Image Retrieval using Fractional Energy of Column Mean of Row transformed Image with Six Orthogonal Image Transforms

Dr. H. B. Kekre*, Dr. Sudeep D. Thepade**, Dr. Archana Athawale***, Paulami Shah****

*(Sr. Professor, MPSTME, SVKM's NMIMS Deemed-to-be University, Vile Parle (W), Mumbai-56, India)
**(Associate. Professor, MPSTME, SVKM's NMIMS Deemed-to-be University, Vile Parle (W), Mumbai-56, India)
***(Asst. Professor, Thadomal Shahani Engg. College, Bandra (W), Mumbai-50, India)
****(M.E. Student, Thadomal Shahani Engg. College, Bandra (W), Mumbai-50, India)

ABSTRACT

The thirst of better and faster retrieval techniques has always fuelled to the research in content based image retrieval (CBIR). The paper presents innovative content based image retrieval (CBIR) techniques based on feature vectors as fractional coefficients of column mean of row transformed images using Discrete Cosine, Walsh, Haar, Slant, Discrete Sine, and Hartley transforms. Here the advantage of energy compaction of low frequency coefficients in transform domain is taken to greatly reduce the feature vector size per image by taking fractional coefficients of column mean of row transformed image. The feature vectors are extracted in six different ways from the column mean of row transformed image, with the first being considering all the coefficients of column mean of row transformed image and then six reduced coefficients sets (as 50%, 25%, 12.5%, 6.25%, 3.125%, 1.5625% of complete column mean of row transformed image) are considered as feature vectors. The six transforms are applied on the colour components of images to extract column mean of row transformed RGB plane respectively. Instead of using all coefficients of transformed images as feature vector for image retrieval, these six reduced coefficients sets for RGB feature vectors are used, resulting into better performance and lower computations. The proposed CBIR techniques are implemented on a database having 1000 images spread across 10 categories. For each proposed CBIR technique 40 queries (4 per category) are fired on the database and net average precision and recall are computed for all feature sets per transform. The results have shown performance improvement (higher precision and recall values) with fractional coefficients compared to complete transform of image at reduced computations resulting in faster retrieval. Finally Walsh transform surpasses all other discussed transforms in performance with highest precision and recall values for 25% of fractional coefficients.

Keywords - **CBIR, Cosine Transform, Walsh Transform, Haar Transform, Sine Transform, Slant Transform, Hartley Transform, Fractional Coefficients, Column Mean.**

1. INTRODUCTION

The computer systems have been posed with large number of challenges to store/transmit and index/manage large numbers of images effectively, which are being generated from a variety of sources. Storage and transmission is taken care by Image compression with significant advancements been made [1, 4, 5]. Image databases deal with the challenge of image indexing and retrieval [2, 6, 7, 10], which has become one of the promising and important research area for researchers from a wide range of disciplines like computer vision, image processing and database areas. The thirst of better and faster image retrieval techniques is till appetizing to the researchers working in some of important applications for CBIR technology like art galleries [12,14], museums, archaeology [3], architecture design [8,13], geographic information systems [5], weather forecast [5,22], medical imaging [5,18], trademark databases [21,23], criminal investigations [24,25], image search on the Internet [9,19,20].

1.1 Content Based Image Retrieval

In literature the term content based image retrieval (CBIR) has been used for the first time by Kato et.al.[4], to describe his experiments into automatic retrieval of images from a database by color and shape feature. The typical CBIR system performs two major tasks [16,17]. The first one is feature extraction (FE), where a set of features, called feature vector, is generated to accurately represent the content of each image in the database. The second task is similarity measurement (SM), where a distance between the query image and each image in the database using their feature vectors is used to retrieve the "closest" images [16, 17, 26]. For CBIR feature extraction the two main approaches are feature extraction in spatial domain [5] and feature extraction in transform domain [1]. The feature extraction in spatial domain includes the CBIR techniques based on histograms [5], BTC [2, 16, 23], VQ [11, 21, 25, 26]. The transform domain methods are widely used in image compression, as they give high energy compaction in transformed image [17, 24]. So it is obvious to use images in transformed domain for feature extraction in CBIR [1]. Transform domain results in energy compaction in few elements, so large number of the coefficients of transformed image can be neglected to reduce the size of feature vector [1]. Reducing the size feature vector using fractional coefficients of column mean of row transformed image and till getting the improvement in performance of image retrieval is the theme of the work presented here. Many Current Retrieval systems take a simple approach by using typically norm-based distances (e.g., Euclidean distance [2]) on the extracted feature set as a similarity function. The main premise behind these CBIR systems is that given a "good set" of features extracted from the images in the database (the ones that significantly capture the content of images.) then for two images to be "similar" their extracted features have to be "close" to each other. The Mean Square Distance between an image P and query image Q can be given as the equation 1 below

