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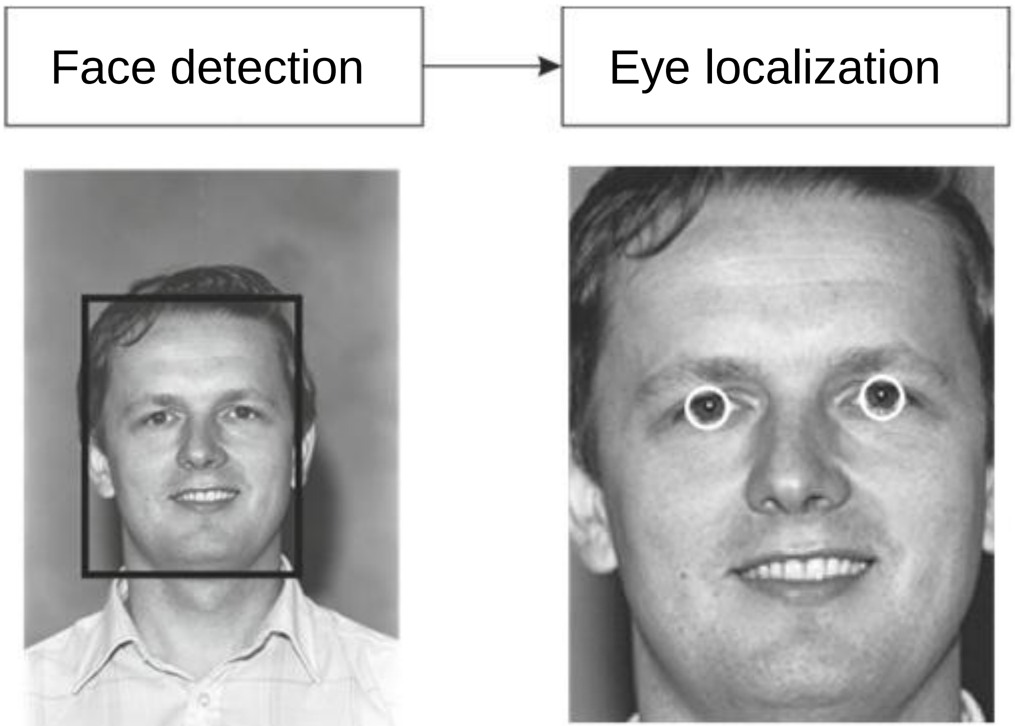
EYE CENTER LOCALIZATION ON A FACIAL IMAGE BASED ON MULTI-BLOCK LOCAL BINARY PATTERNS

Yaroslavl, 2015

Eye localization task



We address the task of accurately localizing the eyes in face images extracted by a face detector

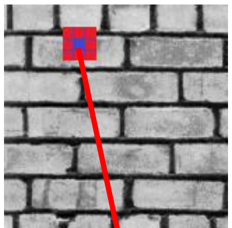
Challenges of eye localization

- wide variety of colors and shapes of eyes
- emotions and facial expressions
- occlusions
- pose
- imaging condition and quality

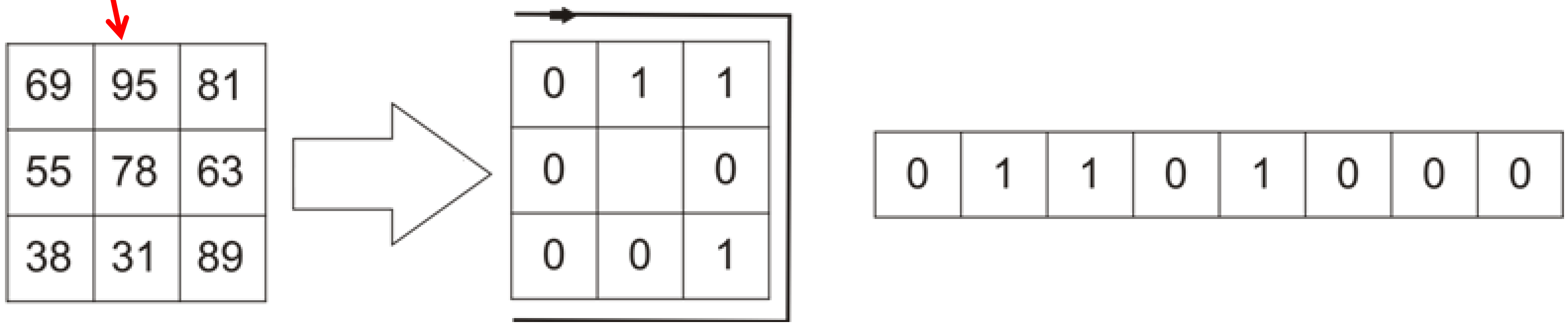
Approaches in eye localization

- measuring eye characteristics
- learning statistical appearance model
- exploiting the spatial structure of the face
- describing the local structure of the image

