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Retrieval of Images using Combination of Features as Color, Color Moments and Hu Moments

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ABSTRACT

In today's digital era, several of the image retrieval systems focus on retrieving images using features from images themselves such as color, shape and textures and are referred as low-level features. In this proposed work, the features like color with HSV color space, color moments and Hu moments are employed to retrieve similar images. Various experimentations were conducted on Wang's database images to test the combination of features for higher performance using precision, recall, accuracy and f-score. The results obtained are compared with one another and also with existing works. The retrieval performance is found to be high for proposed system against existing works.

Keywords: HSV Color; Color Moments; Hu Moments; CBIR;

1 Introduction

Content based image retrieval (CBIR) is a technique used in computer vision applications, using which the similar images from large databases are found and returned as a resultant set based on an input query image. The word content refers to the features like color, shape, textures or any other descriptors that best describes the images. CBIR is used as a standard technique in most searching applications in online search engines. The earlier text based search engines were obtaining the images based on the keyword provided as input, but the images obtained were not appropriate or the accuracy rate was very low against the expected images. In order to overcome this issue, CBIR was introduced with feature extraction from the database images collected and use a similarity measure to compare the best matching images and return to the query system [1].

In this proposed work, we have used the standard ground truth dataset of Wang's database images that comprises of 10 classes with 100 images in each class, making a total of 1000 images in the database [1, 5]. The feature vector for the entire database is collected, processed and stored as feature repository for future reference during querying of images.

In this proposed work, we have used only low-level features of images such as color feature, color moments and the Hu moments that describe the shape. Several experiments have been carried out and distance metric is used to compare the similarity between the database image features with query image features.

The organization of the paper is as follows: section 2 briefs about the related work, section 3 proposed a new CBIR system with an architecture and the different feature extraction techniques, the next section 4 presents the experimental results and discussions, and the final section 5 provides the conclusions and future work.

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2 Related Works

The image retrieval system can be implemented in various ways. The system varies with respect to types of features, number of features, combination of features, distance metrics, Graphical User Interface (GUI), indexing, relevance feedback and the database of images [17, 18].

A combination of features using Annular color histogram in HSV color space, color distribution entropy (CDE), the color level co-occurrence matrix (CLCM) for texture feature and the Hu – invariant moments as shape features are used as feature vector in [2]. A given digital color image is in RGB format as the default color space. In order to make it more convenient depending upon the applications, other color spaces can be used by conversion of RGB to either HSI, HSV, YUV etc., color spaces and are described in [3]. Out of these different color spaces, HSV color space with hue, saturation and value or intensity or brightness are more like the human eye perception of images.

The most popular color feature being used is the HSV color histogram by various researchers. The HSV color histogram feature alone is not enough to provide all the features in diversified image categories. In order to overcome such a limitation, combination of other low-level features is considered to form the feature vectors. One such combination is the texture features obtained by applying the Gabor filters from segmented regions of an image is discussed in [4]. In [5], uses a different combination of image features such as color volume with edge information, the energy feature from Gray-Level Co-occurrence Matrices (GLCM) and salient structure histogram, to retrieve the similar images.

The texture information from GLCM matrix like energy, contrast, entropy and uniformity are used as statistical information and gray color histogram is used to retrieve similar images from the dataset in [6] is discussed. The similarity is calculated with the use of distance metrics along with appropriate weights for different features. In [10], retrieval systems use color moment, local binary patterns and edge features to obtain similar images by using Manhattan similarity metric.

3 Proposed Methods

3.1 Architecture of the system

To implement any CBIR system, there are of two phases namely, online and offline phases. In the proposed work, we have used the features as HSV color histogram, color moments and the Hu's invariant moments. The proposed architecture of the CBIR system is shown in figure 1. In the offline phase, all the images in the repository are processed with feature extraction algorithm and the extracted features are stored for future reference. The online phase is initiated whenever the user submits a query image for which the similar images needs to be retrieved, is processed with the same feature extraction algorithms at runtime. The features obtained for the query image is compared with the features stored in the repository. The similarity metric used is Euclidean distance to get very close proximity images and then rank the images in ascending order of similarity and display the results on the GUI.

