Assorted Color Spaces to improve the Image Retrieval using VQ Codebooks Generated using LBG and KEVR

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ABSTRACT
The paper presents performance comparison of image retrieval methods based on texture feature extraction using Vector Quantization (VQ) codebook generation techniques like LBG and KEVR (Kekre's Error Vector Rotation) with assorted color spaces. The image is divided into non overlapping blocks of size 2x2 pixels (each pixel with red, green and blue component). Each block corresponds to one training vector of dimensions 12. The collection of training vectors is called a training set. The texture feature vector of the images are obtained from the most popular VQ algorithms LBG and KEVR applied on the image training set and codebooks of size 8, 16, 32, 64 128, 256 and 512 are generated. These codebooks are the feature vector set for Content Based Image Retrieval (CBIR). The results are obtained using six different color spaces such as RGB, LUV, YCgCb, YCbCr, YUV and YIQ. For experimentation, the generic image database having 1000 images is used. From the results it is observed that KEVR based CBIR shows better performance over LBG based CBIR. Overall in all codebook sizes KEVR in YUV color space gives the best results with higher precision-recall crossover point values; closely followed by YCbCr color space.

Keywords
CBIR, Texture, Vector Quantization, LBG, KEVR, Color Spaces.

1. INTRODUCTION
The Rapid advancement in modern internet technology has provoked people to communicate and express by sharing images, video, and other forms of online media [1]. The need for faster and better image retrieval techniques is increasing day by day. In Literature very rigorous and excellent survey is available on the image retrieval techniques [2, 3, 4]. Modern image search engines [5] retrieve the images based on their visual contents, commonly referred to as Content Based Image Retrieval (CBIR) systems [6]. There are several applications of CBIR systems like fabric and fashion design, interior design as panoramic views [7,8,9], art galleries [7], museums, architecture/engineering design [4], weather forecast, geographical information systems, remote sensing and management of earth resources [10,11], scientific database management, medical imaging, trademark and copyright database management, the military, law enforcement and criminal investigations, intellectual property, picture archiving and communication systems, retailing and image search on the Internet.

Typical CBIR systems can organize and retrieve images automatically by extracting some features such as color, texture, shape from images and looking for similar images which have similar feature [6]. Generally CBIR systems have two phases. First phase is feature extraction (FE), a set of features, called feature vector, is generated to accurately represent the content of each image in the database. A feature vector is much smaller in dimension as that of the original image [12, 13]. The second phase is matching phase which requires similarity measurement (SM) between the query image and each image in the database using their features computed in first phase so that the most similar images can be retrieved [14, 15]. A variety of feature extraction techniques are available in literature like color based feature extraction techniques include color histogram, color coherence vector, color moments, circular ring histogram [16], BTC extensions [12, 15]. Texture based feature extraction techniques such as co-occurance matrix [17], Fractals [18], Gabor filters [18], variations of wavelet transform [1], Kekre transform [19]. Effort has been made to extend image retrieval methodologies using combination of color and texture as the case in [12] where Walshlet Pyramids are introduced. The combination of color and texture feature extraction methods for CBIR outperforms the CBIR methods that use just color and texture features [5, 10].

In section 2 texture feature extraction using VQ based methods viz. LBG and newly proposed KEVR are discussed. In section 3, technique for image retrieval using vector quantization is proposed. Section 4 discusses various color spaces. Results and discussion are given in section 5 and conclusions are presented in section 6.

