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Face Detection and Recognition System using Digital Image Processing

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Abstract— While recognizing any individual, the most important attribute is face. It serves as an individual identity of everyone and therefore face recognition helps in authenticating any person's identity using his personal characteristics. The whole procedure for authenticating any face data is sub-divided into two phases, in the first phase, the face detection is done quickly except for those cases in which the object is placed quite far, followed by this the second phase is initiated in which the face is recognized as an individual. Then the whole process is repeated thereby helping in developing a face recognition model which is considered to be one of the most extremely deliberated biometric technology. Basically, there are two type of techniques that are currently being followed in face recognition pattern that is, the Eigenface method and the Fisherface method. The Eigenface method basically make use of the PCA (Principal Component Analysis) to minimize the face dimensional space of the facial features. The area of concern of this paper is using the digital image processing to develop a face recognition system.

Keywords— Face recognition system, eigenface method, principal component analysis (PCA), digital image processing.

I. INTRODUCTION

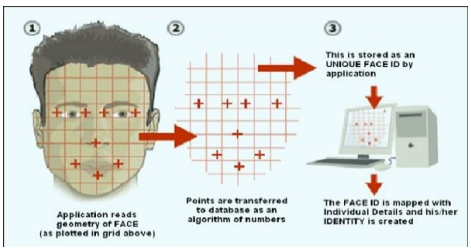
After the face is detected the main task of face recognition system starts as to identify the known or unknown face and act accordingly. Often people are mistaken by the term face detection whereas face recognition means on the other hand is to authenticate a given face data based on the stored face data in the database. Once the face data matches with the database then the system is authenticated [1][2]. There are different approaches that are being followed in the whole process of face recognition. Each process has its own pros and cons, and has also some limitations which makes it different from other approaches [5].

II. DIFFERENT APPROACHES OF FACE RECOGNITION

There are basically two prevailing approaches to the problem of face recognition namely, Geometric approach i.e. the feature based and the other one is the photometric approach i.e. the view based. As the field of face recognition fascinated many researchers resulting which there were many contrasting algorithms developed, out of which three of them have been widely studied in the literature of face recognition[3][4].

We can classify the recognition algorithm into two main approaches:

1) **Geometric:** This approach mainly deals with the spatial correlation uniting the profile (i.e. face) features, also we can simply that dimensional layout of the facial attributes. Some of the main geometrical attributes of a human face are nose, eyes and the mouth. Based on these attributes firstly the face is categorized and then based on these attributes respective spatial intervals and the respective associated gradients are estimated, thereby advancing the process of face recognition. (Fig.1)



2) **Photometric stereo:** It is a methodology of computer vision technology which mainly recuperates the structure of an underlying object from the images that were shot in varying circumstances that were affected by the lighting environment [7]. An arrangement of the surface standards shown by the slope chart that finally

elucidate the retrieved entity's configuration. (Fig. 2)

