Intelligent Horseback Riding Simulator
Using User Identification and Posture Recognition

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Abstract: - In this paper, we introduce an Intelligent horseback riding simulator includes a user identification, a posture recognition and a posture coaching. The user is identified by recognizing user facial information that is extracted from an input image. The posture has recognized by extracting user’s body region and designated feature points of user’s body parts from the input images. The user identification includes face detection and face recognition. The posture recognition includes a body region extraction and a posture feature extraction, which includes a position, an angle about a movement of each of the designated body parts of the user. Proposed horseback riding simulator has posture coaching function that provides to the user with a warning message if the error data of posture is detected by comparing a predetermined standard posture data and provides user customized posture coaching according to exercise capacity of a user. Proposed intelligent horseback riding simulator enables a user to mutually respond to the sports simulator mechanism.

Key-Words: - Intelligent sports simulator, Face detection, Face recognition, Posture recognition, Human-sports simulator Interaction, User customized coaching

1 Introduction
With the recent trend of an aging society, an increasing concern about health and development of exercise machine have become more active [1-2]. In particular, many researches have been conducted on a new IT convergence solution technology to combine a physical fitness promotion technology for personal healthcare and an improvement of motor control with image processing. The IT convergence solution converged with health care, image recognition technology is provided by vision sensor, to acquire user information who tries to utilize sports equipment. In addition, the IT convergence solution has applied to a personal exercise learning or physical fitness promotion by providing user-customized coaching functions for various kinds of sports.

A technology for detecting and recognizing a certain object region from an image acquired at a site have been applied to sports, such as a golf, skating, and horseback riding, [3-7] etc. The methods of correcting and coaching of a user’s posture have proposed that is to provide a proper posture to a user [5-7]. The previous methods of user posture correction and coaching have applied to golf so that image information including a golfer’s swing is acquired by use of a camera, and the golfer’s swing is analyzed by use of the acquired image information. In addition, previous studies have been conducted to acquire motion information at a detailed level by attaching a sensor to a body and analyzing and correcting posture information based on the acquired motion information. In particular, in the recent change in the sports industry from golf to horseback riding, a few developers are suggested a method of coaching a user’s horseback riding posture using a horseback riding simulator. However, there is a need for a method of teaching horseback riding posture using a horseback riding simulator.

In this paper, an intelligent horseback riding simulator is proposed that includes identification of a user, recognition of a user’s horseback riding posture and coaching user’s posture on horseback riding simulator. The user identification is configured to identify a user through user identification information based on user facial information that is extracted from a frontal vision sensor. The posture recognition is configured to calculate user posture information by extracting information related to each of designated body parts of the user from a side vision sensor and back side of vision sensor. The posture coaching is configured to provide the user with instruction in horseback riding posture, based on the user identification information and the user posture information.

2 Intelligent Horseback Riding Simulator
Intelligent horseback riding simulator is composed of user identification, posture recognition, and posture coaching as shown in Fig. 1.
2.1 User Identification

The user identification includes a facial detection, a facial feature extraction and a facial recognition [8-14]. The face detection is configured to extract a facial region of a rectangle shape by recognizing a frontal of a user’s face from the input image. Modified MCT (Modified Census Transform) algorithm is implemented based on Adaboost training procedures [8-10]. The facial features are extracted [11-14] from major feature points of face such as eye, nose, lips, a contour of the user’s face located in the facial region. Facial feature vector has been generated from each face feature point using Gabor wavelet and facial region using LBP as shown in Fig. 2. Gabor feature is considered powerful feature to identify face in real world due to similar model of human being’s eye model. We have combined face feature vector with global feature from whole face image and local feature from landmark point.

