International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 3, Issue 10 (May 2014) PP: 38-47

Sketch Based Image Retrieval Using BMMA and SEMI-BMMA

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Abstract: *During past few years, people have been substantially attracted towards Content-Based Image Retrieval (CBIR) because of its varied multimedia applications. CBIR is one of the most popular research areas of digital image processing. The goal of the CBIR is to extract the visual features of the image such as color, texture or shape. An attempt is made to develop a Sketch Based Image Retrieval (SBIR) making it use of the features such as shape or form of the object [1]. This paper aims to introduce the creation and design of SBIR system making use of extraction techniques of Biased Maximum Margin Analysis (BMMA) and a Semi-Supervised Biased Maximum Margin Analysis (Semi BMMA) [2].. With the help of existing methods, design a task specific descriptor, which can handle the informational gap between a sketch and a colored image. The result of SBIR includes the set of positive images (relevant) and negative images (irrelevant). Iterative process acts on the positive set for the optimal extraction of the object. By using Laplacian regularizer to BMMA, the Semi BMMA integrates the information of unlabelled samples [2] to result in the better extraction of refined set of objects. The SBIR have several applications such as digital libraries, crime prevention, photo sharing sites etc. An important application is a matching a forensic image to gallery of mug shot images.*
Index Terms: *CBIR, SBIR, BMMA, Semi BMMA.*

I. Introduction

In the recent years, CBIR has attracted the attention because of its varied multimedia application. It is initiated by the immense growth of image records and online accessibility of remotely stored images. The traditional search scheme requires the huge image database. In the textual based image retrieval, we can search flexibly using key words but if we use image, we can't apply dynamic methods. Two questions can arises. The first is who yields the keywords. And second is an image can be efficiently represented by keywords.

In most of the cases, if we want to search correctly, some data have to be recalled. In this case, we search the images using some features and these features are called keywords. At this time unfortunately they are not frequently used retrieval systems which retrieve the images using visual information of a sample image. One reason for this is, it is too difficult to give some unique and identifiable information to a text.

In CBIR, an image is represented using some example images and some low-level visual features. They are color, texture , shape, etc. These visual features are extracted to represent the images in the database. This low-level features extracted from images may not accurately detecting the high-level features.

To reduce the gap between this low-level visual features and high-level semantic concepts, Relevance Feedback (RF) scheme is introduced to improve the performance of CBIR. One of the RF technique is Support Vector Machine (SVM).Different versions of SVMs are developed. One class SVM computes the density of positive feedback samples. After this, a biased SVM is developed. It overcomes the difficulties of one class SVM. Varied learning methods are implemented to find intrinsic structure of images and it enhances the performance. With the observation that "*all positive are alike; each negative example is negative in its own way*", a biased learning problem is developed. In this, there is some unknown number of classes, user is only concentrated with positive class. However, all these method has its own drawbacks.

Two class SVM is one of the method used in the past few years. In the RF scheme, user labels number of relevant samples as positive feedbacks and number of irrelevant samples as negative feedbacks. The traditional SVM treats positive and negative feedbacks equally .The problem here is that, different semantic concepts belong to different subspaces and each image can lie in many different subspaces. It reduces the performance of the CBIR. In addition, the traditional SVM is not considering the information of the unlabelled samples too.

This paper aims to develop SBIR system which can retrieve images using sketches. The user has a drawing area where the user can draw the sketches, which are the base of retrieval method.

The retrieval system in the SBIR provides response list to the displaying system. It contains positive and negative feedbacks. That means, from the retrieved images, user labels the number relevant samples as positive feedbacks and number of irrelevant samples as negative feedbacks. For extracting positive feedbacks, the techniques called Biased Maximum Margin Analysis (BMMA) and a Semi-

Supervised Biased Maximum Margin Analysis (Semi BMMA) are used. These schemes are mainly based on the concept that it treats the positive and negative feedback unequally. Also, labeled positive feedbacks are mapped as close as possible and negative feedbacks are separated from positive feedbacks by a maximum margin in reduced subspace.

II. Related Works

Content based image retrieval is a process used for searching the relevant images based on user input. The input could be parameters, sketches or example images. A traditional CBIR system firstly extracts the image features and stored them. Then it compares with image features of database images and displays the results. Feature extraction and similarity measure are very dependent on the features used. Histogram is the most commonly used technique to describe image.