$$ED = \sum_{i=1}^{n} (Vpi - Vqi)^2 \quad (1)$$

Where, Vpi and Vqi be the feature vectors of image P and Query image Q respectively size 'n'.

2. Image Transforms Used

Here six orthogonal image transforms namely Cosine [1, 10, 21, 22, 24], Walsh [1, 11, 18, 19, 26], Haar [27], Slant [27], Hartley [27] and Sine [27] are used for transforming the image columns.

3. Column Mean

If Figure 1 is representing the image with n rows and n columns, the column mean vectors [8], [22] for this image will be as given in equation 2.

Column Mean Vector =
[Avg(Col 1), Avg(Col 2), …., Avg(Col n)] (2)

Row 1	35	34	…	25
Row 2	78	24	…	68
..	…	…	…	…
Row n	68	76	…	45

Avg (Col 1) = (35 + 78+…+68)/n

Fig. 1 Sample Image Template (with size nxn)

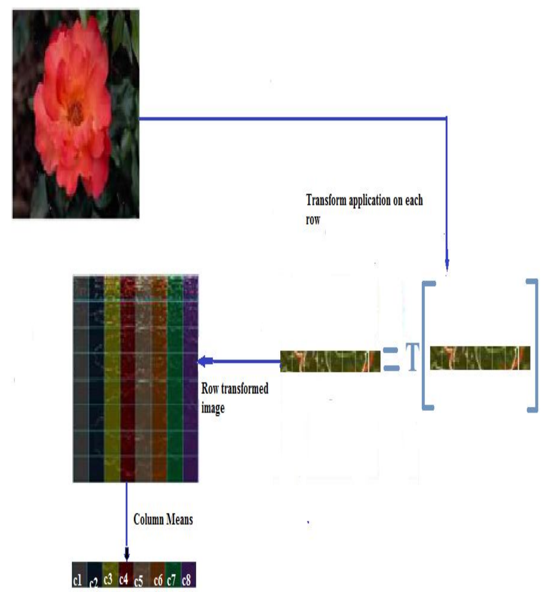

Fig. 2 Color Feature Extraction using Image Transform

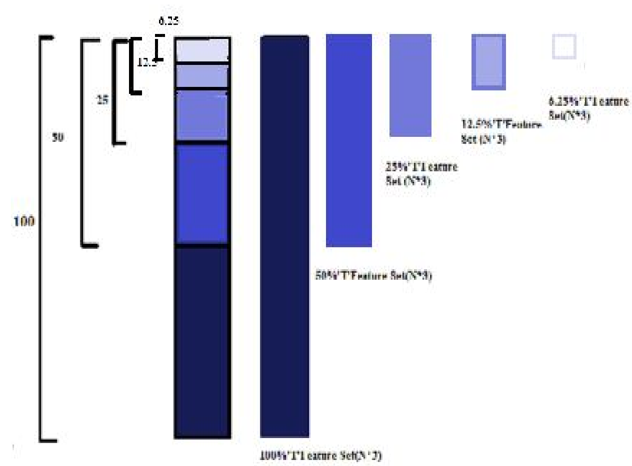

Fig. 3 Fractional Coefficients of column mean of row Transformed Images

4. Proposed CBIR-RGB Techniques

Figure 2 and Figure 3 explains the feature sets extraction used to extract feature sets for proposed CBIR techniques using fractional coefficients of column mean of row transformed images.

