A Survey on Content Based Image Retrieval for Reducing Semantic Gap

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Abstract - *Image retrieval is the process of searching and retrieving images from large image database by using a query image. Now there is an increasing volume of digital images available in the World Wide Web produced by scientific, educational, medical, industrial, and other applications are easily available to users. But it is a challenging task for the user to retrieve an image from this huge volume of image database by manual annotation method or otherwise called as text based retrieval method. Hence we move on to a new image retrieval method called content based image retrieval (CBIR).By combining the low level features and high level semantic feature an image can be retrieved in CBIR. Content based image retrieval uses the visual content of the image to retrieve the image from large image database. But reducing the semantic gap between the low level visual features and the high level image semantics is a challenging task in content based image retrieval. Here in this paper we have provided a comparative study of various techniques of CBIR and the various techniques to reduce the semantic gap between the query image and the retrieved image.*

Key Words*: Content Based Image Retrieval, Semantic Gap, Low level feature, High level feature, Relevance Feedback, Text Based Image retrieval*

1. INTRODUCTION

Content Based Image Retrieval (CBIR) is a searching technique that can be used for retrieving most similar images from the large collection of database and it is also called as Query By Image Content (QBIC) [1]. The term content refers to colors, shapes, textures or any other information that can be derived from the image itself. Hence the recognition and retrieval of information in CBIR is based on content of images only instead of metadata such as keywords, tags or descriptions associated with the images [2].

Types of Image Retrieval

Image retrieval is of two categories:

1. Text-Based Image Retrieval
2. Content-Based Image Retrieval

Text-Based Image Retrieval

Text-based image retrieval is a traditional technique to retrieve an image from database. It uses the keyword annotation to retrieve the image. It has several advantages such as ease of retrieval, adaptable for small databases and keyword usage for representing more images. But it is still time consuming, incomplete and not standardized.

Content-Based Image Retrieval

CBIR uses the visual contents of the image to retrieve digital image from the large set of databases. The visual contents of an image are the low level features such as color, shape, texture and spatial layout. The main advantage of CBIR is having more accuracy when compares with text based image retrieval and reduction of dissimilarity between the semantic content of images. But the image retrieval procedure is complex and slower when compared to text based system.

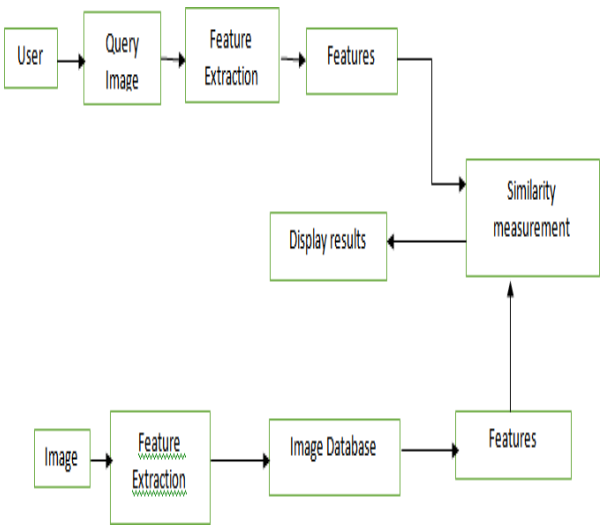

Fig:1.1 CBIR System

The Overview of CBIR system is shown in fig. 1.1. Consider this CBIR system, in which the images are captured by the digital camera and the common features are extracted from the captured image which will be stored in the image database. The features are extracted from various images in the image database by applying feature extraction algorithms and the feature vector values of different images are stored in the feature vector Database. In order to retrieve a particular image from this huge vector database a query image is given as input to the system , the system will then extract the features such as color, texture and shape from the given query image and compute the feature vector value of the query image. The system will match the feature vector of query image with the image in the database and retrieve the

image with same vector values [3]. The efficiency of any CBIR system is based on how it relates the low-level feature with the high-level semantics of an image to improve the accuracy of retrieval.

Content descriptors and feature extraction:

Digital image consists of content which include both visual and semantic content. The visual contents are of general or application dependent, the general visual content are color, shape and texture and the application specific visual content are some domain knowledge content. CBIR uses the visual content of the image to retrieve the image from the database [4]. Feature extraction is the main task in the CBIR systems to retrieve the similar images from database. There are two different types of features are available in an image namely low level and high level semantic features.

