Multimedia Database Systems

University of Konstanz **SS 16**
Data Analysis and Visualization Group
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Submission deadline:
Tue, 28.06.2016, 23:59.

Practical Assignment (90 + 20 points)
-- Image Retrieval --

01.06.2016 – 21.06.2016

Preamble

The aim of this practical assignment is to develop a content-based image retrieval (CBIR) system. The CBIR system should support multiple image features and different similarity measurements. The performance of the CBIR system should be evaluated in a formal quantitative evaluation.

General Information

- You have to form **groups of 2 persons**. Individual submissions are only accepted in special cases.

- You should finish the project in three weeks, since the next exercise will be given on the **22.06.2016** but the final submission deadline is: **Tue, 28.06.2016, 23:59**. You have one additional week to prepare a talk and fix smaller bugs. You will have to present your submissions on **Wed, 29.06.2016** in the regular exercise slot. If you are unable to present your work there, please send us an email.

- You will get (more) detailed descriptions of the data set characteristics, feature extraction approaches and the general introduction of the project in the **exercise slot 01.06.2016**. It will be beneficial for you to be there.

- You may **only use standard Java functionality** in your code. Please write your own code for implementing the data structures and algorithms. (Exception: You may use a Math library, such as Apache Commons Math, for statistical calculations or libraries which are suggested in the Task descriptions.)

- For this practical assignment you can achieve. 90 points plus 20 bonus points for additional work.

Description of the Data Set

Pictures of objects belonging to 101 categories, as well as an additional background/clutter category. About 40 to 800 images per category. Most categories have about 50 images. Collected in September 2003 by Fei-Fei Li, Marco Andreetto, and Marc 'Aurelio Ranzato. The size of each image is roughly 300 x 200 pixels.

Project Tasks

Task 1: Data Acquisition (0 points)

Visit the website http://www.vision.caltech.edu/Image_Datasets/Caltech101/Caltech101.html of the California Institute of Technology and download the Caltech Image Data Set (101_ObjectCategories.tar.gz). The archive file contains 102 folders, but the background/clutter category *"BACKGROUND_Google"* can be deleted.

Task 2: Feature Extraction (5 + 10 + 15 points = 30 points)

In the lecture multiple feature extraction methods were presented. In this task you have to implement three of them.

1. Color histogram (global, local). **(5 Points)**
   (Parameters: number of bins, number of cells)

2. Global Edge histogram **(10 Points)**
   (Convolute the image with Sobel-Operators before computing a histogram similar to the previous task. Java provides methods for the convolution of images, see: ConvolveOp)

3. Texture Haralick Features **(15 Points)**
   (Paper is given Online in Ilias; Implement the gray-level co-occurrence matrix for each of the four directions and the first 12 Haralick features. The feature vector is composed of the range and means of the 12 texture features, i.e. 24 features.)

Task 3: Similarity Measurements (5 + 15 + 5 + 5 points = 30 points)

Please implement the following similarity measures to calculate the similarities between the feature vectors implemented in Task 2)

1. Euclidean Distance **(5 points)**
2. Quadratic Form Distance **(15 points)**
   a. To speed up the processing of the Quadratic Form Distance you can use a Math Library like Apache Commons Math to calculate the Singular Value Decomposition of the similarity matrix. With the decomposed similarity matrix, you can calculate a weighted Euclidean distance instead. See **Query Processing for Quadratic Forms** in 2.2 Distance Functions Page 38. **(5 points)**
   b. To further speed up the processing of the Quadratic Form Distance you can limit how many Eigenvalues of the similarity matrix are used for the similarity calculation. See **Query Processing for Quadratic Forms** in 2.2 Distance Functions. **(5 points)**

Task 4: Graphical User Interface (10 points)

To make the methods of Task 2 and 3 available please implement a graphical user interface. The following functionality must be available: Selecting a query image, choosing a feature extraction method as well as a similarity measure and a result view, which shows similar images. Please also provide an input method for the number of Eigenvalues used in Task 3.2 b). **(10 points)**

Task 5: Evaluation (20 points)

Apply all your implemented descriptors on the dataset.
Test at least five different input images as query objects.

Vary the parameters of the feature extraction methods (bins for the histogram; number of the local cells, amount of gray values) and compare the results.

Evaluate the usefulness of the feature vectors. Show some findings and reason on the advantages and disadvantages of the approaches. Document your results visually (make screenshots or show the rankings by inserting the respective images in a ranking order), as well as in precision/recall curves.

Optional Task: Surprise us! (20 points)

- Try to improve the retrieval performance, this could e.g. be achieved by one or several of the following:
    a. By combining/weighting feature descriptors
    b. By combining/weighting distance functions
    c. By implementing a more advanced image feature descriptor (check out libraries like OpenCV or OpenIMAJ and make some of their functionality available in your tool.)
    d. By implementing a multi-scale approach that takes into account differently scaled version of the input image to compute the descriptors.
    e. Use an index structure to speed up calculation. You can use a library for this task.
- Develop your own ideas and be able to justify them.

Deliverables

A single ZIP-File containing the following parts

- **ZIP File of your Eclipse/Netbeans project source code**
- **A PDF describing a short summary what you implemented and what is missing.**
- **A PDF for the evaluation with descriptions of your findings + screenshots of your tool + precision/recall curves etc.**
- **A PDF describing how to start and use your tool (short with a few screenshots)**
- **Your presentation**