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A SURVEY ON FRAMEWORKS AND TECHNIQUES OF IMAGE MINING

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Abstract:

These days, images are important in every aspect of business, including satellite imagery, commercial imagery, and medical imagery. A subfield of data mining called image mining is concerned with the process of discovering new information about digital photos. The fascinating topic of image mining extends classic data mining from structured to unstructured data, including image data. Image mining techniques are now necessary due to the increase in the quantity of photos and image databases. A set of analytical methods called "image mining" look through a lot of picture data. This study aims to provide an overview of the many categories of frameworks that are used to demonstrate image mining techniques and approaches for image mining applications.

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

Introduction:

Advances in image acquisition and storage technology have led to tremendous growth in significantly large and detailed image databases [1]. 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 [2]. 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

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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. In this paper, we attempt 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. We will also identify possible research directions to bring image mining research to a new height.

Research Issues in Image Mining:

By definition, image mining deals with the extraction of image patterns from 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 from 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. 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.

Perhaps, the most common misconception of image mining is that image mining is nothing more than just applying existing data mining algorithms on images. 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.

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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.

How can we represent the image pattern such that the contextual information, spatial information, and important image characteristics are retained in the representation scheme?

(b) Image features selection.

Which is the important image features to be used in the mining process so that the discovered patterns are meaningful visually?

(c) Image pattern visualization.

How to present the mined patterns to the user in a visually-rich environment?

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 purposes. 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. To this end, such a system typically encompasses the following functions:

Image storage, image processing, feature extraction, image indexing and retrieval, patterns and knowledge discovery.

At present, we can distinguish two kinds of frameworks used to characterize image mining systems: function driven versus information-driven image mining frameworks. The former focuses on the functionalities of different component modules to organize image mining systems while the latter is designed as a hierarchical structure with special emphasis on the information needs at various levels in the hierarchy.

1. **Function-Driven Frameworks**

The majority of existing image mining system architectures [3] fall under the function-driven image mining framework. These descriptions are exclusively application-oriented and the framework was organized according to the module functionality. For example, Mihai Datcu and Klaus Seidel propose an intelligent satellite mining system that comprises two modules:

(a) A data acquisition, preprocessing and archiving system which is responsible for the extraction of image information, storage of raw images, and retrieval of image.

(b) An image mining system, which enables the users to explore image meaning and detect relevant events.

Figure 1 shows this satellite mining system architecture. Similarly, the Multi Media Miner [1] comprises four major components:

(a) Image excavator for the extraction of images and videos from multimedia repository.

(b) A preprocessor for the extraction of image features and storing precomputed data in a database.

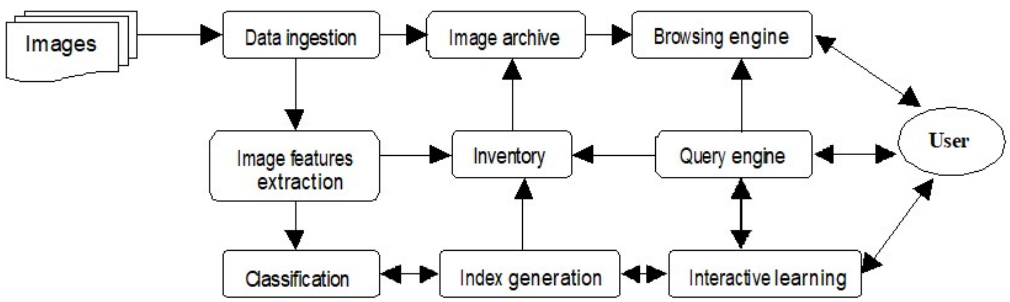

Figure 1: Functionality architecture of an intelligent satellite information mining system

(c) A search kernel for matching queries with image and video features in the database.

(d) The discovery modules (characterizer, classifier and associator) exclusively perform image information mining routines to intelligently explore underlying knowledge and patterns within images.

2. **Information-Driven Frameworks**

While the function-driven framework serves the purpose of organizing and clarifying the different roles and tasks to be performed in image mining, it fails to emphasize the different levels of information representation necessary for image data before meaningful mining can take place. Zhang et. al [4] proposes an information-driven framework that aims to highlight the role of information at various levels of representation. The framework, as shown in Figure 2, distinguishes four levels of information as follows.

