

Graph Embedding Framework on Relevance Feedback: A Survey

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Abstract—To improve the performance of the content based image retrieval (CBIR), relevance feedback (RF) plays an important role as it allows interactive image retrieval. Different RF techniques have been proposed, such as density estimation RF algorithm, subspace learning algorithm, classification based algorithm etc. The existing density estimation algorithm considers only positive samples and classification based algorithms considers positive and negative samples in different groups. Subspace learning algorithm assumes that positive and negative samples are linearly distributed. But existing algorithms are having the main drawback of semantic gap as well as ‘small sample size’ problem. In this paper, we discuss various RF techniques proposed earlier in the literature. The advantages of using a graph embedding framework for RF are also discussed. In addition this paper also provides a comparative study of various methods proposed by researchers in RF.

Keywords—Image retrieval, content based image retrieval (CBIR), relevance feedback (RF).

I. Introduction

Digital images are used throughout science, engineering, business, and personal computing. So digital images are very important class of data with an increased use of computers to hold and store data. Along with the rapid development of digital devices for image and video creation, storage and transmission, huge amount of images and videos are produced every day. Image data includes the raw images and information extracted from images, by automated or computer assisted image analysis. An image retrieval problem is the problem encountered when searching and retrieving images that are relevant to a user’s request from a database. To solve this problem, text-based and content-based are the two techniques adopted for search and retrieval in an image database. In text-based retrieval, images are indexed using keywords, subject headings, or classification codes, which in turn are used as retrieval keys during search and retrieval. Content-based image retrieval systems were introduced to address the problems associated with text-based image retrieval. Content-based image retrieval uses the visual contents of an image such as color, shape, texture, and spatial layout to represent and index the image. In CBIR, low-level features (such as color, shape, and texture, etc.) are extracted which represent the visual content of images. However, the low-level features captured from the images may not

accurately characterize the high-level semantic concepts, as visual features cannot always describe the semantics of the images. This introduces semantic gap which degrades the performance of CBIR. To minimize this semantic gap, relevance feedback (RF) was introduced. So, CBIR with RF increases the accuracy and efficiency of image retrieval.

II. Relevance Feedback

A. Principle of RF in CBIR

In CBIR, low level features of the image [1-4] i.e. color, texture and shape are extracted. The extracted features are stored in form of feature vector in the database.

The principal idea behind the RF is as follows:

- The user initializes a query session by submitting an image.
- The system then compares the query image to each image in the database and returns images that are the nearest neighbors to the query.
- If the user is not satisfied with the retrieved result, he or she can activate an RF process by identifying which retrieved images are relevant and which are irrelevant.
- The system then updates the relevance information, such as the reformulated query vector, feature weights, and prior probabilities of relevance, to include as many user-desired images as possible in the next retrieved result.
- The process is repeated until the user is satisfied or the results cannot be further improved.

There are different methods of relevance feedback:

- Density Estimation Algorithm
- Classification Based Algorithm
- Subspace Learning Algorithm

B. *Density Estimation Algorithm*

One class SVM [5] is one of the density estimation algorithms. In one class SVM, user marks positive and negative samples. But in training process only positive samples are considered for next iteration till user is not satisfied. Here data is represented by feature space and it is mapped into hyper sphere. This technique tries to keep size of sphere as small as possible and also tries to include all training data. To handle non-linear and multi-mode data, kernel function is used.

C. *Subspace Learning Technique*

The performance of the CBIR degrades due to semantic gap. Image can be represented by low-level features as well as high level features. But most of the time any image retrieval system represents image only in terms of the low-level features. But this assumption is very incorrect. To improve performance of CBIR relevance feedback is introduced so that user can retrieve expected result after passing through some iteration. This technique is based on one of the assumption as positive and negative samples are linearly distributed. But this assumption is not true in all cases.

In interactive image retrieval, in first iteration few similar images to query image are displayed. Then user has to label them either as “relevant” or “irrelevant”. Then as per feedback given by the user refined results are displayed in next iteration. This process is continued till user is not satisfied with the result.

But the drawback of this approach is that most of the time users wish to work with small sample size. Due to this reason whenever user labels any image either as positive or negative, it is not a representative of true distribution. This is nothing but ‘small sample size’ problem and is main drawback of subspace learning techniques.

In [8], Semantic Subspace Projection (SSP) is one of the subspace learning techniques. It overcomes the problem of ‘small sample size’. Positive and negative samples are not linearly separated always. So, it separates subspace into different semantic subclasses. But feature space may be non-linear & such non-linear subspace must be properly separated. Separation of non-linear subspace is not done properly in SSP. But Kernel SSP [9] can handle non-linear separable data. It is inefficient for high dimensional data of large size.

