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ANALYSIS OF CONTENT BASED IMAGE RETRIEVAL USING HIERARCHICAL AND K-MEANS CLUSTERING APPROACH

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Abstract: -

Content based image retrieval (CBIR) is becoming a source of exact and fast retrieval. In recent years, a variety of techniques have been developed to improve the performance of CBIR. The proposed CBIR technique uses more than one clustering techniques to improve the performance of CBIR.This optimized method makes use of K-means and Hierarchical clustering technique to improve the execution time and performance of image retrieval systems in high dimensional sets. In this paper the clustering techniques are discussed and analyzed. We propose a method HDK that uses more than one clustering technique to improve the performance of CBIR.

Keywords: - Image, Retrieval, Clustering, K-Means, Hierarchical, Techniques.

1. INTRODUCTION

Interest in the potential of digital images has increased enormously over the last few years, fuelled at least in part by the rapid growth of imaging on the World-Wide Web. Users in many professional fields are exploiting the opportunities offered by the ability to access and manipulate remotely-stored images in all kinds of new and exciting ways. However, they are also discovering that the process of locating a desired image in a large and varied collection can be a source of considerable frustration. The problems of image retrieval are becoming widely recognized, and the search for solutions an increasingly active area for research and development. Problems with traditional methods of image indexing have led to the rise of interest in techniques for retrieving images on the basis of automatically-derived features such as color, texture and shape – a technology now generally referred to as Content-Based Image Retrieval (CBIR). After a decade of intensive research, CBIR technology is now beginning to move out of the laboratory and into the marketplace, in the form of commercial products like QBIC and Virage. However, the technology still lacks maturity, and is not yet being used on a significant scale. In the absence of hard evidence on the effectiveness of CBIR techniques in practice, opinion is still sharply divided about their usefulness in handling real-life queries in large and diverse image collections. Nor is it yet obvious how and where CBIR techniques can most profitably be used.The process of digitization does not in itself make image collections easier to manage. Some form of cataloguing and indexing is still necessary – the only difference being that much of the required information can now potentially be derived automatically from the images themselves. Access to a desired image from a repository might thus involve a search for images depicting specific types of object or scene, evoking a particular mood, or simply containing a specific texture or pattern.

Potentially, images have many types of attribute which could be used for retrieval. This leads naturally on to a classification of query types into three levels of increasing complexity.

Level 1: - comprises retrieval by primitive features such as color, texture, shape or the spatial location of image elements.

Level 2: - comprises retrieval by derived features, involving some degree of logical inference about the identity of the objects depicted in the image.

Level 3: - comprises retrieval by abstract attributes, involving a significant amount of high-level reasoning about the meaning and purpose of the objects or scenes depicted.

1.1. Content Based Image Retrieval (CBIR)

CBIR or **Content Based Image Retrieval** is the retrieval of images based on visual features such as color, texture and shape. Reasons for its development are that in many large image databases, traditional methods of image indexing have proven to be insufficient, laborious, and extremely time consuming. These old methods of image indexing, ranging from storing an image in the database and associating it with a keyword or number, to associating it with a categorized description, have become obsolete. This is not **CBIR**. In CBIR, each image that is stored in the database has its features extracted and compared to the features of the query image. It involves two steps:

- **Feature Extraction:** The first step in the process is extracting image features to a distinguishable extent.
- **Matching:** The second step involves matching these features to yield a result that is visually similar.

Image retrieval in a larger database is quite complex process. For this efficient features must be extracted from the images for its training.

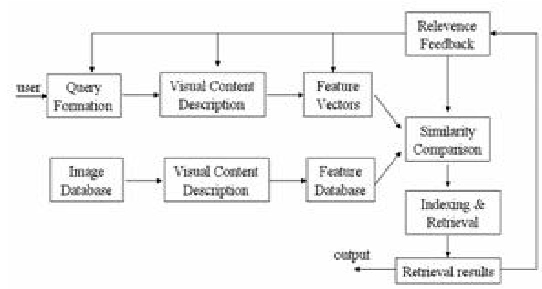

Figure 1.1: - Content Based Image Retrieval

1.2. Related Work

Several reviews of the literature on image retrieval have been published, from a variety of different viewpoints.

