Abstract

Modern image search engines retrieve the images based on their visual contents, commonly referred to as Content Based Image Retrieval (CBIR) systems. Typical CBIR systems can organize and retrieve images from image databases, automatically by extracting some features such as color, texture, shape from images and looking for similar images which have similar feature. One problem of this approach is reliance on visual similarity to judge semantic similarity, which creates problems due to semantic gap between low-level content and high level concepts. Even with the subsistence of this problem, if aggressive attempts are made CBIR can be used for real life applications. For example in spite of the open problems like robust text understanding, Google and Yahoo have become most popular for searching.

The work presented here mainly focuses on efficient CBIR methods with help of representation of converting the visual content of images in feature vector using proposed techniques. The proposed CBIR methods using Colour, Transformed Image, Texture and Shape content are proved to be better and faster using test bed of 1000 variable size images spread across 11 image categories.

In consideration of colour content as feature, the proposed approaches of using ‘image colour averages’ and ‘block truncation coding’ for CBIR are proposed. Image averaging techniques are based on taking averages of colour content of image, which can be considered as feature vector for image retrieval. The image pixel data can be represented in form of the feature vectors with reduced dimensions as row mean (RM), column mean (CM), forward diagonal mean (FDM), backward diagonal mean (BDM). Use of the colour averaging techniques helps in obtaining faster and better
image retrieval techniques. The FDM has been observed to give best performance among these colour averaging based CBIR methods.

Image tiling is dividing image into equal and non-overlapping square parts. The proposed image retrieval techniques using colour averaging methods (like row mean, column mean, forward diagonal mean, backward diagonal mean, row & column mean, forward & backward diagonal mean) combined with image tiling for 4, 16 and 64 tiles are presented. It is observed that except BDM, in other colour averaging based CBIR methods image tiling does not help in performance improvement.

Then the augmentation of colour averaging based CBIR methods is proposed using original and even part of image. The better performance is observed in original with even image part (original + even) for proposed color averaging based CBIR methods.

The main drawback of colour averaging CBIR, dependence of feature vector size on image size, shepherd to the use of Block Truncation Coding (BTC) for feature extraction in image retrieval. Then the BTC-CBIR is extended to ten assorted colour spaces (RGB, HSV, XYZ, HSI, rgb, Kekre’s LUV, YCbCr, YUV, YIQ, Kekre’s YCgCb), to observe that Kekre’s LUV colour space gives the best performance and all luminance-chrominance colour spaces (Kekre’s LUV, YCbCr, YUV, YIQ, Kekre’s YCgCb) give better image retrieval than non-chrominance colour spaces (RGB, HSV, XYZ, HSI, rgb). The effect of image tiling in BTC based image retrieval is tested and multilevel BTC for image retrieval are also proposed. It is observed that Multilevel BTC helps in performance improvement with every increasing level of BTC.
The image transforms which transforms image from one representation to another is mainly advantageous in two aspects. First, the transformation isolates critical components of image patterns which then can directly be accessed for analysis. Second, transformation places image data in more compact form that can be stored and transmitted efficiently. These two advantages of image transforms make them inevitable choice for feature vector size reduction in image retrieval techniques. These aspects of image transforms are exploited in the proposed CBIR techniques using fractional energy, row mean of column transformed image, energy compaction and Principle Component Analysis (PCA).

In CBIR using fractional energy of transformed image, total seven image transforms and fifteen fractional coefficients sets are considered. It is observed that the newly introduced Kekre transform gives best performance with 6.25% fractional coefficients. In all image transforms fractional energy based CBIR proved to be better than considering complete transformed image as feature vector for CBIR. In image retrieval using row mean of column transformed image content, out of the seven mage transforms considered the discrete cosine transform with DC component has given best performance. In CBIR with energy compaction in transform domain it is observed that in the compacted energy for the transformed colour averages gives better performance with drastically reduced feature vector size. In row mean, column mean and row-column mean combination Kekre transform with 94% energy proved to be better. In forward diagonal mean and backward diagonal means the discrete Sine transform is observed to give better image retrieval. In PCA applied on colour averages have shown slight deterioration in performance of image retrieval as compared to PCA applied to complete image data, but
proposed CBIR methods with PCA have shown tremendous savings in computational complexity.

Representation of texture in mathematical terms which can be understood and used by computing applications is very intricate task. Texture representation methods can be classified into three categories, namely structural, statistical and multi-resolution filtering methods. The novel image retrieval techniques are proposed based on texture content of image using mainly three approaches of texture representation.

The proposed transform wavelet pyramid based image retrieval methods are based on multi resolution filtering texture representation. Here the transform wavelet pyramids with seven different levels are formed using Haar transform, Walsh transform and newly introduced Kekre wavelet transform. Each level of wavelet from transform pyramid is treated as feature vector of respective image for image retrieval. Walsh wavelet pyramid and Haar wavelet pyramid based CBIR methods are proved to be better and faster.

As the vector quantization (VQ) codebook represent the statistical colour distribution of the respective image. Using the VQ codebooks as statistical texture features various image retrieval methods are proposed. Using five codebook generation algorithms like Linde-Buzo-Gray (LBG), Kekre’s proportionate error (KPE), Kekre’s error vector rotation (KEVR), Kekre’s median codebook generation (KMCG) and Kekre’s fast codebook generation (KFCG) with various codebook sizes (16, 32, 64, 128, 256, 512) total thirty variations of image retrieval using vector quantization codebooks are proposed and tested for their performance comparison. It is observed that KFCG gives better image retrieval among the considered codebook
generation methods. The KFCG with codebook size 256 has shown best performance for VQ codebook based CBIR methods.

