

# Literature Review of Image Compression Algorithm

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**Abstract:** In this research work, a literature review was conducted to assess the progress made in the field of image compression effects on the face recognition. The DCT algorithms were considered for the review and their application was limited only to JPEG compression. In this review, progress was made in the DCT algorithms of a single image, and a series images from a video, namely 2D DCT and 3D DCT respectively, along with several other algorithms in the application of face recognition were discussed in detail.

**Keywords**— Face recognition, 2D DCT, 3D DCT, image compression and face recognition.

## 1. INTRODUCTION:

Face recognition has been considered as an important subject of research work over the last fifteen years. This subject has gained as much importance as the areas of image analysis, pattern recognition and more precisely biometrics [1-4], because it has become one of the identification methods to be used in e-passports and identification of candidates appearing in various national and international academic examinations. The resolution or the size of the image plays an important role in the face recognition. Higher the resolution the better it is. However, the image compression effects on the face recognition system are not given as importance it deserves in the recent years.

Images are compressed for different reasons like storing the images in a small memory like mobile devices or low capacity devices, for transmitting the large data over network, or storing large number of images in databases for experimentation or research purpose. This is essential due to the reason that

compressed images occupy less memory space or it can be transmitted faster due its small size. Due to this reason, the effects of image compression on face recognition started gaining importance and have become one of the important areas of research work in other biometric approaches as well like iris recognition and fingerprint recognition. Most recent contribution were made in iris recognition [5, 6] and fingerprint recognition [7,8]. In addition to paying importance to standard compression methods in recognition, researchers have focused in developing special purpose compression algorithms, e.g. a recent low bit-rate compression of face images [9].

One of the major drawbacks in the face recognition using compressed images is, the image has to in the decompressed mode. However, the task of decompressing a compressed image for the purpose of face recognition is computationally expensive and the face recognition systems would benefit if full decompression could somehow be eliminated. In other words, the face recognition is carried out while the images are in compressed mode and it would additionally increase computation speed and overall performance of a face recognition system.

The most popular compression techniques are JPEG [10,11] and their related transformations are Discrete Cosine Transform and Discrete Wavelet Transform. It is treated that common image compression standards such as JPEG and JPEG2000 have the highest number of applications for actual usage in real life, since the image will always have to decompressed and presented to a human at some point.

In this review, progress made in the DCT and other algorithms of a single image, and a series images from a video, namely 2D DCT and 3D DCT respectively, in

the application of face recognition are discussed in detail.

## II. TWO DIMENSIONAL DISCRETE COSINE TRANSFORMATION:

The Two dimensional discrete cosine transform (2D DCT) has become one of the most popular transforms for many image compression applications due to its near optimal performances compared to the statistically optimal Karhunen-Loeve transform [12]. The 2D DCT is computationally intensive and as such there is a great demand for high speed, high throughput and short latency computing architectures. Due to the high computation requirements, the 2D DCT processor design has been concentrated on small nonoverlapping blocks (typical 8x8 or 16x16). Many 2D DCT algorithms have been proposed to achieve reduction of computational complexity and thus increase the operational speed and throughput. The two-dimensional DCT can be treated as a composition of two 1D DCT along each dimension. The formal definition is

$$X(l, m) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} x(i, j) \cdot C_{li} C_{mj} \quad (1)$$

Where  $x(i, j)$  is a value of the image element or the pixel which is located at the coordinates  $i, j$ .  $X(l, m)$  is the 2D DCT coefficient at the position  $(l, m)$  and can be computed using the Eq. 1. Index take values  $l, m = 0, 1, \dots, N-1$ . The multiplication of 2D DCT base functions  $C_{li} \cdot C_{mj}$  can be defined as

$$C_{li} C_{mj} = \cos \left[ \frac{\pi}{N} \left( i + \frac{1}{2} \right) l \right] \cdot \cos \left[ \frac{\pi}{N} \left( j + \frac{1}{2} \right) m \right] \quad (2)$$

Considering a block of 8x8 in the image and treating the top left corner as the location of (0,0), a square of frequency components is the product of the 2D DCT. It contains one DC coefficient  $X(0,0)$  at the zero coordinates. The most important elements of the signal are concerned near this DC coefficient.