- Enser [1995] reviews methods for providing subject access to pictorial data, developing a four-category framework to classify different approaches. He discusses the strengths and limitations both of conventional methods based on linguistic cues for both indexing and search, and experimental systems using visual cues for one or both of these. His conclusions are that, while there are serious limitations in current text-based techniques for subject access to image data, significant research advances will be needed before visually-based methods are adequate for this task. He also notes, as does Cawkell [1993] in an earlier study, that more dialogue between researchers into image analysis and information retrieval is needed.
- Aigrain et al [1996] discuss the main principles of automatic image similarity matching for database retrieval, emphasizing the difficulty of expressing this in terms of automatically generated features. They review a selection of current techniques for both still image retrieval and video data management, including video parsing, shot detection, keyframe extraction and video skimming. They conclude that the field is expanding rapidly, but that many major research challenges remain, including the difficulty of expressing semantic information in terms of primitive image features, and the need for significantly improved user

interfaces. CBIR techniques are likely to be of most use in restricted subject domains, and where synergies with other types of data (particularly text and speech) can be exploited.

- Eakins [1996] proposes a framework for image retrieval (outlined in section **Error! Reference source not found.** above), classifying image queries into a series of levels, and discussing the extent to which advances in technology are likely to meet users' needs at each level. His conclusion is that automatic CBIR techniques can already address many of users' requirements at level 1, and will be capable of making a significant contribution at level 2 if current research ideas can be successfully exploited. They are however most unlikely to make any impact at level 3 in the foreseeable future.
- Idris and Panchanathan [1997a] provide an in-depth review of CBIR technology, explaining the principles behind techniques for color, texture, shape and spatial indexing and retrieval in some detail. They also discuss the issues involved in video segmentation, motion detection and retrieval techniques for compressed images. They identify a number of key unanswered research questions, including the development of more robust and compact image content features, more accurate modelling of human perceptions of image similarity, the identification of more efficient physical storage and indexing techniques, and the development of methods of recognizing objects within images. De Marsicoi et al [1997] also review current CBIR technology, providing a useful feature-by-feature comparison of 20 experimental and commercial systems.
- In addition to these reviews of the literature, a survey of "non-text information retrieval" was carried out in 1995 on behalf of the European Commission by staff from GMD (Gesellschaft für Mathematik und Datenverarbeitung), Darmstadt and Université Joseph Fourier de Grenoble [Berrut et al, 1995]. This reviewed current indexing practice in a number of European image, video and sound archives, surveyed the current research literature, and assessed the likely future impact of recent research and development on electronic publishing. The survey found that all current operational image archives used text-based indexing methods, which were perceived to have a number of shortcomings. In particular, indexing vocabularies were not felt to be adequate for non-text material. Despite this, users seemed generally satisfied with existing systems. The report concluded that standard information retrieval techniques were appropriate for managing collections of non-text data, though the adoption of intelligent text retrieval techniques such as the inference-based methods developed in the INQUERY project [Turtle and Croft, 1991] could be beneficial.

2. PROBLEM STATEMENT

Image databases and collections can be enormous in size, containing hundreds, thousands or even millions of images. The conventional method of image retrieval is searching for a keyword that would match the descriptive keyword assigned to the image by a human categorizer. Currently under development, even though several systems exist, is the retrieval of images based on their content, called **Content Based Image Retrieval**, **CBIR**. While computationally expensive, the results are far more accurate than conventional image indexing. Hence, there exist tradeoffs between accuracy and computational cost.

This tradeoffs decreases as more efficient algorithms are utilized and increased computational power becomes inexpensive.

The problem involves entering an image as a query into a software application that is designed to employ CBIR techniques in extracting visual properties, and matching them. This is done to retrieve images in the database that are visually similar to the query image.

3. BACKGROUND STUDY

Content-based image retrieval uses the visual contents of an image such as color, shape, texture, and spatial layout to represent and index the image. The feature vectors of the images in the database form a feature database. To retrieve images, users provide the retrieval system with example images or sketched figures. The systems then change these examples into its internal representation of feature vectors. The similarities /distances between the feature vectors of the query example or sketch and those of the images in the database are then calculated and retrieval is performed with the aid of an indexing scheme. The indexing scheme provides an efficient way to search for the image database. Recent retrieval systems have incorporated users' relevance feedback to modify the retrieval process in order to generate perceptually and semantically more meaningful retrieval results. CBIR operates on a totally different principle, retrieving stored images from a collection by comparing features automatically extracted from the images themselves. The commonest features used are mathematical measures of color, texture or shape; hence virtually all current CBIR systems, whether commercial or experimental, operate at level 1. A typical system allows users to formulate queries by submitting an example of the type of image being sought, though some offer alternatives such as selection from a palette or sketch input. The system then identifies those stored images whose feature values match those of the query most closely, and displays thumbnails of these images on the screen.

3.1. Query Specification

Specifying what kind of images a user wishes to retrieve from the database can be done in many ways. Commonly used query formations are: category browsing, query by concept, query by sketch, and query by example. Category browsing is to browse Fundamentals of Content-Based Image Retrieval through the database according to the category of the image. For this purpose, images in the database are classified into different categories according to their semantic or visual content. Query by concept is to retrieve images according to the conceptual description associated with each image in the database. Query by sketch and query by example is to draw a sketch or provide an example image from which images with similar visual features will be extracted from the database. The first two types of queries are related to the semantic description of images which will be introduced in the following chapters. Query by sketch allows user to draw a sketch of an image with a graphic editing tool provided either by the retrieval system or by some other software. Queries may be formed by drawing several objects with certain properties like color, texture, Proof shape, sizes and locations. In most cases, a coarse sketch is sufficient, as the query can be refined based on retrieval results.

3.2. Color Retrieval

Several methods for retrieving images on the basis of color similarity have been described in the literature, but most are variations on the same basic idea. Each image added to the collection is analysed to compute a color histogram which shows the proportion of pixels of each color within the image. The color histogram for each image is then stored in the database. At search time, the user can either specify the desired proportion of each color or submit an example image from which a color histogram is calculated.

Either way, the matching process then retrieves those images whose color histograms match those of the query most closely. Usually colors are defined in three dimensional color spaces. These could either be **RGB** (Red, Green, and Blue), **HSV** (Hue, Saturation, and Value) or **HSB** (Hue, Saturation, and Brightness). The last two are dependent on the human perception of hue, saturation, and brightness.

3.3. Texture Retrieval

The ability to retrieve images on the basis of texture similarity may not seem very useful. But the ability to match on texture similarity can often be useful in distinguishing between areas of images with similar color. A variety of techniques has been used for measuring texture similarity; the best-established rely on comparing values of what are known as second-order statistics calculated from query and stored images. Essentially, these calculate the relative brightness of selected pairs of pixels from each image. From these it is possible to calculate measures of image texture such as the degree of contrast, coarseness, directionality and regularity, or periodicity, directionality and randomness. Textures can be modeled as quasi-periodic patterns with spatial/frequency representation. The wavelet transform transforms the image into a multi-scale representation with both spatial and frequency characteristics. This allows for effective multi-scale image analysis with lower computational cost. According to this transformation, a function, which can represent an image, a curve, signal etc., can be described in terms of a coarse level description in addition to others with details that range from broad to narrow scales.

3.4. Shape Retrieval

The ability to retrieve by shape is perhaps the most obvious requirement at the primitive level. Unlike texture, shape is a fairly well-defined concept – and there is considerable evidence that natural objects are primarily recognized by their shape. A number of features characteristic of object shape are computed for every object identified within each stored image. Queries are then answered by computing the same set of features for the query image, and retrieving those stored images whose features most closely match those of the query. Two main types of shape feature are commonly used – global features such as aspect ratio, circularity and moment invariants and local features such as sets of consecutive boundary segments. Shape matching of three-dimensional objects is a more challenging task – particularly where only a single 2-D view of the object in question is available. While no general solution to this problem is possible, some useful inroads have been made into the problem of identifying at least some instances of a given object from different viewpoints. One approach has been to build up a set of plausible 3-D models from the available 2-D image, and match them with other models in the database.

