Digital Image Data Compression by Using SVD Technique of PCA Method

Som Raj Thakur [1] Vinay Thakur [1] Naman Sood [1]

[1]*Department of ECE SRI SAI University Palampur*

V.P.O. Sungal Distt. Kangra (H.P.) India PIN Code176062

Lucky212765@gmail.com,

vinay.rajput1@gmail.com,

nmnsood7@gmail.com

Contact No. +918894009208

Abstract—Image compression is an application of data compression that reduces the size of original image with few bits. The main motive of image compression is to reduce the redundancy of the image and to store or transmit data in a reduced form or in small size. PCA (Principal Component Analysis) is the general name for a technique which uses advanced underlying mathematical principles to transforms a number of possibly correlated variables into a lesser number of variables called principal components. PCA took a large set of data and identified an optimal new basis in which to re-express the data. The mathematical principle that we are using in our paper is SVD (Singular Value Decomposition). By using this we transform the higher digital data into lesser set of digital data.

Keywords— PCA, SVD, Transform, correlated, covariance, Karhunen-Loeve Transform etc.

INTRODUCTION

It is well known that the images, often used in variety of computer applications, are difficult to store and transmit. One possible solution to overcome this problem is to use a data compression technique where an image is viewed as a matrix and then the operations are performed on the matrix [5]. The goal of image compression is to represent an image with as few numbers of bits as possible while preserving the quality required for the given application [6]. PCA algorithm can be employed to aid in image compression. Using the newly-derived compression ratios, the result shows that block-to-row PCA outperforms block-by-block PCA in terms of image quality and compression rate [4]. PCA is orthogonal linear transformation which transforms the image data to a new coordinate system such that the greatest variance by some projection of the image data comes to lie on the first coordinate, the second largest variance on the second coordinate, and so on. PCA is linear combination of the original basis and that re-expresses the data optimally. The technique that we are using in PCA is called SVD which is used and discussed in this paper. Digital image is combinations of digital bits which may we similar after a distance or may be differ. The similar bits are then extracted into lesser numbers of bits using proposed method. The reduction in file size allows more images to be stored in a given amount of disk or memory space. Principal Component Analysis (PCA) is the general name for a technique which uses sophisticated underlying mathematical principles to transforms a number of possibly correlated variables into a smaller number of variables called principal components. The first principal component is taken for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is accounts to be along the direction with the maximum variance. The second principal component is keep lid on to lie in the subspace perpendicular of the first. Within this Subspace, this component points the direction of maximum variance [1]. The origins of PCA lie in multivariate data analysis however; it has a wide range of other applications. PCA has been called one of the most important results from applied linear algebra and perhaps its most common use is as the first step in trying to analyse large data sets. In our paper image compression is achieved by using singular value decomposition (SVD) technique on the image matrix. The advantage of using the SVD is the property of energy compaction and its ability to adapt to the local statistical variations of an image [5].

REMAINING CONTENTS PROPOSED WORK

The important condition for the successful image compression is that the data reduction techniques are to provide an efficient representation of the data. Such as the Karhunen- Loeve Transform (KLT), the procedure consists of mapping higher dimensional input space to a lower dimensional representation space by means of linear transformation. In principal component analysis (PCA), the KLT needs to compute the covariance matrix of input data and then extract eigen values and corresponding eigenvectors by solving the Eigen problem. The dimension reduction is achieved by using the eigenvectors with the most significant eigen values as a new orthonormal basis. Fortunately, the eigenvectors can be calculated efficiently using the Singular Value Decomposition (SVD) technique.

In our paper, we discussed the implementation of some image compression algorithm & measure the compression ratio of image. This has the purpose of describing the PCA of a population of data and the possibility of applying it to the compression of digital images. The application of the technique in pattern recognition is also emphasized.

PRINCIPAL COMPONENT ANALYSIS

PCA is a useful statistical technique that has found application in fields such as image compression, face recognition and image fusion. It is a common technique for finding patterns in data of high dimension. PCA is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analysing the data. The other main advantage of PCA is that once you have found these patterns in the data, and you compress the data, i.e. by reducing the number of dimensions, without much loss of information [2].

