Real Time Face Detection on Color Image by Support Vector Machine

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Abstract:

In this research, we present technique of face detection with camera, which human skin is detected by using the color filter as very highly robustness that can cope with the changing of illumination. The technique yields fast searching for information with high-speed access. Utilizing method of Support Vector Machine to verify face of human by human skin detection, the experimental results show efficiency and effectiveness of the system in light of high speed and very high accuracy compared to the other method.

Keywords: Face detection, Support Vector Machine, Skin detection

1. Introduction

Researches in real-time face detection are developed progressively and continuously, which can be applied in many applications, for example, in security systems. Traditionally, most techniques provide two steps for face detection. First, those techniques need to separate the data set that should be the human face out of the background [3] . Mostly, they use the reference image to be the background to check how much the different is among the next images. In doing so, it would benefit this step to reduce the complicated data that will be used in the next step. Second, the techniques require to take the data from the first step to check the correct image. For example, we use PCA or the Principle Component Analysis [4] to separate the human face, or we also use the data set from the first step to be measured with the ellipsoid [1] similarity.

This paper presents a face detection technique that emphasizes on color image associated with the Support Vector Machine (SVM) [7-9] as a recognition system provided the method in three major operating steps. First, we separate the interesting data out of the background of the image by using a reference image as the background to erase the image that we want to check. Second, we get the data from the first step to proceed the skin-color separation in order to reduce the complex of the detecting data. In this step, we use the skin-color filter that is stable for lights and skin types. The skin-color filter is composed of the HSV color model mixing with the YcrCb color model [2]. And third, as the final step, we use the Support Vector Machine Recognition System to check the correct data from the second step. This system is the new recognition system, which can check the correct data more effective than the other ones. In addition, the system emphasizes on finding the Optimum Separate Hyperplane (OSH). With the implementation of these three steps combined to be a real-time face detection system, we found that it brings out a high performance system and achieves fast and stable results in detection processes.

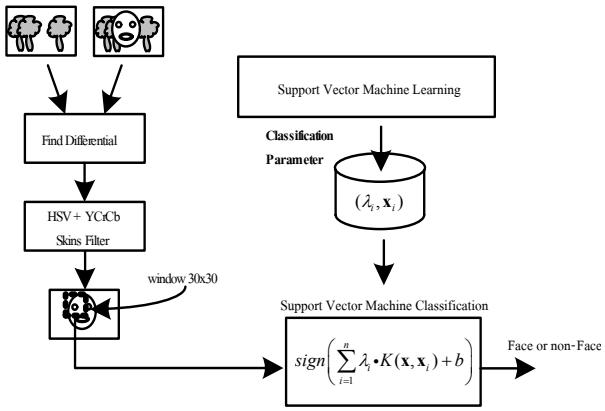

Figure 1 : Face detection systems of operators

2. Background Segmentation

In this technique, to separate information of the image essential, we first increase speed of detection systems by considering that each data to be interested is data image moved into the background image. The image reference is an image other than image background show in Figure 2. The explanation of this definition and terminology can be shown as in Fig. 2.

(a) (b)

Figure 2 : (a) Image background **(b)** Human image in background image

We then use an intersection technique for an image to bring the image of present frame and to search for the difference from the image background. The result is shown in Figure 3.

Figure 3 : result image to search for different present frame as reference image

Note that white pixel image of Fig.3 is data image used for observing changes in background image. Next section shows the better result by suing a human skin filter.

3. Skin Human Color Filter

Given a reference image and data from the previous step, we now make use of a skin human color filter. Since, the quality of face detection depends on the output value produced by support vector machine, we then need to prepare the inputs to that machine by utilizing skin human color in HSV color system with YCrCb color system. Using this technique for filtering information of V and Y in HSV and YCrCb color systems, the brightness of images of each data color system can be defined and distinguished from the image background. The transformation formula from the RGB system to converse between HSV and YCrCb style is shown below:

$$\begin{bmatrix} V \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\ -\frac{1}{\sqrt{6}} & -\frac{1}{\sqrt{6}} & \frac{2}{\sqrt{6}} \\ \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} & 0 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}, \text{ where } H = \tan^{-1}\left[\frac{V_2}{V_1}\right]$$

$$S = \sqrt{V_1^2 + V_2^2}$$

$$Y = 0.299 \cdot R + 0.587 \cdot G + 0.114 \cdot B, \quad (1)$$

$$V = R - Y,\ U = B - Y,$$

$$Cb = 0.5 \cdot (U + 1), \text{ and } Cr = \frac{V}{1.6} + 0.5.$$

Figure 4 shows the result employed the procedure described in this section with fixed values of R,G,B color .