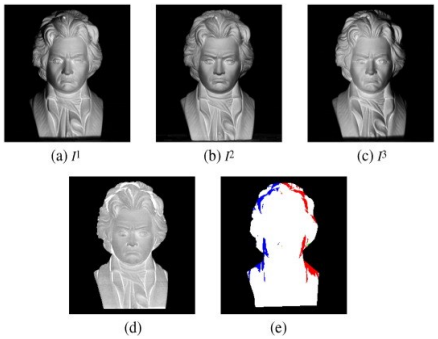


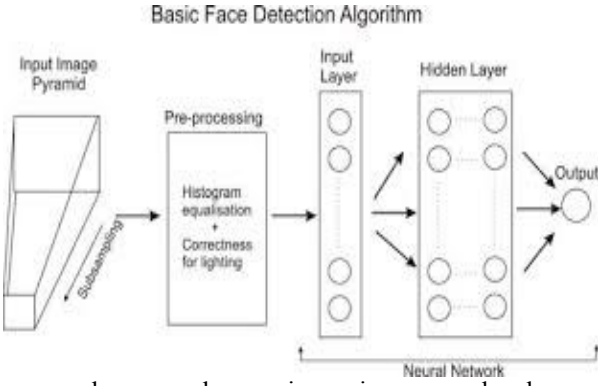
Fig. 2 – Photometric stereo image

III. FACE DETECTION

One of the sub divided image frame makes one class i.e. the one consisting the faces in the image, which marks the first step towards the process of face detection[2][9]. It is inconvenient because in spite of the congruity exist among faces but several factors like age, skin color and facial expression can vary considerably. Then this problem is furthermore intricate by the arrival of factors like environment factors affecting light, risk of imitation and also probability of limited obstruction in image. The face detection system that can easily recognize any face from a given image that too under any circumstance with any kind of lighting environment is thus considered as the finest face detection system.The function of the face detection system can be further bifurcated into two phases. Phase one consists of classification, in which the system based on the input that was in the form of some random images and if the face is present in the image the output comes in the form of yes or no. Face localization is the second phase in which for a given input image it shows a bounding box which comprise the dimensions of exact location of the face in the image.

The process of face detection system is sub-divided as follows:

1) **Pre-Processing:** Before feeding any image to the network it is processed properly to lower down the variability. Frontal faces that are comprised in the front view of the image is thus obtained by cropping the images that contain the human faces[12].On completion of the above step, standard algorithms are used to correct the lighting of the cropped images.
2) **Classification:** To categorize any image as faces or non faces, neural networks are implemented by training on these examples. For the process of classification, we have combined the MATLAB NN toolbox along with the basic implementation of the neural networks.
3) **Localization:** After the process of classification, the bounding box is thus used to localize the searched human face from the results of the trained neural network. There are numerous attributes of face on which work has been done, some of them are: Position, scale, orientation and illumination.



Till now we have seen how an image is processed and how it is being checked for the presence of any face or not. Now, we will talk more about face detection. After the facial attributes are detected in any image all the rest of objects are ignored and our primary concern is with the face. Face detection can be also referred as face localization, where main aim is to find location and size of the known no. of faces present in an image. Primarily there are two approaches that are being followed to recognize facial part in an image, the first approach is the feature base approach and the second approach is the image base approach [6][8][10].

1) Feature based approach:

1.1) Active Shape Model: The ASMs start focusing upon the compounded fixed attributes that are higher in physical level appearance, in simple words we can say that as soon as any input image is given, the task of ASM is to automatically locate the benchmark points, which will elucidate the appearance of any statistically craved entity in a picture. Some of the physical attributes that are higher in appearance are eyes, lips, nose, mouth and eyebrows [4]. A training set composed of images in which the landmarks are manually marked, is used for building a statistical facial model which is also a part of the training stage of an ASM.

1.2) Low level Analysis: Some of the essential low-level visible attributes of a human face are color, motion, intensity and edges etc. Amongst these skin color plays an important role of an attribute to detect a face. As compared to the processing of all other facial attributes, color processing is

considered better as it is faster. Under specific lighting circumstances the color is evenly oriented. Now for the motion estimation it is easy as only a translation model is required. On the other hand, detecting a human face using the skin color attribute has sundry issues like color depiction of an image that contains the face that is basically acquired by a camera is derived from numerous features such as moving entities, atmospheric light and many more. To a great extent there are basically three types of algorithms that are used for detecting a face namely, HIS, YCbCr, and RGB. There are three essential steps that need to be followed in the implementation of these algorithms, that are

a) Categorize the skin area in the color scope,
b) Put in a threshold to disguise the skin area,
c) For detecting the face image draw a bounding box.

1.3) Feature Analysis: The primary focus of these algorithms is to systemic attributes that remain into the existence even if the angle of viewor the lighting circumstances vary, and then make use of these to detect and pinpoint the human faces. These approaches were mainly used for the problem of face localization.

