LITERATURE SURVEY ON SPARSE REPRESENTATION FOR NEURAL NETWORK BASED FACE DETECTION AND RECOGNITION

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ABSTRACT

Face detection and recognition is a challenging problem in the field of image processing. In this paper, we reviewed some of the recent research works on face recognition. Issues with the previous face recognition techniques are , time required is more for face recognition , recognition rate and database required to store the data . To overcome these problems sparse representation based classifier technique can be used .

KEYWORDS

Sparse Representation, Neural Networks, Feature Extraction.

1. INTRODUCTION

Face recognition has attracted broad interests in the area of pattern recognition from the past 20 years. Face recognition is a critical issue in today's world as it is quite easy for a human being, but for the computer it is a difficult task due to high variability among the faces.

The process of face recognition involves comparing an image with a database of stored faces in order to identify the individual in that input image. Simultaneously, numerous face representation and classification methods are developed [2] that are based on neural networks.

Neural network is an interconnected group of artificial neurons that uses a mathematical model for information processing. In order to reduce the storage requirements and improve the performance [4] of a neural network system the Sparse Representation Classification (SRC) method is used. The basic idea of SRC is to extract the minimum features on a face for face recognition. Therefore it helps in increasing the performance and also reduces the database to store the captured faces.

We are motivated to a great extent by the huge research literature in the area of face recognition for addressing various issues by using neural networks. Aim of this paper is to present an extended review on face recognition techniques.

This paper is organized as follows: In section II, we present the neural network approach for face recognition. In section III, we present a detailed related research in the area of face recognition to describe various methodologies. Face recognition techniques are divided into four different

broad categories. First category includes knowledge based methods which capture the knowledge of faces. The second category includes various feature invariant methods, the third category includes template matching methods based on creation of templates and the fourth category includes research papers on appearance based methods. In Section IV, we conclude and elaborate the future scope of face recognition.

2. SPARSE REPRESENTATION FOR NEURAL NETWORK APPROACH

2.1 Sparse Representation classifier Algorithm

Let there are c pattern classes. Training samples of class i form the matrix Ai =[yi1, yi2, . . . , yiMi] ∈ R^(d×Mi) where Mi is the total number of training samples.y = Aw where y is given test sample.

The sparse solution can be obtained by following equation

$$(L0)\ w\hat{}\ 0 = \text{argmin } \|w\|0, \text{ subject to } Aw = y \qquad (1)$$

The problem in equation (1) is NP hard, so if the solution w^ 0 is sparse then problem can be solved as

$$(L1)\ w\hat{}\ 1 = \text{argmin } \|w\|1, \text{ subject to } Aw = y \qquad (2)$$

In the input space training matrix be B = [B1,B2, . . . ,Bc] ∈ R^(N×M), where training samples of class i form the matrix as Bi = [xi1, xi2, . . . , xiMi] ∈R^(N×Mi). Data point xij is mapped into yij = P^T xij under a linear transformation. The matrix can be converted into the one in R^d , A = P^T B.

Representation coefficient vector wij can be obtained by solving the optimization problem in (2). With respect to class s,let δs(wi j) be the representation coefficient vector . v^s ij = Aδs(wij), s = (1, . . . , c) ,this equation gives the prototype of class s. The distance between yij and class s is defined as

$$ds(yij)=\|yij-v\hat{}s(ij)\|2$$

To achieve the better performance , between-class distance ds(xij) must be large and the within class distance di(yij) must be small.

