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Function and Information Driven Frameworks for Image Mining - A Review

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Abstract: The rapid growth of image data in a variety of medium has necessitated a way of making good use of the rich content in the images. Image mining is the process of finding useful images in large image archives. The essential of image mining is high in view of the rapidly expanding bundle of image data. In this paper, we analyse the two image mining framework such as function driven and information driven overall process and discuss the main technology of image mining. The function driven framework spotlighted on the functionalities of different module parts to classify image mining systems. Information-driven framework focused for explicit information hierarchy. Finally, we conclude some research directions and problems of image mining are presented.

Keywords: data mining, image processing, image mining, image mining framework, function-driven framework, information-driven framework.

I. INTRODUCTION

Data mining is one of the most useful methods for exploring large data sets. An Image contains a great deal of information, and thus the amount of knowledge that we can extract from them is enormous. Image mining can automatically discover the hidden information and patterns from the huge number of images and is quickly achievement interest in the field of data mining. It denotes the collaboration of data mining and image processing technology to aid in the analysis and understanding in an image-rich domain.

Image mining can automatically extract semantically meaningful information from image data are increasingly in demand. It deals with the extraction of hidden information, association of image and data or other patterns not clearly gathered in the image databases [2, 3, 4, 5]. It is an interdisciplinary venture that essentially draws upon expertise in artificial intelligence, computer vision, content based image retrieval, database, data mining, digital image processing and machine learning.

Advance development of image procurement and storage technology have lead to marvellous development in very huge and detailed image databases [3]. A massive volume of image data such as digital photographs, medical images and satellite images are generated every day [2]. The World Wide Web is the largest global image repository. An increasing proportion of the contents in digital libraries are images. These images are interpreted and it can expose useful information to the human users. Unfortunately, it is difficult or even impossible for human to discover the underlying knowledge and patterns in the image when handling a large collection of images. Current research in image mining continues to be focused on how best to represent images so that data mining techniques can be applied.

The rest of this paper is organized as follows. Section 2 discusses about the related work of image mining. Section 3 presents the objectives of image mining. Section 4 gives an overview of image mining frameworks. Section 5 and 6 discussed in Function and Information driven framework respectively. Finally, we conclude in section 7.

II. RELATED WORK

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 and (c) Image pattern visualization.

Existing works adapted data mining algorithms such as association rule mining [4, 8, 35], classification [9] [10], clustering [11, 12, 25], object recognition, image segmentation and feature extraction [23, 24], and image indexing and retrieval [26-33] techniques to generate patterns based on pixel level or object level features. While these approaches can discover hidden relationships among appearance features in the images, they ignore the patterns relating to the spatial properties of objects in the images. Recent image mining approaches apply data mining

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techniques after preprocessing the image data to some suitable form for mining.
There have been many advances in technologies like image digitization, storage and transmission. These have caused a number of digital images to increase tremendously. Thus, content based image classification and retrieval systems have been the subject of many multimedia data mining research works in the recent years.
Image mining early systems, such as QBIC [17], VisualSEEK [18] and MARS [19] facilitate classification, indexing and retrieval of images such as color, texture and shape. Hence to overcome this drawback image mining has come into more practice in data mining. The system analyse those stored images whose feature values match those of the query most closely, and displays [16]. The problem of image mining [6] combines the areas of content-based image retrieval, image understanding, data mining and databases.

III. Image Mining Objectives

As a collaborative research field, Image mining has its own objectives as follows: (a) Dependence on spatial information. Spatial information is vital for interpretation of image content but there isn't such requirement in traditional data mining. (b) Dependence on knowledge of a specific field. Interpretation of image contents is achieved through high level semantic, which is produced by knowledge reasoning. Thus, merely by using low-level global visual content features, such as color, texture, shape, is not sufficient for expressing high-level semantic information correctly, which brings around a semantic gap problem, a lot of knowledge of a specific field is needed to solve this problem. (c) Various interpretations for visual mode. For the same visual mode, there has multiple interpretations for it, usually special field experts are needed to take part in the interpretation process. (d) Complexity of the image mining process. Image Mining not only analyzes and discovers a mode, but it also has to deal with the operations related to mining system such as image retrieval, indexing, and storing, which play important roles in the final mining results, all this processes add difficulties to image mining.

