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A Comprehensive Survey on Semantic based Image Retrieval Systems for Cyber Forensics

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Abstract-Cyber forensics includes the areas of computer forensics, network forensics and internet forensics. In Cyber forensics, digital images have been widely used for retrieving criminal images, fingerprints, crime incident images and so on. Since the current cyber forensic tools are not very much furnished with the course of action of huge image data, retrieving of image evidences to prosecute the criminal becomes a big issue, most of the evidence is available in the form of raw semantics. Cyber forensic investigators are often faced with the task of manually examining a huge amount of image data to identify potential evidence by the help of this semantics. Thus semantic based image retrieval system (SBIR) is the latest and best alternative to overcome this drawback. The main objective of this paper is to perform extensive literature survey on the different existing methods of semantic based image retrieval system, to find the pitfalls in the existing methods and to propose a SBIR framework for the development of cyber forensic tools.

Keywords— Cyber Forensics SBIR, Digital image, Semantics and Evidence

I. INTRODUCTION

As the general public has turned out to be increasingly reliant on computers, networks and internet related innovations, which are despite the fact that an aid yet in a few circumstances it has ended up being to be bane. The computerized world is getting to be focuses of crime activities, for example web defacement, vandalism and cyber war. Cyber forensics is another and quickly developing field which is associated with examination of the cyber crimes for gathering potential evidences. Cyber forensics includes the areas of computer forensics, network forensics and internet forensics.

Computers Forensics – is forensics performed on storage media, hard drives, thumb drives, etc.

Network Forensics – is forensics performed on the communication traffic data between networked devices; such as computers, network devices, printers, etc.

Internet Forensics – is forensics performed on global Internet communications from multiple networks.

Cyber forensic investigations are frequently involved in the examination of digital images found on the target media. Any picture in the digital form can be created or copied and stored is called as a digital image or simply image. An image can be illustrated as vector graphic or raster graphic. The images created by mathematical statements (Lines and shapes of 2D or 3D images) are called vector graphics. The images captured or scanned from a sample are called as raster graphics.

A verbal description or verbal facts about an image, pixel and its features called semantics of an image. Simply the significance of an image is called semantics of an image. Image retrieval based on semantics of an image is mainly essential in forensic examination.

Now a day's image retrieval system is an important research area. An image retrieval system is nothing but a computer system for browsing, searching and retrieving images from a large database of digital images. It is one of the most exciting and fastest growing research areas in the field of computer vision. There are several image retrieval methods all are explained very briefly in the literature survey part. This paper mainly focuses on the semantic based image retrieval system for the applications of cyber forensics. Different existing methods of semantic based image retrieval are also discussed in this paper.

This paper is organized as follows, Section I contains the introduction of Cyber forensics and image retrieval system, Section II contains the literature survey of various image retrieval methods, Section III contains the brief description various existing semantic based image retrieval methods and its drawbacks, and Section IV concludes this comprehensive survey.

II. LITERATURE SURVEY OF IMAGE RETRIEVAL METHODS

This paper mainly focuses semantic based image retrieval system for the applications of cyber forensics.

A. Text based image Retrieval

Text based image retrieval method is an old method. It requires a text as query to search for an image. It uses the method of including the metadata, for example keywords, inscribing or depictions to the images. In this way, the keyword might be image name, date of including, erasing, altering and others. This method is easy to implement and fast in retrieval. Google search engine is the best example to this method. Below figure illustrates the Text based image retrieval.

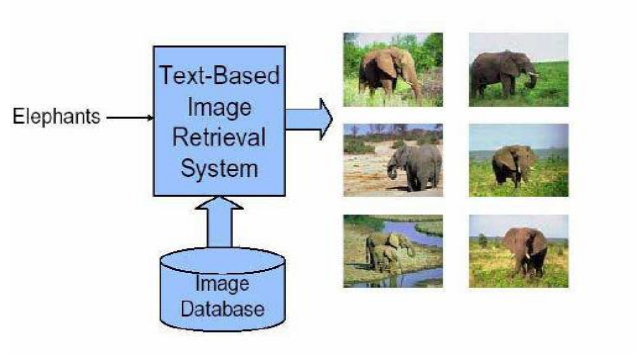

Figure-1

B. Content based image Retrieval

In Content based Image Retrieval a query image will be given as input and the goal is search similar images based on the features of the query image (Ex: Shape, Color and Texture). A CBIR system is composed of a query interface for the acquisition of the query image, databases for storing indexing data and metrics, similarity and retrieval system. In Content based Image Retrieval, a feature extraction module is used to extract the image features from the query image. Below figure illustrates the Content based image retrieval.

