형태분석과 피부색모델을 다층 퍼셉트론으로 사용한 운전자 얼굴추출 기법

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Driver face localization using morphological analysis and multi-layer preceptron as a skin-color model

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ABSTRACT

In the area of computer vision, face recognition is being intensively researched. It is generally known that before a face is recognized it must be localized. Skin-color information is an important feature to segment skin-color regions. To extract skin-color regions the skin-color model based on multi-layer perceptron has been proposed. Extracted regions are analyzed to emphasize ellipsoidal regions. The results from this study show good accuracy for our vehicle driver face detection system.

키워드 Face detection, Multi-layer perceptron, Color model

I. Introduction

The problem of face detection is met in many applications such as security systems, vehicle driver vigilance tracking, emotions recognition etc. Many approaches have been developed. Some of them are based on texture information and facial features [1],[2],[3], while others use skin color information [4],[5].

This paper focuses on identifying a methodology for driver's face localization. A major problem of driver's face localization is in sensing the inattention. of a driver. Generally, many road accidents are a consequence of inattention. A profiled face can be analyzed to recognize loss of attention. In the security system applications, the car engine will only start once the onboard computer has recognized its owner's face.

There are some difficulties in driver's face detection should be considered. The first is related to a wide range of light conditions depending on the time of day. Weather also affects lighting conditions. Additional there are other light sources at night such as interior lights, street lamps and outdoor advertising signs. In the case of an oncoming vehicle, the face will be illuminated too much. The current system is able to detect faces with different skin-color.

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This paper consists of the following sections. Section II briefly describes what has been done by other authors previously and kinds of problems they encountered. Section III considers a skin-color model based on a multi-layer perceptron. It shows advantages and the simplicity of our suggested model. Section IV sets a hypothesis for facial shapes. Principal component analysis allows us to exclude components which don't have facial proportions. Experimental results in different light conditions and backgrounds are shown in Section V.

II. Overview of proposed method and related work

The proposed algorithm can be divided into three stages. First stage is color-skin filtering, which excludes regions with non-skin color. Second stage uses geometrical properties of face to omit skin-color regions which do not contain face components. One of the contributions of this paper is the simple and easy customizable skin-color model which is achieved by using a neural network. Skin color filters make it possible to exclude regions which do not contain skin colors. Skin color filters are usually fast, but the main problem with skin filters consists in choosing appropriate color space with defining skin color domain. Many studies has been done utilizing different color spaces and models such as HIS, YCbCr among others.

In this paper multi-layer perceptron (MLP) is applied to approximate skin-color domain in color space. The color model based on MLP does not require transforming RGB space into any other color spaces. Furthermore it is not necessary to choose boundaries for skin-color domain manually [6][7]. Showing examples of skin and non-skin pixels the model is learning automatically to correctly distinguish skin-color and non skin-color pixels.

Still many skin-color high density regions could remain. It could be arms or clothing with skin color tones. In most of the cases these regions are not connected with the face region and therefore they can be eliminated through morphological analysis

The block schema (fig. 1) shows full process of face detection.

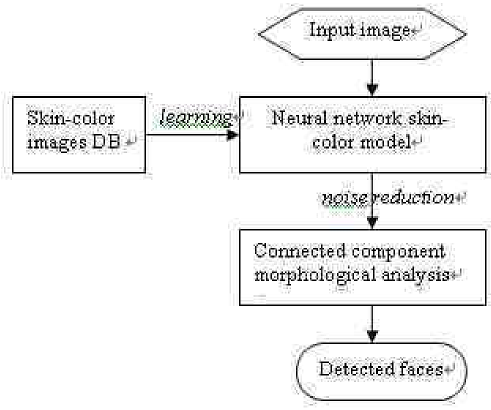

Fig. 1. Flowchart of face detection algorithm.