(a) Pixel Level, also the lowest level, consists of the raw image information such as image pixels and the primitive image features such as color, texture, and shape;

(b) Object Level deals with object or region information based on the primitive features in the Pixel Level;

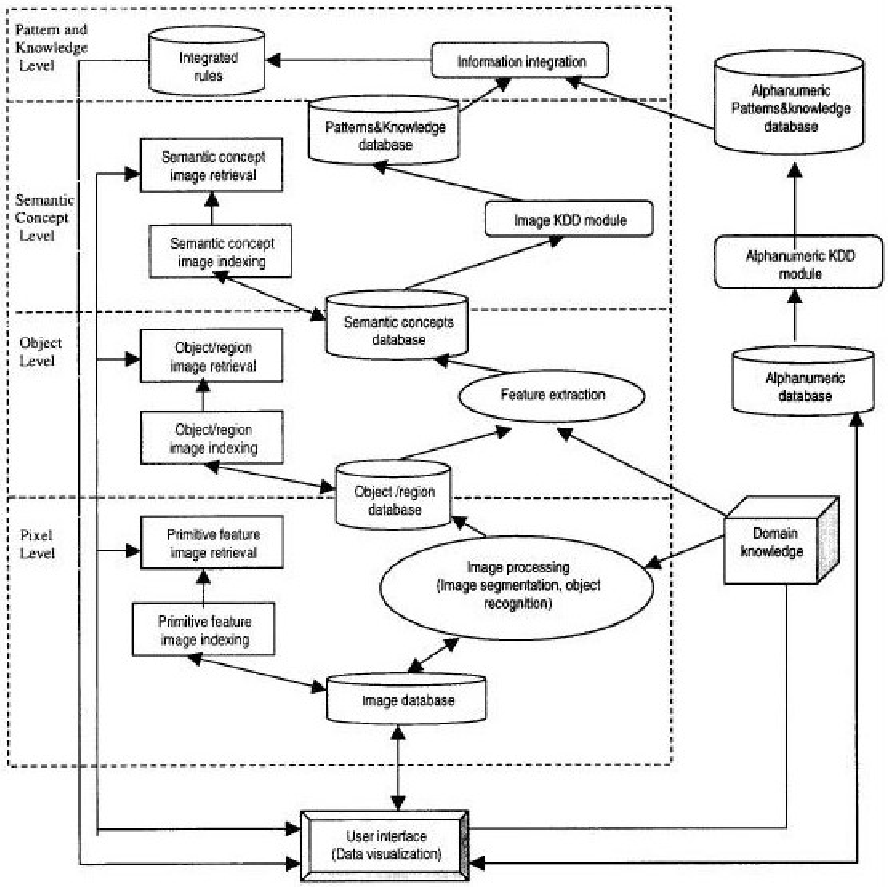

Figure 2: An information-driven image mining.

(c) Semantic Concept Level takes into consideration domain knowledge to generate high-level semantic concepts from the identified objects and regions;

(d) Pattern and Knowledge Level incorporates domain related alphanumeric data and the semantic concepts obtained from the image data to discover underlying domain patterns and knowledge. The four information levels can be further generalized to two layers: the Pixel Level and the Object Level form the lower layer, while the Semantic Concept Level and the Pattern and Knowledge Level form the higher layer. The lower layer contains raw and extracted image information and mainly deals with images analysis, processing, and recognition. The higher layer deals with high-level image operations such as semantic concept generation and knowledge discovery from image collection. The information in the higher layer is normally more semantically meaningful in contrast to that in the lower layer.

Image Mining Techniques:

The techniques which were used by early image miners prior to the invention of suitable framework include pattern recognition, image indexing and retrieval, image classification, image clustering, association rule mining, and neural network. In the following, is a survey on these techniques? The techniques are classified on five levels of information and the associated image or data mining operations. These levels (from top to bottom) are:

a) knowledge extraction level

b) patterns and inter-image relations level

c) semantic concept level

d) region, objects, or visual patterns level

e) pixel level.

1. **Object recognition**

One of the key areas of image mining is object recognition, which operates data on patterns and inter-image relations level. It finds the object relevant to the real world, from the image by processing the provided object models. It is also known as supervised labeling method. The system has four parts, they are:

a) feature detector

b) model database

c) hypothesiser

d) hypothesis verifier.

In 2000, Jeremy and Bonet (2000) [5] proposed a system to find out a specific known object in the image, which applied image processing operations on the set of 'characteristic maps'. In Burl et al. (1999) [6] employed learning techniques to generate recognisers automatically. In this work, classified examples were used to capture the domain knowledge implicitly. Later in 2001, Gibson et al. (2001) [7] developed an optimal FFT-based mosaicing algorithm to find common patterns in images. The results of this work showed that the system worked well on various kinds of images.

