Image Retrieval with Fusion of Thepade's Sorted Block Truncation Coding n-ary based Color and Local Binary Pattern based Texture Features with Different Color Places

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Abstract: ***In these years, there has been a gigantic growth in the generation of data. Innovations such as the Internet, social media and smart phones are the facilitators of this information boom. Since ancient times images were treated as an effective mode of communication. Even today most of the data generated is image data. The technology for capturing, storing and transferring images is well developed but efficient image retrieval is still a primitive area of research. Content Based Image Retrieval (CBIR) is one such area where lot of research is still going on. CBIR systems rely on three aspects of the image content namely texture, shape and color. Application specific CBIR systems are effective whereas Generic CBIR systems are being explored. Previously, descriptors are used to extract shape, color or texture content features, but the effect of using more than one descriptor is under research and may yield better results.***

The paper presents the fusion of TSBTC n-ary (Thepade's Sorted n-ary Block Truncation Coding) Global Color Features and Local Binary Pattern (LBP) Local Texture Features in Content Based Image with Different Color Places

TSBTC n-ary devises global color features from an image. It is a faster and better technique compared to Block Truncation Coding. It is also rotation and scale invariant. When applied on an image TSBTC n-ary gives a feature vector based on the color space, if TSBTC n-ary is applied on the obtained LBP (Local Binary Patterns) of the image color planes, the feature vector obtained is be based on local texture content. Along with RGB, the Luminance chromaticity color space like YCbCr and Kekre's LUV are also used in experimentation of proposed CBIR techniques.

Wang dataset has been used for exploration of proposed method. It consists of 1000 images (10 categories having 100 images each). Obtained results have shown performance improvement using fusion of BTC extracted global color features and local texture features extracted with TSBTC n-ary applied on Local Binary Patterns (LBP).

Keywords**:** ***CBIR, Kekre's LUV, TSBTC n-ary, Wang Dataset***

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I. INTRODUCTION

Recently many technological advancements have been done in computing. One of the major reasons of emergence of such technologies is the increased growth of data. Predominantly due to social networks and smart phones, more image data is being generated. Reliable systems are currently available for the generation, storage and transfer of data. However active research is being done on image retrieval. Keyword-based and content-based [1]-[5] are the 2 major type of image retrieval systems being used. In majority of the scenarios keyword-based image retrieval systems are used. However, this technique relies on manually assigning keywords, file names or other metadata to the image files. In today's age going through this huge quantity of data manually is a very laborious task. Also, the perception of images highly varies based on an individual, thus there exists an ambiguity in assigning these annotations.

Optical characteristics of an image namely, color [6], shape and texture [7] are considered in content-based techniques. Unlike keyword-based techniques there is no intensive manual tasks, instead simple algorithms can be used to extract content-based features from an image. Previously, only one of these three color, shape or texture was used to extract features. However, using combinations of these descriptors [8] may give better results. Most of the retrieval systems today are application specific. Effective generalized image retrieval systems are still in active research. A fusion framework for CBIR using global color features extracted using BTC and TSBTC n-ary applied on color spaces [9] with local texture features extracted using Local Binary Patterns [10] has been proposed in the work presented here.

Remaining paper is arranged as elaborated herewith. The global color and local texture feature fusion based proposed CBIR is explained in section II. BTC, LBP and TSBTC n-ary are explained in sections III, IV and V respectively. Section VI contains information about experimentation environment, section VII contains results and observations of the experiments and last section VIII gives a conclusion.

II. PROPOSED GLOBAL COLOR AND LOCAL TEXTURE FEATURE FUSION BASED CONTENT BASED IMAGE RETRIEVAL

The proposed CBIR with feature fusion of global color features and local texture features is elaborated here in two steps as feature extraction and image retrieval.