One of the popular techniques in the face recognition is vector quantization algorithms. Several methods are proposed already to extract feature vector from the image. They are PCA [13],

Wavelet analysis, LDA [14], EBGm [13] are some of the examples in this regard. Principle Component Analysis (PCA) technique reduces the dimension of data by one order by means of data compression basics and produces the most effective lower dimensional structure of facial patterns [15]. Due to reduction in dimension, it

removes some information which is not useful and precisely decomposes the face structure into orthogonal components. These orthogonal components are known as Eigen faces. Each face image after the application of PCA is represented as a feature vector which is stored in the form of a 1D array. The distance between the respective feature vectors of images is compared to find the match [16]. In LDA, samples of unknown classes are segregated based on training samples of known classes. While the linear characteristics of the faces are treated in LDA, the nonlinear characteristics of face are considered in EBGm. Two dimensional DCT [25] has been used as a feature extraction step in various studies on face recognition. Other popular transforms Walsh-Hadamard transform [27, 28, 29], Wavelet transform also have been proposed [17, 23, 24, 26, 27] in the past. As a different approach, for recognizing objects from large image databases, methods based on histograms were proposed in the recent years. Color histograms were launched initially by Swain and Ballard and developed by others [18, 19, 20, 21, 22].

## III. THREE DIMENSIONAL DISCRETE COSINE TRANSFORMATION:

3D DCT is generally used both for JPEG and MPEG in image and video compression methods. However, these methods are not lossless. With growing demand for higher compression ratio (CR) the quality of the output image or video sequence reduces as a result of removing redundant data. Both methods use Three-Dimensional Discrete Cosine Transform (3D DCT) to produce a kind of spatial frequency spectrum. The coefficients of the DCT matrix of low frequency components can be stored with lower accuracy

accordingly to different sensitivity of human vision to color or brightness changes in large areas than to the high frequency brightness variations.

The MPEG video sequence can be treated as series of 2D images and all such images can be compressed using 3D DCT. Also, it is possible to compressed different images of same size using 3D DCT. This idea differs by using “video cube” which is a cube of  $N \times N \times N$  video elements.

The three-dimensional DCT can be treated as a composition of three 1D DCT along each dimension. The formal definition is

$$X(l, m, n) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} x(i, j, k) \cdot C_{li} \cdot C_{mj} \cdot C_{nk} \quad (3)$$

Where  $x(i, j, k)$  is a value of the video cube element or series of images. For example, 8 images can be considered if a block size of  $8 \times 8$  is taken for transformation. In this configuration,  $k$  is the position of the image. For the pixel which is positioned at the coordinates  $(i, j, k)$ ,  $X(l, m, n)$  is a 3D DCT coefficient at the position  $l, m, n$  and index take values  $l, m, n = 0, 1, \dots, N-1$ .

The multiplication of the 3D DCT base function  $C_{li} \cdot C_{mj} \cdot C_{nk}$  can be defined as

$$C_{li} \cdot C_{mj} \cdot C_{nk} = \cos \left[ \frac{\pi}{N} \left( i + \frac{1}{2} \right) l \right] \cdot \cos \left[ \frac{\pi}{N} \left( j + \frac{1}{2} \right) m \right] \cdot \cos \left[ \frac{\pi}{N} \left( k + \frac{1}{2} \right) n \right]$$

As a result, a cube of frequency components is produced. It contains one DC coefficient  $X(0,0,0)$  at the zero coordinates. The most important elements of the signal are concerned near this DC coefficient.

