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A Study of Different Content Based Image Retrieval Techniques

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Abstract: Interest in image retrieval has increased in large part due to the rapid growth of the World Wide Web. The traditional text based search and retrieval has its own limitations and hence we move to a content based image search and retrieval system. In this paper we present an image retrieval system that takes an image as the input query and retrieves images based on image content. Content Based Image Retrieval is an approach for retrieving semantically-relevant image from an image database based on automatically-derived image features. Content-based image retrieval (CBIR), also known as query by image content (QBIC) and content-based visual information retrieval (CBVIR) is the application of computer vision to the image retrieval problem. "Content-based" means that the search will analyze the actual contents of the image. The term 'content' in this context might refer colours, shapes, textures, or any other information that can be derived from the image itself. Here we deal with colour images.

Keywords: CBIR, shape, texture, text retrieval, feature extraction

I. INTRODUCTION

The need to find a desired image from a collection is shared by many professional groups, including journalists, design engineers and art historians. While the requirements of image users can vary considerably, it can be useful to characterize image queries into three levels of abstraction: primitive features such as colour or shape, logical features such as the identity of objects shown and abstract attributes such as the significance of the scenes depicted. While CBIR systems currently operate effectively only at the lowest of these levels, most users demand higher levels of retrieval.

CBIR operates on a totally different principle from keyword indexing. Primitive features characterizing image content, such as colour, texture and shape, are computed for both stored and query images, and used to identify those images most closely matching the query. Semantic features such as the type of object present in the image are harder to extract, though this remains an active research topic. Image retrieval is the process of browsing, searching and retrieving images from a large database of digital images. The collection of images in the web are growing larger and becoming more diverse. Retrieving images from such large collections is a challenging problem. One of the main problems highlighted was the difficulty of locating a desired image in a large and varied collection. While it is perfectly possible to identify a desired image from a small collection simply by browsing, more effective techniques are needed with collections containing thousands of items. The current state of the art in content-based image retrieval (CBIR), a technique for retrieving images on the basis of automatically-derived features such as colour, texture and shape, is reviewed.

II. TEXT BASED IMAGE RETRIEVAL

Most of the image retrieval systems present today are text-based, in which images are manually annotated by text-based keywords and when we query by a keyword, instead of looking into the contents of the image, this system matches the query to the keywords present in the database.

The disadvantages of this technique are firstly, considering the huge collection of images present, its not feasible to manually annotate them. Secondly, the rich features present in an image cannot be described by keywords completely. It is valid only for one language; with image retrieval this limitation should not exist. Then again, there is the problem of human perception, that is, subjectivity of human perception. There is too much responsibility on the end-user and problem of deeper (abstract) needs. Moreover, there are queries that cannot be described at all, but tap into the visual features of images.

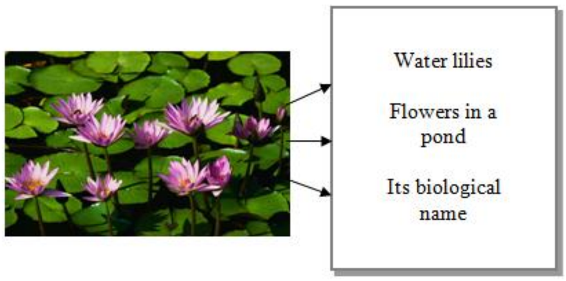

Fig 1: An example of text based retrieval

These disadvantages of text-based image retrieval techniques call for another relatively new technique known as Content-Based Image Retrieval (CBIR).

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III. CONTENT BASED IMAGE RETRIEVAL

The earliest use of the term content-based image retrieval in the literature seems to have been by Kato, to describe his experiments into automatic retrieval of images from a database by colour and shape feature. The term has since been widely used to describe the process of retrieving desired images from a large collection on the basis of features (such as colour, texture and shape) that can be automatically extracted from the images themselves. The features used for retrieval can be either primitive or semantic, but the extraction process must be predominantly automatic. Retrieval of images by manually-assigned keywords is definitely not CBIR – even if the keywords describe image content.