A. Feature Extraction in proposed fusion based CBIR

First step is to convert images to Luminance Chromaticity color space (Kekre's LUV [11] and YCbCr [12]) from RGB color space. Next TSBTC n-ary and BTC are applied first on the obtained Luminance and Chromaticity planes to extract global color features. The Luminance and Chromaticity

planes are taken for extracting their Local Binary Patterns (LBP) with consideration of local neighborhood (here with size 3x3). On these obtained LBPs the TSBTC n-ary and BTC are applied to obtain the local texture features. To have feature fusion for image retrieval, the global color features and local texture features thus obtained are concatenated. The feature fusion gives feature vectors of each image stored in image database. These feature vectors are used to compare images while retrieving them. Flowchart for Feature Extraction is explained in Fig.1.

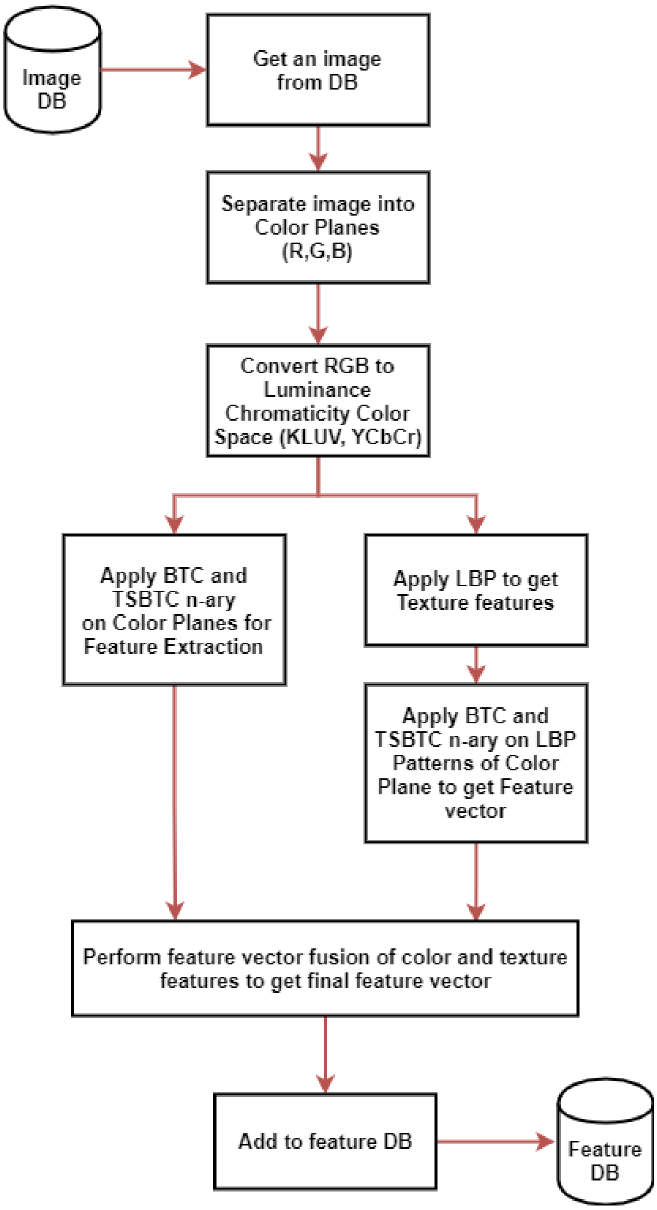

Fig. 1 Feature Extraction flow chart of proposed global color and local texture content features fusion based image retrieval.

B. Proposed Color and Texture Content Feature Fusion Based Image Retrieval

Fusion of global color features obtained from BTC and local texture features obtained from TSBTC n-ary applied on LBP patterns, results into the query image feature vector. This vector of features is then compared against every image's vector of features in features database. To find the similarity between images, Mean Squared Error (MSE) has been used. The lower MSE value denotes more similarity of query image features with database image features. Images are then indexed in order from least MSE value to highest and top 100 images are retrieved for the given query image. Fig.2 shows flow chart for Image Retrieval in proposed CBIR

