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A Hybrid Approach Based on Non Linear Approximation and Holistic Descriptor for Efficient Image Retrieval

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Abstract

Content Based Image retrieval is an efficient tool for accurate image retrieval from web for wide range of application including Object Recognition, Criminal Recognition, Biomedical Diagnosis, Satellite Image Processing etc. Although lots of researches have been reported for this task so far but still Major challenge in CBIR is to analysis of the gap existed between the way of perceiving objects form basic features to complex nature. This paper propose a novel four layer learning based framework for content-based image retrieval. For this task, a robust method by a combination Gabor features and Ripplet Transform of a primary query is extracted in first layer. In second layer additional neighbour queries are extracted from graph based approach. In third and fourth layer optimization of all the adjacent queries are conducted using Support vector Regression. Experimental results demonstrate the effectiveness of the proposed method on widely used CIFAR databases. The performance of the proposed method has been compared with other state-of-the-art Content based image retrieval methods, including recently reported deep Learning based methods. Experimental results show that the proposed architecture achieves significant improvement in retrieval performance.

Keywords: CBIR, Gabor transform, ISVR, Ripplet Transform

I. INTRODUCTION

Image is considered to be one of the most popular assets of this era due to mobile and internet. Massive amount of information is shared among the people around the world daily in the form of Image. As a result, large number of images are being generated an everyday and uploaded on social media. Thus the capacity of digital images is growing world widely at an alarming speed. Typically, due to rapid development of databases system and computer vision, image retrieval has been a very active research area. Human beings may easily understand the contents of a scene and the semantics being expressed. However, for machines automatic arrangement and organization is a difficult task. Such problems of organization and indexing are solved by image retrieval systems.

CBIR refers to the process of obtaining images that are relevant to a query image from a large collection based on their visual content [21] . Text matching is used in text-based querying. The text-based image retrieval method requires the image to be annotated beforehand. Initial text based image retrieval is replaced by Content Based Image Retrieval (CBIR), [22] in picture in 1990s, initial development with the manual annotation of images, which is depends on subjective human perception, and the time and labour requirements of annotation.

As organizing of our work paper is divided in to five sections. Related work to CBIR is discussed in section 2 and Proposed approach is explained in section 3. Outcomes of our experiments on CIFAR benchmarks are given in section 4 and section 5 is concluding our research work.

II. RELATED WORK

From the last several decades CBIR is active research area. Many researcher proposed different solutions for image retrieval form a multiple database. Main attribute while retrieval of image is algorithms accuracy and efficiency. Literature is differ in extracted features and classification techniques. Many researchers uses color features [1-3,5,7] such as Color statistics, Color Moment, Dominant color descriptor , HSV histogram, Color Correlogram, in RGB and Color Spaces. Color features are most widely used due to its simplicity. Some researcher extract Shape features[1,4,5] such as microstructure descriptor, Fourier descriptor. Image retrieval using Hashing is the most studied area[6,8]. Recently due to large research in deep learning and artificial intelligence many researcher use deep neural network for image retrieval task[6,9,10,11]. Some researcher study comparative analysis of different classification techniques[2,12]. Y.rao[13] build the initial Support Vector Machine (SVM) with relevance feedback (RF) to increase the superiority of the retrival. But mostly attention seeker feature is Texture. Texture extraction plays vital role in object recognition. In addition, some recently developed systems are trying to make full use of color, texture and shape features concurrently in order to achieve high performance. Next we present some current progress on the combination of different features in CBIR.

