Image Indexing and Retrieval

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\begin{abstract}
Nowadays the WWW has rapidly growing with the expansion of image databases. From the huge amount of image databases, users have to retrieve relevant images by using an effective and efficient mechanism for image indexing and retrieval. Many techniques have come to fulfill this requirement. One way to fulfill this requirement is the traditional image database indexing and retrieval capabilities in which the image data has to be indexed and fully convert the image data to an electronic presentation. But there are many factors which prohibit the traditional image indexing including lower quality of text and higher cost. Problems of traditional image indexing has led to raise the interest level in investigating the techniques for retrieving images automatically by using intermediate features such as color, shape and texture etc. In this paper, the problem of image indexing and retrieval has been addressed in the context of Content-Based Image Retrieval (CBIR).
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\textbf{Keywords} — Image Indexing; Image Retrieval; Image Database; CBIR;

\section{Introduction}
Images are indexed and retrieved by using textual keywords and visual content. In text/keyword queries, words are used to retrieve relevant images from the large amount of image database and through visual queries (CBIR) images are retrieved by using visual pattern characteristics (features) like color, shape and texture etc. Image retrieval systems which are based on either text-based or content-based retrieval (CBIR) have their limitations. Manual indexing (text indexing) of images is highly labor-intensive and many of them have created problems when having large image database.

The Visual Information Retrieval (VIR) system can use the visual content of the images like color, shape and texture features \cite{1} as indexes. The VIR system is concerned with record storage and retrieval. This system is useful only if it can retrieve the images which have matching capability in real time.

In this system, upon input, images are processed to compute the features to represent the image content. The process is known as indexing (or indexation) \cite{2}. For this, image descriptors (keywords) or indices are assigned to each image which would be used by the system in the matching or similarity phase to retrieve relevant or required images and reject the irrelevant one. The indices are stored in a database and then the images of the database are ranked according to their matching parameters with the query (See Figure 1).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{architecture.png}
\caption{Architecture of Visual Information Retrieval System}
\end{figure}
II. Indexing of Image

The main aim of image indexing is to retrieve the similar type of images from an image database using a given query image (i.e. a pattern match). Each image has its unique feature. Hence image indexing can be done by comparing their selected features, which is extracted from the images [3]. An image is indexed by a vector(v) representing the estimate proportion of texture(t). The procedure for indexing of an image is as follows:

For each pixel p, compute f(p) that is estimated natural texture at p. Finally v is the proportion of pixel which is classified with texture (t) [1]. With the help of this technique we can get the required images from the image database. Currently image indexing techniques are of two types:

1. Textual indexing (Manual)
2. Content-Based indexing (Automated)

A. Textual Indexing

It is very simple indexing technique. In this technique user acquires keywords which are given for a particular image. This technique includes:

- Caption indexing
- Classification

Disadvantages of textual indexing are given below:

- Labor intensive
- Sometimes inconsistency of text
- Time taking

B. Content Based Indexing

In this technique user acquires visual pattern characteristics (features) like color, shape and texture etc. for retrieving a relevant image from the image database. CBIR focuses in how to retrieve relevant images more accurately and efficiently while CBII (Content based image indexing) concerns with how to support the retrieval process. There is no such problem with this technique like the textual indexing have.

Most of the CBIR indexing techniques are based on the following low level features which are contained in the image itself:

- Color
- Shape
- Texture

a) Advantages of CBir

Some of the advantages of CBIR are:

- Clear cut analysis
- Extraction process is purely automatic
- Provides compact storage for large image database

Application area where the CBIR indexing technique is used is mentioned below:

- Crime Prevention
- The Military
- Journalism and Advertising
- Medical Diagnosis
- Cultural heritage

b) Available CBir Systems

a) Qbic

It is best known of all image retrieval systems. It offers retrieval by using features like color, shape and texture and by textual keyword. It is available commercially either in a standalone form or as a part of IBM Product [4].

b) Virage

Another commercial system is the VIR image Engine from Virage. This is available as independent modules. It is easily extended to a system by using new types of query interfaces or customized modules to process collection of images. Application of Virage is Alta vista’s AV Photo Finder.
c) Excalibur
Excalibur offers many image indexing and matching techniques which are based upon proprietary pattern recognition technology. Its application is Yahoo! Image surfer which allows content based retrieval of images from WWW [3].

d) Surfimage
It is an example of European CBIR technology from INRIA. In this system multiple types of image features are combined in different ways and it offers relevance feedback facility.

e) Netra
This system uses features like color, shape, texture and spatial location information which provide region based searching on local image characteristics.

Some search engines for searching images are as below:
- Picsearch
- Ditto
- Animation search
- Kamat house of picture
- Fagan Finder –Image
- 3 DUP
- Alta vista Image search

III. Indexing of Images

For designing an image database system the main problem which is considered is how to access the pictorial data from the image database [7, 8]. The basic aim of Iconic indexing methodologies is the use of pictorial icons as picture indices. An image has two kinds of descriptors:
- External information about its content (in textual form).
- Internal information related to the shape and the spatial arrangement of its pictorial element.
A data structure is used for storing the images which should preserve knowledge embedded in images for making an image database flexible and efficient [6].

