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SIMBA – SEARCH IMAGES BY APPEARANCE

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Abstract: SIMBA is a content based image retrieval system performing queries based on image appearance. SIMBA uses two feature extraction techniques: color and texture feature extraction, provided by Content Based Image Retrieval System. In SIMBA, object position is irrelevant for image similarity hence invariant features are used for the purpose. Based on general construction method, i.e. integration over the transformation group, the invariant feature histograms are derived that catch different cues of image content: features that are strongly influenced by colour and textural features that are robust to illumination changes. The feature extraction does not require any manual interaction, so that it might be used for fully automatic annotation in heavily fluctuating image databases.

Keywords: SIMBA, invariant features, content based image retrieval, colour and texture features.

I. INTRODUCTION

Content based image retrieval (CBIR) technique has been a widespread field of research. Also known as **Query By Image Content**(**QBIC**) and **Content-Based Visual Information Retrieval** (**CBVIR**) is the application of computer vision techniques to the image retrieval problem, that is, the problem of searching for digital images in large databases. CBIR is widespread because of the ever increasing amount of available image data, which requires techniques for efficient access. The features of CBIR can be classified into: colour with/without layout, texture, shape, combinations and motion parameters [1].

There are two invariant features of CBIR are considered in SIMBA: colour and texture. The simplest system uses a colour histogram [12]. Other systems perform a segmentation of the image and compare images based on their features and their absolute or relative locations [9, 5]. Texture is often considered in combination with colour. Invariant features are developed to characterize images independently from absolute object positions. In general objects are subject to quiet complex transformations when projected into an image plane hence are restricted to approximating the real transformations by transformations that can be mathematically treated with reasonable effort. In [2], general methods for construction of invariant features is explained. Here the focus is on the invariant features for the group of translations and rotations. These features have proven to be robust to independent motion of objects, different object constellations, and articulated objects and even to topological deformities. The method does not require error-prone pre-processing of the data as required by segmentation and can be applied directly to the original image data. It is of linear complexity but can be reduced to constant complexity by using Monte-Carlo estimation [7].

ORGANIZATION OF THE PAPER

In Section III, the extraction of colour and texture features is described in brief. In Section IV, considering two different invariant features, i.e. colour feature and brightness independent of illumination changes, SIMBA - a content based image retrieval system, is presented.
In Section V the observation for the query that was performed on SIMBA is shown and finally in Section VI conclusion is given.

EXTRACTION OF COLOUR AND TEXTURE FEATURES

COLOUR FEATURE EXTRACTION:

The key items in colour feature extraction consist of colour space, colour quantization, and the kind of similarity measurements. CBIR uses three colour descriptors, namely, colour moment, colour histogram, and Colour Coherence Vector (CCV).

a) COLOUR MOMENT and COLOUR HISTOGRAM
Mean, variance, and standard deviation are defined for an image of size N X M in the following equations, respectively.

$$\bar{x} = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M} x_{ij}}{NM} \quad (1)$$

$$\delta^2 = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(x_{ij} - \bar{x}\right)^2 \quad (2)$$

$$\delta = \sqrt{\frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}\left(x_{ij} - \bar{x}\right)^2} \quad (3)$$

where x_{ij} is the value of the pixel in row *i* and column *j*.
A histogram is the distribution of the number of pixels for an image. The colour histogram represents the colour

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content of an image [6]. It is robust to translation and rotation [13]. Colour histogram is a global property of an image. The number of elements in a histogram depends on the number of bits in each pixel in an image.

