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A Survey on Image Mining Techniques: Theory and Applications

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Abstract— Image mining is a vital technique which is used to mine knowledge straightforwardly from image. Image segmentation is the primary phase in image mining. Image mining is simply an expansion of data mining in the field of image processing. Image mining handles with the hidden knowledge extraction, image data association and additional patterns which are not clearly accumulated in the images. It is an interdisciplinary field that integrates techniques like computer vision, image processing, data mining, machine learning, data base and artificial intelligence. The most important function of the mining is to generate all significant patterns without prior information of the patterns. Rule mining has been adopting to huge image data bases. Mining has been done in accordance with the integrated collections of images and its related data. Numerous researches have been carried on this image mining. This paper presents a survey on various image mining techniques that were proposed earlier in literature. Also, this paper provides a marginal overview for future research and improvements.

Keywords— Data Mining, Image Mining, Knowledge Discovery, Segmentation, Machine Learning, Artificial Intelligence, Rule Mining, Datasets.

1. INTRODUCTION

Image mining is a technique which handles the mining of information, image data association, or additional patterns not unambiguously stored in the images (Zhang Ji et al. 2001). It utilizes methods from computer vision, image processing, image retrieval, data mining, machine learning, database, and artificial intelligence. Rule mining has been implemented to huge image databases (Ordonez & Omiecinski 1999). There are two most significant techniques. The first technique is to mine from huge amount of images alone and the second technique is to mine from the integrated collections of images and related alphanumeric data. Rule mining technique is exploited (Megalooikonomou et al. 1999) to determine relations between structures and functions of human brain. An image mining algorithm using blob required to be carry out the mining of relations within the context of images is provided by Zaiane & Han (1998).

The main intention of image mining is to produce all considerable patterns without any information of the image content, the patterns types are different. They could be classification patterns, description patterns, correlation patterns, temporal patterns and spatial patterns. Image mining handles with all features of huge image databases which comprises of indexing methods, image storages, and image retrieval, all regarding in an image mining system (Missaoui & Palenichka 2005). The establishment of an image mining system is frequently an intricate process because it implies joining diverse techniques ranging from image retrieval and indexing schemes up to data mining and pattern recognition. Further, it is anticipated that a good quality image mining system provides users with a useful access into the image storage area at the same time it recognizes data patterns and generates knowledge beneath image representation. Such system basically be supposed to bring together the following functions: image storage, image processing, feature extraction, image indexing and retrieval and, pattern and knowledge discovery.

Figure 1 shows a common structure model for image mining System. The system considers a particular sample of images as an input, whose image features are extracted to correspond to succinctly the image content. Besides the significance of this mining task, it is indispensable to think about

invariance problem to certain geometric transformations and robustness concerning noise and other distortions in designing a feature extraction operator. After representing the image content, the model description of a given image - the correct semantic image interpretation - is obtained. Mining results are obtained after matching the model description with its complementary symbolic description. The symbolic description might be just a feature or a set of features, a verbal description or phrase in order to identify a particular semantic (Fernandez et al. 2007).

This paper presents a survey in the next section on various image mining techniques that were proposed earlier. Also, this paper provides a marginal overview for future research and improvements.

2. LITERATURE REVIEW

Numerous researches have been carried on this image mining. This section of the paper presents a survey on various image mining techniques that were proposed earlier.

Developments in area of image acquisition and storage technique have shown the way for incredible growth in extensively large and detailed image databases. The images which are available in these databases, if examined, can provide valuable information to the human users. Image mining facilitates the extraction of hidden information, image data association, or other patterns not clearly accumulated in the images. Image mining is an interdisciplinary effort that provides significant application in the domain of machine learning, image processing, image retrieval, data mining, database, computer vision, and artificial intelligence. Even though the growth of several applications and techniques in the individual research domain mentioned above, research in image mining has to be explored in investigated the research problems in image mining, modern growth in image mining, predominantly, image mining frameworks, modern techniques and systems (Hsu, et al. 2002).

Content based tissue image mining was proposed by Gholap et al. (2005). Biological data management and mining are considerable areas of recent biology research. High throughput and huge information content are two significant features of any Tissue Microarray Analysis (TMA) system. Tissue image mining is resourceful and faster if the tissue images are indexed, stored and mined on content. A four-level system to exploit the knowledge of a pathologist with image examination, pattern identification, and artificial intelligence was proposed in this approach. At Image Processing and Information Level, information such as disparity or color is utilized. At Object Level, pathological objects, comprising cell constituents, are recognized. At Semantic Level, arrangement and configuration of individual cells into sheets in a tissue image are examined. At the uppermost level, Knowledge Level, supposition of the expert is specified.

