Modeling the Human Face and its Application for Detection of Driver Drowsiness

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Abstract—**The detection problem of human face in the image has been studied since the 70s. However, this is a complex problem so there are many research groups on the world interested. In the detection of human face, the pattern of the human in the image, which is a concept showing the relationship between the image information with a human face that definition. The one of paper results is to give a human face model in the space approach, which can detect some states face. From that the paper proposed an algorithm to detect driver drowsiness. The algorithm has been implemented and tested, and it proved effective in cases where the image was taken a direct and bright enough.**

Index Term – **Image Processing, Human Face Recognition and Driver Drowsiness**

I.   INTRODUCTION

THE research on human faces in images is a topic, which has long interested in the field of computer vision. Which detects human faces in images is a problem throughout and always attracted the attention of many research groups around the world.

In fact, there are many problems need to face recognition such as face detection is integrated in the digital camera; the application of access control based on facial recognition is located at the airport, train stations; the application to monitor and track human through the use of camera systems are located in a building or a certain security area; the Hollywood epic film in which the face of actors are transformed into new shapes that we have not heard before like the werewolf, vampire, avatar.

Moreover, in addition to widespread application; this is a difficult problem, not the final solution. In the area of face recognition, the face model in the picture is important research problem. It is a concept showing the relationship between the image information with a definition of the person. One of approaches to model the human face is a combination of geometric features and material characteristics of faces in images based on statistical methods.

The Fig. 1 is Eigenface model; this is the characteristic vector model in face recognition. This model is based on technical on Principal Component Analysis (PCA), in which each pixel is treated as a random variable. To reduce the volume of calculations, Matthew Turk and Alex Pentland [3] gave a formula to reduce the dimensionality of the covariance matrix when calculating the eigenvector and eigenvalue. This model has become popular, not only by the relatively high accuracy, range 60 ~ 90% in many published data on the network, but also because it is quite flexible in the application.

This approach is based on building a statistical model for human face shape, and on that basis to build statistical models for human images material, after that synthesizing to create the human face model

The learning and estimation of the parameters for the model to minimize the error function by an optimization iterative method. The basic objectives of the human face model based on this approach are the analysis and synthesis of human faces in images under specific requirements. According to this research, there are models such as ASM (Active Shape Model) and AAM (Active Appearance Model) given by Cootes (Fig. 2 and Fig. 3).

Figure 1. Model Eigenface of Matthew Turk and Alex Pentland

This paper gives a human face model for Vietnamese adults by spatial structure. Based on the classification and inheritance as enginface model for the human eye, which can determine the state faces. Since this model is given, we propose an algorithm to detect driver drowsiness. The result has been installed and tested proved quite effective.
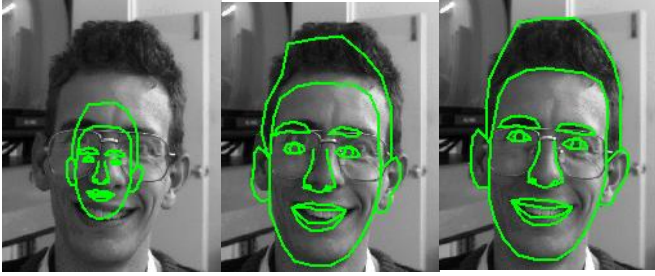

Figure 2. Optimization iterative process of ASM

Figure 3. Optimization iterative process of AAM

The rest of the paper is shown as follows: Section 2 presents a human face model in the image. Section 3 is the algorithm to detect driver drowsiness. The next section presents the experimental results and the conclusion was presented in finally section.

II.   THE HUMAN FACE MODEL IN IMAGES

A.   *The human face in image*

The human face in the image is a region that shows the human face. Finding it in the image is the final result of the human face-detecting problem; it is also the input data for human face recognition problem. Data of the human in image should be analyzed to optimize for efficient use of face detection, which uses the above mentioned human face model. For example, in the problem detects the drowsy driver is discussed in this paper, the human face image is a face that looks slightly face up; face with square frames, edge size of about 100 ~ 200 pixels (Fig. 4).
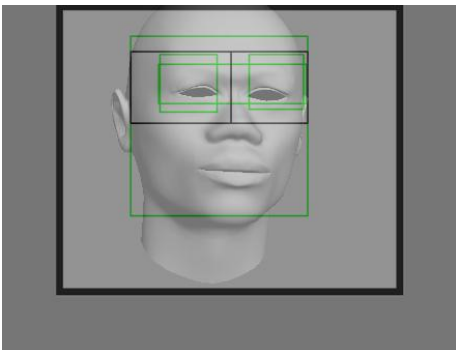

Figure 4. The human face image

In the face area usually appears only at a human face; in this case there are than a one, the face of the driver is the biggest, and the other faces usually smaller because they are in the rear.

