Automatic Detection of Human Faces in Images*

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Abstract

This article contains a proposal for an automatic in-image face detection method, that tries to join several theories, which many authors wrote of before. The method assumes certain circumstances and constraints, respectively. Just because of such constraints it is not applicable universally. Thus, it's not suitable for a starting-point of a more flexible method. On the other hand, however, it is effective enough to be used in an application, where this constraints would not obstruct the employed algorithm and also if the application would require fast execution. Effectiveness of the method was tested on 43 test-images.

1 Introduction

Because of image-databases and "live" video information is growing more and more widespread and expansive, their intelligent or automatic examining is becoming exceptionally important. People, i.e. human faces, are one of most common and very specific objects, that we try to trace in images.

The purpose of automatic in-image face detection methods is obvious: their primary goal is to segment image into regions that contain human face or its parts and into regions which can be - because they don't represent nor human face neither any of its parts - neglected. Let's subject some applications, which make use of these methods:

- most important group represent supervision and security applications,
- then we have video-conferencing applications,
- applications which graphically animate one user's mimicking,
- remote camera control applications,
- etc.

The majority of already developed methods have at least one of these most frequent problems:

- too high computational (time-, space-) complexity and/or
- too low effectiveness.

At this point it is necessary to subject the fact, that automatic face detection as well as most other automatic object-detection methods is a very pretentious task, especially because of significant sample variations, which can't be easily analytically described with parameters.

2 Proposed face detection method

The method in question combines two common approaches, one based on features and the other based on colors. The two basic limitations of the method thus originate from constraints of already mentioned approaches:

- input image must have high enough resolution; the face must be big enough and
- it is sensitive to the complexion (i.e. fair).

Basic idea of the algorithm is: find in image all regions, which contain possible candidates for an eye, then on the basis of geometric face characteristics try to join two candidates into an eye pair and finally, confirm or refuse the face candidate using complexion information.

The method was projected over a set of quite different pictures, i.e. the training set (machine learning wasn't used). The goal of the method was to reach maximum classification accuracy over the images, which meet the following demands and constraints, respectively (beside already mentioned two):

- real-time operation on - for the present - standard personal computer,

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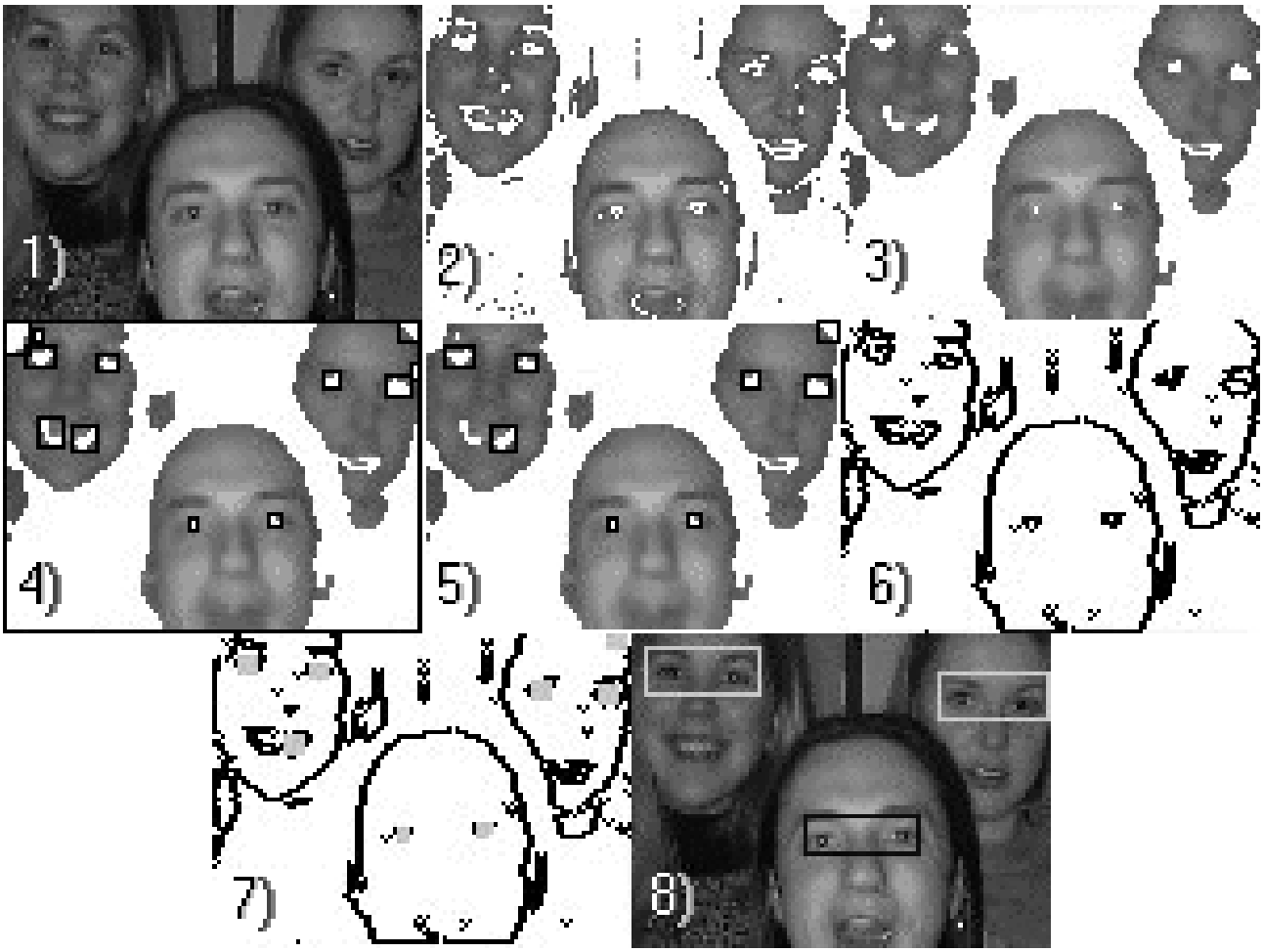