4.1 Feature Extraction for feature vector 'T-RGB'

Here the feature vector space of the image of size NxNx3 has NxNx3 number of elements. This is obtained using following steps of T-RGB

i. Extract Red, Green and Blue components of the color image.

ii. Apply the row Transform 'T' on individual color planes of image to extract feature vector.

iii. Compute the column mean vector to obtain the feature vector.

iii. The result is stored as the feature vector 'T-RGB' for the respective image.

Thus the feature vector database for Discrete Cosine Transform (DCT), Walsh, Haar, Slant, Hartley and Discrete Sine Transform (DST) is generated as DCT-RGB, Walsh-RGB, Haar-RGB, Slant-RGB, Hartley-RGB and DST-RGB respectively. Here the size of feature database is Nx3.

4.2 Query Execution for 'T-RGB' CBIR

Here the feature set of Nx3 for the query image is extracted using transform 'T' applied on the red, green and blue planes of query image. This feature set is compared with other feature sets in feature database using Mean Square distance as similarity measure. Thus DCT, Walsh, Haar, Slant, Hartley, DST transform based feature sets are extracted for query image and are compared respectively with DCT-RGB, Walsh-RGB, Haar-RGB, Slant-RGB, Hartley-RGB and DST-RGB feature sets to find Mean Square distance.

4.3 CBIR using 'Fractional-T-RGB'

As explained in section 4– 4.2 the 'T-RGB' feature extraction and query execution are extended to get 50%,25%, 12.5%, 6.25%, 3.125% and 1.5625% of T-RGB image retrieval techniques.

5. Implementation

The implementation of the three CBIR techniques is done in MATLAB 7.0 using a computer with Intel Core 2 Duo Processor T8100 (2.1GHz) and 2 GB RAM. The CBIR techniques are tested on the image database [15] of 1000 images spread across 10 categories of human being, animals, natural scenery and manmade things. The categories and distribution of the images is shown in Table 1.

Table 1: Image Database: Category-wise Distribution

Category	Tribes	Buses	Dinosaurs	Elephants	Roses
No. of Images	100	100	100	100	100
Category	Monuments	Horses	Mountains	Food Items	Beaches
No. of images	100	100	100	100	100

Fig.4 Sample Database Images

[Image database contains total 1000 images with 10 categories]

Figure 4 gives the sample database images from all categories of images including scenery, flowers, buses, animals, food items, monuments, and tribal people. To assess the retrieval effectiveness, we have used the precision and recall as statistical comparison parameters [1, 2] for the proposed CBIR techniques. The standard definitions of these two measures are given by equations 3 and 4:

$$\text{Precision} = \frac{\text{No. of relevant images received}}{\text{Total no. of images retrieved}} \quad (3)$$

$$\text{Recall} = \frac{\text{No. of relevant images retrieved}}{\text{No. of relevant images in database}} \quad (4)$$

6. Results and Discussion

For testing the performance of each proposed CBIR technique, per technique 40 queries (4 from each category) are fired on the database of 1000 variable size generic images spread across 10 categories. The query and database image matching is done using mean square distance. The average precision and average recall are computed by grouping the number of retrieved images sorted according to ascending average mean square distances with the query image.

The crossover point of precision and recall of the CBIR techniques acts as one of the important parameters to judge their performance [1, 2, 19, 20].

Figure 5 shows the average precision-recall crossover points plotted against percentage of coefficients considered of column mean of row transformed color image as the feature vector for proposed image retrieval techniques using DCT. Uniformly in all image retrieval techniques based on color DCT features 100% fractional feature set based image retrieval gives highest precision and recall values. However, the 50% fractional feature set based image retrieval gives similar performance with a negligible difference of 0.025%.

