Available online at www.sciencedirect.com
ScienceDirect
J. Vis. Commun. Image R. 17 (2006) 1108–1125
JOURNAL OF VISUAL Communication & IMAGE Representation
www.elsevier.com/locate/jvci

Content-based image retrieval using association rule mining with soft relevance feedback

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Received 9 May 2005; accepted 17 April 2006
Available online 19 June 2006

Abstract

With the rapid development of internet technology, the transmission and access of image items have become easier and the volume of image repository is exploding. An efficient and effective query reformulation is needed for finding the relevant images from the database. Relevance feedback (RF) is an interactive process which refines the retrieval results to a particular query by utilizing the user's feedback on previously retrieved images. Most of the existing approaches deal with hard feedback (relevant and nonrelevant) and focus on individual experience only. We propose to facilitate the use of soft feedback (involving excellent, fair, don't care, and bad) to better capture user's intention. To add this feature, all of the traditional RF techniques should be modified accordingly. Further, the meta-knowledge exploited from multiple users' experiences can improve the performance of future retrieval results. We propose a soft association rule mining algorithm to infer image relevance from the collective feedback. The number of association rules is kept minimum based on confidence quantization and redundancy detection. Also, binary search and best-first search techniques are implemented to expedite the process of relevance inference from the association rules. The proposed model provides a more flexible interface for relevance feedback and the experimental results manifest that the retrieval performance of the proposed model is better than that of traditional methods.

Keywords: Association rules; Confidence quantization; Content-based image retrieval; Redundancy detection; Soft relevance feedback

1. Introduction

With the rapid development of internet technology, the transmission and access of image items have become easier and the volume of image repository is exploding. To facilitate the retrieval of image data, many content-based image retrieval (CBIR) systems [1–4] have been developed. These systems provide various means for the users to describe their queries, such as a SQL-like query language, sample query images, iconic query pictures, or sketch query pictures, just to name a few. The system responds to the query by returning a set of database images that are 'similar in content' to the query. The search conducted by CBIR systems can be

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doi:10.1016/j.jvcir.2006.04.004

broadly classified into two classes: *target search* and *category search*. The purpose of target search is to find exactly a specific image, while the purpose of category search is to find a group of images that are similar to the given query. This paper focuses on the discussion of CBIR systems with *query by example* interface, both of target search and category search will be addressed.

Since the user, in general, does not know the composition of the image database, the retrieval system usually provides a browsing function which gives snapshots of the database images in order to help the user select a sample image as the initial query. However, as the images are matched based on low-level features, the target or the similar images may be far away from the query in the feature space and they are not returned in the limited number of retrieved images of the first display. Therefore, the query session is treated as a series of tentative query trials until the target or the similar images are found. The query is iteratively reformulated during the query session such that the query is getting closer to the target or the similar images.

Relevance feedback (RF) is an interactive process which can fulfill the requirements of query reformulation and it proceeds as follows. The user initializes a query session by submitting a sample image as the query. The system then compares the query image to each image in the database and returns t images in one display that are the nearest neighbors to the query. If the user is not satisfied with the retrieval result, he/she can activate an RF process by identifying which retrieved images are relevant and which are nonrelevant. 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 retrieval result. The process is repeated until the user is satisfied or the results cannot be further improved. The general system flow chart of the RF process is shown in Fig. 1.

Most of the existing RF approaches deal with hard feedback (relevant and nonrelevant) and focus on only individual experience (user's interactions with the system within one query session). However, most of the modern image databases are very large and the user is not able to know in anticipation the composition of the stored images, he/she may give incorrect feedback if only a two-level annotation interface is provided. Also, the classifications made by humans are usually soft or fuzzy, it is more flexible for the users to describe their intentions with soft feedback interface which provides multiple-level annotations. To add this feature, all of the traditional RF techniques should be modified accordingly. On the other hand, the meta-knowledge exploited from multiple users' interactions with the system across different query sessions can improve the performance of future retrieval results. With the collective feedback, association rule mining can find the most relevant images with the highest confidence.

In this paper, we present an image relevance association rule mining (IRARM) model with soft relevance feedback. The system uses the a priori association rules for image relevance inference and returns the most relevant images to the user. If the user is not satisfied with the current retrieved images, he/she can identify the relevance level of each retrieved image through our soft feedback interface and activate the embedded soft RF technique to improve the retrieval results. Some theoretical and practical issues will be addressed such as

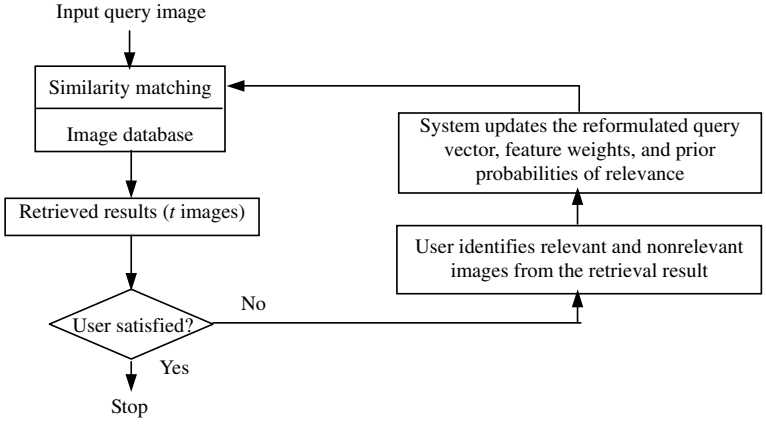

Fig. 1. The general system flow chart of the relevance feedback process.