2. **Image retrieval**

Image retrieval refers to the process of retrieving a particular image from a large database using data mining. Retrieval of images in image mining is done based on some requirement specification. There are three levels of requirement specifications and the complexity also increase with the levels.

a) Level 1 retrieve the image based on some basic features of images such as texture, colour, shape or image elements' spatial location

b) Level 2 is based on image retrieval which derives the logical features such as individual objects or persons from images

c) Level 3 is based on image retrieval by abstract attributes which involves a high level reasoning in order to obtain the meaning of the objects or scenes illustrated.

Kazman and Kominek (1993) [8] introduced three query schemas to retrieve image information. They were

a) query by description

b) query by associate attributes

c) query by image content.

Query by associate attributes refers to the technique of taking the conventional table structure to tailor which fulfils the purpose of image needs. Query by description means the method that uses description along with each image, through which the user can locate the images interested. The image description is often referred as label or keyword.

With the emergence of large-scale image repositories, the problems of vocabulary and non-scalability caused by manual operation have become more pronounced. Hence, content-based image retrieval (CBIR) was proposed to overcome these difficulties.

IBM's QBIC system (Flickner et al., 1995) could retrieve image description by any combination of colour, texture and shape as well as text keyword. This system may be one of the popular systems amongst all other image content retrieval frameworks. It uses R*-tree indexes to improve efficiency. Image retrieval operates data on semantic concept level, region, objects, visual patterns level and pixel level.

3. Image indexing

Apart from focusing on the information requirements at various levels, it is also important to provide support for the retrieval of image data with a fast and efficient indexing scheme. On the contrary, the image database to be searched is too large and the feature vectors of images are of high dimension (in the order of 102) which increases the search complexity. To reduce such complexity reducing dimensionality or indexing high dimensional data can be used. Image indexing handles data and images in region, objects and visual patterns level. Reducing the dimensions can be accomplished using two well-known methods:

a) the singular value decomposition (SVD) update algorithm

b) clustering

Although, the best way to reduce complexity is to perform appropriate multi-dimensional indexing after performing dimension reduction, which provides non-Euclidean similarity measures.

Lin et al. (1994) introduced an efficient technique of colour indexing for retrieving similar type data. In this work, they increased the search time as the size of the database increased. In 2001, Tan et al. (2001) proposed a multi-level nested R-tree index which retrieved the structure efficiently and effectively. It helped to select appropriate technique and also helped to design new technique by prolife the retrieval process. This process helped to evaluate the performance of colour-spatial retrieval techniques, which led to the selection of a suitable new technique.

4. Image classification and clustering

Image classification and clustering refers to the method of arranging the images into clusters which may be done in a supervised or unsupervised way. In supervised classification, the problem is to classify a newly encountered image from a collection of given pre-classified images. Whereas, in unsupervised classification (or image clustering), without any previous knowledge the unlabeled similar type of images are grouped together which leads to cluster generation. Clustering the images based on their content is an important and equally challenging task to infer information from the huge collection of images. This technique is more focused on the levels of inter-image relations, semantic in an image, and regions. However, this technique may operate on the large raw data.

Uehara et al. (2001) discovered the method of grouping a set of images based their low-level visual features. This method also used a binary Bayesian classifier which classified the vacation images into indoor and outdoor categories. The existing statistical parameter was updated using an unsupervised technique for a maximum likelihood (ML) classifier. As a result, a new image lacking corresponding statistical parameter demanded the analysis of corresponding training set.

Wang and Li (1997) proposed an image-based classification method of objectionable websites (IBCOW) which classified the websites to detect if that website was objection enable or based on image content. The early stage of mining process is Image clustering. Important attributes for clustering are texture, colour and shape of a particular image. They can be used separately or in combination. Several clustering techniques are available such as: partition-based algorithms, hierarchical clustering algorithms, mixture-resolving and mode-seeking algorithms, nearest neighbour clustering, fuzzy clustering, evolutionary clustering approaches etc. The abstract features by cluster can be recognised by the domain expert following the image clustering.

5. Association rule mining

Ordonez and Omiecinski (1998) discussed an algorithm for image mining association rules. This algorithm reduced I/O and CPU overhead and operated data or images on region, objects and visual pattern level. They also built the data mining system on the top of CBIR system. This algorithm first segmented images into blobs. Then identified and labelled objects present in the images. Later, similarity measurement was done on those images. The value of similarity measurement being one indicated perfect match on all desired features, whereas zero similarity measurement value referred to the worst match possible on those desired features. To interpret the association rules, this process also provided the auxiliary images with identified objects.

