Demonstration of Image Retrieval Based on Illumination Invariant Textural MRF Features

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ABSTRACT

Content-based image retrieval (CBIR) systems target database images using feature similarities with respect to the query. Our CBIR demonstration utilises novel illumination invariant features, which are extracted from Markov random field (MRF) based texture representations. These features allow retrieving images with similar scenes comprising colour-textured objects viewed with different illumination brightness or spectrum. The illumination invariant retrieval is verified on textures from the Outex database.

Categories and Subject Descriptors

H.3.3 [**Information Storage and Retrieval**]: Information Search and Retrieval; I.4.7 [**Image Processing and Computer Vision**]: Feature Measurement—*Texture,Invariants*

General Terms

Algorithms, Verification

Keywords

Content-based Image retrieval (CBIR), illumination invariants, Markov random fields (MRF), demonstration

1. INTRODUCTION

Content-based image retrieval systems typically query large image databases based on some automatically generated colour and textural features. Optimal robust features should be geometry and illumination invariant. Although image retrieval has been an active research area for many years this difficult problem is still far from being solved and proposed solutions are still very immature. Simpler methods based only on colour features achieve illumination invariance by normalising colour bands or using the colour ratio histogram. However, colour based methods rarely perform sufficiently well in natural visual scenes because they cannot detect similar objects in different location, backgrounds or illumination. Textures are important clues to specify objects present in a visual scene. Unfortunately, the appearance of natural textures is highly illumination dependent. As a consequence, most recent natural texture based classification or segmentation methods require multiple training images captured under full variety of possible illumination and viewing conditions for each class. Such learning is obviously clumsy and very often even impossible if required measurements are not available.

The features employed in our demonstration are based on parametric measures, which are invariant to illumination brightness and spectrum changes and which do not require any knowledge of illumination spectrum. They can be applied for textured object retrieval if only single illumination training image is available for each class.

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2. DEMONSTRATION DESCRIPTION

The purpose of our demonstration is to demonstrate the robust performance of our novel illumination invariant features, which are based on Markov random field (MRF) model [2]. The demonstration consists in illumination invariant retrieval of textures from the Outex database [1], which consists of texture images acquired, under three different illuminations.

The demonstration use case is the following: At first, a user selects query image for content-based image retrieval. The query image can be any image from the provided database. Optionally, the user can change the number of retrieved images. When the retrieve action is performed, the given number of the most visually similar images are shown on the result screen. The performed retrieval is invariant to arbitrary changes of illumination sources spectra.

The target audience of this demonstration are developers of image retrieval systems, digital libraries, or web search engines such as Google.

The illumination invariant features used in the demonstration are based on the simultaneous Causal Autoregressive Random (CAR) field model, which belongs to the family of Markovian random field models. Models were computed over 4 multiresolution levels. The presented features are denoted as "2CAR-KL, $\alpha_1\alpha_3$" in the article [2]. These illumination invariant MRF features achieved on average retrieval recall rates over 89%, which clearly demonstrates their insensitivity to the illumination spectrum variations [2]. The relevant textures were defined as the same texture images with the other two illuminations, regardless any texture classes. Therefore there were 2 relevant images present in the test set for each of retrieved textures, a total amount of 3 textures were retrieved. Furthermore, the test images were also degraded with additive Gaussian noise to test the noise robustness of the demonstrated features.

The Outex database, used in the demonstration, consists of texture images acquired, under three different illuminations. The illumination sources were 2856K incandescent CIE A light source, 2300K horizon sunlight, and 4000K fluorescent TL84, the illumination positions are very close. Moreover, all the textures were acquired with a fixed camera position. The Outex database is available for download at:

`http://www.outex.oulu.fi/temp/orig.html`

The demonstration texture set consists of all 318 textures, each with 3 different illuminations, without any rotation and with 100 dpi resolution. All textures were cropped to the size 512×512.

3. SYSTEM REQUIREMENTS

Our demonstration was developed for a PC computer with installed Java Runtime Environment (JRE) version 6 or later. JRE 6 is freely available for download at the URL:

`http://java.com/en/download/index.jsp`

Moreover, the demonstration needs 300 MB of free disk space on PC with at least 1 GHz processor and 0.5 GB of RAM. The demonstration application was tested on operation system GNU Linux (Fedora Core 6) and Windows XP with Service Pack 2.

4. DEMONSTRATION CONTROL

The demonstration application is a dialog based desktop application, which implements the CBIR use case described in Section 2. The application consists of two screens. The first screen is the input screen, which allows the user to select a query image and change retrieval parameters. The second screen is the result screen, which shows retrieved images.

The input screen (Fig. 1) consists of thumbnail images from the image database and two input fields. The query image can be selected by left click on the image thumbnail in the list in the lower part of the screen. Optionally, in the first input field the user can write the number of query image, while in the second the user can change a number of retrieved images. The "retrieve" button performs the illumination invariant image retrieval. Moreover, in the "image database" menu, the user can select either the original image database or the image database with additive Gaussian noise.