2. VQ BASED METHOD
Vector Quantization (VQ) [20-25] is an efficient technique for data compression. VQ has been very popular in variety of research fields such as video-based event detection [26], speech

data compression, image segmentation, CBIR [5, 10, 14], face recognition, iris recognition, data hiding etc. VQ can be defined as the mapping function that maps k-dimensional vector space to the finite set $\mathbf{CB = \{ C_1, C_2, C_3, ..., C_N\}}$. The set CB is called codebook consisting of N number of codevectors and each codevector $C_i = \{c_{i1}, c_{i2}, c_{i3}, \ldots\ldots, c_{ik}\}$ is of dimension k. The codebook is the feature vector of the entire image and can be generated by using clustering techniques. The method most commonly used to generate codebook is the Linde-Buzo-Gray (LBG) algorithm [20, 21]. The drawback of LBG algorithm is that the cluster elongation is 135^0 with horizontal axis in two dimensional cases which results in inefficient clustering. The disadvantage of LBG is overcome in Kekre's Error Vector Rotation (KEVR) [27] algorithm. To generate the codebook, the image is first divided into fixed size blocks, each forming a training vector $\mathbf{X_i = (x_{i1}, x_{i2}, \ldots\ldots., x_{ik})}$.The set of training vectors is a training set. This training set is initial cluster. The clustering algorithms like LBG and KEVR are then applied on this initial cluster to generate the codebook of desired size. LBG is standard VQ codebook generation algorithm. The KEVR algorithms for codebook generation are discussed. In Kekre Error Vector Rotation algorithm (KEVR) algorithm two vectors v_1 & v_2 are generated by adding error vector to the codevector. Euclidean distances of all the training vectors are computed with vectors v_1 & v_2 and two clusters are formed based on closest of v_1 or v_2. The codevectors of the two clusters are computed and then both clusters are splitted by adding and subtracting error vector rotated in k-dimensional space at different angle to both the codevector. This modus operandi is repeated for every cluster and every time to split the clusters error ei is added and subtracted from the codevector and two vectors v_1 and v_2 is generated. Error vector e_i is the i^{th} row of the error matrix of dimension k. The error vectors matrix E is given in equation 1.

$$E = \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \\ e_5 \\ . \\ . \\ . \\ . \\ e_k \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 & 1 & \ldots\ldots & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & \ldots\ldots & 1 & 1 & -1 \\ 1 & 1 & 1 & 1 & \ldots\ldots & 1 & -1 & 1 \\ 1 & 1 & 1 & 1 & \ldots\ldots & 1 & -1 & -1 \\ 1 & 1 & 1 & 1 & \ldots\ldots & -1 & 1 & 1 \\ \ldots & & & & & & & \\ \ldots & & & & & & & \\ . & & & & & & & \\ . & & & & & & & \\ \ldots & & & & & & & \end{bmatrix} \quad (1)$$

Note that these error vector sequences have been obtained by taking binary representation of numbers starting from 0 to k-1 and replacing zeros by ones and ones by minus ones. Algorithm for KEVR Codebook generation can be explained by following steps

Step 1: Divide the image into non overlapping blocks and convert each block to vectors thus forming a training vector set.

Step 2: initialize i=1;

Step 3: Compute the centroid (codevector) of this training vector set.

Step 4: Add and subtract error vector e_i from the codevector and generate two vector v_1 and v_2.

Step 5: Compute Euclidean distance between all the training vectors belonging to this cluster and the vectors v_1 and v_2 and split the cluster into two.

Step 6: Compute the centroid (codevector) for clusters obtained in the above step 5.

Step 7: increment i by one and repeat step 4 to step 6 for each codevector.

Step 8: Repeat the Step 3 to Step 7 till codebook of desired size is obtained.

3. IMAGE RETRIEVAL USING VQ BASED TECHNIQUES

Image retrieval based on content requires extraction of features of the image, matching these features with the features of the images in the database and retrieving the images with the most similar features. Here, paper discusses the feature extraction technique based on vector quantization.

A. Proposed Feature Extraction Technique

i. Divide the image into blocks of size 2x2 (Each pixel having red, blue and green component, thus resulting in a vector of 12components per block)
ii. Form the training set/ initial cluster from these vectors.
iii. Compute the initial centroid of the cluster.
iv. Obtain the codebook of desired size using LBG/KEVR algorithm. This codebook represents the feature vector/signature of the image.
v. Repeat steps 2-6 for each image in the image database.
vi. Store the feature vector obtained in step 5 in the feature vector database.