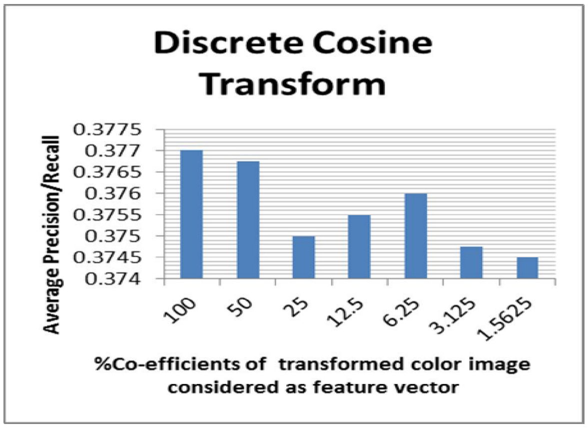

Fig. 5 DCT-RGB based CBIR

Figure 6 shows the average precision-recall crossover points plotted against percentage of coefficients considered of column mean of row transformed color image as the feature vector for proposed image retrieval techniques using Slant transform. Uniformly in all image retrieval techniques based on color slant transform features 50% fractional feature set based image retrieval gives maximum precision and recall values than the full set of coefficients considered.

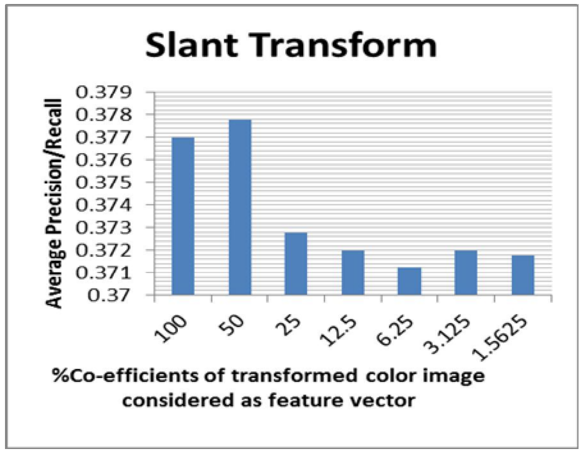

FIG. 6 SLANT-RGB BASED CBIR

Figure 7 shows the average precision-recall crossover points plotted against percentage of coefficients considered of column mean of row transformed color image as the feature vector for proposed image retrieval techniques using Haar transform. Uniformly in all image retrieval techniques based on color Haar transform features 1.5625% fractional feature set based image retrieval gives maximum average precision and recall values as that with the full set of coefficients considered.

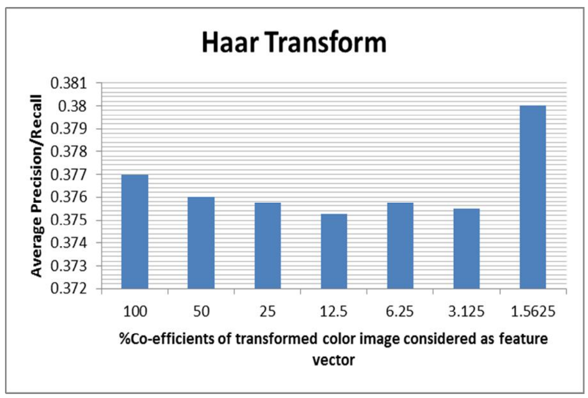

Fig. 7 Haar-RGB based CBIR

Figure 8 shows the average precision-recall crossover points plotted against percentage of coefficients considered of column mean of row transformed color image as the feature vector for proposed image retrieval techniques using Hartley transform. Uniformly in all image retrieval techniques based on color slant transform features 12.5% fractional feature set based image retrieval gives maximum average precision and recall values than the full set of coefficients considered.

