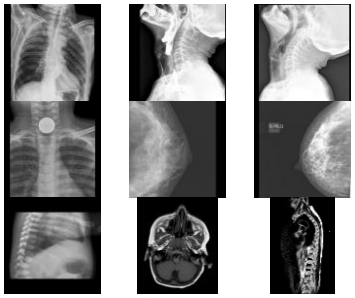

Fig.1 Sample images from the benchmark database

The CA, TA and CD are extracted for each region in the image and the extracted features are combined into a single vector for each region in the image and are normalized as aforementioned in section 2.4. The similarity measure is computed for the feature vector of corresponding regions of both query and target images then the average result of the similarity measure of all the regions of an image is considered for final result.

Different sub-sets of query images from the entire benchmark database is selected to assess the performance of the proposed system and number of images in each sub set is differing depends on the number of images in each modality category. The experiments are executed in the dual core processor, 2 GB memory and 64 bit windows operating system and are carried out using the MATLAB.

B. Performance assessment

To assess the performance of the proposed system, we used average retrieval precision (MAP) [23]. Let I_N be the first N number of images retrieved akin to the query image, M be the number of images in the benchmark database akin to query image, then precision and recall calculation is done as follows in equations (6) and (7) respectively.

$$\text{Precision (P)} = \frac{I_N}{N} \quad (6)$$

$$\text{Recall (R)} = \frac{I_N}{M} \quad (7)$$

For instance the values of I_N, N and M are 60, 100 and 592 respectively then precision P(100) is 60/100=60% and recall R(100)=60/592 =0.10%. The average precision versus recall for CT, MRI, Mammogram, Ultrasound, X-ray images in the proposed and existing system [11] is shown in Fig.2. We also incorporated G-measure which combined the results of precision and recall into single result and provides better results [23] and is computed as follows in equation (8). In Table 2, the G-measure for CT, MRI, Mammogram, Ultrasound and x-ray images are reported.

$$GM = \sqrt{\text{Precision} \times \text{Recall}} \quad (8)$$

It is observed in the results that the proposed combination CA, TA and CD features significantly outperforms the method in [11] and it is because of capturing of local spatial correlation of identified texture elements; capturing the geometric features of prominent edges. The average precision Vs recall of the proposed work and existing work for different modalities