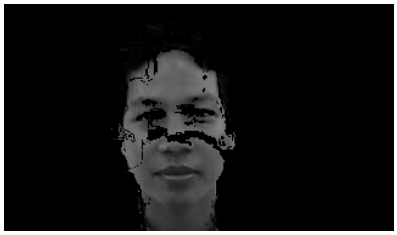

Figure 4 : An example of skin human color by HSV and YcrCb.

4. Support Vector Learning Machine System

Support Vector Machines (SVMs) has been recently introduced as a new technique for pattern recognition. In this technique high generalization performance can be achieved with high quality and speed are guaranteed. In this research, we use this technique to distinguish face image and the case of absence one. The support vector machine is designed to have a decision function $f(\mathbf{x}) = sign(\mathbf{w} \bullet \mathbf{x} + b)$ given training data $(\mathbf{x}_1, y_1) \ldots (\mathbf{x}_n, y_n)$, $\mathbf{x}_i \in \mathbb{R}^n$ with $i = 1, 2, \ldots, n$ and $y_i \in \{-1, 1\}$. To separable of a group of information and to find $\mathbf{w}$ from equation it follows that $\frac{\|\mathbf{w}\|_2^2}{2} + C\sum \xi_i$ regarded as the solution to minimize, subject to $\xi \geq 0$ and $y_i(\mathbf{w} \bullet \mathbf{x}_i + b) \geq 1 - \xi_i$. Thus a robust solution and high distinct one can be achieved, where $C\sum \xi_i$ is the sum of data error for analytic results. The parameter C can be used to increase efficiency of distinguish group data. If value of C has maximized, this will rise error of distinguish information to be minimized, and may be used a long time during the process, resulting difficult to solve. Those equations are subject to $\mathbf{w} = \sum \lambda_i \mathbf{x}_i$, where λ_i are found by solving the quadratic programming [10] for major recognition of data provided as nonlinear data. That data can be transformed into a kernel function in appropriated choices which can be shown in Table 1. The kernel function properties obeys Mercer 's theorem that

$$K(\mathbf{x}, \mathbf{y}) = K(\mathbf{y}, \mathbf{x}) \text{ and}$$

$$\iint K(\mathbf{x}, \mathbf{y}) f(\mathbf{x}) f(\mathbf{y}) d\mathbf{x} d\mathbf{y} \geq 0, \ \forall f \in L^2.$$

Table 1 : Types of kernel functions

Kernel Function	Types of kernel functions
$K(\mathbf{x}, \mathbf{x}_i) = e^{-\|\mathbf{x}-\mathbf{x}_i\|^2}$	Gaussian RBF
$K(\mathbf{x}, \mathbf{x}_i) = (\mathbf{x}^T \mathbf{x}_i + 1)^d$	Polynomial of degree d
$K(\mathbf{x}, \mathbf{x}_i) = \tanh(\mathbf{x}^T \mathbf{x}_i - \Theta)$	Multi Layer Perceptron

As result of recognition into equation to follow that

$$f(\mathbf{x}) = sign\left(\sum_{i=1}^{n} \lambda_i \bullet K(\mathbf{x}, \mathbf{x}_i) + b\right) \quad (2)$$

5. Training Support Vector Machine

In training SVMs, the data to be training requires to be gray level image. We illustrate 1,000 of human face image are stored on data base and, later on, will be recognized by SVMs, as can be seen in the next section. All images have size 30x30 pixels prepared as input data into Support Vector Machine. The data index ranges for SVM are $\lambda_i, 1 \leq i \leq 2,000$ and $\mathbf{x}_i, 1 \leq i \leq 2,000$ which will be used for separating face of human. Figure 5 shows the training process.