CBIR [13] differs from classical information retrieval in that image databases are essentially unstructured, since digitized images consist purely of arrays of pixel intensities, with no inherent meaning. One of the key issues with any kind of image processing is the need to extract useful information from the raw data before any kind of reasoning about the image's contents is possible. Image databases thus differ fundamentally from text databases, where the raw material has already been logically structured.

CBIR draws many of its methods from the field of image processing and computer vision, and is regarded by some as a subset of that field. It differs from these fields principally through its emphasis on the retrieval of images with desired characteristics from a collection of significant size. Image processing covers a much wider field, including image enhancement, compression, transmission, and interpretation.

A. Applications
In the realm of professional image use, the situation is rather different. While there are certainly differences in style between individual design engineers, for example, the nature of the design process imposes a number of inescapable constraints within which all engineers must work. Hence it is possible to generalize to some extent about the way images are used by different professions. Since this report is primarily concerned with image storage and retrieval, it makes sense to limit our discussion by concentrating on uses which involve stored collections of images in some way.

- Crime prevention Medicine
- The Military
- Architecture
- Intellectual property
- Web searching

B. Current techniques for image retrieval
Whilst this review is primarily focused on techniques for the storage and retrieval of electronic images, it is useful to reflect on the traditional practices of picture and other manual collections of images and videos. Image collections of various types are maintained by a wide range of organisations, of all sizes and in a variety of sectors.

The need for efficient storage and retrieval of images has been recognised by managers of large image collections such as picture libraries and design archives for many years. While it is perfectly feasible to identify a desired image from a small collection simply by browsing, more effective techniques are needed with collections containing thousands of items. The normal technique used is to assign descriptive metadata in the form of keywords, subject headings or classification codes to each image when it is first added to the collection, and to use these descriptors as retrieval keys at search time.

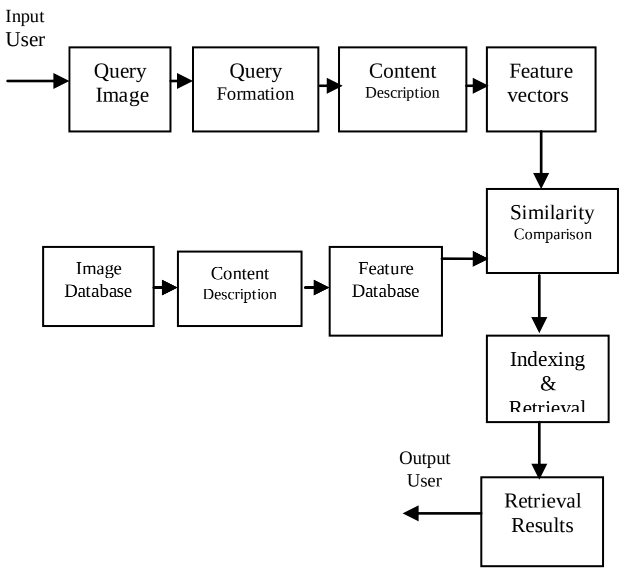

Fig 2: Block Diagram of CBIR system

Colour Retrieval: Several methods for retrieving images on the basis of colour 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 colour histogram which shows the proportion of pixels of each colour within the image. The colour histogram [12] for each image is then stored in the database. At search time, the user can either specify the desired proportion of each colour (75% olive green and 25% red, for example), or submit an example image from which a colour histogram is calculated. Either way, the matching process then retrieves those images whose colour histograms match those of the query most closely. The matching technique most commonly used, histogram intersection, was first developed by Swain and Ballard. Methods of improving on Swain and Ballard's original technique include the use of cumulative colour histograms, combining histogram intersection with some element of spatial matching, and the use of region-based colour querying. The results from some of these systems can look quite impressive.

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Fig 3: Examples of Colour Retrieval

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 (but independent of size or orientation) 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.

