Object Recognition on Horse Riding Simulator System

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***Abstract*—**In recent years, IT convergence technology has been developed to get creative solution by combining robotics or sports science technology. Object detection and recognition have mainly applied to sports science field that has processed by recognizing face and by tracking human body. But object detection and recognition using vision sensor is challenge task in real world because of illumination. In this paper, object detection and recognition using vision sensor applied to sports simulator has been introduced. Face recognition has been processed to identify user and to update automatically a person athletic recording. Human body has tracked to offer a most accurate way of riding horse simulator. Combined image processing has been processed to reduce illumination adverse affect because illumination has caused low performance in detection and recognition in real world application filed. Face has recognized using standard face graph and human body has tracked using pose model, which has composed of feature nodes generated diverse face and pose images. Face recognition using Gabor wavelet and pose recognition using pose graph is robust to real application. We have simulated using ETRI database, which has constructed on horse riding simulator.

***Keywords*—**Horse riding simulator, Object detection, Object recognition, User identification, Pose recognition.

I. Introduction

IT convergence technology and interest in health has made combination sport science and IT technology. Screen golf is a representative sample of an intelligent sports simulator in virtual reality space. Recently, increase in population of riding horse has needed intelligent horse riding system. But, the contents of the screen and the real movement of sports equipment have mostly developed to increase reality on the simulator. In addition to, the height of the horse is almost like a real horse and the horse simulator is schooled and capable of doing advanced movements. The neck is moveable and the leg aids are detected on/behind the girth by sensors. But, it is difficult to implement sense of reality because interaction with human is lack on riding horse simulator.

In this paper, we propose an intelligent horse riding system, which has object detection and recognition functions. To be more concrete, user identification by face recognition [1]-[8], the correct posture detection of riding horse by posture recognition, personalized train by automatic updating of personal data by face recognition and posture recognition, the construction of reality simulator by analysis of intentional motion have processed on the intelligent riding horse simulator. In generally, object recognition [9]-[17] technology applied in real world environment has been made challenge problem because illumination has caused image transformation. Therefore, it is necessary to preprocess image, which preserves inherent feature. In this paper, illumination invariant object recognition is proposed. Face has recognized using Gabor wavelet and face graph, and posture region has detected using DoG filter and local adaptive binarization and posture has recognized posture graph. A posture region from background image is extracted with compensated edges that reserves geometry information of object region. Face recognition using Gabor wavelet and pose recognition using posture graph is robust to real application. We have simulated using ETRI database, which has constructed on horse simulator

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II. Concept of Intelligent Horse Riding Simulator

A correct position of the rides in general can be detected by searching straight posture in the face and in the body as shown in Fig. 1. Detecting pose feature points such as face, hand, foot, and keeping back straight are important factor to take riding horse correctly. We have designed an intelligent horse riding simulator using vision sensor that senses a correct face position by detecting frontal face using frontal camera, and a back straight and the correct position of the hand or foot using side camera and a correct position of shoulder and hip using back camera as shown in Fig. 2. To perform previously mentioned task, object detection and recognition techniques are needed that are face detection and recognition and pose of riders in horse riding simulation environment. But, object recognition performance severely degrades according to pose and illumination condition.

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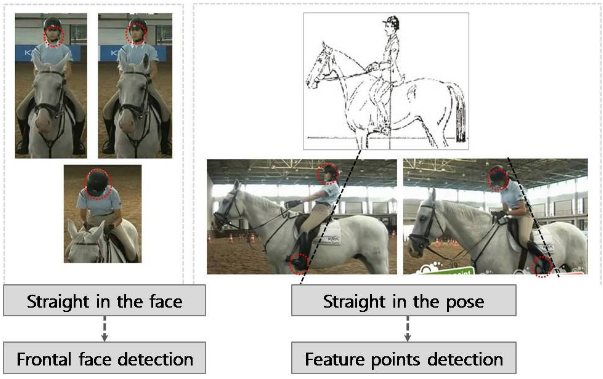

Fig. 1 Detection of face and riders position on riding horse

Pose and illumination variations along with low image resolutions are major factor of degradation of object recognition performance. Especially, illumination and motion on horse riding simulator can adversely affect object detection and recognition. Therefore, combined image preprocessing has progressed to detect object region and face and pose recognition of riders has proposed to overcome the low resolution problem, lighting and pose variations.