Local Binary Patterns



This operator is defined for each pixel by thresholding the 3×3 neighborhood pixel value with the center pixel value. In this way, it can give us a binary sequence defined by local structure of an image

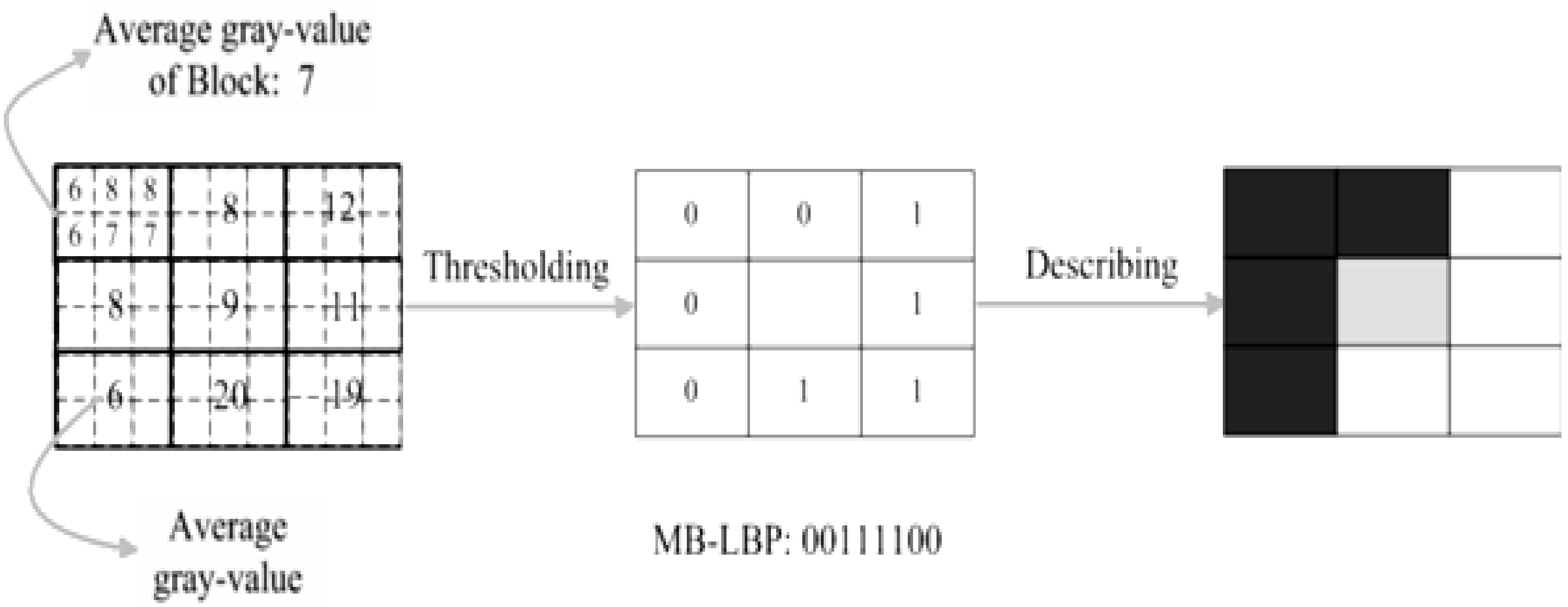


LBP are

- computationally efficient
- invariant to changes in the brightness of the image caused by shooting in different lighting conditions

T. Ojala, M. Pietikäinen, and D. Harwood. A Comparative Study of Texture Measures with Classification Based on Feature Distributions // Pattern Recognition, vol. 29, 1996, pp. 51-59.