B. Query Execution

For a given query image compute the feature vector using the proposed feature extraction technique. To retrieve the most similar images, compare the query feature vector with the feature vectors in database. This is done by computing the distance between the query feature vectors with those in feature vector database. Euclidian distance and correlation coefficient are most commonly used as similarity measure in CBIR. Here Euclidian distance is used as a similarity measure. The proposed KEVR based codebook generation proves to be better than LBG based codebook generation in CBIR.

4. COLOR SPACES

Just as discussed in section 3 for RGB color space, the CBIR using Vector Quantization can be used with other color spaces. Here total six color spaces like RGB, Kekre's LUV [3], YCbCr[15], YUV[9], YIQ[20], Kekre's YCgCb[20] are considered. The six color spaces along with LBG and KEVR codebook generation algorithm extended to 7 different size codebook result into total 84 CBIR methods.

5. RESULT AND DISCUSSIONS

The proposed CBIR techniques are implemented in Matlab 7.0 on Intel Core 2 Duo Processor T8100, 2.1 GHz, 2 GB RAM machine to obtain results. The results are obtained on the general database consisting of 1000 images from 11 different categories (some of these are taken from [28]). To test the proposed method, from every class five query images are selected randomly. So in all 55 query images are used. To check the performance of proposed technique we have used precision and recall. The standard definitions of these two measures are given by following equations.

$$Precision = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_images\_retrieved} \quad (2)$$

$$Recall = \frac{Number\_of\_relevant\_images\_retrieved}{Total\_number\_of\_relevent\_images\_in\_database} \quad (3)$$

The crossover point of precision and recall acts as performance measure of CBIR technique. Higher value of precision-recall at crossover point indicates better performance of image retrieval method. Results are obtained for six different color spaces using LBG and KEVR to generate the codebook of sizes 8x12 16x12, 32x12, 64x12, 128x12, 256x12 and 512x12. Hence in all 84 codebooks are obtained.

Figure 1 shows the average precision/ recall values for LBG-CBIR techniques in RGB color space for the various codebook sizes, the best performance is given by 32x12 codebook size.

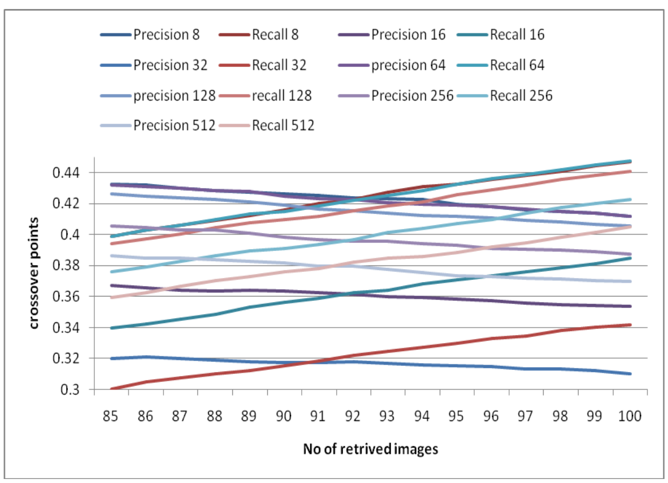

Figure 1: Cross-over points of average precision and recall using RGB-LBG-CBIR for the codebook sizes varying from 16x12 to 512x12.

Figure 2 shows the precision/recall values of different codebook sizes for RGB-KEVR-CBIR methods, Figure 3 shows the comparative analysis of LBG-CBIR for all codebook sizes from 8x12 to 512x12 using different color spaces. From the graph it is observed that the codebook size-32 for LUV color space gives better performance than the other. Figure 4 shows comparative analysis of KEVR-CBIR for all codebook sizes from 8x12 to 512x12 using different color spaces. Here it is observed that the codebook size-128 for YUV color space gives better performance than all the other color spaces.

Figure 5 shows the comparison of the crossover points with respect to all six different color spaces for the LBG codebook size varying from 8x12 to 512x12.