Gabor feature [14] vector \( J_{(\mathbf{x}, \mathbf{y})} \) is defined as following eq. (1) with respect to an intensity value \( I(\mathbf{x}) \) at pixel location \( \mathbf{x} = (x, y) \).

\[
J_{(\mathbf{x}, \mathbf{y})} = \int I(\mathbf{x}) \psi_{j}(\mathbf{x}, \mathbf{y}) d^2 \mathbf{x}
\]

\[
\psi_{j}(\mathbf{x}) = \frac{1}{\sigma^2} \left( \exp\left(-\frac{\|\mathbf{k}\|^2}{2\sigma^2}\right) - \exp\left(-\frac{\|\mathbf{k}\|^2}{4\sigma^2}\right) \right)
\]

(1)

1,520 Gabor feature vectors for a face are derived with 40 Gabor jets for each 38 points.

User’s posture are recognized by comparing standard posture model that has processed by calculating deviation of posture angle between adjacent posture feature points and posture error and classifying posture as shown in Fig. 4. A user posture model has decided by recognizing of user’s posture that has classified in detail to several posture coaching models according to a user exercise capacity such as beginner, intermedier or superior.

2.2 Posture Recognition

The posture recognition includes a user’s body region extraction and a posture feature extraction. The user region is extracted by using 3D depth data and 2D human silhouette information. Human location is detected coarsely using 3D depth information and human silhouette is extracted finely using DOG filters and edge analysis [15].

The feature points for recognizing user’s posture has predesignated feature points, which includes information about a position, an angle and a movement of each of the designated body parts of the user. The Posture feature points are extracted from arm, leg, back and calculated posture angle, which is obtained by comparing to standard posture model of side and back. Posture feature points have composed of 11 points, which are 6 points from side view and 5 points from back view as shown in Fig. 3.

Fig. 1. Intelligent horseback riding simulator

Fig. 2. User Identification

Fig. 3. Posture feature points

Fig. 4. The posture recognition using posture model.
2.3 Posture Coaching
The posture coaching includes user information storage, posture model, and horseback riding instruction modules. The user information storage has a user posture model occurred from posture recognition result and user identification. The posture model is decided by calculating a posture error by matching with a user posture data to a standard posture model. The horseback riding instruction is configured to provide the user with instruction in horseback riding posture through images, which are based on the posture error.

The standard posture model has generated with posture information related to a standard horseback riding posture according to a gait mode of a horseback riding mechanism. The horseback riding instruction is configured to provide the user with a warning message if the posture error is equal to or greater than a predetermined posture model.

And also, posture coaching unit includes an user intended posture calculation and a mechanism control. The intended posture calculation is configured to calculate the user-intended posture by analyzing a gait pattern of horse based on the user posture information. The mechanism control has configured to control the horseback riding mechanism according to a gait mode of horse including a walk, a canter and a trot while corresponding to the user intended posture.

3 Experiments
We have evaluated user identification performance and posture recognition using standard facial database such as FERET and facial data from performance evaluation institution of ETRI. 1623 facial images are tested with respect to 1,196 facial images of FERET and 427 face images of ETRI. The facial database includes facial images with pose variation, lighting variation and expression variation. Facial recognition rate of 98% on FERET and 97% on ETRI have obtained. Performance evaluation for Facial recognition has processed as shown in Fig. 5.

Curvature features are extracted in edge image and the user silhouette is distinguished to head, back and hip regions. Posture features are determined using maximum differential value and center points from curvature feature points. We have obtained encouraging recognition performance of facial images and posture images.

4 Conclusion
We proposed an intelligent horseback riding simulator that includes identification of a user, recognition of a user’s horseback riding posture and coaching user’s posture on horseback riding simulator. The user identification includes face detection and recognition that is extracted from a frontal camera. The posture recognition has processed by extracting posture feature and calculating user posture information by designated body parts of the user from a side camera and back side camera. The posture coaching provides to the user with instruction of horseback riding posture, based on the user identification information and the user posture information.
We have evaluated facial recognition performance on standard facial database of FERET and performance evaluation database of ETRI, and have obtained encouraging recognition performance. In the future, we will improve recognition performance for pose variation facial images using more training facial images and multiple standard face models that have caused failure in facial recognition.

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References: