CONTENT-BASED IMAGE RETRIEVAL OF COATS OF ARMS

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Abstract — The paper describes a content-based image retrieval system for coats of arms. The characteristics of arms are analyzed and specific features for segmentation, object layout, symmetry, etc. developed and implemented. Search queries are formulated and classified into query models which represent similarity of images by the features they use. These models are rated by recall and precision.

INTRODUCTION

Coats of arms are wide spread in European countries. Every region, city, country and many families have their own coat of arms. Arms have their origin in medieval times when knights were difficult to identify because of helmets and armory. People started to use specific patterns and symbols to allow for identification. Heralds had the task to determine to whom a specific coat of arms belonged and over time they became very knowledgeable in this field. They started to collect information about the various arms and also became responsible for ensuring that coats of arms were unique.

Nowadays much of the existing knowledge has been lost and only experts in heraldry can read the various coats of arms. In general, they use reference books that list coats of arms by the objects they contain, in order to help identifying an unknown shield. However, there is no general agreement on the method of index production and different fields, for example, aristocratic and civic arms, show huge differences in the methods applied and in the elements listed. Heraldry experts have expressed strong doubts that even with computer support there will ever be a general systematic index for coats of arms [8].

An arms database with an interface for content-based image retrieval would improve the situation of the experts: the search process would take considerably less time, errors would be minimized and search results would be presented in a compact form. This paper describes the first major step in the development of such a system: the implementation and test of suitable image features.

The next section investigates some advantages of coats of arms for content-based retrieval and gives an overview over the functions implemented. The next two sections describe the test environment and summarize both, the testing process and the gained results. The last section gives a short outlook on future work.

FEATURE DEVELOPMENT

Using coats of arms for content-based image retrieval has - among others - the following advantages: Arms have a synthetic origin and use therefore only a few specific colors and shades. Most arms have a clear structure and are often symmetrical. They contain only few kinds of objects like dragons, lions, Christian symbols, etc.

For the retrieval of similar arms from an image database several features were implemented: one to detect the segmentation of arms, one to find out symmetries and others for the layout of objects in the image, the number of colors and finally, a color histogram. The idea behind these features is that they should be used in combination. By forming query models different types of similarity can be defined (e. g., using the segmentation feature with a color histogram defines a more strict similarity than the color histogram alone).

Figure 1 shows the coats of arms of the German Landkreis Füssen (rural district in Bavaria; from [5]): The image consists of three subareas, uses the typical bavarian national emblem and two Christian symbols for two neighboring dioceses. The segmentation feature divides arms into their subregions. Our example has a typical T-structure with the national emblem on the top and region specific objects underneath: The distance function for this feature determines whether two features have

Figure 1: Coat of Arms, segmentation and object layout.

the same, a similar (e. g., T-form and cross-form) or a different (e. g., horizontal and vertical) segmentation. The symmetry feature divides an image into two halves and subtracts one half from the mirrored other. The feature value is the standardized sum of the resulting pixel values and the distance of two images is the absolute difference between these values.

The third feature calculates the layout of objects in arms (compare [2]). An object is described by the geometrical shape (line, triangle, etc.), size, number of edges,

color and position. The schematic layout of the coats of arms of Füssen is depicted in Figure 1 at the right. The distance function for the object layout sums up the number of similar objects in an image (simObj) and returns D = 1 / (simObj + 1). The number-of-color feature counts all color shades in an image with an area of more than one per cent of the image size. The color histogram feature produces a histogram with six color bins (red, blue, yellow, green, black, white).

TEST ENVIRONMENT

For the tests described in the next section IBM QBIC was used ([3], [4]). The system was extended by a practical web-interface (a perl CGI-script) a search engine for query models (similar to QbQBE) and some C-libraries for vectorization ([2]), object evaluation, etc. The following figure describes the various components of the test environment:

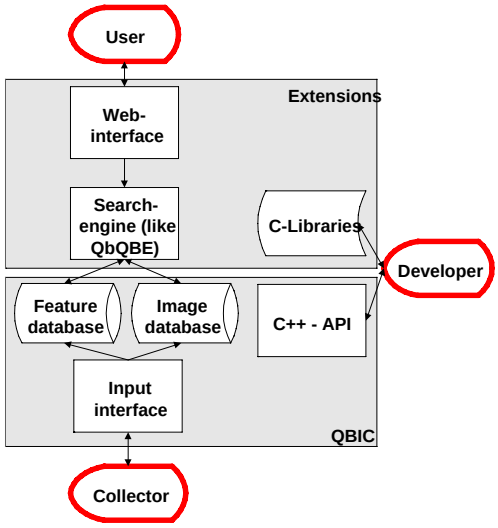

Figure 2: Test environment

The web-interface consists of a query-section (where similarity is defined by the used features and their order), an image section (with the search results) and a result table with statistical information (performance, etc.). Figure 3 shows a typical screen shot.

The coats of arms (444 images) were taken from a heraldry server in the Netherlands ([5]): most of them are German civic arms. Each image was rated according to prominent features (segmentation, etc.) and groups of similar arms were formed (e. g. Bavarian arms, etc.). The features were programmed as C++ classes.

Figure 3: Web interface.

TESTS AND RESULTS

For testing features and query models, first, the performance of each feature (feature and distance computation) was determined. Second, the efficiency of features likely search queries were phrased and a possibly suitable query model derived. Finally, each query model was tested and the average recall and precision values calculated.

feature	feature computation (ms)	distance computation (ms)
Color histogram	14.71	0.0901
number of colors	93.87	0.0676
object layout	171.15	0.0901
segmentation	135.36	0.0676
symmetry	30.87	0.0676

Table 1: Feature performance.

Table 1 summarizes the average performance of each feature on a workstation with an Intel Pentium II processor, 128 MB RAM and Linux (Kernel 2.0.35) as operating system.

The order of features in a query model was determined by the time needed for the calculation of the distance function: features with a fast computation of the distance function were used first. In step 2 the efficiency of each feature (e. g., error rate or the ability of a feature to cluster the image set) was calculated. The segmentation feature for example distinguishes 22 types of segmentations and finds out the correct segmentation for 86% of the arms in the test database.

Table 2 shows the verbose description of search queries and corresponding query models. Each type of search query defines a different type of similarity. Query models implement these different types of similarity by the combination of different features.

no.	search query	model
1	high symmetry, red	symmetry, color histogram
2	vertical segmentation, few colors	segmentation, number of colors
3	big, central image in white or yellow with blue background	object layout, color histogram

Table 2: Search queries and query models.

After that tests were done for each model and the average recall and precision were calculated (using the group information which was made out by hand). The next image shows recall and precision for each search query and an average over all questions:

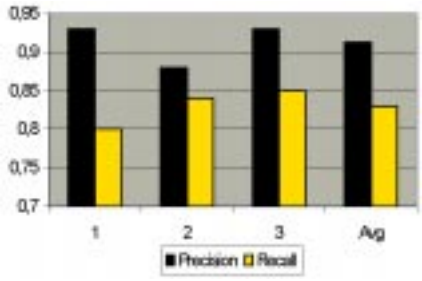

Figure 4: Test results.

Results are satisfactory and range from 0.8 to 0.85 for recall and 0.88 to 0.94 for precision. In most cases the value of precision was higher than the one for recall. Since these variables are interdependent, their values can be partly controlled through the interface.

FUTURE RESEARCH

The next step will be to develop a suitable interface for the end user from the current web interface. It should become possible to initiate queries both by example images and by feature values (e. g., a typical color histogram). The level of the search queries should be raised from the current more technical level to one more suitable for the end user. For example, it should be possible to ask a query for all Bavarian arms. To reach this goal additional features are needed and existing ones have to be improved.

Currently, the problem of ordering features in a query model was solved by using the features with faster distance functions first. For a more sophisticated solution to this problem, an optimization model was developed, which also takes into account the contribution of a feature to cluster the image database into the ordering process. It will be one of the next steps to integrate this model into QBIC.

CONCLUSION

The paper describes a content-based image retrieval system for coats of arms. The characteristics of arms were analyzed and specific features for segmentation, object layout, symmetry, etc. developed and implemented. Search queries are formulated and classified into query models which represent similarity of images by the features they use. These models are rated by recall and precision. Results are promising but leave more than enough space for future work.

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