Figure 1: Basic principles of proposed face detection method: 1. input image, 2. eliminated insignificant colors, 3. image filtered with median filter, 4. segmented white regions, 5. eliminated insignificant regions, 6. traced edges, 7. best possible circles within regions of interest, 8. output image

- plain background,
- uniform image illumination,
- fair-complexion faces, which must be present in the image in their entirety (frontal position) and
- faces, turned round for at most 30 degrees.

Method's effectiveness was tested over independent set of images, i.e. the testing set.

Basic principle of operation is shown on Fig. 1.

The method comprises some thresholds, which play crucial role at finding its effectiveness. They are drafted quite loosely (tolerantly), but they become effective as a sequence. All thresholds were defined experimentally over the training set.

Proposed face detection algorithm

Input: image in BMP format
Output: input image with denoted faces in it
Basic steps of algorithm are:

1. Firstly, completely unimportant colors are eliminated from image (those, which can't represent a face). All insignificant colors are replaced with white color.
2. Image is then converted into greyscale picture (PGM format).
3. It is filtered with median filter.
4. With help of the "Region growth" algorithm white regions are segmented.
5. Regions which can't comprise an eye are eliminated as well.
6. Edges are traced in the image with significant greys.
7. Within preserved regions the algorithm searches for circles (eye candidates) using Hough transform.
8. For each region best possible circles is found.