IV. Image Mining Frameworks

Early work in image mining has focused on developing a suitable framework to perform the task of image mining. The image database containing unrefined image data cannot be directly used for mining purposes. Unrefined image data need to be processed to generate the information that is convenient for prominent mining parts. The mining system is much difficult because it employs a variety of approaches and techniques varying from image indexing and retrieval to data mining and pattern recognition. A high-quality system is likely to give users with a helpful right to use into the image repository and production of knowledge and patterns sheltered the images. Such a system typically incorporate the consequent functions: feature extraction, image indexing and retrieval, image processing, image storage and patterns and knowledge discovery.
Ji Zhang et al. [2] presented an integrated overview of the research issues and developments in the area of image mining. The presentation concluded with some future research directions for image mining, setting up the context for the other presentations in the area of image mining. Image mining frameworks are grouped into two broad categories: function-driven and information-driven.

V. Function-Driven Frameworks

Several image mining systems have been developed for different applications. The majority of existing image mining system architectures [1, 3, 21] 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 [21] proposed 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.
Similarly, the MultiMediaMiner [3] which mines high-level multimedia information and knowledge from large multimedia database 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. (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. The system constructs multimedia data cube facilitating multiple dimensional analyses of multimedia data, primarily based on visual content, and the mining of various kind of knowledge including summarization, comparison, classification, association, clustering.
The function-driven framework spotlighted on the functionalities of different component modules to organize image mining systems, while the latter is a hierarchical structure with an emphasis on the information needs at various levels of hierarchy. Jiang Li and Ram M. Narayanan [13] followed the function-driven framework since it is application-oriented and relatively easy to implement according to the module functionality. Function-driven architecture cannot effectively handle different levels of

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information representation in image mining. This framework serves the purpose of organizing and clarifying the different roles and tasks to be performed in image mining. It is exclusively application oriented and the framework was organized according to the module functionality.

VI. 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. [22] proposed an information-driven framework that aims to highlight the role of information at various levels of representation, which adds one more level of information: the Pattern and Knowledge Level that integrates domain, related alphanumeric data and the semantic relationships discovered from the image data.
This framework used for explicit information hierarchy. This framework represents the first step almost capturing the various levels of information current in image data and addressing the question of what are the issues and work that has been done in discovering useful patterns/knowledge from each level.

The Four Information Levels

In this section, we will describe the four information levels in the Information-Driven Framework such as Pixel level, Object level, Semantic Concept Level and Pattern and Knowledge Level. We will also discuss the issues and challenges faced in extracting the required image features and useful patterns and knowledge from each information level.

A. Pixel Level

The Pixel Level is the lowest layer in an image mining system. It consists of raw image information such as image pixels and primitive image features such as color, texture, and edge information. Color is the most widely used visual feature. Color is typically represented by its RGB values. The distribution of color is a global property that does not require knowledge of how an image is composed of component objects. Color histogram is a structure used to store the proportion of pixels of every color in an image. It is invariant to under translation and rotation about the view axis and changes only slowly under change of view angle, change in scale, and occlusion [32]. Subsequent improvements include the use of cumulative color histogram [31], and spatial histogram intersection [30].

Texture is the visual pattern formed by a sizable layout of color or intensity homogeneity. It contains important information about the structural arrangement of surfaces and their relationship to the surrounding environment [27]. Common representations of texture information include: the cooccurrence matrix representation [12], the coarseness, contrast, directionality, regularity, roughness measures [33], the use of Gabor filter [22] and fractals [17]. [22] develop a texture thesaurus to automatically derive codeword that represent important classes of texture within the collection. Edge information is an important visual cue to the detection and recognition of objects in an image. This information is obtained by looking for sharp contrasts in nearby pixels. Edges can be grouped to form regions.
Content-based image retrieval focus on the information found at the Pixel Level. Researchers try to identify a small subset of primitive features that can uniquely distinguish images of one class from another class. These primitive image features have their limitation. In particular, they do not have the concept of objects/regions as perceived by a human user. This implies that the Pixel Level is unable to answer simple queries.