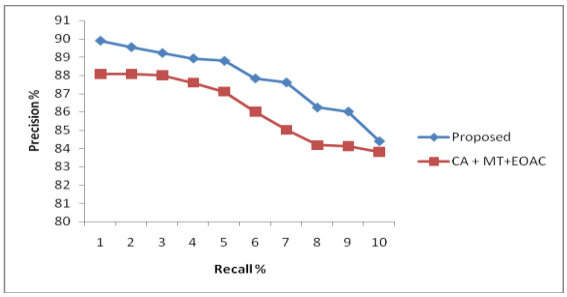

Fig. 2 CT

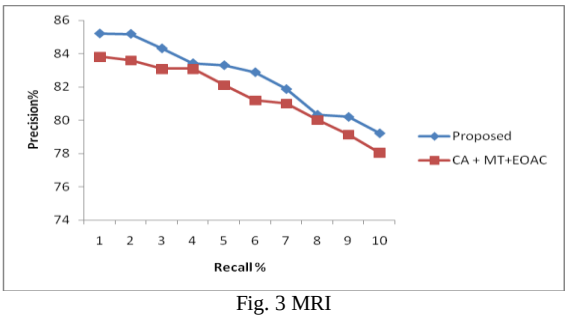

Fig. 3 MRI

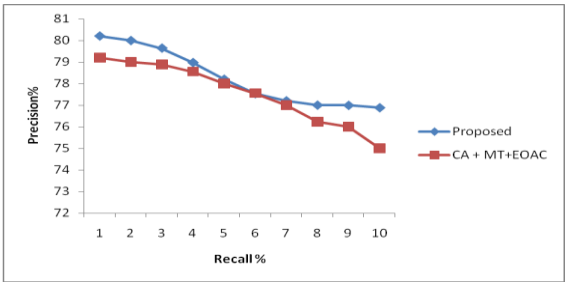

Fig. 4 Mammogram

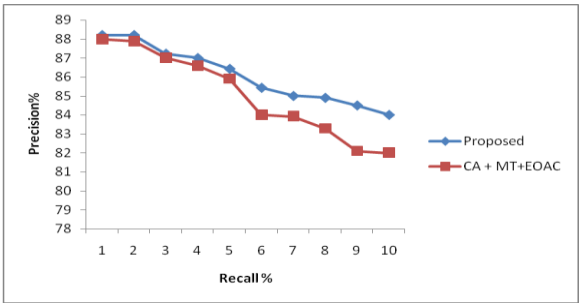

Fig. 5 Ultrasound

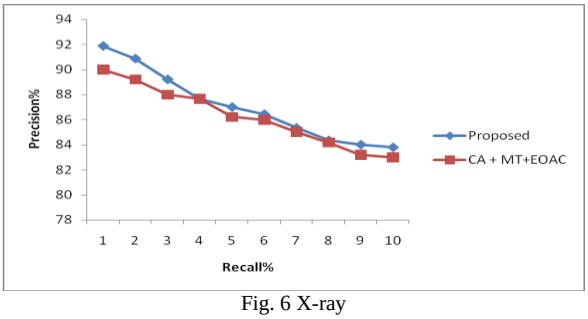

Fig. 6 X-ray

TABLE I GM FOR THE PROPOSED AND EXISTING SYSTEMS FOR THE IMAGES OF VARIOUS MODALITIES IN THE BENCHMARK DATABASE

Method	CT	MRI	Mammogram	Ultrasound	X-Ray
Proposed	87.85	82.61	78.27	86.09	87.05
Existing	86.20	81.56	77.54	85.07	86.25

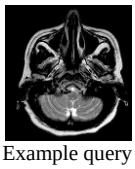

Fig. 7 Example query image

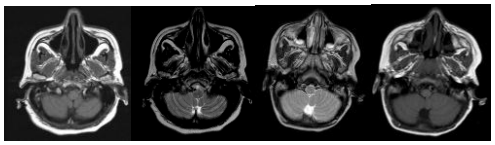

Fig. 8 Top 4 retrieval results obtained with the proposed system corresponding to the query image

IV. CONCLUSION

In this paper, we have proposed a hybrid framework for fast and efficient medical image retrieval system using color autocorrelogrm, texture autocorreloram and chordiogram features. The proposed combination of features is very effective in representing color, texture and shape features. Moreover, features are extracted for each non-overlapping rectangular regions of the image and .the similarity measure is computed for the corresponding regions of both query and target images then the average result of the similarity measure of all the regions in the image is considered for final result which also leads to significant increase in the accuracy. The accuracy of the proposed system is significantly better than that of the existing system and it will be very useful for people working in the medicine domain.

REFERENCES

[1] H. Müller, A. Rosset, A. Garcia, J. P. Vallée, and A. Geissbuhler,"Benefits of Content-based Visual Data Access in Radiology", *Radio Graphics*, Vol. 25, No. 3, pp. 849-858, 2005.

[2] H. L. Tang,Rudolf Hanka and Horace Ho-Shing Ip, "Histological image retrieval based on semantic content analysis", *IEEE Transactions on Information Technology in Biomedicine,* Vol. 7, No. 1, pp. 26-36, 67, 2003.

[3] T. M. Lehmann,M.O. Gu¨ld,T. Deselaers,D. Keysers,H. Schubert,K. Spitzer,H. Ney and B. B. Wein, "Automatic categorization of medical images for content-based retrieval and data mining", *Computerized Medical Imaging and Graphics*, Vol. 29, pp. 143-155, 2005.

[4] Mahmudur Rahman, Md., Daekeun You, Matthew S. Simpson, Dina Demner-Fushman, Sameer K. Antani, and George R. Thoma, "Multimodal biomedical image retrieval using hierarchical classification and modality fusion", *Int J Multimed Info Retr.*, Vol. 2, pp. 159-173, 2013.

[5] M. S. Sudhakar and Bhoopathy K. Bagan, "An effective biomedical image retrieval framework in a fuzzy feature space employing Phase Congruency and GeoSOM", *Applied Soft Computing*, Article in press, 2014.

[6] Subrahmanyam Murala and Q. M. Jonathan Wu, "MRI and CT image indexing and retrieval using local mesh peak valley edge patterns", *Signal Processing*, Vol. 29, No. 93, pp. 400-409, 2014.