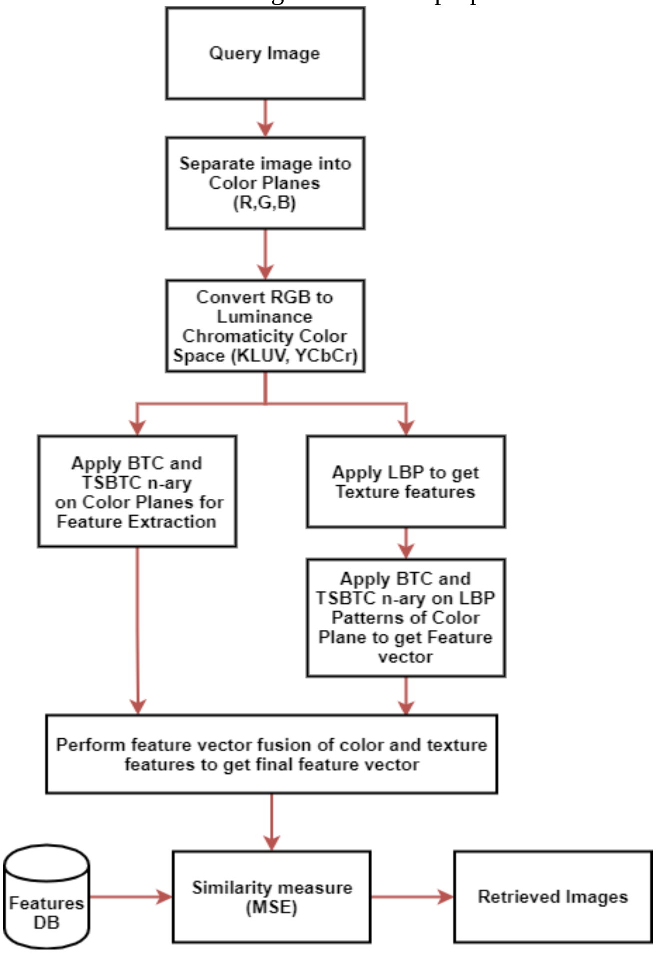

Fig. 2 Image Retrieval flow chart of proposed global color and local texture content features fusion

III. BLOCK TRUNCATION CODING [13], [14]

Block Truncation Coding (BTC) is a color feature extraction algorithm. It has been utilized to take out global color features from images. The algorithm splits image in to its color planes and the mean magnitude of every color plane is computed. Further discussion is done considering the Red plane. Next each pixel value is compared against the average value and the image is divided into two regions: Lower Red and Upper Red. The mean value of these regions is added to the feature vector. Similar process is performed for Green and Blue plane. 4 levels of BTC have been executed on color planes of an image with RGB, YCbCr and KLUV color space to get global color features [15].

IV. LOCAL BINARY PATTERNS

LBP is a texture descriptor algorithm, which elaborates the pixel value of the image by thresholding the locality of every pixel to calculate a binary number. This binary number of each pixel is converted into decimal and stored in the LBP image matrix.
BTC has been implemented on LBP patterns of color planes of an image to get local texture features [15].

V. THEPADE'S SORTED n-ary BLOCK TRUNCATION CODING (TSBTC N-ARY) [16], [17]:

TSBTC n-ary is a faster and better image compression technique compared to BTC. It is rotation and scale invariant. Similar to BTC, here also image of size r x p is divided into different color components, B, G and R. In TSBTC n-ary, every component is converted from a two-dimensional array of size r x p into a Single Dimensional Array (SDA) of length r x p. This SDA is then sorted (sortedSDA) and divided into 'n' equal parts. For every part, mean of all values in that part is calculated. Vector of these mean values represents feature vector of that component. Length of the feature vector for one component is equal to n. Then, similar to BTC, feature vectors of all components are concatenated to get a final feature vector of size 3*n for that image.

For example, if n = 3, features will be calculated as follows. Each color component will have 3 features. If we consider R component, we will have features lR, mR and uR using the equations 1, 2 and 3 respectively. Similarly, for G and B color components.