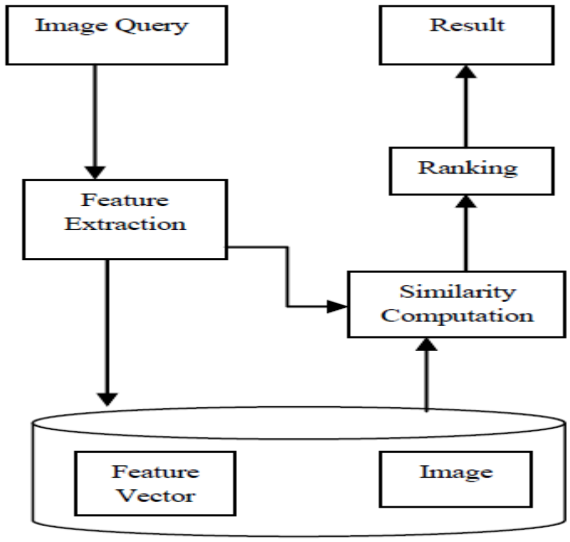


Fig 1: Architecture of CBIR process.

Fig 1 describes the flow of typical CBIR process although content based methods are efficient, they cannot always match user's expectations.

Relevance Feedback (RF) techniques are used to adjust the query by user's feedback. RF is a powerful technique used in traditional CBIR system. It is a process of automatically adjusting an existing query using information fed back by the user about the relevance of previously retrieved objects such that the adjusted query. The issue in relevance feedback is how to utilize the feedback information for improving the retrieval performance. After obtaining retrieval results, user provide the feedback for checking results are relevant or not relevant. If the results are non relevant, the feedback loop is repeated many times until the user is satisfied.

The basic idea behind the RF scheme is to shift the burden of finding the right query formulation from the user to the system. In order to make this true, the user has to provide the system with some information, so that system can perform well in answering the original query.

The concept of RF was introduced into CBIR from the concept of text based information retrieval in the 1998's and then has become a popular technique in CBIR

When a user submits the query image. It firstly extracts the feature vectors and comparing with the feature vectors of database images. Then the retrieval results displays to the user. Then user gives the feed back in the form of relevance judgements expressed over retrieval results. The relevance judgements evaluate the results based on a three value assessments [3]. These three values are relevant, non relevant and don't care. Relevant means, the image relevant to the user, non relevant means, the image definitely not relevant and don't care means the user doesn't say anything about that image. If the user feedback is relevant, then feedback stops. Otherwise it continues until users get satisfied with that result.

The first RF based approach to CBIR in which user and system interact to refine high level queries into low level visual features which addresses the gap between high level semantic concepts and low level visual features. The evaluation parameter used was convergence ratio[4].

Learning in CBIR system is divided into short term learning and long term learning. Most of the researches are focused on query tuning in a single retrieval session. This is commonly known as intra-query learning or short term learning. In contrast, inter-query, also known as long term learning is strategy that attempts to analyze the relationship between the current and past retrieval sessions.

In short term learning, only the feedbacks of the current search session are used in the learning algorithm. The main challenge in this approach is to find the best combination of image features that presents the users query. Such optimum set of feature include features that capture similarities between positive images. So short term learning include support vector machine, Bayesian learning, discriminant learning and so on.
Long term learning utilizes the feedbacks collected during prior retrieval session. It is a cumulative process for collecting fast feedbacks and which are stored in the form of matrix.

Bayesian network as a relevant image that include short term learning, is an adoption model to select a number of good points composing the positive feedback information. It is a powerful tool that is applicable in the point of view of relevance feedback in image retrieval. The precision rate as a function of the number of feedback iterations was used as the performance measure.

A relevance feedback approach based on Bayesian classifier. For positive examples, a Bayesian classifier was used to determine the distribution of the query space. The image set used was the Corel Image Gallery [7]. The images of the same category as the query example were considered as relevant to the query. Positive feedback process was running as following: images from the same category as the query example that were ranked in top 50 were assigned as the positive feedbacks. For negative feedback process the first two irrelevant images were assigned as negative examples.

Support Vector Machine (SVM) is the one of the RF based approach.[8] The traditional SVM is binary classifier. A svm captures the query concept by separating the relevant images from irrelevant images with the hyper plane in a projected space, usually high dimensional one. The projected points on the one side of the hyper plane are considered relevant to the query concept and rest are irrelevant.