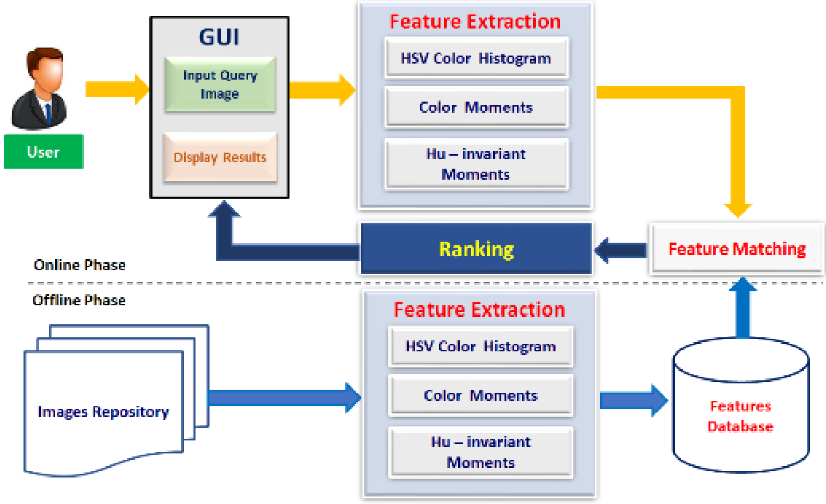

Figure 1: Proposed CBIR Architecture

3.2 Features Extraction techniques

3.2.1 Color

In digital image processing, there are different color space models available. The RGB color space is the most frequently used in generating of images from electronic devices like digital camera or a scanner. But the RGB color model is not suitable for processing of images and make analysis of it. Hence, there are several other models like HSV, HSI, CMYK, L*a*b, etc. that perceives the images in the way human eye perceives images in a natural way. In this work, we have considered the HSV color space model for feature extractions and finding out the moments in an image. The figure 2 shows HSV color model and its hexacone coordinate system [12, 13].

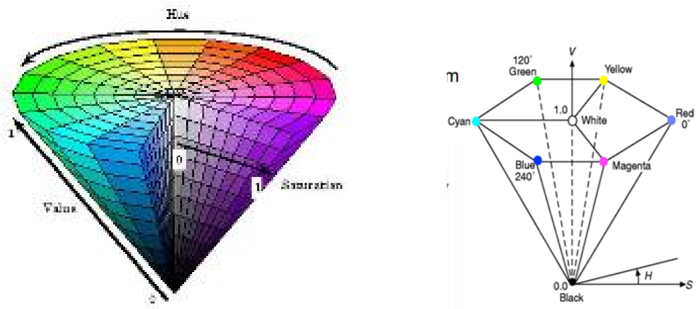

Figure 2: HSV color space – Hue, Saturation and Value [12] and hexacone coordinate system [13]

Hue is the color expressed from 0° to 360° degrees, the colors have the ranges as: for Red color between 0° to 60°, Yellow color is between 61° to 120°, Green color is between 121° -180°, Cyan is between 181°-240°, Blue color is between 240° – 300° and Magenta color is between 301° – 360°. Saturation is the gray color that ranges from 0 – 100 in percentage, 0 being darker and 1 being brighter. The value or brightness is similar to saturation that gives the intensity or brightness of the color ranging from 0 to 100 percent, with 0 being black and 100 is brightest revealing the most color.

The HSV color feature for an image can be obtained by translating the image from RGB color space to HSV color space and is shown in equations (1) to (5). The conversion algorithm is given:

STEPS FOR RGB COLOR SPACE TO HSV COLOR SPACE CONVERSION

Step 1: Normalize the RGB values from 0..255 to 0..1:

$$R' = {}^{R}/_{255}\,,\;\; G' = {}^{G}/_{255}\;\; B' = {}^{B}/_{255} \tag{1}$$

Step 2: Compute $Cmax = \max(R', G', B')$ and $Cmin = \min(R', G', B')$ (2)

$$\Delta = Cmax - Cmin$$

$$\text{Step 3: } Hue = \begin{cases} 60^0 \times \left(\frac{G' - B'}{\Delta}\ mod6\right), Cmax = R' \\ 60^0 \times \left(\frac{B' - R'}{\Delta} + 2\right), Cmax = G' \\ 60^0 \times \left(\frac{R' - G'}{\Delta} + 4\right), Cmax = B' \end{cases} \tag{3}$$

$$\text{Step 4: Saturation: } S = \begin{cases} 0\,, & Cmax = 0 \\ \frac{\Delta}{Cmax}\,, & Cmax \neq 0 \end{cases} \tag{4}$$