Sanjay et al. (2007) put forth an image mining technique using wavelet transform. The author proposed an image mining approach using wavelet transform. It uses common pattern identical, pattern identification and data mining models with the intention that a real life scene/image can be associated to a particular category, assisting in different prediction and forecasting mechanisms. It is a three-step procedure i.e. image gathering, learning and classification. Since wavelet transform uses time frequency association, it can be utilized for image mining as a substitute of Fourier transform. Wavelet transform is utilized to decompose an image into dissimilar frequency sub bands and a small frequency sub band is used for Principal Component Analysis (PCA). Classification assists in recognizing the category to which an image relates with. They have constructed a prototype system for identification using DWT + PCA system. The conception of image mining as a consequence can be competently used for weather forecasting so that one can know the natural disasters that may occur in advance.

Image mining approach using clustering and data compression techniques was projected by Pattnaik et al. (2008). Satellite images of clouds play a substantial role in forecasting weather conditions. Frequency of image acquirement ranges from one image per minute to another image per hour based on the climatic environment. These occurrences results in huge collection and creation of image data warehouse. Permanent storage and transmission of images is a demanding task. In their approach, data mining clustering method together with Vector Quantization (VQ) is implemented to

cluster and compact static color image. Results are shown to demonstrate the findings both subjectively and visually.

Perner (2002) discussed the image mining: subjects, framework, a standard tool and its application to medical-image analysis. A tool and a technique for data mining in picture-archiving systems are provided by this author. It is expected to determine the suitable knowledge for picture examination and identification from the data base of image descriptions. Knowledge-engineering methods are used to acquire a list of attributes for symbolic image descriptions. An expert describes images based on this list and accumulates descriptions in the database. Digital-image processing can be implemented to obtain better imaging of specific image characteristics, or to obtain expert-independent characteristic evaluation. Decision-tree induction is utilized to discover the expert knowledge, provided in the form of image descriptions in the database. This assembled decision tree provides efficient models of decision-making, which can be investigated to maintain image categorization by the expert. A tool for data mining and image processing is developed by this author and its application to image mining is revealed on the task of Hep-2 cell-image categorization. On the other hand, this tool and the technique are standard and can be utilized for other image-mining tasks. They implemented this method in additional medical tasks, for instance, in lung-nodule analysis in X-ray images, lymph-node analysis in MRI and examination of breast MRI.

Decision tree based image processing and image mining technique was projected by Kun-Che et al. (2009). Important information can be hidden in images, conversely, few research talks about data mining on them. In their approach, they developed a common framework depending on the decision tree for mining and processing image data. Pixel-wised image characteristics were extracted and changed into a database-like table which permits a variety of data mining algorithms to make explorations on it. Each tuple of the changed table has a feature descriptor produced by a collection of characteristics in conjunction with the target label of a particular pixel. With the label feature, they adopted the decision tree induction in order to comprehend associations among features and the target label from image pixels, and to build up a model for pixel-wised image processing based on a specified training image dataset. Both experimental and theoretical analyses were performed in their study. Their results confirmed that this model can be extremely capable and effectual for image processing and image mining. It is estimated that by using this model, various existing data mining and image processing methods could be worked on together in different ways. Their model can also be used to generate new image processing techniques, enhance existing image processing methods, or act as a powerful image filter.

Sheela & Shanthi (2007) described the image mining approaches for categorization and segmentation of brain MRI data. Image segmentation plays a vital role in several medical imaging applications by computerizing or assisting the description of anatomical arrangements and additional regions of interest. Automatic recognition of tumors in several medical images is encouraged by the requirement of better accuracy when handling with a human life. Also, the computer assistance is demanded in medical institutions owing to the reality that it possibly will progress the results of humans in such a domain where the false negative cases must be at a very low rate. It has been confirmed that double reading of medical images possibly will show the way for enhanced tumor detection. But the cost implied in double reading is extremely huge, that's why better software to assist humans in medical institutions is of vast interest at the present time. In their approach they developed a system which uses image mining approaches to categorize the images either as normal or abnormal and then divide the tissues of the anomalous Brain MRI to recognize brain related diseases.

