In-Plane Rotational Alignment of Faces by Eye and Eye-Pair Detection

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Abstract

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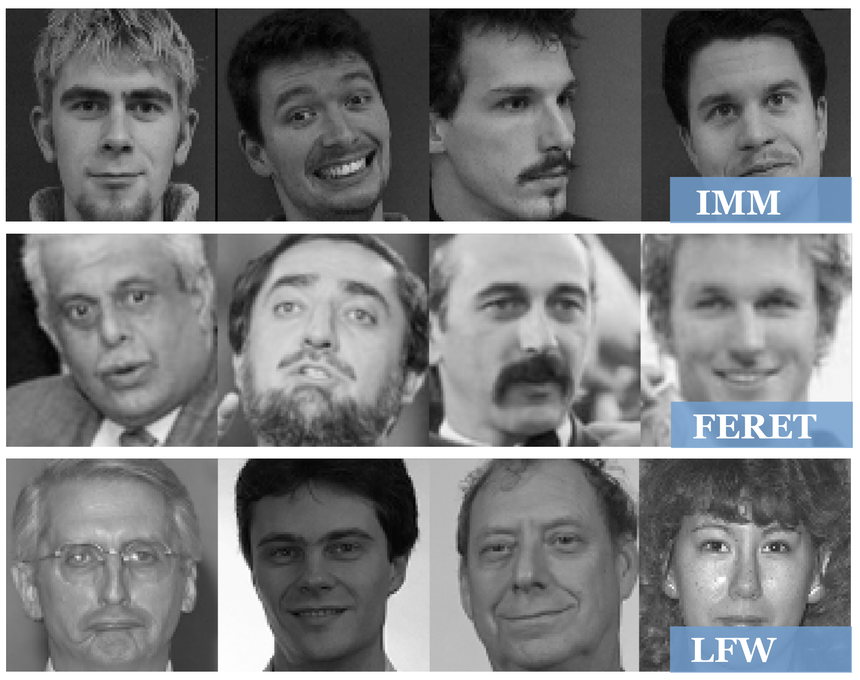
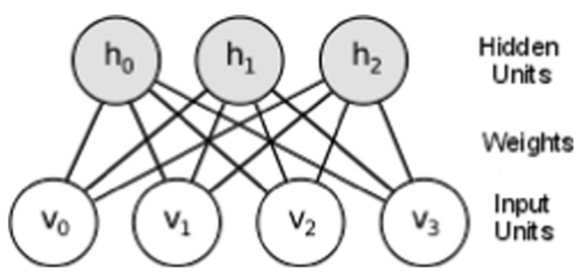
> **A hierarchical detector system** using eye and eye-pair detectors combined with a geometrical method for calculating the in-plane angle of a face image.
> **Two feature methods**, the **RBM** and the **HOG**, are used to extract the feature vector by using a *sliding window*.
> **SVM** is used to accurately localize the eyes.
> **The in-plane angle** is estimated by calculating the arc-tangent of horizontal and vertical parts of the distance between left and right eye center points.
> We tested our approach on **three different face datasets: IMM**, **LFW** and **FERET**.



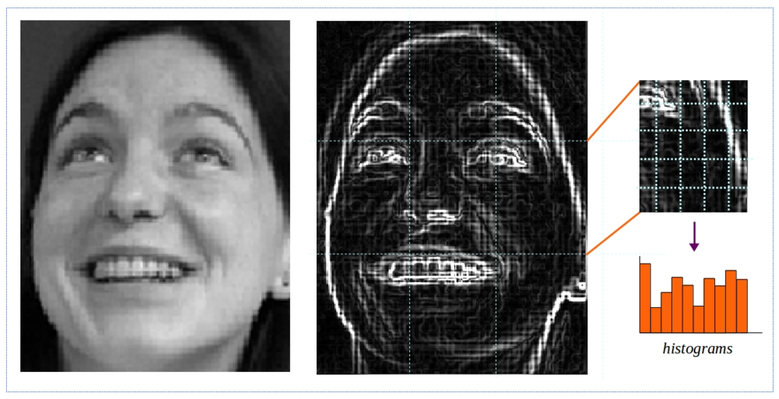
1. Feature Extraction

> **RBM:** An RBM is an energy-based neural network model used for suppression of noise and reducing the dimensionality of the input data. It is composed of two layers: an input and a hidden layer.

> **HOG:** It computes the oriented gradients of an image using gradient detectors.

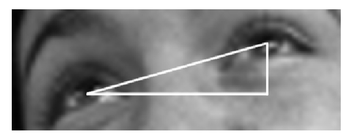


An RBM with 3 hidden and 4 visual (or input) units.