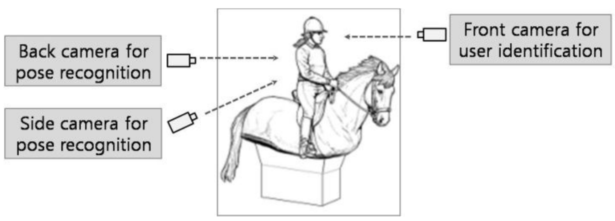

Fig. 2 Multi-vision sensors for intelligent horse riding simulator

We propose an intelligent horse riding simulator, which performs user identification by face recognition, right face position by face detection, a correct posture on riding horse by pose recognition, a personalized train and automatic update of personal data by face recognition and pose recognition, the construction of reality simulator by analysis of intentional user motion have processed on the intelligent riding horse simulator as shown in Figs. 3 and 4.

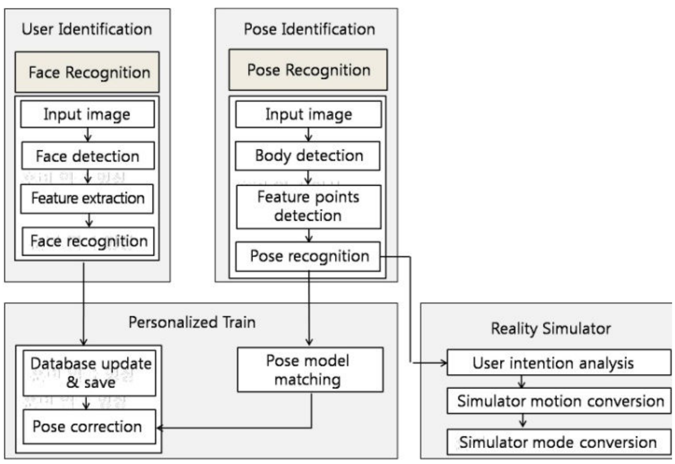

Fig. 3 Concept of intelligent techniques on horse riding simulator

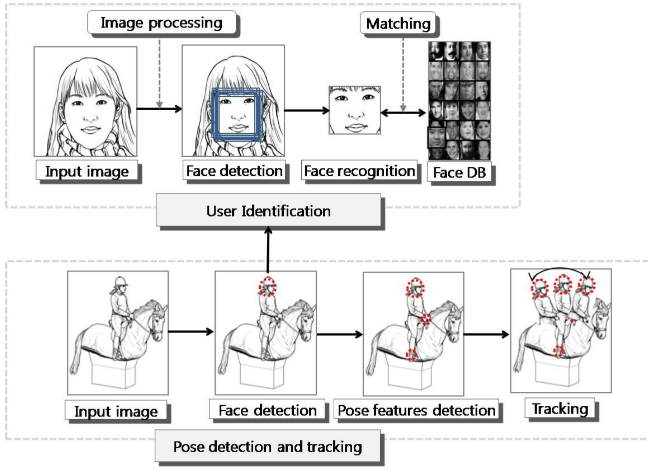

Fig. 4 User identification and pose feature point tracking

III. Face Recognition

To detect straight in the face on the horse riding simulator, we has detected frontal face with frontal camera in the long distance. We have selected gallery image for training with general face frontal image and low resolution image in poor illumination condition like horse riding simulator. Face feature generation and saving has processed with training image. Probe image of test face image has acquired and face region extraction, normalization, feature extraction and face recognition by template matching with trained face template, and then best matching user are shown.

