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Recognition of Object Using Principle Component Analysis

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Abstract: An Efficient method for objects recognition based on application of Principal Component Analysis (PCA). The PCA has been extensively employed for object recognition algorithms. It not only reduces the dimensionality of the image, but also retains some of the variations in the image data. The system functions by projecting image onto a feature space that spans the significant variations among known images. The significant features are known as "eigenvectors", because they are the Principal Component of the set of images. The projection operation characterize an individual image by a weighted sum of the eigenvectors features and so to recognize a particular image it is necessary only to compare these weights to those individuals.

Keywords: Object Recognition, Principal Component Analysis, Eigen values, Eigenvectors, Feature extraction.

I. INTRODUCTION

The object detection problem can be seen as a classification problem, where we need to distinguish between the object of interest and any other object. Natural images which are not limited to any size and which show arbitrarily complex scenes are classified according to whether they contain a certain object or not, this is Generic Object Recognition. In same way Computer system recognize objects at any position, size, and appearance [4]. The given method allows for recognizing objects under such circumstances and shows excellent results [1]. The scheme is based on an information theory approach that decomposes images into a small set of characteristic feature images called 'Eigenvectors', which are actually the principal components of the initial training set of images. Recognition is performed by projecting a new image into the subspace spanned by the Eigenvector and then classifying the image by comparing its position in the featurespace with the positions of the known individuals. The Eigenvector approach gives us efficient way to find this lower dimensional space. Any image can be expressed as linear combinations of the singular vectors of the set of images, and these singular vectors are eigenvectors of the covariance matrices. Object Counting and Monitoring, Optical Character Recognition, Global robot localization, Visual Positioning and tracking etc.

II. LITERATURE REVIEW

A. Gunjan Dashore et al. (2012) introduced an efficient method for face recognition using Principal Component Analysis. The system functions by projecting face image onto a feature space. The significant features are known as "Eigen faces". The projection operation characterize an individual face by a weighted sum of the Eigen faces features and so to recognize a particular face it is necessary only to compare these weights to those individuals[2].

Mohammod Abul Kashem et al.(2011) worked on automatically face detection and recognition system based on principal component analysis (PCA) with back propagation neural networks (BPNN). This system consists of three basic parts, first: the Face Detection part- which automatically detect human face image using BPNN, second: the various facial features extraction, and the third: face recognition are performed based on Principal Component Analysis (PCA) with BPNN[3].

R.Ahilapriyadharsini et al.(2013) proposed Object Recognition method based on Principal Component Analysis to Image Patches. In order to represent the local properties of the images, patches are extracted where the variations occur in an image.

To find the interest point, Wavelet based Salient point detector is used. In order to reduce dimensionality Principal Component Analysis is applied to the image patches and finally the principal components are classified using Support Vector Ma-chine (SVM) classifier [4].

Vivek Banerjee(2013) worked on Principal Component Analysis Based Face Recognition System Using Fuzzy C-means Clustering Classifier. In this paper, PCA is used for dimension reduction, the projected feature space is formed using fuzzy c-means clustering algorithm. The above process can be used to recognize a new face in unsupervised manner [5].

C. L. Chowdhary(2011) compared linear techniques for object recognition. Linear feature extraction techniques for object recognition are based on Principal Component Analysis (PCA) and Independent Component Analysis (ICA). The performed experiments indicate that the present method is well suited for appearance based 3D object recognition and pose estimation [6].

Mamta Dhanda(2012) worked on Face Recognition Using Eigenvectors From Principal Component Analysis. The design is based upon "eigenfaces". The original images of the training set are transformed into a set of eigenfaces E. Then, the weights are calculated for each image of the training set and stored in the set W. Upon observing an unknown image Y, the weights are calculated for that particular image and stored in the vector WY. Afterwards, WY is compared with the weights of images, of which one knows for certain that they are facing [8].