III. Skin-color model

There are many color spaces has been suggest, which provide easy way to separate skin-color domain. Most of these methods apply heuristic approaches to customize boundaries of skin-color domain. However following heuristic methods doesn't provide general or provide particular way to adapt skin-color for new skin-color sample. We suggest unified method to build skin-color model. To do so a skin-color model based on MLP obtained through the training. Strictly speaking we use two layer perceptron with sigmoid activation function in hidden layer neurons and liner activation function for output neuron (Fig. 2). The number of input neurons corresponds to the number of color component i.e. 3 for red, green, blue. The number of neurons in the hidden layer is not

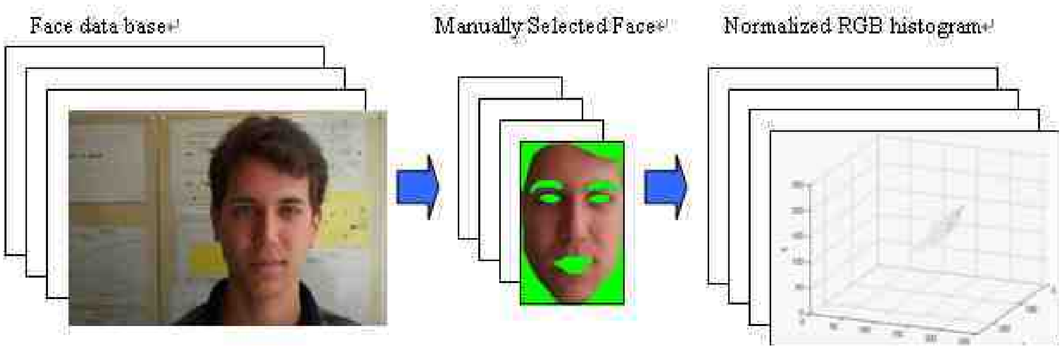

Fig. 3. Preparation of training samples

restricted and can be customized according to complexity of training set. Using trial and error method we set number of hidden neurons equal to 25.

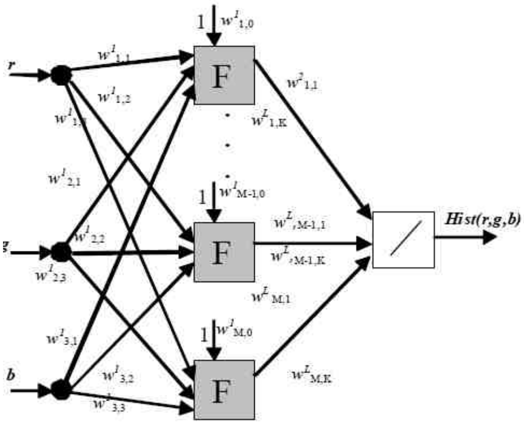

Fig. 2. Two layer perceptron for skin-color space approximation

Training set has to contain two types of subsets. First subset is for positive, i.e. skin-color sample and second for negative non-skin color samples. To obtain skin color samples the frontal face dataset, collected by Markus Weber at California Institute of Technology was utilized. It contains 450 images with 27 unique people under with different lighting/expressions/backgrounds. All these images have been processed manually i.e. facial regions were cut out by hand. Because each of pixels has three color components red, green and blue each of processed faces transformed into RGB color space and thus spatial information is lost (Fig. 3).

Second subset contains negative samples which don't belong to skin-color. Obviously there are plenty of colors which do not belong to skin-color domain. When skin-color domain in RGB space has been formed, negative training samples were obtained by uniformly positioning color vectors in RGB space avoiding skin−colordomain (Fig. 4).

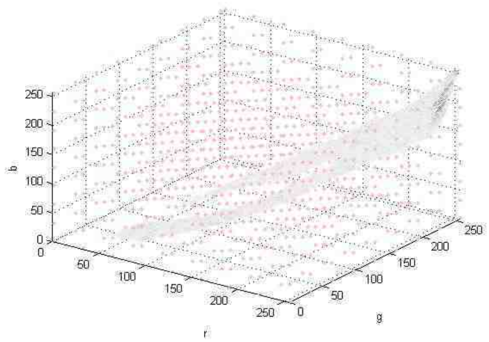

Fig. 4. Cumulative histogram with ne

IV Morphological and shape analysis

Suitable face candidates were extracted by using skin color filtering, i.e. by using MLP skin color approximation and checking the membership of color vectors to skin-color domain. To identify whether the reaming components are faces or not, the prior knowledge of geometrical features of a face are used. The schematic of morphological and shape analysis is illustrated in Figure 5.

An opening operation is required to combine isolated regions with an objective to reduce the

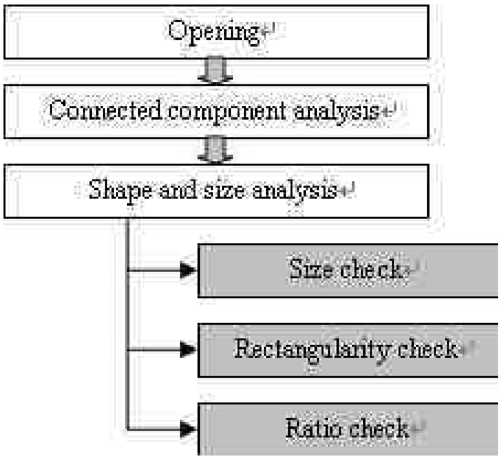

Fig. 5. Flow chart of morphological and shape analysis.

number of regions. After connected components are extracted, each of the target components is to be analyzed separately.