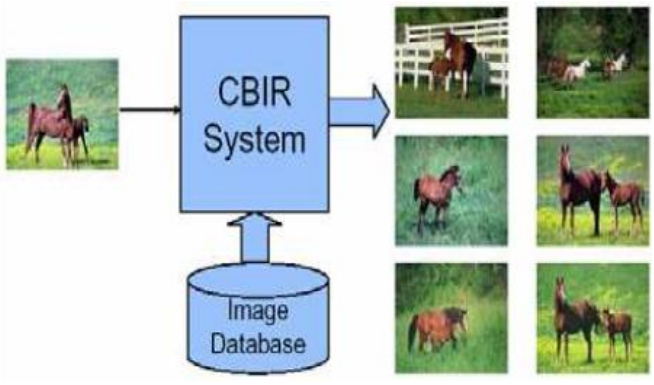

Figure-2

C. Semantic based Image Retrieval

The main task of semantic based image retrieval (SBIR) is to reduce the semantic gap and to discover high-level semantic meaning within an image. The main obstacle in realizing semantic based image retrieval activities is represented by the fact that it is very difficult to describe the semantic content of an image.

Semantic based Image Retrieval systems have the benefits of 1) a more elevated amount of reflection, and 2) less demanding query determination (using natural language). They are, by and by, confined by the measure of their vocabularies, and the way that most images have various semantic interpretations. Below figure illustrates the Semantic based image retrieval.

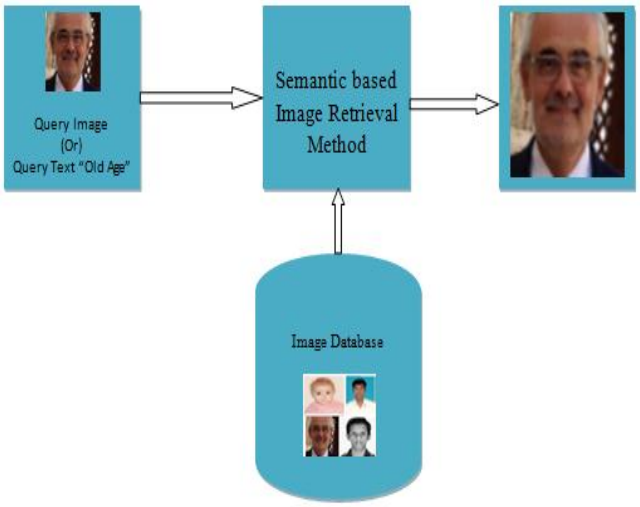

Figure-3

D. Relevance feedback Image Retrieval

The difference between the user's information need and the image representation is called the semantic gap in CBIR systems. The limited retrieval accuracy of image nuclear retrieval systems is essentially due to the intrinsic semantic gap. In order to reduce the gap, relevance feedback is very helpful into CBIR system. In relevance feedback image retrieval system user gives a feedback to the query results, based on the feedback system recalculates weights. The basic idea behind relevance feedback is to integrate human perception subjectivity into the query and involve user to evaluate the retrieval results. Then depending upon user's integration the similarity measures are automatically refined. There are lots of CBIR algorithms has been proposed and most of them work on the finding effectively specific image or group of relevant image to that query image using similarity computation phase. Below figure illustrates the Relevance Feedback image retrieval.

