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A Content-Based Indexing System for Image Retrieval

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Abstract

Background/Objective: The aim of this research paper is to create an image indexing system by identifying and explaining image features. In this research work we are developing an image indexing algorithm. **Method/Analysis:** From the previous researches we select several features that can be considered suitable and can be implemented with the help of Global feature – Boolean Edge Density, Edge Density, Color Sigma, Edge Direction, Color Average and Region feature – Moment Invariant, Grey Level, Region Area. **Finding:** We identified best combinations for different image data set. The experiments show that region based features increase the performance of image retrieval**. Application/Improvement:** While comparing the two image features, i.e. global features are less substantial than the region features.

Keywords: Binary Threshold, Global and Region Features, Image Retrieval, Image Indexing, K-Means Clustering

1. Introduction

Now-a-days, the database frameworks are becoming more famous. The examples include University students' detail information, library book information, livestock market information and grocery information, etc. These all examples provide the facilities of querying and retrieving the data. Every database has a query facility as a fundamental feature.

An index of images is not similar as an index of a book. Providing an image a name and using it as an index is not the process we desire. We want to atomize the process of indexing and retrieval of images.

If we search an image on the basis of a particular color or image in a database the problem persist as we cannot compare every image and their pixel with the query image and the same time the result of it is equal images but not the similar images. This is due to the identical images with different perspectives in an image data set. We need to use features of an image as its index. Image features such as shape, texture, and color can be mixed and can be used as an index.

The benefits of this process are as follows:

1. Instead of storing whole image only feature of images are stored such as shape, texture, color as an index.
2. It saves data storage space.
3. It saves time of storage and retrieval.
4. The use of features as an indexing will increase the accuracy.

Thus, by using image features as an index, we get more proficient and effective indexing system.

1.1 Content Based Image Retrieval (CBIR)

Kato[1] used the term Content-Based Image Retrieval (CBIR) in 1992, to explain the usual retrieval of images from an image database (texture, shape, color) within an image. Since that time, we use this term to explain the process of retrieving preferred images from a huge collection of an image data set on the basis of syntactical image features. Content based indexing & retrieval tools, techniques and algorithms are originating from areas such as pattern recognition, statistics, image processing etc.

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Image queries are categorized into three levels:

1. Primitive features such as texture, color, shape etc.
2. Logical features such as the distinctiveness of the objects shown.
3. Abstract features such as the importance of the scenes depicted.

Whilst Content- Based Image Retrieval system does works most efficiently at the lowest of these levels according to Eakins[2]. Most users require higher levels of retrieval challenging research to reduce the gap between the usefulness of these features and the requirements of the user.

Usually in Content-Based Image Retrieval[3], comparisons are made from a query image and prospective images from the image database by using an image distance technique.

1.2 Application scenarios of CBIR

A broad range of potential application of CBIR technology has been identified. Some potential areas are as under.

1. The Military
2. Intellectual property
3. Architectural and Engineering Design
4. Fashion, Architecture and Engineering Design
5. Advertising & Journalism
6. Medical Diagnosis
7. Remote sensing & Geographical Information Systems (GIS)
8. Art & Historical Research
9. Training & Education
10. Home Entertainment
11. Web Searching
12. Filtering of adult content on the web
13. Travel and Tourism
14. Crime Prevention & Law Enforcement

1.3 Global Features

More or less of the existing CBIR systems extract features from the whole picture not from certain regions in it and these features are referred to as Global features.

Verma and Mahajan[4] used Sobel and canny edge detection algorithm for extracting the shape characteristics of the images. The classified images were then indexed and labeled to retrieve the similar images from the database.

In their experiments the results show that using the canny edge detection technique retrieved similar images from large databases.

Zhang[5] proposed a better retrieval method in this by combining both texture and color features. By calculating both the texture and color features of the images, indexing is done using by combining of these two features of the database images.

Yoo et al.[6] proposed two types of indexing keys to reduce unrelated images for a particular query image.

