Comparative study on evolution of content based image retrieval

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Abstract

This paper focuses on the growing trends in the field of Content Based Image Retrieval (CBIR). As the suggested by its name this technique involves retrieval of peculiar contents of the image from a large database of images. Although significant advancements have already taken place in the field of image compression where time and again new technologies are being developed to reduce the size of the image and optimization of existing image compression techniques is also being done. Since medical imaging produces a huge number of images across the world, such images are stored at local and global databases. In order to perform comparative study of effect of a disease on patients one has to retrieve images with specific content from various databases. We have performed an exhaustive study on the evolution of CBIR from its commencement till present day and have tried to highlight the advancements done so far in this promising technique.

Keywords: Content Based Image Retrieval (CBIR), Hue, Saturation and Value (HSV), K- nearest neighbour (KNN), Query By Image Content (QBIC), Red, Green and Blue (RGB), Relevance Feedback (RF), Support vector machine (SVM)

1. Introduction

CBIR is also known as Query By Image Content (QBIC). In any search engine like Google, Yahoo, etc, if one types about an image the crawler in the search engine matches the user’s query with the description provided for the image and retrieves the results. Till date a mechanism has not been implemented where the user may type about the content of an Image and that particular content is retrieved from a relevant image. The process of retrieving a complete image, a sub image or a partial image on the basis of its content is known as CBIR or QBIC.

CBIR is being aggressively researched across many institutions in India and abroad. Many researchers have proposed and implemented algorithms that perform CBIR. There is a great need for exhaustive research in this field because of its significance in medical sciences, remote sensing, unmanned air vehicles, surveillance. These fields require minute scrutiny of finer details at microscopic and macroscopic levels.

Depending upon how accurately we retrieve a correct image from the database, the research and analysis can be performed. We have undertaken an exhaustive study of this technique by reviewing over 100 papers and have made an attempt to compare various techniques by which CBIR was, is and shall be performed. Each technique is very promising but due to ever growing size of image databases, there is a severe need of the hour to propose and implement more optimized algorithms which perform CBIR at a faster pace and with high accuracy. The same has been explained in detail in the following sections.

2. CBIR Technique

Initially CBIR had emphasised on image properties which mainly comprised of shape, colour and texture of the image. With the advancement in the image processing software because of simultaneous tremendous improvement in the computation capacity of computation devices the emphasis of CBIR shifted towards advance techniques namely:

- Correspondence analysis and hierarchical indexing
2.1 Correspondence Analysis and Hierarchical Indexing [1]

As interpreted from its name, this technique comprises of two sub techniques:

2.1.1 Correspondence Analysis
It performs inferential and statistical technique namely exploratory factor analysis where a new orthogonal set of axis is defined. The manipulation is done in such a way that the variance among the factors can be reduced, which is caused by the axis. Since factor analysis allows one to identify highly correlated data, thus we select only those factors which cause maximum variance and other factors are not considered. In a way one applies principle of parsimony and the number of factors affecting the variance is reduced. The feature vectors of the image are mapped into their corresponding coordinates. Consequently the imaging operations are performed on a relatively lower sized dimensional space.

2.1.2 Hierarchical Indexing
In hierarchical index representation an image is represented by means of a vector x which in turn points to classes of similar images. The indexing is performed by means of a clustering algorithm called Ascendant Hierarchical Classification. Vector pairs are made, and then those factors which are close to one another are merged. The factor used is the Euclidean distance. Clusters of merged vectors are formed on a criterion. After sufficient number of clusters is formed, clusters are made to merge among themselves with the cluster centroid distance as a factor. As we perform inferential analysis technique of Analysis of Variance, we try to reduce the with-in class variance. This method is repeated for a few times until a binary tree is formed. The binary tree is used as a hierarchical index structure which points to the image, thus in a way optimizing the image archival and retrieval.

2.2 Semantic Content [2]
This involves creation of a semantic index by means of which the speed of data retrieval operations is improved. The indexed image is fed to a visual feature detector, which helps assigning labels to the sub-images. Then the semantic analysis of the image is performed to improve the accuracy of the semantic labelling, as it identifies the incorrect assignment(s) of labels to sub-images, which is done by visual detectors. Based on the results of the visual detectors a final label map is formed. This label map is used to construct the semantic content representation structure. Finally, the semantic content is used for retrieving image.

