Review on Digital Image Processing using Principle Component Analysis

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Abstract- **Digital image processing remains a challenging domain of programming for several reasons. First the issue of digital image processing appeared relatively late in computer history, it had to wait for the arrival of the first graphical operating systems to become a true matter. Secondly, digital image processing requires the most careful optimizations and especially for real time applications. Science of image processing combines intuition and mathematics**

Aim of the project "Image Processing based smart system for Human Gesture Identification" is recognition of Human Gesture. Automatic analysis of facial gestures is an area of intense interest in the human-computer interaction design community. Gesture recognition is human interaction with a computer in which human gestures are recognized by the computer. The primary goal of gesture recognition research is to create a system which can identify specific human gestures and use them to convey information. Some of the important human gestures to be studied are:

1. **Identification of face expressions. i.e. Happy, Angry, Sad etc.**
2. **Motion detection**

I. INTRODUCTION

Image Processing is any form of information processing for which the input is an image, such as photographs or frames of video; the output is not necessarily an image, but can be for instance a set of

features of the image. Most image processing techniques involve treating the image as a two dimensional signal and applying standard signal-processing techniques to it.

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An image defined in the "real world" is considered to be a function of two real variables, for example, $a(x, y)$ with a as the amplitude (e.g. brightness) of the image at the *real* coordinate position (x, y).

II. PRINCIPAL COMPONENT ANALYSIS

Principal component analysis (PCA) is a vector space transform often used to reduce multidimensional data sets to lower dimensions for analysis.

PCA was invented in 1901 by Karl Pearson. PCA involves the calculation of the eigenvalue decomposition of a data covariance matrix or singular value decomposition of a data matrix, usually after mean centering the data for each attribute. PCA is the simplest of the true eigenvector-based multivariate analyses. Often, its operation can be thought of as revealing the internal structure of the data in a way which best explains the variance in the data. If a multivariate dataset is visualized as a set of coordinates in a high-dimensional data space (1 axis per variable), PCA supplies the user with a lower-dimensional picture, a "shadow" of this object when viewed from it's (in some sense) most informative viewpoint.

PCA is mathematically definedas an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. PCA is theoretically the optimum transform for a given data in least square terms.

PCA can be used for dimensionality reduction in a data set by retaining those characteristics of the data set that contribute most to its variance, by keeping lower-order principal components and ignoring higher-order ones. Such low-order components often contain the "most important" aspects of the data. However, depending on the application this may not always be the case.

Properties and Limitations of PCA

PCA is theoretically the optimal linear scheme, in terms of least mean square error, for compressing a set of high dimensional vectors into a set of lower dimensional vectors and then reconstructing the original set. It is a non-parametric analysis and the answer is unique and independent of any hypothesis about data probability distribution. However, the latter two properties are regarded as weakness as well as strength, in that being non-parametric, no prior knowledge can be incorporated and that PCA compressions often incur loss of information.

The applicability of PCA is limited by the assumptions made in its derivation. These assumptions are:

- Assumption on Linearity

We assumed the observed data set to be linear combinations of certain basis. Non-linear methods such as kernel PCA have been developed without assuming linearity.

- Assumption on the statistical importance of mean and covariance

PCA uses the eigenvectors of the covariance matrix and it only finds the independent axes of the data under the Gaussian assumption. For non-Gaussian or multi-modal Gaussian data, PCA simply de-correlates the axes. When PCA is used for clustering, its main limitation is that it does not account for class separability since it makes no use of the class label of the feature vector. There is no guarantee that the directions of maximum variance will contain good features for discrimination.

- Assumption that large variances have important dynamics

PCA simply performs a coordinate rotation that aligns the transformed axes with the directions of maximum variance. It is only when we believe that the observed data has a high signal-to-noise ratio that the principal components with larger variance correspond to interesting dynamics and lower ones correspond to noise.

Gesture recognition is human interaction with a computer in which human gestures are recognized by the computer. The primary goal of gesture recognition research is to create a system which can identify specific human gestures and use them to convey information. Some of the important human gestures to be studied are:

1. Identification of face expressions. i.e. Happy, Angry, Sad etc.
2. Hand motion detection
3. Limb movement detection

III. METHODOLOGY

In order to detect the facial expression of a person i.e. surprise, happiness, disgust, anger, sadness, etc. some of the major steps are as follows:

IV. PREPROCESSING

First step is the local level image processing and begins before the actual gesture recognition takes place. It involves image capturing, smoothing (to suppress noise or other small fluctuations in the image), edge detection (edges are pixels where brightness changes abruptly) RGB to HSI space for color segmentation (Since in this space the dynamic range of the skin color is quite narrow thus enabling the differentiation of the face from other objects in the scene), image segmentation (to distinguish objects from background), image filtering (to eliminate noises, ridge ruptures and stuck ridges, and extract minutiae reliably even from poor quality) and compression, and finally the centering of the image.

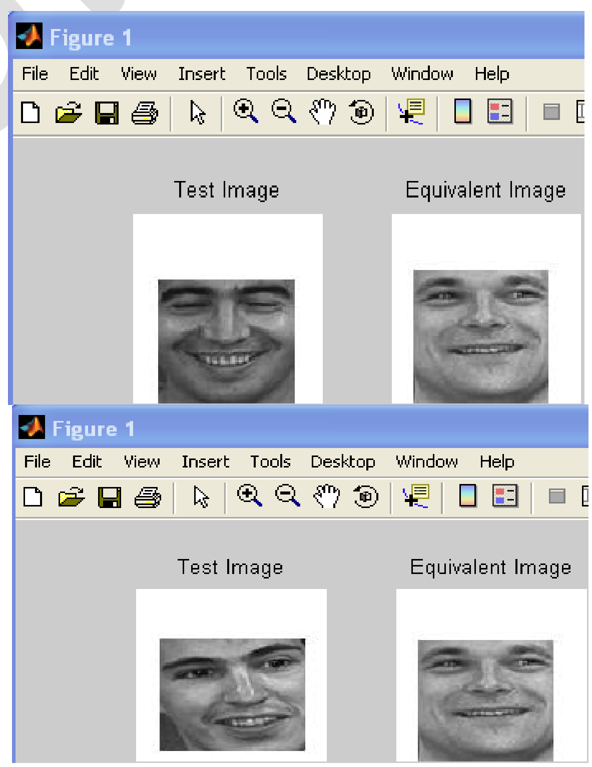
Feature Extraction

The feature extraction extracts the information such as edges, region etc. It helps in locating the predominant facial features which are necessary for the identification of the gesture

Gesture Recognition

It involves the development of set of algorithms which are performed on preprocessed image to recognize the gesture. An overall process is shown in fig. 1. First of all, an example database of gestures is collected which is used to train an artificial neural network. After training, the network finds the important gesture and abstracts them. Once it has learned the gestures, it will recognize any real time feature exposed to it.

V. RESULTS



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