Figure 6 shows the comparison of the crossover points with respect to all six different color spaces for the KEVR codebook size varying from 8x12 to 512x12.

In case of KEVR-CBIR, LUV, YCbCr and YUV gives better performance. YCbCr color space gives best performance within all color spaces at codebook size-128. The performance increases for the codebook size 8x12 to 128x12 and then the performance decreases due to the formation of voids in the codebooks.

In both the algorithms YCbCr, LUV and YUV color space gives better result as compare with other color spaces. Figure 7 shows the comparative analysis of LBG-CBIR and KEVR-CBIR with respect to the all six color spaces and for all seven codebook sizes varying from 8x12 to 512x12. Over all KEVR-CBIR in YUV color space gives better performance as compared to other color spaces.

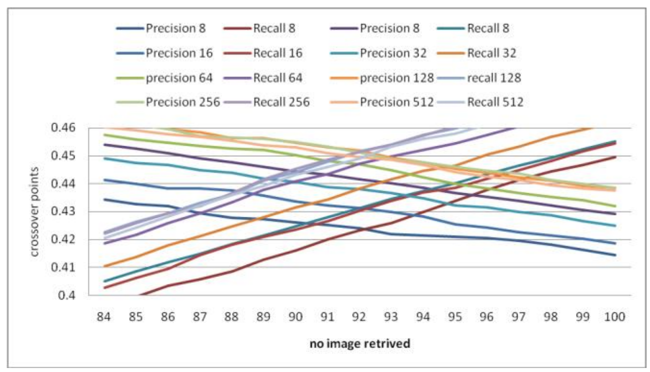

Figure 2 **:** Cross-over points of average precision and recall using RGB-KEVR-CBIR for the different codebook sizes varying from 16x12 to 512x12.

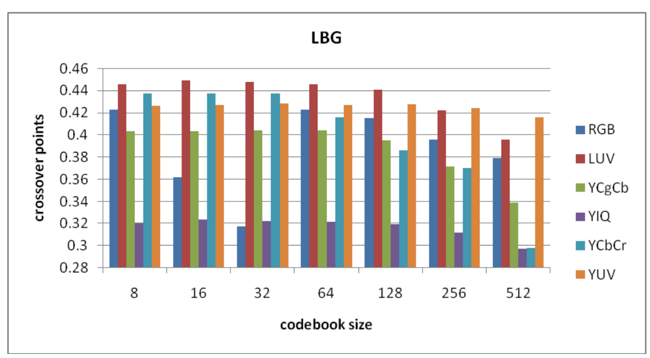

Figure 3: Crossover points of Average Precision and Average Recall plotted against the codebook size varying from 8x12 to 512x12 for the proposed LBG-CBIR methods for the six different color spaces viz. RGB, LUV, YCgCb, YIQ, YCbCr, and YUV.

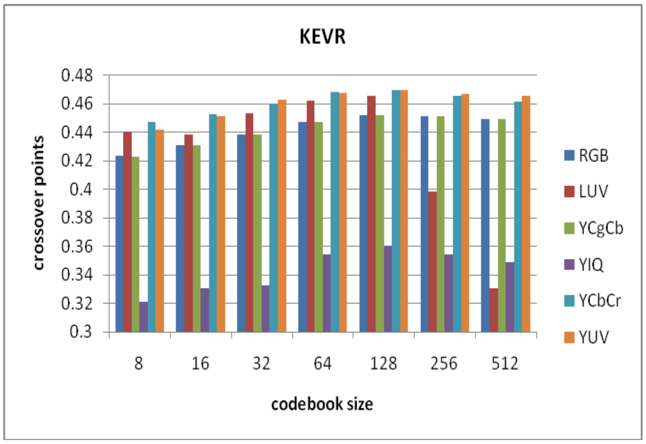

Figure 4: Crossover points of Average Precision and Average Recall plotted against the codebook size varying from 8x12 to 512x12 for the proposed KEVR-CBIR methods for the six different color spaces viz. RGB, LUV, YCgCb, YIQ, YCbCr, and YUV.