Low level feature

Low level image features are image characteristics that are captured by computers for the purpose of recognition and classification such as pixel intensity, pixel gradient orientation, color, texture and shape [5]. The color features are extracted by using color histogram or color moments algorithm. The texture features of the images are extracted by using Gray-level Co- occurrence Matrix (GLCM), Tamura Texture Feature algorithm and the Shape features are extracted by using Histogram of Edge Directions, Hu-Monents Feature Extraction, Zernike Moments algorithm.

High level feature

High level or semantic image features are the features commonly used by human to describe images such as objects, actions, keywords, text descriptors, to interpret images.

SIMILARITY MEASUREMENTS

Euclidean distance

The similarity measure score is calculated by applying Euclidean distance between the query image and each image in the database.

$$d(q, r_i) = \sqrt{\sum^{n} (f_j(q) - f_j(r_i))^2}$$

Where,

q is the query image,
r_i is a reference image i from the reference database,
f_j is the jth feature, and
n is the dimensionality of the feature space.

A smaller distance indicates a higher degree of similarity between the query image and image in the Database.

Manhattan distance

Similarity also measured by using Manhattan distance, which is the distance between two points (such as query image and database image) measured along axes at right angles,

$$d_{MD}(q, r_i) = \sum_{j=1}^{n} \left| f_j(q) - f_j(r_i) \right|$$

Correlation

It is commonly used technique for calculating similarity between query and the database image.

$$r = \frac{\sum_{j-1}^{n} (f_j(q) - \overline{f_j})(f_j(r_i) - \overline{f_j})}{\sqrt{\sum_{j-1}^{n} (f_j(q) - \overline{f_j})^2} \sqrt{\sum_{j-1}^{n} (f_j(r_i) - \overline{f_j})^2}}$$

PERFORMANCE MEASURES:

Many methods are available for measuring the performance of Content based image retrieval systems. The most common performance measures used in image retrieval system are precision and recall.

Precision (P):

Precision (P) is defined as the ratio of the number of relevant images retrieved to the number of total retrieved image.

Recall (R):

Recall (R) is defined as the number of retrieved relevant images over the total number of relevant images available in the database.

High precision means that less relevant images are returned or more relevant images are retrieved, while high recall means few relevant images are missed.

2. LITERATURE SURVEY

Mark Pardijs proposed an user-centered reduction of the semantic gap in CBIR

There is a problem to translate the user need for a specific image in a comprehensive manner to CBIR system. Recall and precision is an old technique that tells the performance of the system for a given query but not show how it is useful to the user [6]. User's perspective is also not satisfied

because user's one idea can bring different results and user's different idea can bring same result. The proposed method uses user specific system to translate user need into a clear query and based on this query the system gives meaningful results. It's advantages are

- Combination of both user-specific idea and high- level semantic algorithms to retrieve an image by reducing semantic gap.

Anuja Khodaskar proposed Content Based Image Retrieval with Semantic Features using Object Ontology

The very important requirement of CBIR is accurate characterization of visual information. This paper focuses on reducing the semantic gap between the visual information and human semantics. It achieves this by focusing only on constructing high level features using object ontology instead of low level features.

In this, the system provides intervals for low level image features, where each interval corresponds to intermediate level descriptors of an image like different shades of a color (dark green, green, light green, etc).These descriptors form a simple vocabulary called object ontology which provides qualitative aspects of high level query concept for retrieving images with more relevance. By using these features precision and recall values gets increased.

Grishma Y.Bobhate proposed reduction of the semantic gap using pseudo relevance feedback algorithm

Extraction of the global feature from every image. Color is extracted using color moments, texture using Gabor wavelet transform and edges using Sobel Edge Detectors. Retrieval occurs in three steps. They are

Hybrid Graph construction: Low-level features are extracted and an image similarity graph is constructed using KNN graph and image-tag directed graph is constructed using ENN graph.

Random Walk model: This model proposed a hybrid graph to smoothly employ the visual and tag information for image retrieval task.

Pseudo Relevance Feedback: Using RF query, list of ranked images are retrieved and these are accumulated to predefined similarity metrics. The images may be relevant or not. Non-relevant images are refined based on feedback and new list of images are given to the user.