1. The major colors' set signature is linked with color information.
2. The distribution block signature is linked with spatial information.

1.4 Regions Features

Region based retrieval system maps images at the object level and tries to overcome the problems of global based search system. It decomposes an image into regions by using image segmentation. If the decomposition is ideal the image regions are matched at the object level[7].

Wang et al.[8] suggested the IRM (Integrated Region Matching) algorithm, which allows comparing a region of one picture with a number of regions of another picture. This is an example of the many much relationship between any two image regions. The similarity between two images may be labelled as the weighted sum of distances in the feature space.

Zhang et al.[9] proposed the matter of effective and efficient content based image retrieval by presenting an indexing and recovery scheme. He mixes texture, shape and color, data for the retrieval and indexing. This System uses these region features acquired through unsubstantiated segmentation, as contrasting to concern them to the entire image area. Fuzz Club stress on improving on color feature when color histogram bin are not autonomous.

Swain and Ballard[10] proposed histogram intersections as a similarity measure. However, given that histograms are sensitive to noise due to their sparse nature. Stricker and Orengo extended this work to use a cumulated histogram and introduced the use of color moments with a weighted Euclidean distance metric to determine image color similarity. This extension helped to improve the accuracy of the image matching since the histograms were far less susceptible to noise.

Zhang and Hu[11] identified seven moment invariants to shape transformations and were derived from the second and third moments. Other well known methods of shape representation are area and circularity as well as

minimum and maximum axis all of which have been employed in the QBIC retrieval system by IBM.

Jain and Vailaya[12] in their research paper on "Image retrieval using color and shape" suggested efficient retrieval of images using the shape and color content in images. Their approach relies on image features that utilize image cues such as shape and color. According them earlier approaches which concentrate on pulling out a single summarizing feature, their method joins features that exemplify both the shape and color in pictures.

Sajjanhar and Lu[13] in their research paper they compared Fourier descriptors and moment invariants for image retrieval and found in their process are not drastically contradictory.

1.5 Problem

In this research work, the problem is to find out the best features or characteristics of an image as an index and combining those features for successful retrieval[14]. From the previous researches about image features for indexing[15]. We select several features that can be considered suitable and can be implemented as follows:

Global feature – Boolean Edge Density, Edge Density, Color Sigma, Edge Direction, Color Average.

Region feature – Moment Invariant, Grey Level, Region Area.

However the problem lies in combining features to make an effective index for each and every image.

There are still few question say

1. If we combine two or more different methods it will be more effective than using each method separately.
2. Can be improved retrieval by combining region and global feature.

In the past, there are many studies those are based on Tree structure and it uses image features.

We required a tree structure to handle the image data structure features that should be suitable as an index. Same time for creating the index we should constraints on algorithm and tree structure. The study shows that a detailed and precise query requires searching through the least number of indexing entries.

For retrieval process, it is very difficult to match the features for similarity.

We need similarity method that should be easy to use and quick to compute. The comparison of the images, then considers the features similarity[16,17]. The target images the query image are evaluated on the bases of their features[18].

2. Material and Method

The aim of this research work is to create an image indexing system by identifying and explaining image features.

In this research work we are developing an image indexing algorithm. This algorithm based on the study of various image features of computation and their utilities. In the research work we study the different combination of image feature for successful retrievals of images[16,17].

In this research, we focus on selection of feature rather than the tree structure. To handle our data structure we use R-Tree for image indexing. We also test the image indexing by putting some queries on the indexed database for retrieval.

There are still few question say

1. If we combine two or more different methods it is more effective than using each method separately?
2. Can be improve retrieval by combining region and global feature?

To solve the problem, we develop a data structure which consist two parts

a. Global data structure consisting global features
b. Region data structures consisting of regions data.

The global data structure consists of Boolean Edge Density, Edge Density, Color Sigma, Edge Direction, and Color Average. Whereas the region data structure consists of Moment Invariant, Grey Level, Region Area.