Step 5: Value: $\mathrm{V} = \mathrm{Cmax}$ (5)

Algorithm 1: The HSV color histogram computation as feature now computed as follows:

Step 1: Split the images into 3 different planes as Hue H, Saturation S and Value V

Step 2: Each plane of H, S and V is quantized by specifying quantization levels as of 8, 4 and 2 respectively

Step 3: Compute the maximum value for each plane of H, S and V

Step 4: Find the indexes of all the pixel values for the quantized channel values

Step 5: Indicate the pixel value to be 1 for index with channel value not zero

Step 6: Normalize the feature vector of 64 bins to be unit sum

Thus, the above steps are used to compute the HSV color histogram of size 8 x 4 x 2 equal to 64 bins of feature.

3.2.2 Color moments

The color moments are features of an image that are invariant towards scaling and rotation. It characterizes the color distribution of an image. The following are the color moments computed for color images:

1. Mean – it is the 1st color moment computed as average color of the image and is given by equation (6):

$$\mu_i = \sum_{j=1}^{N} \frac{1}{N} p_{ij} \tag{6}$$

where N is number of pixels in the image and p_{ij} is the value of the j^{th} pixel of the image at the i^{th} color channel.

2. Standard Deviation – 2nd color moment and is given by equation (7):

$$\sigma = \sqrt{\left(\frac{1}{N}\sum_{j=1}^{N}\left(p_{ij} - \mu_i\right)^2\right)} \tag{7}$$

where μ_i is the mean value for i^{th} color channel.

3. Skewness – 3rd color moment that describes how asymmetric is the color distribution and given by equation (8):

$$s_i = \sqrt[3]{\left(\frac{1}{N}\sum_{j=1}^{N}\left(p_{ij} - \mu_i\right)^3\right)} \quad (8)$$

4. Kurtosis – 4th color moment that provides the description regarding shape of the color distribution [13] and is given by equation (9):

$$K = \frac{E\,(x-\mu)^4}{\sigma^4} \quad (9)$$

where μ is mean of x, σ is second color moment of x and $E(t)$ expected value of quantity t.

The color moments are computed for three channels of the image in HSV color space and a total of 12 moments (3 channels x 4 moments) are extracted as second feature vector.

3.2.3 Hu – Invariant moments

The Hu – Invariant moments of an image are invariant to transformations like translation, scaling, rotation and reflection. These moment features can be extracted using central geometric moments of an image, given by equation (10):

$$\mu_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}(x - x_c)^p (y - y_c)^q f(x,y)\,dxdy \quad (10)$$

where $x_c = m_{10}/m_{00}$, $y_c = m_{01}/m_{00}$ are the coordinates of centroid.

The central moments in terms of geometric moments is given by equation (11):

$$\mu_{pq} = \sum_{k=0}^{p}\sum_{j=0}^{q}\binom{p}{k}\binom{q}{j}\left(-1^{k+j}\right)x_c^k y_c^j m_{p-k,q-j} \quad (11)$$

There are seven such Hu – moments [14] as given from equations (12) to (18):

$$\emptyset_1 = \eta_{20} + \eta_{02} \quad (12)$$

$$\emptyset_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \quad (13)$$

$$\emptyset_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \mu_{03})^2 \quad (14)$$

$$\emptyset_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \mu_{03})^2 \quad (15)$$

$$\emptyset_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})\,[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (16)$$

$$\emptyset_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \quad (17)$$

$$\emptyset_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] - (\eta_{30} - 3\eta_{12})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \quad (18)$$

3.2.4 Similarity Measure

The similarity metrics used in our proposed work is the Euclidean distance. There are three different features considered for experiments with individual color histogram as experiment 1, color histogram is combined with color moments as experiment 2 and then combination of color histogram with shape features extracted with Hu moments as experiment 3. The distances are found for individual features between query image and images in the database with weights as given in the equation (19).

$$D_{(q,db)} = w_1 S_{CHist} + w_2 S_{Cmom} + w_3 S_{Hu} \quad (19)$$

Where,

q refers to query image

db refers to database images features respectively

The weights in experiment 1 is $w_1 = 1.00$ because of only one feature, in experiment 2 the weights are $w_1 = 0.68$ of color histogram and $w_2 = 0.32$ for color moments, in experiment 3 the weights are $w_1 = 0.73$ for color histogram and $w_2 = 0.27$ for Hu-invariant moments.