Kranthi Kumar proposed Relevance Feedback: a proposed method for reducing semantic gap in Content-Based Image Retrieval using images with relevance level

This approach uses two different aspects to retrieve the similar images and reduce the semantic gap. First one is query expansion which solves the issue of how to effectively use the feedback information to improve the retrieval result. Second one, Interactive Relevance Feedback approach, which uses Multimedia Object Model for updating the weights dynamically and Articulating Relevance Feedbacks for determining if the objects are similar or not.

This approach greatly reduces the user's effort of composing a query and captures the user's information need more specifically. Therefore the user intervention in the CBIR retrieval system is reduced.

Sanjay Singh proposed an effective mechanism to neutralize the semantic gap

It uses Evolutionary Programming (EP) to retrieve images. Three processes are used for retrieval,

- CBIR using low-level feature.
- CBIR using high-level feature.
- Analysis of low-level and high-level feature.

Low-level features are extracted from both querying and database imaging. These features are compared using Squared Euclidian Distance (SED) and images with similar low-level features are extracted. After that query keyword which is a high level feature is obtained from extracted images. Based on this query keyword, another set of relevant images are retrieved. K-Means algorithm is used for identifying group of pixels having similar gray levels. After clustering, Canny edge detection method is used to remove the diverse edges. Texture information is retrieved using rotation invariant LBP-HF and color feature is using color histogram. Based on indices, the low-level and high-level features are compared. Finally the images having similar visual and semantic meaning are retrieved.

Kranthi Kumar proposed a novel approach to self-order feature reweighting in CBIR to reduce semantic gap using Relevance Feedback

This paper uses various weight update strategies for reducing the semantic gap. Initially the low level features are extracted from the input images and feature vectors are constructed. Feature database is checked with the feature vectors obtained to validate the similarity. This is done by using weighted Minkowski distance. Next to it, assign the weights to the features based on the distance of similarity. If the distance is less, reassign the weights based on self-order reweighting to get more images. Finally image retrieval is done with the help of highest rank value images. Rank value is assigned based on the weights of a feature.

Umar Manjoor proposed semantic image retrieval: an ontology based approach

The paper uses domain specific ontology for image retrieval relevant to the user query. The query can be in the form of a text or an image. Three different modules are used for image retrieval. They are

- Query engine-builds the query for the input. If the query is a text, then SPARQL is used and if it is an image, objects in the image are detected using shape based feature detection. After this objects are passed to color based feature extraction technique such as MTH and texture based classification technique as proposed by Mohnson Zandetal.

Finally low-level features are extracted after that the query is generated by using SPARQL and it will be converted into high level ontology concepts.

Image processing-image returned by search engine may not be relevant to the user query therefore the content of each image needs to be verified. Each object in the database is compared with the query image if it matches with the set.

- Ontology manager-inserts the new relevant images features and concepts.
- Matching module-SPARQL query image is matched with the database image. If it is successful, ranking module is adopted and if it is unsuccessful image search, image processing and ranking are adopted.

Charulata Leuva proposed Content Based Image Retrieval using Machine Learning Technique

In this paper, CBIR uses Support Vector Machine (SVM) for reducing semantic gap between user and the system. SVM classifies data into relevance training set and Gabor filtering is used for extraction of features.

At first, SVM does the following concept: given the two class training set, it anticipates the image information in a higher dimensional space and classification of information between two classes are done using hyperplane with the help of kernel function. Second, Gabor filtering involves element extraction by minimizes the instability of the two dimensional virtualizations in the space and recurrence field. Finally, the imbalance training set is solved and images are retrieved.

Danial Carlos proposed a Semi-Supervised Learning algorithm for Relevance Feedback and Collaborative Image Retrieval

Machine Learning methods are retrained to define a ranked list containing more relevant images. This paper uses RF approach and Collaborative Image Retrieval (CIR) to get feedback from users and based on the feedback, images are retrieved.

RF gets feedback from single user and reduces the number of iterations needed for providing relevant results. Collaborative image retrieval (CIR) gets feedback from different users. Semi-supervised learning is used to implement the above approaches and it learns from both labeled and unlabelled data. After learning, ranked lists are obtained and cohesion measure is used to measure the quality of ranked lists. The images which are having higher ranked lists are having more similarity and this achieves 95% confidence level for retrieval.