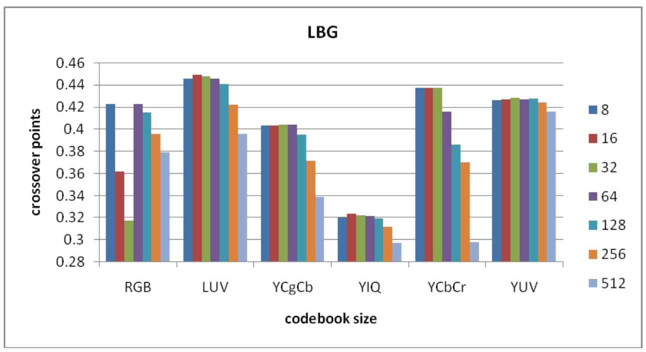

Figure 5: Crossover points of Average Precision and Average Recall plotted against different color spaces for the LBG-CBIR methods

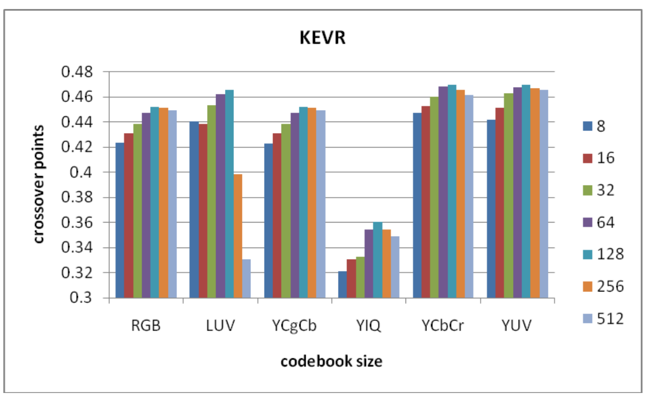

Figure 6: Crossover points of Average Precision and Average Recall plotted against different color spaces for the KEVR-CBIR methods

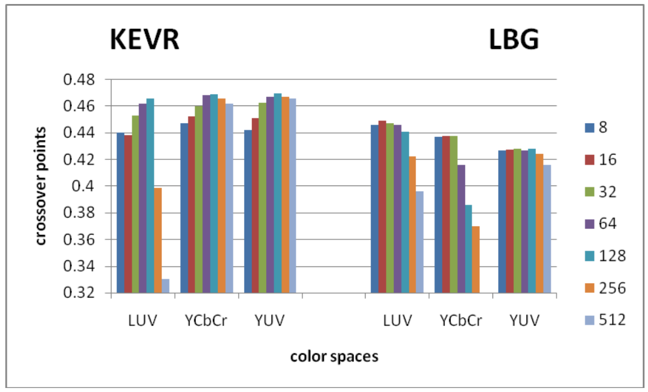

Figure 7: Crossover points of Average Precision and Average Recall plotted against color spaces for the proposed LBG-CBIR and KEVR-CBIR methods.

6. CONCLUSION

The use of vector quantization codebooks as the texture feature vectors in six different color spaces viz. RGB, LUV, YUV, YCgCb and YCbCr color spaces for image retrieval is proposed in this paper. For vector quantization the clustering algorithms used are well known Linde-Buzo-Gray (LBG) and Kekre's Error Vector Rotation (KEVR) algorithm. The seven codebook sizes varying from 8x12 to 512x12 are obtained using LBG and KEVR. Thus the two codebook generation algorithms and seven different codebook sizes per algorithm using six different color spaces result in 84 proposed image retrieval techniques. From the results it is observed that the KEVR based CBIR in YUV color space outperforms all the other color spaces.

7. REFERENCES

[1] Sanjoy Kumar Saha, Amit K. Das, B. Chanda, "CBIR using Perception based Texture and Color Measures", In : 17th Int. Conf. on Pattern Recognition(ICPR'04), Vol. 2, (Aug 2004).