The texture patterns generated using non sinusoidal orthogonal transforms can be considered with binary or ternary image maps to form structural texture feature vectors of image, which give innovative image retrieval methods based on texture patterns. Here three image transforms namely Haar, Walsh and Kekre are considered to form four or sixteen or sixty four texture patterns. These texture patterns are considered with image maps (binary for Walsh and ternary for Haar & Kekre) generated using global threshold, local threshold and intermediate thresholds (intermediate 4 and intermediate 9) to form feature vectors of the respective image from image database. Three transforms, three texture pattern sets and four image map generation methods results into 36 variations of proposed CBIR method, which are discussed and tested for performance comparison. It is observed that Haar 16 texture patterns with intermediate 4 image maps have shown best performance.

Shape representation can be mainly of two types boundary based or region based. Only outer boundary of the shape is used in boundary based shape representation. Generally gradient operators and morphological operations are used to extract the boundary of shape as edges present in the image. Application of gradient operators gives first order derivative of the image where edges in only one direction can be determined (horizontal or vertical or diagonal). To get the complete boundary of the shape in the image in form of connected edges slope magnitude method is used with gradient operators.
The image retrieval methods are proposed based on the shape content as edges present in the image extracted using seven different methods alias Sobel mask with slope magnitude method (Sobel-SMEI), Robert mask with slope magnitude method (Robert-SMEI), Prewitt mask with slope magnitude method (Sobel-SMEI), Canny operator with slope magnitude method (Canny-SMEI), edge morphological operations (morphological-EI), top hat transform (Top-Hat-EI), bottom hat transform (Bot-Hat-EI). These edge images are directly used as feature vectors for CBIR using Shape-Edge image. The gradient edge images are observed to give better performance than the morphological edge images in proposed CBIR methods using shape content.

The novel image retrieval methods are proposed using edge image content with block truncation coding (BTC), where BTC is applied on shape-edge images, which have given better performance. For further performance improvement the CBIR techniques are proposed using row mean of column transformed edge images, where Kekre transform with Robert slope magnitude edge image gave the best performance. At last newly proposed image retrieval methods using shape Walsh texture patterns with even better performance are elaborated with the augmentation using even image parts. It is observed that Walsh texture patterns applied on original + even image part gives best results with Robert slope magnitude edge images.
Organization of the Thesis

Chapter 1: Introduction
The chapter instigates with the need of image retrieval followed by problems in text based image retrieval and basics of content based image retrieval. Then applications of CBIR are discussed. The current research areas in CBIR are explored. Towards the end of the chapter the scope of the research work presented here is elucidated which helps to improve the reading pleasure.

Chapter 2: Review of Literature
The field of CBIR has seen tremendous amount research work in diverse directions. The quick review of approaches of taking image content as feature vector for CBIR is the main motto of this chapter. The chapter does the survey in four folds as CBIR using colour content, transformed image content, texture content and shape content. In each fold after discussing some of the popular CBIR feature extraction methods, the proposed approaches are also briefly discussed.

Chapter 3: Image Retrieval using Colour Content
In this chapter the image retrieval techniques based on colour content are presented using two approaches of feature vector generation as ‘image averaging’ and ‘block truncation coding’. The chapter covers some basics like computation of colour means and block truncation coding theory. Then the proposed CBIR methods are elaborated with the experimental results and observational conclusions. The image tiling and ten assorted colour spaces are also considered to improve the performance of proposed CBIR methods.
Chapter 4: Image Retrieval using Transformed Image Content

The seven popular orthogonal image transforms are explicated in the chapter. Then the proposed CBIR techniques to exploit the transformed image content using approaches like fractional energy, row mean of column transformed image, energy compaction and Principle Component Analysis (PCA) are presented.

Chapter 5: Image Retrieval using Texture Content

The chapter discusses the proposed texture content based CBIR methods. The texture representation techniques mainly can be categorized as structural, statistical and multi-resolution filtering. Then the novel image retrieval techniques are proposed based on texture content of image using these three approaches of texture representation.

Chapter 6: Image Retrieval using Shape Content

Shape representation can be mainly of two types boundary based or region based. The proposed image retrieval methods based on the shape content as edges present in the image extracted using seven different methods alias Sobel mask with slope magnitude method (Sobel-SMEI), Robert mask with slope magnitude method (Robert-SMEI), Prewitt mask with slope magnitude method (Sobel-SMEI), Canny operator with slope magnitude method (Canny-SMEI), edge morphological operations (morphological-EI), top hat transform (Top-Hat-EI), bottom hat transform (Bot-Hat-EI) are presented.

Chapter 7: Conclusions and Further work

In this chapter conclusions are drawn based on the results obtained from chapter 3 to chapter 6. Also the further work in the area is proposed.
References
List of references used in earlier chapters is given.

Appendix I
The sample images from the image database (of 1000 images) used for experimentation and results of the CBIR methods given in chapter 3 to chapter 6 are given. For each of the 11 imager categories from the image database, few sample images per class are shown with the details of respective image class.

Appendix II
The papers published so far in the area are listed here.