Saurabh P.Bahurupi et al.(2012) proposed a method of Principal Component Analysis for Face Recognition. In this paper image in the training set can be represented as a linear combination of weighted eigenvectors called as "Eigenfaces". These eigenvectors are obtained from covariance matrix of a training image set called as basis function. The weights are found out after selecting a set of most relevant Eigenfaces. Recognition is performed by projecting a new image (test image) onto the subspace spanned by the eigenfaces and then classification is done by distance measure methods such as Euclidean distance [9].

Liton Chandra Paul et al.(2012) addresses the building of face recognition system by using Principal Component Analysis (PCA). This paper shows that the training set is represented weighted eigenvectors called eigenfaces. These eigenvectors are obtained from covariance matrix of a training image set. The weights are found out after selecting a set of most relevant Eigenfaces. Recognition is performed by projecting a test image onto the subspace spanned by the eigenfaces and then classification is done by measuring minimum Euclidean distance [10].

Hussein Rady(2011) gives a face recognition system for personal identification and verification using Principal ComponentAnalysis with different distance classifiers. Different classifiers were used to match the image of a person to a class obtained from the training data. These classifiers are:the City*Block Distance Classifier, the Euclidian distance classifier,the Squared Euclidian Distance Classifier, and the Squared Chebyshev distance Classifier. The Euclidian Distance Classifier produces a recognition rate higher than the City*Block Distance Classifier which gives a recognition rate higher than the Squared Chebyshev Distance Classifier. Also, the Euclidian Distance Classifier gives a recognition rate similar to the squared Euclidian Distance Classifier [11].

Satonkar Suhas S. et al.(2012) proposed Face Recognition Using Principal Component Analysis and Linear Discriminant Analysis on Holistic Approach in Facial Images Database. This involves extraction of its features and then recognizes it, regardless of lighting, ageing, occlusion, expression, illumination and pose. Principal component analysis and linear discriminant analysis are tested and compared for the face recognition of facial images database[12].

III. Problem Definition

Previous work faced several problems. These include the image size and lightning of the room. A solution to this problem was to focus a white light on a image before we take picture. Other problem was the picture's background. When a picture is taken for a person, unwanted disturbances from the surrounding that result in a low accuracy. The work is related to object recognition using PCA. The algorithm can be used for effectively recognizing objects under varying circumstances. The work involves collection of samples, feature extraction, design and training of the PCA and testing. Current work deals with recognition of a region of intrest from image. Each of the pixels in a region is similar with respect to some characteristic or computed property, such as colour, intensity, or texture. The problem of carrying out recognition using PCA is related to the classification of pixels as per certain properties similar in nature [7]. The components of the system are Signal Capture: Here an image of an object or a scene is captured by a digital camera or is scanned for use as theinput to the system [7]. Feature Extraction: Features are the characteristics of the objects present in an image. Feature extraction is the procedure of extracting certain features from the image. In the research, the features were extracted based on shape and color of the image. PCA eigenvector creation: This is a feature vector. Its operation can be thought of as revealing the internal structure of the data in a way that best explains the variance in the data [16]. Euclidean Distance Classifier: The minimum distance between test image and training image is considered to be known, otherwise it is unknown [5]. Object classification**:** Object classification step categorizes detected objects into predefined classes.

IV. METHODOLOGIES

In this papers design and implementation of the Object Recognition System can be subdivided into three main parts.

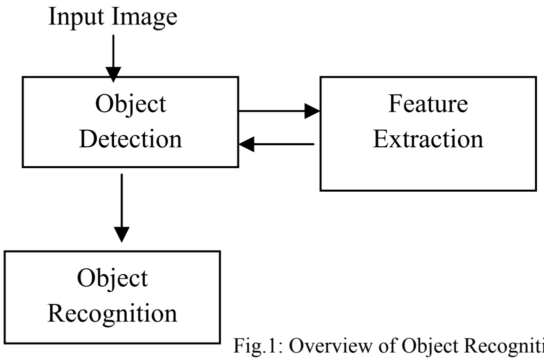

Fig.1: Overview of Object Recognition System

1. Object Detection: where a photo is searched to find object then image processing cleans up the image for easier recognition.
2. Feature Extraction: The second part is to perform various features extraction from image using Principal Component Analysis [3].
3. Object Recognition: where that detected and processed object is compared to a database of known objects, to decide what that object is.