3.2.5 Performance Evaluation Metrics

To evaluate the performance of the CBIR system, random inputs of images as queries are submitted and based on the retrieved results, precision and recall values are calculated using the equation (20) and (21). Using the values from equations (20) and (21), accuracy and F-score are calculated using the equations (22) and (23).

$$Precision = \frac{Number\ of\ Relevant\ Images\ Retrieved}{Total\ Number\ of\ Images\ Retrieved} \tag{20}$$

$$Recall = \frac{Number\ of\ Relevant\ Images\ Retrieved}{Total\ Number\ of\ Images\ in\ database} \tag{21}$$

$$Accuracy = \frac{Precision + Recall}{2} \tag{22}$$

$$F - score = 2 \times \frac{Precision \times Recall}{Precision + Recall} \tag{23}$$

4 Results and discussions

4.1 Experiment-1

This experiment was carried out with the HSV color histogram as feature consists of 64 bins. Images from various categories are chosen randomly and are given as input to the CBIR system. The average value of precision and recall of individual category are calculated and averaged over all categories to know the overall performance of the system. The results are shown in Table 1 and the graph plot is shown in figure 3.

Table 1. Average values precision and recall with various categories for experiment-1

Classes	Experiment-1 HSV Color Histogram			
	Precision (%)	**Recall** (%)	**Accuracy** (%)	**F-Score** (%)
Africans	81.68	69.76	75.72	75.25
Beaches	20.47	19.51	19.99	19.98
Buildings	61.78	52.09	56.94	56.52
Buses	61.20	58.42	59.81	59.78
Dinosaurs	96.07	63.71	79.89	76.61
Elephants	34.34	31.91	33.13	33.08
Flowers	57.52	52.59	55.06	54.94
Horses	90.44	67.42	78.93	77.25
Mountains	30.61	29.37	29.99	29.98
Food	80.20	74.87	77.54	77.44
Average	**61.43**	**51.96**	**56.70**	**56.30**

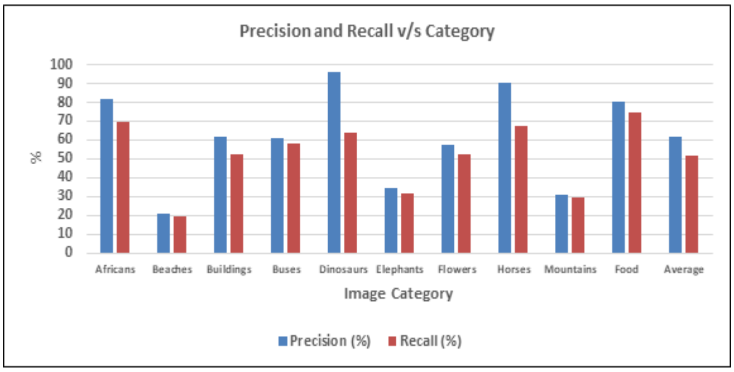

Figure 3: Performance of experiment 1

4.2 Experiment-2

This experiment was carried out with the HSV color histogram with 64 bins and the color moments with 12 features. The average value of precision and recall of individual category are calculated and averaged over all categories to know the overall performance of the system. The results are shown in Table 2 and the graph plot is shown in figure 4.

Table 2. Average values precision and recall with various categories for experiment-2

Classes	Experiment-2 HSV Color Histogram + Color Moments (Mean + SD + Skewness + Kurtosis)			
	Precision (%)	**Recall** (%)	**Accuracy** (%)	**F-Score** (%)
Africans	53.37	47.07	50.22	50.02
Beaches	49.31	47.34	48.33	48.30
Buildings	38.21	36.23	37.22	37.19
Buses	77.82	66.21	72.02	71.55
Dinosaurs	99.76	69.40	84.58	81.86
Elephants	70.69	60.60	65.65	65.26
Flowers	56.24	53.41	54.83	54.79
Horses	86.68	71.95	79.32	78.63
Mountains	61.53	56.78	59.16	59.06
Food	48.27	44.54	46.41	46.33
Average	**64.19**	**55.85**	**60.02**	**59.73**

