Gradientface based Face Recognition Using R

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Keywords: Face detection, face recognition, gradientface

In this application, we implement a full functional face recognition system, whose core routines are written in *R*. The main motivation is to exploit the efficiency of R for the implementation of a recently introduced concept of gradientface [Zhang2009] in a real-life application.

Face recognition is an important research field that attracts attention for more than two decades. The field reached a certain level of maturity so that face recognition systems are encountered in a wide area of applications ranging from surveillance systems to user authentication in laptops. However, it is still an active research topic due to the complexities, such as lighting conditions, pose of the head, facial expression and possible occlusions, confronted in different applications. Gradientface [Zhang2009] is a recently proposed feature extraction method that provides robustness to illumination changes. It yields significant performance improvements over canonical eigenface [Turk1991] and fisherface [Belhumeur1997] approaches.

Gradientface approach is based on the fact that the ratio of the y-gradient of image $I(x, y)$ to the x-gradient of image is an illumination invariant measure, which is shown in [Zhang2009]. Gradientface feature is computed using the following equation:

$$g = \arctan\left(\frac{I_y}{I_x}\right), g \in [0, 2\pi),$$

in which I_x and I_y represent x and y gradients of the image, respectively.

The computation of image gradients is ill-posed due to noise and quantization. Therefore, in order to compute stable image gradients and more importantly to extract an illumination invariant measure that is robust to noise, image is firstly smoothed by a Gaussian kernel function given below.

$$G(x, y, \sigma) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}},$$

where σ is the variance of the kernel.

The core routines of this application (gradientface feature extraction, database generation, and query) are implemented in *R*. The overall system structure is shown in Figure 1. In the database generation stage, the gradient face of each face in the given set (hair and other irrelevant parts are excluded) is computed. The resultant gradientface is downsampled to a fixed size of 24x24 for the sake of computational efficiency. Each gradientface is written to a binary file separately. In the query stage, firstly, face detection is performed on the input image. For the face detection, the cascaded detector of Viola & Jones is employed [Viola2004] via the *python* interface of OpenCV [OpenCV] implementation. Then, the gradientface feature of the detected region is computed. The query feature is downsampled to the pre-determined size and then compared against the whole set in the database by means of 2-D cross correlation. The candidate with highest correlation value is returned as the match, if the correlation value is above a given threshold.

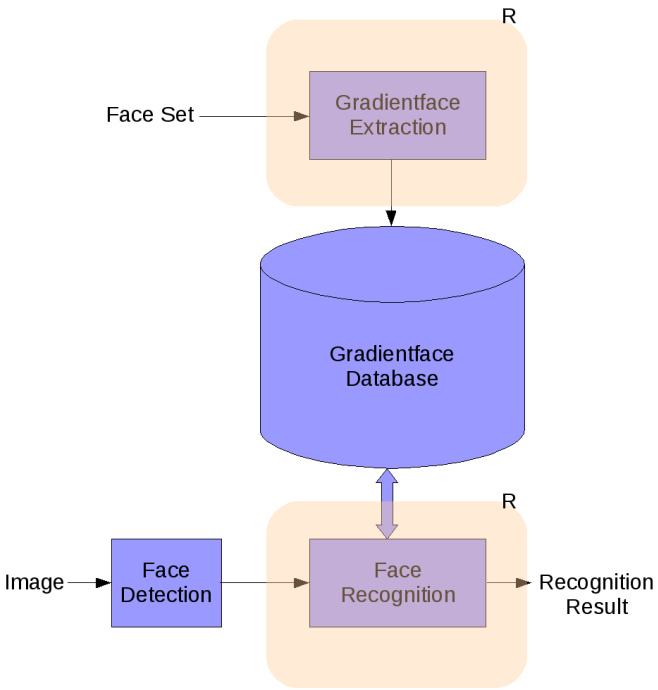

Figure 1. System structure.

The system is implemented in a server/client fashion. The database generation and query is performed through a web interface. The core routines are accessed via *php*. The system properties are listed in Table 1.

OS: Linux (Suse 11.1)
Web server: Apache 2 (2.2.10)
PL: *R* (2.10.1), *python* (2.6), *php* (5.2.6)
R Packages: **stats**, **rimage**

Table 1. System properties.

As a result, efficient structure of R made the real-life implementation of a novel techniqe possible in a very short period of time.

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