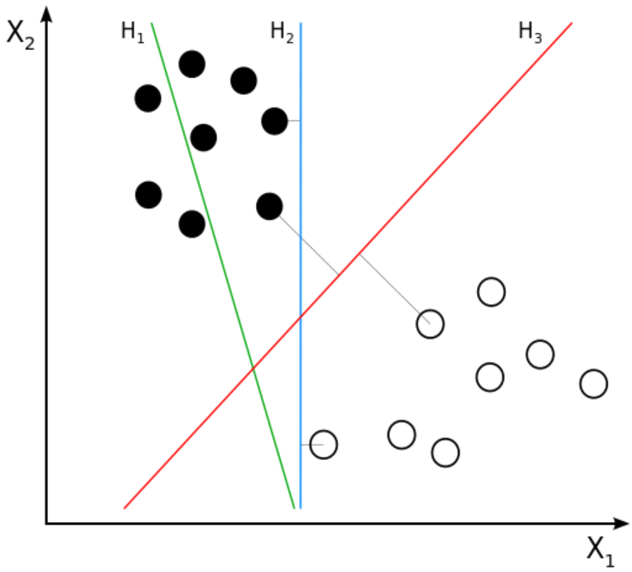


Fig 2: SVM Hyper planes

This SVM have mainly two drawbacks. First it treats positive and negative samples equally which is not appropriate, since the 2 groups of training feedbacks have distinct properties. Second most of the svm based RF techniques don’t take the unlabelled samples. To overcome these draw backs, BMMA and SemiBMMA are introduced in this paper.

III. Problem Domain

CBIR is a system for retrieving an image from the database using visual information such as color, texture, or shape. Before the spreading of information technology a huge number of data had to be managed, processed and stored. It was also textual and visual information. Parallelly of the appearance and quick evolution of computers an increasing measure of data had to be managed. The growing of data storages and revolution of internet had changed the world. The efficiency of searching in information set is a very important point of view. In case of texts we can search flexibly using keywords, but if we use images, we cannot apply dynamic methods. Two questions can come up. The first is who yields the keywords and the second is an image can be well represented by keywords. In many cases if we want to search efficiently some data have to be recalled. The human is able to recall visual information more easily using for example the shape of an object, or arrangement of colors and objects. Since the human is visual type, we look for images using other images, and follow this approach also at the categorizing.

In this case we search using some features of images, and these features are the keywords. At this moment unfortunately there are not frequently used retrieval systems, which retrieve images using the non-textual information of a sample image. What can be the reason? One reason may be that the text is a human abstraction of the image. To give some unique and identifiable information to a text is not too difficult. At the images the huge number of data and the management of those cause the problem. The processing space is enormous.

This paper is about to develop sketch based image retrieval system, which can retrieve using a sketches in frequently used database. The user has a drawing area where he can draw sketches, which are the base of the retrieval method.

IV. Problem Identification

The Sketch Based Image Retrieval (SBIR) was introduced in QBIC and Visual SEEK systems. In these systems, user draws the colour sketches and blobs on the drawing area. The images were divided into grids and the colour and texture features were determined in these grids. The application of the grids was also used in other algorithms, for example in the edge histogram descriptor (EHD) method. The disadvantage of this method is that they are not invariant opposite rotation, scaling and translation. Lately the development of difficult and robust descriptors is emphasized. Another research approach is the application of fuzzy logic or neural networks. In these cases the purpose of the investment is the determination of suitable weights of image features.

Even though the measure of research in the sketch based image retrieval increases, there is no widely used system sketch based image retrieval system. Our goal is to develop content based image retrieval system which databases are available for anyone looking back to free hand drawing. The user has a drawing area where he can draw all the shapes and moments which are expected to occur in the given location and with a given size. The retrieval results are grouped by color for better clarity. Our most important task is to bridge the information gap between the drawing and the picture, which is helped by own preprocessing and transformation process. In our system the iteration of the utilization process is possible, by the current results looking again, thus increasing the precision.

V. Problem Statement

This paper aims to develop SBIR system which can retrieve similar relevant images using BMMA and SemiBMMA techniques.