$$lR = \frac{3}{r*p}\sum_{i=1}^{\frac{r*p}{3}} sortedSDAR(i) \quad (1)$$

$$mR = \frac{3}{r*p}\sum_{i=\frac{r*p}{3}+1}^{\frac{2*r*p}{3}} sortedSDAR(i) \quad (2)$$

$$uR = \frac{3}{r*p}\sum_{i=\frac{2*r*p}{3}+1}^{r*p} sortedSDAR(i) \quad (3)$$

$$lG = \frac{3}{r*p}\sum_{i=1}^{\frac{r*p}{3}} sortedSDAG(i) \quad (4)$$

$$mG = \frac{3}{r*p}\sum_{i=\frac{r*p}{3}+1}^{\frac{2*r*p}{3}} sortedSDAG(i) \quad (5)$$

$$uG = \frac{3}{r*p}\sum_{i=\frac{2*r*p}{3}+1}^{r*p} sortedSDAG(i) \quad (6)$$

$$lB = \frac{3}{r*p}\sum_{i=1}^{\frac{r*p}{3}} sortedSDAB(i) \quad (7)$$

$$mB = \frac{3}{r*p}\sum_{i=\frac{r*p}{3}+1}^{\frac{2*r*p}{3}} sortedSDAB(i) \quad (8)$$

$$uB = \frac{3}{r*p}\sum_{i=\frac{2*r*p}{3}+1}^{r*p} sortedSDAB(i) \quad (9)$$

In this experiment, TSBTC n-ary was applied on 3 color spaces, namely RGB, KLUV and YCbCr, with values for n ranging from n=2 to n=17. Highest accuracy was observed for TSBTC 17-ary applied on KLUV color space.

VI. EXPERIMENT ENVIRONMENT

Experimentation is performed on Wang Dataset [18] which comprises of 1000 images. There are 100 images in every class, making 10 classes of images. Programming language used is Python. Mean Squared Error (MSE) is utilized to estimate the difference of two images. The accuracy of the proposed method is considered as a ratio with denominator being the total count of images retrieved and numerator with total relevant retrieved images.

$$MSE = \frac{\sum_{j=1}^{N}(y_j - \hat{y}_j)^2}{N} \quad (10)$$

where y_j and $\hat{y}_j$ denote the j[th] element in the feature vector of an image. Total count of elements in vector of features is denoted by N.

$$Accuracy = \frac{Count\ of\ relevant\ images\ retrieved}{Total\ count\ of\ images\ retrieved} \quad (11)$$

Fig. 3. 10 sample images from every category of 10 categories from wang dataset of 1000 images

Fig. 3. shows the 10 sample images from wang dataset. Each image belongs to one of the 10 categories from the dataset. 10 categories which exist in the dataset are Tribal people, beach, monuments, bus, dinosaur, elephant, flowers, horses, mountains and food items.

VII. RESULTS AND DISCUSSION

The experiments are performed for the CBIR with global color features extracted using TSBTC n-ary, the CBIR with local texture features obtained from TSBTC n-ary applied on LBP patterns, the CBIR with fusion of global color features from BTC [15] and TSBTC n-ary and the proposed CBIR with fusion of global color and local texture features. The observations of the accuracy of image retrieval with explored variations are elaborated in this section.

A. Image Retrieval with global color features extracted using TSBTC n-ary with Color Spaces

The TSBTC n-ary feature extraction method variations with value of 'n' ranging from 2 to 24 is explored for global color feature based CBIR using various color spaces and respective accuracies are mentioned in table I. Here the performance comparison of retrieval accuracy at different TSBTC n-ary features as well as different color spaces is done. Along with the RGB color space, YCbCr and KLUV color spaces are also explored here for accuracy improvement in image retrieval.

Here for RGB color space a trend of notable increase in accuracy can be seen from TSBTC 2-ary to TSBTC 8-ary after which it stabilizes giving the highest accuracy of 39.37% at TSBTC 9-ary. For YCbCr color space the considerable increase in accuracy is seen from TSBTC 2-ary to TSBTC 8-ary after which the accuracy stabilizes, giving the highest accuracy of 39.78% for TSBTC 21-ary and for Kekre's LUV color space (KLUV) good increase in accuracy is seen from TSBTC 2-ary to TSBTC 8-ary after which it stabilizes, giving the highest accuracy of 40.68% at TSBTC 17-ary. Thus, it can be concluded that implementation of TSBTC n-ary gives better results for KLUV color space when compared with RGB and YCbCr color spaces.