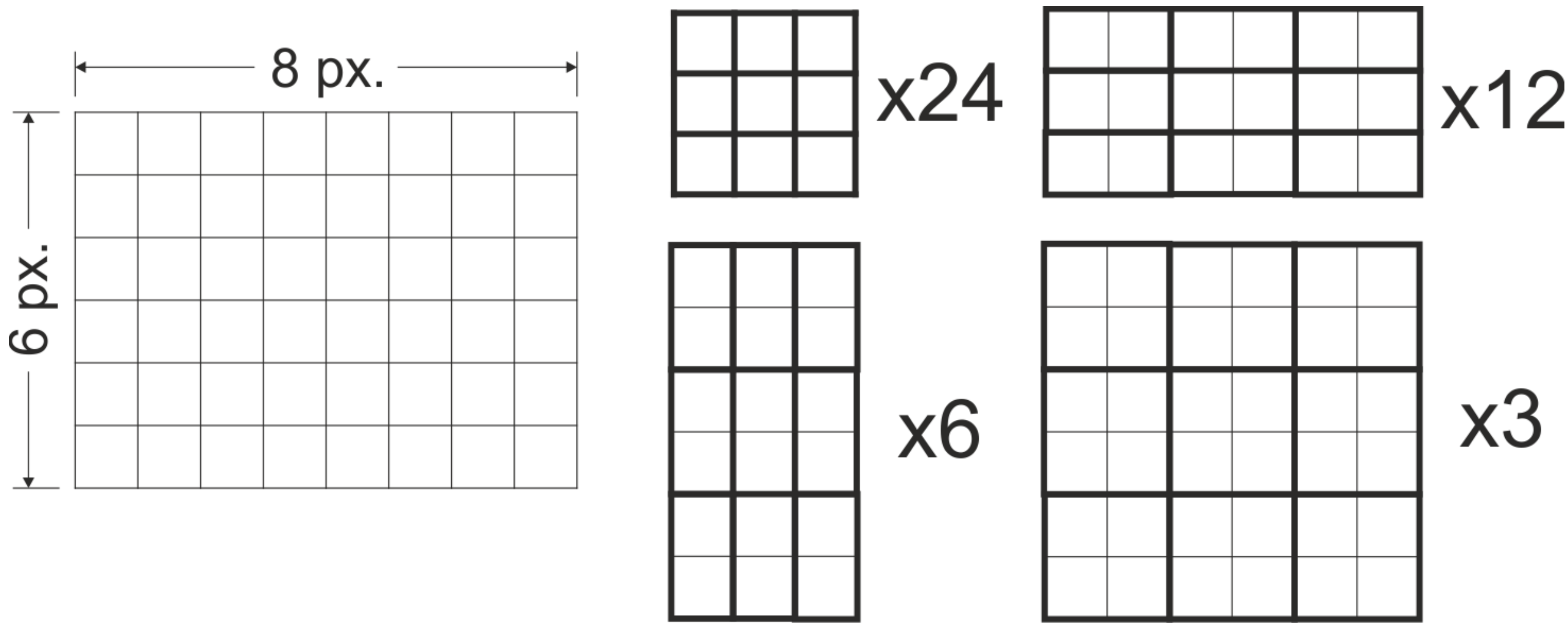
Multi-Block Local Binary Patterns



Integral image is used for rapid computation of MB-LBP operators.

L. Zhang, R.Chu, S. Xiang, S. Liao, S. Z. Li Face Detection Based on Multi-Block LBP Representation, Advances in Biometrics, Lecture Notes in Computer Science, Volume 642, 2007, pp. 11-18.

Multi-Block Local Binary Patterns



For resolution 8x6: S = 45 features
21x15: S = 2450 features
21x21: S = 4900 features

The eye training samples

Training dataset : $(\mathbf{x}_i; y_i), .., (\mathbf{x}_i; y_i), .., (\mathbf{x}_N; y_N)$

$(\mathbf{x}_i; +1)$

$w_i = w_e$

$(\mathbf{x}_i; -1)$

$w_i = w_e^-$

The start weights should satisfy the following condition : $\sum_{i=1}^{N} w_i = 1$

Classification stage

Ideal classifier:

$$F(\mathbf{x}) = \begin{cases} +1, & for\ \mathbf{x} \in e \\ -1, & for\ \mathbf{x} \in \bar{e} \end{cases}$$