VI. Proposed System

In the SBIR system, firstly the user draws a sketch or loads an image. When the drawing has been finished or appropriate representative has been loaded, the retrieval process is started. The retrieved image is first preprocessed. After that the feature vector is generated, then using the retrieval system a search is executed in the previously indexed database. The retrieving process is done using BMMA and SemiBMMA process. As a result of searching, result set is displayed to the user, which appears in the user interface on a systematic form.

6.1 Global Structure of the SBIR

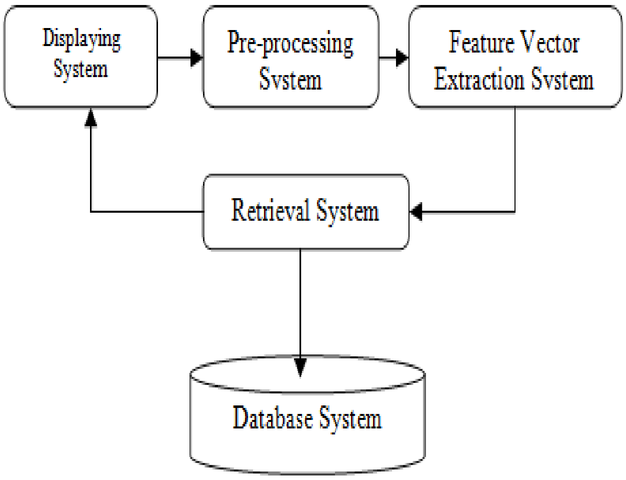


Fig 3: Global structure of the system

The global structure of the system contains preprocessing system, displaying system, feature vector extraction system, retrieval system and database system.

A. Preprocessing System

Preprocessing system which eliminates the problem caused by the diversity of images. The input of the preprocessing system is one sketch image and output is the processed result set. The system was designed for the database containing relatively simple images but even in such cases large difference can occur among images in file size or resolution.

B. Feature Vector Extraction System

Feature vector stores the feature vectors of the database images. Mainly edge histogram method is used in this system. One problem was encountered in the extraction of features in the hand drawing sketches. An information gap arise between retrieved sketch and coloured image of the database. This is avoided by the images in the database is converted into images.

C. Database Management System

Data base system contains three modules. The storage, data manipulation and retrieval. The storage module provides images, information and the associated feature vectors are uploaded to database. The file name, size and format of the image are attached. The retrieval results are obtained by usage of query module. The retrieval results contacts the database which provides the descriptors.

D. Retrieval System

As the feature vectors are ready, the retrieval can start. The output of the retrieval system is the response list of the query image.

E. Displaying System

The displaying system provides response list to the user. It contains positive and negative feedbacks. That means, from the retrieved images, user labels the number relevant samples as positive feedbacks and number of irrelevant samples as negative feedbacks. For extracting positive feedbacks, the techniques called Biased Maximum Margin Analysis (BMMA) and a Semi-Supervised Biased Maximum Margin Analysis (Semi BMMA) are used. These schemes are mainly based on the concept that it treats the positive and negative feedback unequally. Also, labeled positive feedbacks are mapped as close as possible and negative feedbacks are separated from positive feedbacks by a maximum margin in reduced subspace.

6.2 Proposed Scheme Structure

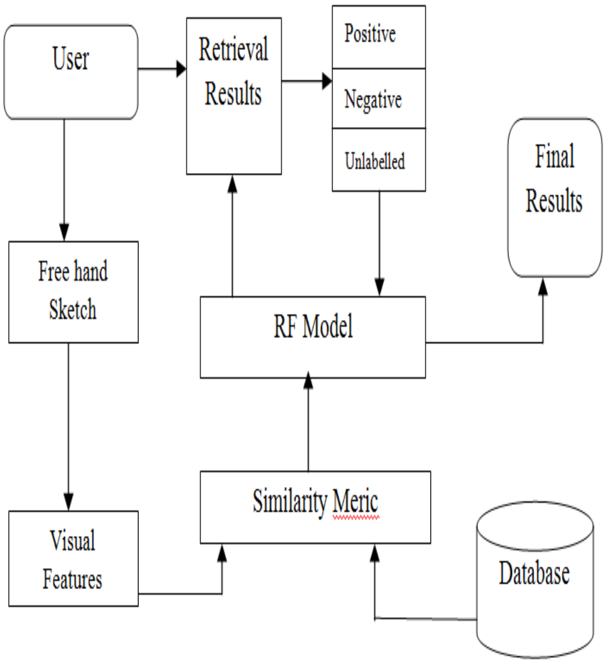


Fig 4: Sketch of Proposed scheme.

In this Fig 4 when a image query is submitted by the user, i.e, user draws an image or loads the image to the system. It firstly extracts its low-level visual features. Then all the images are arranged on the basis of similarity metric i.e. Euclidian distance. If the user is satisfied with the resulting image, then the process is completed and the results are displayed to the user.

Most of the time, the user is not satisfied with the first results because of the semantic gap. Then the user will label the most relevant images as positive feedbacks in the results. All the remaining images are labeled as negative feedbacks by the system. Based on positive and negative feedbacks, RF model can be trained on the basis of various existing algorithms. Then all the images are re-arranged on the basis of new similarity metric. After each round of iteration, the user will check whether the results are satisfied or not. If so, the process is completed otherwise it repeats until the user is satisfied with the expected results.

6.3. BMMA and Semi BMMA

The positive and negative feedbacks have distinct properties for CBIR. The SVM based RF treats positive and negative feedbacks equally. One problem is that different semantic concept lie in different semantic subspaces and each image can lie in any different concept subspaces. To avoid this problem, we use BMMA for SVM RF scheme. In this, negative feedbacks which have different concept with query image are separated by maximum margin from positive feedbacks which share similar concept with query image. So we can easily map the positive and negative feedbacks onto semantic subspace in accordance with human perception of image contents.

Using Laplacian regularizer to the BMMA, we can easily use the information of unlabelled samples in database, which is called SemiBMMA for the SVM RF. The result of the Laplacian regularizer is based on the local consistency which was inspired by the recently emerging varied learning community and can effectively depict the weak similarity between unlabelled samples.

Then the remaining images in the database are projected on the semantic subspace and a similarity measure is applied to sort the images. For SVM based RF, the distance to the hyper plane is the criterion to separate query relevant samples i.e. positive feedbacks from the query irrelevant samples i.e. negative feedbacks. After the projection step, all the positive feedbacks are clustered together while negative feedbacks are well separated from positive feedbacks by a maximum margin. So the resultant SVM classifier is much simpler and better than in the original high dimensional feature space.

BMMA aims to learn a projection matrix 'α' such that in the projected space, the positive samples have high local within-class similarity, but the samples with different labels have high local between-class separability.

6.4 Mathematical Concept of BMMA and SemiBMMA

In each round of feedback iteration, there are n samples $P = \{p_1, p_2 \ldots\ldots\ldots\ldots\ldots p_n\} \epsilon\ R^h$. For simplicity, we assume that the first n^+ samples are positive feedbacks, $p_i(1 \leq i \leq n^+)$, the next n^- samples are negative feedbacks $p_i(n^+ + 1 \leq i \leq n^+ + n^-)$, and all others are unlabelled samples $p_i(n^+ + n^- + 1 \leq i \leq n)$.

Let $l(p_i)$ be the class label of sample P_i. We denote $l(p_i)=1$ for positive feedbacks, $l(p_i)= -1$ for negative feedbacks and $l(p_i)=0$ for unlabelled samples. To better show the relationship between the proposed approaches, we use the similar notations and equations in graph embedding frame work.

Firstly, two different graphs are formed: 1) the intrinsic graph G, which characterizes the local similarity of feedback samples, 2) the penalty graph G^p, which characterizes the local discriminant structure of the feedback samples.

For all positive feedbacks, we first compute the pair wise distance between each pair of positive feedbacks. Then for each positive feedback P_i, we find its k_i nearest neighbourhood positive feedbacks, which can be represented as a sample set N_i^s, and put an edge between x_1 and its neighbourhood positive feedbacks.

Basically, the intrinsic graph measures the total average distance of the $|N_i^s|$ nearest neighbourhood sample pairs, and is used to characterize the local within-class compactness for all the positive feedbacks.

For the penalty graph G^p, its similarity matrix represents geometric or statistical properties to be avoided and is used as a constraint matrix in the graph embedding framework. In the BMMA, the penalty graph is constructed to represent the local separability between the positive class and the negative class. More strictly speaking, we expect that the total average margin between the sample pairs with different labels should be as large as possible.

