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DEEP LEARNING FOR FACE RECOGNITION UNDER COMPLEX ILLUMINATION CONDITIONS BASED ON LOG-GABOR AND LBP

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Abstract : - In this project, we propose a novel method based on deep learning to solve the adverse impact imposed by illumination variation in the face recognition process. Firstly, illumination preprocessing is applied to improve the adverse effects of intense illumination changes on face images.

Secondly, the Log-Gabor filter is used to obtain the Log-Gabor feature images of different scales and directions, then, LBP (Local Binary Pattern) features of images subblock is extracted. Lastly, texture feature histograms are formed and input into the deep belief network (DBN) visual layer, then face classification and recognition are completed through deep learning in DBN. Experimental results show that superior performance can be obtained in the developed approach by comparisons with some state-of-the-arts.

Index Terms – Face Recognition, deep learning, Illumination conditions, deep belief network

I. INTRODUCTION

1.1 - System Overview:

Face acknowledgment has been an exploration hotspot in design acknowledgment and picture preparing in the previous hardly any years because of its agreeableness and comfort. As of late, numerous calculations have been proposed by scholars. Mostpast explores can get fulfilling acknowledgment execution under uniform light conditions with frontal face pictures. Notwithstanding, it is as yet a difficult examination territory in light of the fact that even the pictures of same individual appear to be changed because of impediment, enlightenment, articulation and posture variety, which can cause sharp decrease in acknowledgment rate . Improvement of face acknowledgment execution in complex light climate is as yet a troublesome issue in the field of man- made brainpower and PC vision. As of now, homegrown and abroad specialists have proposed various light handling calculations for face pictures under complex brightening conditions, and accomplished generally great test results. They can be generally isolated into two classifications: 2-D and 3-D based models. Face acknowledgment strategy dependent on 3-D model is successful to defeat the impact of mentality and brightening in ecological components. Regardless, how to figure the portrayal model for order errands, for example, FR is still a difficult issue. Lately, inadequate portrayal (or scanty coding) has been pulling in a lot of consideration because of its incredible accomplishment in picture preparing , and it has likewise been utilized for FR and texture characterization. In light of the discoveries that common pictures can be by and large coded by structural natives (e.g., edges and line sections) that are subjectively comparative in . As a rule, the scanty coding issue can be detailed as

$$\min_{\alpha} \|\alpha\|_1 \quad \text{s.t.} \quad \|y - D\alpha\|_2^2 \le \varepsilon \qquad \text{-------}(1)$$

where y is the given signal, D is the dictionary of coding atoms, α is the coding vector of y over D, and ε > 0 is a constant. Recent ly, Wright et al. applied sparse coding to FR and proposed the sparse representation based classification (SRC) scheme. By coding a query image y as a sparse linear combin ation of all the training samples via Eq. (1), SRC classifies y by evaluating which cl ass could result in the minimal reconstruction error of it.

1.2 Existing System

FR is among the most important and well-studied problems in computer vision [20]. However, illumination and pose variations are still some open problems that need to be solved. Facial images are taken in environments that are usually not under control, which contain variations in viewpoint and illumination; therefore, these two factors play a vital role in the efficiency of recognition. Developing an algorithm that can handle variations in illumination, pose, facial expression, and occlusion, etc., altogether, still seems to be a very challenging task.

The FR algorithms suffer from two problems. First, in general, there is only a limited number of training images. Second, the existence of variations in illumination and poses, in addition to facial expressions, complicates the task. Although there have been a number of proposed methods to overcome these problems using the property of symmetry in face, such problems are still considered open and are not yet solved. A recent method has been proposed by the authors of References, wherein, they improve the rate of FR recognition accuracy by using the symmetry property of the face, to using Symmetry for Collaborative Representation-Based Classification (SCRC).

II. LITERATURE REVIEW

Y. Huixian, H. Dilong, L. Fan, L. Yang, and L. Zhao. "Face recognition based on bidirectional gradient center symmetric local binary patterns." Journal of Computer-Aided Design & Computer Graphics, vol. 29, pp. 130-136, 2017.

Face recognition is used to identify or verify a person using biometric parameters. Face recognition is successfully applied today in law enforcement, surveillance, entertainment, banking, security system access, and personal identification, among others. The most used face recognition techniques used are Eigenfaces [1-3], Fisherfaces [4], Laplacian faces [5], and Neural Networks [6]. In practice, there is some difficulty in dealing with different illuminations, poses, facial expressions, ageing, and so on. For human beings face recognition is an easy task, while face recognition is quite a difficult task for a computer. A digital image is made up of a finite number of elements, each of which has a particular location and value. These elements are known as pixel and picture elements and are important in face recognition.

Y. Chen, X. Zhao, and X. Jia. "Spectral-spatial classification of hyperspectral data based on deep belief network. " IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol.8, no. 6, pp. 2381-2392, 2015.

In this paper, we introduce a deep learning approach into hyperspectral image classification. A new feature extraction (FE) and image classification framework are proposed for hyperspectral data analysis based on deep belief network (DBN). First, we verify the eligibility of restricted Boltzmann machine (RBM) and DBN by the following spectral information-based classification. Then, we propose a novel deep architecture, which combines the spectral-spatial FE and classification together to get high classification accuracy.