It is constructed as a superposition of weak classifiers:

$$F(\mathbf{x}) = sign(\sum_{t=1}^{T} f_t(\mathbf{x}))$$

$$\mathbf{x} = (x^1, .., x^k, .., x^S)$$

$x^k \in$ [0;255]

S is the number of MB-LBP values for chosen resolution

Constructing weak classifiers

Weak classifiers are constructed as multi branch decision trees:

$$f^k(\mathbf{x}) = f^k(x^1,\ldots,x^k,\ldots,x^S) = \begin{cases} a_1,\ \textit{если}\ \ x^k = 1 \\ \ldots \\ a_j,\ \textit{если}\ \ x^k = j \\ \ldots \\ a_{256},\ \textit{если}\ \ x^k = 256. \end{cases}$$

$$a_j = \frac{\sum_i^N w_i y_i \delta(x_i^k = j)}{\sum_i^N w_i \delta(x_i^k = j)}$$

$a_j > 0$, if the number of eye samples with appropriate feature value is bigger than number of negative eye patterns

Gentle AdaBoost

In step t, the weak classifier $f_t(x)$ is chosen so as to minimize the weighted squared error:

$$f_t(\mathbf{x}) = \min_{f^k \in F} \sum_{i=1}^{N} w_i (y - f^k(\mathbf{x}_i))^2$$

The weights are updated :

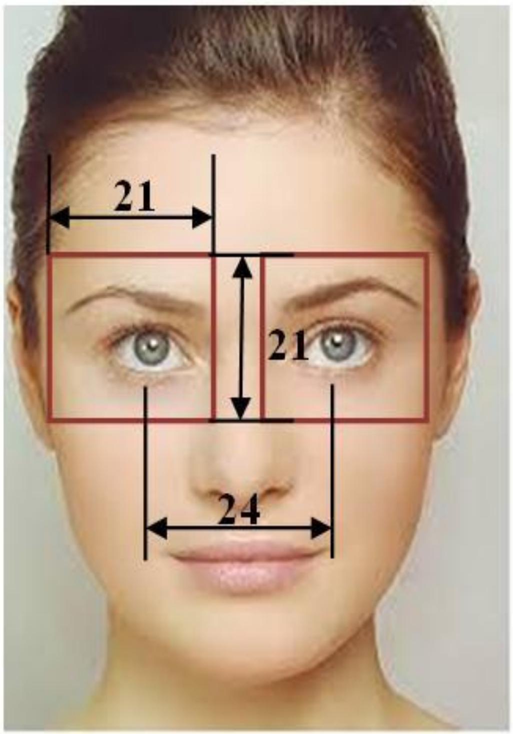
$$w_i' = w_i e^{-y_i f_t(\mathbf{x}_i)}$$

If the sample is classified incorrectly at this step the weight for this sample becomes bigger.

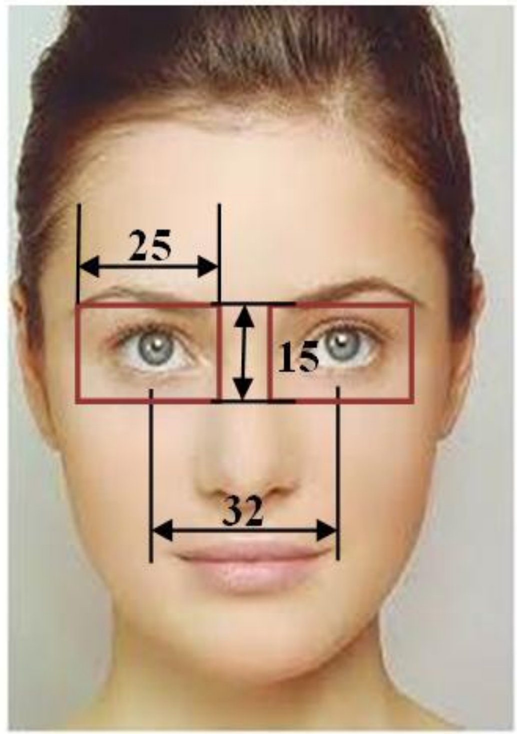
Schapire R.; Singer Y. Improved Boosting Algorithms Using Confidence-rated Predictions // Machine Learning, vol. 37, issue 3, 1999, pp. 297-336.