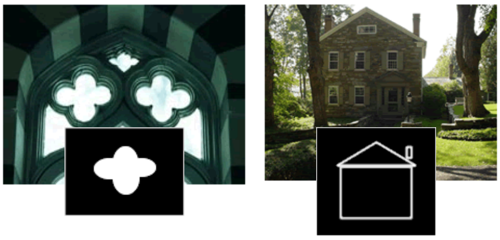

Fig4: Examples of Shape Retrieval

Texture: Texture is a difficult concept to represent. The identification of specific textures in an image is achieved primarily by modelling texture as a two-dimensional gray level variation. The relative brightness of pairs of pixels is computed such that degree of contrast, regularity, coarseness and directionality may be estimated. The problem here is in identifying patterns of co-pixel variation and associating them with particular classes of textures such as “silky” or “rough”

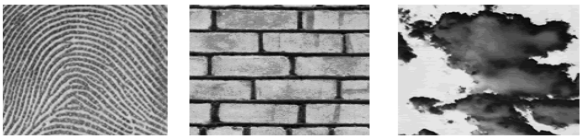

Fig 5: Examples of Texture Retrieval

IV. COLOUR BASED CONTENT BASED IMAGE RETRIEVAL

This module deals with image search by using colour as the attribute. Firstly, an image database containing random images is formed. The images are selected such that they have a range of colours. Next, this image database is loaded in the program. Each image is read from the database, and the colour histogram is computed for it. This is done in a sequential manner. Once the colour histogram for all the images is computed, it is stored in a file. Whenever there is a query this file is loaded. The colour histogram value of each image in the database which is already stored in the file is subtracted from the colour histogram value of the query image. When the difference is zero, the image from the database corresponding to the particular value is displayed along with the colour histogram.

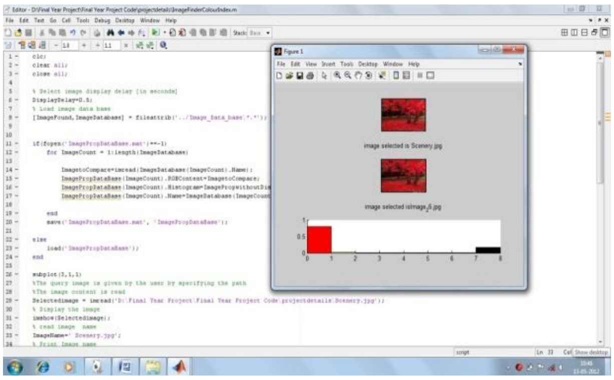

Fig 6: Illustration of the working of the first module

From the above figure we can note that irrespective of the way the query image is named, it can be retrieved from the database as the parameter used, the colour histogram, is unique for each image.It is to be noted that the query image is one of the existing images in the database. Hence, this code is effective to know whether the query image is one of the images in the database or not.