Content based image mining approach was explained by Conci & Castro (2002). Image mining presents unique distinctiveness suitable to the richness of the data that an image can show. Successful assessment of the results of image mining by content requires that the user point of view (of likeness) is used on the performance parameters. Comparison among different mining by resemblance systems is particularly challenging owing to the great variety of methods implemented to represent resemblance and the dependence that the results present of the used image set. Other obstacle is the lag of parameters for comparing experimental performance. In their paper they described an evaluation framework for comparing the influence of the distance function on image mining by color.

Experiments with color similarity mining by quantization on color space and measures of likeness between a sample and the image results have been carried out to illustrate the proposed scheme. Important aspects of this type of mining are also described.

Aksoy & Cinbis (2009) proposed a new image mining technique using directional spatial constraints. The significant contributions in their approach include expanding the association model to numerous reference objects, integrating the spatial information into the Bayesian decision rule as spatial priors for background classification, and facilitating dynamic queries by using directional associations as spatial parameters with support for the visibility of image areas that are incompletely enclosed by reference objects. They also demonstrated the efficiency of this technique using quantitative and qualitative results on contextual classification and retrieval of elevated spatial resolution satellite imagery. Retrieval performance was evaluated by the author using precision (percentage of the correctly detected objects among all detections in the result set) and recall (percentage of the accurately identified objects between all objects in the ground truth) using a ground truth that was constructed by manually identifying the objects satisfying each query.

A new image mining approach was described by Jiang & Ngo (2003). Given several images, initially they use attributed relational graph (ARG) to characterize them. An image segmentation algorithm described by Felzenszwalb & Huttenlocher (1998) on the input sample images and encodes each image segment with a node of the ARG. Then they used ARGs to represent the input images, the next step is to discover the common patterns embedded in these ARGs. An inexact maximal common sub-graph (IMCS) algorithm was proposed by them in order to achieve this goal. This algorithm has two dissimilarities with algorithms to the conventional maximal common sub-graph (MCS) difficulty: (a) this algorithm is taking on multiple graphs, while the conventional difficulty is for just two graphs; (b) this algorithm seeks for inexact maximal common sub-graph, whereas the traditional problem is for exact maximal common sub-graph. The reason why we employ inexact maximal common sub-graph algorithm is obvious, in real applications, inputs always contain errors due to distortion, inaccurate observations, and so on.

Srivastava & Oza (2004) proposed a knowledge driven image mining technique. The author addresses the issue of automatically mining the multispectral images using Mercer Kernels with the hope of identifying a technique to automatically construct tags for images that denote the percentage of cloud cover, the percentage of presence of other geophysical processes such as snow, ice, melting regions, drought regions, and fire hazard. A kernel function is defined as the inner product of the mapped data in the feature space. The author proposed a new technique for automatic knowledge driven image mining based on the theory of Mercer Kernels, which are extremely nonlinear symmetric positive definite mappings from the original image space to a very high, probably infinite dimensional feature space. In that high dimensional feature space, linear clustering, prediction, and classification techniques can be used and the results can be mapped back down to the original image space. Therefore, highly nonlinear structure in the image can be obtained via the use of popular linear mathematics in the feature space. The author proposed the theory of Mercer Kernels, illustrated its use in image mining, discussed a new technique to construct Mercer Kernels directly from data, and compared the results with conventional techniques on data from the MODIS (Moderate Resolution Spectral Radiometer) instrument taken over the Arctic region.

An image mining approach for clustering shoe prints was proposed by Sun et al. (2008). The main objectives of their work are (i) to cluster shoe prints, (ii) to analyze the results of each clustering algorithm, (iii) to use a visualization tool to see how the clusters are affected by changes of input variables, and (iv) to examine the differences in the distributions of variables from cluster to cluster. The author conducted experiments to cluster a sequence of shoe prints through clustering techniques in WEKA. In order to make the experiment more convincible, the RGB values of images chosen are relatively close, so the images are not as identifiable. The author used the partitioning-based clustering techniques, namely k-means and expectation maximization (EM) in their proposed work. The author confirms that no single machine learning scheme is appropriate for all image mining problems.