III. IMAGE SEGMENTATION

In computer vision, image segmentation is the process of partitioning a digital image into multiple segments (sets of pixels, also known as super pixels). The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics.

Applications

Some of the practical applications of image segmentation are: Face Recognition

Thresholding

The simplest method of image segmentation is called the thresholding method. This method is based on a clip-level (or a threshold value) to turn a gray-scale image into a binary image. The key of this method is to select the threshold value (or values when multiple-levels are selected). Several popular methods are used in industry including the maximum entropy method, Otsu's method (maximum variance), and k- means clustering.

Clustering Methods

The K-means algorithm is an iterative technique that is used to partition an image into K clusters. The basic algorithm is:

- Pick K cluster centers, either randomly or based on some heuristic
- Assign each pixel in the image to the cluster that minimizes the distance between the pixel and the cluster center
- Re-compute the cluster centers by averaging all of the pixels in the cluster
- Repeat steps 2 and 3 until convergence is attained (e.g. no pixels change clusters)

Histogram Based Methods

Histogram-based methods are very efficient when compared to other image segmentation methods because they typically require only one pass through the pixels. In this technique, a histogram is computed from all of the pixels in the image, and the peaks and valleys in the histogram are used to locate the clusters in the image. Color or intensity can be used as the measure. A refinement of this technique is to recursively apply the histogram-seeking method to clusters in the image in order to divide them into smaller clusters. This is repeated with smaller and smaller clusters until no more clusters are formed.

Region-Growing Methods

The first region-growing method was the seeded region growing method. This method takes a set of seeds as input along with the image. The seeds mark each of the objects to be segmented. The regions are iteratively grown by comparing all unallocated neighboring pixels to the regions. The difference between a pixel's intensity value and the region's mean, , is used as a measure of similarity. The pixel with the smallest difference measured this way is allocated to the respective region. This process continues until all pixels are allocated to a region. Seeded region growing requires seeds as additional input.

For each iteration it considers the neighboring pixels in the same way as seeded region growing. It differs from seeded region growing in that if the minimum is less than a predefined threshold T then it is added to the respective region Aj. If not, then the pixel is considered significantly different from all current regions A iand a new region An+1 is created with this pixel. One variant of this technique, proposed by Haralick and Shapiro (1985), is based on pixel intensities. The mean and scatter of the region and the intensity of the candidate pixel is used to compute a test statistic. If the test statistic is sufficiently small, the pixel is added to the region, and the region's mean and scatter are recomputed. Otherwise, the pixel is rejected, and is used t form a new region.

A special region-growing method is called -connected segmentation (see also lambda-connectedness). It is based on pixel intensities and neighborhood-linking paths. A degree of connectivity (connectedness) will be calculated based on a path that is formed by pixels. For a certain value of , two pixels are called -connected if there is a path linking those two pixels and the connectedness of this path is at least. -connectedness is an equivalence relation.

Level Set Methods

The level set method was initially proposed to track moving interfaces by Osher and Sethian in 1988 and has spread across various imaging domains in the late nineties. It can be used to efficiently address the problem of curve/surface/etc. propagation in an implicit manner. The central idea is to represent the evolving contour using a signed function, where its zero level corresponds to the actual contour. Then, according to the motion equation of the contour, one can easily derive a similar flow for the implicit surface that when applied to the zero-level will reflect the propagation of the contour.

The level set method encodes numerous advantages: it is implicit, parameter free, provides a direct way to estimate the geometric properties of the evolving structure, can change the topology and is intrinsic. Furthermore, they can be used to define and optimization framework as proposed by Zhao, Merriman and Osher in

1996. Therefore, one can conclude that it is a very convenient framework to address numerous applications of computer vision and medical image analysis. Furthermore, research into various level set data structures has led to very efficient implementations of this method.

Fast Marching Methods

The fast marching method has been used in image segmentation, and this model has been improved (permitting a both positive and negative speed propagation speed) in an approach called the generalized fast marching method.

Graph Partitioning Methods

Graph partitioning methods can effectively be used for image segmentation. In these methods, the image is modeled as a weighted, undirected graph. Usually a pixel or a group of pixels are associated with nodes and edge weights define the (dis) similarity between the neighborhood pixels. The graph (image) is then partitioned according to a criterion designed to model "good" clusters. Each partition of the nodes (pixels) output from these algorithms are considered an object segment in the image. Some popular algorithms of this category are normalized cuts, random walker minimum cut, isoperimetric and partitioning and minimum spanning tree-based segmentation.

Multi-Scale Segmentation

Image segmentations are computed at multiple scales in scale space and sometimes propagated from coarse to fine scales. Segmentation criteria can be arbitrarily complex and may take into account global as well as local criteria. A common requirement is that each region must be connected in some sense.

