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UNIQUE CBIR – A Unified Method of Retrieving Similar Images

G. UmaMaheswar
Sr.Consultant ,CMC Centre
Hyderabad, Telengana,India

P. Ramana Reddy, PhD
Prof. ECE Dept, JNTUA College of Engg.Anantapuramu,AP, India

ABSTRACT
Content Based Image Retrieval (CBIR) is a method of extracting image features and calculate visual similarity based on these features. Lot of research activity is continuing for optimizing and improving the feature extraction methods focusing on colour, texture and shape features to minimize the semantic gap. Relevant Feedback (RF) is one variant of CBIR wherein the user provides feedback by selecting the most relevant image from retrieved images and make it a query image for the subsequent iterations. The RF methods improved the performance of the overall system in multiple iterations but the time taken for the total process increases on the other hand. This paper attempts to address the semantic gap problem by having the user interface in the forward path by adding some more key requirements of the user for narrowing down the search options thereby increasing the system performance and reducing the retrieval time.

Keywords
Content Based Image Retrieval - Relevant Feedback – Similarity - Feature Vector

1. INTRODUCTION
The proliferation of internet for exchange of information increased the need for content storage. Large amount of application development and process automation has led to increase in text based data storage. But over a period of time, with the need for data analytics and wide popularity of social network coupled with user Information Technology awareness increased the storage requirements for video and images also. The size of the image data bases have increased from Gigabytes to Petabytes. The number of images has increased from few hundred thousand to the order of billions. This created a need for searching the required images from the large group of images.

Content Based Image Retrieval (CBIR) is one such search procedure where in the system retrieves the images from database similar to query image. Content-based image retrieval uses the visual contents of an image such as color, shape, texture, and spatial layout to represent, compare and index the images. In a typical CBIR system, visual contents of the images extracted and described by multi-dimensional feature vectors and saved as feature database. The query image is provided to the system by the users for which the similar images are to be retrieved. The system then changes this query image into its internal representation of feature vector. The similarities /distances between the feature vectors of the query image and those of the images in the database are then calculated and retrieved with the aid of an indexing scheme [1].

It has been observed that there exists a gap between the images retrieved and the query image which is referred to as Semantic gap in the literature [2]. This is the gap between the user expectations from the system and the system understanding of user requirements. This is due to the fact that neither a single features nor a combination of multiple visual features could fully capture high level concept of images [3]. Besides, the performance of image retrieval system based on low level features is not satisfactory.

There have been many attempts to reduce the gap by researching on the more efficient methods of low level feature descriptors and also to allow user interference in the feedback path for expressing the more relevant retrieved images thereby to narrow the search options [4]. This method is popularly known as CBIR with RF (Relevant Feedback). There are many experiments which suggested various work arounds to improve the performance of the RF methods.

The RF methods improved the performance [5] of the overall system in multiple iterations. The number of iterations is increased to improve the performance of the system but the time taken for the total process increases on the other hand.

This paper attempts to address the semantic gap problem by having the user interface in the forward path by adding some more key requirements of the user for narrowing down the search options thereby increasing the system performance and reducing the retrieval time. The further topics will elaborate on this concept.

2. PROPOSED METHOD
In addition to having multiple features, the other approaches for improving the performance are to provide the user interference in the searching process. There are numerous methods [6, 7] that have used the user interference in the feedback path (Popularly known as CBIR with Relevant Feedback - CBIR-RF) thereby selecting the relevant images from the retrieved image and using the most relevant image as query image in the subsequent iteration.