Each image includes global feature and region feature. This shows each region data and global data are pointing to each other. R tree will store all region data structures. A rectangle will represent each region data structure in the R- tree and used at the searching stage. We use 600 x 600 dimensions as a linear normalization size to overcome to possibilities of different sizes of images.

We have selected 10 image dataset from the different image repository. The dataset is namely Animal(100 training images), Car (81 training images), Flower(106 training images), Face (133 training images), Fruit(89 training images), House (100 training images), Lake(100

training images), Mountain (110 training images), Plane and Sunset (130 training images). We have chosen 300 images randomly from each category for training purpose. The images are real world, and with high intra-class variability.

2.1 Image Indexing Model

The Figure 1 shows the steps of process the image starting from the original image to the image features are inserted into the tree structure.

1. Firstly Using the Binary Threshold technique we split the object from the image background.
2. We divide image features into two parts
   1. Global section 2. Regional section
3. Quantization technique is applied to simplify the colors in Global section.
4. As described in the Global feature all features are calculated and stored into the data structure.
5. Applied the K-Mean Clustering with Binary Threshold (T) resultant image. Here we are using the value of k is 15.
6. Applying the labelling algorithm to detect the regions spatially.
7. As described in the Region feature all features are calculated and stored into the data structure.
8. Afterwards, in R-Tree insert all region data structures point to corresponding global data structure.

2.2 Image Retrieval Model

As we can see in the Figure 2 the query image is in the retrieval system & indexing system is similar. First, it goes through the pre-processed and then goes to the Global and Regional feature calculated the different values and insert into the R-tree structure. Here we applied the Euclidean distance and some other retrieval process used in the image indexing system to calculate the comparison among query image and data set images features.

As we can see in the indexing system retrieval system is also split into the two parts, first is Global Region and second is Region. Where Global region finds the similarities of Global features and Region feature find the similarities of Region features.

After calculation of Global and Region features the system will give the average value of similarities. Then the system will have one value that is used for comparing between the query image and data set image. The system

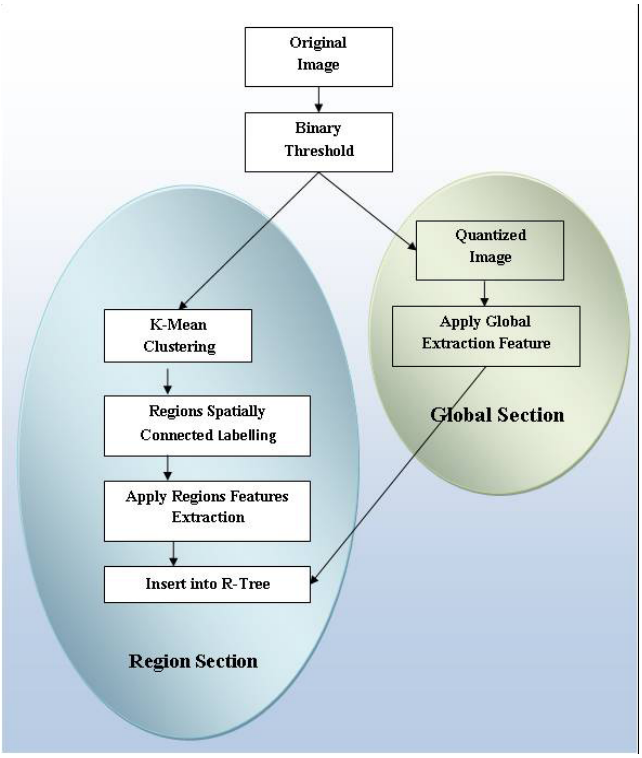

Figure 1. Indexing System.

