Content-Based Image Retrieval Systems (CBIRs) Across the Globe: A Review

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Abstract

Purpose - Images form the human perception. The study aims to provide an overview of the Content Based Image Retrieval systems along with their peculiar features and modus operandi for retrieving the relevant images.
Design/methodology/approach – An exhaustive and extensive literature search was performed to identify the various Content Based Image Retrieval systems prevalent across the globe. A detailed search on several databases-Scopus, Web of Science was carried out for retrieving the related literature. The websites of Content Based Image Retrieval systems were also accessed to gauge the additional insights about a particular system.
Findings - A number of Content Based Image Retrieval systems have evolved over time, implementing the low level features such as texture, color and shape for the retrieval of images. However, to find the exact match for the users query Content Based Image Retrieval systems (CBIRs) should work at higher semantic levels to understand the meaning and context of the search queries for the efficient retrieval of images.
Research limitations - The study provides an overview of a number of Content Based Image Retrieval Systems (CBIR) without detailed account of technical architecture and evaluative frame work of each system.

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Practical implications - The study finds its implications for making a comparative assessment of different image retrieval systems based on image content. It will also be helpful for the users to select a system to retrieve precise images using content features of the query image.
Originality/value - The study is first of its kind to throw light on major content based image retrieval systems available across the globe.
Paper type – Review

Keywords - Image retrieval; Color; Texture; Shape; World Wide Web; Annotation-Based Image Retrieval (ABIR).

Introduction

"An image is called a digital image when a computer is able to read, store and display it. It is said to be formed from a set of dots termed as pixels which are stacked in a pre-set distribution of stakes and dins. Each dot or pixel is meant to describe a part of a particular image in a specific color or in any grey color's shade" (Getty Research Institute, 2000). With the advent of internet everything has changed from manual to digital so did the information retrieval processes which where earlier only the work of librarians, archivists etc. Internet and its smart child, "World Wide Web" [WWW] have revolutionized almost all the manual processes and has given life to the idea conceived by Vannevar Bush in 1945 of automatic information search, giving rise to various new forms of information retrieving one among them is image retrieval systems. The WWW has turned out to be a gigantic warehouse of visuals, different from the traditional archives as it is highly dispersed, plan less and negligibly indexed (Smith & Chang, 1997). Moreover, as latest tools began to make their inroads in the information retrieval sphere tools like multimedia- enabled web browsers, and smart phones images over the web got a hike as well, that flooded the web world with the image content resulting in the making of several image Information Retrieval systems to handle the image traffic over the internet as well as store the same (Goodrum, 2000). Automatic image retrieval started with Annotation Based Image Retrieval (ABIR) as a simple querying of databases that store image as textual records. The inspiration to use image content for retrieval emerged with growth in computational capabilities; further the idea of Content Based Image Retrieval (CBIR)

caught fascination of the computer science researchers due to performance dependence on the feature extracting and computer vision algorithms (Smeulders, Worring, Santinini, Gupta, & Jain, 2000). The query terms are linked with the filenames and the corresponding text to the image, if this matching doesn't work out, the text surrounding the image is employed for the retrieval. Ranking in this system is done on the commonness of the query terms and data linked with the image. At the time of retrieval process first of the web pages with less analysis of images are brought out and shown to the user (Lazarinis, 2010). There are currently two types of automatic image retrieval techniques based on textual retrieval termed as ABIR and other working on low- level features like color, shape and size of the images helping the efficient and speedy retrieval of the required images from the image hubs termed as CBIR (Inoue, 2009).

CBIR systems in addition to their advanced characteristics also provide the traditional search functions of text based search using the description or notations of the text embedded in the images and are considered as improvement over ABIR (Jansen, 2008).Image retrieval has recently caught attention of researchers and studies are done to evaluate image search engines particularly CBIR to improve their image retrieval effectiveness (Çakır, Bahçeci, & Bitirim, 2008).

The paper is an attempt to provide an overview of CBIR systems and their underlying features. It also discusses various systems using CBIR architecture for the precise and speedy retrieval of sought images.