Face detection by Adaboost algorithm [3] using MCT feature is robust to real world environment which has low resolution and blurring by movement on horse riding simulator. User identification has recognized face using combined face features of Gabor wavelet and local Gabor XOR patterns. A 2D Gabor kernel is shown in (1).

$$\psi_{\mu,\nu}(z)=\frac{\|k_{\mu,\nu}\|^2}{\sigma^2}e^{(-\|k_{\mu,\nu}\|^2\|z\|^2/2\sigma^2)}\left[e^{ik_{\mu,\nu}z}-e^{-\sigma^2/2}\right] \quad (1)$$

where μ and ν defines the orientation and scale of Gabor kernels, $z=(x,y)$, $\|.\|$ denotes the norm operator. Wave vector $k_{\mu,\nu}=k_\nu e^{i\phi\mu}$, $k_\nu=k_{\max}/f^\nu$ and $\phi_u=\mu(\pi/8)$. $k_{\max}/f^\nu$ is maximum frequency and f is the spacing factor between the kernels in frequency domain. ν is the frequency with $\nu=0,...,\nu_{\max}-1$ and μ is the orientation with $\mu=0,...,\mu_{\max}-1$, $\nu_{\max}=5$, $\mu_{\max}=8$, $\sigma=2\pi$.

Gabor transformation of a given face image is shown in Fig. 5.

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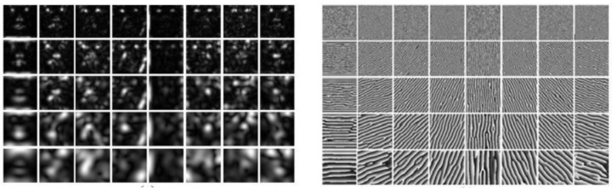


(a) (b)

Fig. 5 Visualization of Gabor magnitude and phase (a) Gabor magnitude (b) Gabor phase

We have used local Gabor XOR patterns, which are quantized into different ranges. And then local XOR patter operator is applied to quantize magnitude and phase of the central pixel. It is shown in Fig. 6.

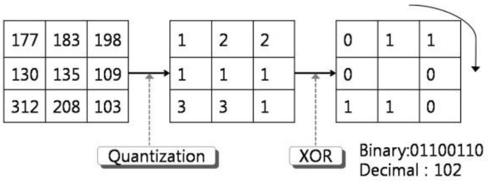


Fig. 6 An example encoding method of Local XOR pattern

In face detection, all the face images are normalized to 35 pixels of eye centers. For feature extraction Gabor filters and then local binary patterns of LGXP are used.

IV. Object Recognition

A. Local Adaptive Binarization

Pose image with low contrast and shadow around human body can be occurred by non-uniform illumination in indoor horse riding system. These problems have occurred low discriminative ability between body part and background image. Local adaptive binarization method has applied to overcome illumination problem by computing threshold for each pixel in local window. The threshold has decided by analyzing the intensity of pixels in local window. A threshold $t(x,y)$ of center pixel (x,y) in a $w \times w$ window is appeared in (2).

$$t(x,y) = m(x,y)\left\{1 + k(1 - \frac{s(x,y)}{R})\right\} \tag{2}$$

$m(x,y)$ is mean and $s(x,y)$ is standard deviation of the intensities of pixel (x, y) in a $w \times w$ window. R is the maximum standard deviation and k is a value in [0.2, 0.5]

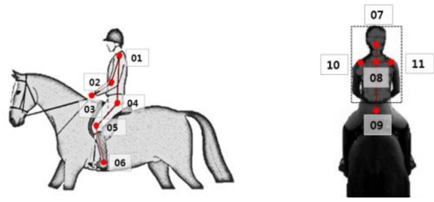
B. DoG Filter

The inherent geometric information of the human body region can be transformed due to the non-uniform lighting condition. The difference of Gaussian filter is considered as an effective algorithm to extract deformed edges of the object. In (3), DoG filter detects edges by differencing between Gaussian images at specific theta and calculates zero crossing values.

$$DoG(x,y) = \frac{e^{-\frac{(x^2+y^2)}{2\sigma_1^2}}}{2\pi\sigma_1^2} - \frac{e^{-\frac{(x^2+y^2)}{2\sigma_2^2}}}{2\pi\sigma_2^2} \tag{3}$$

C. Pose Features

Feature nodes of side pose captured by side camera have selected to recognize pose of upper body such as shoulder, elbow, and hand location. And also another side feature nodes have selected to recognize pose of lower body such as hip, knee, and foot location are as shown in Fig. 7 (a). Other feature nodes of back side captured by back camera have selected to recognize pose of back body such as head, shoulder, hip location are as shown in Fig. 7 (b).