D. *Classification Based Algorithm*

AdaBoost [15] is one of the classification based technique. AdaBoost uses different classifiers for ‘relevant’ and ‘irrelevant’ samples. There are three variant of AdaBoost. First variant is known as Aggressive Boosting where the weights for the incorrectly classified objects are increased and the weights of the correctly classified objects are decreased at the same step size ‘k’. Second variant is Conservative Boosting where the weights are changed only in one direction. Either the weights of the correctly classified objects are decreased, or the weights of the misclassified objects are increased. Third variant is Inverse Boosting where instead of increasing the

likelihood of ‘difficult’ objects, we decrease it, thereby gradually filtering them out.

In [13], AdaBoost algorithm is used. In this algorithm, for each iteration of image retrieval marginal classifier is redesigned using user’s feedback information and irrelevant images are removed from database. However, the existing AdaBoost algorithms do not explicitly take sufficient measures to deal with this problem. Different component classifiers can be used as decision trees or as neural networks to improve the performance of AdaBoost. But when Decision Trees are used as component classifiers, decision of tree size is a critical factor. When neural networks are used as component classifiers, controlling overfitting is a major issue. Diversity between different classifiers used affects a lot on the overall performance of AdaBoost. It is also known that there is an accuracy/diversity problem in AdaBoost, which means that the more accurate the two component classifiers become, the less they can affect each other. Only when the accuracy and diversity are well balanced, then only AdaBoost can perform in excellent manner. It is very difficult to find out perfect marginal classifier which can balance accuracy and diversity. The decision boundary in this schema may be unstable when few number of example images are available.

In [25], regularized linear regression framework is used for interactive image retrieval. This method considers image feature space as a linear feature space. It considers both labeled and unlabeled images and highlights geometrical structure of image manifold. Here adjacency graph is created to model local image manifold structure. This graph structure is updated using user feedback. It uses prior information to change classifier. The classifier used minimizes the error and also respects graph structure. As it considers image manifold, it results in better performance than subspace learning techniques.

Support Vector Machine (SVM) [32] is one the most active technique. In different pattern classification problems, it provides good generalization performance with proper theoretical foundation. But, SVMs usually regard the problem as a strict binary classification task without noticing an important feature of relevance feedback. In real-world relevance feedback tasks, the number of negative samples is more than the positive samples. Moreover, the positive samples are often clustered in the same way while the negative examples are positioned in different ways. This imbalance problem may cause the positive samples to be camouflaged by the negative samples if they are treated without any bias.

Directly using SVM as an RF scheme has two main drawbacks. First, it treats the positive and negative feedbacks equally, although this assumption is not appropriate since all positive feedbacks share a common concept, while each negative feedback differs in diverse concepts. Secondly, it does not take into account the unlabeled samples, although they are very helpful in constructing a good classifier.

The main drawback of most of the relevance feedback techniques is the ‘semantic gap’ and ‘small sample size’ problem. But along with SVM if graph embedding

TABLE I

COMPARISON BETWEEN DIFFERENT RELEVANCE FEEDBACK TECHNIQUES

RF Technique	Advantage	Disadvantage
One-Class SVM	It tries to cover maximum number of training samples in small size of hyper sphere.	It neglects negative samples for training which degrades overall performance of CBIR.
Semantic Subspace Projection	It overcomes drawback of 'small sample size'.	It is inefficient for high dimensional data of large size.
Adaboost	It minimizes retrieval time using component classifier	Performance dependson marginal classifierand it is very difficult to find perfect marginal classifier
Regression	Considers image manifold in image retrieval.	Performs better for linear image manifold and fails in highly non-linear manifold.
Support Vector Machine	It classifies positive and negative samples as per the user feedback and increases speed of retrieval.	It considers positive and negative feedback equally.

framework [33] is used as RF technique then these drawbacks can be minimized. The features of such techniques are,

- It doesn't consider positive and negative samples equally.
- It shows similarity between positive samples.
- It shows dis-similarity between positive and negative samples.
- It maximizes the margin between positive and negative samples.
- It considers unlabeled samples to design better classifier which can improve the performance of the image retrieval system.
- The proposed system uses graph embedding framework which is effective to capture the intrinsic geometry structure in the original feature space.

As per the survey Table I give comparison between different RF techniques and briefly highlight their advantages and disadvantages.

III. Conclusion

Using relevance feedback the performance of content based image retrieval system can be increased. From the survey it is clear that there are various RF techniques have been introduced to remove semantic gap. SVM is one of the most popular RF techniques. The drawbacks of the SVM can be removed by combining graph embedding framework along with it.

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