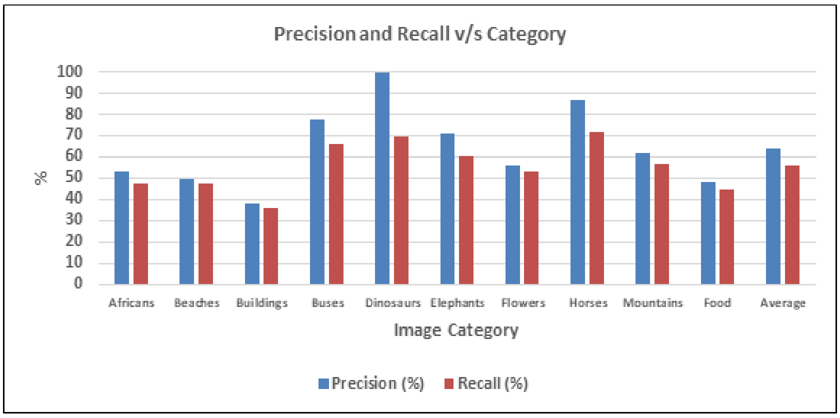

Figure 4: Performance of experiment 2

4.3 Experiment-3

The experiment-3 is carried out with the HSV color histogram 64 bins and Hu-invariant moments with 7 features. The average value of precision and recall of individual category are calculated and averaged over all categories to know the overall performance of the system. The results are shown in Table 3 and the graph plot is shown in figure 5.

Table 3. Average values precision and recall with various categories for experiment-3

Classes	Experiment-3 HSV Color Histogram + Hu-Invariant Moments			
	Precision (%)	**Recall** (%)	**Accuracy** (%)	**F-Score** (%)
Africans	88.66	81.63	85.15	85.00
Beaches	48.00	48.00	48.00	48.00
Buildings	77.06	65.03	71.05	70.54
Buses	85.75	84.87	85.31	85.31
Dinosaurs	96.59	69.91	83.25	81.11
Elephants	53.44	51.82	52.63	52.62
Flowers	64.82	63.49	64.16	64.15
Horses	95.65	78.39	87.02	86.16
Mountains	58.20	58.20	58.20	58.20
Food	88.28	84.70	86.49	86.45
Average	**75.64**	**68.60**	**72.12**	**71.95**

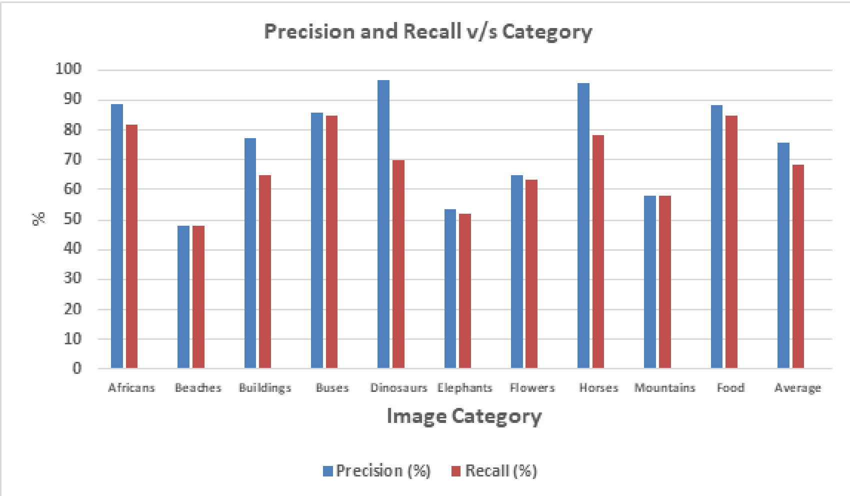

Figure 5: Performance of experiment-3

4.4 Relative study

4.4.1 Self-relative study

The performance of the experiments conducted is compared as in table 4.