Rajendran & Madheswaran (2009) discussed an improved image mining technique. An enhanced image mining technique for brain tumor classification using pruned association rule with MARI algorithm is presented in their paper. The method proposed makes use of association rule mining technique to classify the CT scan brain images into three categories namely normal, benign and malign. It combines the low-level features extracted from images and high level knowledge from specialists. The developed algorithm can lend a hand to the physicians for well-organized classification with multiple keywords per image to get better the accuracy. The method proposed in this paper classifies the brain CT scan images into three categories: normal, benign and malignant. The experimental result on pre-diagnosed database of brain images showed 96% and 93% sensitivity and accuracy respectively.

In association with the above mentioned research works Qin et al. (2003) explained the methods of remote sensing image mining based on concept lattice. The author described the theory of concept lattice and the techniques of association rule mining depending on concept lattice, established the techniques into remote sensing image mining, examined and illustrated the spectrum characteristics mining, texture characteristics mining, shape characteristics mining and spatial distributing laws mining, analyzed the application of remote sensing image mining, such as the automation classification, intelligent retrieval of remote sensing image. Hsu et al. (2000) illustrated image mining in IRIS. There is an increasing requirement for systems that can frequently examine images and obtain semantically significant information. IRIS and an Integrated Retinal Information system, has been designed to give medical experts simple access to the screening, trend and progression of diabetic-related eye diseases in a diabetic patient database. The author showed that mining approaches can be used to exactly obtain features in the retinal images. Especially, the author applied a classification technique to decide the conditions for tortuosity in retinal blood vessels.

Victor & Peter (2010) put forth a new minimum spanning tree based clustering algorithm for image mining. The minimum spanning tree clustering algorithm is proficient of detecting clusters with irregular boundaries. The author presented a minimum spanning tree depending on the clustering technique using weighted Euclidean distance for edges, which is vital constituent in constructing the graph from image. The technique constructs ‘k’ clusters with segments. This approach is very much capable of protecting detail in low variability image regions while not considering detail in high-variability regions which is the main advantage of this approach. This approach has handled the problems of undesired clustering structure and redundant huge number of clusters.

Effective research in the field of image retrieval and mining has turned out to be a significant research area because of significant applications in digital image databases. At present, a huge segment of information is in image form; it is necessary and certainly there is a significant requirement to search for images by means of content. Image mining has a wide range of applications in different sectors like medical diagnosis, space research, biology, remote sensing, etc. Hemalatha & Devasena (2011) proposed a research to find out the accurate images while mining an image (multimedia) database and developed an innovative technique for mining images by means of LIM dependent image matching method with neural networks. This approach is independent of several parameters setting to produce a robust solution. It is developed and implemented on MATLAB and is investigated with the images of several databases. Suitable measures were developed to estimate the performance of the system. The performances of the LIM dependent image matching method results were significant and comparable.

Yanai (2003) describes a common image classification method with an automatic knowledge acquisition scheme from the Web. This approach used three phases for the processing. Initial phase is the gathering period i.e. it collects images related to specified class keywords from the Web. Second phase is the learning period where it extracts image attributes from collected images and relates them with each class. Third phase is the classification period which categorizes an unknown image into dissimilar classes in proportion to class keywords by using the association among the image attributes and the classes.

Silakari et al. (2009) developed a structure which concentrates on color as characteristic using Color Moment and Block Truncation Coding (BTC) to obtain the features for image dataset.

Subsequently K-Means clustering technique is performed to cluster the image dataset into several clusters. Kobylinski & Walczak (2007) developed an application of Binary Threshold Histogram (BTH), a color characteristic description technique, to the creation of a meta-database index of multiple image databases.

Dubey (2010) illustrated about an Image mining methods which is dependent on the Color Histogram, texture of that Image. The query image is considered, then the Color Histogram and Texture is created and in accordance with this the resultant Image is found. They have examined a histogram-based search techniques and color texture techniques in two different color spaces, RGB and HSV. Histogram search distinguish an image through its color distribution. It is revealed that images retrieved by using the global color histogram possibly will not be semantically related although they share comparable color distribution in some results.

3. FUTURE ENHANCEMENTS

Image mining is an extension of data mining technique. Most of the image processing algorithms include image mining. Therefore, image mining is always an emerging field and it has attracted a lot of researchers to investigate its applications in recent years.