IV. Image Indexing of Text

To perform retrieval on text based images one has to characterize the document content in a meaningful way. Researchers have addressed a number of problems which is ranging from attempting to identify proper nouns and automatic image abstracting [9]. These types of techniques are appropriate for indexing lower quality text or documents where the recognition results are expected to be poor.

A. Text characterization
De silva and Hull [10], have addressed the dilemma in document images for detecting a proper noun. Proper noun corresponds to the name of people, places and particular object for indexing. In this approach, the document image is segmented into words and the proper nouns are filtered by examining the words, image properties and its relationship to its neighbors. It is very expensive to run contextual post-processing on the recognized image data which may have to be identified over half a million names, not to mention the problems associated with word recognition itself [9]. The complexity of post-processing step is reduced by performing pre-classification in which it is possible to extract additional information from the image that is not available in the recognized text. The basic idea of providing a characterization and matching/similarity measure is essential for all retrieval problems, including the retrieval of document images.

V. Classical Indexing and Retrieval

The text which is created electronically has both structured and unstructured components [9]. It is useful to differentiate between document indexes which depend on objective, structured identifiers, such as author names, titles and publishers, and non-objective identifiers which are extracted directly from the text content [9, 12]. If the textual analysis provides structured identifiers, standard database operations can be used to query textual database. And if the unstructured identifiers, method for characterizing the full text content is used in which converted document must be developed.

The basic idea behind many techniques of text indexing and retrieval is to provide the ability to characterize the text corpus in meaningful ways, which allow users to provide a query as a set of keywords, and to provide an effective mechanism to retrieve images in ranked order. One of the most common ways to characterize a document’s image content is to consider the full text document and filter out the words which
have negligible amount of effect on the content, and then represent the document by a term vector consisting of the frequencies of meaningful terms. Once the text or documents are indexed, the resulting index vectors can be considered as the signatures and used for retrieval [9]. To query the collection, a simple measure can be used to compute the distance between the query vector and the document vector.

VI. Document Indexing Structure

There are two ways to index heterogeneous textual image or document:

1. Layout Structure (physical)
2. Semantic Structure (logical)

At the structure level most of the work done relies on the output of the document analysis process. In a typical document decomposition technique first step will be to perform a physical segmentation of document which provides information about physical characteristics. This technique is followed by two type of labeling known as functional and logical labeling. The functional labeling provides general use of specific physical constructs, and logical labeling provides a document’s semantic components description. Jaisimha et al. [13] present an overview of text and graphics retrieval system [9] in their system allows keywords searches on raw OCR results but do not provide mechanism to handle degraded documents. After manual segmentation, system allows matching of similar images to suggest the similar capabilities which are available for signature.

VII. Image Caption Indexing

Image caption indexing finds the relationship between caption’s content and image description. It has been observed the caption can be a valuable tool, both as a method to retrieve relevant images and for image interpretation [9]. Srihari uses association between an image and its caption for performing recognition and content based retrieval [14, 15]. The PICTON system tries to parse the caption and extract the name information and relative locations. Candidate’s faces are recognized automatically in the image and for labeling caption information is used. The system is able to differentiate the use of gender in languages as well as spatial relationship.

VIII. The Proposed Image Retrieval System

In image retrieval we have a set of reference images and want to find out the relevant images from the set. The most similar image is the result of the query image which will be retrieved in ranked order (See Figure 2). For achieving this; the procedure is given below [16].

1. Construct the indexing structure over the set of reference images.
2. Calculate the similarity measures between a query image and each of the images in the set of reference images.
3. Rank the most similar images according to computation.
4. Display the relevant images which users want to retrieve.

Let there are n number of images, which are indexed effectively by vectors \((v_1, v_2, v_3, ..., v_n)\) and \((v_1', v_2', v_3', ..., v_n')\) then we define their distance to be [1].

\[
D(I, I') = \sum_{i=1}^{n} (v_1 - v_2)^2
\]  

Figure 2: Observation of Image Retrieval
IX. Evaluation Metrics of Image Retrieval

In order to evaluate the performance of retrieval systems, we have to use performance criteria when there are more than one relevant images in the database with respect to a given query [17] for effectiveness of the retrieval in terms of recall and precision methods.

The recall ‘R’ means the ability to retrieve all the relevant images by the retrieval system from the database.

\[
R = \frac{\text{Number of significant images retrieved}}{\text{Total number of significant images in the database}}
\]

In contrast, the precision ‘P’ measures the ability to reject irrelevant ones (i.e. retrieve only relevant images).

\[
P = \frac{\text{Number of significant retrieved images}}{\text{Total number of images retrieved}}
\]

This Recall vs. Precision method is telling us about the measure of efficiency of retrieved images using image retrieval techniques which are also known as fill ratio.

X. Conclusions and Future Work

In this paper we have attempted to provide some background of past research on both indexing and retrieval of images. We have summarized the retrieval system ultimately in the perspective of both indexing and retrieval to make use of powerful features offered both in content based and in the underlying content of the text images. These types of systems will need to address the complex tradeoffs between speed of algorithm and quality of retrieved images. We have addressed the indexing technique in a comprehensive manner. For indexing of image, additional efforts will be devoted in further research. By using RDBMS a great amount of flexibility is achieved for retrieving an image concurrently [6]. To integrate the techniques, we would be using some Relational Database Management System (RDBMS) to develop new applications.

References