One-Dimensional Hierarchical Signal Segmentation

Witkin's seminal work in scale space included the notion that a one-dimensional signal could be unambiguously segmented into regions, with one scale parameter controlling the scale of segmentation. A key observation is that the zero-crossings of the second derivatives (minima and maxima of the first derivative or slope) of multi- scale-smoothed versions of a signal form a nesting tree, which defines hierarchical relations between segments at different scales. Specifically, slope extreme at coarse scales can be traced back to corresponding features at fine scales. When a slope maximum and slope minimum annihilate each other at a larger scale, the three segments that they separated merge into one segment, thus defining the hierarchy of segments.

Image Segmentation and Primal Sketch

There have been numerous research works in this area, out of which a few have now reached a state where they can be applied either with interactive manual intervention (usually with application to medical imaging) or fully automatically. The following is a brief overview of some of the main research ideas that current approaches are based upon. The nesting structure that Witkin described is, however, specific for one- dimensional signals and does not trivially transfer to higher-dimensional images. Nevertheless, this general idea has inspired several other authors to investigate coarse- to-fine schemes for image segmentation. Koenderink proposed to study how iso- intensity contours evolve over scales and this approach was investigated in more detail by Lifshitz and Pizer.

Unfortunately, however, the intensity of image features changes over scales, which implies that it is hard to trace coarse-scale image features to finer scales using iso-intensity information. Lundeberg studied the problem of linking local extreme and saddle points over scales, and proposed an image representation called the scale-space primal sketch which makes explicit the relations between structures at different scales, and also makes explicit which image features are stable over large ranges of scale including locally appropriate scales for those.

Bergholm proposed to detect edges at coarse scales in scale-space and then trace them back to finer scales with manual choice of both the coarse detection scale and the fine localization scale. Gauch and Pizer studied the complementary problem of ridges and valleys at multiple scales and developed a tool for interactive image segmentation based on multi-scale watersheds. The use of multi-scale watershed with application to the gradient map has also been investigated by Olsen and Nielsen and been carried over to clinical use by Dam Vincken proposed a hyper stack for defining probabilistic relations between image structures at different scales.

The use of stable image structures over scales has been furthered by Ahuja and his co-workers into a fully automated system. A fully automatic brain segmentation algorithm based on closely related ideas of multi-scale watersheds has been presented by Undeman and Lundeberg and been extensively tested in brain databases. These ideas for multi-scale image segmentation by linking image structures over scales have also been picked up by Florack and Kuijper. Bijaoui and Rue associate structures detected in scale-space above a minimum noise threshold into an object tree which spans multiple scales and corresponds to a kind of feature in the original signal.

IV. PROPOSED WORK REGULARIZED ROBUST CODING (RRC)

The conventional sparse coding model in Eq. (4) is equivalent to the so-called LASSO

$$\min_{\alpha} \left\| y - D\alpha \right\|_2^2 \ \text{s.t.} \ \left\| \alpha \right\|_1 \le \sigma$$

where σ > 0 is a constant, y=[y1;y2;⋯;yn]∈ n is the signal to be coded , D=[d1, d2,⋯, dm] ∈ n×m is the dictionary with col umn vector dj being its jth atom, and α ∈ m is the vector of coding coefficients. In the problem of face recognition (FR), the atom dj can be simply set as the training face sample (or its dimensionality reduced feature) and hence the dictionary D can be the whole training dataset. If we have the prior that the coding residual e = y−Dα follows gaussian distribution, the solution to Eq. (4)

It can be seen from Fig.4.1(e) that the proposed model can well fit the heavy tail of the empirical distribution, much better than the Gaussian and Laplacian models. Meanwhile, Laplacian works better than Gaussian in fitting the heavy tail, which explains why the sparse coding model in Eq. (7) (or Eq. (5)) works better than the model in Eq. (4) (or Eq. (7)) in handling face occlusion and corruption.

Face acknowledgment is normally utilized in security frameworks. Other than that, it is also used in human PC association. So as to build up this task eigenfaces method is utilized for preparing and testing faces. It has gotten critical consideration upto the point that some face acknowledgment gatherings have risen. A general statement of the issue can be figured as follows, given still or video pictures of a scene, at least one people in the scene can be recognized utilizing a put away information base of faces. The arrangement of the issue includes face location, highlight extraction from the face areas and acknowledgment. To build up this venture we utilized the eigenfaces strategy. Eigenfaces are a bunch of eigenvectors utilized in the PC vision issue of human face acknowledgment. A bunch of eigenfaces can be produced by performing a mathematical measure called head segment examination (PCA) on an enormous set of images portraying diverse human appearances. The critical method in PCA depends on Karhumen-Loeve change. On the off chance that the picture components are viewed as random variables, the picture might be viewed as an example of a stochastic cycle. The center of the research is to discover the precision of eigenfaces technique in face recognition.2We have centered our examination toward building up