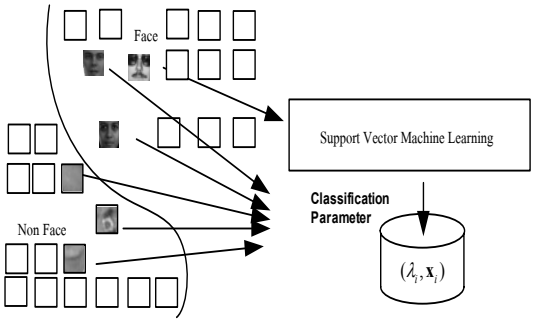

Figure 5 : Training SVMs process

6. Face detect with Support Vector Machine

With input images in pyramid [5] processing via the make use of support vector machine, having considered the sign Assign {+1}, we can arrange a face of human image and save center position of information and assign it to a specific position. Figure 6 shows the know-how.

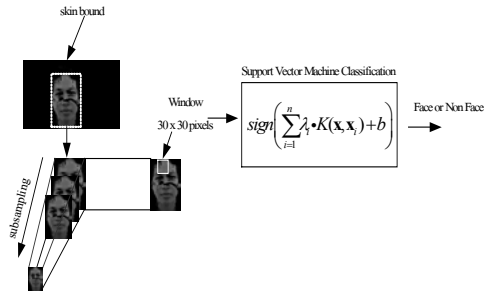

Figure 6: Face detection by Support Vector Machine.

7. Experimental results

The test-based in this research contains a Pentium III 1 GHz PC with 256 Mb memory used for testing image sizes of 320x 200 pixels by every 5 frame/time. Experimental results are shown in Table 2. As can be seen in the Table, our proposed method SVM has high accuracy and speed detection compared to the other method [6] .

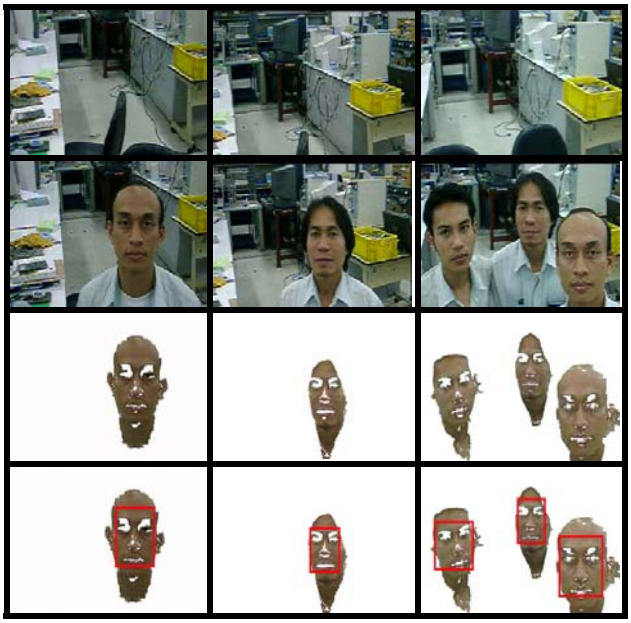

Figure 7 : Result Skin Filter + SVM

System	1'st human image		3'rd human image	
	Accuracy	Speed	Accuracy	Speed
Mutilayer peceptorn	35%	0.32 s	31%	0.34 s
SVM	39%	0.25 s	36%	0.25 s
Skin+multilayer peceptorn	86.5%	0.28 s	82.3%	0.29 s
Skin + SVM	97.3%	0.21 s	95.3%	0.22 s

Table 2 : Comparison on speed and accuracy of the proposed scheme and other method.

8. Conclusion

In this research, a technique of real time face detection to reduce complex having robustness against the changing of illumination is addressed and implemented. The proposed technique has three steps. First, we separate the data set that should be the human face out of the background using background reference. Second, we use human skin detection to reduce error and to improve detection accuracy. Third, the Support Vector Machine technique is employed for fast speed and highly accuracy in the detecting procedure. Experimental results show that the accuracy of the face detection equals to 97.3% for the first facial image and equals to 95.3% for detection of third image. This implies that system has high accuracy and efficiency.

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