

Image Retrieval Using Mean Shift Clustering

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Abstract -Content-based image retrieval (CBIR) is a widely used technique for retrieving images from large database. But there are many issues with this method regarding its performance. So there is scope to improve the processing. In recent years, different techniques have been implemented to improve the performance of CBIR. The proposed CBIR system uses kernel mean shift clustering, which is density based clustering. It is a nonparametric method and uses pairwise constraints to guide the clustering process. Since, Clustering is the method of an unsupervised classification but it is observed that whenever a small amount of supervision is provided to clustering, it increases the clustering performance significantly. The existing methods, such as k-mean clustering, are sensitive to initialization. Performance of the system will improve in terms of precision and recall. The performance of the proposed system is compared with the existing method.

Keywords- Semi-supervised kernel clustering; mean shift clustering; Content based image retrieval; low rank kernel learning

I. INTRODUCTION

Content Based Image Retrieval (CBIR) is the efficient technique for searching images. It plays an important role in image processing. It is used for automatic ranking and retrieval of images based upon features of images. CBIR method is important for researchers, because it requires proficient and intelligent schemes for classifying and retrieval of Images. The main aim is to support image retrieval which is mainly based on properties of content that is the color, shape and texture which are usually set into feature array. These are the low level features and High level features may be distinctive content of image. A single feature may correspond to small part of the image property. Due to this, different and many features are considered to improve the retrieval process. Recently, the research focuses on CBIR systems that is fetching the exact corpus of relevant images and decreasing the retrieval time of the system [2]. For this, various techniques have been developed to improve the performance of CBIR system. Clustering is out of them.

Clustering is the method which is used to collect the data into partitions of homogeneous objects. It is also called unsupervised learning because a prior knowledge is not available for classification. It utilizes the inter-relationships among a collection of data and groups them into similar clusters. The objective of clustering algorithms is to form useful but unknown classes of data. Clustering can be categorized into two groups: supervised (including semi-supervised) and unsupervised [3]. It is observed that a small amount of supervision is helpful to

increase the performance of clustering [1]. So, the focus is on semi-supervised clustering.

The proposed method uses mean shift clustering to perform clustering on feature database. It is a nonparametric technique which does not require prior knowledge about the number of clusters, and does not constrain the shape of the clusters [21]. Mean shift is a simple iterative procedure. First, it defines a window (i.e. circle) in the interested region, then shifts each centre point to the average of data points in its neighbourhood within that window. Generally, the radius of the window is given by the user or estimated manually. This radius is also known as bandwidth parameter of mean shift method. Mean shift method iteratively locates the stationary points of a density function that are also known as modes [1,18,21]. These modes are further corresponds to the clusters in the data. The Kernel trick is used to map input space from low dimensional space to high dimensional space.

In many cases, this mapping is sufficient to achieve the desired separability between different clusters. In many cases, some additional information about problem domain is often available with unlabelled data. For example, a partial labelling of the data or number of clusters [1,21]. Now-a-days, the semi-supervised clustering methods have received lot of attention. That are aim to incorporate some labelled data with unlabelled data in the clustering algorithm. Therefore, the proposed system uses the semi-supervised kernel mean shift clustering. It uses some must-link and cannot-link pairwise constraints to guide the clustering process.

This paper is organized as follows: In Section I, a brief introduction of content based image retrieval systems and proposed system. Section II describes the related work in which we describe the motivational survey, efficiency and drawbacks of previous system. Section III describes the implementation details with mathematical model, process block diagram and datasets. Section IV describes the performance parameters to calculate results. And finally in Section V, we conclude with the summary of this paper.

II. RELATED WORK

The goal of this study is to provide a complete review of different clustering methods used in CBIR system.

Yixin Chen et. al. [6] have developed cluster-based retrieval of images by unsupervised learning (CLUE), for increasing user interaction with image retrieval systems by fully

utilizing the similarity information. CLUE extracts image clusters by applying a graph-theoretic clustering algorithm to a corpus of images in the proximity of the query. CLUE is dynamic.