Table- I: Performance comparison of different color spaces in CBIR at TSBTC n-ary global color features

Color Features	Percentage Accuracy		
	RGB	**YCbCr**	**KLUV**
TSBTC 2-ary	39.11	38.897	39.512
TSBTC 3-ary	39.323	39.363	40.158
TSBTC 4-ary	39.235	39.525	40.362
TSBTC 5-ary	39.294	39.731	40.54
TSBTC 6-ary	39.318	39.728	40.608
TSBTC 7-ary	39.305	39.72	40.6
TSBTC 8-ary	39.355	39.768	40.652
TSBTC 9-ary	**39.369**	39.757	40.667
TSBTC 10-ary	39.353	39.745	40.663
TSBTC 11-ary	39.342	39.735	40.674
TSBTC 12-ary	39.361	39.751	40.666
TSBTC 13-ary	39.356	39.735	40.668
TSBTC 14-ary	39.358	39.741	40.679
TSBTC 15-ary	39.361	39.757	40.67
TSBTC 16-ary	39.36	39.761	40.678
TSBTC 17-ary	39.349	39.773	**40.68**
TSBTC 18-ary	39.356	39.761	40.669
TSBTC 19-ary	39.352	39.773	40.665
TSBTC 20-ary	39.348	39.775	40.66
TSBTC 21-ary	39.354	**39.78**	40.672
TSBTC 22-ary	39.348	39.773	40.66
TSBTC 23-ary	39.353	39.77	40.668
TSBTC 24-ary	39.347	39.773	40.667
Average	**39.330**	**39.691**	**40.571**

Table- II: Top 3 performers of TSBTC n-ary global color features based CBIR

Rank	Color Features	Color Plane	Percentage Accuracy
1	TSBTC 17-ary	KLUV	40.68
2	TSBTC 14-ary	KLUV	40.679
3	TSBTC 16-ary	KLUV	40.678

The Top 3 performers of the global color features extracted using TSBTC n-ary with color spaces with reference to percentage accuracy of image retrieval are given in table II.

B. Image Retrieval with texture features extracted using TSBTC n-ary applied on LBP of color planes of different color spaces

Table III gives retrieval accuracy of TSBTC n-ary applied on LBP patterns to extract the local texture features. Here TSBTC n-ary is applied up to 17 levels on the local binary patterns (LBP) obtained from image color planes in RGB and KLUV color spaces respectively referred as LBP RGB and LBP KLUV. It is observed that for both LBP RGB and LBP KLUV accuracy shown more variations from TSBTC 2-ary up to TSBTC 7-ary, after which it stabilizes. Highest accuracy of 29.43% for LBP RGB is achieved at TSBTC 12-ary and accuracy of 35.28% for LBP KLUV is achieved with TSBTC 3-ary. The TSBTC n-ary performs better on LBP patterns of KLUV color space when compared with LBP patterns of RGB as indicated by average accuracy values of LBP RGB and LBP KLUV.

Table- III: Performance comparison of Image Retrieval with texture features extracted using TSBTC n-ary applied on LBP of color planes of different color spaces

Texture Features	Percentage Accuracy	
	LBP RGB	LBP KLUV
TSBTC 2 –ary on LBP	28.662	34.062
TSBTC 3-ary on LBP	27.979	**35.282**
TSBTC 4-ary on LBP	29.083	35.047
TSBTC 5-ary on LBP	29.102	35.136
TSBTC 6-ary on LBP	29.132	34.891
TSBTC 7-ary on LBP	29.389	34.794
TSBTC 8-ary on LBP	29.428	34.768
TSBTC 9-ary on LBP	29.419	34.787
TSBTC 10-ary on LBP	29.373	34.724
TSBTC 11-ary on LBP	29.403	34.695
TSBTC 12-ary on LBP	**29.434**	34.691
TSBTC 13-ary on LBP	29.381	34.562
TSBTC 14-ary on LBP	29.42	34.585
TSBTC 15-ary on LBP	29.39	34.592
TSBTC 16-ary on LBP	29.42	34.526
TSBTC 17-ary on LBP	29.402	34.577
Average	**29.214**	**34.732**

The Top 3 performers of the local texture features extracted using TSBTC n-ary with LBP of color spaces with reference to percentage accuracy of image retrieval are given in table IV.