In principal component analysis we find the directions in the data with the most variation, i.e. the eigenvectors corresponding to the largest eigen values of the covariance matrix, and project the data onto these directions. The motive for doing this is that the most second order information are in these directions. The choice of the number of directions is often guided by trial and error, but principled methods also exist. If we denote the matrix of eigen vectors sorted according to eign value by $\tilde{U}$, we can do than PCA transformation of the data as $Y\tilde{UX}^T$. The eigen vectors are called principal components. By selecting only the first d row of Y, we have projected the data from n down to d dimensions.

PCA BY SVD

We can use SVD to perform PCA. We decompose X using SVD, i.e.

$$X = UTV^T$$

And find that we can write the covariance matrix as

$$C = \frac{1}{n} XX^T = \frac{1}{n} UT^2 UT^T$$

In this case U is a $n \times m$ matrix. Following from the fact that SVD routine order the singular values in descending order we know that, if $n < m$, the first n columns in U corresponds to the sorted eigenvalues of C and if $m \geq n$, the first m corresponds to the sorted non-

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zero eigenvalues of C. The transformed data can thus be written as

$$Y = U^{\sim T} X = U^{\sim T} U T V^T$$

Where U is a simple $n \times m$ matrix which is one on the diagonal and zero everywhere. To conclude, we can write the transformed data in terms of the SVD decomposition of X. Here, we perform a principal component analysis of this matrix, using the SVD method [3].

COMPRESSION RATIO

It is defined as the ratio of original image size to the compressed image size. The expression for calculating compression ratio is used as:

$CR = \alpha / \beta.\mu + \theta + \varphi$

Where, α = size of frame of an image (i.e. m x n) β = size of feature matrix CX (i.e. q x d)

μ = no. of sub-frames in a frame (i.e. L)

θ = size of row projection matrix X (i.e. n x d)

φ = size of column projection matrix Z (i.e. m xq)

Here every element of matrix C X takes on average 8 bits. If CX is further to be used with any other algorithm of compression.

STEPS FOR IMAGE COMPRESSION USING SVD

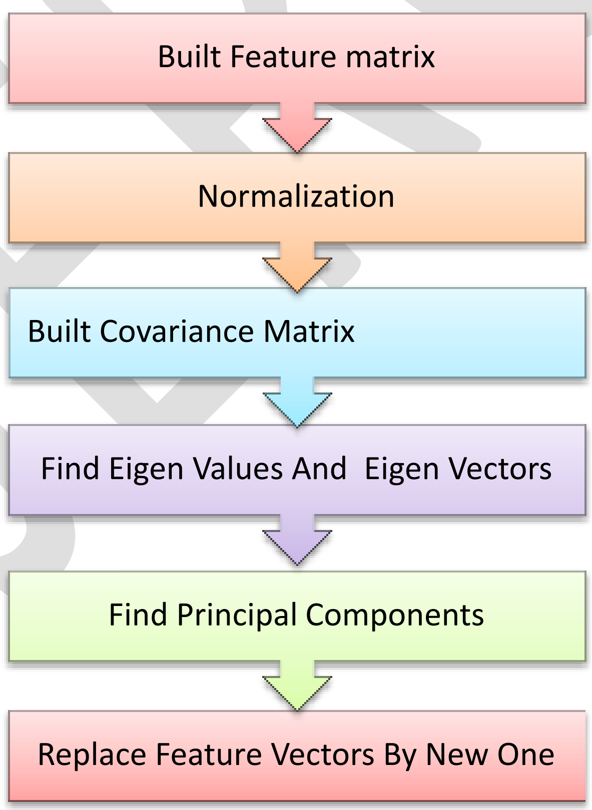

Fig. 1 Steps for Image Compression using SVD

a) For PCA to work properly, we have to subtract the mean from each of the data dimensions. The mean subtracted is the

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average across each dimension. Thus, the resulting matrix X is formed.

b) Obtain the feature column vector matrix CX from the given image data. Each column of the matrix defines a feature vector.

c) Obtain the covariance matrix .

d) Using characteristic equation (λi-Ea) =0. Obtain the Eigen values. These Eigen values forms the covariance matrix E*y*.

e) Calculate the eigenvectors matrix by considering the Eigen values. Eigenvectors should be normalized.

f) Transformation W is obtained by considering the eigenvectors as their columns.

g) Obtain the features vector matrix by computing $CY = CXW^T$ .The new features are linearly independent.

h) For compression of an image, the dimensionality of the new feature vector is reduced by setting small Eigen values l to zeros.