Image is divided into patches and from each patch LBP features are extracted. This integrated approach is proposed in N. Shrivastava et.al.[14].To assist this features color and shape features are also extracted. C. Celik [15] states the semantic gap in low and higher level futures and overcome this problem using Local Feature Descriptors from various well known keypoints extraction methods such as Scale Invariant Feature Transform (SIFT), Speeded-Up Robust Features (SURF), Histograms of Oriented Gradients (HoG), Local Binary Pattern (LBP) and Local Ternary Pattern (LTP). H. Zang et.al.[16] combine saliency detection and edge detection for estimation of shadowed regions and extract the useful information. G Raghuwansi et.al [17] use Curvelet transform and selects and assigns weights to the regions of the image on the basis of their contribution to image contents, using a new region-weight assignment scheme. Also Moment invariant is used for shape extraction. X Sun et.al. [18] proposed Attention-Aware Feature Pyramid Ordinal deep Hashing to extract visual and semantic information. They extract local salient structure from all scale. G. Raghuwanshi et.al [19] proposed hybrid method by combining Tetrolet transform and Euclidean distance metric. Shape and color features are also used. S. Ercoli et.al.[20] extract visual descriptors by using hash codes. This further classified using Neural network.

III. PROPOSED METHODOLOGY

In First layer method consider the query image as the labelled image, and the remaining images are considered unlabeled. 2D Holistic Gabor features are extracted from query image and all the image. Following equation have effective for representation,

$$HD(F)_{\theta_k, f_i, \sigma_x, \sigma_y}(x,y) = exp\left(-\left[\frac{x_{\theta_k}^2}{\sigma_x^2} + \frac{y_{\theta_k}^2}{\sigma_x^2}\right]\right).\cos(2\pi f_i x_{\theta_k} + \varphi) \quad (1)$$

To assist and efficient retrieval Nonlinear Approximation of Ripplet transform is also extracted. It can resolve 2D singularities. Also it have the anisotropic property to settle 2D singularities in extraction of texture.

To reduce the feature dimension well known GLCM features are extracted.

i. Entropy: $= -\sum_{i=1}^{K}\sum_{j=1}^{K} p_{ij}\log_2 p_{ij}$ (2)

ii. Energy = $\sum_{i,j} p(i, j)^2$ (3)

Homogeneity = $\sum_{i=0}^{G-1}\sum_{j=0}^{G-1}\{P(i, j)\}^2$ (4)

iii. Correlation: $= \sum_{i=1}^{K}\sum_{j=1}^{K}\frac{(i-m_r)(j-m_c)p_{ij}}{\sigma_r\sigma_c}$ (5)

iv. Contrast: $= \sum_{i=1}^{K}\sum_{j=1}^{K}(i-j)^2 p_{ij}$ (6)

For each query, weighted graph is generated from both the features. The retrival success can be estimated by the weights or distance by using,

$$C = F (V, E, W) \quad (7)$$

v is a vertices, e is a edges and w is a lot of weights.

Then K neighbours are estimated for each query from CIFAR dataset, Y= {y1, . . ., yl, yl+1, . . ., yn} with the distance V and weight W is,

$$W_{ij} = exp\left(-\frac{d^2(Q,A_i)}{\sigma y^2}\right) \quad (8)$$

d (V_i, V_j) denotes the feature distance between the V_i and V_j, and W_{ij} is the edge weight of E_{ij}. σ is a weight constant. This will give two retrieval image lists by using the graph-based holistic Gabor Descriptor Nonlinear approximation of Ripplet transform algorithms.

In second layer Graph anchors are estimated from retrieved list of graph-based holistic Gabor Descriptor Nonlinear approximation of Ripplet transform algorithms. Proposed method consist of four layer architecture.