Table- IV: Top 3 performers of TSBTC n-ary on LBP local texture features based CBIR

Rank	Texture Features	Color Plane	Percentage Accuracy
1	TSBTC 2-ary on LBP	KLUV	35.282
2	TSBTC 5-ary on LBP	KLUV	35.136
3	TSBTC 4-ary on LBP	KLUV	35.047

C. Proposed Image Retrieval using feature fusion color features extracted using Multilevel BTC and TSBTC n-ary with various color spaces

Previously BTC [15] has been used in CBIR to extract global color features and provided good results on YCbCr and KLUV color space. The color features fusion for the features obtained using BTC and TSBTC n-ary is tried for four BTC levels (as Level 1 to level 4) with color spaces (RGB, YCbCr and KLUV) and TSBTC n-ary (from n=2 to n=24) with color spaces (RGB, YCbCr and KLUV). After experimentation for all possible fusion variations of the color features; obtained top five accuracy values and respective combinations are shown in Fig 4. It is perceived that fusion of Level 3 BTC on KLUV and TSBTC 17-ary on KLUV gives highest retrieval accuracy of 41.56% which is greater than the previous best of TSBTC n-ary KLUV observed in table II. This leads to the conclusion that combining features extracted using BTC and TSBTC n-ary yield better results indicating improved image retrieval.

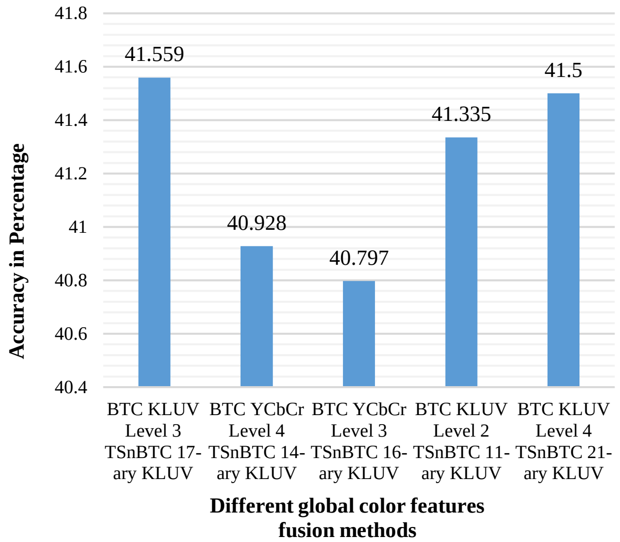

Fig. 4. Performance comparison of image retrieval method variations with color feature fusion of features extracted using BTC and TSBTC n-ary for observed top five variations with higher retrieval accuracy values

D. Image Retrieval with Feature Fusion of color features from Multilevel BTC and TSBTC n-ary with texture features from Multilevel BTC & TSBTC n-ary applied on LBP of color planes

In the experiment, features of best performing methods of BTC [15] & TSBTC n-ary applied directly on color planes were concatenated with features of best performing methods of BTC & TSBTC n-ary applied on LBP patterns. As observed for table III the LBP with KLUV has shown better performance in image retrieval. Here all the possible BTC and TSBTC n-ary color features are considered with texture features obtained from LPB KLUV and the image retrieval accuracy values are obtained.

Fig.5. represents the top five retrieval accuracy values observed among all experimented variations of proposed color and texture feature fusion based CBIR technique. Here it is observed that BTC-color features always give better results when compared with TSBTC n-ary color features. Also, TSBTC n-ary applied on LBP based texture features give better results than BTC applied on LBP based texture features. Hence fusion of BTC color features and TSBTC n-ary applied on LBP texture features achieves better results in comparison with other fusion variations. The highest accuracy of 43.7% is obtained from fusion of global color features from BTC level 3 applied on KLUV color plane and local texture features from TSBTC 3-ary applied on LBP patterns which are calculated using KLUV color plane.