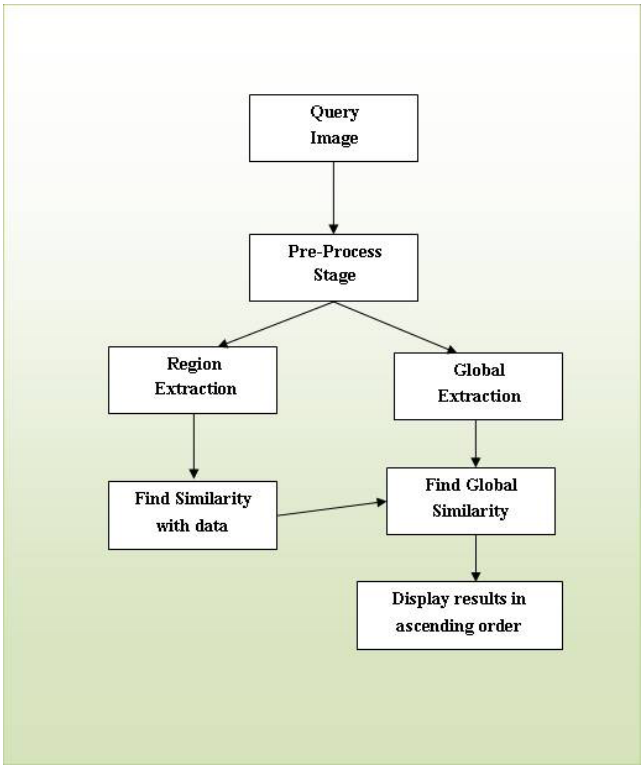

Figure 2. Image Retrieval System.

will identify which similarity value matched with which image in the image data set. The system will order by those similarity values in ascending order that was computed against the image dataset.

The similar value images will come up first as a result. In retrieval system we put on/off the image features are used at comparison.

So when we want to use similarity by using the only global feature or only region feature or combination of both features. This will help us to find the best combination that which features is best for whom. In region comparison process first regions will be extracted and then find the similarity the data set and then this result is compared with the global similarity of the feature.

This reduces the computation time of comparison. Because all images of data set are not go through the global comparison of the system.

Sometime it may be possible that some relevant image are not included, the reason behind is filter process.

3. Results and Discussion

This outcome of the research has been obtained from experiments using image data set of approx 1000 color images. These images are primarily divided into 10 data sets like Animal, Sunset, Plane, Mountain, Lake, House, Fruit, Flower, Face, Car. For finding the best combination of image's features of the current image data set. We turn off the Region feature and 8 combinations of Global features is performed & those are given bellow:

Global feature Combination 1:
i. Color sigma.
ii. Edge density.
iii. Color average.
iv. Boolean edge density.
v. Edge direction.

Global feature Combination 2:
i. Color sigma.
ii. Edge density.
iii. Color average.
iv. Boolean edge density.

Global feature Combination 3:
i. Color sigma.
ii. Edge density.
iii. Color average.

Global feature Combination 4:
i. Color sigma.
ii. Color average.

Global feature Combination 5:
i. Color average only.

Global feature Combination 6:
i. Color sigma only.

Global feature Combination 7:
i. Edge density only.

Global feature Combination 8:
i. Color average.
ii. Boolean edge density.
iii. Edge direction.

Precision and Recall have been calculated from the above 8 mentioned combination.

We got an average precision and recall after applying randomly on the half of the image data set.

As we can see in the Figure 3 that combination number two, three and eight showed a good results as compared with the other combinations this is displayed.

We have come to the conclusion that the 3rd number combination gives the best results as compared with the other combinations.

In 9th combination we combined the region features with the 3rd combination (color sigma, color average, edge density).

In 9th combination we can examine in the Figure 4 there is a significant gain in the precision.

