Comparative Study on Content Based Image Retrieval

Sowmya Rani , Rajani N., and Swathi Reddy

Abstract—**Content-based image retrieval (CBIR) is a technology that in principle helps to organize digital picture archives by their visual content. Anything ranging from an image similarity function to a robust image annotation engine falls under the purview of CBIR. In all current approaches the one problem is the visual similarity for judging semantic similarity which is problematic between low level content and high level concepts due to the semantic gap. In order to improve the retrieval accuracy of CBIR systems, research focus has been shifted from designing sophisticated low-level feature extraction algorithms to reduce the 'semantic gap' between the visual features and the richness of human semantics. This paper attempts to provide a comprehensive survey of the recent technical achievements in feature extraction for image retrieval.**

***Index Terms*—CBIR, colour, texture and shape**

I. Introduction

CBIR is the application of computer vision techniques to the image retrieval problem, that is, the problem of searching for digital images in large databases."Content-based" means that the search will analyze the actual contents of the image rather than the metadata such as keywords, tags, and/or descriptions associated with the image. In CBIR, images are indexed by their visual content, such as color, texture, shape. Also having humans manually enter keywords for images in a large database can be inefficient, and may not capture every keyword that describes the image. Thus a system that can filter images based on their content would provide better indexing and return more accurate results [1].Research and development issues in CBIR cover a range of topics, many shared with mainstream image processing and information retrieval. Some of the most important are:

1) Bridging the semantic gap between human vision and machine
2) Feature extraction from images and their storage
3) Similarity measure

With the development of the Internet, and the availability of image capturing devices such as digital cameras, image scanners, the size of digital image collection is increasing rapidly. Efficient image searching, browsing and retrieval tools are required by users from various domains, including remote sensing, fashion, crime prevention, publishing, medicine, architecture, etc. For this purpose, many general purpose image retrieval systems have been developed. The table below gives some of the CBIR systems, with the features they extract and learning algorithms used to extract the features and similarity matching [2].

TABLE I: CBIR System With Low Level Features and Learning Algorithm

CBIR system	Low level features	Learning algorithm	Similarity matching
RETIN	1.color 2.Texture	color histogram output of Gabor transform	Weighted minkowski distance
KIWI	1.color 2.shape	color histogram Gabor filters	Euclidean space
iPURE	1.color 2.Texture 3.shape 4. Spatial	average color in CIE's LUV space wold decomposition Fourier descriptor location-centroid	Euclidean space

II. Feature Extraction

CBIR systems perform feature extraction as a pre-processing step. Once obtained, visual features act as inputs to subsequent image analysis tasks such as similarity estimation, concept detection, or annotation. A feature is referred to capture a certain visual property of an image, either globally for the entire image, or locally for a small group of pixels. Most commonly used features include those reflecting color, texture, shape, and salient points in an image [3].

Low-level image feature extraction is the basis of CBIR systems. Depending on the application image features can be either extracted from the entire image or from regions in CBIR. Current CBIR systems are region-based because it has been found that users are usually more interested in specific regions rather than the entire image. Global feature based retrieval is comparatively simpler. Representation of images at region level is proved to be more close to human perception system [3]. Then, low-level features such as color, texture, shape or spatial location can be extracted from the segmented regions. Similarity between two images is defined based on region features.

III. Image Segmentation

Image segmentation refers to the process of partitioning a digital image into multiple segments i.e sets of pixels. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. Image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics. Table shows a comparison between the various segmentation techniques with regard to the information they use to perform the segmentation [4].

Manuscript received March 16, 2012; revised June 12, 2012.

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DOI: 10.7763/IJFCC.2012.V1.97

TABLE III: COMPARISON BETWEEN SEGMENTATION TECHNIQUES

Segmentation Technique	Information used in Segmentation	Method of Segmentation
Thresholding	Color	Simple Comparison Between Pixels And The Threshold
Live Wire	Edge	2D Graph Search Using Dynamic Programming
Snakes	Edge	Energy Minimization of Internal and External Functions
Graph cut	Color and Edge	Max-Flow/Min-Cut Algorithm For Energy Minimization

IV. COLOR FEATURE

Color feature is one of the most widely used features in image retrieval. Color are defined on a selected color space Color spaces shown to be closer to human perception and used widely in RBIR include, RGB, LAB, LUV, HSV (HSL), YCrCb and the hue-min-max-difference (HMMD).Selection of a proper color space and use of a proper color quantization scheme to reduce the color resolution are common issues for all color-based retrieval methods.

A. RGB Color Space

Red, green, and blue are the three primary additive colors which are represented in three dimensions. The RGB color space is the most prevalent choice for digital images. However, a major drawback of the RGB space is that it is senseless.

B. CMY Color Space

CMY color space is used for color printing. Cyan, Magenta, Yellow are the complements of Red, Green and Blue. They are called subtractive primaries because they are obtained by subtracting light from white. Hence, the CMY color space has the same drawback as RGB.

*C. C.I.E. L*u*v* Color Space*

Color is identified by two coordinates, x and y, in the C.I.E. L*u*v* Color Space. Lightness L* is based on a perceptual measure of brightness, and u* and v* are chromatic coordinates. Also, color differences in an arbitrary direction are approximately equal in this color space. Thus, the Euclidean distance can be used to determine the relative distance between two colors. However, coordinate transformation to the RGB space is not linear.