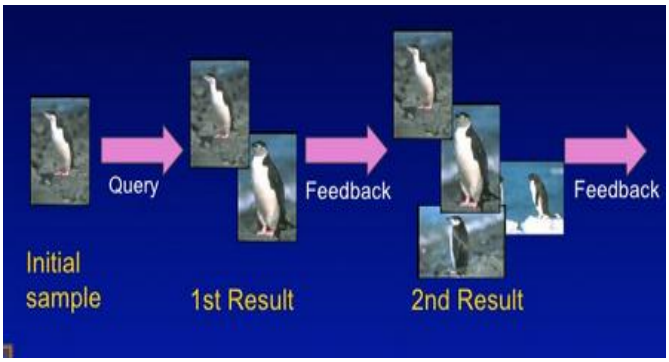

Figure-4

E. Sketch based Image Retrieval

Image retrieval methods which utilize sketch content as input are alluded to as Sketch Based Image Retrieval systems. In a few different ways an image can be recovered from the database utilizing client queries as input. One of the effective methods and famous methods for retrieval is as Sketch Based Image Retrieval which isn't important to have a high expertise to draw the question sketch. Paper audits the different sketch based image retrieval methods utilized as a part of image handling and an examination of every one of these methods is likewise done. The retrieval framework utilizing sketches can be compelling and basic in our everyday life, for example, Medical finding, advanced library, web indexes, wrongdoing anticipation, photograph sharing destinations, geological data, and detecting remote systems. Below figure illustrates the Sketch based image retrieval.

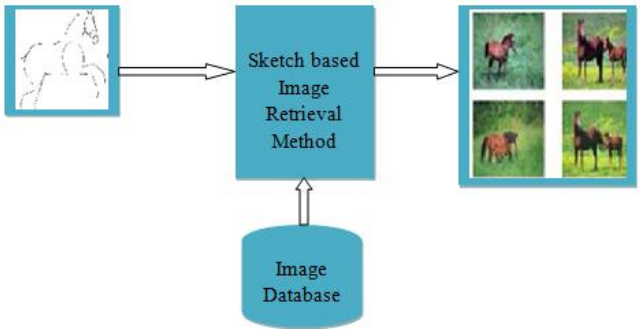

Figure-4

III. EXISTING SEMANTIC BASED IMAGE RETRIEVAL METHODS

Tanya Piplani [1] proposed two approaches known as Caption based retrieval and Embedding space retrieval. In Caption based retrieval A state-of-the-art convolutional neural network architecture is used for extracting image based features and converting the input into a vector of embedding that is semantically rich. This vector can then be used to train different task like classification, detection or can be used as part of a pipeline for some other task. In Embedding space retrieval, a pre-initialized state-of-the-art convolutional neural network (ResNet-101) is used to extract semantic information from the image frames to construct features that represent the content of the image. We call this vector V (x_i). V (x_i) = CNN (x_i). These two proposed approaches evaluated using qualitative and quantitative metrics.

Max H. Quinn et al. [2] described a novel architecture called Situate for retrieving instances of a query visual situation in a collection of images. Situate combines object localization models based on visual features with probabilistic models that represent learned multi-object relationships. Situate learns these models from labeled training images. It applies these models to a new image via an active search process that attempts to ground components of the query situation in the image that is, to create bounding boxes that localize relevant objects and relationships, and that ultimately provide a situation match score for the situation with respect to the image. The match scores can be used to rank the images in the collection with respect to the query: the highest ranking images can be returned to the user.

Wei Wang et al. [3] proposed a new approach for semantics-based image retrieval. They used color-texture classification to generate the codebook which is used to segment images into regions. The content of a region is characterized by its self-saliency and the lower-level features of the region, including color and texture. The context of regions in an image describes their relationships, which are related to their relative-saliencies. High-level (semantics-based) querying and query-by-example are supported on the basis of the content and context of image regions. This approach consists of three levels. At the pixel level, color-texture classification is used to form the semantic codebook. At the region level, the semantic codebook is used to segment the images into regions. At the image level, content and context of image regions are defined and represented on the basis of their saliencies to support the semantics retrieval from images. The saliency of image regions, which describes the perceptual importance of the regions, is used for the semantics-based image retrieval. It helps refine the content and context of regions to represent the semantics of regions more precisely.