Data mining algorithm was applied to produce object association rules. Priyatharshini and Chitrakala (2013) described the method of using association rule in case of image retrieval. According to this method, for each query image, all association rules which used the query image as the antecedent (A) must be found. The consequent (B) were the candidate images for retrieval procedure. Afterwards, those candidate images were ranked according to their confidence value. If the candidate image set was empty or consisted of less no. of images than it should be present then the system picked several images randomly from the database which would give every image a chance to establish the association rules. Deshpande (2011) presented a data mining technique for finding image content-based association rule. The purpose of this experiment was to do feasibility study of data mining approaches based on image content.

The frequent item set discovered by traditional association rule algorithm using iteration, needed large calculation. This issue demanded a simpler approach for image mining (Jain et al., 2013). Thus, the technique of image mining (Banda et al., 2014; Chen and Mei, 2014) was divided into four important phases: image pre-processing, feature extraction, conversion of image database to transaction database, and applying association rule mining (Wang et al., 2014; Herold et al., 2011; Khodaskar and Ladhake, 2014) to this transaction database. The proposed new association rule algorithm (Deshpande, 2010) reduced the number of scans for a priori algorithm.

Literature Survey:

According to Josh Jelin et al., (2013) the image is being compared using the given inputs. It represents the simple way of comparing any given two images and saying whether it is matching or not exactly. They have used the regression algorithm to represent the features of the images being compared. On the main process it has not much efficient to recognize the similarity of the image as needed.[9]

By the proposal of Ji Zhang et al., (2012) the paper represents the highlights of the image mining techniques and the increasing demand in the current scenario. The images being analyzed gives the appropriate results on the basis of the user specification. There have been many algorithms newly proposed and designed to perform the action of image retrieval.[10]

Mahip M. Bartere et al., (2012) has projected the system of image mining technique with specific characteristics due to the evolution of enormous amount of data. In this paper the image is being compared by their attributes following different mining techniques. It measures the quantization and color matching prospect of the image being compared.it is a special framework designed to implement the process.[11]

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On referring to the paper presented by Shaikh Nikhat Fatma et al., (2012) the main aim is to determine several image patterns in which the images are substantial with the number of prospects. It separates the unique image on the group of images to identify its high level features. This frame work figure out the major problems and tasks for finding the useful patterns of the image data.[12]

Nishcol Mishra et al., (2012) has presented a paper to collect data on the emergence of social network sites. Network have been gathered immense popularity and become a major part of millions of people's life. Those network sites are tremendously huge in content and contain a massive amount of multimedia data which is waiting for analyzing and mining. It give the opportunity in multimedia data mining which includes audio video and text. It mainly focused on content based image retrieval.[13]

Md. Farooque et al., (2003) has projected the advanced technique for the collection of huge amount of data in different fields on online. The user handled the image retrieval technique in resourceful manner. Many techniques are proposed to solve the problem of image retrieval. It shows significant part in image indexing and retrieval.[14]

Shao-Yi Chien and Liang-Gee Chen., (2008) has given the solution for video analysis systems. It deals with the morphology operations. It provides interconnection between processing elements which can be retrieved. It is implemented using macro processing chip, tiling and pipelined-parallel techniques.[15]

According to Barbora Zahradnikova, Sona Duchovicova and Peter Schireiber et al., (2015) has a enormous amount of data in numerous forms accessible for the people. Most of the image data in the fields of automation meteorology, forensic criminology and robotics. Gaining more useful information from image database has created a great impact in the society. Image mining methodologies comprises computer vision, artificial intelligence, machine learning, image retrieval, statistics and recognition. It describes in identifying the direction of the future research.[16]

Peter Stanchev et al., has published a new method for image retrieving with high semantic attributes. It is mainly focused on bringing up the low quality image data to a high quality in all the aspects of color, size, shape and texture. It uses the fuzzy logic algorithm to convert the image data. [17]

Preeti Chouhan et al., has proposed an advanced technique on image retrieval based on data mining. It combines the facts of image processing, artificial intelligence, machine learning, data mining and databases. It randomly collects the data of previously stored to analyze them. Thus it uses all the characteristic features of image such as color, texture, and other dominant factors. It uses a specific method of Gray Level Co-occurrence Matrix to find the texture of images. Similarly many methods are followed to represent each characteristics.[18]

Conclusion:

The primary goal of picture mining is to extract lost information and eliminate crucial data for each person's predictable needs. The majority of image mining techniques have been covered in this work. Each of these strategies has benefits and drawbacks of its own. We discuss the emphasised need for image mining in this study in order to analyse the ever-increasing amount of image data. Additionally, two types of image mining frameworks have been observed: information-driven and function-driven frameworks. Furthermore, the early image mining techniques—image retrieval, object identification, image indexing, image classification and clustering, association rule mining, and neural networks—were also covered. In summary, image mining presents a promising area of study. In its early stages, image mining research remains stagnant, and many problems have not yet been solved.

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