Real-Time Face Detection System

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1. Introduction

The current evolution of computer technologies has enhanced various applications in human-computer interface. Face and gesture recognition is a part of this field, which can be applied in various applications such as in robotic, security system, drivers’ monitor, image processing, and video coding system.

Since human face is a dynamic object and has a high degree of variability, we propose the method combine feature-based and image-based approach \cite{1} to detect the point between the eyes (hereafter we call it Between-the-Eyes) by using Six-Segmented Rectangular filter (SSR filter). The proposed technique can achieve real-time processing speed with high reliability for changes of lighting conditions.

In this paper, research objectives, progresses developed so far, and future plan are introduced.

2. Research Objectives

At the first stage, this research is focused on real-time face detection system for human-robotic interface. The aim is to develop the reliable and flexible system to detect faces of various sizes under different conditions in order to create the interactive action between human and robot. Then the objective will be broaden into real applications for industrial purpose as explain later in Section 5.

3. Face Detection Using SSR

The proposed SSR filter, which is the rectangle divided into 6 segments as shown in Fig.1 (a), operates by using the concept of bright-dark relation around Between-the-Eyes area as explained by Fig.1 (b) and (c). We select Between-the-Eyes as face representative because it is common to most people and easy to find for wide range of face orientation \cite{2}.

We use an intermediate representation of image called “integral image” from Viola and Jones’ work \cite{3} to calculate sums of pixel values in each segment of SSR filter. Firstly, SSR filter is scanned on the image and the average gray level of each segment is calculated from integral image. Then, the bright-dark relations between each segment are tested to extract its center as a candidate point for Between-the-Eye as shown in Fig.1 (d).

4. Real-Time Face Detection System

Because SSR filter extracts not only the true Between-the-Eyes but also some false candidates, the stereo camera system as shown in Fig.2 (a) is used to find the distance information and the suitable Between-the-Eyes template size. Then, the Between-the-Eyes candidates are evaluated by using a template of Between-the-Eye (as shown in Fig.2 (b)) matching technique. Finally the true Between-the-Eyes can be detected.

The processing flow of Real-Time face detection system is shown in Fig. 3, where Fig.4 is one of the experimental results. The uppermost-left image is a monochrome image of the right camera. Only this part is used in template matching. The upper corner of the uppermost-right image is the Between-the-Eyes candidate area after cutting and scaling to match the average matching template. Its binarized image of detected eyes and eyebrows after eye detection process is displayed below. The lower image is the image obtained from the right camera, and the lowest image is obtained from the left camera.

Up to now, our system can be used to detect only single face with the inclination less than $10^\circ$. We implement this system on PC with Xeon 2.2 GHz CPU. The system can run at 30 frames/sec with detection rate of 92%.

5. Future Study

Firstly, the development to enhance our system to be able to detect multi-face, faces of different sizes and gestures, and face with inclination as shown in Fig. 5 (a) by using the suitable filter and neural network technique should be investigated. Then with the corporation of VLSI and image processing section of the Multimedia Information Science Laboratory, Ritsumeikan University, face detection system and its application can be implemented for real industrial purpose. One application that captures our interest is to apply face detection to video restoration system \cite{4}. The idea of this technique is shown in Fig. 5. Moreover, by combining real-time face detection and human/gesture recognition, the automatic security camera system could be developed.

References

Figure 1. Concept of SSR Filter: (a) the proposed rectangular filter divided into six segments. (b) Nose area is brighter than right and left eye area. (c) Eye area is relatively darker than cheekbone area. (d) Example of the extracted Between-the-Eyes candidates.

Figure 2. Evaluation Procedure for selecting the true Between-the-Eyes: (a) Stereo camera system. (b) Average Between-the-Eye template and its variance used in template matching technique.

Figure 3. Processing flow Real-Time Face Detection

Figure 4. Detection Result

Figure 5. (a) Example image of multi-face of various sizes with inclinations. (b) Application of Face Detection on Video Restoration using Genetic Algorithm (GA)