### QUANTIZATION:

The human eye allows removing a lot of redundant information in the zone of higher frequency coefficients. This can be achieved by dividing each frequency component by an appropriate constant and by rounding it to the nearest integer. As a consequence, many of the higher frequency coefficients become zero. The quantized can be computed with

$$X_4(l, m, n) = \frac{X(l, m, n)}{Q(l, m, n)}$$

(3)

Where  $X(l, m, n)$  are the frequency coefficients before quantizing  $X_4(l, m, n)$  are the frequency coefficients after quantizing and  $Q(l, m, n)$  are the quantizing coefficients. This operation produces lossy information and as a result these components cannot be restored in the decompression process due to loss of information occurred when the coefficients are rounded. The advantage of carrying out such an operation is it results in lesser amount of data to store. It is necessary to decide which constant will be used for quantizing each frequency component therefore the quantization cube must be defined. Its segments determine the compression ratio and the quality of output video sequence.

### ENTROPY CODING:

Entropy coding is one of the popular methods of lossless data compression. One of the most common techniques in the entropy coding is the Huffman coding which is also used in JPEG and MPEG. Data is the quantized cube, in the case of a video or set of images, must be rearranged into a “zig-zag” order. If it is a single image, then it is known as a quantized block. The more zeros will be in the straight line the less data will be necessary to store. Consequently it also influences the final compression ratio.

A 3D face recognition method was proposed by some researchers in ref [30]. This method consists of 3 parts, namely, face feature detection, face alignment and face matching which in turn include surface matching, principal component analysis (PCA) [31] and linear discriminant analysis (LDA) [32]. In the recognition method detailed in [30], the initial step is to identify the face feature points. Such identified feature points are located automatically. These feature points are used in rotating and translation so that the unknown probe faces and those in the database are frontal facing. To match up the probe and database face more efficiently, they are aligned to a fixed position and a surface matching method is used. One of the important aspects in the face recognition is to identify the areas in the face which are less susceptible to facial expression. Usually, the area

between forehead and nose are ideal for this purpose. To achieve this, the face row with the nose tip is identified and then the horizontal face slice is segmented out slice by slice between the nose row and 100-120 rows above it. The distance between images stored in the database, also known as database candidates and unknown probe slice is calculated by the vertical distance. Since each contour slice does not have a line equation, a replacement is to connect each neighboring point with a straight line.

Therefore, the vertical distance line, created in the process explained above, will intersect with two lines from the database and the probe; and the distance between the two intersection points will be the distance required. As the faces of the database and the probe are not aligned using Iterative Closest Point (ICP) [33], using only the surface matching method will not result accurate face recognition. To achieve a good face recognition, Principal Component Analysis (PCA) [31] along with Linear Discriminant Analysis (LDA) [32] is performed in addition on the 20 closest matches from the surface matching result. For the PCA with LDA method, instead of using 2D gray images, the method proposed in [34] uses 3D range information instead to create the LDA Eigen space. This 3D face recognition method is performed on both compressed and uncompressed 3D range images to determine how much degradation the recognition rate will have due to using compressed images.

#### IV. CONCLUSION:

In this review, the progress made in the area of face recognition using various compression algorithms especially 2D DCT and 3D DCT. While 2D DCT is limited to compression of only the images, the 3D DCT can be applied both to the compression of both videos and a set of images. Based on the study conducted, though there is great deal of progress made in the area of 2D DCT related face recognition in decompressed mode and compressed modes, it is not so in the case of 3D DCT related face recognition. 3D DCT can be used to compress multiple images depending upon the block size chosen, with higher compression ratios compared to the 2D DCT. Hence there is a great opportunity to deploy the 3D DCT in

face recognition.