B.   *The eye human in image*

For a human face, there may be many people in the frame but for the human eye in the frame, only one eye. In the drowsiness detection problem of a driver, the eye image is defined as a square image; it includes the eye and brow area above the eyes, its edge size is about 25 ~ 50 pixels. In the case open eye, the pupil area is approximately 30 pixels, located at 1/3 of image from the bottom area (Fig. 5)

Figure 5. Area of eye in image

There have been many researches of the status of the eye, such as gaze detection and blink detection. The gaze detection focuses on the eye-opening case and analyses of the position of the pupil in the eye; while the blink detection often focus on the change of the eye image, without regard to the eye is closed or opened (Fig. 6).

This paper considers only the most basic two states of the eye: closed and opened. To determine this status, the paper uses the eye image data as the input of SVM (Support Vector Machine) to be class as between two states of the eye.
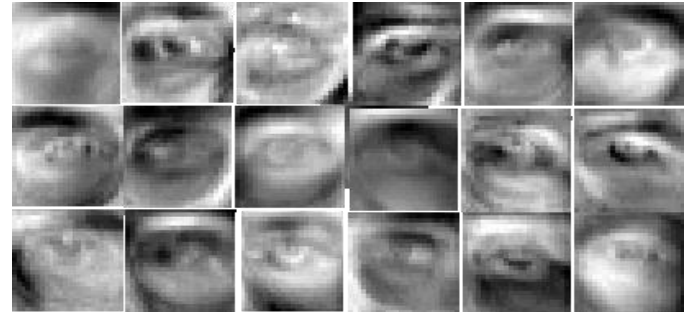

Figure 6. Eye Model of Eigenface

C.   *The spatial approach of human face model*

To optimize the parameters of the model that corresponds to the faces of the Vietnamese, we refer to the anthropometric signs of Vietnamese adults [1]. The Information on anthropometric was measured in people are shown in Table 1.

Table 1. Data of Vietnamese face

Subjects	Students and Free workers in Hanoi, Bac Giang
Quantity	959 persons
Age	From 18 to 55
Sex	Male: 460 Female: 499
Hometown	Hanoi, Bac Ninh, Bac Giang, Nam Dinh, Thanh Hoa

Based on anthropometric signs that have been statistied and analyzed correspondently to four basic models of the Vietnamese face (Fig. 7), the paper has built the corresponding parameters for the human face model.
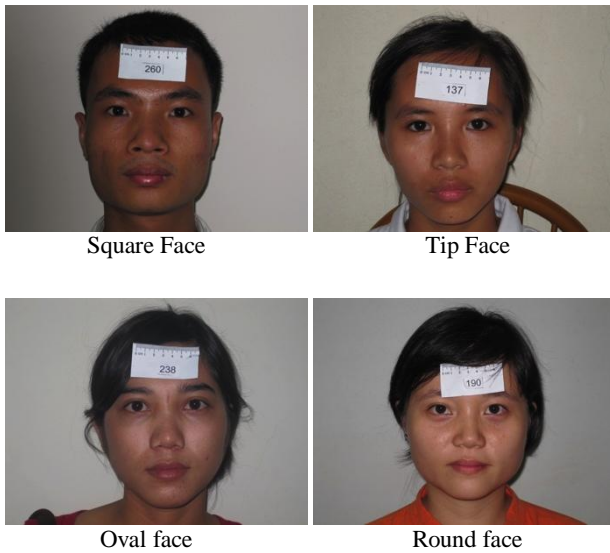

Figure 7. Four Vietnamese face models

This paper presents a simple model but effective to detect quickly and accurately the human face, as well as the face components based on the analysis of face and location of the human face components in the image.

The human face model includes the limited areas of the face and the face components. To estimate the parameters of the model, we need to analyze in detail the location of human face images.

In the drowsiness detection problem of driver, there should be a camera mounted in front of the driver, and set marginally below that it does not interfere with the driver's vision. The camera angle was fixed, the driver seat position is also fixed and the driver always looks straight ahead. So in the frame of the camera obtained human face image that always face straight and slightly from below.

In this human face image area, the eyes appear in rectangle with size (le_w_1, le_w_2) x (ep_h_1, ep_h_2), similar with right eye, from re_w_1 to re_w_2.

The nose appears in the rectangle (n_w_1, n_w_2) x (n_h_1, n_h_2).

The mouth is located under the nose; it is in the range of (m_w_1, m_w_2) of face image.

By defining the parameters used this simple model, the search space is reduced a lot. Since it is very easy to build face detection component for detecting problem the drowsy driver.

III.   THE ALGORITHM OF DROWSINESS DETECTION

A.   The drowsiness status

The drowsiness status of driver is determined by the eyes closed continuously in predetermined time duration; it is measured in seconds or frames.

B.   The algorithm

- Objective: Determine the eyes in the frame is closed or opened.
- Input: `image I` (is frame be taken from the camera or video file)
- Output: `-1/0/1` (no face/closed eyes closed/opened eyes)
- Variables:

```
o   Region:      face_region,      eyepair_region,
    lefteye_region,    righteye_region,    face,
    eyepair, lefteye, righteye;
o   List<Region>: face_list;
o   EdgeMap: face_edge;
o   Integer: model_id;
o   FaceModel: model;
```

The steps:

Step 1: Determine the face

```
o   face_region = GetFaceRegion(I);
o   Normalize(face_region, I);
o   face_list = DetectFaces(face_region, I);
o   if size_of(face_list) = 0, return -1;
o   face = GetBiggestObject(face_list);
o   Segment(face, I);
o   face_edge  = ProcessEdge(face, I);
o   model_id = RecognizeModel(face_edge);
o   model = GetFaceModel(model_id);
```

Step 2: Determine the eyes

```
o   eyepair_region = GetEyePairRegion(face,
    model);
o   eyepair = DetectEyepair(eyepair_region, I);
o   if eyepair = null, return -1;
o   lefteye_region = GetLeftEyeRegion(eyepair,
    model);
o   lefteye = DetectLeftEye(lefteye_region, I);
o   if lefteye = null, return -1;
o   righteye_region = GetRightEyeRegion(eyepair,
    model);
o   righteye = DetectRightEye(righteye_region,
    I);
o   if righteye = null, return -1;
```

Step 3: Recognize the eye status

```
o   NormalizeEyes(I, lefteye, righteye);
o   if IsClosedEye(I, lefteye) or IsClosedEye(I,
    righteye), return 0;
    else return 1;
```

The complexity of the algorithm is $O(n^3)$, so that model optimization to reduce the search window is very important for detecting problem.

IV.   EXPERIMENTAL RESULTS

The testing program is built on Visual C++ with Library OpenCV fro Intel. The program receives input data from the source video or webcam, and then notifies the faces state of driver. Program data were collected in several different conditions such as laboratory, in cars. The experimental results show that the program runs with real-time speed and accuracy is very high in testing data set (Table 2, Fig. 8).

Table 1. The parameter for testing

	Square face	Tip face	Oval face	Round face
ep_h_1	0.142857	0.166667	0.142857	0.166667
ep_h_2	0.433333	0.500000	0.433333	0.500000
le_w_1	Left_eyepair	Left_eyepair	Left_eyepair	Left_eyepair
le_w_2	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2
re_w_1	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2	(Left_eyepair+Right_eyepair)/2
re_w_2	Right_eyepair	Right_eyepair	Right_eyepair	Right_eyepair
n_w_1	0.333333	0. 333333	0. 333333	0. 333333
n_w_2	0.666667	0. 666667	0. 666667	0. 666667
n_h_1	Bottom_eyepair	Bottom_eyepair	Bottom_eyepair	Bottom_eyepair
n_h_2	0.723333	0.750000	0.723333	0.750000
m_w_1	0.250000	0.250000	0.250000	0.250000
m_w_2	0.750000	0.750000	0.750000	0.750000

Figure 8. Experimental result

V. CONCLUSION

The face model is a concept that has many applications is deployed. However there are still many open issues. This paper gives a simple model to apply for detection quickly and accurately the faces and facial components. Form that to use for drowsiness detection of drivers. This paper is limited in terms of data collected enough light.

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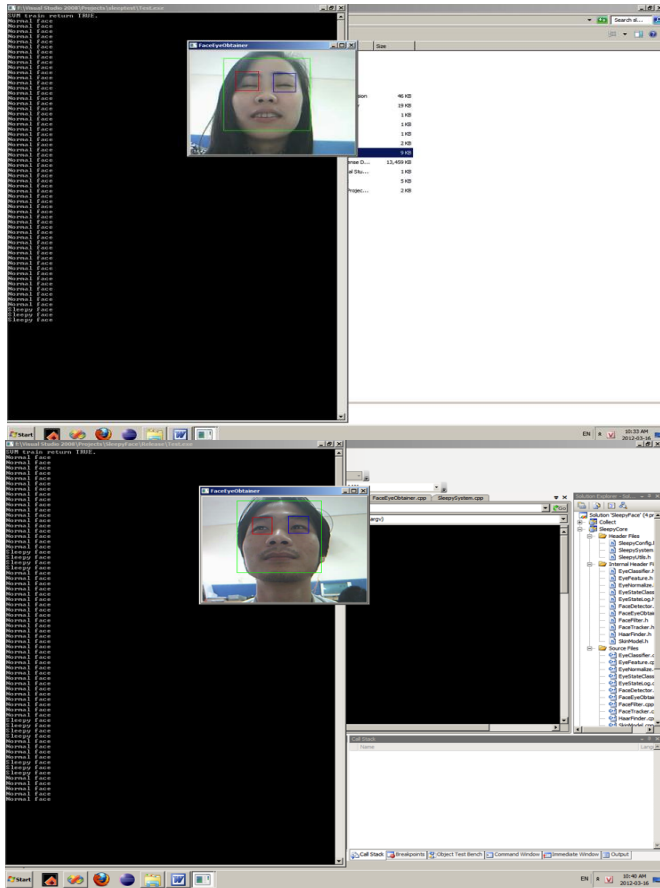
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