A size check is done to throw out components with a small area. The cut off value depends on the number of layers in the Gaussian pyramid. To decrease processing time each image (video frame)decomposed into Gaussian pyramid. First color filtering applied for low resolution layer then the segmentation result gradually transformed to higher resolution layers. The higher the layer (low resolution) the lower is the threshold value. The area of a face reduces to 4 times from lower to higher level. It is expected that the size of a face should not be lower than a size of (45x60)/2=2700, where 45x60 is the smallest size of a face that can be detected. The product is divided by two to account for possible noise and holes inside the plate. To exclude components that do not have a rectangular shape, rectangularity checkis used. The rectangularity was calculated as follows:

$$R = \frac{S_{comp}}{S_{cover}}, \qquad (1)$$

where Scomp is area of component and Scover is a reaofrectangle which covers the component.

For the best case, R has a value equal to 0.9. The remaining components were analyzed in order to exclude components which are too narrow or long. This analysis is done effectively by calculating the ratio of deviation along the principal axes. Usually the proportion of a face is close to 0.75.

4. Experimental results and conclusion

In our experiments we attached a web camera across from driver's face. While the driver was driving the car, our system analyzed the input video stream. Visual analysis showed good localization abilities during the day time however algorithm should be improved for night time. A particular example of day time face detection is shown in the figure 6. Another set of experiments was done in order to simulate toll road system. Thus the photo camera with better resolution (4 Mega pixels) was located in about 5 meters from the driver.

It is common at toll road systems to take pictures of toll vehicles in order either to recognize vehicle license plate or to match driver face with police database. Our experiment showed good face localization in 16 cases of total 20 snapshots. This is equal to 80% localization rate for people with different skin color (Asian, Caucasian, Africans)

Fig. 7. Face detection during night time (toll road system simulation). a) original picture, b) after skin color segmentation , c) final result after morphological analysis

5. Conclusion

To improve face localization, we propose to combine multilayer-perceptron as a skin-color model and morphological analysis for non-face component. detection. The use of multi-layer perceptron with 25 hidden neurons showed good skin-color domain approximation which allowed us to create a skin-color filter. The combination of a skin-color filter with the morphological analysis leads to a face localization system with an 80% localization rate. As a further research we are planning to improve localization rate by adding texture features detection.

References

1. D'Orazio, T., Leo, M., Cicirelli, G., Distante, A.: An algorithm for real time eye detection in face images. Inter. Conf. on Pattern Recognition. Volume 3 (2004) 278 - 281.
2. Hyungkeun, Jee, Kyunghee, Lee, Sungbum, Pan: Eye and face detection using SVM Conference on Intelligent Sensors, Sensor Networks and Information, (2004) 577 - 580.
3. Nguyen, D., Halupka, D., Aarabi, P., Sheikholeslami, A.: Real-time face detection and lip feature extraction using field-programmable gate arrays. IEEE Transactions on Systems, Man and Cybernetics,PartB, Volume 36, Issue 4 (2006), 902 - 912.
4. Naseem, I.,Deriche, M.; Robust human face detection incomplex color images. IEEE International Conference on Image Processing. Volume 2 (2005), 338-41.
5. Butler, D., Sridharan, S., Chandran, V.: Chromatic colour spaces for skin detection using GMMs. Inter. Conf. on Acoustics ,Speech, and Signal Processing. Volume 4 (2002) 3620-IV-3623.
6. Chen, C., Chiang, S.-P., Detection of human faces in colour images. IEE Proceedings on Vision, Image and Signal Processing. Volume 144(1997) 384 - 388.
7. Phil Chen, Dr. Christos Grecos, A Fast Skin Region Detector, ESC DIVISION RESEARCH 2005
8. Orlando J. Hernandez and Mitchell S. Kleiman, Face Recognition Using Multispectral Random Field Texture Models, Color Content, and Biometric Features. Proceedings of the 34th Applied Imagery and Pattern Recognition Workshop 2005.

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