#### References

- [1] Zhao W., Chellappa R., Rosenfeld A., Phillips P.J., Face Recognition: A Literature Survey, *ACM Computing Surveys*, Vol. 35, Issue 4, December 2003, pp. 399-458
- [2] Delac K., Grgic M., A Survey of Biometric Recognition Methods, *Proc. of the 46th International Symposium Electronics in Marine, ELMAR-2004*, Zadar, Croatia, 16-18 June 2004, pp. 184-193
- [3] Li S.Z., Jain A.K., ed., *Handbook of Face Recognition*, Springer, New York, USA, 2005
- [4] Delac, K., Grgic, M. (eds.), *Face Recognition*, I-Tech Education and Publishing, ISBN 978-3-902613-03-5, Vienna, July 2007, 558 pages
- [5] Rakshit, S., Monro, D.M., An Evaluation of Image Sampling and Compression for Human Iris Recognition, *IEEE Trans. on Information Forensics and Security*, Vol. 2, No. 3, 2007, pp. 605-612
- [6] Matschitsch, S., Tschinder, M., Uhl, A., Comparison of Compression Algorithms' Impact on Iris Recognition Accuracy, *Lecture Notes in Computer Science - Advances in Biometrics*, Vol. 4642, 2007, pp. 232-241
- [7] Funk, W., Arnold, M., Busch, C., Munde, A., Evaluation of Image Compression Algorithms for Fingerprint and Face Recognition Systems, *Proc. from the Sixth Annual IEEE Systems, Man and Cybernetics (SMC) Information Assurance Workshop*, 2005, pp. 72-78
- [8] Mascher-Kampfer, A., Stoegner, H., Uhl, A., Comparison of Compression Algorithms' Impact on Fingerprint and Face Recognition Accuracy, *Visual Communications and Image Processing 2007 (VCIP'07)*, *Proc. of SPIE 6508*, 2007, Vol. 6508, 650810, 12 pages
- [9] Elad, M., Goldenberg, R., Kimmel, R., Low Bit-Rate Compression of Facial Images, *IEEE Trans. on Image Processing*, Vol. 16, No. 9, 2007, pp. 2379-2383
- [10] Skodras A., Christopoulos C., Ebrahimi T., The JPEG 2000 Still Image Compression Standard, *IEEE Signal Processing Magazine*, Vol. 18, No. 5, September 2001, pp. 36-58