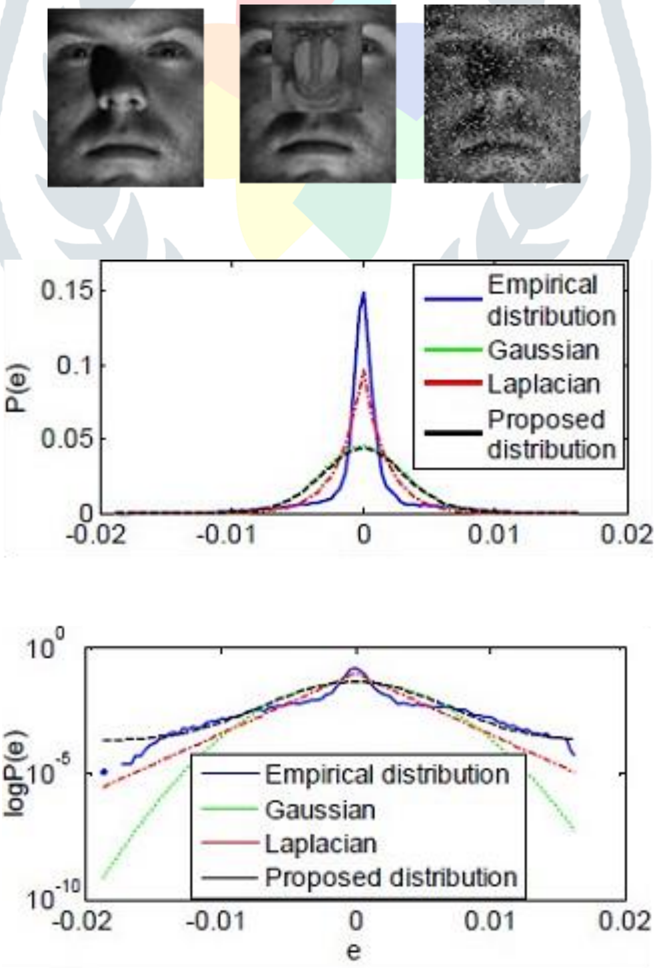

Fig 4.1 The distributions of residual e

Problem articulations

In security framework, many sort of secret word are utilized to get to the private and confidential information. Such secret word can be as embed characters (key in pin) and touch keen card utilizing RFID innovation. Passwords and PINs are hard to remember and can be taken or speculated; cards, tokens, keys and so forth can be misplaced, overlooked, purloined or copied; attractive cards can become corrupted and confused. By created face acknowledgment it more secure because facial picture had been utilized as the ID. It likewise assists with keeping away from any duplicated identification.(2) Other issue is to indentifying certain lawbreakers particularly in identification technique utilized by the police. Face acknowledgment assists with perceiving the facial image in more proficient and exact so as to coordinate with the personality stored in the information base.

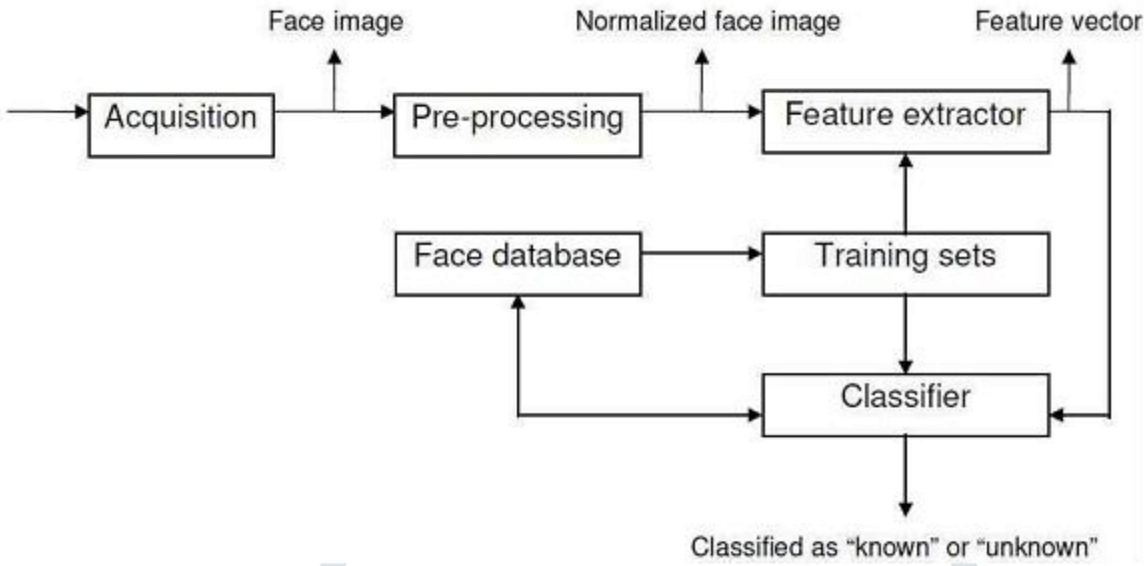

Fig 4.2 Outline of a typical face recognition system

V. MATLAB

Introduction to MATLAB

MATLAB is a superior language for specialized figuring. It coordinates calculation, representation, and programming in a simple to-utilize climate where issues and arrangements are communicated in recognizable numerical documentation. Average uses incorporate

- Math and calculation Algorithm advancement Data procurement
- Modelling, recreation, and prototyping
- Data examination, investigation, and perception
- Scientific and designing illustrations
- Application advancement, including graphical UI building

MATLAB is an intuitive framework whose essential information component is an exhibit that doesn't need dimensioning. This permits you to take care of numerous specialized registering issues, particularly those with lattice and vector plans, in a small amount of the time it would take to compose a program in a scalar non intelligent language, for example, C or FORTRAN.

