Eye Tracking and Blink Detection for Human Computer Interface

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ABSTRACT
Eye plays an important role in collecting information of face characteristics. The eye region includes information of gesture, identity, gender and etc. It can be used in many applications such as gesture understanding, fatigue driving, eye blink detecting, disabled-helping domain, psychology domain, human-machine interaction, face recognition in video, and so on. Eye tracking is the focus problem in the researching domain of human-machine interaction. In this paper a new method of eye tracking is proposed because in older method detection algorithm has poor real time performance. This method combines the location and detection algorithm with the grey prediction for eye tracking. The model is used to predict the position of moving eye in the next frame, and then this position is taken as the reference point for the searching region of eye. Experimental results show that the grey prediction model can explore out the latest law of motion to overcome the shortcoming that a linear filter must assume the motion law in advance. Thus it can achieve robust tracking of eye. Furthermore it can build the real-time online grey prediction model under the polar coordinate system, making it unnecessary to convert the model.

1. INTRODUCTION
Eye tracking along with blink detection are used to provide human-computer interaction face Detection, Eye tracking and Blink detection are used to locate the eye position The difficulty of eye tracking is that eye is affected by many factors including lighting, gesture and covering objects. Eye Tracking based on neuron network and template matching rely on the training sample and template seriously. Because iris is reactive to the infrared light, the technique of eye locating with infrared light has wide application. But it needs special hardware devices and the infrared camera. Kalman filtering and mean shift are introduced into eye tracking system for improving the correctness of tracking. But Kalman filtering has errors while approximating the non-linear system. The mean shift algorithm always cannot track an object correctly if it varies sharply for an instant.

Grey prediction model provides reference point and reduces the search region. It locate accurate position. In this model adjustments can be made according to the eye movements and tracking in noisy images is possible .It detecting volunteer and non-volunteer blinks. Combined with color, luminance and shape information we can efficiently replace the mouse actions.

Grey system theory takes all random variants as the grey variants varying in a certain scope. It analyzes these variants not with the statistical law but with the data processing methods that can collate the chaotic raw data into generating data of strong regularity. That is to say, the grey system theory doesn't build the raw data model but the generating data model. The grey prediction processes the original data and builds the grey model to deduce and grasp the law of system development. A new eye tracking algorithm combing skin-color based face detection, rule-based eye location and grey prediction model is proposed in this paper.

2. FACE DETECTION BASED
Skin-color has the effective features for fast face detection.In the YC_bC_r model chroma and luminance information are separated from each other, which limits the distribution of skin-color. Here, C_b and C_r are chroma information. Statistical data show that human skin color of face is in the range of roughly C_r [90,125], Cb [135,165]. According to this range, if both Cr and C_b meet the conditions, we set the points to 1, Otherwise we set them to 0. Skin-color can be represented by a few simple parameters, so it can be calculated out rapidly; the feature of skin-color is constant under a certain lighting conditions , skin-color in color space has clustering features and skin-color difference is only decided the brightness. Therefore, skin-color has the effective features for fast face detection.

3. EYE LOCATION BASED
From the obtained face region, the holes' areas are calculated out, and then the holes with too small area are excluded. Using the threshold method the image is color-reversed, and then marked with the 8-connection; finally the area of each region is calculated. If it is too large, eye is also removed; if it is too small, the desired results cannot be produced. In this paper, the threshold is taken as the average area after removing the largest one. The shape of eye is similar to an ellipse shape. Taking into account the possible errors during binarization, we believe that human eye is a regular shape. Accordingly, we can calculate the centroid of each hole. For each region, if its centroid coordinates are within this region, the region is regarded to be regular; otherwise it is irregular so that it is not the eye region.

We can calculate the center of mass C_L of H_L and C_R of H_R respectively for any given H. If $C_R(x)$- $H_R(x)>T$ and $\alpha<30$, the hole pair H is possible to be eye. After being handled with the above, the region including eye and brow is obtained, but some other regions may still exist. The number of residual holes is summed and the centers of mass for each hole are calculated. If the number of regions is even, the X coordinates of the center of mass of the former half are added up according to the region number, and then are reduced by the X coordinates of the second half. If the result is within the range of 10 pixels, we can consider that these centroids are arranged in pairs. The number of regions is used again to determine eye's position. If the number is 3, the centroid pair with least vertical distance and larger horizontal distance is eye; if he number is 4 and the centroids are in pairs, the centroid pair located at the lower position is eye; if the entroids aren't in pairs, the centroid pair with least vertical distance and larger horizontal distance is eye. Experimental results show that higher accuracy rate can be achieved using the rule for eye detection.

4. GREY PREDICTION MODEL

Therefore the grey model is actually the generated data model instead of the original data model obtained by the common modeling method.

Suppose $X^{(0)}=(x^{(0)}(1),x^{(0)}(2),\ldots x^{(0)}(n))$ and

$X^{(1)}=(x^{(1)}(1),x^{(1)}(2),\ldots x^{(1)}(n))$,then the original form of GM (1,1) model is as follows:

$$X^{(0)}(k)+az^{(1)}(k)=b, \qquad (1)$$

Where

$$Z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1),k=2,3,\ldots n \qquad (2)$$

$$X^{(1)}(k)=\sum_{i=1}^{k} x^{(0)}(i), \quad k=1,2,\ldots n; \qquad (3)$$

If $\hat{a} = (a,b)T$ is parameter vector and

$$Y=\begin{pmatrix} x^0(2) \\ x^0(3) \\ . \\ . \\ X^0(n) \end{pmatrix} \qquad B=\begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ . & \\ . & \\ -z^{(1)}(n) & 1 \end{pmatrix} \qquad (4)$$

The least Square Estimation parameters of GM (1,1) model $x^{(0)}(K)+az^{(1)}(K)=b$ satisfy

$\hat{a}= (B^T B)\text{-}1B^TY$, and the estimated parameters are obtained. As ref.[11],the original form of GM(1,1) model can be converted into:

$$x^{(0)}= \lambda_1 - \lambda_2 \; x^{(1)}(k-1) \qquad (5)$$

Where $\lambda 1 = \dfrac{b}{1+0.5a}$ and $= \dfrac{a}{1+0.5a}$ .And

$\hat{X}^{(1)} = (\hat{X}^{(1)}(1), \hat{X}^{(1)}(2), \ldots, \hat{X}^{(1)}(n))$ is the time response sequence of GM(1,1) model, where

$$\hat{X}^{(1)}(k)=(x^{(0)}(1)-\frac{b}{a})\, e^{-a(k-1)}+\frac{b}{a},$$

$$k=1,2\ldots n. \qquad (6)$$

Substitute $x^{(1)}(k-1)$in formula(5) by the response values $\hat{x}^{(1)}(k-1)$,we can get

$$X^{(0)}(k)=(\lambda_1 \text{-} \lambda_2[(X^{(0)}(1)-\frac{b}{a})\, e^{-a(k-2)}+\frac{b}{a}]$$

$$= \lambda_1 - \lambda_2 \frac{b}{a} + (\lambda_2 \frac{b}{a} - \lambda_2 (X^{(0)}(1)) \, e^{-a(k-2)}$$

Since $\lambda_2 \frac{b}{a} = \frac{a}{1+0.5a} * \frac{b}{a} = \frac{b}{1+0.5a} = \lambda_1$, the prediction formula is

$$X^{(0)}(k)=(\lambda_1 \text{-} \lambda_2(X^{(0)}(1))e^{-a(k-2)} \qquad (7)$$

While we have obtained the center points of eye region for the first four frames according to the eye location rule, we can use two GM(1,1)models to predict on directions of *x* and *y* respectively. Then we will have good center reference point of eye region for the fifth frame. Here the equation is:

$$Y=\begin{pmatrix} x^0\ (2) \\ x^0\ (3) \\ \\ x^0\ (4) \end{pmatrix} \qquad B=\begin{pmatrix} -z^{(1)}\ (2) & 1 \\ -z^{(1)}\ (3) & 1 \\ & \\ -z^{(1)}\ (4) & 1 \end{pmatrix} \tag{8}$$

Where x^0 (1) , x^0 (2) , x^0 (3) , and x^0 (4) represent positions of the first four center points of the eye region respectively. Then we can get

$$\begin{pmatrix} a \\ \\ b \end{pmatrix} = (B^T - B)^{-1} B^T Y \tag{9}$$

so the prediction value of fifth point is

$$X^{(0)}\ (5)=(\lambda_{1-}\lambda_2(X^{(0)}\ (1)\ )e^{-3a} \tag{10}$$

5. RESULTS AND ANALYSIS

The grey prediction model GM doesn't assume the law of motion in advance. Instead it makes accumulated generating operation with sub-sample and poor information the result of which can reduce the effect of random disturbances and extract valuable information.

So it can correctly describing and effectively monitoring the behavior of motion and law of evolvement of system so that the inherent law of eye motion can be explored out. Historical data are used for predicting motion of eye, their varying trend will elagged compared with real data because more and more historical information is generated with the movement of object. However, at the same time, there are some new random disturbances or driving effects into the system so that the development of the system has been affected gradually.

Especially when qualitative variation occurs in the prediction system with quantitative variations accumulating to some extent, the new prediction system is completely different to the old system. So the method of this paper adds more new data and removes old data that cannot reflect the characteristic of system. Provides reference point Reduces the search region locate accurate position Adjustments can be made according to the eye movements

- Tracking in noisy images is possible.
- Detect volunteer and non-volunteer blinks.
- Combined with color, luminance and shape information.
- Efficiently replace the mouse actions

6. REFERENCES

(1)Bojko Agnieszka, Gaddy Catherine, Lew Gavin, et al. Evaluation of drug label designs using eye tracking. Proceedings of the Human Factors and Ergonomics Society 49th Annual Meeting, 2005, p 1033- 1037.

(2) Miyazaki Shota, Takano Hironobu, Nakamura Kiyomi. Suitable check points of features surrounding the eye for eye tracking using template matching. Proceedings of the SICE Annual Conference, SICE 2007, 2007.

(3) Horng Wenbing ,Chen Chihyuan A real-time driver fatigue detection system based on eye tracking and dynamic template matching. Tamkang Journal of Science and Engineering, v 11, n 1, 2008, p 65- 72.

(4) Castaneda Benjamin , Luzanov Yuriy, Cockburn Juan C. A modular architecture for real-time feature-based tracking.IEEE International Conference on Acoustics, Speech, and Signal Processing, 2004, p V- 685-V-688.

(5) Dong Wenhui, Wu Xiaojuan, Qu Peishu. Eye Tracking Based on Rules and the Kalman Filtering. Computer engineering & science, v28, n11, 2006, p27-29.

(6) Chen Yanqin, Luo Dayong. Real time eye tracking based on Kalman filter and mean shift algorithm. Pattern recognise and artificial intelligence, v17, n2, 2004, p173-177.

(7)Mao Ninfeng, Zhang Xingming, Guo Yucong. Fast rule-based eyes location algorithm. Computer Engineering, 2004, 30(9): p154 -156.