V. TEXTURE

Texture is the visual patterns that have properties of homogeneity that do not result from the presence of only a single colour or intensity. The texture descriptors provide measure of properties such as smoothness, coarseness and regularity. Statistical approaches yield characterization of texture as a smooth, coarse, grainy and so on. Texture provides important information in image classification as it describes the content of many real-world images such as fruit skin, clouds, trees, bricks, and fabric. Hence, texture is an important feature in defining high-level semantics for image retrieval purpose [6].

The texture feature extraction techniques are - Steerable Pyramid, Contourlet Transform, Gabor Wavelet Transform , Complex Directional Filter Bank - Texture boundary detection, Texture classification , Color texture , Fourier descriptors , Hierarchical textures , surface roughness characterization , Structural texture representations, Statisticaltexture representations, Texon invariants and representations ,Texture-based region segmentation, oriented Patterns ,Wavelet-based texture descriptor .

VI. SHAPE

Shape is a key attribute of segmented image regions, and its efficient and robust representation plays an important role in retrieval. Shape is a fairly well-defined concept. Shape features of general applicability include aspect ratio, circularity, Fourier descriptors, moment invariants, consecutive boundary segments etc. Shape features have shown to be useful in many domain specific images such as man-made objects[7]. For example in object based image retrieval, simple shape features such as eccentricity and orientation are used. The system SIMPLIcity (Semantics-sensitive Integrated Matching for Picture LIbraries), an image database retrieval system uses normalized inertia of order 1–3 to describe region shape[8].

The shape feature extraction techniques are- Shape from contours, defocus, focus, geometric constraints , multimodal integration, line drawings, Monocular Depth Cues, Structure from motion, multiple sensors, perspective, photo-consistency, photometric motion, Photometric Stereo, Polarization, Surface shape from shading, shadows, specularities, structured light, texture motion and shape from zoom.

VII. SIMILARITY MEASUREMENT

Similarity or distance measure place an important role in image retrieval process. It compares the values between points or angles or sets or vectors. Performances of the measures include classification accuracy, threshold value selection, noise robustness, execution time, and the capability of automated selection of templates/objects.

Some of the similarity measurement for colour feature are- Histogram Quadratic Distance Measure (HQDM), Integrated Histogram Bin Matching (IHBM), Histogram intersection, Histogram Euclidean distance, Minkowski-metric, Manhattan distance, Canberra distance, Angular distance, czekanonski coefficient, Inner product, Dice coefficient, Cosine coefficient, Jaccard coefficient, optimal colour composition distance(OCCD) and Earth movers distance.

Some of the similarity measurement for texture feature are- Kull back-leiber distance, Tree structured wavelet transform, Generalized Gaussian density(GGD), Histogram method, wavelet transform, Pyramid structured wavelet transform(T'WT), Multiresolution simultaneous autoregressive model(MR-SAR) ,weighted Euclidean distance, Monte-Carlo method and Earth movers distance. Kullback-Leibler distance provides greater accuracy and flexibility in capturing texture information.

Some of the similarity measurement for shape feature are-

Perceptual distance, Polygon approximation method, Fourier descriptor method, Dynamic Time Wrapping(DTW), Angular distance, Inner product, Dice coefficient, Ray distance and Ordinal co-relation.DTW develops a efficient distance calculation scheme which is consistent with the human visual system in perceiving shape similarity.

VIII. Relevance Feedback

Relevance feedback is developed for information retrieval, is a supervised learning technique used to improve the effectiveness of information retrieval systems. The main idea of relevance feedback is using positive and negative examples provided by the user to improve the system's performance.

Some of the algorithms of relevance feedback are-Gaussian Estimator, Principal component Analysis, Bayesian feedback algorithm, Expectation maximisation algorithm, Robertson/Sparck-Jones algorithm, BM25 algorithm, LM algorithm, Support Vector machines, Rocchio algorithm, genetic algorithm, Back propagation algorithm, pseudo relevance feedback algorithm, Kohonen.s learning vector quantization (LVQ) algorithm, tree-structured self-organizing map (TS-SOM).

Supervised learning is the machine learning task of inferring a function from supervised (labeled) training data. The training data consist of a set of training examples.Approaches and algorithm to supervised learning includes likeAnalytical learning, Artificial neural network , Back propagation , Boosting , Bayesian statistics ,Case-based reasoning , Decision tree learning , Inductive logic programming ,Gaussian process regression , Kernel estimators ,Learning Automata , Minimum message length (decision trees, decision graphs, etc.), Naive bayes classifier ,Nearest Neighbor Algorithm ,Probably approximately correct learning (PAC) learning ,Ripple down rules.

Unsupervised learning refers to the problem of trying to find hidden structure in unlabeled data. Since the examples given to the learner are unlabeled, there is no error or reward signal to evaluate a potential solution. This distinguishes unsupervised learning from supervised learning and reinforcement learning.Approaches to unsupervised learning includes like clustering (e.g., k-means, mixture models, hierarchical clustering),blind signal separation using feature extraction techniques for dimensionality reduction (e.g., Principal component analysis, Independent component analysis, Non-negative matrix factorization, Singular value decomposition).Among neural network models, the self-organizing map (SOM) and adaptive resonance theory (ART) are commonly used unsupervised learning algorithms.

IX. Conclusion

CBIR is a fast developing technology with considerable potential. Research in CBIR in past has been focused on image processing, low level feature extraction etc. It has been believed that CBIR provides maximum support in bridging 'semantic gap' between low level feature and richness of human semantics. This paper provides comprehensive survey on feature extraction, feature extraction in various CBIR systems with their learning algorithm and similarity matching. Various supervised and unsupervised approaches are given.

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