- The future research work may include the implementation of the Bayesian networks for relevance feedbacks and more extensive tests with other examples of image forensic work.
- It is also envisaged that subjective testing will be performed with input from forensic experts.
- Some possible future studies that may be conducted in the area of image mining include the experimentations on other image elements such as textures, shape, and so forth.
- It will also be interesting to investigate hidden relationships among images. For example, intensive and extensive exploratory pattern analysis involved in the existing systems in database can be very useful.

4. CONCLUSION

This paper presents a survey on various image mining techniques that was proposed earlier by researchers for the better development in the field of content based image retrieval. The purpose of the mining is to produce all considerable patterns without prior knowledge of the patterns. Important information can be hidden in images, conversely, few research talk about data mining on them. Image segmentation is the primary phase in image mining. In other words, image mining is simply an expansion of data mining in the field of image processing. Image mining handles with the hidden knowledge extraction, image data association and additional patterns which are not clearly accumulated in the images. Also, this paper provides a marginal overview for future research and improvements. Certain possible future investigations that are discussed may be done in the area of image mining which included the experimentations on other image elements such as textures, shape, etc.

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Table 1:

The following table discusses the noteworthy techniques that are discussed in the literature.

Author Name	**Technique Used**
Gholap et al. (2005)	A four-level system to exploit the knowledge of a pathologist with image examination, pattern identification, and artificial intelligence is used.
Sanjay et al. (2007)	Image mining approach using wavelet transform. Wavelet transform is utilized to decompose an image into dissimilar frequency sub bands and a small frequency sub band is used for Principal Component Analysis (PCA).
Pattnaik et al. (2008)	Data mining clustering method together with Vector Quantization (VQ) is implemented to cluster and compact static color image.
Perner (2002)	Decision-tree induction is utilized to discover the expert knowledge, provided in the form of image descriptions in the database.
Kun-Che et al. (2009)	Pixel-wised image characteristics were extracted and changed into a database-like table which permits a variety of data mining algorithms to make explorations on it.
Sheela et al. (2007)	Developed a system which uses image mining approaches to categorize the images either as normal or abnormal and then divide the tissues of the anomalous Brain MRI to recognize brain related diseases.
Aksoy et al. (2009)	Integrating the spatial information into the Bayesian decision rule as spatial priors for contextual classification, and facilitating dynamic queries by using directional associations as spatial parameters with support for the visibility of image areas that are incompletely enclosed by reference objects.
Jiang & Ngo (2003)	Attributed Relational Graph (ARG) to characterize the images.
Srivastava et al. (2004)	A new technique for automatic knowledge driven image mining based on the theory of Mercer Kernels, which are extremely nonlinear symmetric positive definite mappings from the original image space.
Hemalatha et al. (2011)	Innovative technique for mining images by means of LIM dependent image matching method with neural networks.
Silakari et al. (2009)	Binary Threshold Histogram (BTH), a color characteristic description technique to create index.

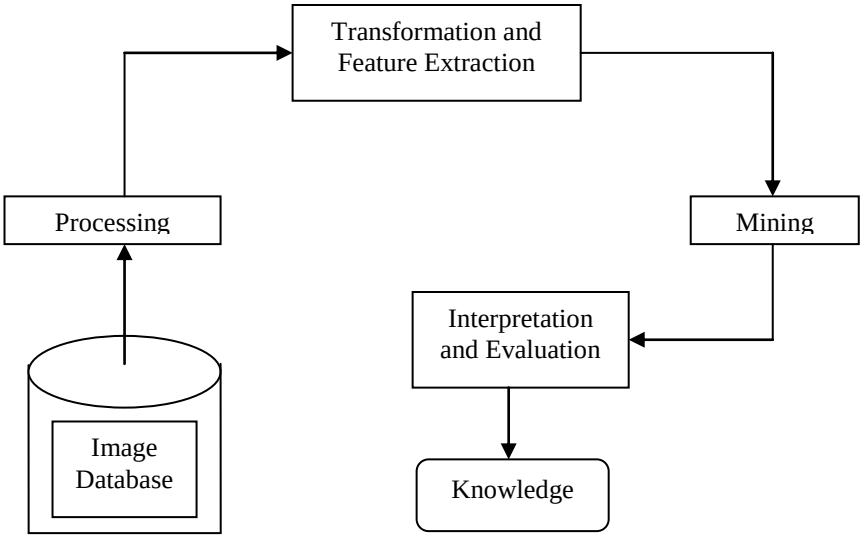

Figure 1: General Image Mining System