Table 4. Comparison of performance with experiments conducted

Classes	Experiment-1		Experiment-2		Experiment-3	
	Precision (%)	Recall (%)	Precision (%)	Recall (%)	Precision (%)	Recall (%)
Africans	81.68	69.76	53.37	47.07	88.66	81.63
Beaches	20.47	19.51	49.31	47.34	48.00	48.00
Buildings	61.78	52.09	38.21	36.23	77.06	65.03
Buses	61.20	58.42	77.82	66.21	85.75	84.87
Dinosaurs	96.07	63.71	99.76	69.40	96.59	69.91
Elephants	34.34	31.91	70.69	60.60	53.44	51.82
Flowers	57.52	52.59	56.24	53.41	64.82	63.49
Horses	90.44	67.42	86.68	71.95	95.65	78.39
Mountains	30.61	29.37	61.53	56.78	58.20	58.20
Food	80.20	74.87	48.27	44.54	88.28	84.70
Average	**61.43**	**51.96**	**64.19**	**55.85**	**75.64**	**68.60**

From the above table 4, it is observed that the experiment-1 with only color histogram feature, the performance is moderate and in experiment-2 by the combination of color histogram with color moments, there is an improvement in precision and recall by 2.67% and 3.89% respectively. The experiment-3 gives better improvement in precision and recall than experiment-2 by 11.45% and 12.75% respectively.

4.4.2 Relative study against existing systems

The performance metrics of the proposed work is compared against works in [15], [16] and [6] and are shown in table 5. In the table 5, Pr represents Precision and Re for Recall.

Table 5. Comparison of performance with existing systems

Classes	Existing Work [15]		Existing Work [16]		Existing Work [6]		Proposed Work Experiment-3	
	Pr (%)	Re (%)	Pr (%)	Re (%)	Pr (%)	Re (%)	Pr (%)	Re (%)
Africans	73.00	14.60	68.30	14.10	73.33	16.00	88.66	81.63
Beaches	39.25	7.85	54.00	19.20	55.66	21.15	48.00	48.00
Buildings	46.25	9.25	56.20	17.40	63.25	14.23	77.06	65.03
Buses	82.50	16.50	88.80	12.10	86.75	21.15	85.75	84.87
Dinosaurs	98.00	19.60	99.20	10.10	92.52	50.12	96.59	69.91
Elephants	59.25	11.85	65.80	14.90	67.00	25.25	53.44	51.82
Flowers	86.00	17.20	89.10	11.20	86.00	22.34	64.82	63.49
Horses	89.75	17.95	80.30	13.40	75.00	21.66	95.65	78.39
Mountains	41.75	8.35	52.20	21.30	71.23	15.00	58.20	58.20
Food	53.45	10.69	73.30	13.20	69.25	21.35	88.28	84.70
Average	**66.92**	**13.38**	**72.70**	**14.60**	**73.99**	**22.82**	**75.64**	**68.60**

We can observe from the above table that, the proposed work has higher performance than existing works in [15], [16] and [6], with respect to average precision by 1.65% and average recall by 45.78% respectively.

4.4.3 Accuracy and F-Score metrics computation

The metrics Accuracy and F-score are computed and used here to compare existing and proposed works as shown in table 6. The proposed work has given higher values with respect to accuracy and F-score as 23.71% and 37.07% respectively. In the table 6, Acc represents Accuracy

Table 6. Comparison of Accuracy & F-Score with existing and proposed works

Classes	Existing Work [15]		Existing Work [16]		Existing Work [6]		Proposed Work	
	Acc (%)	F-Score (%)	Acc (%)	F-Score (%)	Acc (%)	F-Score (%)	Acc (%)	F-Score (%)
Africans	43.80	24.33	41.20	23.37	44.67	26.27	85.15	85.00
Beaches	23.55	13.08	36.60	28.33	38.41	30.65	48.00	48.00
Buildings	27.75	15.42	36.80	26.57	38.74	23.23	71.05	70.54
Buses	49.50	27.50	50.45	21.30	53.95	34.01	85.31	85.31
Dinosaurs	58.80	32.67	54.65	18.33	71.32	65.02	83.25	81.11
Elephants	35.55	19.75	40.35	24.30	46.13	36.68	52.63	52.62
Flowers	51.60	28.67	50.15	19.90	54.17	35.47	64.16	64.15
Horses	53.85	29.92	46.85	22.97	48.33	33.61	87.02	86.16
Mountains	25.05	13.92	36.75	30.25	43.12	24.78	58.20	58.20
Food	32.07	17.82	43.25	22.37	45.30	32.64	86.49	86.45
Average	**40.15**	**22.31**	**43.65**	**24.32**	**48.41**	**34.88**	**72.12**	**71.95**

