A Study on Image Mining Techniques

K. R. Yasodha
M.Phil Research Scholar
PG & Research Department of Computer Science
Gobi Arts &Science College (Autonomous)
Gobichettipalayam, Erode, India

K.S. Yuvaraj
PhD Research Scholar
PG & Research Department of Computer Science
Gobi Arts &Science College (Autonomous)
Gobichettipalayam, Erode, India

Abstract

Image mining is a very important technique which is used to mine knowledge easily from image. Image mining handles with the hidden knowledge extraction, image data association and additional patterns which are not clearly accumulated in the images. The most important function of the mining is to generate all important patterns without previous information of the patterns. Rule mining has been adapting to huge image databases. Numerous researches have been carried on this image mining. This paper presents a study on various image mining techniques that were proposed earlier in literature. Also, this paper provides a marginal overview for future research and improvements.

Keywords --- Image mining, image indexing and retrieval, object recognition, image classification, image clustering, association rule mining.

I. INTRODUCTION

Advances in image acquisition and storage technology have led to tremendous growth in significantly large and detailed image databases[6]. The world wide web is regarded as the largest global image repository. An extremely large number of image data such as satellite images, medical images, and digital photographs are generated every day. These images, if analyzed, can reveal useful information to the human users. Unfortunately, there is a lack of effective tools for searching and finding useful patterns from these images. Image mining systems that can automatically extract semantically meaningful information (knowledge) from image data are increasingly in demand. The fundamental challenge in image mining is to determine how low-level, pixel representation contained in a raw image or image sequence can be efficiently and effectively processed to identify high-level spatial objects and relationships. In other words, image mining deals with the extraction of implicit knowledge, image data relationship, or other patterns not explicitly stored in the image databases. It is an interdisciplinary endeavor that essentially draws upon expertise in computer vision, image processing, image retrieval, data mining, machine learning, database, and artificial intelligence[15]. While some of the individual fields in themselves may be quite matured, image mining, to date, is just a growing research focus and is still at an experimental stage. The main obstacle to rapid progress in image mining research is the lack of understanding of the research issues involved in image mining. Many researchers have the wrong impression that image mining is just a simple extension of data mining applications; while others view image mining as another name for pattern recognition. This study attempted to identify the unique research issues in image mining. This will be followed by a review of what are currently happening in the field of image mining, particularly, image mining frameworks, state-of-the-art techniques and systems. Identify possible research direction to bring image mining research to a new height.

II. IMAGE MINING ISSUES

By definition, image mining deals with the extraction of image patterns form a large collection of images. Clearly, image mining is different from low-level computer vision and image processing techniques because the focus of image mining is in extraction of patterns form large collection of images whereas the focus of computer vision and image processing techniques is in understanding and/or extracting specific features from a single image[16]. While there seems to be some overlaps between image mining and content-based retrieval (both are dealing with large collection of images), image mining goes beyond the problem of retrieving relevant images. In image mining, the goal is the discovery of image patterns that are significant in a given collection of images[15]. Figure 1 shows the image mining process. The images from an image database are first preprocessed to improve their quality. These images then undergo various transformations and feature extraction to generate the important features from the images. With the generated features, mining can be carried out using data mining techniques to discover significant patterns[14]. The resulting patterns are evaluated and interpreted to obtain the final knowledge, which can be applied to applications. Perhaps, the most common misconception of image mining is that image mining is nothing more than just applying existing data mining algorithms on images[6]. This is certainly not true because there are important differences between relational databases versus image databases.
A. Absolute Versus Relative Values

In relational databases, the data values are semantically meaningful. For example, age is 35 is well understood. However, in image databases, the data values themselves may not be significant unless the context supports them. For example, a grey scale value of 46 could appear darker than a grey scale value of 87 if the surrounding context pixels values are all very bright.

B. Spatial information (Independent versus dependent position)

Another important difference between relational databases and image databases is that the implicit spatial information is critical for interpretation of image contents but there is no such requirement in relational databases. As a result, image miners try to overcome this problem by extracting position-independent features from images first before attempting to mine useful patterns from the images.

C. Unique Versus Multiple Interpretations

A third important difference deals with image characteristics of having multiple interpretations for the same visual patterns. The traditional data mining algorithm of associating a pattern to a class (interpretation) will not work well here. A new class of discovery algorithms is needed to cater to the special needs in mining useful patterns from images.