Adaptive Eye Localizer

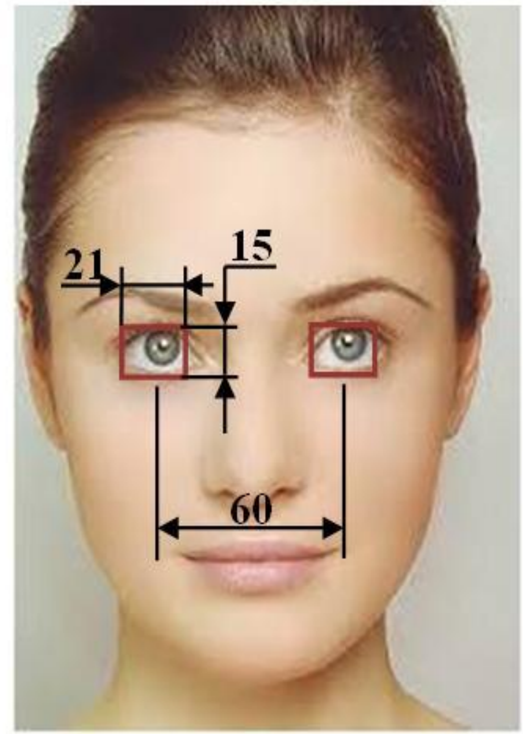
$$F(\mathbf{x}) = \sum_{t=1}^{T} f_t(\mathbf{x})$$