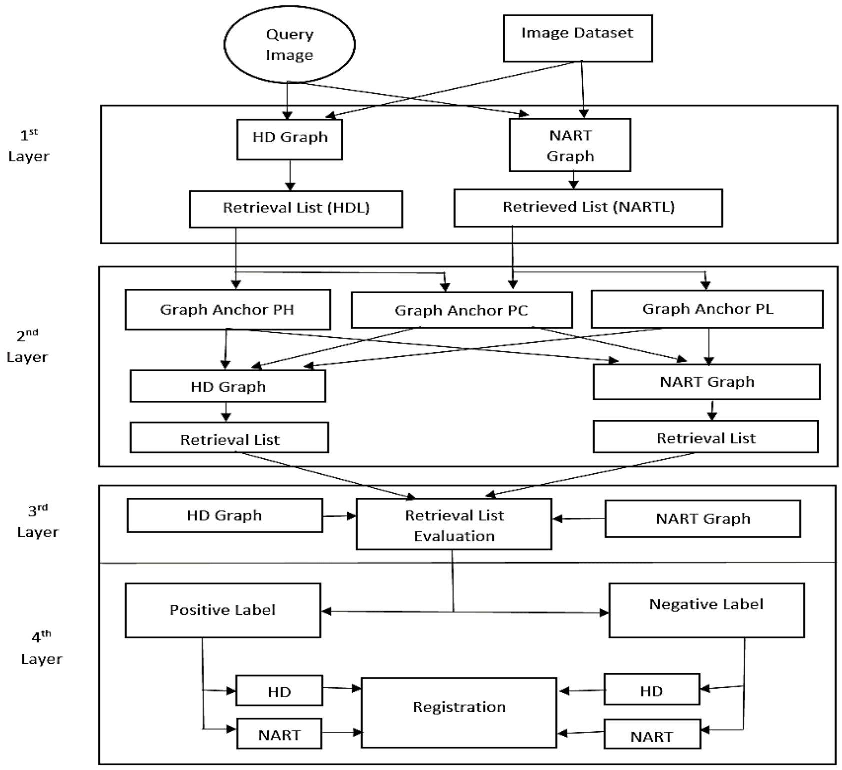

Fig 1: Architecture of Proposed method

For each anchor, then further images are retrieved using reranking method,

$$\begin{pmatrix} L_Q \\ L_{A1} \\ L_{A2} \\ \dots \\ L_{An} \end{pmatrix} = \begin{pmatrix} A_1 & A_2 & \dots & A_m \\ N_{11} & N_{12} & \dots & N_{1m} \\ N_{21} & N_{22} & \dots & N_{2m} \\ \dots & \dots & \dots & \dots \\ N_{m1} & N_{m2} & \dots & N_{mm} \end{pmatrix} \quad (9)$$

Where, Q is the graph anchor act as a query, N is retrieved image matrix and A1, A2, . . ., Am are the top positioned images retrieved images.

In third layer ,Thus have three retrieved list. Normalized similarity score (NSS) between two images. The SS between the retrieved images N_{ij} and Q is derived by,

$$NSS(Q, N_{ij}) = norm|| \; NSS(Q, A_i) \, . \mathrm{NSS}(A_i, N_{ij}) \; || \quad (10)$$

Then these queries are labelled using the prior knowledge. such as positive data and negative data. This approach can reduce the influence of some inappropriate images on the retrieval result to a certain extent.

In fourth layer ISVR is trained with these data. ISVR determines the combination of the feature weights by solving a standard kernel and on a gradient descent optimization problem.

while training it will transform the data into a higher dimensional feature space to make it possible to perform the linear separation and thus making classification problem easy.

$$y = \sum_{i=1}^{N} \left(\alpha_i - \alpha_i^*\right) . \left\langle \varphi(x_i), \varphi(x) \right\rangle + b \quad (11)$$

In this layer positive data $\{(x_1, y_1), \ldots, (x_l, y_l)\} \in x_i$ x,where x_i denote the input optimized features and y_i denote target either positive or negative depending upon the labelling. The ISVR is to find $y = \langle \omega, \phi(x) \rangle \mathrm{H} + b$, where ω and $\phi(x)$ denote the vectors obtained from reproducing Kernel Hilbert space H .