In paper [7], a methodology for training adaptations of an RBF-based relevance feedback network, planted in automatic content based image retrieval (CBIR) systems, through the principle of unsupervised hierarchical clustering was proposed by Kambiz Jarrah et.al. The self-organizing tree map (SOTM) has shown an effective behavior in minimizing human interactions and automating the search process by efficiently dividing an unknown and nonuniform data space into more significant clusters.

Liu Pengyu et.al. [8] have proposed an image retrieval system based on image content using fuzzy logic and presented concept of partition the entire database based on content self-organized. They have used modified fuzzy c-means (MFCM) clustering scheme to group the database before retrieval and derived a new method to evaluate the fuzzy weight. The MFCM is less time consuming.

Liu Pengyu et. al. [10] have also presented modified fuzzy C-means (MFCM) clustering index algorithm, in order to decrease the time of clustering. MFCM is applied to transform high-dimension feature space into lower-dimension feature space by using Karhunen-Loeve (K-L) transformation. It forms the effective organization and improve retrieval speed.

In [12], R. Chary et. al. have defined an approach for Image Retrieval using cluster mean method using K-Means clustering method, where images are initially clustered into clusters having same threshold values. Image feature values are achieved from the images and saved into the database. They have proposed a method using image feature values which provides faster image retrieval and also finds the most relevant images in large image databases.

M. A. Bouker et. al. [13] have focused on a color indexing of images to develop an image retrieval system. A Mean-Shift is a statistical algorithm which is used to design the color distributions of images as two-dimensional Gaussian kernels.

Recently, Abdul jawad A. Amory et. al. have developed an approach that matches one window from the query image to all windows in each image in the image dataset and returns the closet matching, in [15]. This comparison is depending on features vector of gray-level intensity. To separate each window into K clusters, they have used K-mean clustering algorithm.

In recent work on CBIR systems, Deepika Nagthane [16] has developed four target search techniques that are Naive Random Scan Method (NRS), local neighbouring movement (LNM), and neighbouring divide-and conquer (NDC), and global divide-and-conquer (GDC) techniques. The target search techniques uses the concept of voronoi diagram [17] approach to remove the extra search space and step toward the target image with less iteration. To improve the performance K-means

clustering method is used. K-means clustering technique is helpful to decrease the elapsed time of the system.

Based on this literature survey, it is realized that many clustering methods, such as K-means clustering, spectral clustering and fuzzy C-means clustering, require the prior knowledge about number of clusters. So, we define number of clusters randomly. Because of this, we may get wrong number clusters as a result. This will also increase the time complexity. Hence, proper cluster extraction is vital for CBIR to increase the precision and recall.

This motivates us that there is need to improve the performance of existing CBIR system. For this, it is very important to find effective and efficient clustering methods. Kernel mean shift clustering is one of the most powerful methods. It is nonparametric i.e. it does not require any prior knowledge about number of clusters and size, shape and density of cluster. Related works on kernel mean shift clustering are also investigated and it was observed that when we apply some supervision to this method, it improves the clustering performance significantly. If this clustering method is combined with CBIR System, efficiency of existing CBIR system can be improved.

III. IMPLEMENTATION DETAILS

In the proposed system a feature database is created using different feature extraction techniques, for example, GIST descriptors for MIT scene dataset etc. There are two inputs to the proposed system, one is the image database and the other is a query image. The pre-processing is performed on both the inputs. After that apply the semi-supervised kernel mean shift clustering algorithm on the feature database. In that, the system will select b labelled points randomly from each class. From these points, all possible must-link constraint pairs are generated for each class and same number of cannot-link constraint pairs are selected from set of cannot-link pairs [1,5]. Then initial kernel matrix is computed using Gaussian kernel. The scale parameter is selected from a wide range of values and the target distances are calculated. Finally, the mean shift bandwidth parameter k is calculated [1]. In this way, the kernel mean shift clustering [1,19,21] is performed and clusters are generated. The cluster centroids are labelled for each cluster. Finally, system matches the query image with the cluster centroids in the database using Euclidean distance metric. And the output is the set of best K images. Performance is evaluated using precision and recall. Also, the adjusted rand (AR) index is used to compare the clustering performance with different clustering techniques [23].