In addition to the need for new discovery algorithms for mining patterns from image data, a number of other related research issues also need to be resolved. For instance, for the discovered image pattern to be meaningful, they must be presented visually to the users. This translates to following issues:

(a) Image pattern representation
(b) Image features selection
(c) Image pattern visualization.

III. IMAGE MINING FRAMEWORKS

Early work in image mining has focused on developing a suitable framework to perform the task of image mining. An image database containing raw image data cannot be directly used for mining purpose[10]. Raw image data has to be first processed to generate the information usable for high-level mining modules. An image mining system is often complicated because it requires the application of an aggregation of techniques ranging from image retrieval and indexing schemes to data mining and pattern recognition. A good image mining system is expected to provide users with an effective access into the image repository and generation of knowledge and patterns underneath the images.

At present, two kinds of frameworks can be used:

(a) Function-Driven Framework
(b) Information-Driven image Frameworks.

IV. IMAGE MINING TECHNIQUES

Besides investigating suitable frameworks for image mining, early image miners have attempted to use existing techniques to mine for image information. The techniques frequently used include object recognition, image indexing and retrieval, image classification and clustering, association rules mining, and neural network.
A. Object Recognition

Object recognition has been an active research focus in field of image processing. Using object models that are known a priori, an object recognition system finds objects in the real world from an image. This is one of the major tasks in the domain of image mining. Automatic machine learning and meaningful information extraction can only be realized when some objects have been identified and recognized by the machine. The object recognition problem based on models of known objects[4]. Specifically, given a target image containing one or more interesting objects and a set of labels corresponding to a set of models known to the system, what object recognition does is to assign correct labels to regions, or a set of regions, in the image. Models of known objects are usually provided by human input a priori.

In general, an object recognition module consists of four components, namely, model database, feature detector, hypothesizer and hypothesis verifier. The model database contains all the models known to the system. The models contain important features that describe the objects. The detected image primitive features that describe the objects[4]. The detected image primitive features in the pixel level are used to help the hypothesizer to assign likelihood to the objects in the image. The verifier uses the models to verify the hypothesis and refine the object likelihood. The system finally selects the object with the highest likelihood as the correct object.

Recently , Jeremy S. De Bonet, aiming to locate a particular known object in an image or set of images, design a system that processes an image into a set of “characteristic maps”.

B. Image Retrieval

Image retrieval requires that images be retrieved according to some requirement specifications. The requirement specifications can be classified into three levels of increasing complexity:[2]

(a) Level 1 comprises image retrieval by primitive features such as color, texture, shape or the spatial location of image elements. Examples of such queries are “retrieve the images with long thin red objects in the top right-hand corner” and “retrieve the images containing blue stars arranged in a ring”

(b) Level 2 comprises image retrieval by derived or logical features like objects of a given type or individual objects or persons. Examples include “retrieve images of round table” and “retrieve images of jimmy”

(c) Level 3 comprises image retrieval by abstract attributes, involving a significant amount of high-level reasoning about the meaning or purpose of the objects or scenes depicted. For example, image retrieval queries such as “retrieve the images of football match” and “retrieve the images depicting happiness”.

Rick kazman and john kominek describe three query schemas for image retrieval: Query by Associate Attributes, Query by Description and Query by Image Content. In Query by Associate Attributes, only a slight adaptation of conventional table structure is needed to tailor it to fit the image needs. The images are appended as extra field. Image retrieval is performed based on other associated attributes within the same table. In Query by Description, the basic idea is to store image descriptions, also known as labels or keywords, along with each image so that users can locate the images of interest using the descriptions. The image descriptions are normally generated manually and assigned to each image in the image preprocessing stage. It suffers from the drawbacks of the “vocabulary problem”[5] and non-scalability. In the early 1990’s, because of the emergence of large-scale image repository, the two difficulties of vocabulary problem and non-scalability faced by the manual annotation approach became more and more acute. Content-based image retrieval is thus proposed to overcome these difficulties. There are three fundamental bases in content-based image retrieval, namely, visual information extraction, image indexing and retrieval system application. Many techniques have been developed in this direction, and many image retrieval systems, both research and commercial, have been built[9].