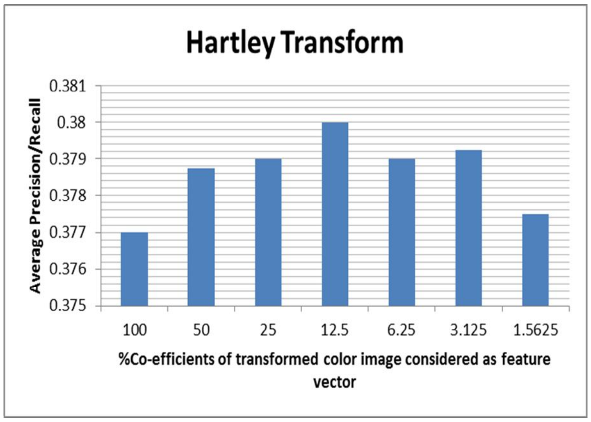

Fig. 8 Hartley-RGB based CBIR

Figure 9 shows the average precision-recall crossover points plotted against percentage of coefficients considered of column mean of row transformed color image as the feature vector for proposed image retrieval techniques using DST transform. Uniformly in all image retrieval techniques based on color DST transform features 100% feature set based image retrieval gives highest precision and recall values that However, the 50% fractional feature set based image retrieval gives similar performance with a negligible difference of 0.05%.

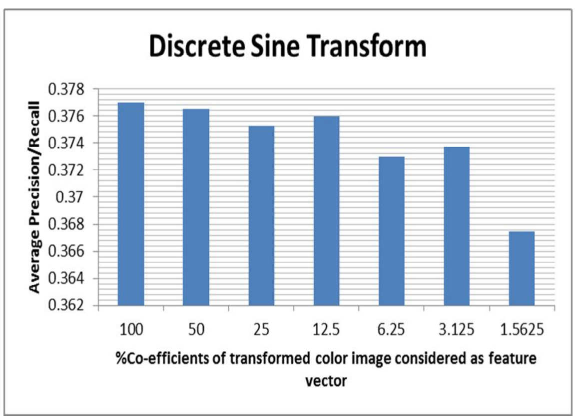

Fig. 9 DST-RGB based CBIR

Figure 10 shows the average precision-recall crossover points plotted against percentage of coefficients considered of transformed color image as the feature vector for proposed image retrieval techniques using Walsh transform. Uniformly in all image retrieval techniques based on color Walsh transform features 25% fractional feature set based image retrieval gives highest precision and recall values as that with the full set of coefficients considered.

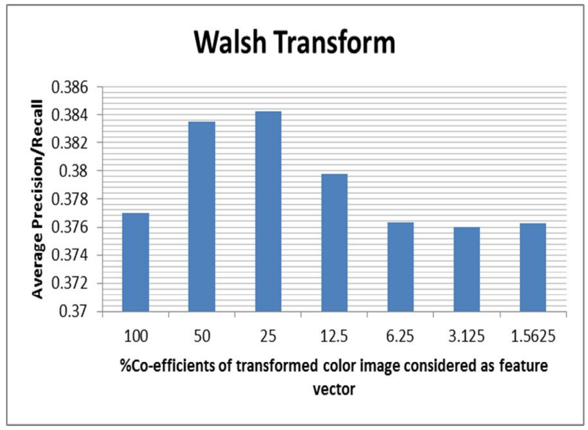

Fig. 10 Walsh-RGB based CBIR

Figure 11 and Figure 12 gives the comparisons of the six transforms method in RGB plane. Walsh transform surpasses all other discussed transforms in performance with highest precision and recall values for 25% of fractional coefficients