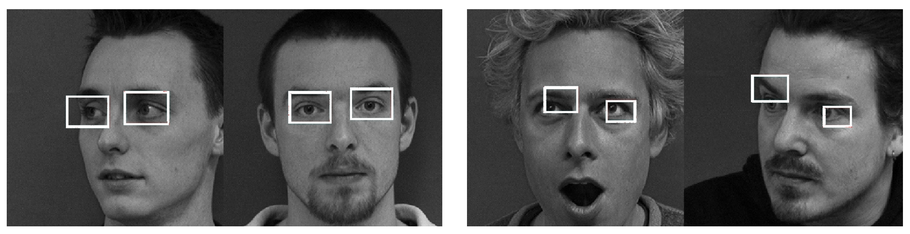
2. Roll angle calculation

$$\text{angle} = arctan(\frac{y}{x})$$



$$y = eye(left)_y - eye(right)_y$$

$$x = eye(left)_x - eye(right)_x$$



Eyes localized with less (left) and more (right) than a localization error of *0.2*

3. Evaluation Methods

> **the eye localization error**

$$e = \frac{d(d_{eye}, m_{eye})}{d(m_{eye_l}, m_{eye_r})}$$

> **the angle estimation error**
the absolute value of the difference between manually obtained and automatically estimated angles.

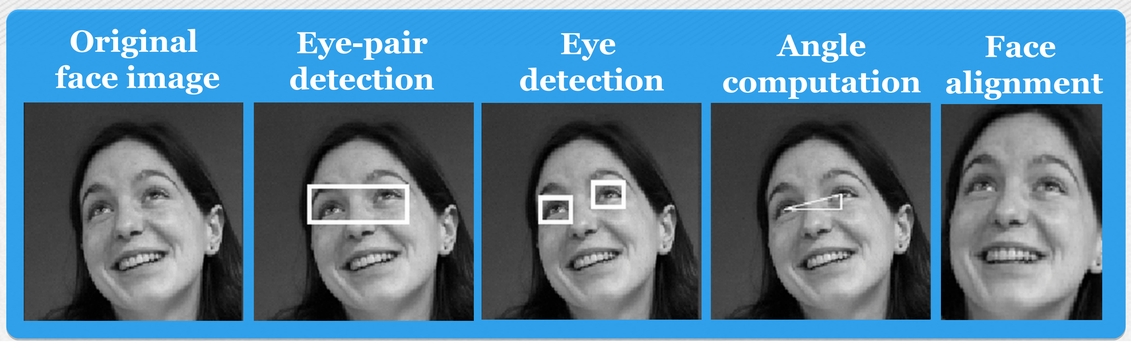
4. Face Recognition

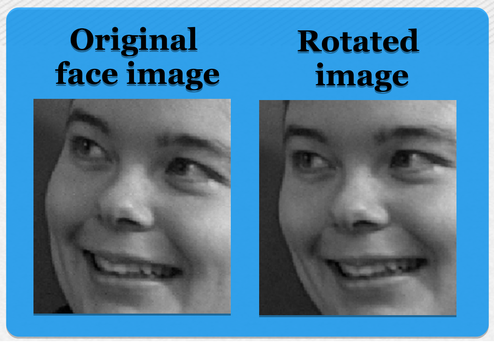
> We used **HOG** with **3 x 3 x 9** and **60 x 66** pixels resolution (W x H), obtained **82.75%**

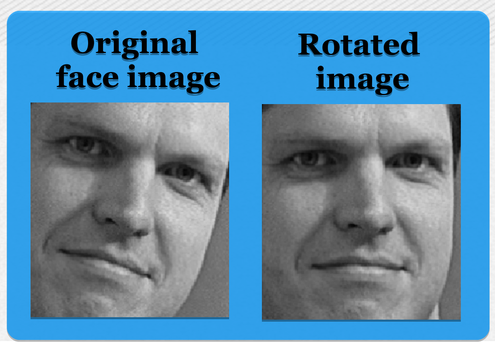
Method	Dataset	Left eye	Right eye	Average
RBM	IMM	.046 ± .002	.043 ± .002	.044 ± .002
	LFW	.071 ± .004	.069 ± .005	.070 ± .004
	FERET	.069 ± .009	.079 ± .011	.074 ± .010
HOG	IMM	.044 ± .006	.041 ± .004	.042 ± .005
	LFW	.066 ± .003	.071 ± .005	.069 ± .004
	FERET	.064 ± .009	.071 ± .010	.067 ± .009

Method	Dataset	Average error	Successful rotations < 2.5
RBM	IMM	1.35 ± .066	90.0 ± 1.9
	LFW	2.30 ± .083	65.5 ± 2.3
	FERET	2.38 ± .118	80.9 ± 2.6
HOG	IMM	1.47 ± .082	80.0 ± 2.6
	LFW	2.46 ± .096	63.4 ± 2.6
	FERET	2.64 ± .120	76.5 ± 2.8

	Detected by RBM+SVM	Detected by HOG+SVM
Non-Rotated	74.50	75.50
Auto. Rotated	**82.75**	81.75
Improvement	8.25	6.25







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