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CONCLUSION

We conclude that Principal Component Analysis is a mathematical procedure that transforms a number of correlated variables into a number of uncorrelated variables called principal components. PCA computes a compact and optimal description of the data set with minimum loss of information. The results obtained by using the proposed working method for color image compression are found impressive on account of both compression ratio and quality of reconstructed image. Since, the proposed algorithm is based on PCA we see that the algorithm has lower complexity and is very time efficient. PCA found its applications as image compression.

REFERENCES:

[1] D. Padmini, "Different Levels of Image Fusion Techniques in Remote Sensing Applications and Image Classification" International Journal of Advanced Research in Computer Science and Software Engineering (IJARCSSE) 4(8), August - 2014, pp. 199-206.

[2] Y. Murali Mohan Babu, Dr. M.V. Subramanyam, Dr. M.N. Giri Prasad, "PCA based image denoising", An International Journal (SIPIJ) Vol.3, No.2, April 2012.

[3] Rasmus Elsborg Madsen, Lars Kai Hansen and Ole Winther, "Singular Value Decomposition and Principal Component Analysis" February 2004.

[4] Lim, S.T, Yap, D.F.W. , "Medical image compression using block-based PCA algorithm", IEEE, Sept. 2014, pp. 171-175.

[5] Singh S.K. , Kumar S., "A Framework to Design Novel SVD Based Color Image Compression" Computer Modeling and Simulation, 2009. EMS '09. Third UKSim European Symposium, ISBN 978-1-4244-5345-0, Nov. 25-27th, 2009.

[6] Koon-Pong Wong "Fractal image coding for emission tomographic image compression", Nuclear Science Symposium Conference Record, 2001 IEEE (Volume:3), ISBN 0-7803-7324-3, Nov. 4-10th, 2001.

Fig.1 Original image

Fig. 2 First Principal component image

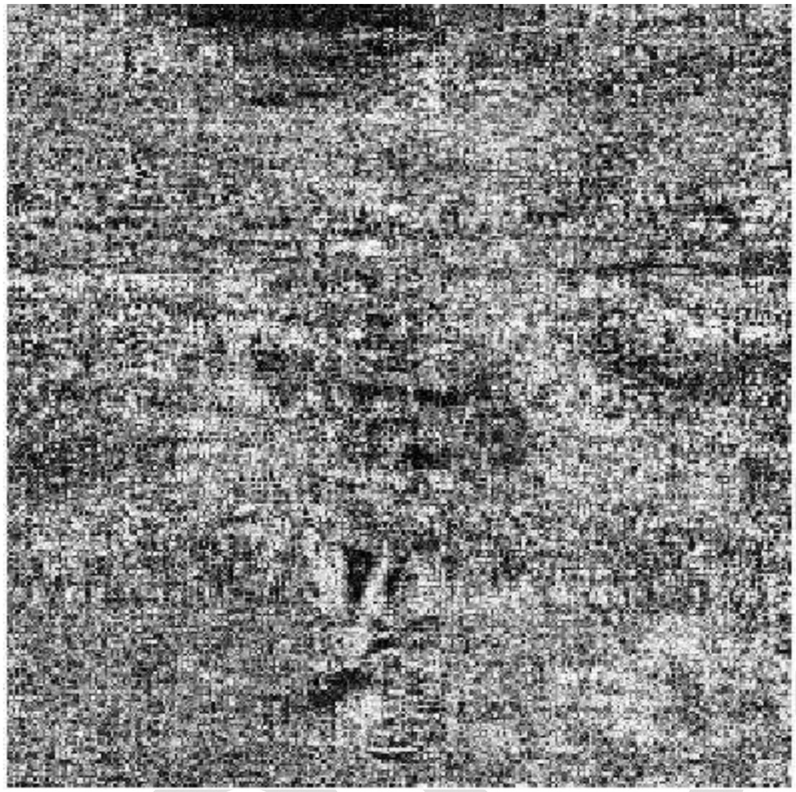

Fig.3 Compressed Image