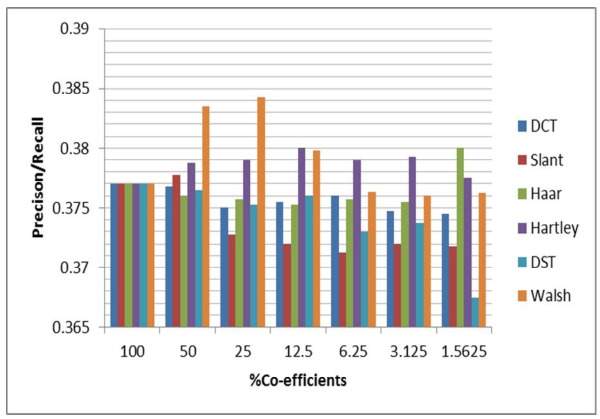

Fig. 11 Transform Comparisons in RGB based CBIR

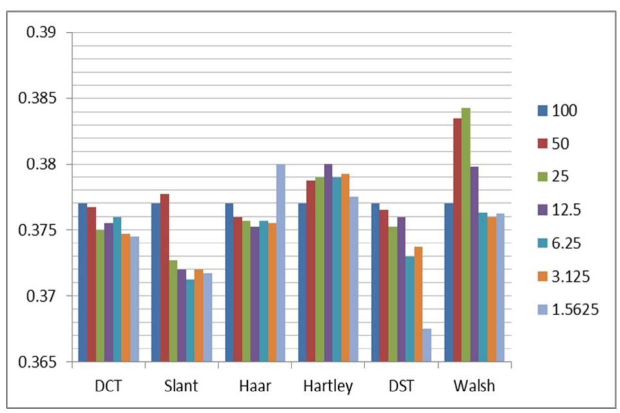

Fig. 12 Transform Comparison in RGB based CBIR

7. Conclusion

In the information age where the size of image databases is growing exponentially more precise retrieval techniques are needed, for finding relatively similar images. Computational complexity and retrieval efficiency are the key objectives in the image retrieval system. Nevertheless it is very difficult to reduce the computations and improve the performance of image retrieval technique. Here the performance of image retrieval is improved using fractional coefficients of column mean of row transformed images at reduced computational complexity. In the transforms (Slant, Hartley, Walsh and Haar), the average precision and average recall values for CBIR using fractional coefficients are higher than CBIR using full set of coefficients. Hence the feature vector size for image retrieval could be greatly reduced, which ultimately will result in faster query execution in CBIR with better performance. In all Walsh transform with fractional coefficients (25 % in RGB) gives best performance with highest crossover points of average precision and average recall. Thus feature extraction in lesser time is possible with increased performance. Finally the conclusion that the fractional coefficients gives better discrimination capability in CBIR than the complete set of transformed coefficients and image retrieval with better performanc at much faster rate can be done from the proposed techniques and experimentation done.

REFERENCES

[1] H.B.Kekre, Sudeep D. Thepade, "Improving the Performance of Image Retrieval using Partial Coefficients of Transformed Image", International Journal of Information Retrieval (IJIR), Serials Publications, Volume 2, Issue 1, 2009, pp. 72-79(ISSN: 0974-6285)

[2] H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Augmented Block Truncation Coding Techniques", ACM International Conference on Advances in Computing, Communication and Control (ICAC3-2009), pp. 384-390, 23-24 Jan 2009, Fr. Conceicao Rodrigous College of Engg., Mumbai. Is uploaded on online ACM portal.

[3] H.B.Kekre, Sudeep D. Thepade, "Scaling Invariant Fusion of Image Pieces in Panorama Making and Novel Image Blending Technique", International Journal on Imaging (IJI), www.ceser.res.in/iji.html, Volume 1, No. A08, pp. 31-46, Autumn 2008.

[4] Hirata K. and Kato T. "Query by visual example – content-based image retrieval", In Proc. of Third International Conference on Extending Database Technology, EDBT'92, 1992, pp 56-71

[5] H.B.Kekre, Sudeep D. Thepade, "Rendering Futuristic Image Retrieval System", National Conference on Enhancements in Computer, Communication and Information Technology, EC2IT-2009, 20-21 Mar 2009, K.J.Somaiya College of Engineering, Vidyavihar, Mumbai-77.

[6] Minh N. Do, Martin Vetterli, "Wavelet-Based Texture Retrieval Using Generalized Gaussian Density and Kullback-Leibler Distance", IEEE Transactions On Image Processing, Volume 11, Number 2, pp.146-158, February 2002.

[7] B.G.Prasad, K.K. Biswas, and S. K. Gupta, "Region –based image retrieval using integrated color, shape, and location index", International Journal on Computer Vision and Image Understanding Special Issue: Colour for Image Indexing and Retrieval, Volume 94, Issues 1-3, April-June 2004, pp.193-233.

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

[9] Stian Edvardsen, "Classification of Images using color, CBIR Distance Measures and Genetic Programming", Ph.D. Thesis, Master of science in Informatics, Norwegian university of science and Technology, Department of computer and Information science, June 2006.

