A Fast 360-Degree Rotation Invariant Face Detection System

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Abstract

We present a fast face detection system that can detect faces rotated to any angle in the image plane. Our system has two major characteristics: 1) It is very fast. On a Pentium4 3GHz machine, the average detection time for faces which can be as small as 20x20 in a QVGA sized image is approximately 0.1 seconds. 2) It has a very low false detection rate. The false detection is less than 3 per 100 images.

1. Introduction

Face detection is becoming a more and more important technology. It can be used not only as a preprocessing for automatic face recognition and other facial image processing, but also as a key technology for security systems and many other applications. Many face detection algorithms proposed focus on detecting upright, frontal faces. In practice, while photos are taken, people do not always turn their faces upright. It is also possible that when a photo is scanned into the computer, the photo is not set upright. In such cases, rotation invariant face detection becomes important.

We demonstrate a fast face detection system that is 360-degree rotation invariant.

2. Characteristics of our system

For many applications, two things are very critical for the face detection system to be useful:

(1) High speed of the detection. Some applications require the system to reach a speed of less than 0.1 seconds per image. Also due to the fast development of input devices, the image size is becoming bigger and bigger, hence the speed of detection is more and more important.

(2) Low false detection rate. Many applications require the system to detect the faces very accurately. False detection may cause very bad results.

We made a lot of efforts to improve both the speed and accuracy of the face detection system.

First, the speed of our 360-degree rotation invariant system is very high. It is fast enough to do real-time rotation invariant face detection.

Secondly, even while keeping the detection rate to a high level, we have successfully reduced the false detection rate remarkably.

Detailed performance is described in Section 4.

3. Description about the demo system

We show two demos, one of face detection in still image, and the other of face detection in a video sequence.

The still images are of size from 320x240 to 320x548. The image size of the video is 320x240.

The computer used is a Pentium4 3GHz notebook PC.

The minimum face size is set to 20x20 and the maximum face size is set to the size of the image (shorter edge of the image).

The average detection time for still images is approximately 0.1 seconds.

Face detection in the video is only done by searching faces frame by frame; no tracking technique is used. The frame rate is about 10 fps.

4. Experiment results

Our experiments showed good results on our photo databases. From a data set of 5843 portrait photos, the detection rate is 96%. The detection rate is more than 70% when dealing with large occlusion of the face, pose changes or bad lighting condition.

On a Pentium4 3GHz PC, the speed of the detection has reached 0.1 seconds per image while the image size is 320x240 and the minimum face size is set to 20x20 and the maximum size is set to image size. It can be used for real-time face detection in video sequences while no tracking is necessary.

The false detection rate is reduced remarkably. On average, less than 3 false detections can be found per 100 QVGA sized images with complicated backgrounds.

Examples of the detection results are shown in the figures.

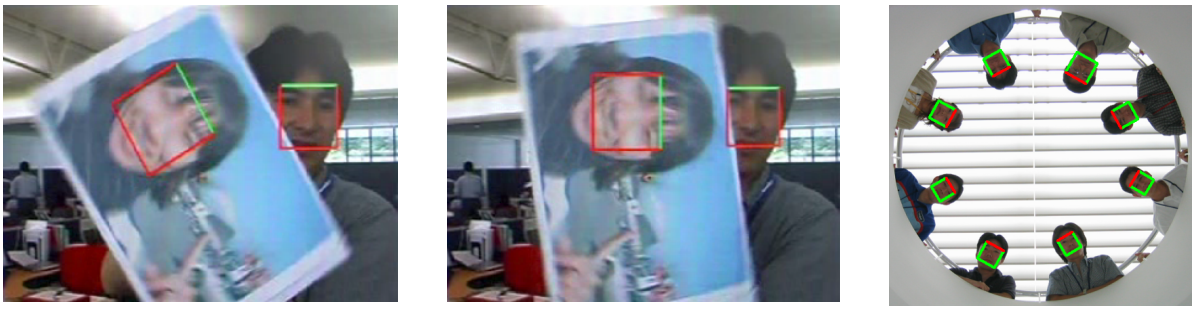

Figure 3: Examples of rotation invariant face detection

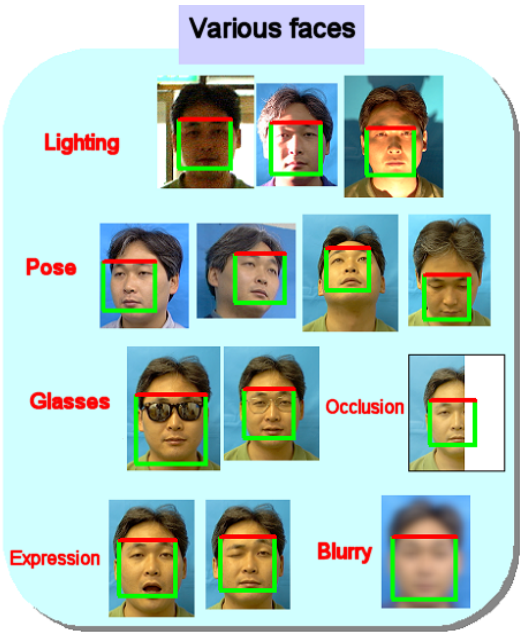

Figure 2: Samples of detection results of faces under various conditions

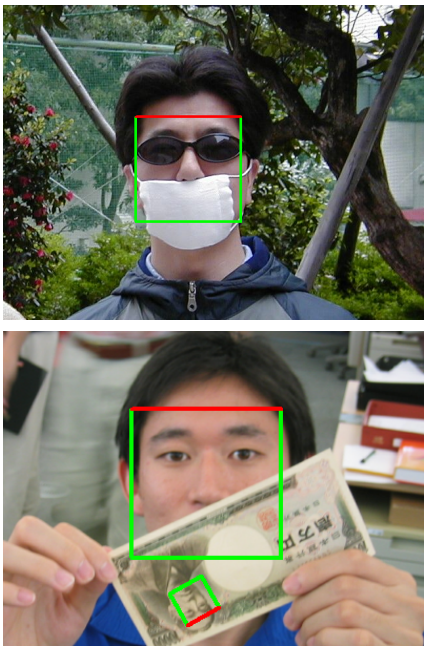

Figure 1: Detection results of occluded faces

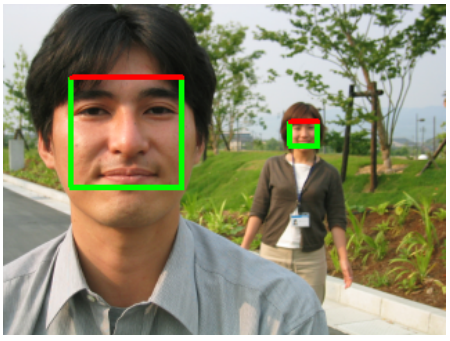

Figure 4: Example of detecting different sized faces

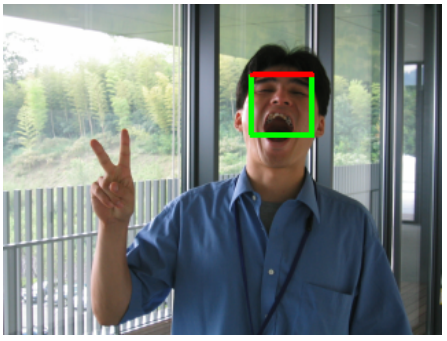

Figure 5: Detection result of a face with changes of expression