V. CONCLUSION

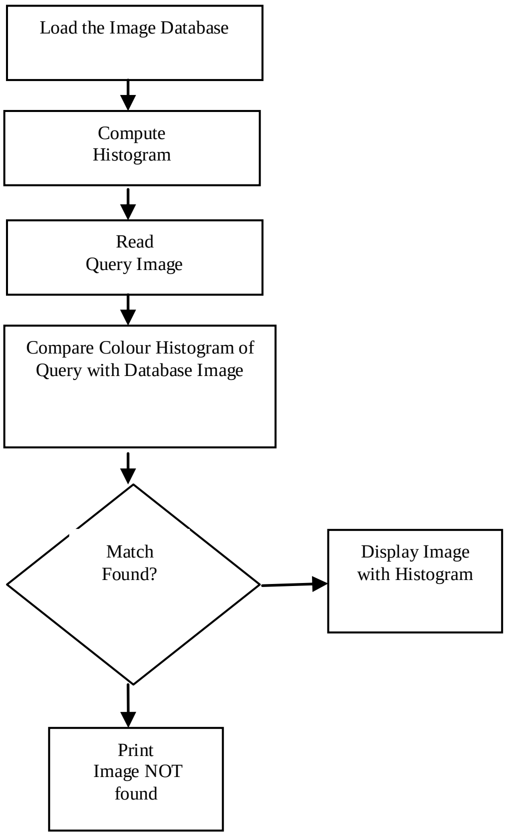

Fig 7: Flowchart of Image Retrieval Based on Colour

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VI. SHAPE BASED CONTENT BASED IMAGE RETRIEVAL

A. Feature Extraction

High-level feature extraction concerns finding shapes in computer images. To be able to recognize faces automatically, for example, one approach is to extract the component features. This requires extraction of, say, the eyes, the ears and the nose, which are the major facial features. To find them, we can use their shape: the white part of the eyes is ellipsoidal; the mouth can appear as two lines, as do the eyebrows. Shape extraction implies finding their position, their orientation and their size. This feature extraction process can be viewed as similar to the way in which we perceive the world. More complex pictures can be decomposed into a structure of simple shapes. In many applications, analysis can be guided by the way in which the shapes are arranged. For the example of face image analysis, we expect to find the eyes above (and either side of) the nose, and we expect to find the mouth below the nose.

In feature extraction, we generally seek invariance properties so that the extraction process does not vary according to chosen (or specified) conditions. That is, techniques should find shapes reliably and robustly irrespective of the value of any parameter that can control the appearance of a shape. As a basic invariant, we seek immunity to changes in the illumination level. We seek to find a shape whether it is light or dark. In principle, as long as there is contrast between a shape and its background, the shape can be said to exist, and can then be detected. Following illumination, the next most important parameter is position. We seek to find a shape wherever it appears. This is usually called position, location or translation invariance as shown in the figure below.

Fig 8: Illustration of position invariance

We often seek to find a shape irrespective of its rotation (assuming that the object or the camera has an unknown orientation). This is usually called rotation or orientation invariance as shown in the figure below.

Fig 9: Illustration of orientation invariance

We might seek to determine the object at whatever size it appears, which might be due to physical change, or to how close the object has been placed to the camera. This requires size or scale invariance.

These are the main invariance properties which need to be considered for shape extraction techniques.

Fig 10: Illustration of scale invariance

In addition, since we are concerned with shapes, there may be more than one in the image. If one is on top of the other it will occlude, or hide, the other, hence all the shapes of one object will not be visible. But before we can develop image analysis techniques, we need techniques to extract the shapes. Extraction is more complex than detection, since extraction implies that we have a description of a shape, such as its position and size, whereas detection of a shape merely implies knowledge of its existence within an image. To extract a shape from an image, it is necessary to identify it from the background elements. This can be done by considering the intensity information or by comparing the pixels against a given template. In the first approach, if the brightness of the shape is known, then the pixels that form the shape can be extracted by classifying the pixels according to a fixed intensity threshold. Alternatively, if the background image is known, this can be subtracted to obtain the pixels that define the shape of an object superimposed on the background.

B. Implementation

This module deals with image search by using shape as the attribute. A database of images containing various shapes is formed. Images containing basic geometric shapes like circle, triangle, rectangle and square are considered. The images can contain either a single shape or multiple shapes in it. The shape which is recognised as an object can be of a larger size or smaller size, may have different orientations in different images, and may be placed anywhere in the image. The images are chosen such that the objects in it have a darker shade of colour and the background is bright so that there is a good contrast.

The file containing the images is loaded. The query is given by the user in the form of an image. A file containing properties of each shape discussed above is formed and loaded whenever there is a query. First the colour image is converted to gray scale, then to a binary image in which the object(s) present in the image appear black and the background appears white. Next, this image is inverted in colour, that is, the object appears white and the background appears dark.

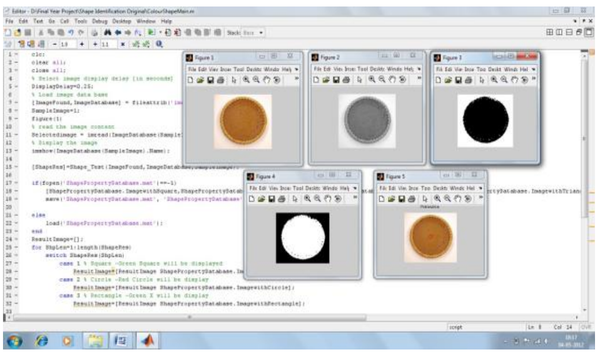

Fig 11: Illustration of the input image in different forms

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The properties of the shape in the input image are compared with the properties of various shapes which are stored in the file. The images in the database which have the same shape as the query image are output to the user. This is termed as indexing, where the properties of the images are compared instead of the image itself.