[10] H.B.Kekre, Tanuja Sarode, Sudeep D. Thepade, "DCT Applied to Row Mean and Column Vectors in Fingerprint Identification", In Proceedings of International Conference on Computer Networks and Security (ICCNS), 27-28 Sept. 2008, VIT, Pune

[11] Zhibin Pan, Kotani K., Ohmi T., "Enhanced fast encoding method for vector quantization by finding an optimally-ordered Walsh transform kernel", ICIP 2005, IEEE International Conference, Volume 1, pp I - 573-6, Sept. 2005.

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

[13] H.B.Kekre, Sudeep D. Thepade, "Image Blending in Vista Creation using Kekre's LUV Color Space", SPIT-IEEE Colloquium and International Conference, Sardar Patel Institute of Technology, Andheri, Mumbai, 04-05 Feb 2008.

[14] H.B.Kekre, Sudeep D. Thepade, "Color Traits Transfer to Grayscale Images", In Proc.of IEEE First International Conference on Emerging Trends in Engg. & Technology, (ICETET-08), G.H.Raisoni COE, Nagpur, INDIA. Uploaded on online IEEE Xplore.

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

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

[17] H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, PrathmeshVerlekar, SurajShirke,"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),Volume:10, Number 1, January 2010, (ISSN: 1738-7906) Available at www.IJCSNS.org.

[18] H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, PrathmeshVerlekar,SurajShirke,"Walsh Transform over Row Mean and Column Mean using Image Dr. H. B. Kekre, Sudeep D. Thepade & Akshay Maloo International Journal of Image Processing (IJIP) Volume (4): Issue (2) 155 Fragmentation and Energy Compaction for Image Retrieval", International Journal on Computer Science and Engineering (IJCSE),Volume 2S, Issue1, January 2010, (ISSN: 0975–3397). Available online at www.enggjournals.com/ijcse.

[19] H.B.Kekre, Sudeep D. Thepade,"Image Retrieval using Color-Texture Features Extracted from Walshlet Pyramid", ICGST International Journal on Graphics, Vision and Image Processing (GVIP), Volume 10, Issue I, Feb.2010, pp.9-18, Available online
[20] H.B.Kekre, Sudeep D. Thepade,"Color Based Image Retrieval using Amendment Block Truncation Coding with YCbCrColor Space", International Journal on Imaging (IJI), Volume 2, Number A09, Autumn 2009, pp. 2-14. Available online at www.ceser.res.in/iji.html (ISSN: 0974-0627)
[21] H.B.Kekre, Tanuja Sarode, Sudeep D. Thepade,"Color-Texture Feature based Image Retrieval using DCT applied on Kekre's Median Codebook", International Journal on Imaging (IJI), Volume 2, Number A09, Autumn 2009,pp. 55-65. Available online at www.ceser.res.in/iji.html.
[22] H.B.Kekre, Sudeep D. Thepade, "Image Retrieval using Non-Involutional Orthogonal Kekre's Transform", International Journal of Multidisciplinary Research and Advances in Engineering (IJMRAE), Ascent Publication House, 2009, Volume 1, No.I, pp 189-203, 2009. Abstract available online at www.ascent-journals.com (ISSN: 0975-7074)
[23] H.B.Kekre, Sudeep D. Thepade, "Boosting Block Truncation Coding using Kekre's LUV Color Space for Image Retrieval", WASET International Journal of Electrical, Computer and System Engineering (IJECSE), Volume 2, Number 3, pp. 172-180, Summer 2008. Available online at http://www.waset.org/ijecse/v2/v2-3-23.pdf
[24] H.B.Kekre, Sudeep D. Thepade, Archana Athawale, Anant Shah, Prathmesh Verlekar, Suraj 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), BabasahebGawde Institute of Technology, Mumbai, 13-14 March 2010, The paper will be uploaded on online Springerlink.
[25] H.B.Kekre, Tanuja K. Sarode, Sudeep D. Thepade, Vaishali Suryavanshi, "Improved Texture Feature Based Image Retrieval using Kekre's Fast Codebook Generation Algorithm", Springer-International Conference on Contours of Computing Technology (Thinkquest-2010), Babasaheb Gawde Institute of Technology, Mumbai, 13-14 March 2010, The paper will be uploaded on online Springerlink.
[26] H.B.Kekre, Tanuja K. Sarode, Sudeep 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, 26-27 Feb 2010, The paper is invited at ICWET 2010. Also it will be uploaded on online ACM Portal.
[27] Dr. Sudeep Thepade, Ph.D. Thesis, "New Approached of feature Vector Extraction for Content Based Image Retrieval", pp. C4-2 to C4-8, Supervisor Dr. H.B.Kekre, MPSTME, SVKM's NMIMS (deemed to be University), Mumbai, 2011