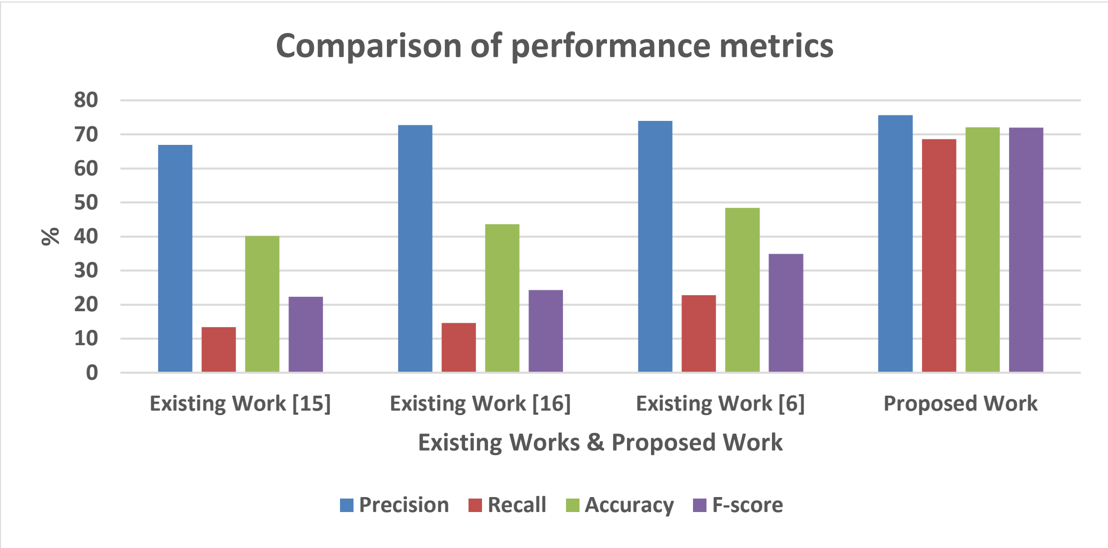

Figure 6: Comparison of performance with existing systems and proposed system

4.5 Results

The following figures from 7 to 18 shows sample results from the proposed work.

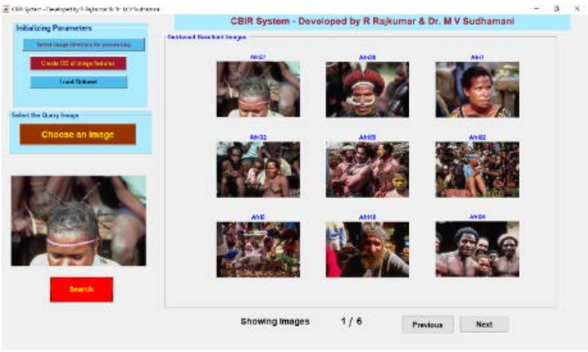

Figure 7: Query in class Africans # 1 (pp 1)

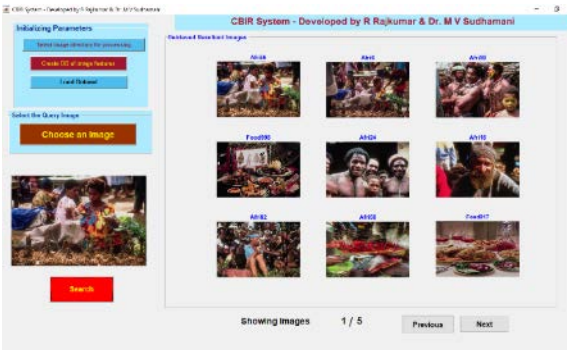

Figure 8: Query in class Africans # 2 (pp 1)

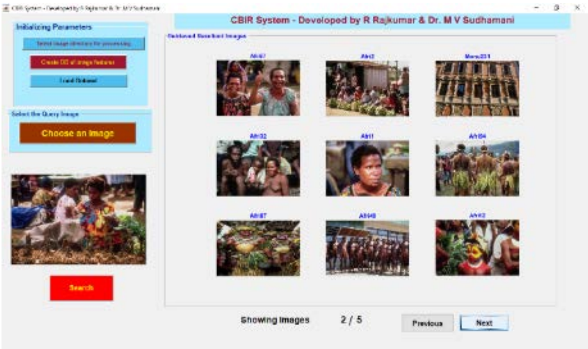

Figure 9: Query in class Africans # 2 (pp 2)

Figure 10: Query in class Africans # 2 (pp 4)