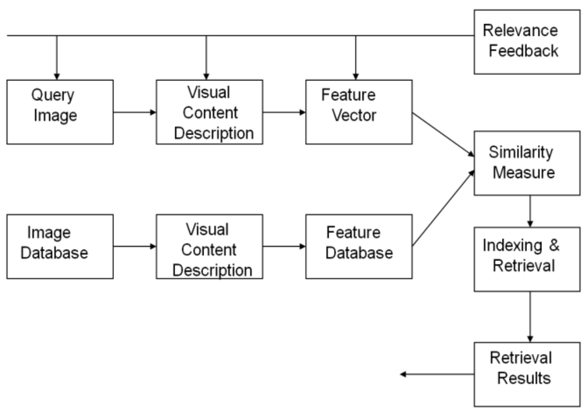

Figure 1.a. CBIR with Relative Feedback

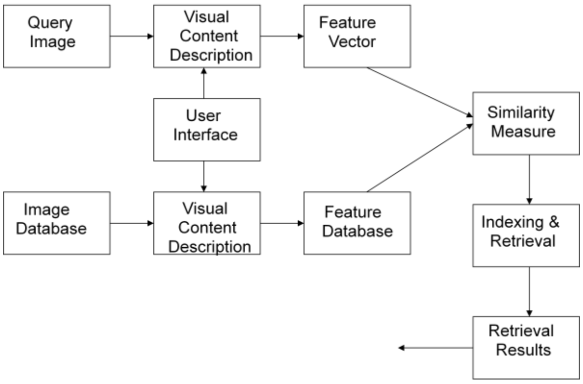

Figure 1.b. CBIR with Detailed Frontend User Interface

Although the RF methods improve the performance, the amount of time they take is more than the single iteration time. This impact of the retrieval is significant for the large image database sizes. The second limitation of these methods is in providing an image as the input even in the subsequent iterations. This will not reduce the semantic gap between mapping of extracted features and human perceived semantics significantly.

To overcome the above mentioned limitations and also to narrow down the search process, the user has to provide the context for the search in terms of his choices. This provision will set the expectations of the user and also will help in reducing the gap. The user has a choice to closely select the similar images by clearly specifying his requirements. Hence it is proposed to have the user interface in the forward path of the search process and also map the user needs with the feature descriptors [8,9] as shown in the figure (1.b).

A new method is proposed namely, UNIQUE (UNIfied QUEry) method of CBIR which is the combination of query image along with lot of user provided information. It allows user to clearly define his intent to search the database from the list of options provided to him.

The subjectivity in the visually perceived semantics is more important parameter. This makes image content description a subjective phenomenon of human perception, characterized by human psychology, emotions, and imaginations. This parameter is considered and hence, the user selected, user definable semantic features are combined along with the query image. There are multiple choices made available to the user to select / define his requirements. The list of features and their definable parameters make the system more users friendly and intuitive. The descriptions for the feature are mapped to the user understandable terms which are shown in Figure (2). These are mapped to the appropriate feature detection methods at the back end. The feature vector is formed with the selected features provided by the user through the user interface.

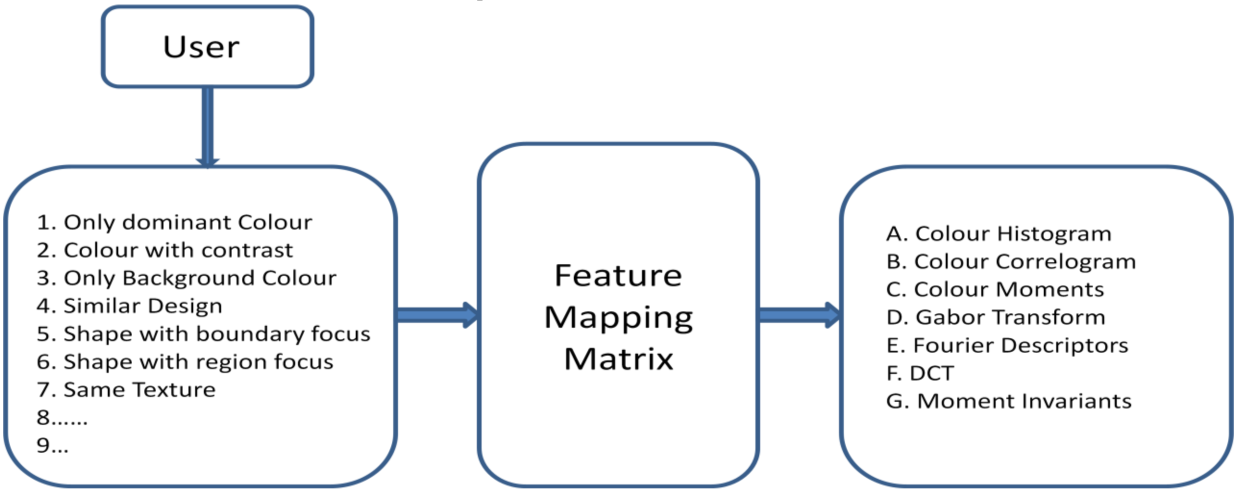

Figure 2. User –System Feature Mapping Matrix

The proposed UNIQUE System is scalable and manageable. The number of features and their detection methods can be increased coupled with the suitability of that method for a particular feature selected by the user. There exists a relation between the front end user requirements and back end feature detection system through the proposed algorithm.

2.1 Steps involved:

1. The user will have ‘ X ’ (X = { x1, x2, x3, …..}) options corresponding to the possible selection criteria. Along with the query image, the specifications from this selection box also are provided as input.
2. The user choices are multiplied by the binary weights attached to each selection (either 1 or 0).
3. The resultant scalar product will have the right combination of features to be detected and represented. The feature detection methods are finite. Y = { y1, y2, y3,….}.
4. Example: If the user selects, x1 and x5 as the required criteria, then the product would result a vector of [1, 0, 0, 0, 1, 0, 0]. This value is mapped to Y = Y1 and Y3.
5. The System has a feature database corresponding to the selected feature detection methods identified to match the combination of the user choices. In the above example the corresponding values for Y1 and Y3 are extracted.
6. The corresponding values for the query image are also calculated and their distance is calculated using the Euclidian measure.

7. The distances for each database image for all the identified methods are calculated, averaged and indexed in the ascending order of the distance.

8. The top 'n' images having the least distances below the threshold value are retrieved and presented.

2.2 Experiments:

The images are taken from Wang database. There are 10 categories having 100 images in each category. These are divided into two groups, each having 500 images. The Colour, texture and shape features are considered for extraction. The Colour Histogram [10], Colour Correlogram, Colour Moments [11] are the methods considered under Colour feature category. Similarly Gabor and Wavelet Transform for Texture [12] and Moment Invariant Method and Fourier Descriptors [13] for shape feature are considered.

The descriptors for all the thousand images in all the above mentioned seven methods are calculated and stored in the database. The experiments are conducted in two categories of 500 image each. The query image is selected from one these 10 categories and calculated the Precision and Recall for all the methods.

