Automatic Face Recognition Using Gabor Wavelet and Robust Structured Sparse Representation

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Abstract: Automatically facial recognition has become more and more important today. But FR still remains a challenge problem in computer vision. So in this paper we proposed a new approach that use Gabor wavelet for facial feature extraction and robust structured sparse representation for classification. Gabor wavelet has been widely used in the face recognition task because it’s good imitation of human visual. The structured sparse representation based classification (SSRC) is used for classifying the test images robustly. Unlike sparse representation based classification (SRC), the SSRC explicitly takes structure of the dictionary into account for a better classification.

Keywords: Gabor Wavelet, Structured sparse representation classification, Face Recognition.

I. Introduction

Human face detection and recognition is one of an energetic area of study, straddling a number of disciplines such as pattern recognition, image processing and computer vision with wide range of applications such as identity verification, video-surveillance, facial expression extraction, and advanced human-computer interaction. A necessitate to develop robust face recognition algorithm is due to highly complex distribution and worse recognition performance as a result of wide-range variations of human face due to pose, illumination, and expression.

Face detection is a process how to determine the position, size and pose of a face image in the input picture. It is a key problem of automatic face recognition system and a key technology of face information processing. It has attracted significant attention over the past few years in the field of computer vision and pattern recognition.

Face recognition is the process of identifying human with the use of face characteristics. Face recognition is a growing research area in biometrics; particularly it has a huge involvement in law enforcement, commercial, and social services.

From the last few decades, several feature extraction methods have been proposed for face recognition and have achieved high recognition rates. However, it is still difficult for a machine to recognize human faces accurately with a single training image due to low interpersonal variations and large intrapersonal variations, which happened due to variations in pose, expression, illumination, scaling and other.

Wavelet transform is a good signal "space-frequency" analysis tool. It has good local properties whenever in the time or frequency domain. As wavelet gradually refined high-frequency signals in the time domain or frequency domain, it can focus the signal on any details.

Two-dimensional wavelets transform is realized by computing the convolutions of a bank of two-dimensional Gabor filters and the grey values of pixels in an area around a given position in an image. Two-dimensional Gabor wavelets transform seems to be a good approximation to the receptive fields of the simple cells in the visual cortex of mammals and it’s the compromise accuracy in the time domain and frequency domain. So, two-dimensional Gabor wavelets have been introduced into the face recognition area.

Face detection and recognition have many methods today, the Gabor wavelet function has feature of space locality, frequency selectivity and direction selectivity. It can detect and extract frequency and direction information of facial area. It is an effective tool in facial image analysis and description. It has a robust facial feature description.

Based on this characteristic, the feature extraction is addressed by using Gabor wavelets and classification by structured sparse on face images.
Firstly, it utilizes Gabor wavelet to extract face feature and constructs human face training samples set. Then, it uses structured sparse for classification machine to determine whether existing human face or not in the input picture and the human face position.

II. Related Works

Robust Sparse Coding for Face Recognition: This paper proposed a new scheme, namely the robust sparse coding (RSC), by modeling the sparse coding as sparsity constrained robust regression problem. The RSC seeks for the MLE (maximum likelihood estimation) solution of the sparse coding problem, and it is much more robust to outliers (e.g., occlusions, corruptions, etc.) than SRC. An efficient iteratively reweighted sparse coding algorithm is proposed to solve the RSC model.

Robust Face Recognition via Sparse Representation: Based on a sparse representation computed by 1-minimization, they propose a general classification algorithm for image-based recognition. This new framework provides new insights into two crucial issues in face recognition: feature extraction and robustness to occlusion.

Face Recognition Based on Gabor with 2DPCA and PCA: Unlike a sine wave, a wavelet has its energy concentrated in time. Wavelets are well suited for the analysis of transient, time-varying signals. When processing an image uses a group Gabor nuclear with five scale and eight directions, the data obtained is enormous.

Face Recognition based on Sparse Representation and Error Correction SVM: Sparse Representation Discrimination Analysis (SRDA) by combining the sparse representation theory and the manifold learning model together. The SRDA algorithm can maintain not only the sparse reconstruction relationship of original data, but also the spatial structure in low dimensional space. Then, the SRDA feature is integrated with the error correction SVM to build a new face recognition system.

Face Detection Using Gabor Wavelet and SVM: Firstly, the Gabor wavelet features of human face and non-human face samples set are extracted and the training samples set are constructed. Then, support vector machine are trained and the optimal classification decision function is calculated. The comparative experiment results show that the method has the characteristics such as simplification, lower calculation complexity, high efficiency, better detection and allocation accuracy for facial and vertical human face image.