In the area of commercial systems, IBM’sQBIC system is probably the best known of all image content retrieval systems. It offers retrieval by any combination of color, texture or shape, as well as text keyword. It uses R*-tree indexes to improve search efficiency. More efficient indexing techniques, an improved user interface ,and the ability to search grey-level images are incorporates in the latest version. Virage is another well-known commercial system. This is available as a series of independent modules, which system developers can build into their own programs. Excalibur, by virtue of its company’s pattern recognition technology, offers a variety of image indexing and matching techniques[11]. As far as the experimental systems, there have been a large number of such systems available. The representatives are photobook, Chabot, visualSEEk, MARS, informedia, surfimage and synapse.

C. Image Indexing

Image mining systems require a fast and efficient mechanism for the retrieval of image data. Conventional database systems such as relational databases facilitate indexing on primary or secondary key(s), currently, the retrieval of most image retrieval system is, by nature. Similarity –based retrieval. In this case, indexing has to be carried out in the similarity space. One promising approach is to first perform dimension reduction and then use appropriate multi-dimensional indexing techniques that support non-Euclidean similarity measures. Indexing techniques used range from standard methods such as signature file access method and inverted file access method, to multi-dimensional methods such as K-D-B tree, R-tree, R*-tree and R+-tree, to high-dimensional indexes such as SR-tree, TV-tree, X-tree and iMinMax[4].

Other proposed indexing schemes focus on specific image features. Presents an efficient color indexing scheme for similarity-based retrieval which has a search time that increase logarithmically with the database size. Proposes a
multi-level R-tree index, called the nested R-trees for retrieving shapes efficiently and effectively[10]. With the proliferation of image retrieval mechanisms, give a performance evaluation of color-spatial retrieval techniques which serves as guidelines to select a suitable techniques and design a new technique.

D. Image Classification and Image Clustering

Image classification and image clustering are the supervised and unsupervised classification of images into groups respectively in supervised classification, one is provided with a collection of labeled (pre-classified) images, and the problem is to label newly encountered, unlabeled images. Typically, the given labeled(training) images are used to do the machine learning of the class description which in turn are used to label a new image. In image clustering, the problem is to group a given collection of unlabeled images into meaningful clusters according to the image content without a priori knowledge[8]. The fundamental objective for carrying out image classification or clustering in image mining is to acquire content information the users are interested in from the image group label associated with the images.

Intelligently classifying image by content is an important way to mine valuable information from large image collection. The classification module in the mining system is usually called classifier. Recognizes the challenge that lies in grouping images into semantically meaningful categories based on low-level visual features. Currently, there are two major types of classifiers, the parametric classifier and non-parametric classifier. An unsupervised retraining technique for a maximum likelihood(ML) classifier is presented to allow the existing statistical parameter to be updated whenever a new image lacking the corresponding training set has to be analyzed[12].

Image clustering is usually performed in the early stages of the mining process. Feature attributes that have received most attention for clustering are color, texture and shape. Generally, any of the three, individually or in combination, could be used. There is a wealth of clustering techniques available: hierarchical clustering algorithms, partition-based algorithms, mixture-resolving and mode-seeking algorithms, nearest neighbor clustering, fuzzy clustering and evolutionary clustering approaches. Once the images have been clustered, a domain expert is needed to examine the images of each cluster to label the abstract concepts denoted by the cluster.

E. Association Rule Mining

Association rule mining generate rules that have support and confidence greater than some user specified minimum support and minimum confidence thresholds. A typical association rule mining algorithm works in two steps. The first step finds all large itemsets that meet the minimum support constraint. The second step generates rules from all the large itemsets that satisfy the minimum confidence constraint.

An association rule mining is a typical approach used in data mining domain for uncovering interesting trends, patterns and rules in large datasets. Recently, association rule mining has been applied to large image databases. There are two main approaches. The first approach is to mine from large collections of images combined collections of images and associated alphanumeric data. C. Ordonez al present an image mining algorithm using blob needed to perform the mining of associations within the context of images[7]. A prototype has been developed in Simon Fraser university called multimedia miner where one of its major modules is called MM-Associate. It uses 3-dimensional visualization to explicitly display the associations. In another application, association rule mining to discover associations between structures and functions of human brain. An image system called BRA in-image database has also been developed. Though the current image association rule mining approaches are far from mature and perfection compared its application in data mining field, this opens up a very promising research direction and vast room for improvement in image association rule mining[14].

F. Neural Network

A neural network, by definition, is a massively parallel distributed processor made up of simple processing units, each of which has a neural propensity for storing experiential knowledge and making the knowledge available for use[10]. Neural networks are fault tolerant and are good at pattern recognition and trend prediction. In the case of limited knowledge, artificial neural network algorithms are frequently used to construct a model of the data.