For each feedback sample, we find its k_2 neighbour feedbacks with different labels and put edges between corresponding pairs of feedback samples

For each unlabelled samples $p_i(n^+ + n^- + 1 \leq i \leq n)$, for each unlabelled samples we find its k_1 nearest unlabelled samples which can be represented as a sample set N_i^{ii} , and put an edge between the unlabelled p_i and its neighbourhood unlabelled samples. This matrix term is known as Laplacian matrix.

The motivation for introducing this term is inspired by the regularization principle, which is the key to enhancing the generalization and robust performance of the approach in practical applications. There are lot of possible ways to choose a regularizer for the proposed BMMA. In this work we chose the Laplacian regularizer, which is largely inspired by the recently emerging manifold learning community. Actually, this scheme can preserve weak (probably correct) similarities between all unlabeled sample pairs and thus effectively integrate the similarity information of unlabeled samples into the BMMA. By integrating the Laplacian regularizer into the supervised BMMA, we can easily obtain the Semi BMMA for the SVM RF. The difference between BMMA SVM and SemiBMMA SVM for two classes of feedbacks can be shown in Fig:5

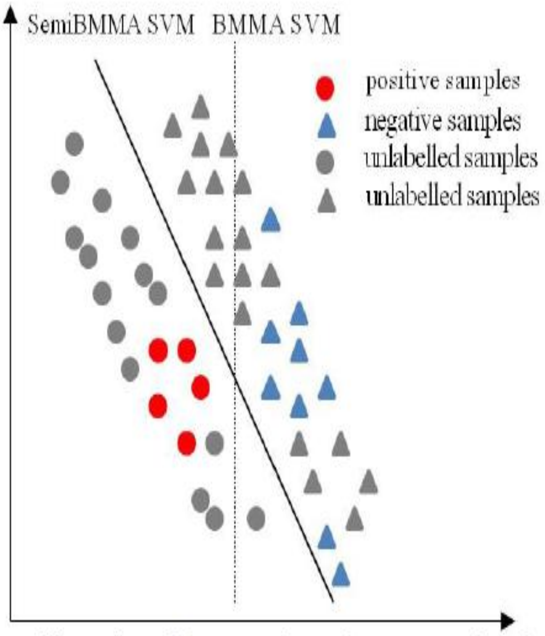


Fig 5: SVM hyper plane comparison between BMMA SVM and SemiBMMA SVM for two classes of feed backs

6.5 SemiBMMA Algorithm

Input: P = $\{p_1, p_2 \ldots\ldots\ldots\ldots p_n\} \epsilon\ R^h$, stand for all feedback samples and unlabelled samples which include the positive set P^+, the negative sample set P^-, and unlabelled samples

.

Step 1: Construct the supervised intrinsic graph G and calculate the matrix value of positive feedbacks

Step 2: Construct the supervised penalty graph G^p and calculate the matrix value of negative feed backs.

Step 3: Construct the Laplacian regularizer and calculate the matrix value of unlabelled samples

Step 4: Calculate the projection matrix α : project all positive , negative and remaining samples in the database on to the reduced subspace respectively.

Output: Positive and Negative samples Y^+ and Y^- , in this reduced subspace.

VII. Simulation

The proposed work has been implemented in MATLAB. MATLAB (matrix labortary) is a numerical computing environment. MATLAB (matrix laboratory) is a numerical computing environment and fourth generation programming language. Developed by math works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interface, and interfacing with programs written in other languages, including C, C++, Java, and Fortran.we can also use MATLAB to analyze and visualize data using automation capabilities, thereby avoiding the manual repetition common with other products. Programming and developing algorithms is faster with MATLAB than with traditional languages because MATLAB supports interactive development without the need to perform low-level administrative tasks, such as declaring variables and allocating memory. Thousands of engineering and mathematical functions are available, eliminating the need to code and test them yourself. At the same time, MATLAB provides all the features of a traditional programming language, including arithmetic operators, flow control, data structures, data types, object-oriented programming, and debugging features. MATLAB helps you better understand and apply concepts in a wide range of engineering, science, and mathematics applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology.