Umar Manzoor et al. [4] proposed Semantic Image Retrieval: An Ontology based Approach which uses domain specific ontology for image retrieval relevant to the user query. The user can give concept / keyword as text input or can input the image itself. Semantic Image Retrieval is based on hybrid approach and uses shape, color and texture based approaches for classification purpose. Mammal's domain is used as a test case and its ontology is developed. The proposed system is trained on Mammals dataset and tested on large number of test cases related to this domain. The proposed system has been tested on large number of test cases; experimental results show the efficiency and effectiveness of the proposed technique.

Manikandan Kalimuthu et al. [5] proposed an efficient semantic-based facial image-retrieval (SFIR) system using APSO and squared Euclidian distance (SED). The proposed technique consists of three stages: feature extraction, optimization, and image retrieval. Initially, the features are extracted from the database images. Low-level features (shape, color, and texture) and high-level features (face, mouth, nose, left eye, and right eye) are the two features used in the feature-extraction process. In the second stage, a semantic gap between these features is reduced by a well known adaptive particle swarm optimization (APSO) technique. Afterward, a squared Euclidian distance (SED) measure will be utilized to retrieve the face images that have less distance with the query image.

Anuja khodaskar et al. [6] proposed a frame work for semantic analysis of image by knowledge driven approach, this approach start with Image content analysis with respect to semantic concepts, design image database and knowledge base on the basis of semantic content and retrieval, presentation and modification of image reference database or knowledge base for knowledge delivery intention. The proposed framework for semantic analysis of image enhances performance of image retrieval system. There are three main steps for semantic analysis and retrieval of images, first, Image content analysis with semantic concepts, second, design image database or knowledge base on the basis of semantic content and finally, Design image database or knowledge base for information or knowledge delivery.

V. Lavrenko et al. [7] proposed an approach to learning the semantics of images which allows us to automatically annotate an image with keywords and to retrieve images based on text queries. We do this using a formalism that models the generation of annotated images. In this approach every image is divided into regions, each described by a continuous-valued feature vector. Given a training set of images with annotations, then they did a computation through a joint probabilistic model of image features and words which allow predicting the probability of generating a word given the image regions. This approach works significantly better than a number of other models for image annotation and retrieval. This approach works directly on the continuous features.

Manish Chowdhury et al [8] presented a novel content based image retrieval (CBIR) system based on a new Multiscale Geometric Analysis (MGA)-tool, called Ripplet Transform Type-I (RT). To improve the retrieval result, a fuzzy relevance feedback mechanism (F-RFM) is also implemented. Fuzzy entropy based feature evaluation mechanism is used for automatic computation of revised feature's importance and similarity distance at the end of each iteration. The proposed method of ripplet transform based image coding is suitable for representing low level features (color, texture, edge etc.) of the images. The proposed CBIR system based on RT features is able to improve the accuracy of the retrieval performance and to reduce the computational cost. The retrieval performance is improved further using fuzzy based RFM within 2 to 3 iterations. The proposed mechanism could be tested for video retrieval as future scope of research.

Yixin Chen et al. [9] presented a new approach that significantly automates the examination process by relying on image analysis techniques. The general approach is to use previously identified content (e.g., contraband images) and to perform feature extraction, which captures mathematically the essential properties of the images. Based on this analysis, they considered a feature set database that allows to automatically scanning a target machine for images that are similar to the ones in the database. This approach is very useful for Digital forensic investigators to overcome the task of manually examining a large number of (photographic) images in order to identify potential evidence.

An important property of this approach is that it is not possible to recover the original image from the feature set. Therefore, it becomes possible to build a (potentially very large) database targeting known contraband images that investigators may be barred from collecting directly. The same approach can be used to automatically search for case-specific images, contraband or otherwise, or to provide online monitoring of shared storage for early detection of certain images.

They performed a set of experiments to evaluate the suitability of the CBIR techniques used for forensic purposes. In particular, they tested the robustness of the query results by searching the reference database for versions of the original images obtained through common transformations, such as resizing. This work presents a sound and practical approach to the problem of automating the forensic examination of images. Unlike other approaches, such as hashing, this approach is based on image analysis and is very stable in that it can locate not only the original image but also many common variations of it.