The colour histogram can be used to efficiently calculate the mean and standard deviation of very large data sets. This is especially important for images, which can contain millions of pixels. The sum of all elements in the histogram must be equal to the number of pixels in the image.

$$Number\ of\ Pixels = \sum_{i=0}^{255} \mathrm{h[i]} \tag{4}$$

where 'h' is the histogram of the image. Therefore, the mean and standard deviation are calculated using the colour histogram by the following equations.

$$\bar{x} = \frac{\sum_{i=0}^{255} i*h[i]}{Number\ \ of\ pixels} \tag{5}$$

$$\delta = \sqrt{\frac{1}{Number\ \ of\ pixels}\sum_{i=0}^{255} h[i] * (i - \bar{x})^2} \tag{6}$$

Colour histogram does not consider the spatial information of pixels. Therefore, different images may have similar colour distributions.

b) COLOUR COHERENCE VECTOR (CCV)

In Colour Coherence Vector (CCV) approach, each histogram bin is partitioned into two types, coherent and incoherent. If the pixel value belongs to a large uniformly-coloured region then it is referred to coherent otherwise it is called incoherent [8]. In other words, coherent pixels are a part of a contiguous region in an image, while incoherent pixels are not. A colour coherence vector represents this classification for each colour in the image.

TEXTURE FEATURE EXTRACTION

Texture refers to visual patterns with properties of homogeneity that do not result from the presence of only a single colour such as clouds and water [10]. Texture features typically consist of contrast, uniformity, coarseness, and density. CBIR uses two texture descriptors, namely, Grey-level co-occurrence matrix and 2D Discrete Wavelet Transform.

a) GREY-LEVEL CO-OCCURRENCE MATRIX

Grey-level co-occurrence approach uses Grey-Level Co-occurrence Matrices (GLCM) whose elements are the relative frequencies of occurrence of grey level combinations among pairs of image pixels. The GLCM can consider the relationship of image pixels in different directions such as horizontal, vertical, and diagonal. The co-occurrence matrix includes second-order grey-level information, which is mostly related to human perception and the discrimination of textures [3]. Four statistical features of the GLCMs are computed. The features are energy, entropy, contrast, and homogeneity. G *X* G GLCM P_d for a displacement vector d = (dx, dy) is defined as follows. The (i, j) of P_d is the number of occurrences of the pair of grey-level i and j which are a distance d apart. A number of texture features are listed as follows.

$$Energy = \sum_{i=1}^{N}\sum_{j=1}^{N} {P_d}^2(i,j) \tag{7}$$

$$Entropy = -\sum_{i=1}^{N}\sum_{j=1}^{N} P_d(i,j) \log P_d\,(i,j) \tag{8}$$

$$Contrast\ = \sum_{i=1}^{N}\sum_{j=1}^{N} (i-j)^2 P_d(i,j) \tag{9}$$

$$Homogeneity\ = \sum_{i=1}^{N}\sum_{j=1}^{N} \frac{P_d(i,j)}{1+|i-j|} \tag{10}$$

b) 2D DISCRETE WAVELET TRANSFORM

The wavelet representation of a discrete signal X consisting of N samples can be computed by convolving X with the low-pass and high-pass filters and down sampling the output signal by 2, so that the two frequency bands each contains N=2 samples. With the correct choice of filters, this operation is reversible. This process decomposes the original image into two sub-bands: the lower and the higher band [11]. This transform can be extended to multiple dimensions by using separable filters. A 2D DWT can be performed by first performing a 1D DWT on each row (horizontal filtering) of the image followed by a 1D DWT on each column (vertical filtering).

I. SIMBA

SIMBA is an online prototype for content based image retrieval system implemented using the colour invariant features and brightness invariant features. This system contains nearly 2500 photograph images. The users of SIMBA can combine features that are strongly influenced by the image colour with the proposed textural features that are calculated from the luminance layer only. By assigning weights to these features the user can adapt query according to his needs or according to the image content [1]. SIMBA is constructed as a client-server system, providing faster query performance and the possibility of data protection.