Linear optimization can be done by,

$$R = \frac{1}{2}\|\omega\|^2 + c\sum_{i=1}^{l} L(y_i, x_i, f). \quad (12)$$

Where L(y_i, x_i, f) denotes the $\in$ - loss function given by

$$L(y_i, x_i, f) = |y - f(x)|_{\in} = \max(0, |y - f(x)| - \in) \quad (13)$$

$$\min_{\omega,b,\xi,\tilde{x}i} \frac{1}{2}\|\omega\|^2 + c\sum_{i=1}^{l}\left(\xi^2 + \tilde{\xi}^2\right) \quad (14)$$

Subject to
$$\begin{cases} f(x_i) - y_i \le \in + \xi_i, i = 1, \ldots, l \\ y_i - f(x_i) \le \in + \xi_i, i = 1, \ldots, l \\ \xi_i, \tilde{\xi}_i \ge 0 \end{cases}$$

This problem can be solved by the Lagrangian theory as follows:

$$\omega = \sum_{i=1}^{l} (\hat{\alpha}_i - \alpha_i) \phi(x_i), \quad (15)$$

Where $\{\hat{\alpha}, \alpha\}, i = 1, \ldots, l$ denotes the Lagrangian multipliers with respect to the constraints given in Eq(4), and the solution are given by,

$$\max_{\alpha_i, \hat{\alpha}_i} \sum_{i=1}^{l} y_i (\hat{a}_i - \alpha_i) - \in \sum_{i=1}^{l} (\hat{a}_i + \alpha_i) - \frac{1}{2} \sum_{i,j=1}^{l} (\hat{a}_i - \alpha_i)(\hat{a}_j - \alpha_j) \left(K(x_{i,} x_j) + \frac{1}{c}\zeta i, j \right) \quad (16)$$

Subject to

$$\begin{cases} \sum_{i=1}^{l} (\hat{\alpha}_i - \alpha_i) = 0 \\ 0 \le \alpha_i, 0 \le \hat{\alpha}_i, i = 1, \ldots, l, \end{cases}$$

Where $K(x_i, x_j) = \langle \phi(x_i), \phi(x_j) \rangle H$ and $\zeta_{i,j}$ represents the Kronecker symbol. This problem can be resolved using some disassemble methods of the SVR.

IV. EXPERIMENT AND RESULTS

In CIFAR-100 dataset, there are total 100 Class. Each Class contain 500 images for training Purpose. Following Figure 2, indicate the 10 sample images out of 500 images of each class. Each row indicate class number and column indicates the sample number.

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Table 1: CIFAR-100 Image Dataset with class name

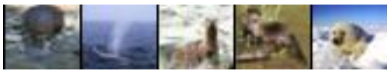
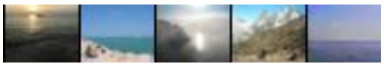
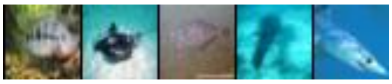
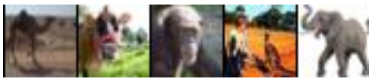
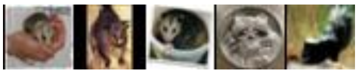
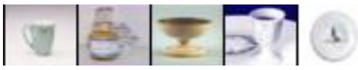
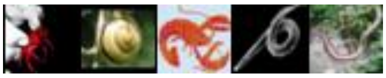
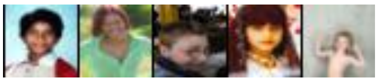
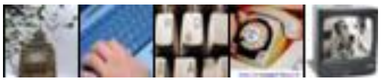
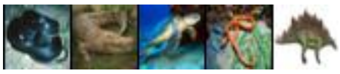
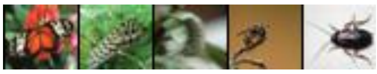
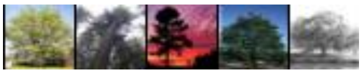
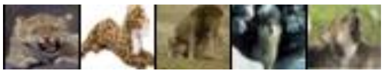
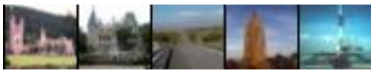
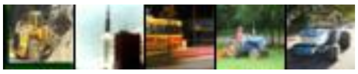
Class No.	Class	Class name	Class No.	Class	Class name
1		Aquatic mammals	11		Large natural outdoor scenes
2		Fish	12		large omnivores and herbivores
3		Flowers	13		Medium-sized mammals
4		Food containers	14		Non-insect invertebrates
5		Fruit and vegetables	15		People
6		Household electrical devices	16		Reptiles
7		Household furniture	17		Small mammals
8		Insects	18		Trees
9		Large carnivores	19		Vehicles 2
10		Large man-made outdoor things	20		Vehicles 1