Even through there has been a lot of research work wth regard to neural network and its applications, it is relatively new in the image mining domain[13]. A noteworthy research work that applied neural network to image mining is the Artificial Neural Network(ANN) developed by G.G Gardner et al [14]which provides a wholly automated approach to fundus image analysis. A site mining tools, based upon the fuzzy ARTMAP neural network, provides an intuitive means by which an image analyst can efficiently and successfully mine large amounts of multi-sensor imagery for Feature Foundation Data(e.g. roads, rivers, orchards ,forests).

V. IMAGE MINING REAL WORLD APPLICATION

This study describes a real-world application of image mining involving satellite images. Satellite images are an important source of information. One useful application of satellite images is to examine the paths and trends of forest fires over the years, thereby enabling firefighters to have a better understanding of the behavior of such forest fires in order to combat these fires effectively. The satellite image mining application can need:

(a) An efficient and effective spatial clustering technique for large-scale multi-resolution incremental clustering that are adaptable in dynamic environment;
(b) An image indexing scheme based on cluster-related semantic concepts to achieve high-level image retrieval in the satellite image database;
(c) Fire cluster information to discover any spatial and temporal trends and patterns of fire development in terms of scale, area, time duration and location.

The mining of fire patterns from satellite images involves the following 6 steps which corresponds to the information-driven framework level[6]

A. Image Processing
In the lowest pixel level, image processing technique(simple thresholding technique) is used to extract the spatial location information of fire spots. The spatial location of a fire spot is represented by its altitude and longitude in the map. Such spatial information is stored in the Hotspot database.

B. Database Integration
The commercial satellite typically generate 2 to 3 images of a specified location every day and the extracted fire locations of each image, that is .the latitude and longitude, is stored in individual table of the Hotspot database. Thus , it is necessary for us to carry out database integration before trying to mine the image information over a longer time interval, say a week, a month or a year.

C. Spatial Clustering
Once the integration is completed, then perform spatial clustering using a state-of-the-art clustering method, called FASTCiD,FASTCiD is well suitable for this application because of it is highly efficient and effective in performing clustering of large dynamic spatial databases. The cluster label of each fire is obtained after this clustering process.

D. Semantic Cluster Concept Generation
Using FASTCiD, it is very easy to automatically obtain the information regarding the spatial layout, the area and the density of a specific cluster. Based on these information, are able to define a few semantic cluster concepts, such as center cluster, left cluster, dense cluster, sparse cluster, big cluster, small cluster and so on.

E. Semantic Concept Image Indexing and Retrieval
After the generation of cluster semantic concepts, semantic concept indexing of Hotspot images is built to support high-level image retrieval based on these semantic concepts. Examples of such images retrieval are: “retrieval all the Hotspot images which have dense cluster in the center of the images”, and “retrieval all the Hotspot images in which the clusters located in the left and lower corners are all small ones”.

F. Trends and Patterns Mining
Finally, it is desirable to produce dome spatial and temporal trends and patterns of the forest fire. To this end, they explore the fire cluster information to discover any spatial and temporal trends and patterns of fire development in terms of scale, area, time duration and location. These trends and patterns are potentially useful for better understanding of the forest fires behavior.

VI. CONCLUSION AND FUTURE RESEARCH DIRECTIONS
This study highlighted the need for image mining in view of the fast growing amounts of image data. Point out the unique characteristics of image databases that brings with it a whole new set of challenging and interesting research issues to be resolved. In addition, also discussed techniques that are frequently used in the early works in image mining, namely, object recognition, image retrieval, image indexing, image classification and clustering, association rule mining and neural network.

In summary, image mining is a hopeful field for research. Image mining research is still in its infancy and many issues remain solved. Specifically, image mining research to progress to a new height, the following issues need to be investigated:
(a) Propose new representation schemes for visual patterns that are able to encode sufficient contextual information to allow for meaningful extraction of useful visual characteristics;
(b) Devise efficient content-based image indexing and retrieval techniques to facilitate fast and effective access in large image repository;
(c) Design semantically powerful query languages for image databases;
(d) Explore new discovery techniques that take into account the unique characteristics of image data;
(e) Incorporate new visualization techniques for the visualization of image patterns.

REFERENCES