Author Biographies

Dr. H. B. Kekre has received B.E. (Hons.) in Telecomm. Engineering. from Jabalpur University in 1958, M.Tech (Industrial Electronics) from IIT Bombay in 1960, M.S.Engg. (Electrical Engg.) from University of Ottawa in 1965 and Ph.D. (System Identification) from IIT Bombay in 1970 He has worked as Faculty of Electrical Engg. and then HOD Computer Science and Engg. at IIT Bombay. For 13 years he was working as a professor and head in the Department of Computer Engg. at Thadomal Shahani Engineering. College, Mumbai. Now he is Senior Professor at MPSTME, SVKM's NMIMS. He has guided 17 Ph.Ds, more than 100 M.E./M.Tech and several B.E./ B.Tech projects. His areas of interest are Digital Signal processing, Image Processing and Computer Networking. He has more than 270 papers in National / International Conferences and Journals to his credit. He was Senior Member of IEEE. Presently He is Fellow of IETE and Life Member of ISTE Recently 11 students working under his guidance have received best paper awards. Five of his students have been awarded Ph. D. from NMIMS University. Currently he is guiding Eight Ph.D. students.

Dr. Sudeep D. Thepade has Received B.E.(Computer) degree from North Maharashtra University with Distinction in 2003, M.E. in Computer Engineering from University of Mumbai in 2008 with Distinction, Ph.D. from SVKM's NMIMS (Deemed to be University) in July 2011, Mumbai. He has more than 08 years of experience in teaching and industry. He was Lecturer in Dept. of Information Technology at Thadomal Shahani Engineering College, Bandra(W), Mumbai for nearly 04 years. Currently working as Associate Professor in Computer Engineering at Mukesh Patel School of Technology Management and Engineering, SVKM's NMIMS (Deemed to be University), Vile Parle(W), Mumbai, INDIA. He is member of International Advisory Committee for many International Conferences, acting as reviewer for many referred international journals/transactions including IEEE and IET. His areas of interest are Image Processing and Biometric Identification. He has guided five M.Tech. projects and several B.Tech projects. He more than 115 papers in National/International Conferences/Journals to his credit with a Best Paper Award at International Conference SSPCCIN-2008, Second Best Paper Award at ThinkQuest-2009, Second Best Research Project Award at Manshodhan 2010, Best Paper Award for paper published in June 2011 issue of International Journal IJCSIS (USA), Editor's Choice Awards for papers published in International Journal IJCA (USA) in 2010 and 2011.

Dr. Archana A. Athawale has received B.E.(Computer) degree from Shivaji University in 1996, M.E. in Computer Engineering (VJTI) from University of Mumbai in 1999, Ph.D. from SVKM's NMIMS (Deemed to be University) in July 2011, Mumbai. She has more than 11 years of experience in teaching. She is presently working as Asst. Prof working in Computer Engineering Department of Thadomal Shahani Engineering College at Bandra, Mumbai. She is a life member of ISTE and member and Counselor for CSI at her College. She has guided more than 15 M.E. projects and several B.E. projects. She has about 50 papers in National/International Conferences/Journals to her credit.

Mrs. Paulami J. Shah has received B.E.(Computer) degree from Mumbai University in 2001, pursuing M.E. in Computer Engineering (Thadomal) from University of Mumbai .She has 3 years of experience in teaching. She has industry experience of 2 yrs. As system analyst at WNSGS, Vikhroli.