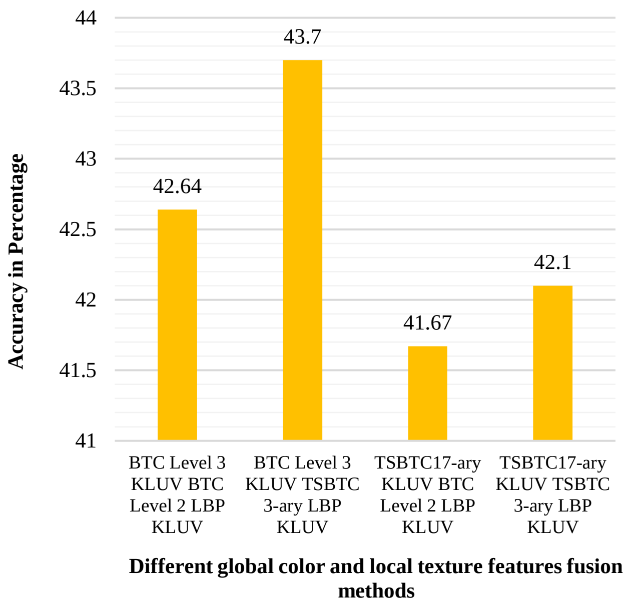

Fig. 5. Performance comparison of proposed color and texture feature fusion based CBIR for observed top five variations with higher retrieval accuracy values

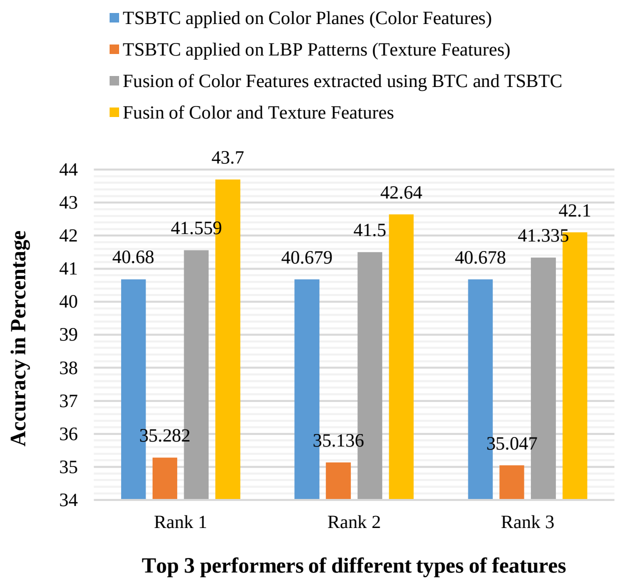

Fig. 6 Performance comparison of top 3 methods of global color features, local texture features and their fusion in proposed CBIR

Fig. 6 shows performance comparison of top 3 performers of TSBTC n-ary applied on color planes, TSBTC n-ary applied on LBP patterns, fusion of Multilevel BTC and TSBTC n-ary global color features and proposed fusion of global color and local texture features. Here it is observed that TSBTC n-ary applied on color planes provides better results when compared to TSBTC n-ary applied on LBP patterns. Fusion of global Color and local Texture features shows improvement in accuracy providing the best result among only global color or only local texture features

VIII. CONCLUSION

In this modern digital era image retrieval utilizes content-based features of an image expressed in form of shape, color and texture. These are objective as compared to textual description and hence more accurate. The proposed fusion technique combines global color and local texture features extracted using Multilevel BTC and TSBTC n-ary applied on color planes and on LBP patterns of color planes with various color spaces. Experimentation is performed on 1000 images of Wang dataset which comprises of 10 classes. The color features extracted using TSBTC n-ary applied on color planes shown increase in accuracy from TSBTC 2-ary to TSBTC 8-ary, after which it stabilizes. Texture features extracted using TSBTC n-ary applied on LBP Patterns shows increase in accuracy from TSBTC 2-ary till TSBTC 8-ary, after that it stabilizes. The fusion of BTC and TSBTC n-ary color features for global color and local texture content give the best results, with combination of BTC Level 3 applied on KLUV color planes and TSBTC 3-ary applied on LBP patterns of KLUV color plane. The proposed fusion of CBIR with global color & local texture features has given performance boost in retrieval accuracy.

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