Fig 2: CIFAR 100 Dataset (Class 1 to 10)

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Following Fig 3 shows image the retrieval based on the query. Query is shown in upper side on first position, remaining are the retrieved images. For understanding purpose ten retrieved images are shown.

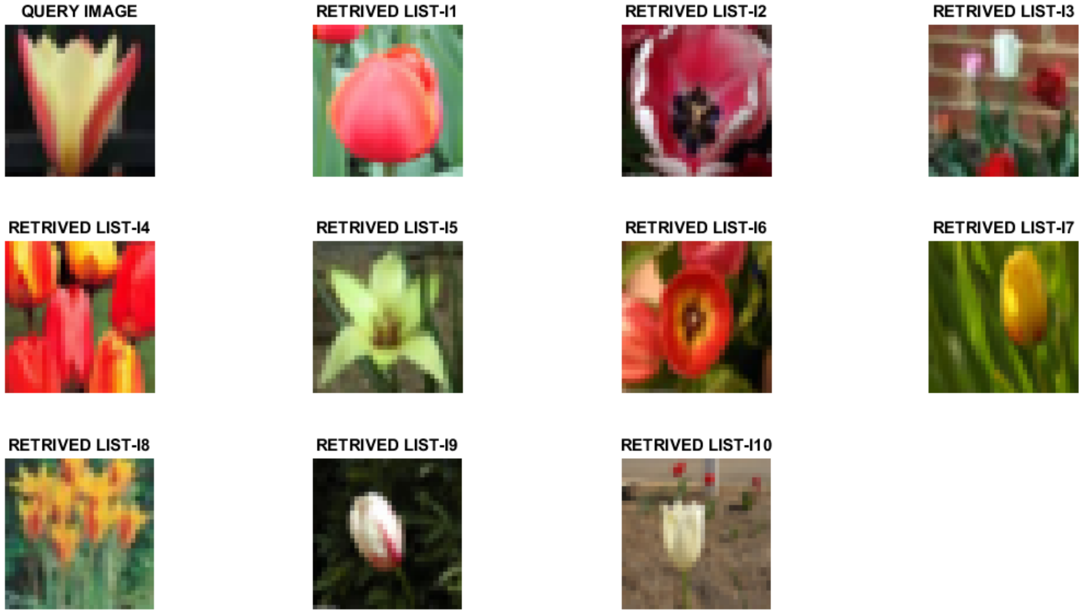

Fig 3: Image Retrieval for Query for proposed method

Following Fig 4 shows the accuracy of 100 class. Maximum accuracy achieved is 99% and Minimum accuracy is 94% approximately. Average accuracy is 97 approximately.

$$\text{Retrieval Accuracy} = \frac{\text{Correctly retrieved images}}{\text{Total No of } \textit{Retrieved} \text{ Images}}$$