WORKING of SIMBA:

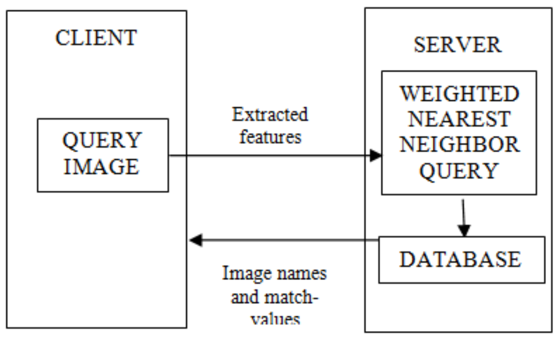

Fig 1 . Working of simba (basic)

The search client, which can be located on any computer in the Internet, analyzes the query image and only sends the extracted features to the database server. The query image stays private as the image does not leave the client's computer. The database server holds pre-calculated features of all database images. When a query request from the client arrives the server performs a weighted nearest neighbor query in terms of histogram intersection and returns resulting image names or URLs and additional information like the match-value to the client [1].

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DEPLOYMENT:
SIMBA currently runs on:
1. SGI O2 MPIS R5000 (web-client)
The O2 is an entry-level UNIX workstation introduced in 1996 by Silicon Graphics Inc. to replace their earlier Indy series. The O2 uses a single MPIS microprocessor and was intended to be used mainly for multimedia.

2. IBM RS6000 (server)
RISC System6000 or RS6000, is a family of RISC-based UNIX servers, workstations and supercomputers made by IBM in the 1990s. The RS6000 family replaced the IBM RT computer platform in February 1990 and was the first computer line to see the use of IBM's POWER and POWERPC based microprocessors.

SIMBA also runs on Windows as well as various other UNIX systems and can be accessed from anywhere in the Internet.

II. OBSERVATIONS

Using the MPEG-7 test dataset the results obtained with SIMBA is presented. The results considering the colour features are very intuitive for the user while the texture features are less intuitive. The first set of figures are chosen in such a way that the results are not satisfying when using colour features only. However, sometimes the colour features are sufficient already [3].

The query image in figure 1 displays a sunset. There is no sunset image with similar colour in the database, thus the result is not satisfactory. Applying the texture features different sunset images in the database is caught better.

(a) Search Template

87107.8 54349.9 54076.1 51989.6

50936.4 50841.4 50625 49918.5

(b)

(a) Search template – Sunset (b) Results and histogram intersection values using colour features only (not satisfactory).

(a) Search Template

87896.7 85192.1 84943.7 84419.4

84312.2 83914 83882.5 83126.6

(b)

Fig 2 . (a)Search template – Sunset (b) Results and histogram intersection values using texture features only (satisfactory).

(a) Search Template

86580.1 3438.1 66659.5 64599.5

62691.7 62550.4 62537.2 59991.4

Fig 3 . (a) Search Template (b) Results and histogram intersection values using colour features only (satisfactory).

(a)Search Template

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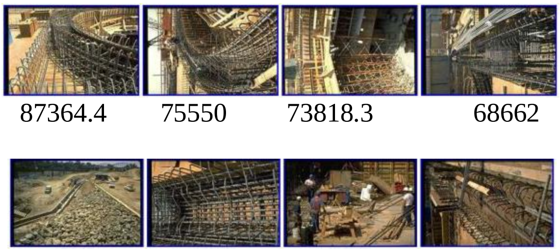

87364.4 75550 73818.3 68662

68181.5 67894.8 65086.25 64739.7

(b)

Fig 4 . (a) Search Template (b) Results and histogram intersection values using an equally weighted combination of colour and texture features (satisfactory).

III. CONCLUSION

A content based image retrieval system is presented which is based on invariant features. A previous system that paid much attention to colour is extended by novel invariant textural features. By weighting the features types according to needs or according to the image type, the user is able to improve the retrieval results considerably. In contrast to many existing image retrieval systems SIMBA does not rely on error-prone pre-processing steps but derives its features directly from the original image data. All transformations performed are continuous mappings thus ensuring a smooth degradation of the features if the image data is changed moderately. As none of the methods require manual interaction, the system can be used for fully automatic generation of annotations in heavily fluctuating image databases.

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