[2] Yong Rui, Thomas S. Huang, "Image Retrieval: Current Techniques, Promising Directions, and Open Issues", Journal of Visual Communication and Image Representation vol. 10, pp.: 39–62, 1999.

[3] J. Weszka, C. Dyer, and A. Rosenfeld, "A comparative study of texture measures for terrain classification", IEEE Trans. on Sys., Man. and Cyb. SMC-6(4), 1976.

[4] P. P. Ohanian and R. C. Dubes, "Performance evaluation for four classes of texture features", Pattern Recognition 25(8), 1992, 819–833.

[5] H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, Vaishali S., "Improved Texture Feature Based Image Retrieval using Kekre's Fast Codebook Generation Algorithm", In: Springer-Int. Conf. on Contours of Computing Tech. (Thinkquest-2010), 13-14 March, BGIT, Mumbai (2010).

[6] H.B.Kekre, Sudeep D. Thepade, A.Athawale, A.Shah, P.Verlekar, S.Shirke, "Walsh Transform over Row Mean and

Column Mean using Image Fragmentation and Energy Compaction for Image Retrieval", In.: Int. Journal on Comp. Science and Engg. (IJCSE),Vol 2S, Issue 1, (Jan. 2010).

[7] H.B.Kekre, Sudeep D. Thepade, "Creating the Color Panoramic View using Medley of Grayscale and Color Partial Images", In: WASET Int. Journal of Electrical, Computer and System Engineering (IJECSE), Vol. 2, No. 3, Summer 2008. Available online at www.waset.org/ijecse/v2/v2-3-26.pdf (2008).

[8] H.B.Kekre, Sudeep D. Thepade, "Rotation Invariant Fusion of Partial Images in Vista Creation", WASET International Journal of Electrical, Computer and System Engineering (IJECSE), Volume 2, No. 2, Spring 2008. Available online at www.waset.org/ijecse/v2/v2-2-13.pdf (2008)

[9] H.B.Kekre, Sudeep D. Thepade, "Scaling Invariant Fusion of Image Pieces in Panorama Making and Novel Image Blending Technique", Int. Journal on Imaging (IJI), Autumn 2008, Volume 1, No. A08, Available online at www.ceser.res.in/iji.html (2008).

[10] H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, "Image Retrieval by Kekre's Transform Applied on Each Row of Walsh Transformed VQ Codebook", In.: Invited at ACM-Int. Conf. & Workshop on Emerging Trends in Tech. (ICWET),TCET, Mumbai, 26-27 Feb 2010, uploaded on ACM Portal. (2010)

[11] H.B.Kekre, Sudeep 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 Vector", In.: Int. Journal of Comp. Science &Network Security,Vol.10, No.1, Jan2010,www.IJCSNS.org. (2010).

[12] H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Color-Texture Features Extracted from Walshlet Pyramid., In: ICGST Int. Journal on Graphics, Vision & Image Processing (GVIP), Vol. 10, Issue I, pp.9-18, (Feb. 2010)

[13] H.B.Kekre, Sudeep D. Thepade, "Using YUV Color Space to Hoist the Performance of Block Truncation Coding for Image Retrieval", In.: Proc. of IEEE Int. Advanced Computing Conference 2009 (IACC'09), 6-7 March 2009 Thapar University, Patiala, INDIA,(2009).

[14] H. B. Kekre, Tanuja K. Sarode, Sudeep D. Thepade, "Image Retrieval using Color-Texture Features from DCT on VQ Codevectors obtained by Kekre's Fast Codebook Generation", In.: ICGST-Int. Journal GVIP, Vol. 9, Issue 5, pp. 1-8, (Sept 2009).

[15] H.B.Kekre, Sudeep D. Thepade, "Color Based Image Retrieval using Amendment Block Truncation Coding with YCbCr Color Space.", In.: Int. Journal on Imaging (IJI), Vol. 2, No. A09, Autumn 2009, pp. 2-14. Available online at www.ceser.res.in/iji.html (2009)

[16] Wang Xiaoling, "A Novel Cicular Ring Histogram for Content-based Image Retrieval", In.: First International Workshop on Education Technology and Computer Science.(2009).

