible for robots to possess human thinking and learning capabilities.

This article summarizes the deep face recognition based on Gabor features, and introduces in details face recognition technologies, such as the classification of face recognition systems, expounds the facial Gabor features and Gabor wavelets, and introduces the basic structure of deep learning. Finally, we analyze and outlook the problems and development trends of deep face recognition research based on Gabor features.

2. Face Recognition Technology

In recent years, along with the rapid development of science and technology, face recognition technology has been developed and applied widely. The realization mechanism of face recognition is mainly to extract the feature information of the face from the face image, and compare the extracted face with the database, so as to recognize the face.

A face recognition system mainly includes face image acquisition and detection, face image preprocessing, face image feature extraction and face and facial image matching and recognition.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0038

2.1 Face Image Collection and Detection

Facial image collection: We can use the camera to collect different facial images, such as images of different expressions and different lighting conditions.

The face image has many pattern features, such as skin color, histogram, structure, template and Haar features, etc. We can extract the feature information of face images to realize the face detection function [3].

2.2 Face Image Preprocessing

The pre-processing of face image is to segment, feature extraction and matching of the input face image [4]. An important part of the face recognition process is preprocessing. During the collection process of face images, due to different collection environments, such as the intensity of light or use different equipment, these images often have disadvantages such as noise and low contrast. In addition, the distance during the acquisition process makes the size and position of the face in the middle of the whole image uncertain. In order to ensure the consistency of face size, position and face image quality in the face image, the image must be pre-processed.

2.3 Face Image Feature Extraction

Face image feature extraction: the process of modeling face images, also known as face representation. There are three main types of face image feature extraction methods: method based on geometric features, method based on template matching and method based on model.

2.4 Facial Image Matching and Recognition

Face image matching and recognition: We can use database to store the data of the face image, and obtain the feature data of the facial image by the feature extraction algorithm. We compare the extracted data with the data in the database, and if it is close or equal, the face to be detected is the same person as the face in the database.

Face recognition is the process of comparing the attributes of the recognized facial images with the acquired facial feature samples and making judgments based on the similarity of the data.

3. Gabor Wavelet

3.1 Definition and Characteristics of Gabor Wavelet

The frequency of Fourier transform cannot change with time and reflects the overall characteristics. However, Gabor wavelet can provide all the information of the signal and the information about the intensity of the signal change. Gabor wavelet has strong robustness: to some certain extent, image rotation and distortion can be included, and it is not sensitive (in the light and posture changes), and the texture characteristics of face images can be described well.

The Gabor wavelet kernel function is defined as follows:

$$g_{u,v}(k,z)=\left(//k//^2 / \sigma^2 \right) \exp\left(- //k//^2 //z//^2 / 2\sigma^2 \right)\left[\exp(ikz) - \exp(\sigma^2/2) \right] \tag{1}$$

$$k = k_\upsilon e^{i\phi_u} \tag{2}$$

Here, k_υ defines the scale of the wave vector k, ϕ_u defines the direction of the wave vector k, and $\exp(\sigma^2/2)$ is used as the compensation for the DC value, $k_\upsilon = k_{max}/f^{\upsilon}$ is the sampling scale.

By analyzing the Gabor wavelet kernel function, it can be known that when the parameter σ is determined, since the center frequency is inversely proportional to the time domain bandwidth, when the center frequency is small, the low-frequency information of the image is extracted; when the center frequency is large, the high-frequency features of the image are extract.

3.2 Gabor features of human faces

We can obtain the response in a certain frequency domain of the image by the Gabor kernel function, and the characteristics of the image by the response result obtained by the Gabor kernel function. If

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0038

we use multiple different frequencies of Gabor kernels to obtain image response in different frequency domains, the characteristics of the image in each frequency range can be determined, and these characteristics can describe the frequency information of the image.

When using Gabor wavelet to extract face features, we usually use multiple Gabor filters in different directions and scales to form a filter bank. The Gabor feature of a face image is expressed as the grayscale image $E(x, y)$ Convolution with a set of Gabor filters [5], and the expression is:

$$G_{u,v}(x,y)= E(x, y) * g_{u,v}(k,z) \tag{3}$$

$G_{u,v}(x,y)$ is the Gabor feature of human face.

4. Deep Learning

4.1 Method and structure

The deep learning model is a data-driven feature extraction method. The model extracts abstract features hierarchically from a large amount of data, and non-linearly combines features at different levels to achieve the goal of extracting essential features of the data [6].

The structure of typical deep learning models can be roughly divided into three categories: Generative deep structures, which mainly include restricted Boltzmann machines [7], autoencoders [8], deep belief networks [9], etc.; Discriminative deep structure, mainly including deep feedforward network [10], convolutional neural network [11], etc.; Hybrid structure.

Deep learning can be divided into unsupervised and supervised learning according to whether the data has labels or not [12]. Unsupervised learning methods mainly include: restricted Boltzmann machines, autoencoders, deep belief networks, deep Boltzmann machines, etc. Supervised learning methods mainly include: Deep feedforward network, deep stacked network and convolutional neural network, etc.

Deep learning has seven typical applications in face recognition: face recognition methods based on convolutional neural networks (CNN), deep nonlinear face shape extraction methods, and robust modeling of face poses based on deep learning , Fully automatic face recognition in a constrained environment, face recognition under video surveillance based on deep learning, low-resolution face recognition based on deep learning, and recognition of face-related information based on deep learning [13].