(a) (b)

Fig. 7 Pose feature nodes

D. Pose Recognition

We have generated pose model with training pose images, which are composed of professional trainer images. 11 kinds of pose feature points have extracted with side and back pose images, and pose features have normalized, and then user pose has recognized by matching with pose model.

V. Experiments

We have evaluated performance of the proposed method with 640x480 images of ETRI database, which has considered time and illumination variations. The proposed algorithm has been tested on computer with Intel(R) Core(TM) i7 CPU, 970@3.20GHz, 2.99GB RAM.

A. Face Detection and Recognition

We have tested recognition performance with 710 face images for 150 persons. Face images have captured within 1m distance to the camera and have acquired in poor illumination condition. We have got face recognition rate of 91% with 646 images and matching speed of 0.01 seconds. False face recognition has occurred by shady face images, which have had a part of shadowed face. Face detection has evaluated with 80 face images, which have captured almost 3m distance to the camera and user was riding on horse simulator. The poor accuracy of 80% face detection has been obtained because poor illumination condition and motion blurring by fast movement of horse riding simulator. And face recognition performance with camera in long distance has evaluated. It had more poor face recognition rate because of small size face, low quality image due to illumination and motion burring. Image enhancement to get clear image and compensated feature extraction are needed that can improve recognition

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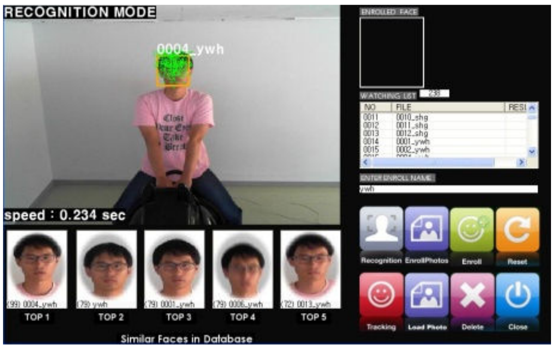
performance in real world environment. Fig. 8 (a) and (b) show the example of face detection and recognition on horse riding simulator.

(a)



(b)

Fig. 8 Performance evaluation of (a) Detection of straight in the face and (b) Recognition of face in long distance

Face recognition with poor illumination condition is shown in Fig. 9.

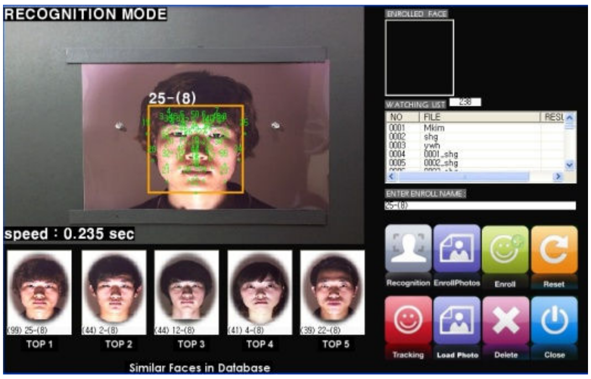


Fig. 9 Face recognition in low illumination environment

B. Pose Recognition

We have evaluated pose recognition performance with 80 pose images for 80 persons. Pose images have captured within 1.5m distance to the side camera and back camera, respectively. Pose feature points are extracted and normalized, and pose is recognized by matching with pose model is as shown in Fig. 10.

Fig. 10 Side pose and back pose feature detection

VI. Conclusion

We propose an intelligent horse riding simulator, which performs user identification by face recognition, right face position by face detection, a correct posture on riding horse by pose recognition. And also, a personalized train and automatic update of personal data by face recognition and pose recognition, the construction of reality simulator by analysis of intentional user motion have processed on the intelligent riding horse simulator.

We have applied combined image preprocessing method, local adaptive threshold and the difference of Gaussian filter, to detect human body in poor illumination condition. We have tested face recognition under diverse illumination and long distance. Still we have challenge problem for recognizing object such as face and human body because of poor illumination and motion blurring. Image processing, face graph and pose model will be improved to get clean object region and more stable recognition performance.

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