III. Feature extraction via Gabor wavelet

In face recognition system the feature based method finds the important features on the face and represents them in an efficient way. Physiological studies found that the cells in the human virtual cortex can be selectively tuned to orientation and to spatial frequency. This confirmation that the response of the simple cell could be approximated using Gabor Wavelet.
In 1946, Gabor proposed one dimension Gabor wavelet. In 1985, Daugman J proposed two dimensions Gabor wavelet. Gabor wavelet is used in the field of human face recognition for its correlation with biologic. The receptive field space structure of the mammalian visual simple cortical cell can be described with Gabor mathematic function. The simple cells are irresponsive to large acreage diffused light and havestricely selectivity to the edge position and azimuth. Gabor wavelet feature description method is a integrated method which is based on gray and features. It has some great properties such as space position selection, direction selection, frequency selection and orthogonality. It extracts the Gabor wavelet coefficients of different direction and scale as features from data gray distribution. It uses a group of feature and position to describe objects. Simultaneity, the Gabor function has good space and frequency resolution. So, it is a good detector. The extraction of local features in an image can be effectively done using Gabor wavelets.

Wavelet-based analysis of signals is an interesting and relatively new tool. The 2-D Gabor filters is a linear transform used for edgedetection and texture discrimination. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be very appropriate for texture representation and discrimination. The Gabor kernels show strong characteristics of spatial locality and orientation selectivity, which are suitable for deriving local and discriminating features for facial expression classification. The transform of Gabor wavelet can be defined as:

\[
\varphi(x, y, \omega, \theta) = \frac{1}{2\pi\sigma^2} e^{-\left(\frac{x^2 + y^2}{2\sigma^2}\right)} \left[ e^{i\omega x'} - e^{-\frac{\omega^2}{2}} \right]
\]

\[
x' = x \cos \theta + y \cos \theta
\]

\[
y' = -x \sin \theta + y \cos \theta
\]

In this equation, \((x, y)\) is the pixel position in the spatial domain \(\omega\) is the radial center frequency, \(\theta\) is the orientation of Gabor filter, and \(\sigma\) is the standard deviation of the round Gaussian function along the x and y-axes.

### III. Classification Using Structured Sparse

Classification is one of the most fundamental problems in machine learning and has numerous applications in different areas including computer vision. Recently, there has been an increasing interest in classification problems where the data across multiple classes come from a collection of low-dimensional linear sub-space. The important problems in face recognition is, the data lie in multiple low-dimensional subspaces of a high dimensional ambient space. However, most existing classification methods do not explicitly take into account the multi-subspace structure of the data. An important class of methods that deals with data on multiple subspaces relies on the notion of sparsity.

Specifically, the sparse representation-based classification (SRC) method looks for the sparsest representation of a test example in a dictionary composed of all training data across all classes.

When it comes to the problem of robust classification, the SRC method offers a great advantage over many classification methods since it can effectively deal with corrupted data within the same sparse representation framework. While sparse representation-based methods have been shown to be effective for classification, there still remain questions about classification in the multi-subspace setting using sparse representation which have not been sufficiently explored or have not been answered yet. When the number of training data in each class is small, sparse recovery methods have good theoretical guarantees. However, classification algorithms do not perform well.

#### 3.1 Classification via structured sparse Representation

Although the SRC method described above has a good performance in reconstruction and classification, it does not explicitly take into account the multi-subspace structure of the data. The dictionary of the training data has a structure in which data from each class form few blocks of the dictionary.

![Fig 3. Block Structure of FR](image)

The structured sparse representation is looking for the representation of the test sample that involves least blocks from the dictionary. Formally, the objection can be formulated as:

\[ \text{Minimize} \| X \|_0 \text{ subject to } \| X \|_2^2 \leq T \]
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\[ P_{l_q/l_0} : \min \sum_{i=1}^{n} I(||C[i]||q > 0) \]

Where \( I(\cdot) \) is an indicator function, \( q \geq 1 \) and \( c[i] \in \mathbb{R}^{m_i} \) are the entries of \( c \) corresponding to the \( i \)-th block of the dictionary, which contains \( m \) values. \( B[ij] \in \mathbb{R}^{D \times m} \) are training sample with \( D \) dimensions and organized in blocks as shown in the figure above. Note the optimization problem seeking for the minimum number of nonzero coefficient blocks to represent the test sample, and \( P_{l_q/l_0} \) is an NP-hard problem. The \( l_1 \)-relaxation of this problem is given as:

\[ P_{l_q/l_1} : \min \sum_{i=1}^{n} ||C[i]||_q \]

Where \( q \geq 1, P_{l_q/l_1} \) is a convex optimization problem which can be solved in polynomial time. The SRC objection \( P_{l_1} \) can be thought as a structured sparserepresentation with the objection \( P_{l_1} / l_1 \). By solving then \( P_{l_q/l_1} \) problem, we reconstruct the test sample for comparison, and the \( i \)-th class with the minimum reconstruction residual should be the class that the test image belongs to.

IV. Conclusion

In this paper, a new method for automatically facial recognition was proposed, which uses Gabor wavelet for feature extraction and SSRC for classification. The experimental results have shown that the Gabor plus SSRC method has improved the recognition rate compared with some previous methods including SVM and SRC, especially when the test images facing different degree of corruption and occlusion.

References: