United Institute Of Informatics Problems at CLEF2009: Medical Image Retrieval Task

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Abstract

This paper describes methods and results archived by our research group at the Cross Language Evaluation Forum (CLEF'2009). In our work we concentrated on the medical image retrieval task. All the attention was given to the retrieval based on nine visual topics only. No textual information was considered.

Our goal was to develop and comparatively assess image descriptors for content based retrieval on the large medical image database. In addition to results of official relevance judgment, time- and computational efficiency of the algorithms has also been of our interest.

An approach based on generalized co-occurrence matrices was used. The following elementary image characteristics have been utilized: signal intensity, absolute value of the intensity gradient and the angle between the gradient vectors in the pixel pairs.

Categories and Subject Descriptors

H.3 [**Information Storage and Retrieval**]: H.3.1 Content Analysis and Indexing; H.3.3 Information Search and Retrieval; H.3.4 Systems and Software; H.3.7 Digital Libraries

Keywords

Medical imaging, CBIR, Generalized co-occurrence matrix, Distance measure

1 Introduction

This paper describes basic methods and results archived during the medical image retrieval competition of CLEF 2009 [1]. Since we are working with visual information only, most of attention is given to generalized co-occurrence matrices as image descriptors.

2 Methods

Image retrieval procedure consists of two steps. Initially, image content is represented by global features, i.e. descriptors are calculated. Next, the descriptors are compared to a sample image in order to find most similar ones.

2.1 Image descriptors

Generalized co-occurrence matrices [2] extend classical Haralick matrices [3] first introduced in 1973. Co-occurrence matrix for gray level image can be a matrix of relative frequencies $P(i,k,d)$ with which the pixels with gray levels i,k occur in the image by distance d apart (Fig. 1).

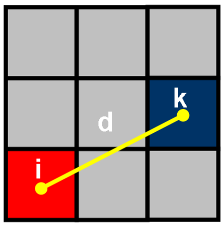

Figure 1: Pair of pixels with gray levels i,k at distance d.

As both variables take continuous values, the construction of such a histogram will require their quantization. Depending on the range of relative distances considered and the number of bins used, this step could be quite computationally intensive. However, it is not necessary to consider a large range of distances. Depending on the task we want to perform, we may restrict ourselves to only a small range of. If this distance value is small, the histogram will contain local information concerning the described shape or texture. If the value is large, global information is conveyed.

Taking into account the extensive experience on the medical image analysis, classification and recognition using these descriptors, the following elementary image characteristics have been utilized:

- brightness (signal intensity);
- absolute value of the intensity gradient;
- the angle between the gradient vectors in the pixel pairs.

As it was shown experimentally [4, 5], together with the information on their variation in space these elementary image characteristics may describe the image structure properly.

A multidimensional co-occurrence matrix of a general form that combines all of above characteristics and relationships looks as follows:

$$W = \|w\left(I(i), I(k), G(i), G(k), A(i,k), d(i,k)\right)\|,$$

where

$i = (x_i, y_i), k = (x_k, y_k)$ is an arbitrarily pair of pixels,
$d(i,k)$ is the distance between them,
$I(i), I(k)$ is the intensity of the pixels,
$G(i), G(k)$ is the absolute values of brightness gradients,
$A(i,k)$ is the angle between the directions of the gradients.

The color images were converted into gray images using:

$$I = 0.3 \times R + 0.59 \times G + 0.11 \times B$$

2.2 Similarity measures

The histograms/co-occurrence matrices that represent different images have to be compared and their difference be expressed by a single number if possible. This can be achieved with the help of a metric defined to measure the ”distance” between two histograms.

As a similarity measure of the classes (topics), the following distances were tested:

- canberra metrics

$$d_{canberra}(X,Y) = \sum_{i=1}^{n} \frac{|x_i - y_i|}{x_i + y_i},$$

- manhattan metrics

$$d_{manhattan}(X,Y) = \sum_{i=1}^{n} |x_i - y_i|$$

- and absolute value of correlation coefficient

$$d_{correlation}(X,Y) = \left| \frac{E(XY) - E(X)E(Y)}{\sqrt{E(X^2) - E^2(X)}\,\sqrt{E(Y^2) - E^2(Y)}} \right|,$$

where E is the expected value operator, $X = (x_1, x_2, \ldots, x_n)$ and $Y = (y_1, y_2, \ldots, y_n)$ are feature vectors.

Some visual topics could contain several images as a query, so we tried two types of distance measures to the group of images:

$$d_{centroid}(X,Y) = mean(x_i)$$

and minimum distances

$$d_{min}(X,Y) = min(x_i).$$

Additionally, color control was used during the retrieval: if the query contained color/gray images, corresponding images were moved at the top of the results.

3 Experiments

Initially, due to descriptors' normalization, original images were scaled down:

- proportional rescaling to 320 pixels width;
- rescaling to 150×150 pixels;
- rescaling to 300×300 pixels.

After that different types of descriptors were calculated and stored into binary files (Table 1). In our experiments we have chosen 5–7 bins for every dimension of the co-occurrence matrix. Average time for generation one image descriptor was about half of a second.

Descriptor	Number of elements	Database of descriptors
GGAD	1944	570Kb
GGGD	2907	852Kb
IIGGAD	54432	16Gb

Table 1: Types of descriptors used in our experiments

Various types of descriptors and metrics in combination with image rescaling, produced 42 runs.

In our opinion, the best retrieval results on such a common database were achieved with IIGGAD descriptors and minimum distance on manhattan metrics (Fig. 2). Thus only two runs were submitted (Table 2)

Figure 2: A snapshot of the retrieval result (top 15 results, visual topic # 5)

Run title	Description
UIIPMinsk_45_8_1244619573674	300×300 images, IIGGAD, minimum manhattan
UIIPMinsk_45_8_1244704201053	150×150 images, IIGGAD, minimum manhattan

Table 2: Two runs submitted by UIIPMinsk group

4 Results and discussion

As it was our first experience at this competition, we erroneously did not run mixed and semantic topics. Thus, only 9 out of 25 topics were submitted. According to a general number of relevant results our two runs can by ranked 3rd and 6th respectively out of 13 visual runs.

Generalized co-occurrence matrices are intended to find visually similar images. As some topics can by semantically the same but visually absolutely different, employment of textual information has more potential. Despite all this, generalized co-occurrence matrices showed very promising results as similarity measures of medical images.

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