[7] Subrahmanyam Murala and Q. M. Jonathan Wu, "Local ternary co-occurrence patterns: A new feature descriptor for MRI and CT image retrieval", *Neurocomputing*, Vol. 119, pp. 399-412, 2013.

[8] Prithaj Banerjeea, Ayan Kumar, Bhuniab Avirup Bhattacharyyac, Partha Pratim Royd and Subrahmanyam Muralad, "Local Neighborhood Intensity Pattern–A new texture feature descriptor for image retrieval", *Expert Systems with Applications*, Vol. 113, pp. 100-115, 2018.

[9] Ashnil Kumar, Jinman Kim, Lingfeng Wen, Michael Fulham and Dagan Feng, "A graph-based approach for the retrieval of multi-modality medical images, *Medical Image Analysis*, Vol. 18, No. 2, pp. 330-342, 2014.

[10] K. Seetharaman and S. Sathiamoorthy, "A unified learning framework for content based medical image retrieval using a statistical model", *Journal of King Saud University-Computer and Information Sciences*, Vol. 28, No. 1, pp. 110-124, 2016.

[11] G. H. Liu, Z. Y. Li,L. Zhang and Y. Xu, "Image retrieval based on micro-structure descriptor. *Pattern Recognition.* Vol. 44, No. 9, pp. 2123-2133, 2011.

[12] K. Seetharaman and S. Sathiamoorthy, "An Improved Edge Direction Histogram and Edge Orientation AutoCorrlogram for an Efficient Color*", Proceedings of International Conference on Advanced Computing and Communication Systems (ICACCS -2013),* Coimbatore, India, Dec. 19- 21, 2013.

[13] K. Seetharaman and S. Sathiamoorthy, "A Novel scheme for texture feature characterization using a statistical approach", *Proceedings of International Conference on Advanced Computing and Communication Systems (ICACCS -2017),* Coimbatore, India, 6-7 Jan. 2017.

[14] K. Seetharaman, "Texture analysis based on a family of stochastic models", Signal and Image Processing Applications (ICSIPA), *IEEE International Conference*, pp. 518-523, 2009.

[15] K. Seetharaman and M. Kamarasan, "Statistical framework for image retrieval based on multiresolution features and similarity method", *Mul. Tools App.*, Vol. 3, No. 1, pp. 53-66, 2014.

[16] Adnan Qayyum Syed Muhammad Anwar Muhammad Awais Muhammad Majid, "Medical image retrieval using deep convolutional neural network", *Neurocomputing*, Vol. 266, pp. 8-20, 2017.

[17] Vibhav Prakash Singh and Rajeev Srivastava, "Automated and effective content-based mammogram retrieval using wavelet based CS-LBP feature and self-organizing map", *Bio cybernetics and biomedical engineering*, Vol. 38, No. 1, pp. 90-105, 2018.

[18] Xiaolong Wang, Hong Zhang and Guohua Peng, "A chordiogram image descriptor using local edgels", *J. Vis. Commun. Image R.*, Vol. 49, pp. 129–140, 2017.

[19] Y. D. Chun,N. C. Kim, and I. H. Jang, Content-Based Image Retrieval using Multiresolution Color and Texture Features, *IEEE Transactions on Multimedia*, Vol. 10, No. 6, pp. 1073-1084, 2008.

[20] G. Qiu and K. M. Lam, Frequency layered color indexing for content-based image retrieval. *IEEE Trans. Image Process*. Vol. 12, No. 1, pp. 102–113, 2003.

[21] Iqbal, Kashif, Odetayo, O. Michael, James and Anne, "Content-based image retrieval approach for biometric security using color, texture and shape features controlled by fuzzy heuristics", *Journal Comput. Syst. Sci*. Vol. 78, pp. 1258-1277, 2012.

[22] G. H. Liu and J. Y. Yang, "Content-based image retrieval using color difference histogram", *Pattern Recognition*, Vol. 46, pp. 188-198, 2013.

[23] Yesu bai Rubavathi Charles and Ravi Ramra, *International Journal of Electronics and Communications (AEÜ),* Vol. 70, No. 3, pp. 225-233, 2016.