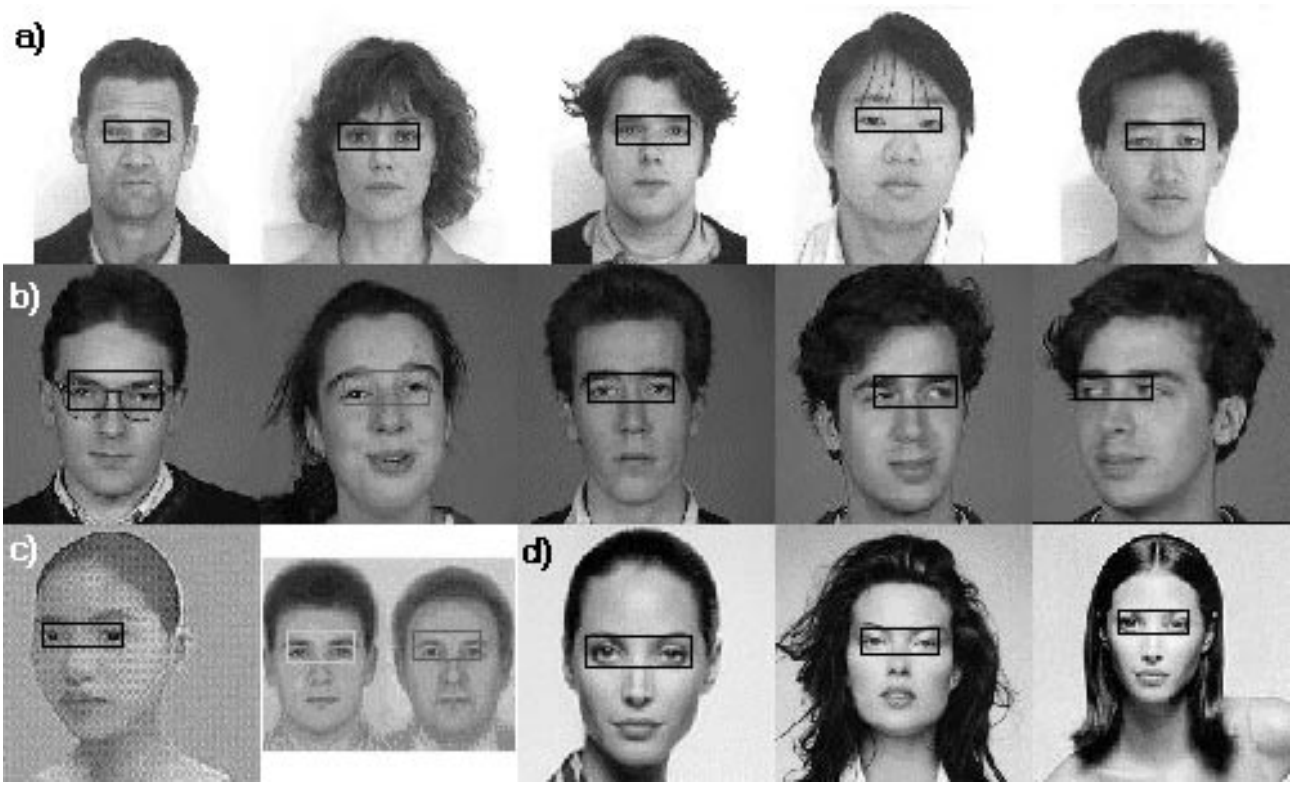

Figure 2: Some positive results from test set: a) from PICS database, b) from M2VTS database, c) computer graphics face animations, d) images of professional photographs.

9. Using geometric face characteristics algorithm finds partner circles representing pairs of eyes.

10. For face candidate confirmation, color information of the whole face is used. With help of this information the algorithm also (loosely) predicts the probability of a face.

3 Results

In order to get reliable results regarding algorithm's effectiveness, this method was tested over independent testing set. The set consists of images taken from two public image-databases (PICS, M2VTS), few realistic face animations and a couple of celebrity pictures.

Common feature of all images is their bigger or lesser suitability for identification documents. Celebrity pictures are included in the test because they were taken by professional photographers.

All images of the testing set don't meet the demands, stated in chapter 1, but exactly these illustrate the proposed method's drawbacks very well. Images, which in advance didn't have good chances, are:

- images with face turned towards side-view position and
- images with a complex background.

There are five images of this kind in the testing set, in two out of these the method successfully detected a face. The fact, that in both images faces were turned towards profile position, tells us that the method tolerates small deviations.

Table 1 presents testing results over entire testing set, Figs. 2 and 3 however, illustrate the method's effectiveness. False positives could be eliminated in subsequent processing.

Generally speaking, glasses represent certain problem (e.g. compact frames or sun-glasses), but hairdress, moustache, beard and different mien don't!

complete testing set - 43 images - 44 faces	
number of detected faces	number of hits
51	43

Table 1: Results of the method over the whole testing set. There were 8 false positive and 1 false negative detected faces.

4 Conclusion

From these result we can conclude, that taking into account specific constraints, classification accuracy achieved by this method is almost 100 percent. These

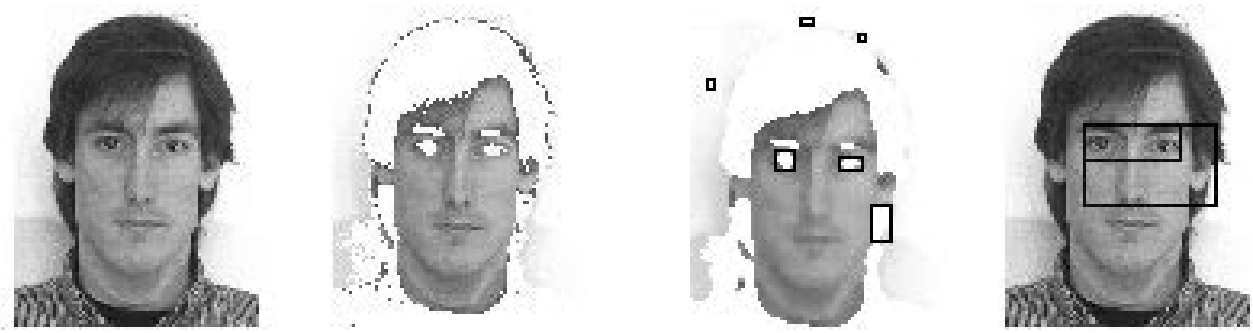

Figure 3: Most typical negative result from testing set; error is caused by uneliminated background, which corresponds to complexion (rightmost region)

constraints hold if we bound ourselves on a particular image domain, which meets special requirements. In other words, the method can be effective enough for an application, which wouldn't suffer from algorithm constraints and which would require fast operation.

The proposed method could, for example, serve as a front part of a face recognition system. Falsely detected faces could be eliminated using correspondence to the database of already known faces. This was exactly the purpose of the method's conception.

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