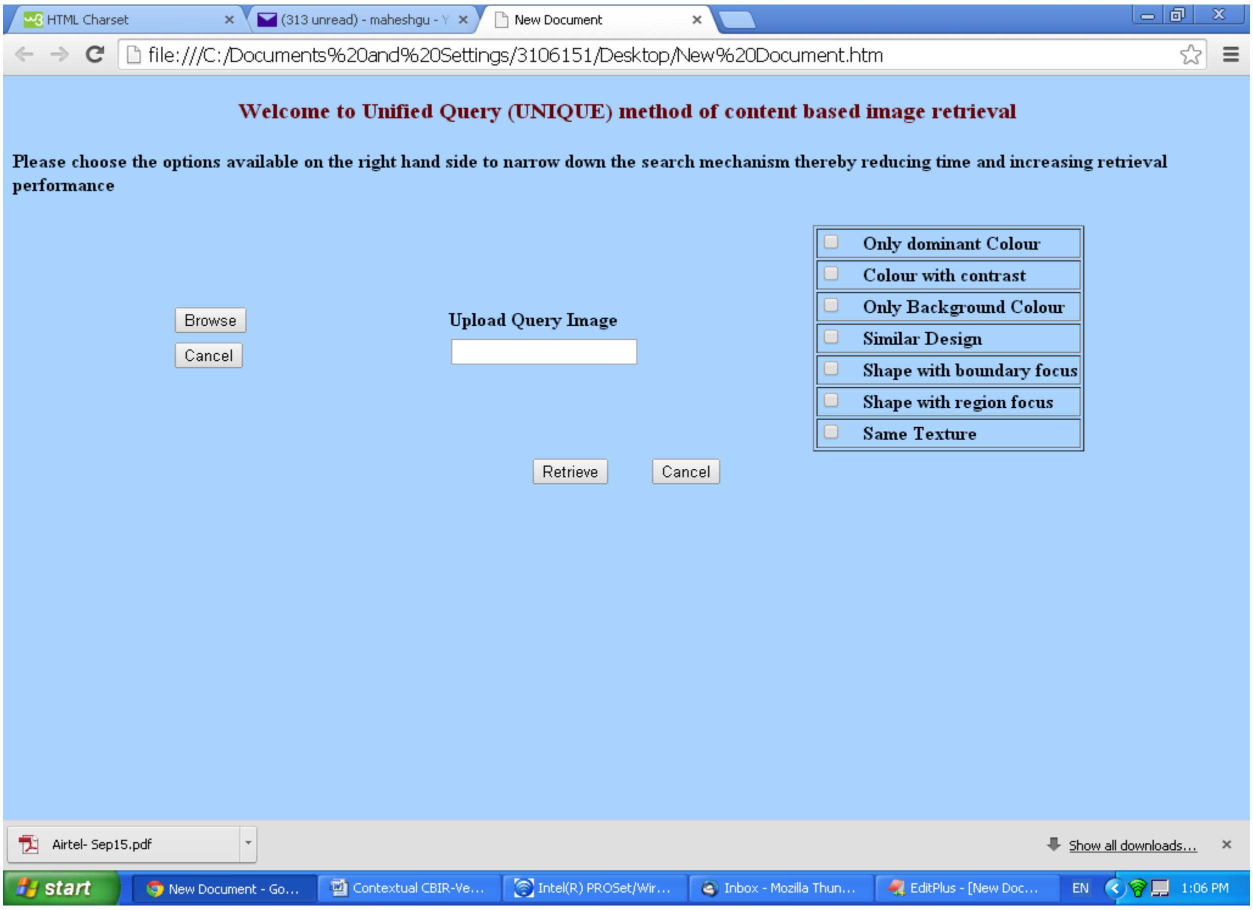

Figure 3. The User Interface

$$\text{Precision} = \frac{\text{No.of relevant images retrieved}}{\text{Total No.of Relevant Images in the database}}$$

$$\text{Recall} = \frac{\text{No.of relevant images retrieval}}{\text{Total No.of Relevant Images in the database}}$$

The query image is selected from one of the 1000 images and search is conducted. The top 10 images are considered relevant. The search is performed on all the 1000 images of 10 categories. The detailed results for all the 10 categories are recorded and the performance summary is provided in the table-1.

Table -1(a): The Performance parameters

	AFRICANS		BUILDINGS		BUSES		BEACHES		DINOSAURS	
Detection Method	Precision	Recall	Precision	Recall	Precision	Recall	Precision	Recall	Precision	Recall
Colour Histogram	51	61	53	57	55	60	71	62	76	80
Colour Correlogram	61	62	54	62	58	64	57	54	71	74
Colour Moments	56	54	47	54	62	60	73	67	77	84
Wavelet Transform	55	51	62	65	45	53	44	39	56	65
Gabor Transform	58	56	66	61	51	54	52	43	47	56
Fourier Descriptors	47	52	68	65	68	71	55	46	65	70
Moment Invariants	56	48	71	62	61	65	64	59	68	72

Table -1(b): The Performance parameters

	HORSES		ELEPHANTS		MOUNTAINS		ROSES		TABLES	
Detection Method	Precision	Recall	Precision	Recall	Precision	Recall	Precision	Recall	Precision	Recall
Colour Histogram	72	70	64	60	68	74	66	74	57	60
Colour Correlogram	56	60	46	52	48	60	68	71	51	52
Colour Moments	68	65	69	62	61	72	71	75	61	55
Wavelet Transform	55	56	52	56	57	64	55	62	52	56
Gabor Transform	54	58	57	48	61	62	58	52	39	45
Fourier Descriptors	64	66	66	56	72	64	76	69	73	65
Moment Invariants	56	58	64	62	59	72	71	64	65	78

These values are obtained separately for individual methods. The combination of the methods is evaluated based on the user inputs at the Search Interface.

The tests were done with UNIQUE CBIR interface using various query images and choosing the required options from the list. In the first experiment, the dinosaur image is taken as a query image. The user choices are Shape with boundary focus as the shape of the dinosaur is unique and the texture is also specific. User need not know what feature detector methods that the algorithm should use. The requirements are captured from the user interface and the feature selection vector is formed with these choices. The corresponding detector methods are identified internally by the system based on the analysis and accordingly Gabor and Invariable moment methods are selected by the system for calculating the similarity and the performance parameters subsequently. The other results are given in the table-2.

Table -2. The Performance Parameter with UNIQUE CBIR

Method	Time Taken (in Sec)	Precision	Recall
Query Image - Dinosaur Choices: 1. Shape with boundary focus 2. Same texture type	25.2	84	78
Query Image - Bus Choices : 1. Shape with region focus 2. Same Colour	24.3	78	80

Query Image - Rose Choices: 1. Dominant Colour 2. Same texture	21.6	75	72
Query Image - Beach Choices : 1. Back ground Colour 2. Colour with contrast	23.8	68	72

3. CONCLUSION

The image content description is a subjective phenomenon of human perception, characterized by human psychology, emotions, and imaginations. This is the reason for semantic gap in CBIR. The root cause for the semantic gap is understood and tried to reduce by providing more options to the user to define his requirements clearly. The results are satisfactory compared to the many systems proposed in the literature [14,15]. The comparison is done with RF methods with respect to retrieval time. In RF method, there is a probability of non-convergence whereas it is definite in UNIQUE method.

4. FUTURE WORK

The number of user choices and the number of feature detection methods limited in this paper. The same can be increased to further narrow the search and improve the results. More detection methods can be added; especially object detection methods will help in better the retrieval efficiency with a small penalty on retrieval time. The binary weights in the mapping of the features to the user choices can be modified with any non-linear machine learning algorithms to have more accurate results. The averaging of the distance measurement can also be changed with user defined weights.

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