7.1 MatLab Key Features in the model

- High-level language for numerical computation, visualization, and application development
- Interactive environment for iterative exploration, design, and problem solving
- Mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration, and solving ordinary differential equations
- Built-in graphics for visualizing data and tools for creating custom plots
- Development tools for improving code quality and maintainability and maximizing performance

VIII. Input Output Model

Input	*Process*	*Output*
Free hand Sketch	Extraction of feature vectors	Feature vector of Sketch Image
Feature Vector of Sketch Image	Comparing the Feature Vector of Database image	Series of Images which is similar to database Images
User gives the Positive Feedback	Extract the Feature vector of the positive feedbacks	Feature vector of the positive Feed back
Feature vector of the Positive Feedback	Comparing the Feature vector of positive feedback with feature vector of database images.	Final Result, which contains user relevant images.

IX. Data Flow Model

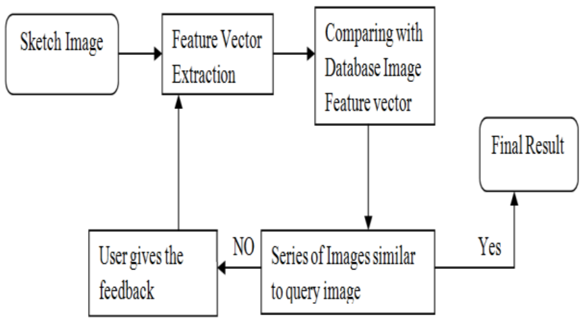


Fig 6: Data Flow Model

In Fig 6, when user draws an image or loads an image, the system firstly extracts the feature vector of sketch image. These feature vectors is compared with the feature vector of database images with the help of BMMA and SemiBMMA. As a result, we can get the group of images which is similar to the sketch image or query image. If the user is satisfied with this results, then the process is completed otherwise user gives the feedback to the system. Again the process is continued based on the positive feedbacks. After this, final result is presented to the user that contains user relevant images.

X. Result Analysis

10.1 Referenced database

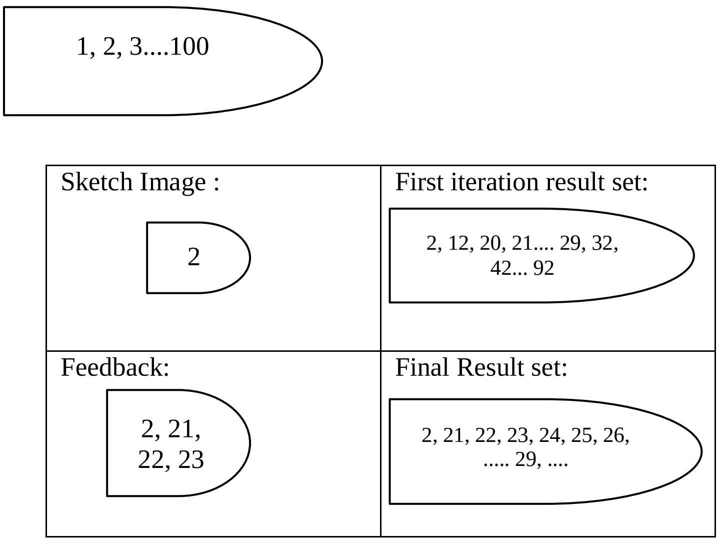
The Microsoft Research Cambridge Object Recognition Image database is used in this project. This database contains 209 realistic objects. All objects have been taken from 14 different orientations with 450 450 resolution. This database is widely used in computer and psychology studies. Some images of the database can be shown in the fig 7.

Fig 7: Database

10.2 Conceptual Set Model

To understand the SBIR concept clearly, consider the integer number system (1-100) as database. The user draws number ‘2’ as sketch image and loads to the SBIR system. Resultant set of system consists of 2,12,20....29,32,42....92. In this set, user label 2,20,21,22 as positive images and loads to the system. Then 2,20,21,22...29 are the first 12 image of the final result.

Database:



XI. Conclusion

CBIR is one of the research areas in digital image processing. Among the objectives of this paper performed to design, implement and test a sketch-based image retrieval system. Two main aspects were taken into account. The retrieval process has to be unconventional and highly interactive. The robustness of the method is essential in some degree of noise, which might also be in case of simple images.SVM based RF technique is one of the popular method to bridge the semantic gap and it increases the performance of the CBIR. In this we use BMMA and SemiBMMA technique for extracting the positive feedbacks of the user which enhances the performance of the sketch based image retrieval.

ACKNOWLEDGEMENT

The authors wish to thank the CSE department for their support and help in completing this work.

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