Within-class scatter can be defined as follows:

$$\begin{aligned} 1/M \sum ij\ di(yij) &= 1/M \sum ij\ \|yij-v\hat{}i(ij)\|2. \\ &= 1/M \sum ij\ (yij-v\hat{}i(ij))\hat{}T\ ((yij-v\hat{}i(ij)) \\ &= tr(Sw) \end{aligned}$$

Between-class scatter can be defined as follows :

$$1/M(c-1) \sum ij\ ds(yij)=1/M(c-1) \sum ij\ )=\|yij-v\hat{}s(ij)\|2=tr(Sb).$$

Where tr represent trace operator. To achieve better result, maximize this function

$$J(p)=tr(Sb)/tr(Sw).$$

2.2 Steps of algorithm

1.Choose initial projection matrix P=P0 and let k=1.
2.The sparse representation coefficient vector [1] wij is calculated for each training sample in the transformed space.
3.Construct [2] within class scatter matrix(Sw) and between class scatter matrix(Sb) . Calculate the generalized eigen vectors of these two matrices corresponding to the largest eigen value to form Pk.
4. Increment k by 1 and check the following condition.

$$[J(Pk)-J(Pk?1)]/J(Pk) < E(epsilon)$$

5. Repeat from 2 to 5, until the step 4 gives the correct value.

6. If result of 4 gives correct value, then P*=Pk.

The system authenticates the person by comparing the captured image with the stored face images. Sparse representation classifier [1] method used to reduce the dimensionality of the data. The theory of sparse representation helps to choose the training images to improve the performance of a neural network system. Neural network consists of interconnected processing elements called nodes or neurons that work together to produce an output function. Here output function is the face recognition process from the database.

There are many algorithms implemented on face recognition but there are some issues which are solved by using sparse representation concept which explained in above algorithm. Some of the issues are performance of face recognition,recognition rate and the database required to store faces.

3. RELATED RESEARCH WORK

Face detection methods are classified into following four different broad categories. They are:

(i) Knowledge based method
(ii) Feature Invariant method
(iii) Template matching method
(iv) Appearance based method.

3.1 KNOWLEDGE BASED METHODS

These are the rule-based methods. They try to capture our knowledge of faces such as symmetric eyes and translate them into a set of rules. For example, rule becomes as, face has two symmetric eyes, and usually eye area is darker than the cheeks.Usually, these rules capture the relationships between features which are selected for face recognition.In following diagram we can see the difference of facial regions.

Yang and Huang developed a system [17] that consists of three levels of rules. At the highest level, all faces are scanned and a set of rules are formed. At level 2 edges are detected. At level 3

set of rules that respond to facial features such as the eyes and mouth are determined and faces are detected. Kotropoulos and Pitas [18] also presented a rule- based method. In this method, facial features are used to locate the boundary of a face. Subsequently, eyes, nose and the mouth detection rules are used to detect the faces.

3.2 FEATURE INVARIANT METHODS

There exist features which are invariant over variabilities such as different poses and lighting conditions. Facial features such as eyes, nose, mouth, and hair-line are extracted using edge detectors and a statistical model is built to describe their relationships and to verify the faces.

3.2.1 FACIAL FEATURES

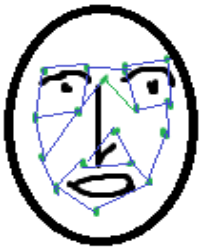
Leung et al. developed a method which is based on local feature detectors and random graph matching [19]. Goal of this method is to find face pattern (two eyes, two nostrils, and nose/lip junction). Facial features of the same type such as eyes are selected and their relative distance is computed. Facial template is defined by Gaussian derivative filters which helps to detect faces. Faces are matched by using Gaussian derivative filter response.

3.2.2 MULTIPLE FEATURES

Most of the methods utilize the features such as skin colour, hair colour, shape, and nose for face recognition. Yachida et al. proposed fuzzy theory for colored images [20]. Fuzzy theory is extended to handle the concept of partial truth. In this paper fuzzy models are used as the distribution of skin and hair color. Shape of face contain (m*n) square cells which are described as pixels. Each pixel is classified as hair, skin, face and skin-like, hair-like regions are generated. For face recognition these regions are compared [21].

3.3 TEMPLATE MATCHING METHODS

Template matching methods try to define a face as a function. These methods try to find a standard template of all the faces. For example, a face can be divided into eyes, face contour, nose and mouth. Also a face model can be built by edges.