Content-Based Image Retrieval (CBIR)

This is based on the description of low-level features that include color, texture, and shape, which are automatically extracted from the images themselves (Flickner et al., 1995). It highlights the accomplishments of the computer science and computer vision research communities that are meant to develop new methods and technologies that are superior and can easily tackle the problems or disadvantages of textual annotation of images represented by text based image retrieval systems. The number of such problems, disadvantages are considerable and prove fatal for the survival of textual annotation based systems (Enser, 2000). A general purpose CBIR system finds applicability in various areas like hosting a particular collection of images. There are many things that are to be taken into consideration while designing a CBIR system ranging from choosing the dimensions of feature vector, retrieval algorithm to be used, the process of final presentation of results

and the most important one i.e. selection of image features (Vassilieva, 2009). CBIR drafted on texture, shape and color features of the images, works by providing transitional results by differentiating the features one by one with all of the database images. The techniques of fusion and ranking are then applied to add up these transitional results to produce the most accurate final output for the query image (Park, Baek, & Lee, 2005). In a CBIR system, the image signals are analyzed on the basis of their visual contents, as colors, shapes and textures, which are also called as low-level features. The features can be gathered from the objects present in the images and their corresponding images that can be identified through the whole image or the objects present in them and are called as contents of the image, the images are sought by calculating the similarity in terms of these low-level features between a sought image and a set of images present in the database of the system, various feature extracting and similarity computing methods have been proposed (Lew, Sebe, Djerasa, & Jain, 2006). The methods of extraction for the low-level features of the images include the devising of algorithms which is sometimes difficult to formulate due to computational costs involved, once it is made then it can extract the low-level features (Inoue, 2004). The content-based image retrieval focuses on image indexing at the lowest level called as dot or pixel level and the search features based on pixel comparison and its implementation (Wang, 2000).

Here is the description of features used in the current approaches of CBIR.

Color

Searching images on the basis of color similarity is done by calculating a histogram for color on each individual image which then compares the pixel levels with the definite values that are termed as colors by the humans within the database images. Research in vogue for this feature is trying to divide color areas by specific areas and by three-dimensional association among different color areas (Carson, Belongie, Greenspan, & Malik, 1997).

Texture

It is hard task to represent perception of texture as concluded by the researchers. Checking of particular texture in a specific image is mainly done by displaying it as a plane of grey level variants. The comparative

glare of units of pixels is calculated in a manner so that the amount of regularity, coarseness, contrast, and the directions are computed (Tamura, Mori, & Yamawaki, 1978).

Shape

In order to use this feature for getting the accurate results, the queries are usually drafted by asking users to draw a shape or choose a shape from the examples of images returned by the system. In calculating the shape feature of the relevant image for the retrieval, a CBIR system uses a technique that computes boundaries, aspect ratio circularity and lines in the images, after this process the system checks for the regions of entropy or constancy by using edge detection and region growing techniques. The main problem encountered in using this feature is working with the images having touching or coinciding shapes (Goodrum, 2000).

The various prominent, advanced and currently in use CBIR initiatives/systems including web image search engines and online image databases across the globe are as:

QBIC (Query by Image Content)

Product of Almaden Research Center of the IBM one of the global leaders in techno innovation and development, it provides search using any mix of shape, texture and color with an added feature of search by keyword (Flickner et al., 1995). A palette, which is used to draft the queries for this system by giving an example query image or user has the freedom of drawing his query in the form of a sketch of an anticipated shape on the screen. After getting its query this smart system gathers and saves the low-level features of texture, color and shape from all the images of the system database (Faloutsos et al., 1994). QBIC then examines the query and each of the system database image is verified, most of the relevant results are then brought in front on the screen of the user as thumbnails. Newly released version of QBIC is preloaded with more intelligent indexing technique and incorporation of more user friendly interface has been also taken care of, wherein a user can look for the images in the grey level and an improved facility storyboarding of videos is also provided (Niblack et al., 1998).

Virage

Brain child of Virage, Inc. this system works in a pre- processing mode in which it smoothens and enhances the contrast earliest of gathering the features then the evaluation of color changes in hue and the dominant color, relative locations of colored areas in which the images with same amount of color, and color in same corresponding areas and images with same color are evaluated together, tint color space and color saturation, roughness, granularity and repetitiveness are also taken into account to denote the characteristic boundaries of varied shapes to calculate a structure value. This intelligent system also has a time driven facility for queries of video nature including, fades and wipes, scene breaks or cuts, dissolves, object discontinuities and object motion (Johansson, 2000). This efficient system runs as independent series module and as exiting management systems add-on feature. "More sophisticated product of the Virage Inc. is AltaVista's Photo Finder, which offers web users to get images by evaluating the content similarity" (Bach, et al., 1996).