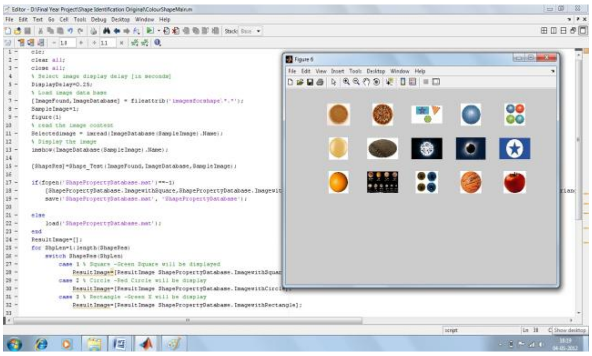

Fig 12: Illustration of the output to the query

From the above figure, we can see that images that contain more than one circle are output, images that contain circle of different sizes are output and images that contain a circle along with other shapes are also output. Hence the user can get a range of images from which he can choose a particular output.

If the query has a shape which is not one of the basic shapes which were mentioned earlier, then a statement saying image not found is displayed.

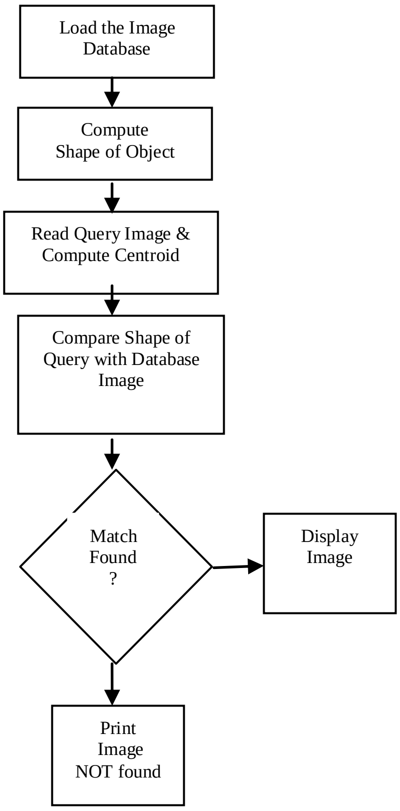

Fig 13: Flowchart of Image Retrieval Based on Shape

VII. CONCLUSION

The ability to retrieve and compare diagnoses of similar-looking radiographs could provide valuable training for medical students. Retrieval of buildings with similar appearance to compare function, or to trace the development of architectural styles, could be useful for architecture students. The list of such applications may not be endless, but is quite lengthy.

Video asset management is an area that is already benefiting from CBIR technology, in the form of shot boundary detection and key frame extraction. Even if manual annotation techniques are used for the remainder of the indexing process, considerable cost savings can be demonstrated. The availability of more sophisticated products such as Islip's Media key Digital Video Library System, the commercial version of Carnegie-Mellon University's Info media is likely to increase the importance of CBIR in video asset management still further. Whether more general image database users such as stock shot agencies, art galleries and museums can benefit from CBIR is still an open question.

There is thus an argument for the involvement of an experienced search intermediary who can translate a user's query into appropriate image primitives, and refine the search in consultation with the user in the light of output received. This kind of role is less fanciful than it might seem – it is simply trying to exploit the same approach as some researchers into semantic image retrieval. The only difference is that it would use humans instead of machines, and therefore probably has a higher chance of success. For image database users such as graphic designers, the ability to retrieve specific images is of marginal usefulness. The role of images in stimulating creativity is little understood – images located by chance may be just as useful in providing the designer with inspiration as those retrieved in response to specific queries. In these circumstances search intermediaries are likely to be of little use, and the often capricious performance of CBIR becomes an advantage. The ability of systems like QBIC to display sets of images with underlying features in common, even if superficially dissimilar, may be just what the designer needs, particularly if any retrieved image may be used to start a further search. Such content-assisted browsing might turn out to be a valuable, if unforeseen, application of CBIR.

In conclusion, CBIR is clearly a technology with potential. The next five to ten years will reveal whether this potential can be turned into solid achievement.

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