1.3.1) Feature Searching:

a) Viola Jones Method: This technique was mainly given by Paul Viola and Michael Jones to detect any object by minimizing the computational time thereby achieving the high accuracy rate in detecting face. This proposed method proved to be 15 times faster than the existing systems with an accuracy of around 95%with approx. 17 frames per second. This approach makes use of Haar-like attributes and is built on the notion of integral image, on the other hand boosting algorithm AdaBoost is used to minimize incompletely arranged attributes. It is basically used on the gray-scale images.
b) Gabor Feature Method: This technique was proposed by Sharif et al which uses Elastic Bunch Graph Map (EBGM) algorithm for detecting the face with implementation of the Gabor filters. On a given image the proffered technique applies 40 various Gabor filters. The outcome of this comes out to be images with varying angles and positions are collected. In the next step the fiducial points are marked that are of maximum intensity. According to the distance these points are reduced and after that the distance amongst the reduced points is calculated with the use of the distance formula. The final step is to compare the distance values with those in the database. If the values match that means the face is detected. Gabor filter equation:

$$g_{\lambda\theta\psi\sigma\gamma}(x,y) = exp(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2})cos(2\pi\frac{x'}{\lambda}+\psi)$$

$$x' = xcos(\theta)+ysin(\theta),$$
$$y' = ycos(\theta)-xsin(\theta).$$

2) Image based approach:

2.1) Neural Network: In the recent years neural network is getting more attention in regard to the pattern recognition problem like Object recognition, OCR and self-driving robot. Neural network turns out to be very feasible for the problem of face detection. The only drawback of this system is that, it requires a very fine-tuned network architecture to get an exceptional performance. Propp and Samal designed one of the first neural network for face detection, which contained 1024 input units and two output units. Feraud and Bernier came up with an advanced method for facial detection with the use of auto associative neural networks. After this model Lin et al. came up with new approach of face detection by making the use of probabilistic decision-based neural network. Learning rules and feasibility explanation are comprised within the Radial Basis Function, which is related with theprobabilistic decision-based neural network.

2.2) Linear Sub-Space Method (LSSM):

Eigen Face Method (EFM): Kohonen took the initiative of implementing the Eigen vectors for the problem of face recognition, by making use of simple neural network; for recognizing a human face in aligned and

normalized position. Further advancement in this was done by Kirby and Sirovich by making use of Linear Encoding. A vector of size m*n represent the images and then the mean square error is minimized.

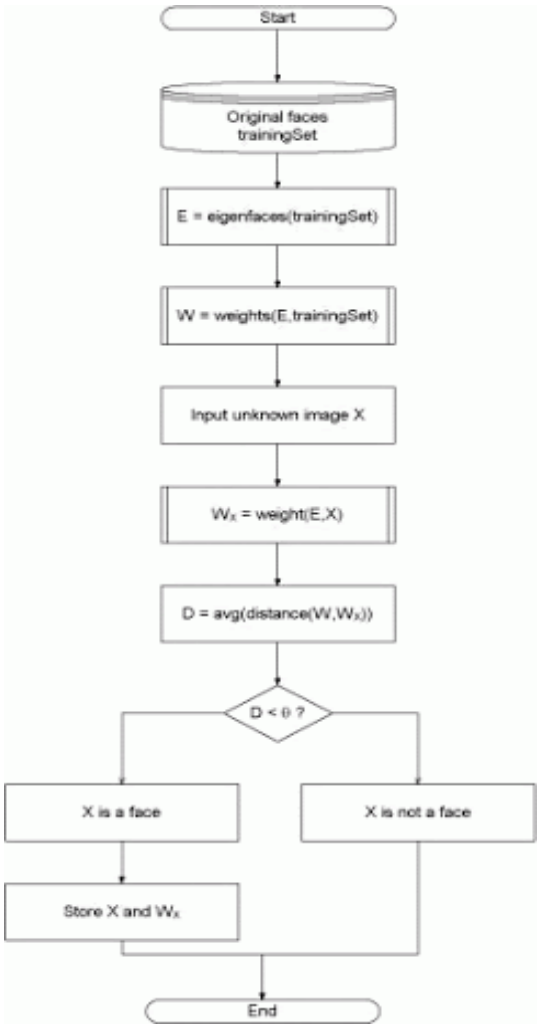


Fig. 4: Eigen Face Method

2.3) Statistical Approach:

Principal Component Analysis (PCA): Immediately identifying the variation amongst the human face is not so obvious but then PCA comes into the picture and proves to be the appropriate procedure to deal with the problem of face recognition. PCA does not work on the age-old principle of categorizing the geometrical attributes but on the other hand check that which all factors will affect the faces that are present in a picture. In the system of face recognition, these factors are commonly known as Eigen faces and the reason behind is because when they are organized they look similar to the human face. PCA was used on a great extent in the field of pattern recognition for classification problem. PCA proves itself to be very strong with the potential of data reduction and interpretation.

IV. DIGITAL IMAGE PROCESSING

Curiosity for the digital image processing technique basically originated by taking into concern two primary implementations [7]:

a) Refining the pictorial data for proper interpretation and explanation.
b) Organizing the scene information for independent recognition to be done by the device.

The main focus in the second application area is fetching the image data in computer process able conformation [11].

It has a wide area of practical implementation which include automatic character recognition, in the field of military for authentication purpose and automatically authenticating the fingerprints, and many more applications.

An image can be referred to as a 2D light intensity function f(x,y), where the spatial coordinates are denoted by (x, y). The brightness or gray levels of the image is proportional to the value of f at any point (x, y). The image processing is broadly categorized into three types namely,

1) Low level processing (LLP)
2) Medium level processing (MLP)
3) High level processing (HLP)

The first type of processing i.e. low-level processing only deals with only fundamental operations such as rotating an image, reading an image, resizing an image, histogram equalization and also converting the RGB to gray-level. After this a raw image is derived. The image thus obtained is a raw image [2][3]. Fetching the area of interest from the outcomes of the LLP is mainly handled by MLP. The segmentation process i.e., identification of edges is also handled by the medium level processing. The task of the high-level processing is to bring advancement in the medium-level processing by adding AI to it.

1) Fundamental steps in image processing:
   a) Image acquisition: obtaining a digital figure in the form of a picture.
   b) Image pre-processing: its role is to refine the pictures in such a way, so that the success rate is high in other phases.
   c) Image segmentation: its role is to form integral part of the entity from the segregated images.
   d) Image description: its role is to fetch attributes that are of higher significance and plays a vital role in differentiating one class from the other.

e) Image recognition: based on the data provided by the description, allocate a label to it.

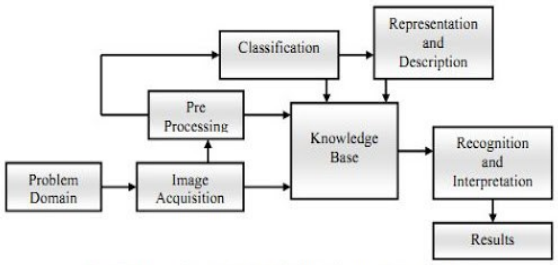


Fig 5.1: Fundamental steps in digital image processing

CONCLUSION

Since the no. of Eigen faces to be used is restricted in PCA transformation that's why the system did not have an accuracy of more than 90% for both manual and automatic face recognition. A further work that needs to be done is in the field of fully automated frontal view face detection system which when displayed virtually shows a perfect accuracy. The real-world performance of this designed system will be far more precise. In view of attaining a high accuracy rate the designed and developed system was not adequately strong. One of the main reasons behind this flaw is that the sub-system of the face recognition system does not exhibit minute changes in degree of steadiness to scale or rotation of the segmented face image. The performance of this system can be compared with the manual face detection only if we integrate the eye detection system with the developed system.

The other executed applications exhibited an exceptional result and returned exceptionally good on the PCA technique and distorted arrangement. Appropriate use of this developed system of face recognition and detection is in the field of surveillance and mugshot matching. This system after integration with the eye detection system could be mainly serve as an authentication system in the ATM Machines and Home security systems. There are many advancements possible in this field as this serves as insight into what the future will be in the field of computer vision.

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