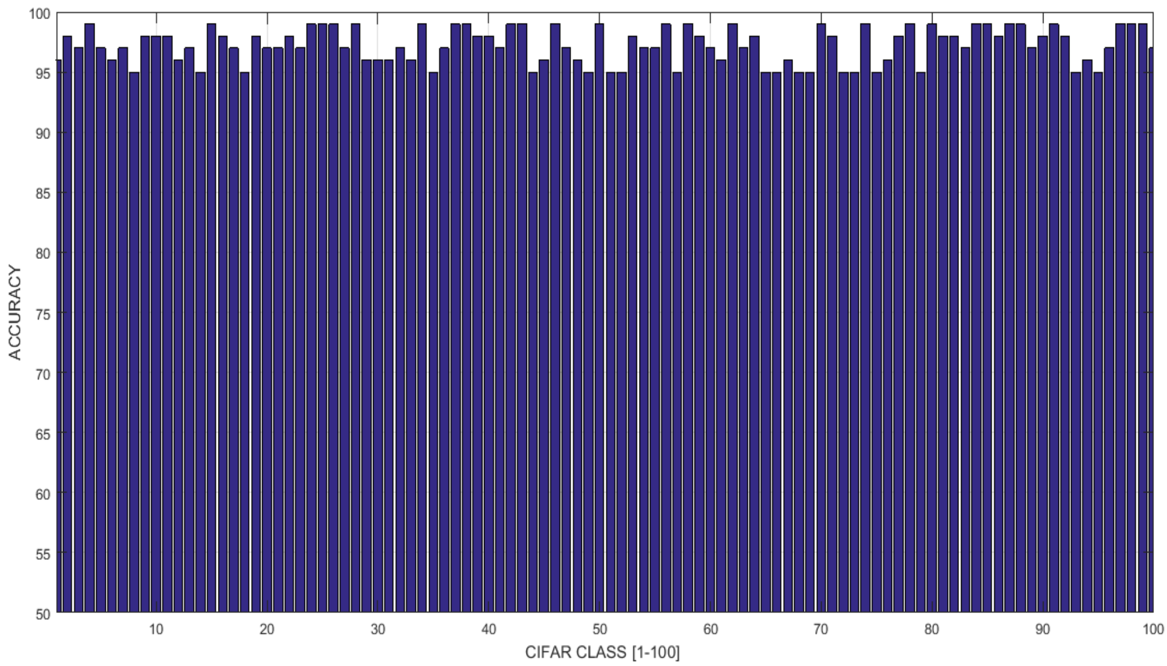

Fig 4: Class wise average accuracy of 100 class.

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Following from Fig 5-Fig 8 shows the performance analysis of Proposed method with well known methods of image retrieval. For Comparison of proposed method, LBP [14], LFD[15],]CT[17] PDH[18] and VDNN[20] are considered. All the models are tested on CIFAR 100 dataset.

Fig 5 shows the comparison of accuracy of existing techniques and proposed method. The Accuracy achieved using proposed hybrid approach is 97% that shows proposed method outperforms the other similar methods