3.3.1 PREDEFINED TEMPLATES

Sakai et al. [22] used many subtemplates for the eyes, nose, mouth, and face contour to model a face for face recognition.. Line segments describe each subtemplate. Location of face is found by contour template. Face recognition is performed by matching the subtemplates.

Tsukamoto et al. presented a model for face pattern [23] in which image is divided in number of blocks and qualitative features are found for each block. Features in this model are described as lightness and edgeness. Faceness[24] is calculated at every position of an image by using template block . Threshold value is defined and if faceness measure is above the threshold then face is detected.

3.3.2 DEFORMABLE TEMPLATES

Yuille et al. used [25] deformable templates which are described as parameterized templates to model facial features for example eyes. To link edges in the input image to corresponding parameters energy function is defined. By minimizing an energy function, face is detected.
Lanitis et al. [26] described a method that gives shape and intensity information. Sampled contours of images such as the eye boundary, nose, chin, cheek are manually labeled, and to represent shape vector points are used. The face is deformed to the average shape, and intensity parameters are extracted. Face recognition is performed which is based on shape and intensity parameters.

3.4 APPEARANCE BASED METHODS

The templates in appearance-based methods are learned from the examples in the images [4]. In general, appearance-based methods rely on techniques from statistical analysis and machine learning to find the relevant characteristics of face images.

3.4.1 FEATURE EXTRACTION

Jian Yang and Delin Chu [1], have proposed the sparse representation-based classifier method. This method have great potential for face recognition. This paper[1] presents a dimensionality reduction technique. Sparse Representation Classifier maximizes the ratio of between-class reconstruction residual to within-class reconstruction residual. This method achieves good result in face recognition.

3.4.2 EIGEN ANALYSIS

This method represent faces using Principal Component Analysis method .Goal of this eigen analysis is to represent face as eigen vectors .These eigen vectors are stored in one dimensional array format and then used to detect faces. In paper [3] the authors proposed a robust approach for feature extraction for face detection and recognition.

3.4.3 SUPERVISED LEARNING CONCEPT

It is machine learning task of inferring function from labelled training data. Supervised learning analyzes the training data and produces inferred function, which can be used for mapping new examples [6].

In [4], the authors proposed a two-phase method for face recognition. The first phase of the proposed method is to represent the face as a linear combination of all the sample faces. The

second phase represents the face as a linear combination of nearest neighbours of the face which is going to be matched with the database.

3.4.4 KERNEL METHODS

Kernel methods[9] are class of algorithms for image analysis . Image analysis is to find extract the features of faces .Kernel methods contains support vector machine, which use supervised learning concept that analyze and recognize patterns for classification.

Paper [10] examines the theory of Kernel Fisher Discriminant analysis (KFD) and develops a two-phase KFD framework, i.e., kernel principal component analysis (KPCA) plus Fisher Linear Discriminant Analysis (LDA).

Linear discriminant analysis (LDA) method used in pattern recognition which finds a linear combination of features . The resulting combination of the features used for reduction of features used in face recognition. In [10], the theory of kernel Fisher discriminant analysis (KFD) is examined in a Hilbert space.A Hilbert space is an vector space which posses the structure that allows length and angle to be measured for the features which are used for face recognition.

3.4.5 CREATION OF TEMPLATE BASED ON SELECTED FEATURES

In [5], a face recognition system using Principal Component Analysis (PCA) with Back Propagation Neural Networks (BPNN) is proposed which helps to provide an efficient and robust face recognition [16]. It also focuses on face variations, especially Pose, Expression,Lighting conditions. The dimensionality of face image is reduced by the PCA and the recognition is done by the BPNN.

4. CONCLUSION AND FUTURE SCOPE

Face recognition has received substantial attention from researches in biometrics, pattern recognition field and computer vision communities. Face recognition can be applied in Security measure at Air ports, Passport verification, Criminals list verification in police department, Visa processing , Verification of Electoral identification and Card Security measure at ATM's. In this paper, we reviewed some of the recent research works on face recognition .We classified face recognition approaches using knowledge based methods, feature invariant method, template based methods and appearance based methods.