4.2 Deep Learning Model (convolutional neural network as an example)

Convolutional Neural Network (CNN) mainly includes 5 layers: input layer, convolution layer, pooling layer, fully connected layer and output layer. The network generally uses a combination of multiple convolutional layers and pooling layers, and uses a multi-layer fully connected feedforward neural network at the end. The training process uses a back propagation algorithm [14].

4.2.1 Data input layer

The input layer is usually a face pixel matrix, which is obtained from the face image to be trained or tested in face recognition.

4.2.2 Convolutional layer

The essence of the convolutional layer is to extract features from the input image, and extract features by translating a convolution kernel on the original image. Each feature is a feature map. The first convolutional layer may only extract some low-level functions. As the number of layers in the network increases, more complex functions may be repeatedly extracted from the low-level functions.

4.2.3 Pooling layer

The pooling has a very extensive application. The purpose of pooling is to reduce the amount of calculation and leave the most obvious characteristics of the data. Due to the dimensionality reduction of the feature map by the pooling layer, the amount of calculation and the number of parameters are reduced, which can prevent the occurrence of over-fitting to a certain extent.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0038

4.2.4 Fully connected layer

The fully connected layer has its own neurons, and each of its neurons will be connected to all neurons in the previous layer [15]. The mathematical expression of this layer is:

$$y_k^i = f\left(\sum_{j=1}^{n} x_j^{(i-1)} * w_{kj}^i + b_k^i\right) \tag{4}$$

4.2.5 Output layer

The output layer is also a fully connected layer, and the softmax logistic regression [16] expression will be used in the output layer as follows:

$$P(C_i = i|x) = e^{\alpha_i^! x} / \sum_{i=1}^{n} e^{\alpha_i^! x} \tag{5}$$

5. Analysis and Outlook

Compared with other face feature extraction methods, Gabor wavelet has many advantages: first, Gabor wavelet has good robustness; second, it can extract image features very effectively; third, Gabor wavelet is based on the idea of localization of short-time Fourier transform, which is developed on this basis. Compared with Fourier transform, wavelet transform has better time-frequency window characteristics. Fourth, the wavelet transform has the characteristics of multi-scale, which can observe the characteristics of the signal in many aspects. However, Gabor wavelets also have some shortcomings. For example, the accuracy of the analysis results depends on the selection of a suitable wavelet basis function, the selection method of the optimal wavelet basis has yet to be studied, and the redundancy of wavelet transform is very large. These problems also need to be in the future. Get continuous exploration and continuous improvement.

Since not all wavelet bases are suitable for different decomposition situations, the optimal choice of wavelet bases has always been an important content of wavelet theoretical research. We need to consider these characteristics of wavelet bases when choosing wavelet bases: Orthogonality, compact support, attenuation, symmetry and regularity.

References

[1] Quansheng Xu, Meiyi Li. Research on the location and extraction method of facial image feature points[J]. Journal of Shenyang University of Technology, 2007(01): 90-94.

[2] PANG Y, YUAN Y, LI X. Gabor-based region covariance matrices for face recognition[J]. IEEE Transactions on Circuits and Systems for Video Technology, 2008, 18(7): 989-993.

[3] Jing Wang. Design and implementation of image attendance system based on face recognition[J]. Wireless Internet Technology, 2015(10): 52-53.

[4] Huijun Shen. Research and implementation of image preprocessing methods for face recognition[J]. Technology and Innovation, 2014(18):119-120.

[5] Ruimin Chai, Zhenji Cao. Face recognition method based on Gabor wavelet and deep belief network [J]. Computer Applications, 2014, 34(09): 2590-2594.

[6] Xiong Li, Kaifu Wen, Xiaoming Zhong, Hui Yang, Dehao Qin. Development of face recognition attendance management system based on deep learning [J]. Laboratory Research and Exploration, 2019, 38(07): 115-118+123.

[7] Hinton G E. A practical guide to training restricted Boltzmann machines[J]. Momentum,2012,9 (1): 599-619.

[8] G. E. Hinton,R. R. Salakhutdinov. Reducing the Dimensionality of Data with Neural Networks[J]. Science, 2006,313(5786).

[9] Geoffrey E. Hinton,Simon Osindero,Yee-Whye Teh. A Fast Learning Algorithm for Deep Belief Nets[J]. Neural Computation, 2006,18(7).

[10] Bari H A, Tong Y. Deep feedforward networks: application to pattern recognition[C]// Proceedings of International Conference on Neural Networks (ICNN'96), 1996:1422-1426.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202107_7(7).0038

[11] Lecun Y, Bottou L, Bengio Y, et al. Gradient-based learning applied to document recognition[J]. Proceedings of IEEE, 1998, 86(11):2278-2324.

[12] Shao Ling, Wu Di, Li Xuelong. Learning deep and wide: a spectral method for learning deep networks.[J]. IEEE transactions on neural networks and learning systems,2014,25(12).

[13] Jucheng Yang, Na Liu, Shanshan Fang, Ying Xie. A review of face recognition methods based on deep learning [J]. Journal of Tianjin University of Science and Technology, 2016, 31(06):1-10.

[14] Ruidong Bao, Min Zhao. A review of research on face recognition based on convolutional neural networks [J]. Software Guide, 2018, 17(04): 6-8.

[15] Yulian Yang, Yuxiang Guan, Yi Shen, Hao Chen, Xia Zhu. Face recognition based on convolutional neural network [J]. Electronic Test, 2020(21): 60-61+99.

[16] Meilin Li. Research on face detection based on two-layer cascaded convolutional neural network [D]. Liaoning Technical University, 2019.