4. PROPOSED METHODOLOGY

Content-based image retrieval uses the visual contents of an image such as color, shape, and texture to represent and index the image. To retrieve images, users provide the retrieval system with example images or sketched figures. The system then changes these examples into its internal representation of feature vectors. The similarities /distances between the feature vectors of the query example or sketch and those of the images in the database are then calculated and retrieval is performed. The indexing scheme provides an efficient way to search for the image database. Recent retrieval systems have incorporated users' relevance feedback to modify the retrieval process in order to generate perceptually and semantically more meaningful retrieval results.

The study of the proposed system can be categorized into three modules:-

Module 1:- Content based Image Retrieval using HOG of Wavelet subbands.

Module 2:- A New Generalized Gaussian Density and HOG based content image retrieval system.

Module 3:- A New content based image retrieval using curvelet Transform. CBIR differs from classical information retrieval. In that approach, image databases are primarily unstructured, since digitized pictures consist strictly of arrays of pixel intensities, with no inherent. One of the key problem associated with any reasonably image process is that they got to extract helpful information from the large volume of available information before concerning whether the image's contents is feasible.

Module -1: - Color feature is the most significant one in searching collections of color images of arbitrary subject matter. Color plays very important role in the human visual perception mechanism. All methods for representing color feature of an image can be classified into two groups: color histograms and statistical methods of color representation. The most frequently used color spaces are as follows: RGB (red, green, and blue used in color monitors and cameras), CMY (cyan, magenta and yellow), CMYK (cyan, magenta, yellow, and black used in color printers), Lab (CIE L*a*b, lightness, a and b are two color dimensions, from green to red and from blue to yellow) HSI, HSV (hue, saturation, and value). The Lab space relies on the international standard of color measurement developed by the International Commission on Illumination CIE (Commission International de Eclairage). The HSV space is similar to spaces HSI, HSL, and HSB. The HSV space is used more frequently because the RGB to HSV transformation is simpler from the computational standpoint compared to the RGB to Lab transformation. The each image has its own properties and components. These properties and components are extracted using the following two techniques, such as,

1. Discrete Wavelet Transformation (DWT).
2. Histogram Oriented Gradient (HOG).

Module -2: - CBIR, also known as query by image content and content-based visual information retrieval which is the application of computer vision. The problem in image retrieval is of searching for digital images in large databases. In the CBIR system, the relevance between a query and any target image is ranked according to a similarity measure computed from the visual features. In CBIR each image that is stored in the database has its features extracted and compared to the features of the query image. It involves mainly two steps:

- Feature Extraction: The first step in this process is to extract the image features to a distinguishable extent. Feature is anything that is localized and detectable. In an image noticeable features include objects, color, shape, corners, lines, spatial location, motion and texture.
- Matching: The second step involves matching these features to yield a result that is visually similar. Feature Extraction plays main role in retrieving. This gives images distinctive value which makes its to differentiate with other type of images. This proposed methodology utilizes two techniques.

1. DWT with Generalized Gaussian Distribution (GGD) and
2. Histogram of Oriented Gradient (HOG)

Based feature extraction for the images.

Module -3: - A CBIR system using different feature of images through four different methods, two were based on analysis of color feature and other two were based on analysis of combined color and texture feature using wavelet coefficients of an image. To extract color feature from an image, one of the standard ways i.e. color histogram was used in YCbCr color space and HSV color space. Daubechies' wavelet transformation and Symtel's wavelet transform were performed to extract the texture feature of an image. Feature extraction is a key issue in content-based image retrieval (CBIR). In the past, a number of texture features have been proposed in literature, including statistic methods and spectral methods. However, most of them are not able to accurately capture the edge information which is the most important texture feature in an image. Recent researches on multi-scale analysis, especially the curvelet research, provide good opportunity to extract more accurate texture feature for image retrieval. Curvelet was originally proposed for image denoising and has shown promising performance.