Our literature review indicates that problem of face recognition is still a challenge having following issues. These are large database, recognition time and recognition rate.Some of the important research papers studied and tabular overview is presented in next part of the paper.

Table. 1 Overview

Year/Authors	Based on	Limitations/ongoing work
1994 G. Yang and T. S. Huang	Knowledge of face	Difficulty in building appropriate set of rules
1995, T.K. Leung, M.C. Burl, and P. Perona	Facial Features	Can't achieve good results with variations in pose,shape
1999, H. Wu, Q. Chen, and M. Yachida	Multiple Features	Detect faces with features such as beard and glasses.
1993, A. Tsukamoto, C.-W. Lee, and S.Tsuji	Predefined Templates	Subtemplates used for future work
2012, Stefanos Zafeiriou, Georgios Tzimiropoulos, Maria Petrou,Tania Stathaki	Eigen Analysis	Face Recognition time is more
2011, Yong Xu, Jian Yang, Jing-Yu Yang	Supervised Learning Concept	In the future, anyone can explore the applications of this two-phase classification framework on other methods
2011, Yong Xu, Jian Yang, Jing-Yu Yang	Supervised Learning Concept	In the future, anyone can explore the applications of this two-phase classification framework on other methods
2005, Jian Yang, Alejandro F. Frangi, Jing-yu Yang	Kernel Methods	Difficulty in analyzing and recognizing patterns for classification
2011,Mohammod Abul Kashem, Md. NasimAkhter, Shamim Ahmed	Creation of template	Database size is more to store templates

REFERENCES

[1] Jian Yang, Member, Lei Zhang, Yong Xu,Jingyu Yang, "Sparse Representation ClassifierSteered Discriminative Projection With Application to Face Recognition", IEEE Transactions on Neural Networks and Learning Systems, Vol. 24, NO. 7, July 2013.

[2] Ran He, Wei-Shi Zheng,Bao-Gang Hu and Xiang-Wei Kong," Two-Stage Non negative Sparse Representation for Large-Scale Face Recognition", IEEE Transactions on Neural Networks and Learning Systems, Vol. 24, no. 1, January 2013.

[3] S. Zafeiriou, G. Tzimiropoulos, M. Petrou, and T. Stathaki, "Regularized kernel discriminant analysis with a robust kernel for face recognition and verification," IEEE Trans. Neural Netw. Learn. Syst., vol. 23, no. 3, pp. 526–534, Mar. 2012.

[4] Y. Xu, D. Zhang, J. Yang, and J.-Y. Yang, "A two-phase test sample sparse representation method for use with face recognition," IEEE Trans. Circuits Syst. Video Technol., vol. 21, no. 9, pp. 1255–1262, Sep. 2011.

[5] Mohammod Abul Kashem, Md. Nasim Akhter, Shamim Ahmed, and Md. Mahbub Alam," Face Recognition System Based on Principal Component Analysis (PCA) with Back Propagation Neural Networks (BPNN)", Canadian Journal on Image

[6] J. Mairal, F. Bach, J. Ponce, G. Sapiro, and A. Zisserman, "Supervised dictionary learning," in Proc. Adv. NIPS, vol. 21. 2009.

[7] J. Wright, A. Yang, A. Ganesh, S. Sastry, and Y. Ma, "Robust fac recognition via sparse representation," IEEE Trans. Pattern Anal. Mach. Intell., vol. 31, no. 2, pp. 210–227, Feb. 2009.

[9] J. Yang, A. F. Frangi, Z. Jin, and J.-Y. Yang, "Essence of kernel Fisher discriminant: KPCA plus LDA," Pattern Recognit., vol. 37, pp.2097–2100, Oct. 2004.

[10] J. Yang, A. F. Frangi, J.-Y. Yang, D. Zhang, and Z. Jin, "KPCA plus LDA: A complete kernel fisher discriminant framework for feature extraction and recognition," IEEE Trans. Pattern Anal. Mach. Intell., vol. 27, no. 2, pp. 230–244, Feb. 2005.

[11] Terence Sim, Member,Simon Baker,and Maan Bsat," The CMU Pose, Illumination, and Expression Database,", IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 25, No. 12, December 2003.

[12] Tae-Kyun Kim,and Josef Kittler," Locally Linear Discriminant Analysis for Multimodally Distributed Classes for Face Recognition with a Single Model Image ," IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 27, No. 3, March 2005.

[13] R. He, B.-G. Hu, W.-S. Zheng, and Y. Guo, "Two-stage sparse representation for robust recognition on large-scale database," in Proc. 24th AAAI Conf. Artif. Intell., 2010, pp. 475–480.

[14] K. C. Lee, J. Ho, and D. Driegman, "Acquiring linear subspaces for face recognition under variable lighting," IEEE Trans. Pattern Anal. Mach. Intell., vol. 27, no. 5, pp. 684–698, May 2005.

[15] P. Belhumeur and D. Kriegman, "What Is the Set of Images of an Object under All Possible Lighting Conditions," Int'l J. Computer Vision, vol. 28, pp. 245-260, 1998.

[16] T.Yahagi and H.Takano, (1994) "Face Recognition using neural networks with multiple combinations of categories," International Journal of Electronics Information and Communication Engineering.,vol.J77-D-II, no.11, pp.2151-2159.

[17] G. Yang and T. S. Huang, "Human Face Detection in Complex Background," Pattern Recognition, vol. 27, no. 1, pp. 53-63, 1994.

[18] C. Kotropoulos and I. Pitas, "Rule-Based Face Detection in Frontal Views," Proc. Int'l Conf. Acoustics, Speech and Signal Processing vol. 4, pp. 2537-2540, 1997

[19] T.K. Leung, M.C. Burl, and P. Perona, "Finding Faces in Cluttered Scenes Using Random Labeled Graph Matching," Proc. Fifth IEEE Int'l Conf. Computer Vision, pp. 637-644, 1995

[20] H. Wu, Q. Chen, and M. Yachida, "Face Detection from Color Images Using a Fuzzy Pattern Matching Method," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 21, no. 6, pp. 557-563,June 1999.

[21] H. Wu, T. Yokoyama, D. Pramadihanto, and M. Yachida, "Face and Facial Feature Extraction from Color Image," Proc. Second Int'l Conf. Automatic Face and Gesture Recognition, pp. 345-350, 1996.

[22] T. Sakai, M. Nagao, and S. Fujibayashi, "Line Extraction and Pattern Detection in a Photograph," Pattern Recognition, vol. 1, pp. 233-248, 1969.

[23] A. Tsukamoto, C.-W. Lee, and S. Tsuji, "Detection and Tracking of Human Face with Synthesized Templates," Proc. First Asian Conf. Computer Vision, pp. 183-186, 1993

[24] A. Tsukamoto, C.-W. Lee, and S. Tsuji, "Detection and Pose Estimation of Human Face with Synthesized Image Models," Proc. Int'l Conf. Pattern Recognition, pp. 754-757, 1994.
[25] A. Yuille, P. Hallinan, and D. Cohen, "Feature Extraction from Faces Using Deformable Templates," Int'l J. Computer Vision, vol. 8, no. 2, pp. 99-111, 1992.
[26] A. Lanitis, C.J. Taylor, and T.F. Cootes, "An Automatic Face Identification System Using Flexible Appearance Models," Image and Vision Computing, vol. 13, no. 5, pp. 393-401, 1995.
[27] D. Donoho, "Compressed sensing," IEEE Trans. Inf. Theory, vol. 52, no. 4, pp. 1289–1306, Apr.2006.

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