MULTI-QUERY CONTENT BASED MEDICAL IMAGE RETRIEVAL

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ABSTRACT

This paper focuses on applying multi-query single-group methods to improve the content based image retrieval performance. The Multi-query-Max and Multi-query-Avg methods were applied using different numbers of query examples, namely three, five, and ten. The dataset contained medical images. The results obtained from the multi-query methods are compared to the single-query approach. The multi-query outperformed the single-query approach in all cases, meaning three, five, and ten queries based retrieval. Additionally, the Multi-query-Max method gives the best results on the bases of MAP (Mean Average Precision) value, when for the feature extraction purposes the Edge Histogram Descriptor (EHD) is used.

I. INTRODUCTION

The archives and repositories of enormous multimedia information exist nowadays. Their growth increases the need of highly sophisticated and advanced methods with efficient retrieval capabilities. In that context, the development of the content based retrieval (CBIR) systems goes to the highly progressed direction. Their progress is even more significant because of their wide use in many different fields including fingerprint identification, biodiversity information systems, digital libraries, crime prevention, medicine, historical research [1].

For more than a decade, image retrieval systems that support single image query have been widely used. They are continuously improved to enhance the retrieval response to the end user. Different techniques are used to improve the image retrieval systems such as multi-feature scheme, relevance feedback, region-based retrieval etc. [2]. However, they have some disadvantages. For instance, the major drawback of the relevance feedback approach is the speed of performance. For the region-based approach, neither the single nor multiple ROI (region of interest) methods can determine the importance between regions [2].

In general, many investigations have shown that single image queries are not sufficient for better retrieval performance [3] or they are inadequate according to their disadvantages. To express the required information, single image or, even more, single region is not sufficient. Moreover, it is believed that it is not possible to gain scalable, satisfactory query performance by using the query-by-one-example approach [4], which makes it inappropriate for achieving higher retrieval performance [2].

Although the most of the CBIR systems are based on the single query model only, it may be desirable or more suitable to search image database using more than one query images for detailed knowledge representation [5]. Multi-query approach arises to overcome some of the methods limitations used by the traditional CBIR systems to improve the retrieval efficiency. Moreover, the relationship of visual content in the multiple images contained in the query could be explored to represent the user's query more precisely.

In this paper, the focus is on applying two multi-query single group techniques. We use the maximum of multiple queries (MQ-Max) and the Average of multiple queries (MQ-Avg) methods [6]. The experiments are performed over the database of medical image obtained from ImageCLEF 2009 [7]. The motivation for applying multi-query image retrieval for medical purposes comes from the necessity for better and more complete expressing the query used for the retrieval of the most similar medical images. In medical context, it is crucial to increase the semantic similarity between the query and the resulting images.

The retrieval process is performed on the bases of multiple-query methods using three, five and ten queries and then is compared with the results obtained from the single query approach.

The paper is organized as follows. Section 2 presents the related work. In section 3, the details about multiple-query methods are given. Section 4 contains the description of the experimental setup including the dataset, feature extraction algorithms, the methods used in the experiments and experimental results as well. The concluding remarks are given in section 5.

II. RELATED WORK

Different researchers use multi-query image retrieval with various ways of integration. In [8], the approach that extracts different descriptors from the images and then combines them using linear combination is described. This combination is subsequently used as an input to the similarity calculation phase. The Query-by-Groups (QBG) approach is proposed in [9]. Different images in this approach are selected as queries and labelled as relevant (positive), irrelevant (negative) or neutral (do not contribute to the search). Then, the positive

examples are grouped in the separate groups which are included in the retrieval phase. Rather than grouping images in positives or negatives, the separation on the bases of the visual image feature is made in [10]. This is performed by clustering the query images at first, and then generation of the average image used as a query in the retrieval process.

Another approach considers selection of the Regions on interest (ROIs) [11]. The feature extraction is performed for different regions in parallel and using the best ones to calculate distances.

While in [12] the combination of the separate ranked lists on the bases of the rank of the list elements is used, in [13] the combination of the appropriate scores in the ranked lists is performed.