$F'(\mathbf{x})$

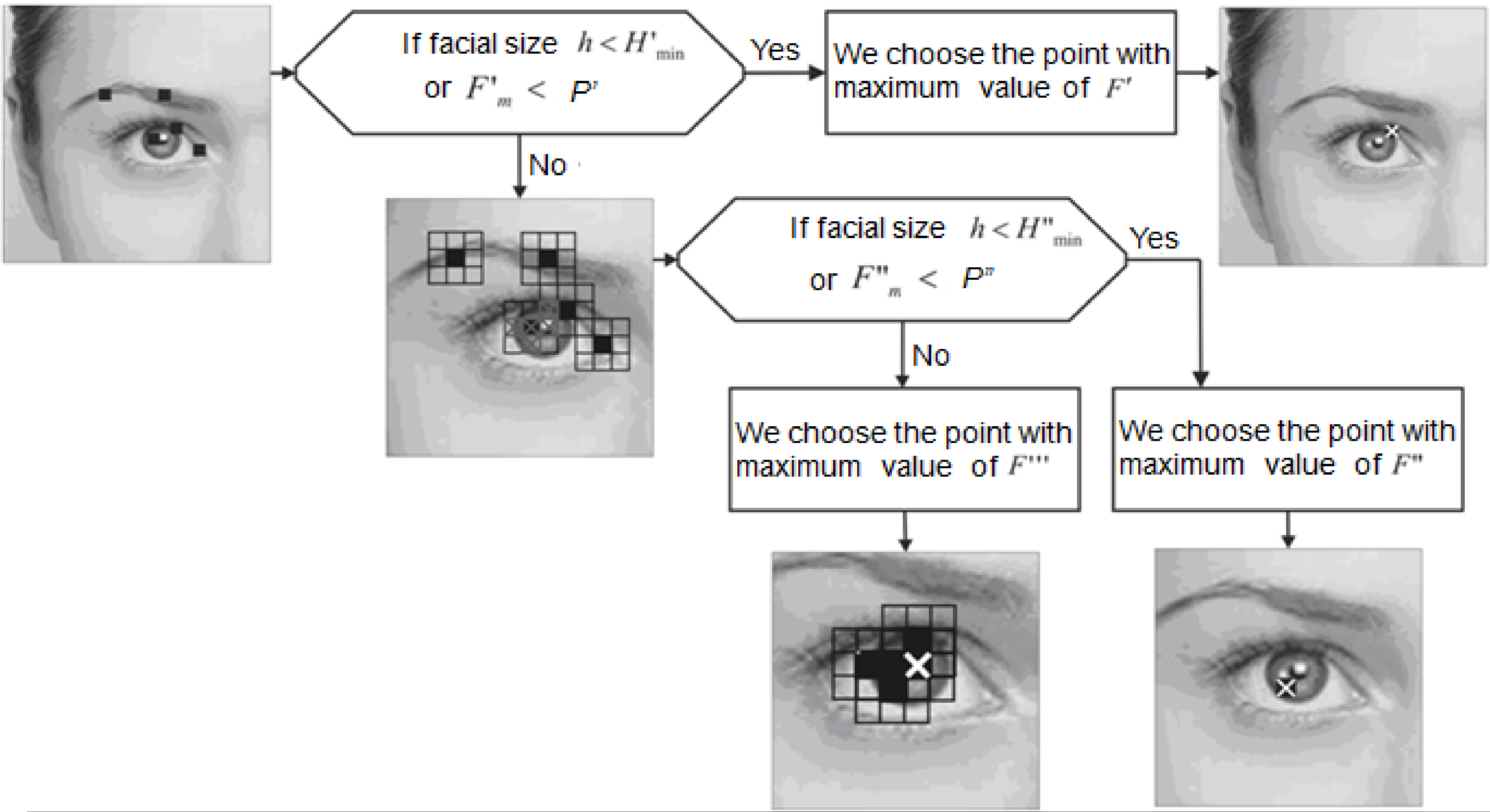


$F''(\mathbf{x})$



$F'''(\mathbf{x})$

Adaptive Eye Localizer



Evaluation

The FERET database: 3,363 images

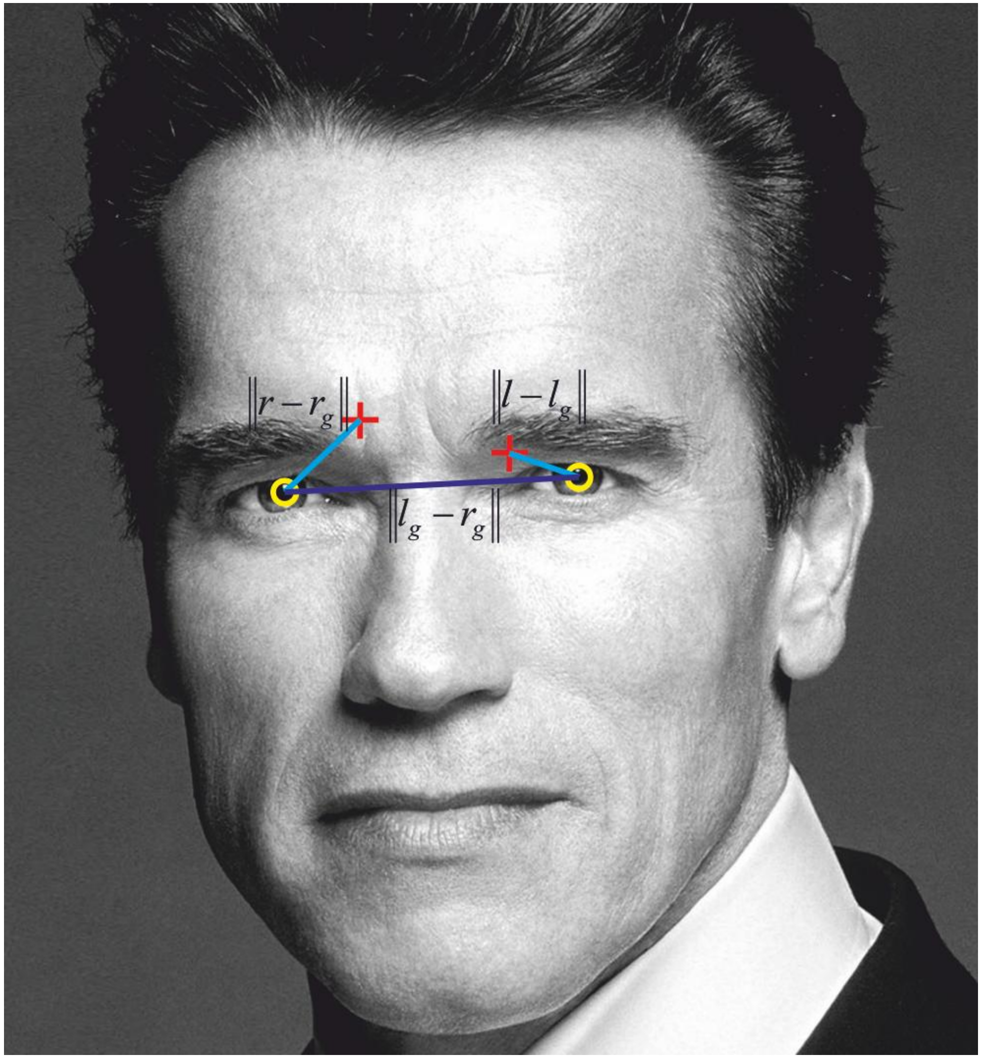
MB-LBP and Bayesian algorithms are trained on 1000 of 3,363 images while training for gradient detector is not required.