The MATLAB System:

The MATLAB framework comprises of five fundamental parts

- **Development Environment:**

This is the arrangement of devices and offices that assist you with utilizing MATLAB capacities and documents. A significant number of these devices are graphical UIs. It incorporates the MATLAB work area and order window, an order history, an editorial manager and debugger, and programs for survey help, the workspace, documents, and the pursuit way.

- **The MATLAB Mathematical Function Library:**

This is a tremendous assortment of computational calculations going from rudimentary capacities, similar to entirety, sine, cosine, and complex math, to more modern capacities like framework backwards, grid Eigen esteems, Bessel capacities, and quick Fourier changes.

- **The MATLAB Language:**

This is an elevated level network/cluster language with control stream proclamations, capacities, information structures, input/yield, and article arranged programming highlights. It permits both "programming in the little" to quickly make down to business discard projects, and "programming in the enormous" to make huge and complex application programs.

- **Graphics:**

MATLAB has broad offices for showing vectors and grids as charts, just as commenting on and printing these diagrams. It incorporates significant level capacities for two-dimensional and three-dimensional information perception, picture preparing, movement, and introduction designs. It additionally incorporates low-level

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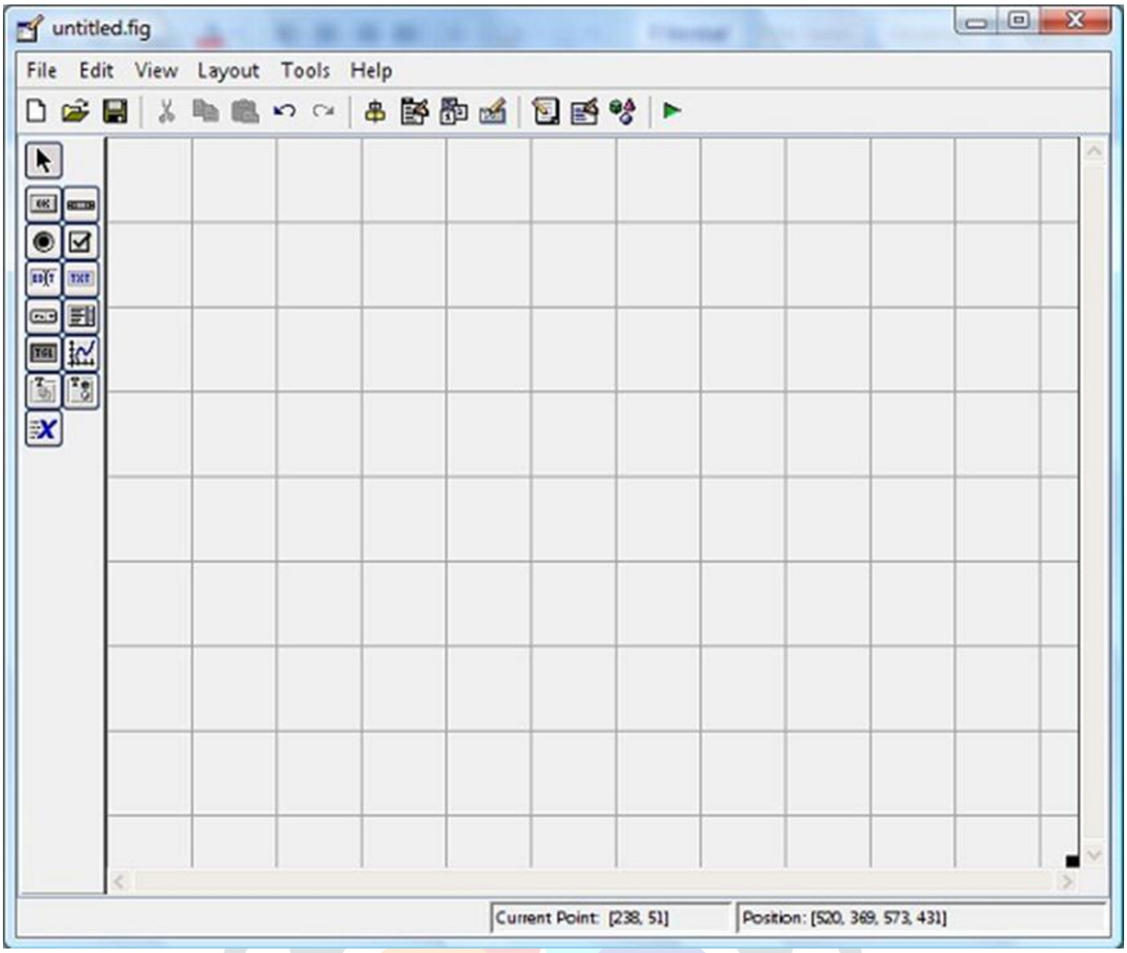

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- Graphics:

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- The MATLAB Application Program Interface (API):

This is a library that permits you to compose C and FORTRAN programs that communicate with MATLAB. It incorporates offices for calling schedules from MATLAB (dynamic connecting), calling MATLAB as a computational motor, and for perusing and composing MAT-documents.

Different tool compartments are there in MATLAB for figuring acknowledgment methods, yet we are utilizing IMAGE PROCESSING tool stash.

Name	**Description**
Double	Double _ precision, floating_ point numbers the Approximate.
Uint8	unsigned 8_bit integers in the range [0,255] (1byte per Element).
Uint16	unsigned 16_bit integers in the range [0, 65535] (2byte per element).
Uint 32	unsigned 32_bit integers in the range [0, 4294967295](4 bytes per element).
Int8	signed 8_bit integers in the range [-128,127] 1 byte per element)
Int 16	signed 16_byte integers in the range [32768, 32767] (2 bytes per element).

Int 32	Signed 32_byte integers in the range [-2147483648, 21474833647] (4 byte per element).
Single	single _precision floating _point numbers with values In the approximate range (4 bytes per elements)
Char	characters (2 bytes per elements). Logical values are 0 to 1 (1byte per element).

VI. RESULTS AND DISCUSSION

In order to verify the operational effectiveness of the proposed system, the proposed system is designed ,coded, implemented and tested in the Matlab environment and the simulation results are presented as follows

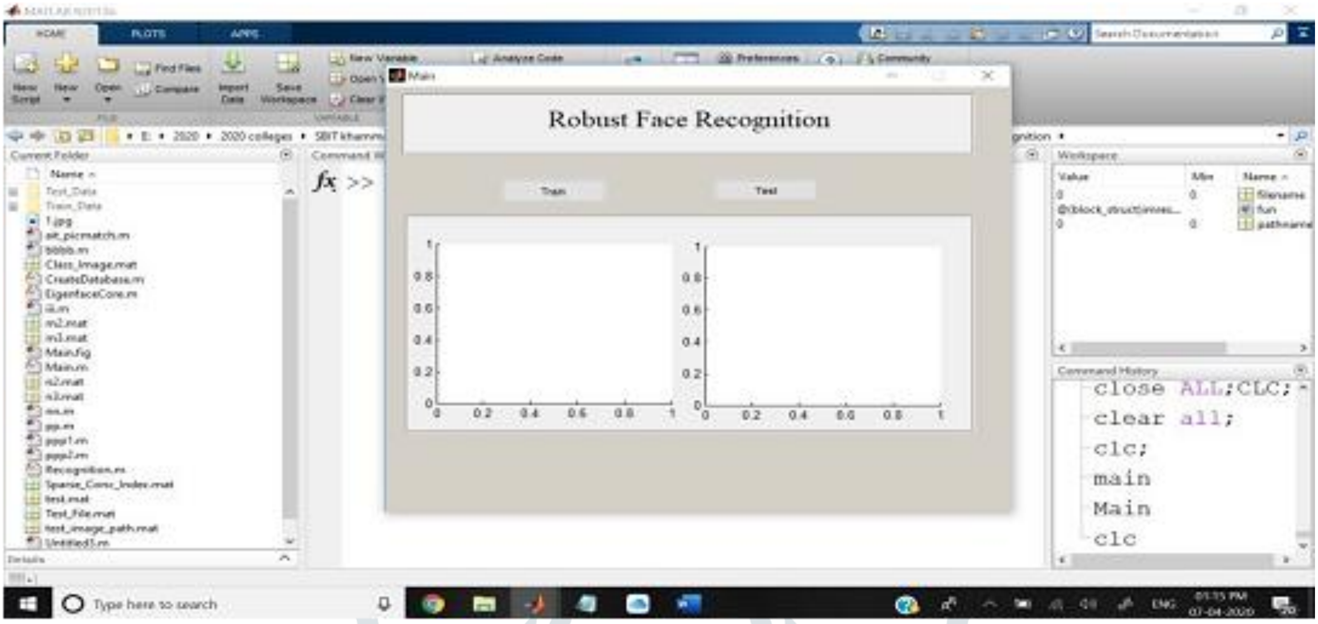

Fig 6.1 Open face recognition graphical user interface

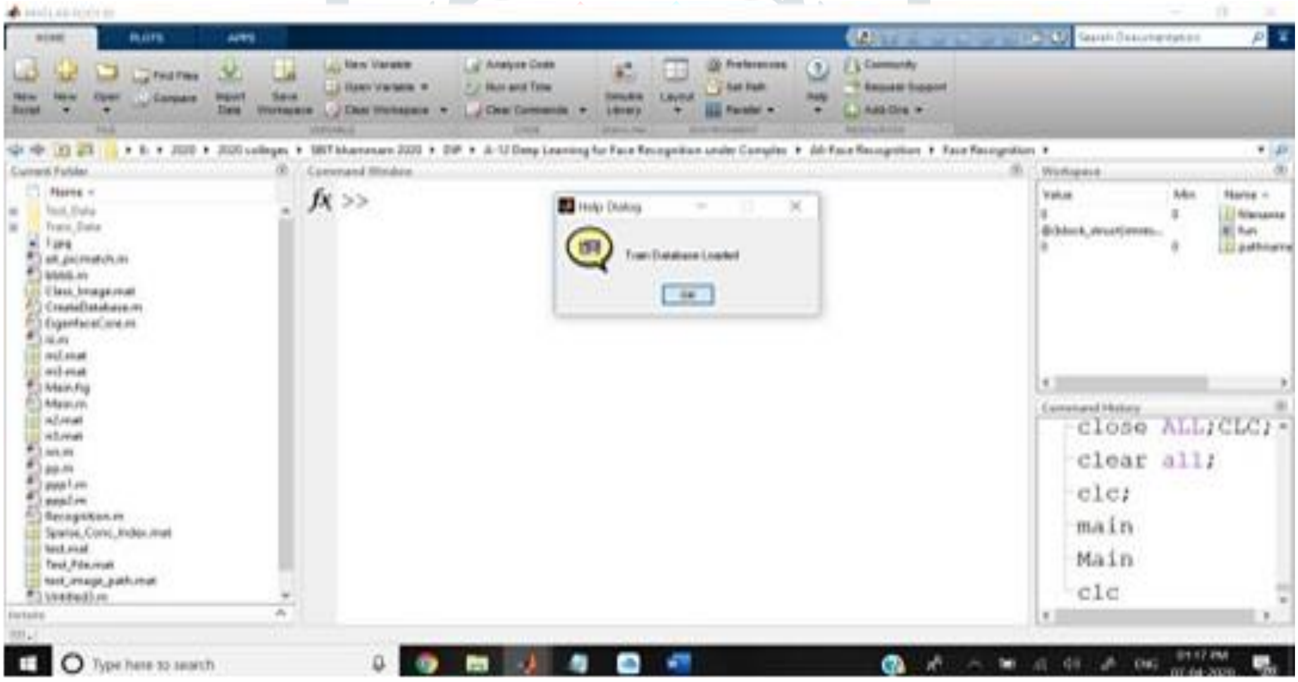

Fig 6.2 Select train data base and load data base folder

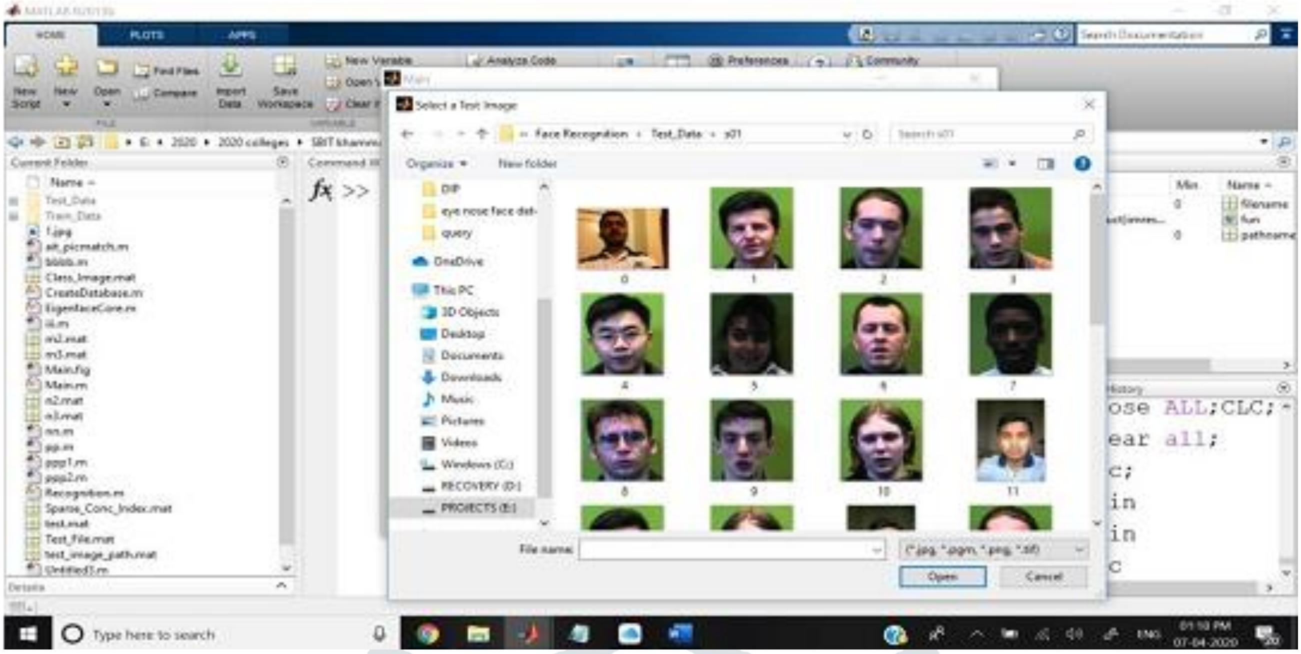

Fig 6.3 Open test data base images and select any one image

VII CONCLUSIONS & FUTURE SCOPE

A novel method based on deep learning to solve the adverse impact imposed by illumination variation in the face recognition is proposed in this paper. In order to improve the adverse effects of intense illumination changes on face images, illumination preprocessing is applied. Log-Gabor filter is used to obtain the Log- Gabor feature images of different scales and directions, and LBP features of images are extracted. Then, these texture features are learned by DBN network to complete the classification and the recognition. Experimental results have shown that the proposed method has superior performance in face recognition by comparing with some state-of-the-arts.