Che-Yen Wen et al [10] provided a retrieval method for digital image databases of crime scene photos. Experimental results are used to show the capability of the proposed method. This paper shows the potential of applying the image databases to forensic sciences, such as case data management. The visual features database is used to stores visual features, which extracted from images collection database. The text annotation repository contains key words and free-text descriptions of images. Multidimensional indexing is used to achieve fast retrieval and to make the system scalable to large image collections. The retrieval engine includes a query interface and a query processing unit. The query interface, typically employing graphical displays and direct manipulation techniques, collects information from user and displays retrieval results. The query-processing unit is used to translate user queries into an internal form. In order to gap the bridge between visual features and semantic means, the query-processing unit is

usually used to Communicate with the search engine in as interactive way.

Ben Bradshaw [11] described an approach to image retrieval based on the underlying semantics of images. To extract these semantics a hierarchical, probabilistic approach is proposed. The labels that are extracted in this case are man-made, natural, inside and outside. The hierarchical framework combines class likelihood probability estimates across a number of levels to form a posterior estimate of the probability of class membership. Unlike previous work in this field, the proposed algorithm can determine probabilities at any point in the scene and only a small number of images are required to train the system. To illustrate the potential of such an approach a prototype image retrieval system has been developed; initial results from this system are also mentioned in this paper.

Table-1

S. No	Author Name	Year	Proposed Method	Drawbacks
1	Tanya Piplani	2018	Caption based retrieval and Embedding space retrieval	The use of triplet based losses to learn the embedding for Embedding Space Retrieval is not explored.
2	Max H. Quinn, Erik Conser, Jordan M. Witte, Melanie Mitchell	2018	SBIR through Active Grounding of Visual Situations	This research has to be extended for expanding the kind of object attributes that can be detected by agents, expanding the types of relationships that can be identified (e.g., recognizing that two objects have the same orientation).
3	Wei Wang, Yuqing Song and Aidong Zhang	2002	Region Saliency approach for SBIR	It helps refine the content of regions to represent the semantics of regions more precisely. About Context not described.
4	Umar Manzoor, Mohammed A. Balubaid	2016	An Ontology based approach for SBIR	The proposed system has been tested on large number of test cases for low level features only.
5	Manikandan Kalimuthu and Ilango Krishnamurthi	2015	SBIR using Adaptive Particle Swarm Optimization and Squared Euclidian Distance	Only three high level features are extracted. Child age, Middle age and Old age.
6	Anuja khodaskar and Siddarth Ladhake	2015	A knowledge driven approach for image analysis	High level features are not described clearly. There is a similarity difference between images.
7	V. Lavrenko, R. Manmatha and J. Jeon	2014	Used a formalism that models the generation of annotated images.	This model works directly on the continuous features. Not suitable for larger datasets (both training and test data).
8	Manish Chowdhury, Sudeb Das and Malay Kumar Kundu	2014	Ripplet transform and fuzzy relevance feedback	Ripplet transform based image coding is not suitable for representing high level features
9	Yixin Chen, Vassil Roussev, Golden G. Richard III, Yun Gao	2013	A new frame work for CBIR based forensics	Image retrieval based on semantics is not possible. But effective content based image retrieval.
10	Che-Yen Wen and Chiu-Chung Yu	2005	Color Descriptor Extraction	The integration of multiple features for better characterizing images is not possible using this method.
11	Ben Bradshaw	2000	A multilevel approach for underlying labeling of images	Quantitative comparisons are not made due to lack of consistent test sets.

IV. CONCLUSION AND FUTURE SCOPE

This paper represents about the basics of cyber forensics and different image retrieval methods. Since current cyber forensic tools are not set up with beneficial semantic based image retrieval methods, there is a strong need of advancement of novel methods and frameworks in cyber forensics tool development in perspective of image retrieval methods.

We hope earnestly this paper will cater the needs of novice researchers and students who are involved with the domains of cyber forensics and image retrieval systems.

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