Excalibur

A product evolved from a similar type of philosophy used by Excalibur Technologies, a name that produced Visual Retrieval Ware product using database applications (Feder, 1996). The system comes with different forms of image matching and indexing using the parent organisations owned pattern recognition technology. The product is available in the market as an applications development tool instead of a standalone retrieval software. This product was used by one of the giants of the web namely Yahoo for its image retrieving based on content of the images (Qawasmeh, 2002).

MARS (Multimedia Analysis and Retrieval System)

Product of University of Illinois's Beckman Institute for Advanced Science and Technology. The system is based on matching color, 3-D arrangement, shape and texture features and accepts queries based on the combination of these features including textual inscriptions as well with a scope for intricate queries that can be formulated using Boolean operators. Anticipated features for a user can be had from using an

example i.e. pointing to an image that has such features or selecting colors and textures from a palette provided by the system (Jeng, Li, Zhang, & Zhang, 2004). This system is based on the idea relevance feedback. It allows access to a variety of features and resembling measures and it learns by letting the user mark the images as highly relevant, relevant, no-opinion, non-relevant, or highly non-relevant (Johansson, 2000).

VIPER (Visual Information Processing for Enhanced Retrieval)

A product of University of Geneva's Computer Vision Group. Primarily matches color and texture based on one of the main and concept of primitives and calculating and distinguishing the low- level features. The VIPER Image Engine offers necessary tools that lead to the formation of a user interface by providing user facilities like image query, image insertion, inclusion of keywords, and support for several popular image file formats and weight adjustment for re-query. Another added feature is that of the query canvas, offering queries-by-sketch with the help of a bitmap editor wherein user can draw a sketch of the picture using the tools available for drawing and then coloring it by using the colors from the palette, besides this a user can edit an existing image on the canvas using the drawing tools. Queries are mainly based on the users choice of primitive combinations i.e. when two images are compared, a similarity score is calculated for each primitive in a specific query combination using distance function within that particular primitive (Gupta, 1997).

PhotoBook

Brain child of Media Laboratory, Massachusetts Institute of Technology a system for making searches in image databases computing the content in the images. The principle of working followed by this system is comparison making in the features associated with the images, and not the images itself. Parameter values of models fitted to images are actually the features, the models correspond to shape, texture and color, which are checked by making use of one from hub of matching algorithms incorporated in this system (Smith & Chang, 1997). Power driven annotation are used for the description of images, searcher descripts images and then system locates relevant images by comparing

the low level features and then descripts those images itself. "Four Eyes" is a new and most advanced system using feature combination, it takes a note of the user search behaviour and then uses that data to provide the user best matches by giving negative and positive images driven by the user relevance feedback mechanism (Johansson, 2000).

VisualSeek / SaFe (Spatial and Feature Query System)

An innovative image retrieval tool which lets the enquirer to formulate the queries by drawing 3-D patterns of areas of color, it then locates the most relevant images having the same areas of color as that of the query image. Before performing this process the retrieval system gathers and then adds descriptions to the images based on the color regions in the images. A great range of compound queries based on a mixture of color and distribution is computed by this intelligent system because it uses a proactive indexing technique for color region sizes and relative spatial locations (Smith & Chang, 1996).

WebSeer

A product of University of Chicago basically an image search engine having an image filled database of over three million. This system categorises images on their visual characteristics, innovative features of the system include face detector and multiple keyword search using the incorporated text including HTTP reference, page title or alternate text field of HTML reference (Frankel, Swain, & Athitsos, 1996).

Simplicity (Semantics-sensitive Integrated Matching for Picture Libraries)

Developed at university of Stanford, this system classifies images in a manner to semantically differentiate the expressive variances, e.g. Graph non graph, objectionable-benign, textured-non textured and indoor-outdoor (Wang, Li, Chan, & Wiederhold, 1999).

NETRA

A part of Alexandria Digital Library project made by University of California's department of Electrical and Computer Engineering, the database works on a pattern of classifying the images robotically into 6-

12 non- overlapping similar areas. This classification is done with the use of an edge flow algorithm that uses 'edges' in the features like shape, texture and color to denote the similar areas, and indexes these features individually. The scheme used for indexing brings in the use of dominant colors from the query image in order to chisel the color area (Ma & Manjunath, 1997).

PicSearch

A business enterprise created by Robert Risberg and Nils Andersson with a purpose to give web users an image search engine with high rate accuracy in a family friendly atmosphere, it helps its users to make use of wide range of visual assets of the internet ("Picsearch," 2015). This system is embedded with its in-house crawlers that crawls the web that creates a searchable directory of images. When a query is placed in this system by a user results are brought to him in the form of thumbnails which are classified in the order of their relevance with the query image, user clicks these thumbnail images and the system takes him to the original source where the image is hosted ("Picsearch," 2016).