A. Process Block Diagram

In the proposed CBIR system, given a query image, the system must output the top k similar images retrieved from the image database.

Therefore, the working of proposed system is divided into two modes, on-line and off-line. In the off-line mode, the system will generate the feature database and perform clustering

on it. Different clusters will be formed and they will be labeled with one centroid. All centroids will be stored for further process. In the on-line mode query image is taken as input, its features are extracted and are then compared with only those centroids that are stored. This will reduce the runtime complexity as the matching is not performed with the whole database.

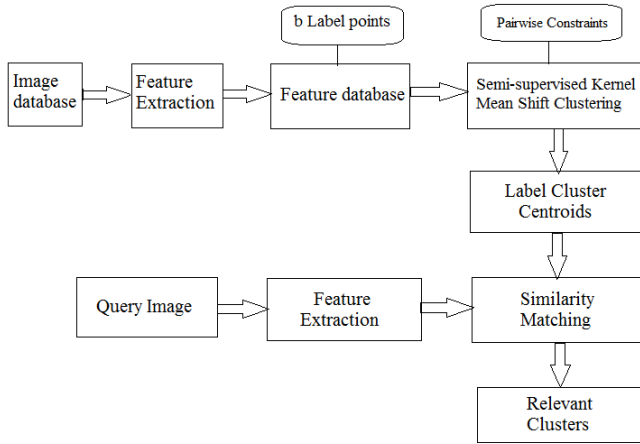


Fig.1. Block diagram of proposed system

System Architecture

1. Feature extraction: First the feature database is generated by performing feature extraction on the input image database. GIST features are extracted for MIT scene database. From this feature database b points are selected randomly and labeled to make a set of must-link pairs. The features of query image are also extracted.

2. SKMS Clustering: Semi-supervised Kernel mean shift clustering algorithm consists of four stages

• Initial parameter selection: This method is used to select the scale parameter σ for the initial Gaussian kernel function using the sets of must-link and cannot-link pairs and target distances. Given two input sample points $x_i, x_j \in \mathbb{R}^d$, the Gaussian kernel function is given by,

$$K_{\sigma}(x_i, x_j) = \exp\left(-\frac{\|x_i - x_j\|^2}{2\sigma^2}\right) \in [0,1]$$

Where σ is the scale parameter.

The target distances are calculated using,

$$d_m = \min(d_1, 0.05) \text{ and}$$

$$d_c = \max(d_{99}, 1.95)$$

where d_1 and d_{99} are the 1st and 99th percentile of distances between all pairs of points in the kernel space.

• Low rank kernel learning: When the initial kernel matrix has rank $r \leq n$, the $n \times n$ matrix updates can be modified to achieve a significant computational speed-up. Using singular value decomposition (SVD), the system will compute an $n \times n$ low-rank kernel matrix K such that rank

$$K = r \leq n \text{ and } \frac{\|K\|_F}{\|K_{\sigma}\|_F} \geq 0.99.$$

• Setting the mean shift parameters: This method is used to automatically select the bandwidth parameter using the pairwise must-link constraints. For given j^{th} constraint pair $(j_1, j_2) \in M$, the system will compute the pairwise distances in the transformed kernel space between the first constraint point j_1 and all other feature points as

$$d_i = (\mathbf{e}_{j_1} - \mathbf{e}_i)^T K (\mathbf{e}_{j_1} - \mathbf{e}_i), i = 1, \dots, n, i \neq j_1.$$

These points are then sorted in the increasing order of d_i . The bandwidth parameter k_j for the j^{th} constraint corresponds to the index of j_2 in this sorted list.

• Selecting the Trade-Off parameter: This method is used to select the trade-off parameter to weight the objective function for kernel learning. System will select γ by performing a two-fold cross-validation over different values of γ and the clustering performance is evaluated using the scalar measure Adjusted Rand (AR) index [23]. The adjusted rand index is defined by,

$$R_{adj}(C, C') = \frac{\sum_{i=1}^K \sum_{j=1}^{K'} \binom{m_{ij}}{2} - t_3}{\frac{1}{2}(t_1 + t_2) - t_3}$$

Each cross-validation step involves learning the kernel matrix with the specified γ and clustering the testing subset using the kernel mean shift algorithm and the transformed kernel function.

