Face Detector Combining
Eigenfaces, Neural Network and Bootstrap

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A critical issue in an automatic face recognition system is the determination of the region containing a face in an image with a cluttered background. This paper presents a new method that optimizes the detection task through the use of Eigenfaces, neural networks and a bootstrap algorithm.

The main component of the proposed method is a non-linear operator that detects the presence of a well-framed face image in 20x20 pixel windows. To detect faces larger than the window size the input image is successively reduced by a factor of 1.2 and the procedure is applied at each scale.

To obtain a compact representation of the face images, the method applies Principal Component Analysis (PCA) directly to the pixel intensities of face images. Each image window analyzed by the detection algorithm is then projected upon the *n* principal components, the so-called Eigenfaces. The dimensionality reduction thus achieved implies in a reconstruction error, the DFFS – Distance from Features Space. The patterns representing an image window are formed by the *n* projections plus the DFFS.

These patterns are submitted to a feed forward neural network trained through the backpropagation algorithm with momentum. A bootstrap procedure builds a training set in a semi-automatic way. The entire training procedure involves the following steps:

a) the training set is initialized with examples of the *face* and *non-face* classes,
b) each image window undergoes illumination compensation,
c) the projections onto the Eigenfaces and the DFFS are computed,
d) the neural network is trained,
e) new images not containing faces are submitted to the network and false *face* detections are collected,
f) a part of the false detections is randomly selected and incorporated to the *non-face* class of the training set,
g) return to b)

The system was trained with an image database containing 400 well-framed face examples (10 pictures for each of 40 people). These images were rotated and scaled to generate a training set of 8800 *face* examples. The same number of *non-face* examples was initially created by randomly choosing pixel intensities for same sized windows. Additional *non-face* examples were automatically collected by the bootstrap algorithm through five iterations.

The method was tested in a set of scenes that included both pictures and drawings of faces. The proposed system reached 80.5% detection rate with 52 false detections. When face drawings were excluded the rate reached 87.7%. Experiments also indicated that the increase of the number of iterations in the bootstrap reduces the number of false detections. In comparison, the best performance reported in the literature for the same image set was 91.6% with 4 false detections, when initially using 15750 *non-face* examples and 150 iterations of the bootstrap procedure.

It is reasonable to expect a further performance improvement on the proposed method through the increase of the number of *face* examples with more iterations of the bootstrap procedure.

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