- [11] Wallace G.K., The JPEG Still Picture compression Standard, Communications of the ACM, Vol. 34, Issue 4, April 1991, pp. 30-44.
- [12] K. R. Rao and P. Yip. *Discrete Cosine Transform; Algorithms, Advantages and Applications*. Academic Press Inc., 1990.
- [13] P. N. Belhumeur, J. P. Hespanha, D. J. Kriegman. "Eigen faces vs. fisher faces: Recognition using class specific linear projection". *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 19(7):711-720, 1997
- [14] M. Begum, N. Nahar, K. Fatimah, M. K.Hasan and M. A. Rahaman. "An Efficient Algorithm for Codebook Design in Transform Vector Quantization". WSCG, 2003
- [15] F. Basit, M. Y. Javed and U. Qayyum. "Face Recognition Using Processed Histogram and Phase-only Correlation (POC)". International conference on Emerging Technologies (ICET), 2007
- [16] M. J. Swain and D. H. Ballard, "Indexing via color histogram", In Proceedings of third international conference on Computer Vision (ICCV), Osaka, Japan, 1990.
- [17] H. K. Ekenel, R. Stiefelhagen. "Analysis of Local Appearance Based Face recognition: Effects of Feature Selection and Feature Normalization". International Conference on Computer vision and Pattern Recognition Workshop, 2006
- [18] G. L. Gimel'farb, A. K. Jain. "On retrieving textured images from an image database". *Pattern Recognition*, 29(9):1461-1483, 1996
- [19] C. Dorai, A. K. Jain, Cosmos. "A representation scheme for free form surfaces". *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 19(10):1115-1130, 1997
- [20] B. Huet, E. R. Hancock. "Line pattern retrieval using relational histograms". *IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)*, 21(12):1363-1370, 1999
- [21] Y. Li, E. R. Hancock. "Face Recognition using Shading-based Curvature Attributes". *IEEE Proceedings of the 17th International Conference on Pattern Recognition (ICPR'04)* 1051-4651/04
- [22] H.B.Kekre, S. D. Thepade. "Improving the Performance of Image Retrieval using Partial Coefficients of Transformed Image". *International Journal of Information Retrieval (IJIR)*, Serials Publications, 2(1):72-79, 2009
- [23] H.B.Kekre, T. Sarode, S. D. Thepade. "DCT Applied to Row Mean and Column Vectors in Fingerprint Identification". In Proceedings of International Conference on Computer Networks and Security (ICCNS), VIT, Pune, 2008
- [24] H.B.Kekre, S. D. Thepade, A. Athawale, A. Shah, P. Verlekar, S. Shirke. "Energy Compaction and Image Splitting for Image Retrieval using Kekre Transform over Row and Column Feature Vectors". *International Journal of Computer Science and Network Security (IJCSNS)*, 10(1): 2010, (ISSN: 1738-7906) Available at [www.IJCSNS.org](http://www.IJCSNS.org).
- [25] H.B.Kekre, S. D. Thepade, A. Athawale, A. Shah, P. Verlekar, S. Shirke. "Performance Evaluation of Image Retrieval using Energy Compaction and Image Tiling over DCT Row Mean and DCT Column Mean". Springer-International Conference on Contours of Computing Technology (Thinkquest-2010), Babasaheb Gawde Institute of Technology, Mumbai, 2010
- [26] H. B. Kekre, T. K. Sarode, S. D. Thepade. "Image Retrieval by Kekre's Transform Applied on Each Row of Walsh Transformed VQ Codebook". (Invited), ACM-International Conference and Workshop on Emerging Trends in Technology (ICWET 2010), Thakur College of Engg. And Tech., Mumbai, 2010
- [27] H. B. Kekre, Ms. T. K. Sarode, S. D. Thepade. "Image Retrieval using Color-Texture Features from DCT on VQ Codevectors obtained by Kekre's Fast Codebook Generation". *ICGST International Journal on Graphics, Vision and Image Processing (GVIP)*, 9(5):1-8, 2009. Available at: <http://www.icgst.com/gvip/volume9/Issue5/P1150921752.html>.
- [28] H. B. Kekre, S. Thepade, A. Maloo. "Image Retrieval using Fractional Coefficients of Transformed Image using DCT and Walsh Transform". *International Journal of Engineering Science and Technology*, 2(4): 362-371, 2010
- [29] H. B. Kekre, S. Thepade, A. Maloo. "Performance Comparison of Image Retrieval Using Fractional Coefficients of Transformed Image Using DCT, Walsh, Haar and Kekre's Transform". *CSC-International Journal of Image processing (IJIP)*, 4(2)142-155, 2010
- [30] Wei Jen Chew, Kah Phooi Seng, Heng Fui Liau and Li-Minn Ang, " New 3D Face Matching

Technique for 3D Model Based Face Recognition", accepted by International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS), 2008.

[31] M. Turk and A. Pentland. Eigen faces for recognition. *Journal of Cognitive Neuroscience*, 3(1):71-86, Mar. 1991.

[32] P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman. Eigen faces vs. Fisher faces: Recognition using class specific linear projection. *IEEE Trans. Pattern Analysis and Machine Intelligence*, 19(7):711-729, Jul. 1997.

[33] P. Besl and N. McKay. A method for registration of 3-D shapes. *IEEE Trans. Pattern Analysis and Machine Intelligence*, 14(2):239-256, 1992.

[34] W.J. Chew \*, K.P. Seng, W.C. Chia, L.M. Ang and L.W. Chew, 3D Face Recognition System with Compression, *Proceedings of the International MultiConference of Engineers and Computer Scientists 2009 Vol I*