Of the rest 2,363 frontal images, the 2,350 images for which the face detector detected a face correctly were retained for testing.

The BioID database: 1,521 images

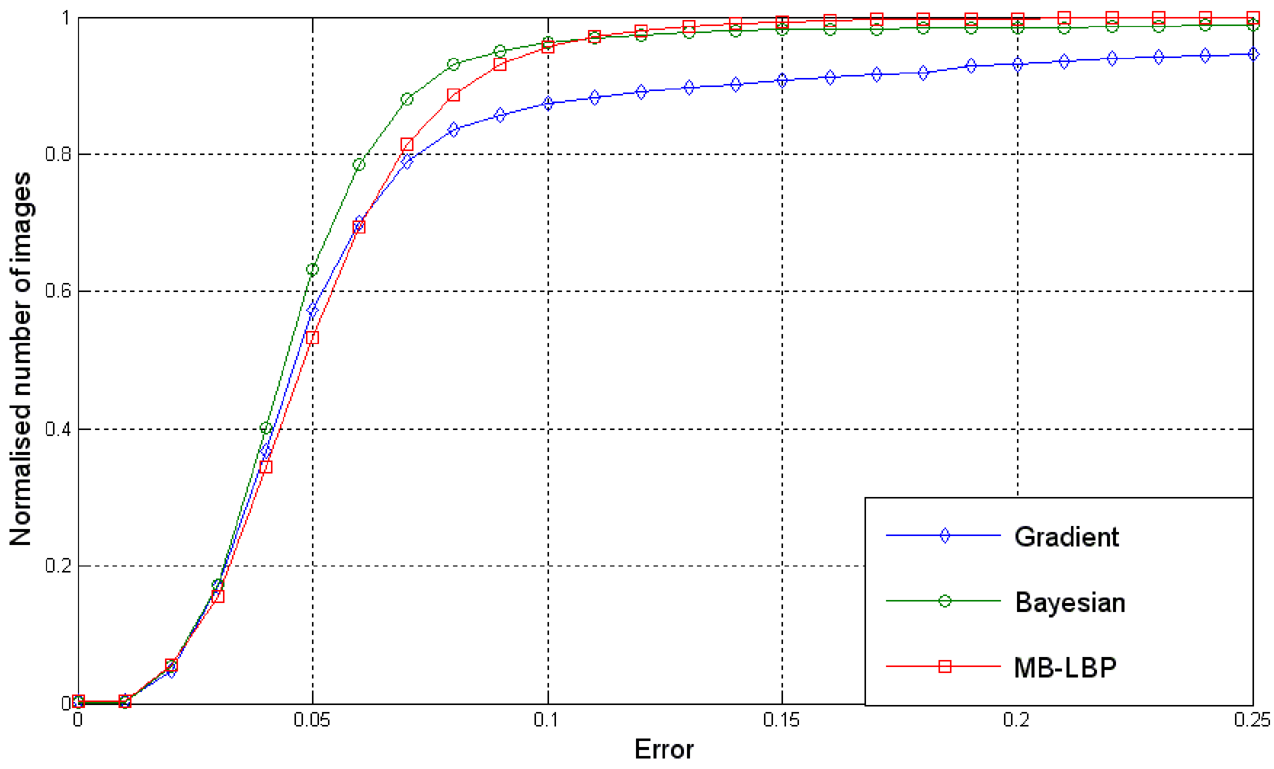
Of the 1,521 images, the 1,469 images for which the face detector detected a face correctly were used for testing.