Pranoti P.Mane has proposed an effective technique for CBIR to reduce the semantic gap based on an optimal classifier technique

CBIR involves two steps for retrieval-Artificial Bee Colony (ABC) based training and image retrieval. Images in the database other than query image are preprocessed using median filter to remove noise and resizing using Gray scale transformation. Low-level features are extracted using Gabor filter, gray level co-occurrence matrix and Hu-Moment shape feature techniques. Extracted features are clustered using K-Means technique. After clustering, the input is trained using Artificial neural Network (ANN) based ABC technique. In ANN test images are checked with trained images. Finally the similarity matched images are retrieved from the database.

This method has several advantages over other techniques. They are

- Reduce number of iterations required to achieve enhanced retrieval accuracy.
- Re-work is not required when new image is added to the database.

Paul C. Kuo proposed Bridging the Semantic Gap in Content Based Image Retrieval

In this paper, CBIR involves alternative approaches for feature extraction and similarity measurement. Colortexture moments, columns-of-interest, harmony-symmetry-geometry, SIFT (Scale Invariant Feature Transform), and SURF (Speeded Up Robust Features) are used as feature generation modalities and Graph matching, Earth Mover's Distance, and relevance feedback are used as similarity matching modalities.

For feature extraction, initially visual features are extracted and in addition to that photometric and geometric features are also extracted. Visual features involve basic features (color, texture, etc) of an image, whereas photometric includes features from high level intensity pixels and geometric includes features from shapes of an image. Similarity measurement is done using rank similarity matching method. These processes are implemented based on the above mentioned approaches and this proposal slowly reduces the semantic gap between the user and the system.

A.Anandh proposed CBIR system based on semantic information using color, texture and shape features

This proposal uses a technique for image content descriptor with three features like color, texture and shape. Feature extraction can be done by using auto-correlogram for color,

Gabor Wavelet for texture and wavelet transform for shapes. Using RGB query the features extracted are converted into feature vectors. The manhattan distance is used to measure the similarity between the images in the database with query images and relevant images are retrieved.

Parvin N proposed Content Based Image Retrieval using feature extraction in JPEG domain and Genetic Algorithm

Image retrieval is done in the compressed domain because most of the images in the internet are in the form of JPEG format. Genetic algorithm is used for the retrieval of images from the database. At first level, Huffman coding is used to extract DCT features such as color, texture and shape. After this, logical features are extracted from the above level result. Finally, the features are extracted based on the abstract attributes which results in the primitive features or the content of an image. This every level of feature extraction is called Successor's generation which is employed for fine tuning of output at each level to retrieve more relevant images.

3. COMPARISON OF DIFFERENT METHODS

Following table Tab.1 shows the comparison of different methods used for feature extraction and similarity measurements with dataset used and their pros and cons.

Table.1 Comparison Table

Title	Dataset used	Feature extraction	Similarity Measurement techniques	Advantage	Disadvantage
User-centered reduction of the semantic gap in CBIR	Corel image database	Color histogram	Latent Semantic Indexing (LSI)	Reduces the semantic gap consistently.	It Includes user feedback in forms of RF, While at the same time, the search process has to be user friendly.
Content Based Image Retrieval with Semantic Features using Object Ontology	Mammals dataset	MTH	Matching Module	The semantic features with object ontology can increase the precision and recall values.	-
Reduction of the semantic gap using pseudo relevance feedback algorithm	Any dataset	Color moments, Gabor wavelet transform, edge orientation histogram	Hybrid graph	It provides more user interaction to improve retrieval performance	It does not include all the information pieces to improve the retrieval performance.
Relevance Feedback: a proposed method for reducing semantic gap in Content-Based Image Retrieval using images with relevance level	COREL image datasets	color histogram, color moments, Tamura, co-occurrence matrix, Fourier descriptor, chamfer shape descriptor	Euclidian distance measure	It greatly reduces the user's effort of composing a query and captures the user's information Need more specifically.	CBIR systems stop at lower levels of feature abstractions due to difficulty in automatically Extracting higher level image features.
An effective mechanism to neutralize the semantic gap	Corel image database	Color histogram LBP histogram	Squared Euclidian Distance (SED)	The proposed CBIR system claims effectiveness in retrieving images that are most similar in visual content and also in the semantic sense.	-
A novel approach to self order feature reweighting in CBIR to reduce semantic gap using Relevance Feedback	COREL database	Color Co-occurrence Matrices (CCM)	Minkowski distance	self order feature reweighting approach in CBIR to reduce semantic gap reduce number of iterations.	The calculation of standard deviation used in the weight factor becomes inaccurate and thus, the class representation becomes poor
semantic image retrieval: an ontology based approach	Mammals dataset	MTH Algorithm	Matching Module	This approach is fast and effective	CBIR still lacks to understand the semantic analysis of the image