On the bases of the performed experiments in [3], it is shown that multi-query approach leads to the improvement in the retrieval effectiveness by approximately 9 to 20 percentages in comparison with the single query method. Even though, the obtained results are still far from the ideal because of inadequate knowledge and representation of the human perceptual process [2] and leave huge room for improvements. That is the reason why this area is still one of the biggest challenges and one of the most researched.

III. Query by Multiple Examples

Although the single-query approach is generally accepted in the traditional CBIR systems [14, 15], it is found to be insufficient and, accordingly, inappropriate for a wide range of problems [3]. To overcome these problems and improve the retrieval performance of the CBIR systems, the multi-query image approach arises.

Using the multi-query method, several images, representing the query, assist the retrieval process. This leads to achieving a more accurate description of user's intentions [16]. The system measures the similarities between the one image in database and all images in the multi-query representation to obtain the retrieval rank for each image in database. An advantage of the multi-query is considered as a supplement to the limitation of the using single–query approach, which is the description of the image content [5].

Depending on the method of query image usage, multi-image query content-based image retrieval can be separated into the single group approach and the multi-group approach [2].

A. Single-group approach

In the single group approach, all query images are considered equally important in the process of retrieval. There are different levels of integration that could be considered in this case. One of those includes calculating distances between the image to be ranked from the database and all images in the query set [2]. The rank for each image in the database is then calculated as

$$D(X_i, Q) = \underset{m}{F}(d(X_i, Q_j)). \quad (1)$$

where X_i denotes the image from the database to be ranked, Q is the set of query images, Q_j stands for each image in the multi-query set where $j \epsilon [1,m]$. F could be any function that appropriately combines the distances to each query image such as minimum or average.

Another case that could be considered in the case of single-group approach is combining the feature vectors into a single query context rather than combining the outputs [2].

The main advantage of the single-group multi-query approach is that it overcomes the limitations of the single-query approach. Moreover, it is easy for implementation and the top ranked images are similar to the most images in the query. However, this method leaves room for improvement basically because it does not treat the similarities between the query images [2].

B. Multi-group approach

This approach requires dividing images in the query set into different groups on the bases of their similarities, usually positives and negatives. By using this multi-group approach, irrelevant samples/features will not have crucial, or even any, impact the retrieval result and individual positive requirements are assured to be satisfactory at the same time. The main drawback of this approach is that there is possibility, which is not very rare, to have an image in the query set that contains positive and negative feature, thus making the grouping process more difficult than it seems to be. Another disadvantages is that this process might not be implemented automatically, leading to the necessity of manually grouping the query images by the user himself. This way, there is still the lack of detecting the important features/components within the positive query group.

IV. Experimental Setup

A. Dataset

The dataset contains medical images obtained from the ImageCLEF 2009 [7]. It consists of medical radiological images collected randomly from daily routine work at the Department of Diagnostic Radiology. Most of the images are secondary digitalized images from plain radiography, but there are also images from other modalities, such as CT and ultrasound imaging. It is important to notice that the dataset contains a wide variability, including images of different body parts of patients from different ages, different genders, varying viewing angles, and with or without pathologies. The

quality of radiological images varies considerably as well, and there is high within–category variability together with a strong visual similarity between many images belonging to different classes [17].

The experiments were conducted with three, five, and ten query images. The image set that is searched contains 12677 images.

B. Feature extraction

Three different algorithms are used for feature extraction: Edge Histogram Descriptor (EHD) [18], Local Binary Patterns (LBP) [19,20], Brightness and Texture Directionality Histogram (BTDH) [21]. The experiments are performed in the case of all three descriptors separately.

C. Single-query Retrieval

The single query retrieval is performed at first. The distance between the query image and all images in the database (12677 in total) is calculated. For this purpose, the Euclidean distance is used. This is repeated in three cases, where images are described with EHD, LBP, and BTDH descriptors separately.

D. Multi-query Retrieval

For the multi-query purposes, two single-group methods are used. Using the first method, maximum of multiple queries (MQ-Max), each query is used separately and independently from the other queries in the same set. When the retrieval phase finishes, the retrieved ranked lists are combined so that the rank of each image in the database is determined as the maximum of the individual scores obtained from each query. Three types of query sets are considered, the query set with three, five, and ten query images.

The other method, Average of multiple queries (MQ-Avg) is very similar with the first one, and belongs to the single-group multi-query methods as well. The main difference lies in the phase of combining the ranked lists. In this case, rather than calculating the maximum of each score, the image score in the final ranked list is calculated as the average of the individual scores.

E. Experimental results

The medical image retrieval process is tested and analysed from a few different aspects. Two different multi-query approaches are applied to the dataset of medical images, MQ-Max, and MQ-Avg. The experiments are done with a different number of queries in the query set. The images in their bases are represented by three kinds of descriptors, EHD, LBP, and BTDH. As an evaluation technique, the Mean Average Precision is used.

Fig. 1 depicts the fop 20 ranked images using the single query method, while the fig. 2 shows the top 20 ranked images using multi query methods with ten images in the query set.

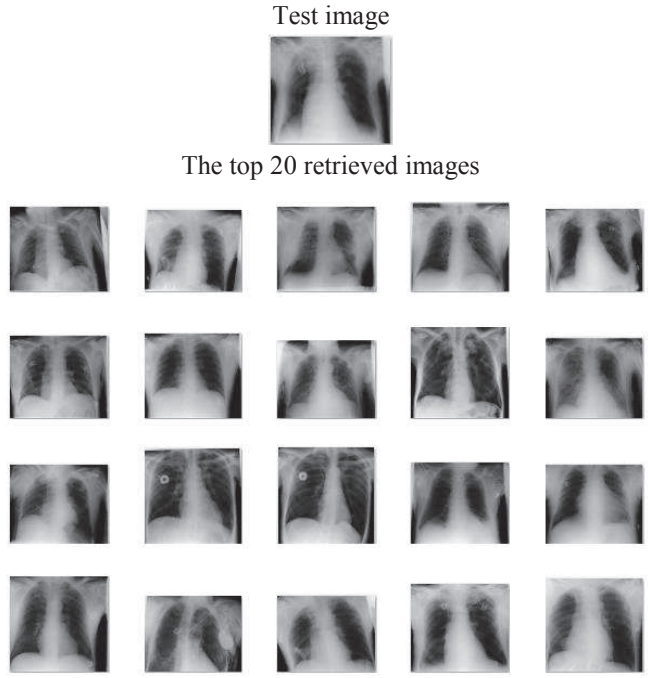

Figure 1: The results from the single-query retrieval (feature extraction algorithm: BTDH).

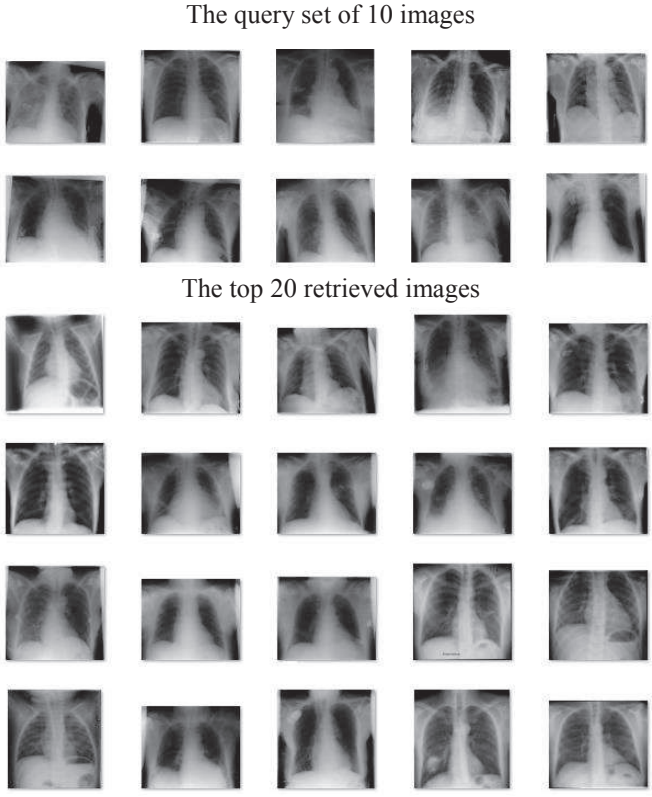

Figure 2: The results from the multi-query retrieval (feature extraction algorithm: BTDH).

The retrieved images depicted on fig. 1 and fig. 2, are obtained when the BTDH algorithm is used for the feature extraction process. It should be noticed that the top 20 retrieved images shown on fig. 2 are the same for MQ-AVG and MQ-MAX method, which means that there is no difference between the methods decisions, taking into consideration the top 20 images.

There is another important thing that should be emphasized when making a comparison between the first 20 retrieved images using the single- and multi-query algorithm. The top 20 images retrieved using multi-query method all belong to the same class as the test images, while in the first 20 images in the case of single-query approach, there is one image (the 16th image counting by rows) that belongs in different class of the query image class.

Table 1 represents the results when single-query retrieval is used in the case of all three descriptors used in the feature extraction phase.

Table 1: Single-query retrieval in the case of EHD, LBP, and BTDH descriptors individually.

Descriptor	MAP (%)
EHD	20,45
LBP	14,85
BTDH	11,92

In Table 2, Table 3, and Table 4, the results obtained from the multi-query methods in the case of three, five, and ten images, using the three descriptors separately are given respectively.

Table 2: Multi-query retrieval in the case of EHD descriptors individually, and 3, 5 and 10 images in the query set.

MAP (%)	Multi-query method	
No. of queries	MQ-Max	MQ-Avg
3	26,19	26,49
5	27,02	28,79
10	27,84	30,01

Table 3: Multi-query retrieval in the case of LBP descriptors individually, and 3, 5 and 10 images in the query set.

MAP (%)	Multi-query method	
No. of queries	MQ-Max	MQ-Avg
3	17,38	17,45
5	18,22	19,85
10	16,31	21,23

Table 4: Multi-query retrieval in the case of BTDH descriptors individually, and 3, 5 and 10 images in the query set.

MAP (%)	Multi-query method	
No. of queries	MQ-Max	MQ-Avg
3	14,60	14,51
5	16,64	16,16
10	17,15	15,87

By analysing the results, it can be concluded that both multi-query methods outperform the single-query method in all cases. Additionally, it can be concluded that the best result (on the bases of MAP) is obtained when the images are described with EHD descriptor. In this case the MQ-Avg method with ten query images gives the best results (MAP=30,01%).

If the LBP algorithm is used for the feature extraction, again MQ-Avg method and ten images in the query set leads to the best result (Map = 21,23%). Rather than that, when BTDH algorithm is used for feature extraction, MQ-Max method with ten query images outperforms MQ-Avg method with three, five and ten query images, as well as MQ-Max with three and five images (MAP=17,15%).

It is important to notice that, the raising number of queries in the query set (from three to ten) usually (but not always) leads to slightly better results. However, there are exceptions in this. The reason is that the single-group type of multi-query methods is used in the experiments. This means that the similarities between the query images are not treated and the positive or negative features/components/examples are not considered. Thus increasing the number of query images sometimes might signify the positive and sometimes the negative features/components leading to positive or negative influence to the final decision.

V. Conclusion

In this paper, multi-query single-group methods were applied with the aim to improve the content based medical image retrieval performance. Different numbers of query examples, three, five, and ten, were used and the results were combined using Multi-query-Max and Multi-query-Avg methods. The comparison between the results obtained with these methods, as well as with the single-query approach was made. It was concluded that the multi-query outperformed the single-query approach in all cases. Additionally, the results were analysed when different feature extraction algorithms were used for feature extraction, Edge Histogram Descriptor, Local Binary Patterns, and Brightness and Texture Directionality Histogram. It was noticed that in the case when images are

described with Edge Histogram Descriptor, the results are the best in general. The results were compared on the bases of Mean Average Precision. The best value of MAP was obtained with MQ-Avg method and ten images in the query set. It was also concluded that the bigger number of images in the query set not always leads to better results.

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