The first part is the Object Detection. The basic goal is to study, implement, train and test the Principal Component Analysis system. Given as input an arbitrary image, which could be a image captured by a digital camera or a scanned photograph. The first stage in object detection is performed in a number of color models. To name a few are RGB, YCbCr, HSV, YIQ, YUV, CIE, XYZ, etc[3]. Experiments were performed in RGB and GRAY color models. The second part is to perform various features extraction from image using Principal Component Analysis (PCA). Feature extraction consists in localizing the most characteristic within images that depict object. This paper is based on color and shape feature extraction. The third part consists object recognition which is accomplished by PCA based algorithm. This is based on principal component-analysis (PCA) technique, which is used to simplify a dataset into lower dimension while retaining the characteristics of dataset. Image Detection, Principal component analysis and Euclidean Distance Classifier are the major implementations of this paper.

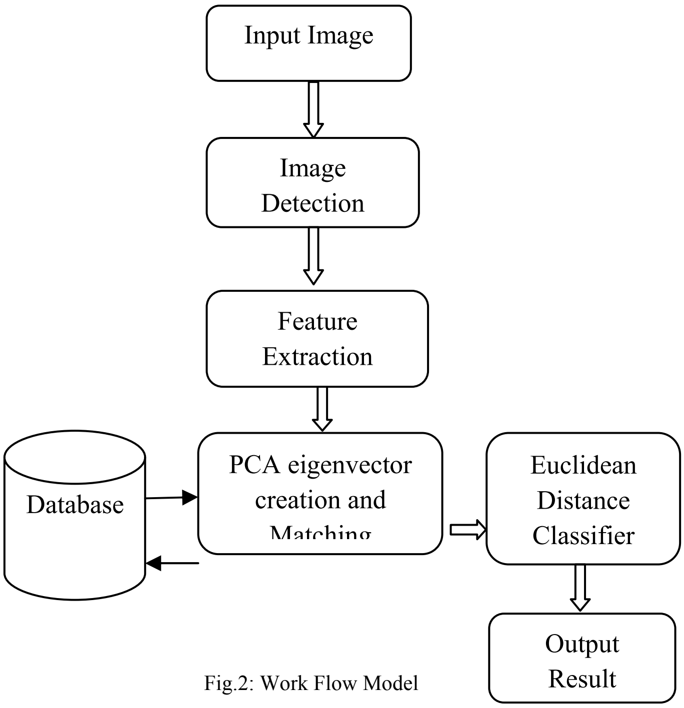

Fig.2: Work Flow Model

V. PRINCIPLE COMPONENT ANALYSIS (PCA)

Principal component analysis (PCA) is a statistical procedure that converts a set of observations of possibly correlated variables into a set of uncorrelated variables called principal components [13]. The number of principal components is less than or equal to the number of original variables [13]. PCA is a commonly used method of object recognition.

To perform PCA for object recognition several steps are undertaken:

Stage 1: Subtract the Mean of the data from each variable (our adjusted data)

Stage 2: Calculate and form a covariance Matrix

Stage 3: Calculate Eigenvectors and Eigen values from the covariance Matrix

Stage 4: Chose a Feature Vector.

Stage 5: Multiply the transposed Feature Vectors by the transposed adjusted data [2]

Stage 6: Calculation of Euclidean distance

STAGE 1: Mean Subtraction

Mean subtraction (mean centering) is necessary for performing PCA to ensure that the first principal component describes the direction of maximum variance matrix[14].The first thing we need to do is to form a training data set. 2D image I_i can be represented as a 1D vector by concatenating rows. Image is transformed into a vector of length N = mn.

$$I = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{1n} \\ \vdots & \ddots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}_{mxn} \xrightarrow{\text{concatenation}} \begin{bmatrix} x_{11} \\ \vdots \\ x_{1n} \\ \vdots \\ x_{2n} \\ \vdots \\ x_{mn} \end{bmatrix}_{1xN} = x$$

Let M such vectors x_i (i = 1, 2, ..., M) of length N form a matrix of learning images, X. First we determine the vector of mean values Ψ, and then subtract that vector from each image vector.

$$\Psi = \frac{1}{M}\sum_{i=1}^{M} x_i$$

$$\Phi_{i=} x_{i\,-}\,\Psi$$

Averaged vectors are arranged to form a new training matrix (size N×M); A = (φ1 φ2 … φM)[5] .