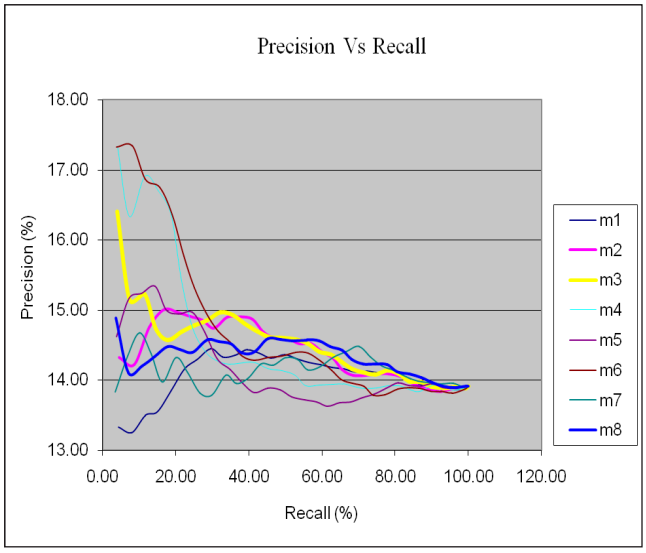

Figure 3. Combination 1-8 (Precision vs Recall).

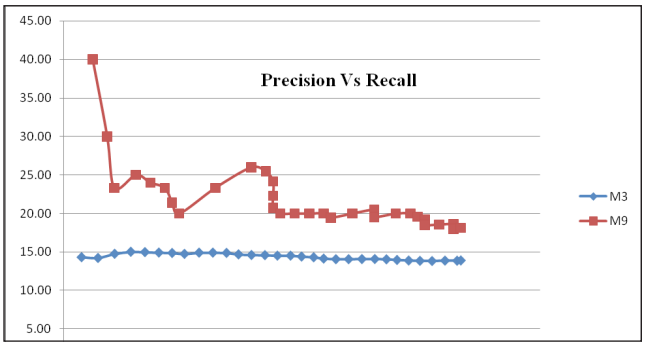

Figure 4. Combination 3 and 9 (Precision vs Recall).

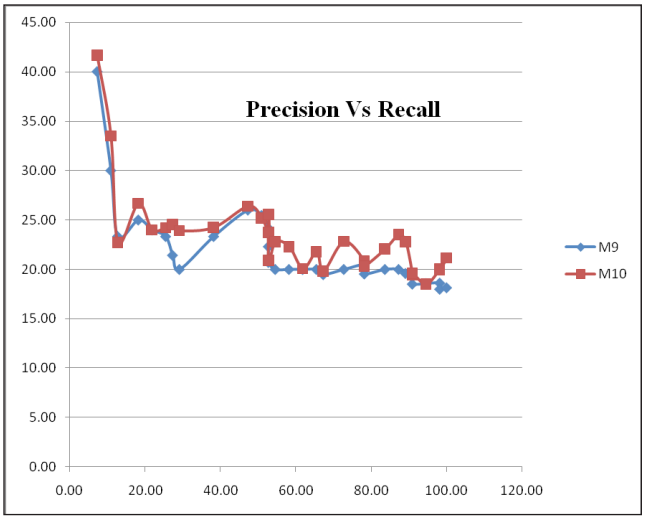

Figure 5. Combination 9 and 10 (Precision vs Recall).

In our 10th combination binary threshold is turn off from the system that require time, since the system has to recomputed all the feature value and the data structure.

In Figure 5 we exam that at some point it show us high precision but in overall it almost the same as 9th combination. As we can see it shows higher precision value, but in by and large it's value is almost the same.

When we use region feature only for the comparison what we have observed that in some case retrieval results are incredible in term of from out of 10 images only 1 is unrelated.

4. Conclusion

Indexing is the most important part of Content based Image Retrieval system. A good indexing provides good retrieval.

The indexing provides relevant data to the retrieval process to find a similarity among image that has been queried with the image data set. Accurate information about an image is necessary to achieve good retrieval results. As a matter of fact a system that execute most excellent with one image data set may not perform same with other image data set.

Thus we can say that indexing is very much affected by image retrieval process from an image data set. As we can see from the results that no complete indexing system that is best and can handle each and every type of image data set. In this research work we have worked on multiple combination of image features.

While comparing the two image features, i.e. global features are less substantial than the region features. Results have shown in the process of indexing that if we use more features of an image as an index it increases the time and space to process it and they have higher chances of redundancy.

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