The K-means algorithm is:

(i) Decide on the value of K.

(ii) Start off with K arbitrary centers. They may be chosen randomly, or as the centroids of arbitrary starting partitions of the caseset.

(iii) Consider each case in sequence; find the centre to which the case is closest. Assign the case to that cluster. Recalculate the centre of the new and old clusters as the centroids of the points in the cluster.

(iv) Repeat until the clusters are stable.

(v) Repeat for different initial centres. Choose the best clustering, in terms of minimum within cluster sum of squares.

Hierarchical Clustering methods

These can be either agglomerative, or divisive.

Agglomerative:

(i) Find the two cases which are closest, and form them into a cluster, Continue agglomerating cases and clusters on the same basis (single nearest neighbour; **single linkage method**) until one cluster is obtained. Single linkage clustering can lead to chaining.

(ii) This can be avoided by defining the "working distance" between two cases at any iterative stage to be the distance between the most distance members of the two clusters to which they belong. This is called the **complete linkage method.**

(iii) A cluster, once initiated by bringing together 2 cases, may be represented by its centroid. Hence clusters could be merged based on the distance between their centroids. Hence we would have an agglomerative k-means type of method.

Divisive:

Start with the whole case set. Divide into two subsets in some optimal way. Then subdivide each subset, again optimally. Not simple.

5. THE PERFORMANCE EVALUATION

The Corel image dataset consists of mainly six different images. The corresponding accuracy of the query images to display these images before and after relevance feedback has been observed for combined DWT and HOG image retrieval. The accuracy before and after relevance feedback for this image retrieval is shown in the table 1.

Query Image	Accuracy (%) without RF	Accuracy (%) with RF	Number of Iterations
Beaches	72	82	3
Building	65	74	2
Dinosaur	93	98	2
Elephant	82	88	2
Food	74	85	3
Rose	88	92	2
Average	79	86	2

TABLE 5.1 Sample Data Structure

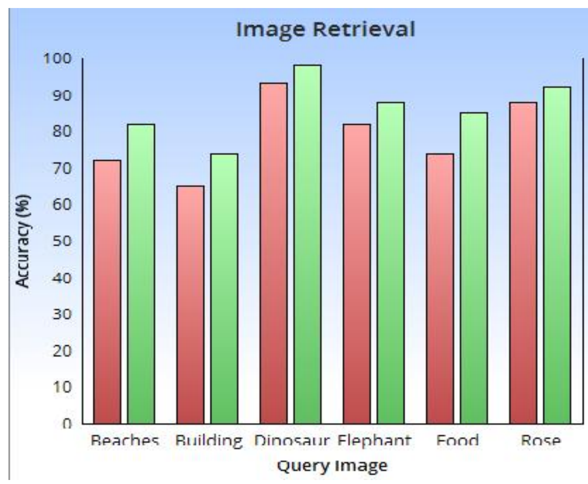

Figure 5.1: - image Retrieval

6. CONCLUSION

The dramatic rise in the sizes of images databases has stirred the development of effective and efficient retrieval systems. The development of these systems started with retrieving images using textual connotations but later introduced image retrieval based on content. This came to be known as CBIR or Content Based Image Retrieval. Systems using CBIR retrieve images based on visual features such as colour, texture and shape, as opposed to depending on image descriptions or textual indexing. In this project, we have researched various modes of representing and retrieving the image properties of colour, texture and shape. Due to lack of time, we were only able to fully construct an application that retrieved image matches based on colour and texture only. The application performs a simple colour-based search in an image database for an input query image, using colour histograms. It then compares the colour histograms of different images using the Discrete Wavelet Transform (DWT). Further enhancing the search, the application performs a texture-based search in the colour results, using wavelet decomposition and energy level calculation. It then compares the texture features obtained using the Generalized Gaussian density (GGD). A more detailed step would further enhance these texture results, using a shape-based search.

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