STAGE 2: Covariance Matrix

The covariance matrix that is formed of the image data represents how much the dimensions vary from the mean with respect to each other [2]. The definition of a covariance matrix is**:**

$$C = \frac{1}{M}\sum_{n=1}^{M} \varphi_n\,\varphi_n^T = AA^T$$

$$L = AA^T$$

Covariance matrix C has dimensions N×N. We know from linear algebra theory that for a PxQ matrix, the maximum number of non-zero eigenvalues that the matrix can have is min(P-1,Q-1). Since the number of training images (P) is usually less than the number of pixels (M*N), the most non-zero eigenvalues that can be found are equal to P-1. So we can calculate eigenvalues of A^T*A (a PxP matrix) instead of A*A^T (a M*NxM*N matrix). A^T*A is the surrogate of covariance matrix A*A^T.

STAGE 3: Eigenvectors and Eigen values

Eigen values are a product of multiplying matrices however they are as special case. Eigen values are found by multiples of the covariance matrix by a vector in 2 dimensional space (i.e. a Eigenvector)[2]. If v_i and μ_i are eigenvectors and eigenvalues of matrix A^TA, then:

$$A^T A v_i = \mu_i v_i$$

Multiplying both sides of above equation with A from the left, we get:

$$AA^T A v_i = A\mu_i v_i$$

$$AA^T (Av_i) = \mu_i (Av_i)$$

$$C(Av_i) = \mu_i (Av_i)$$

Comparing equations, we can conclude that the first M–1 eigenvectors e_i and eigenvalues λ_i of matrix C are given by Av_i and μ_i, respectively.

STAGE 4: Feature Vectors

Once Eigenvectors are found from the surrogate of covariance matrix, the next step is to order them by Eigen value, highest to lowest [2]. Here the data can be compressed and the weaker vectors are removed producing a lossy compression method.

STAGE 5: Transposition

The final stage in PCA is to take the transpose of the feature vector matrix and multiply it on the left of the transposed adjusted data set (the adjusted data set is from Stage 1 where the mean was subtracted from the data)[2].

STAGE 6: Euclidean distance

Classification is done by determining the distance. The most common is the Euclidean distance, but other measures may be used. This paper presents the results for the Euclidean distance. If the minimum distance between test image and training image Eigenvectors is higher than a threshold θ, the test image is considered to be unknown, otherwise it is known. If A and B are two vectors of length D, the distance between them is determined as follows [5].

$$d(A,B) = \sqrt{\sum_{i=1}^{D}(a_i - b_i)^2} = ||A - B||$$

VI. Experimental Results

The method is evaluated using car, bird and flower dataset. It contains 150 training images (50 car, 50 bird and 50 bird images) and 18 test images, containing 6 images same as in training images, containing 12 images from other places. The first step in the proposed methodology is the extraction of features. In this work color and shape feature are extracted. In order to reduce the dimensionality, the PCA is applied to the extracted feature. The PCA coefficients are fed to the Euclidean distance classifier for classify the images. The experiment shows a result of 94%.

Fig. 3: Pictures from the training database.

Fig. 4: Test images and recognized images from the training database

VII. Conclusion and Discussion

It is concluded that the proposed method focuses on Object Recognition in Complex Images under varying illumination, rotation, scaling conditions. Features are extracted and PCA transformation is applied to extracted features. Euclidean distance classifiers are used for better performance. Hence the proposed algorithm can be used for effectively recognizing objects under varying circumstances.

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