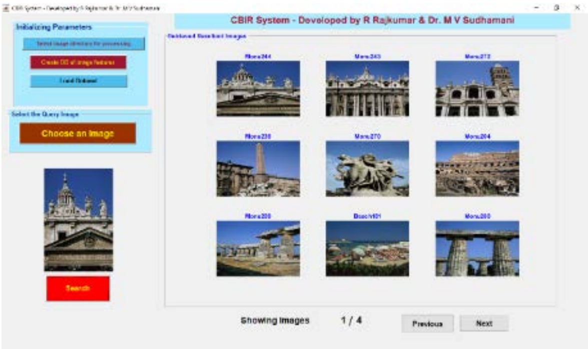

Figure 11: Query in class Buildings # 1 (pp 1)

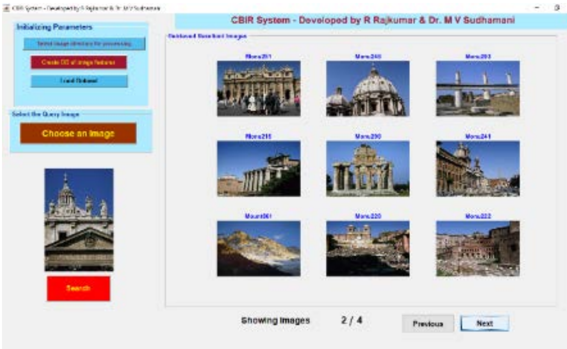

Figure 12: Query in class Buildings # 1 (pp 2)

Figure 13: Query in class Bus # 1 (pp 1)

Figure 14: Query in class Bus # 1 (pp 2)

Figure 15: Query in class Bus # 1 (pp 3)

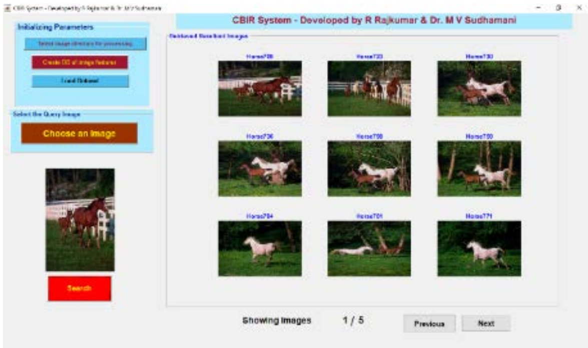

Figure 16: Query in class Horses # 1 (pp 1)

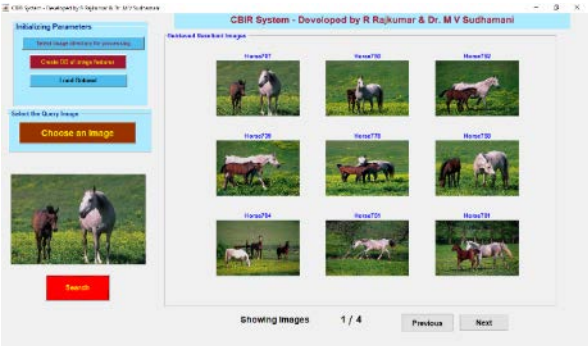

Figure 17: Query in class Horses # 2 (pp 1)

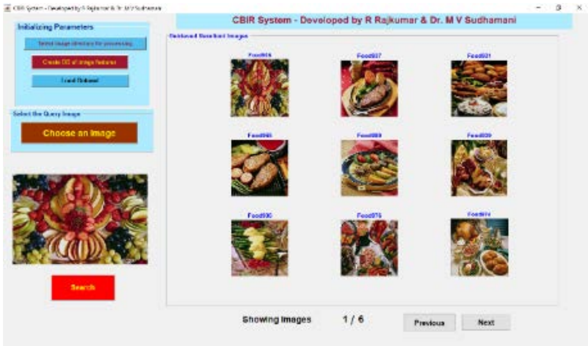

Figure 18: Query in class Food # 1 (pp 1)

5 Conclusion

This paper presents a work carried out using the low-level features of an image like HSV color histogram, color moments and Hu-invariant moments. Different experiments were carried out on the proposed CBIR system using the above features and combinations of the same on Wang's dataset of 1000 images of 10 classes. The performance of the system was observed using the average precision, recall, accuracy and F-score. The performance was compared with the existing works and found that the proposed system has performed better. In future work, there is a scope for improvement in proposed work by considering various other combinations of image features.

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