[17] Jing Zhang, Gui-li Li, Seok-wum He, "Texture-Based Image Retrieval By Edge Detection Matching GLCM", In.: 10th Int. conf. on High Perf. Computing and Comm., (Sept. 2008)

[18] Xiaoyi Song, Yongjie Li, Wufan Chen, "A Textural Feature Based Image Retrieval Algorithm", In.: Proc. of 4th Int. Conf. on Natural Computation. (Oct. 2008).

[19] H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Non-Involutional Orthogonal Kekre's Transform", In.: Int. Journal of Multidisciplinary Research & Advances in Engg. (IJMRAE), Vol.1, No. I, www.ascent-journals.com (209).

[20] R. M. Gray, "Vector quantization", In.: IEEE ASSP Mag., pp.: 4-29, (Apr. 1984).

[21] Y. Linde, A. Buzo, and R. M. Gray, "An algorithm for vector quantizer design", In.: IEEE Trans. Commun., vol. COM-28, no. 1, pp.: 84-95. (1980).

[22] H. B. Kekre, Tanuja K. Sarode, "An Efficient Fast Algorithm to Generate Codebook for Vector Quantization", In.: 1st Int. Conf. on Emerging Trends in Engg. and Technology, ICETET-2008, Raisoni COE, Nagpur, India, pp.: 62- 67, 16-18 July 2008. (2008).

[23] H. B. Kekre, Tanuja Sarode, "Fast Codebook Generation Algorithm for Color Images using Vector Quantization", In.: Int. Journal of Comp. Sci. & IT, Vol.1, No.1,(Jan 2009).

[24] H. B. Kekre, Tanuja K. Sarode, "Fast Codevector Search Algorithm for 3-D Vector Quantized Codebook", In.: WASET Int. Journal of cal Comp.Info. Science & Engg. (IJCISE), Vol. 2, No. 4, pp. 235-239, Available: http://www.waset.org/ijcise.(Fall 2008)

[25] H. B. Kekre, Tanuja K. Sarode, "Fast Codebook Search Algorithm for Vector Quantization using Sorting Technique", In.: ACM Int. Conf. on Advances in Computing, Comm. and Control (ICAC3-2009), pp: 317-325, 23-24 Jan 2009, FCRCE, Mumbai. (2009).

[26] H. Liao, D. Chen, C. Su, H. Tyan, "Real-time event detection and its applications to surveillance systems", In.: IEEE Int. Symp. Circuits & Systems, Kos, Greece, pp.: 509–512, (May 2006).

[27] H. B. Kekre, Tanuja K. Sarode, "New Clustering Algorithm for Vector Quantization using Rotation of Error Vector", In.: Int. Journal of Computer Science & Information Security, Vol. 7, No. 03. (2010).

[28] http://wang.ist.psu.edu/docs/related/Image.org (Last referred on 23 Sept 2008).

[29] H.B.Kekre, Sudeep D. Thepade, "Boosting Block Truncation Coding with Kekre's LUV Color Space for Image Retrieval" WASET International Journal of Electrical Computer and Systems Engineering (IJECSE), Volume 2, Number 3, pp. 172-180, Spring 2008. http://www.waset.org/ijecse.

[30] H.B.Kekre, Sudeep D. Thepade, "Improving 'Color to Grey and Back' using Kekre's LUV Color Space", In Proc. of IEEE International Advanced Computing Conference 2009 (IACC'09), Thapar University, Patiala, INDIA, 6-7 March 2009. Is uploaded and available online at IEEE Xplore

[31] H.B.Kekre, Sudeep D. Thepade, Adib Parkar, "A Comparison of Kekre's Fast Search and Exhaustive Search for various Grid Sizes used for Colouring a Greyscale Image", In Proc. of 2nd IEEE International Conference on Signal Acquisition and Processing (ICSAP 2010), IACSIT, Bangalore, pp. 53-57, 9-10 Feb 2010.

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