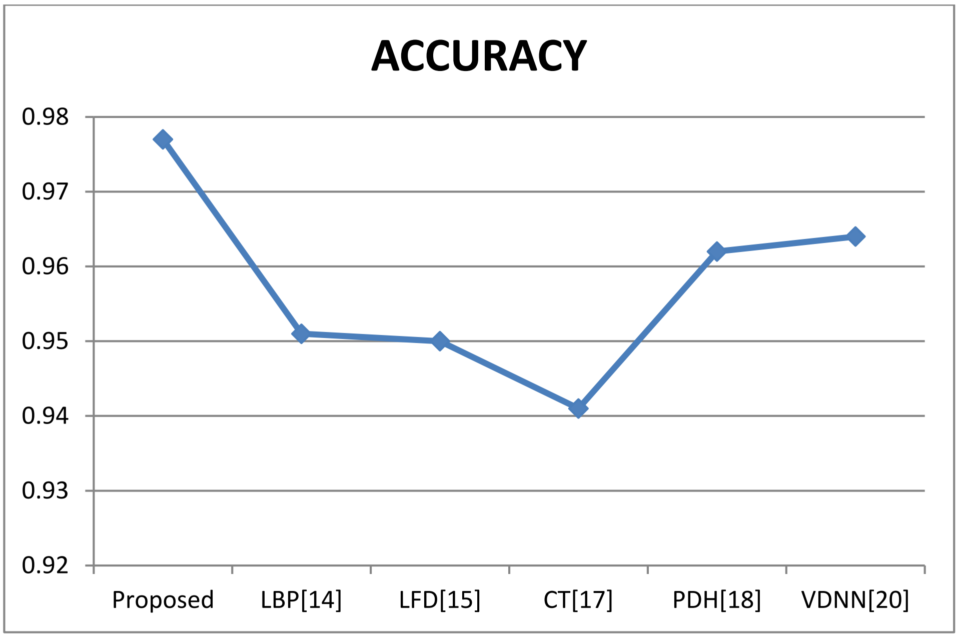

Fig 5: Comparison of Accuracy of various method

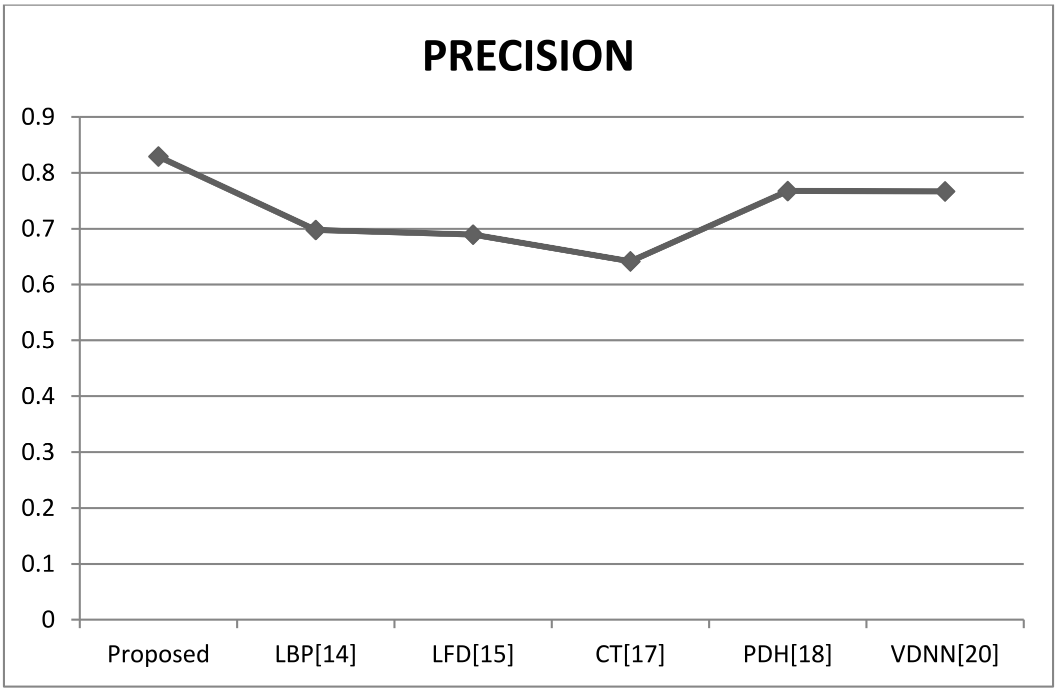

Fig 6: Comparison of Precision of various method

Fig 6 shows comparison of precision parameter with different existing methods. Figure shows that proposed method achieves 85% Precision where as rest of methods precision parameter is less than 75%.

