CHAPTER 1

INTRODUCTION

The application of digital imaging in several domains such as, academics, government, hospitals, engineering, architecture, commerce, crime prevention, journalism, fashion and historical research have increased rapidly (Mohamed 2010). There are several issues in the searching and retrieval of images from a large image database (DB). Text-based and Content-Based Image Retrieval (CBIR) are the two important techniques for the search and retrieval of images from an image DB.

Text-based retrieval is non-standardized, because different users use different keywords for annotation (Salamah 2010). CBIR is the retrieval of relevant images from an image DB, based on the automatically derived visual features like color, texture and shape which represent the information content of the image. These features are the low level features of the image. The low level features of all the images in the image DB, are extracted and stored in the feature DB. For retrieving similar images, the CBIR system compares the low level features of the query image with that of the each DB image, using the statistical distance measure. The images having the least distance from the query image are more similar. The images with the least distances are displayed as the output (Herwindiati & Isa 2009).

The images having high feature similarities may be very different from the query image in terms of semantics. This is referred to as the semantic gap problem. The CBIR system which reduces this semantic gap is
called as the Semantic Content Based Image Retrieval (SCBIR). The semantic learning schemes are trained with the known training set feature vectors, and predict the semantic concept of a given image feature vector. During the retrieval phase, the similarity distance is calculated between the query image feature vector and the feature vectors of all the images in the predicted category. These distance values are sorted in the ascending order, and the top images with the least distances are given as output to the user, who gives the relevance feedback (RF) about the output. If the obtained output is satisfactory, then the process can be stopped. Otherwise, the parameters of the semantic learning schemes are modified based on this feedback, and new results are produced. This loop continues till the user gets satisfactory results.

The main objective of this research is to incorporate the semantic meaningfulness into the image retrieval system. This research is based on the Semantic Cluster Matrix (SCM) approach to achieve a SCBIR system, by combining the support vector machine (SVM), semantic template (ST) and the RF mechanism. This approach provides semantically relevant images for the trained and untrained category images. The image retrieval system must be robust when the query image is subjected to various kinds of geometric transformations like translation, scaling and rotation. Also, it should be robust under noisy conditions. Hence, this research work tests the robustness of the semantic CBIR system under geometric transformations and noisy conditions.

1.1 MOTIVATION

Research in CBIR traditionally focuses on the development of efficient feature extraction, pattern recognition and indexing techniques. The performance of the traditional CBIR system is affected by the mismatch between the low-level features and their high-level semantics. Several
researchers tried many approaches for reducing the semantic gap between the low level visual features and the high level image semantics (Vompras 2009).

Rahman et al (2007) have worked extensively to reduce the semantic gap in CBIR. Their work is the motivation for this research. Rahman et al (2007) developed a framework for medical image retrieval, based on the machine learning technique and the RF mechanism for reducing the semantic gap. They used the Support Vector Machine – Pair Wise Coupling (SVM-PWC) for multi class classification, and the Fuzzy C-Mean (FCM) clustering for the categorization of images. They have also used the RF mechanism to incorporate the user perception in the retrieval system. The SVM-PWC used in their work requires $n \times (n-1) / 2$ binary SVM classifiers, for training n-class classification problem. This consumes more amount of time when the number of classes in the DB becomes high. Madzarov et al (2009a) developed the Support Vector Machine-Binary Decision Tree architecture (SVM-BDT), which requires (n-1) binary classifiers for training an n-class classification problem.

Liu et al (2009) developed a clustering scheme, which can evolve to include more new semantic categories. The semantic similarities among the image regions are obtained with the help of the user query and the feedback history. The affinity matrix stores the users’ feedback about the image. It requires five iterations of the RF for each query image which is time consuming. The issues discussed in these works served as the motivation to develop a semantic learning algorithm.

1.2 OBJECTIVES OF THE THESIS

Based on the issues discussed above, the objectives of this work are formulated as follows:
(i) Develop the SVM- Binary decision tree (SVM-BDT), to predict the semantic concept of an image.

(ii) To reduce the search space and perform quick retrieval, using the prefiltering approach.

(iii) To build a semantic region based image retrieval (SRBIR) system based on the dominant foreground region of the image.

(iv) To enhance the SRBIR system, using a new structure called the Semantic Cluster Matrix (SCM).

(v) To compare the performance of the SCM with other semantic content-based image retrieval systems.

(vi) To enhance the robustness of the system under geometric transformations. To develop a feature vector which would be invariant when subjected to geometric transformations.

(vii) To evaluate the robustness of the system under noisy conditions.

(viii) To incorporate parallelism in the semantic CBIR using multi threading, to reduce the time needed for retrieval.

1.3 PROBLEM FORMULATION

Considering the issues available in the existing semantic CBIR schemes, this research work aims at developing some methods to support the semantic CBIR. The problem is to develop a semantic CBIR system, which learns about the existing semantic categories in the training dataset, using the machine learning concept, SVM. The system must provide the correct retrieval results not only for the trained category images, but also for the images belonging to the untrained category. Hence, the problem is extended
to find an adaptive learning scheme which would adaptively learn about the new category of images at the time of testing, and produce the correct results for the new categories in the near future. Also, the system should produce the correct result when a query image contains objects subjected to some of the geometric transformations, like translation, scaling and rotation. The system will be invariant under geometric transformations, if the features extracted from the image have the invariant property under those transformations. Also, the system should produce the correct results, when the given query image contains any type of noise. While developing a semantic CBIR scheme, the retrieval time must be minimized by reducing the search space and by applying parallelism. Hence, the problem is to develop an invariant and adaptive semantic CBIR scheme to provide quick retrieval.

1.4 ORGANIZATION OF THE THESIS

Based on the objectives stated above, the work has been carried out and presented in the thesis as given below.

Chapter two gives an overview of the concepts, tools and standard techniques available for this work, and the literature review. This chapter covers the various steps involved in the CBIR system such as feature extraction, dimensionality reduction and similarity measures in its opening section. The subsequent section discusses the techniques available for the semantic CBIR, and the various works carried out in the semantic content based image retrieval. Then, it discusses the various performance measures available for evaluating the performance of a CBIR system. The last section presents the various CBIR components used in the various recent works.

Chapter three explains the use of the SVM-Binary decision tree approach for the CBIR. It discusses the 108 low level features extracted from the images. The dimensionality reduction technique used in reducing the
dimension of the feature vector is presented. These reduced feature vectors are used in the construction of the SVM-BDT for multi-class classification, which is explained in detail. The use of prefiltering to reduce the search space is presented. Chapter four focuses on the semantic region based image retrieval (SRBIR) system, based on the dominant foreground region and semantic learning. The segmentation algorithm presented extracts the dominant foreground region from the given image. Also, the construction of the SVM-BDT with the help of the semantic template, using the region level features is explained. This region based image retrieval system is compared with the other decision tree induction methods.

The new method for adaptive learning in region based image retrieval is covered in chapter five. The SVM-BDT approach provides good results for the already trained category images. But for untrained category images, it fails to give the correct classification. Hence, an adaptive learning scheme is developed, which learns the new semantic categories during the testing time by constructing the SCM. The adaptive learning scheme and SCM are explained in detail. The performance of the system for both the trained and untrained category images is analyzed. The robustness of the system under various geometric transformations and noisy conditions, is presented in chapter 6. The use of parallelism to reduce the retrieval time is also explained. The time complexity analysis of sequential and parallel search is presented.

Chapter seven concludes with a summary of the work done and the contributions made. It also suggests a few topics for future work that could be carried out, in continuation of this research.