Content Based Image Retrieval using Machine Learning Technique	Any dataset	Gabor Filter Color Histogram Color Coherent Vector (CCV)	Mahanthan Distance	1) Improve the performance of CBIR. 2) It can solve the problem of imbalance training dataset	It have done only using binary classification of SVM.
Semi-Supervised Learning algorithm for Relevance Feedback and Collaborative Image Retrieval	MPEG-7Brodatz dataset	Segment Saliences(SS) Local Binary Patterns (LBP)	Cosine similarity measure (COS)	RF gets feedback from single user and reduces the number of iterations needed for providing relevant results.	Each iteration rank list should be updated
An effective technique for CBIR to reduce the semantic gap based on an optimal classifier technique	Corel, Coil, and Caltech 101 Database	Gabor Filter, Gray Level Co-occurrence Matrix and Hu-Moment shape feature techniques	ANN system	It narrows down the search space and also could handle large image database.	-
Bridging the Semantic Gap in Content Based Image Retrieval	Wang, Coil100, MIR Flickr	grey level co-occurrence matrix or auto-correlation function.	Graph matching, Earth Mover's Distance	It slowly reduces the semantic gap between the user and the system.	It leads to difficulty in finding a single best representation of the query image
CBIR system based on semantic information using color, texture and shape features	Corel image database, Li image database and Caltech-101 image database.	Color auto-Correlogram, Gabor Wavelet and Wavelet Transform	Manhattan distance	It achieves better retrieval accuracy in comparison with the existing methods through information derived from feature extraction algorithms	-
Content Based Image Retrieval using feature extraction in JPEG domain and Genetic Algorithm	STL-10 dataset	color histogram	Euclidian Distance (ED)	The results improve a lot with relevance feedback from the end user when genetic algorithms are deployed in compressed domain.	-

4. Semantic gap reduction techniques

Object ontology

It describes the image using its semantics. Intermediate level descriptors are used to describe low-level features. Semantics are used to represent high-level features.

For example: grass-a region filled with green color, here values are mapped with low-level features.

Machine Learning tools

Supervised machine learning algorithms such as Support Vector Machine (SVM), Decision tree and Artificial Neural Network (ANN) and unsupervised algorithm such as K-Means algorithm are used in image retrieval processes. Here unsupervised algorithm can group together similar regions in an image without any measurements of outcome.

Relevance Feedback (RF)

Retrieved image result is shown to the user. Here the retrieved image may be relevant or non-relevant. With the help of Machine Learning algorithm the needs of the user is known. Image retrieval and machine learning tools are used until the user gets satisfied.

Semantic templates

Semantic templates give the concept of the image with the help of attributes such as color, shape and texture or with an example icon and scene. These concepts are converted into a template by using RF.

It needs more knowledge for processing hence overcome by interactive RF without requiring the user to have more knowledge of feature representation.

Web image retrieval

Web image retrieval makes use of keywords such as text features or visual features such as color, shape and texture feature or hyperlinks for retrieval. Fetching of an image is done using web crawler and keywords are extracted which are informative sources of web. Image contents are used to match the best images in the retrieval system.

5. Conclusion

In this paper the various technical achievements in content based image retrieval system are reviewed. This paper provides a comprehensive survey of various techniques used for feature extraction, similarity measures, semantic gap reduction and performance measures of the query image and the image in the database. It is concluded that although considerable amount of work has been done in this area but still there is lack of a generic approach for reducing the semantic gap between the low level feature and high-level semantic feature of the image. Hence it is always an open issue to provide better algorithm for reducing this semantic gap.

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