The result screen (Fig. 2) shows the query image and query parameters in the upper part of the screen. The result of the query, which consists of thumbnails of retrieved images, is shown in the lower part of the screen. The performed retrieval is invariant to arbitrary changes of brightness and spectrum of illumination sources. The user can also select one of the result images as the query image for the next retrieval task. This can be performed by right click on the image and choosing the "retrieve" item from its pop-up menu. The "input" button returns to the input screen.

A video of the demonstration application have been captured and it is freely available at the URL:

`http://ro.utia.cas.cz/demos/civr-demo.html`

The video shows using of the demonstration application as it is described in this section. The video is stored in avi format with XVID codec.

5. CONCLUSIONS

We demonstrate new illumination invariant features advantageously applicable for content based image retrieval systems. These features are derived from the underlying Markov random field texture representation and they are invariant to arbitrary variations of brightness and spectrum of illumination sources. The performance of the proposed features is shown in illumination invariant image retrieval on textures from the Outex database, which consists of texture images acquired, under three different illuminations. These features are simultaneously robust to image degradation by the additive Gaussian noise.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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[2] P. Vacha and M. Haindl. Image retrieval measures based on illumination invariant textural mrf features. In *ACM International Conference on Image and Video Retrieval (CIVR'07), accepted.* ACM, July 9-11 2007.

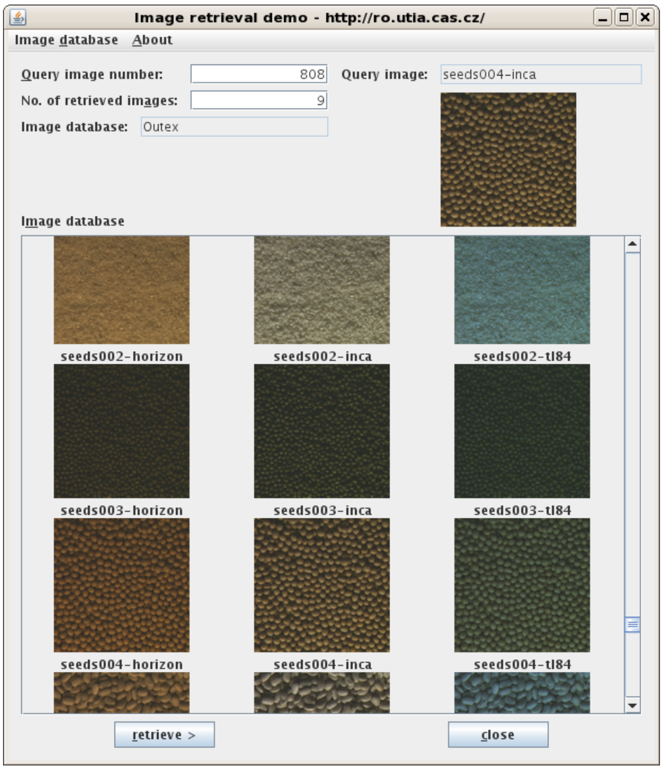

Figure 1: Input screen. Left click on the image thumbnail selects this image for retrieval. Optionally, a user can change the number of retrieved images.

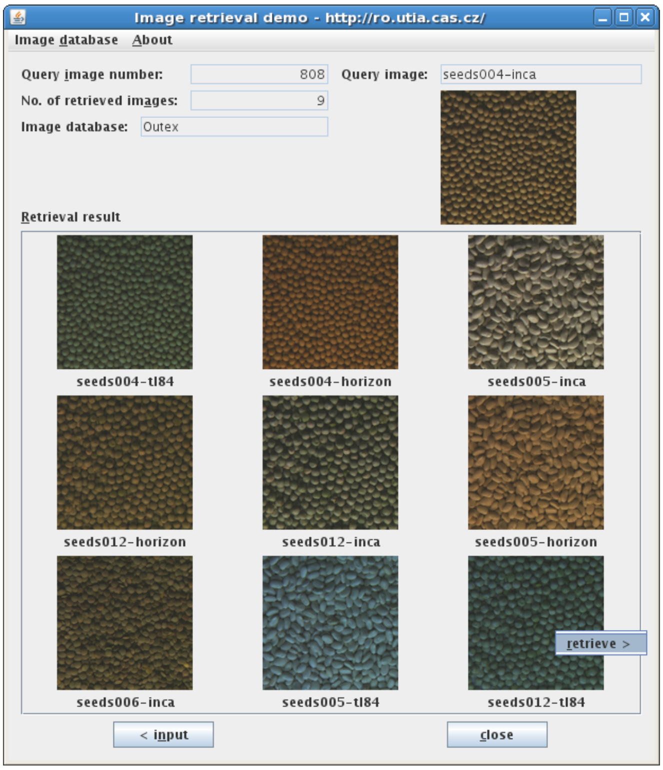

Figure 2: Result screen. The query is revised in the upper part, while retrieved images are shown in the rest of the screen. A user also can select one of result images as the next query image by right click on it and choosing "retrieve" in its pop-up menu.