2.3 Shape Analyzer and Similarity Computation [3]
In order to perform shape analysis and similarity computation one should perform image segmentation. The segmentation is done by means of DBSCAN algorithm based tool. This algorithm is a density based clustering method, which can discover clusters of arbitrary shape in the presence of noise. Shape features are extracted with initially, 20 features and then the same is reduced to 8 features using Principle Component Analysis, as discussed by M. Emre Celebi et al. Images and shape features are stored in an object relational database for better retrieval efficiency. By now the query image is segmented and its shape features are extracted. In order to perform image similarity computation we need to determine the distance between the query image and the database image. The distance metric used is the city block distance metric. Once the distances are computed they are arranged in the ascending order. The most similar images are on the top of the list.

2.4 Texture Analysis [4, 5, 6]
This CBIR method involves retrieval of texture of an image. Texture retrieval is performed by means of M-band wavelet histogram technology. As discussed in previous studies, a similarity is established between the query image and target image. Depending upon the factor of similarity between images, they are retrieved from the database. Further recall and precision are used as two performance parameters to evaluate the performance of the retrieval.

As discussed by Éderson. A. G. Dorileo et al. have performed CBIR using K- nearest neighbour (KNN) classifier which is based on the factor of Euclidean distance (as discussed in previous studies as well). The value of K was varied from 5 to 215 in 5 steps. 50 images were selected out of which 15 were randomly selected. Here again precision of retrieval was taken into consideration. Precision is computed as a ratio of the number of retrieved relevant images to the total number of retrieved images. The relevant image is distinguished from the non relevant one by a weight of 1 or 0 respectively being assigned. The assigned scores are summed up and are divided by the total number of retrieved images.

As discussed by Priyanka P. Buch et. al, they have performed CBIR using colour in addition to texture along with chi-square distance and Euclidean distance as factors for retrieval of images. Firstly an image is converted to HSV (Hue, Saturation and Value) format from an RGB (Red, Green and Blue) format. The H, S and V are equalized and their mean variance and skewness are determined. These moments are combined to form a 9 dimensional single vector. Following methods are used to extract texture features:-
• Wavelet Transform
• Extraction of Textures using Gabor filter.

2.5 Relevance Feedback [7]

Relevance Feedback (RF) has gathered great momentum over the years as a promising, power full, and an advanced technique for CBIR. Many advancements and optimizations have been performed in CBIR using RF. Many RF methods have been developed in recent years:

1. One approach is that the weights of various features to adapt to the user’s perception are adjusted.
2. Another approach is that the density of the positive feedback examples is estimated.
3. Support vector machine (SVM) has also been used as a classification method for RF.

These methods all have their own limitations, respectively:

1. The method in is only heuristic based.
2. The density estimation method loses information contained in negative samples.
3. Classification based method treats the positive and negative samples equally.

The dependent variable of efficacy of RF for CBIR is influenced by the two independent variables – optimization of BDA and efficiency of RF. The two independent variables are also interrelated as explained below.

RF is one of the many techniques for CBIR. A fair amount of research on CBIR has undertaken over the years but BDA and its modified versions have played a crucial role in improving CBIR technology. The tremendous growth in data storage technology which allows the size of images and number of images to store data of size 64 Gigabytes in less than 1 cm² area has up played the size of images and number of images being stored rise tantamount. Reason being there does a greater need to further optimizing the BDA and in turn the RF technique for CBIR.

3. Future Scope and Work

Although a great deal of research has been performed in CBIR, there is a lot which can be done to improve the existing CBIR systems. The focus should be on optimizing proposed algorithms and thus making them more efficient. Statistically inclined results can be achieved and better methodologies can be involved in the future.

4. Conclusion

In this paper we have presented an analysis of different approaches being proposed by various researchers to improve CBIR. We have noticed a significant improvement in the algorithms, over the years performing CBIR as it is a fast developing technology. A lot can be done in this field of research as a considerable potential is possessed by it. The same should be exploited where ever it is appropriate.

References


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