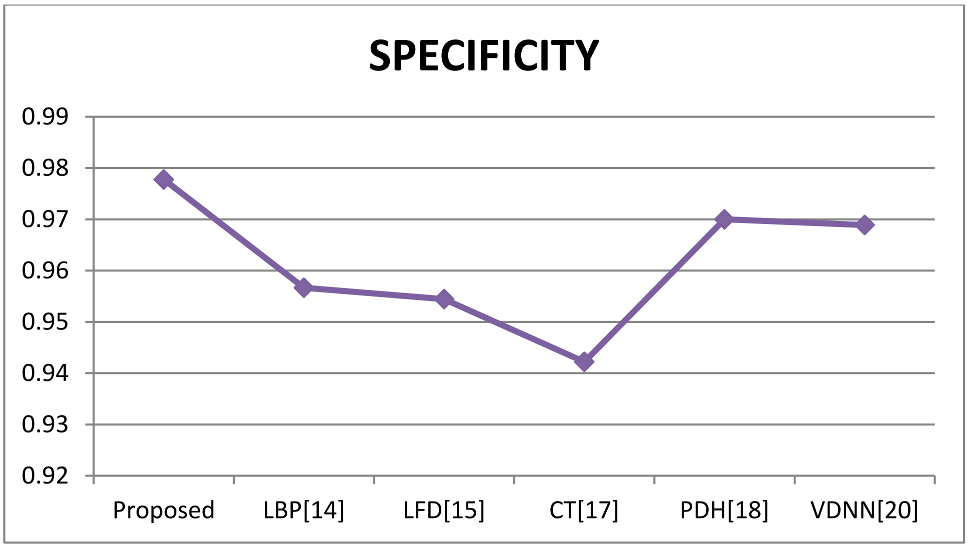

Fig 7: Comparison of Specificity of various method

Fig 7 shows that proposed method achieve 98% specificity and other methods specificity is less than the proposed method.

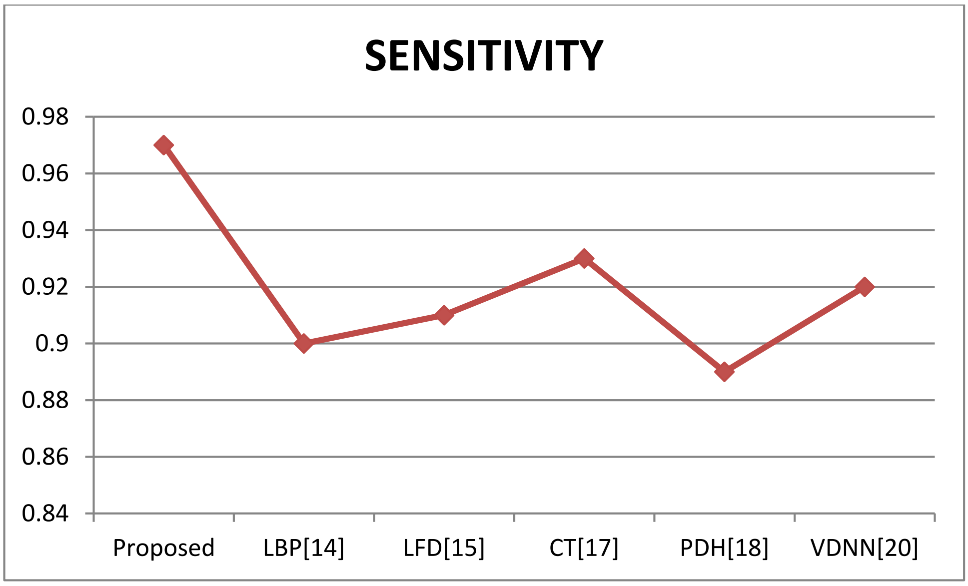

Fig 8: Comparison of Sensitivity of various method

Figure 8 shows that proposed method achieve 97% sensitivity which is higher than the rest of the existing methods.

V. CONCLUSION

Content Based Image retrieval is an efficient tool for accurate image retrieval from web for wide range of application. This paper propose a novel four layer learning based framework for content-based image retrieval. Experimental results demonstrate the effectiveness of the proposed method on widely used CIFAR databases. The performance of the proposed method has been compared with other state-of-the-art Content based image retrieval methods, including recently reported deep Learning based methods. Experimental results show that the proposed architecture achieves significant improvement in retrieval performance. Proposed method achieves 98% accuracy.

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