AltaVista

Image searching engine with high rate of popularity stocked with a good number of advanced features whereby web surfers look for photos in black & white or in color. This system has a big back end database with almost 11.5 million images at its helm. It gives users the options of thumbnail viewing of images having print descriptions as well. Moreover, a user can make the use of its advanced search features to look deeply the sources of image (Qawasmeh, 2002).

Google Images

This search engine is the property of world leaders in web innovations and search engines namely google.inc, it processes the words that are nearby the image, image content is determined by the image capture method (Qawasmeh, 2002). It provides searching feature by search by image for conducting reverse image searches which enables it to provide an interface whereby the keyword typing in the search box is left out and the user searches the web by dropping in an image as the query. Results come as web results, pages with the image, different

resolutions of the image and similar images e.g. when a person makes a query using an image of any historical place, he may get the answers in the form of similar images or the description of the same monument or address of the webpages having the same monument picture ("Everything explained today," 2016).

Tineye Search

Tineye is a commercial image search engine made with innovative and customizable image finding solutions that uses image recognition and computer vision. The image recognition and retrieval are efficient and robust that helps in the fast and precise image searches to its clients. Moreover, the mobile searching facility is also provided by the company ("Tineye," 2016).

BING Images

Bing images is an online image search engine committed to provide its users the best accurate findings for their query images, offering an ease of access to the worthy content in terms of images, for which Bing automatically crawls the web to make an index of new as well as updated images in a manner to show most accurate results for a user- initiated search or action (Bing, 2016).

Yahoo (Picture Gallery)

This image search engine has an inbuilt bot that itself gathers and develops an index of the Images it offers the searchers an image browsing mode in different classes with an advanced feature of searching with color, furthermore a user is able to look for the images in the gallery (Qawasmeh, 2002).

World Wide Web Region-based Image Search Engine

It is a system made to access the World Wide Web content, for indexing purpose an advanced form of K-mean algorithm is stacked in the system. Making gathered regions as a base, specific features are accumulated using boundary information from the shape, color and texture.

The database stores the features with an extra bit of information like the URL place and index procedure's date. The searcher can use the

indexed content available on the web by making use of a smart user friendly interface. This system provides the output in the form of links to the content which are ranked to their relevance score to the query image (Ardizzoni, Bartolini, & Patella, 1999).

CANDID

Developed by Los Alamos National Laboratory, a distinguishing algorithm for browsing databases having digital images. The algorithm helps in the retrieval based on content of the query image using query by example methodology. The system allows a user to provide a query image in to the system, after that the similar images present in the database of the system are retrieved. The algorithm used in this system the features of shape, texture and color are computed using a signature for every individual image that is stored in the database. Signatures are matched using probability density functions of feature vectors (Kelly & Cannon, 1994).

Conclusion

The universe of images is continuously growing to a great extent with the technological advancements and expansion of the web. Information professionals and computer scientists have worked in close proximity to amalgamate the features of the images in order to devise such systems that can retrieve precise images from the ever expanding image universe. These efforts have led to the development of various image retrieval systems based on text ABIR and content CBIR of the images. However, difficulty in manual text tagging for a large database and its unavailability and inaccuracy in ABIR have resulted a rapid interest in the development of content-based image retrieval CBIR systems, which not only successfully managed image corpus over the web, but also increased the retrieval efficiency of images for the greater satisfaction of increasing number of user queries. At times, CBIR systems also provide text-based search functionality for notations and text descriptions embedded within images (Jansen, 2008).

In a CBIR system, the image signals are analyzed on the basis of their visual contents, such as color, shape and texture, which are called as low-level features. These features are extracted from the images and the objects present in them involving various feature extracting and similarity computing methods and devising of algorithms. However to

formulate algorithms is made difficult by the computational costs involved (Inoue, 2004; Lew et al., 2006). The advantages of CBIR are also limited by the usage of low-level features (texture, color, shape) which are unable to precisely perceive the meaning of queries, resulting in the Semantic Gap. The main question of addressing the semantic gap still remains a hurdle in the way of CBIR technology which can be explored further so that image retrieving will be based on semantics of the query and images. That will bring a new dawn in the field of image retrieving. There is a scope for future research involving evaluation of different CBIR systems using evaluative measures in different fields of knowledge showing most efficient image retrieval system for precise image searching in a particular field.

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