- Cluster centroids are stored for calculating Euclidean distance from query image.
- Then Euclidean distance is calculated and images are ranked.
- Finally the top K images are retrieved from the image database as output.

B. Dataset

Two types of data are used i.e. Synthetic data and real data to generate alternative clustering solutions with high quality.

a) Synthetic data:

1. Olympic Circles

The Olympic circles data consists of noisy points along five intersecting circles each comprising 300 points. The bandwidth parameter k will be 15 – 35.

b) Real data:

1. Corel Data Set

The Corel dataset consists of 10 categories and contains 1000 JPEG images. Each image is 256*384 pixels in size.

2. MIT Scene Data Set

The data set consists of 8 classes and contains 2688 labeled images. Each image is 256 × 256 pixels in size and belongs to one of the eight outdoor scene categories, four natural and four man-made. Only 7.44% data of real data is used as label points per class. The range of bandwidth parameter will be 4-14.

C. RESULT AND DISCUSSION:

1) Performance Metrics

To evaluate the performance of CBIR system, recall and precision, these two measurements are used. For a query q , the data set of images in the database that are relevant to the query q is denoted as $L(q)$, and the retrieval result of the query q is denoted as $R(q)$. The images which are relevant but are not retrieved from the database is denoted by $N(q)$. The precision of the retrieval is defined as the fraction of the retrieved images that are indeed relevant for the query.

$$\text{Precision} = \frac{L(q)}{R(q)}$$

The recall is the fraction of relevant images that is returned by the query.

$$\text{Recall} = \frac{L(q)}{L(q) + N(q)}$$

Usually, a tradeoff must be made between these two measures since improving one will sacrifice the other. In typical retrieval systems, recall tends to increase as the number of retrieved items increases; while at the same time the precision is likely to decrease.

2) Experimental Setup

In order to check the performance of the proposed system, the Corel dataset of 1000 natural JPEG images is used. These images are manually classified into 10 semantic categories, and this categorization will be the ground truth for clustering. Size of all images is either 256 X 384 or 384 X 256.

Because the ground truth is known, the performance of clustering is verified. In online mode, the each dataset image is given as query image, then precision and recall is calculated.

3) Result Table

In offline mode, the whole database of 1000 images is given as input to the system. The obtained clusters are verified across ground truth. The table shows the clustering results. The clustering process requires 5.33 minutes for 90 images of 9 categories and 7.45 minutes for 100 images of 10 categories.

Table 1: Result of clustering process for 100 images

Sr. No.	Cluster No.	Correctly Classified	Incorrectly Classified										Total	
			1	2	3	4	5	6	7	8	9	10		
1.	Elephant	10			2							2		14
2.	Rose	6					1					3		10
3.	Dinosaur	6							1				5	12
4.	African	10								1			2	13
5.	Dish	8											4	12
6.	Bus	9								5	1			15
7.	Horse	9		4	2							1		16
8.	Building	4					1	1					2	8

IV. CONCLUSION

Although this area has been explored for decades, no technique has been achieved the desired accuracy in distinguishing images. Earlier CBIR systems consist of low level feature extraction such as color, texture and shape and similarity measures for the comparison of images. But later on different image features and clustering techniques are used for Image retrieval. It is seen that among all clustering techniques, K-Means is widely used clustering technique in the process of content-based image retrieval. K-Means performs efficiently and reduce elapsed time. But it is sensitive to initialization, shape of the clusters and outliers. Because of this, the proposed CBIR system uses semi-supervised kernel mean shift clustering method. Unlike the other methods, mean shift clustering does not need the number of clusters as input and can identify clusters of different shapes, sizes and density. Since locality is imposed by the bandwidth parameter, mean shift is more robust to outliers. This method is also suitable for large data sets [1].

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