Evaluation



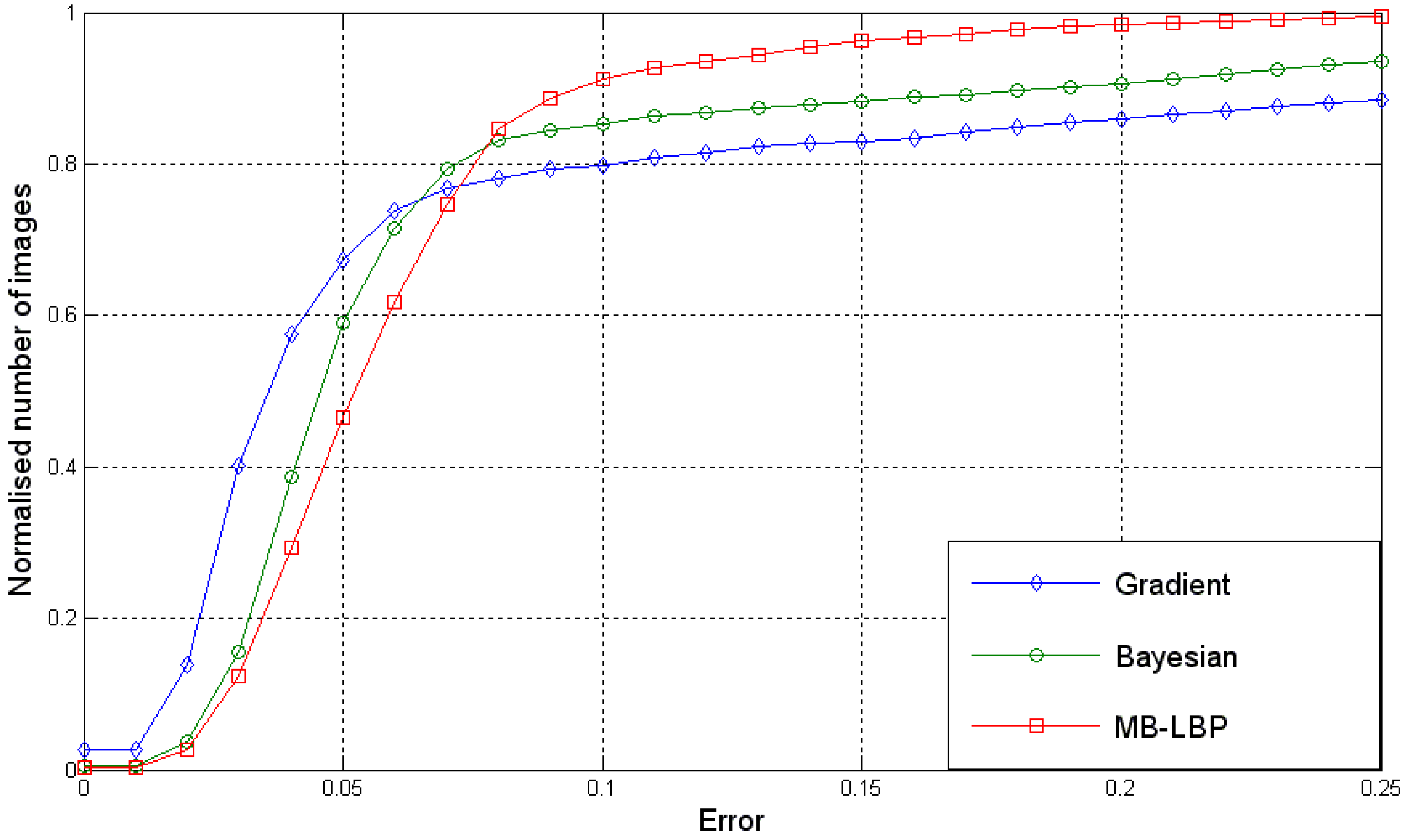
$$err = \frac{\max(\|l - l_g\|, \|r - r_g\|)}{\|l_g - r_g\|}$$

Experimental results: FERET



1. Bayesian approach: M. R. Everingham and A. Zisserman. Regression and classification approaches to eye localization in face images // IEEE International Conference on Automatic Face & Gesture Recognition, 2006, pp. 441-446.
2. Gradient approach: Timm F., Barth E. Accurate Eye Centre Localisation by Means of Gradients // 6th International Conf. Computer Vision Theory and Applications, 2011.

Experimental results: BioID



Time costs

Algorithm	Time of processing
Gradient	587 ms
Bayesian	367 ms
MB-LBP	44 ms

Visual examples

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