Future Scope

In future we are using own data base in the place of using particular data base .A facial recognition system is used to identify and verify a person from an image or video source. It uses biometric software's along with AI enabled devices for mapping facial features and brings out the recognition step. A facial recognition software differentiates a face from rest of the background

VIII REFERENCES

1. Zhao, R. Chellppa, P.J. Phillips, and A. Rosenfeld, "Face recognition: A literature survey," ACM Computing Survey, vol. 35, no. 4, pp. 399–458, 2003.
2. M. Turk and A. Pentland, "Eigenfaces for recognition," J. Cognitive Neuroscience, vol. 3, no. 1, pp. 71–86, 1991.
3. P.N. Belhumeur, J.P. Hespanha, and D.J. Kriengman, "Eigenfaces vs. Fisherfaces: recognition using class specific linear projection," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 19, no. 7, pp. 711–720, 1997.
4. B. Heisele, P. Ho, and T. Poggio, "Face recognition with support vector machine: Global versus component-based approach," Proc. IEEE Int'l Conf. Computer Vision, 2001.
5. A. Lanitis, C.J. Taylor, and T.F. Cootes, "Automatic Interpretation and Coding of Face Images Using Flexible Models," IEEE Trans. Pattern An alysis and Machine Intelligence, vol. 19, no. 7, pp. 743-756, 1997.
6. T. Ahonen, A. Hadid, and M. Pietikainen, "Face description with local binary patterns: Application to face recognition," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 28, no. 12, pp.2037–2041, 2006.
7. A. Leonardis and H. Bischof, "Robust recognition using eigenimages," Computer Vision and Image Understanding, vol. 78, no. 1, pp. 99-118, 2000.
8. S. Chen, T. Shan, and B.C. Lovell, "Robust face recognition in rotated eigenspaces," Proc. Int'l Conf. Image and Vision Computing New Zealand, 2007.
9. A.M. Martinez, "Recognizing Imprecisely localized, partially occluded, and expression variant faces from a single sample per class," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 24, no. 6, pp. 748-763, 2002.
10. S.Z. Li and J. Lu, "Face recognition using nearest feature line method," IEEE Trans. Neural Network, vol. 10, no. 2, pp. 439-443, 1999.
11. J.T. Chien, and C.C. Wu, "Discriminant waveletfaces and nearest feature classifiers for face recognition," IEEE
12. Trans. Pattern Analysis and Machine Intelligence, vol. 24, no. 12, pp. 1644-1649,2002.
13. J. Laaksonen, "Local subspace classifier", Proc. Int'l Conf. Artific ial NeuralNetworks, 1997.
14. K. Lee, J. Ho, and D. Kriegman, "Acquiring linear subspaces for face recognition under variable lighting," IEEE

15. Trans. Pattern Analysis and Machine Intelligence, vol. 27, no. 5, pp. 684–698, 2005. [14] S.Z. Li, "Face recognition based on nearest linear combinations," Proc. IEEE Int'l Conf. Computer Vision and Pattern Recognition, 1998.
16. I. Naseem, R. Togneri, and M. Bennamoun, "Linear regression for face recognition," IEEE Trans. Pattern Analysis and Machine Intelligence, vol. 32, no. 11, pp. 2106-2112, 2010.
17. M. Elad and M. Aharon, "Image denoising via sparse and redundant representations over learned dictionaries," IEEE Trans. Image Processing, vol. 15, no. 12, pp. 3736–3745, 2006.
18. J. Mairal, M. Elad, and G. Sapiro, "Sparse representation for color image restoration," IEEE Trans. Image Processing, vol. 17, no. 1, pp. 53–69, 2008.
19. J. Wright, A.Y. Yang, A. Ganesh, S.S. Sastry, and Y. Ma, "Robust face recognition via sparse representation," IEEE
20. Trans. Pattern Analysis and Machine Intelligence, vol. 31, no. 2, pp. 210–227, 2009. [19] J. Wright and Y. Ma, "Dense error correction via l1 minimization," IEEE Trans. Information Theory, vol. 56, no. 7,pp. 3540–3560, 2010.29
21. M. Yang and L. Zhang, "Gabor Feature based Sparse Representation for Face Recognition with Gabor OcclusionDictionary," Proc. European Conf. Computer Vision, 2010.
22. J. Mairal, F. Bach, J. Ponce, G. Sapiro, and A. Zisserman, "Learning discriminative dictionaries for local imageanalysis," Proc. IEEE Conf. Com puter Vision and Pattern Recognition, 2008.
23. K. Huang and S. Aviyente, "Sparse representation for signal classification," Proc. Neural Information andProcessing Systems, 2006.
24. B.A. Olshausen and D.J. Field, "Sparse coding with an overcomplete basis set: a strategy employed by V1?" VisionResearch, vol. 37, no. 23, pp. 3311–3325, 1997.