B. Object Level

The focus of the Object level is to identify domain-specific features such as objects and homogeneous regions in the images. While a human being can perform object recognition effortlessly and instantaneously, it has proven to be very difficult to implement the same task on machine. The object recognition problem can be referred to as a supervised labelling problem based on models of known objects. 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. An object recognition module consists of four components: model database, feature detector, hypothesizer and hypothesis verifier [15]. 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 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.

To improve the accuracy of object recognition, image segmentation is performed on partially recognized image objects rather than randomly segmenting the image. The techniques include characteristic maps to locate a particular known object in images [16], machine learning techniques to generate recognizers automatically [6], and use a set of examples already labelled by the domain expert to find common objects in images [10]. Once the objects within an

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image can be accurately identified, the Object Level is able to deal with queries.

C. Semantic Concept Level

While objects are the fundamental building blocks in an image, there is "semantic gap between the Object level and Semantic Concept level. Abstract concepts such as happy, sad and the scene information are not captured at the Object level. Such information requires domain knowledge as well as state-of-the-art pattern discovery techniques to uncover useful patterns that are able to describe the scenes or the abstract concepts. Common pattern discovery techniques include: image classification, image clustering, and association rule mining.

With the Semantic Concept Level, queries involving high-level reasoning about the meaning and purpose of the objects and scene depicted can be answered. It would be tempting to stop at this level. However, careful analysis reveals that there is still one vital piece of missing information – that of the domain knowledge external to images. Neither the Pixel level, the Object level, nor the Semantic Concept level is able to support such queries.

D. Pattern and Knowledge Level

To support all the information needs within the image mining framework, we need the fourth and final level: the Pattern and Knowledge Level. At this level, we are concerned with not just the information derivable from images, but also all the domain-related alphanumeric data. The key issue here is the integration of knowledge discovered from the image databases and the alphanumeric databases. A comprehensive image mining system would not only mine useful patterns from large collections of images but also integrate the results with alphanumeric data to mine for further patterns. Two kinds of information are used together to perform the functional brain mapping. By ensuring a proper flow of information from low level pixel representations to high level semantic concepts representation, we can be assured that the information needed at the fourth level is derivable and that the integration of image data with alphanumeric data will be smooth.

The four information levels can be further generalized to two layers: the first two levels form the lower layer and the next two layers 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.

High-dimensional indexing schemes and retrieval approaches are also integrated in the framework to maintain the pour of information along with the levels. this framework represents the first step towards capturing the different levels of information present in image data and addressing the question of what are the issues and challenges of discovering useful patterns/knowledge from each level [22].

VII. **Conclusion**

In this paper, we have examined two frameworks for image mining: function-driven and information-driven. The function-driven framework serves the purpose of organizing and clarifying the different roles and tasks to be performed in image mining. We have proposed a four-level information-driven framework for image mining systems. High-dimensional indexing schemes and retrieval approaches are also integrated in the framework to maintain the pour of information along with the levels. Image mining is a promising field for research, however, it is still at the beginning and for future development the following problems need to be considered: (a) Improvement on image preprocessing technologies including image segmentation, feature extraction and object recognization. (b) Suggest an integrated image representation model and representation techniques. (c) Formulate highly capable and extensible image mining algorithms for established techniques are hard to directly apply on image database. (d) Initiate domain information into image mining, which are essential for thoughtful mining results.

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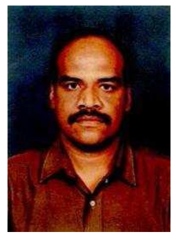
BIOGRAPHIES



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