Intelligent Stretching Exercise Training System

Chien-Cheng Lan[1], Ya-Hsin Hsueh[2*], Sung-Hua Tsai[3], and Cheng-Han Hsieh[2]

***Abstract*—** In the times of intense competition and advanced technology, many office workers and researchers sit on the chair for a long time for work, maintain the same postures all day, and seldom walk around, which induces stiff muscles and the pain of neck and back. The stretching exercise can guide user to reduce the pain and relax each muscle of the body. Therefore, the aim of this study is to develop an Intelligent Stretching Exercise Training System, which is based on the Microsoft Visual Studio architecture and combined with a Bluetooth module and flex sensors. Through the 6 stretching exercises designed by the Intelligent Training (i-Training) software proposed in this study, the user can receive visual feedback and text messages after completing the stretching exercise. The system reminds the user about the correction of the current stretching posture, which guides the user to improve the muscle tension.

***Keywords*—**Exercise, Microsoft Visual Studio, stretching, visual feedback.

I. Introduction

OFFICE workers often sit on the chair for a long time and seldom walk around when they work. Almost maintaining the same postures all day may induce muscle stiffness, even migraine, dysautonomia, and scoliosis. From 2001 to 2013, repetitive musculoskeletal injury related cases are 80% in diseases with medical payments [1] in Taiwan. The epidemiology statistical data show that about 50-60% adults seek medical advice because of neck and back pain, and up to 85% of neck and back pain results from wrong postures because their heads often lean forward and the neck muscles are tight [2]. Although the treatment is effective, if people do not stretch stiff muscles completely, the muscles are still tight, which induces recurrent pain. Therefore, people should develop the habit of stretching exercise in daily life.

If people do stretching exercise with wrong postures, it is not effective and may hurt muscles again or may result in chronic problems [3]. However, people cannot know if their postures are correct when they exercise, and wrong postures may cause serious sports injuries. Therefore, we aim to develop an Intelligent Stretching Exercise Training System for guiding users to complete effective stretching exercise.

The aim of the proposed Intelligent Stretching Exercise Training System is based on the guide to stretching exercise, which combines image processing and wearable devices. With integral images, the system can calculate the position of human faces quickly [4] and recognize the motion of users. By using the visual data, the system can determine if the motion of users fits the correct stretching exercise, and it focuses on the postures, the flexibility, the segmental arrangement, and core control [5]–[6]. The wearable devices can guide to overcome the problem of blind spots and improve the accuracy of image motion determination. Through the human-computer interaction, users can know how to stretch correctly, and the system can detect and remind users about the correct postures, which can provide the best effect.

II. System Architecture and Design Method

The Intelligent Stretching Exercise Training System consists of the Microsoft Visual Studio architecture, the Bluetooth module, and the flex sensors, as shown in Fig. 1.

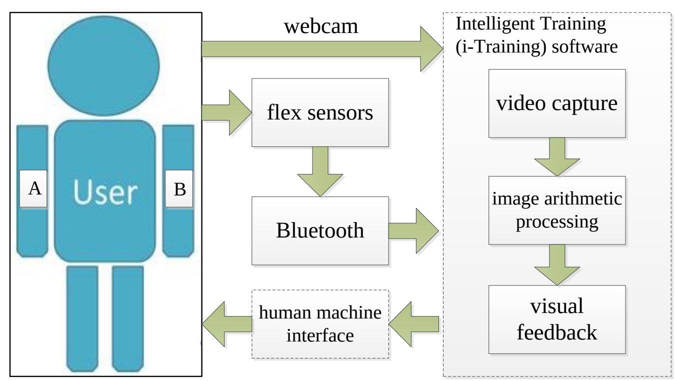

Fig. 1 The architecture of Intelligent Stretching Exercise Training System

We use Microsoft Visual Studio to design the Intelligent Training (i-Training) software, including three parts of the video capture, the image arithmetic processing, and the visual and text messages feedback. First, by using a laptop or a PC equipped with a webcam, the system can film the stretching postures of the user, and the captured images can provide the information for image arithmetic processing. At the same time, the user wears flex sensor modules on the elbows (A and B points, as shown in Fig. 1). When the user do the stretching exercise, the flex sensor modules will transmit the signals to the i-Training through the Bluetooth, which can be used to determine if the postures are correct. Finally, the i-Training

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will display the correct posture image and messages to inform the user about how to do the correct stretching exercise for achieving visual feedback effects.

The system training process is shown in Fig. 2. The user can set the preparation time before training and choose the type of stretching exercise. After checking the type of stretching exercise, the system will start to detect the face position of the user and determine that if the user's face is in the specified preset range of the system completely, which is used as the optimal distance between the body and the webcam, ensuring the high accuracy of the system of the determination of user's stretching movements.

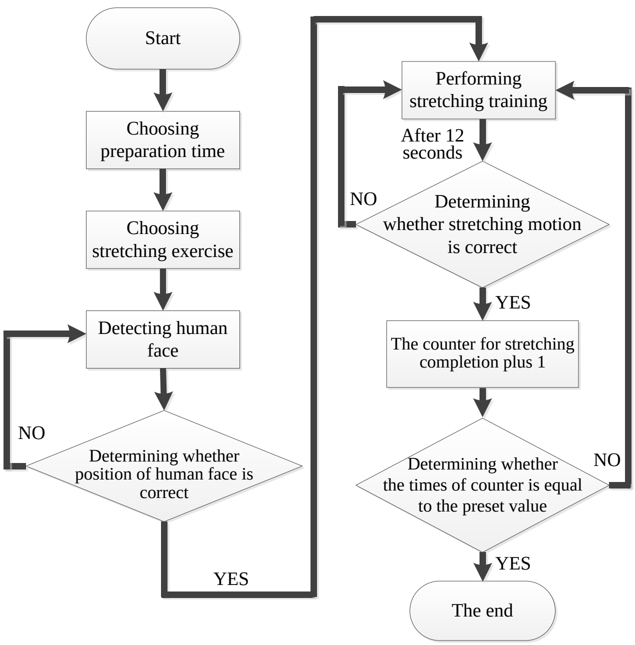


Fig. 2 The flow chart of Intelligent Training (i-Training) software

The i-Training is a program structured in a laptop or a PC, mainly including the background separation, the skin color detection, and the motion determination. The hardware includes the Bluetooth transmission, and flex sensor application. The system applies a webcam to record videos and combines image processing algorithms, which can automatically detect and give visual feedback to the user.

A. Background Separation

The biggest difference between the character and the background is that the character will move and the background is stationary, so we use the mobile search method to conduct the background separation, which can effectively detect the motion of actual objects. The system uses mobile search method and compares the photographs filmed by the webcam at two points in time, as shown in Fig. 3(a) and 3(b). Based on the principle that the background is stationary, if the corresponding pixel values of two images are similar, it is determined as the background. If the corresponding pixel values of two images are not similar, it is determined as the character. In Fig. 3, we present the result with binarization. The black area represents a character, and the white area is the background, as shown in Fig. 3(c).

(a) (b) (c)

Fig. 3 (a) The image of a stationary person before moving. (b) The action image of a person after moving. (c) The image result after the background separation processing

B. Skin Color Detection

After the RGB color space is converted into the YCbCr color space, the system will separate the skin color from the background color with skin color detection, and image binarization will be applied by using the threshold. The occupied value ranges of skin color and the components of Cb and Cr can be used to distinguish the skin color and the background color. The value range is as in (1).

$$\begin{aligned} 105 &< Cb < 120 \\ 130 &< Cr < 180 \end{aligned} \quad (1)$$

The limit of the value range is the threshold. With this threshold, the skin color and the background color can be separated. If the value of Cr in the image pixel is between 105 and 120, and the value of Cr is between 130 and 180, this image pixel will be binarized as black. If the value of Cr is not between 105 and 120, and the value of Cr is not between 130 and 180, this image pixel will be binarized as white.

The skin color detection of this system mainly detects the skin color of human face by detecting the pixels that are in the preset range. The user can adjust the distance between the body and the webcam according to the occupied range size of skin color. At the box in Fig. 4(a), the skin color occupies 6214 pixels, which is identified as too close distance between the body and the webcam. At the box in Fig. 4(b), the skin color occupies 3239 pixels, which is identified as appropriate distance between the body and the webcam.

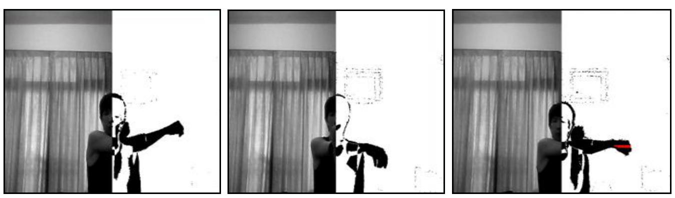
(a) (b)

Fig. 4 (a) The result of skin color detection that is too close. (b) The result of skin color detection that the human face position is at an appropriate distance

C. Motion Determination

The motion determination applies the body parts after the background separation to calculate the motion range. When the user does correct stretching exercise, the system can calculate the proper value according to proportion of the body. However, before the calculation, the system will set the occupied size of the user in the image and detect head with skin color detection to calculate the distance between the body and the webcam for controlling the range size of body proportion. When the user does upper back stretching, shoulder stretching, and arm stretching, the system determines whether the stretching motion is correct according to this method. If the motion is horizontal and straight, the stretching motion is correct. Whether a threshold on the Y-axis establishes continuously can be also used to determine if the stretching motion is correct.

Fig. 5(a) shows that when the system determines that the user is doing right shoulder stretching, it will determine that the stretching motion is incorrect if the arm is not in horizontal state. If the flex sensor module on the arm determines that the user's elbow is in bending state and the stretching motion does not achieve horizontal state, the system will also determine that the stretching motion is incorrect, as shown in Fig. 5(b). Fig. 5(c) shows that the red range represents the range of the correct motion and the user's elbow is not in bending state, so the system can accurately determine that the user does the correct arm stretching motion.

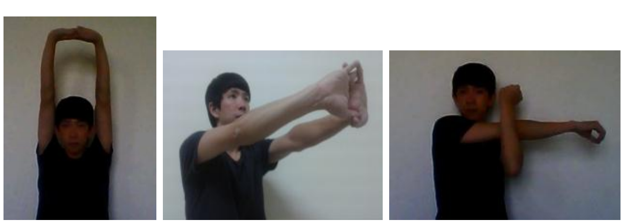


(a) (b) (c)

Fig. 5 (a) The arm is not in horizontal state, so the stretching motion is incorrect. (b) The elbow is in bending state, so the stretching motion is incorrect. (c) The arm and the elbow are both in horizontal state, so the stretching motion is correct

III. STRETCHING EXERCISE INTRODUCTION

The stretching exercises of the proposed system include upward stretching, upper back stretching, left and right shoulder stretching, and upper and lower arm stretching, as shown in Fig. 6(a)-6(f). The upward stretching can stretch the deltoid muscle, the levator, and the upper thorax muscle. The upper back stretching can stretch the upper back muscle groups and the arm muscle groups. The left and right shoulder stretching can stretch the rear deltoid muscle and the triceps. The upper and lower arm stretching can stretch the upper arm muscle groups and the finger extensor. This system combines a webcam and guides the user to do the 6 correct stretching exercises for achieving the best stretching effects and release the muscle tension.



(a) (b) (c)

(d) (e) (f)

Fig. 6 (a) Upward stretching. (b) Upper back stretching. (c) Left shoulder stretching. (d) Right shoulder stretching. (e) Upper arm stretching. (f) Lower arm stretching

IV. RESULTS

The Intelligent Stretching Exercise Training System develops the human machine interface of Intelligent Training (i-Training) software through Microsoft Visual Studio architecture. Users can choose the times of 6 stretching exercises arbitrarily. Before users do the stretching exercise, the system will detect the skin color and set the distance between the body and the webcam, as shown in Fig. 7. The Area 1 on the left is the video transmitted by the webcam, and the Area 2 on the right will show the instructional video after users choose the kind of stretching exercise. After the instructional video is played, it will show the incorrect motion image of users and use text messages to inform users about how to do the correct stretching exercise.

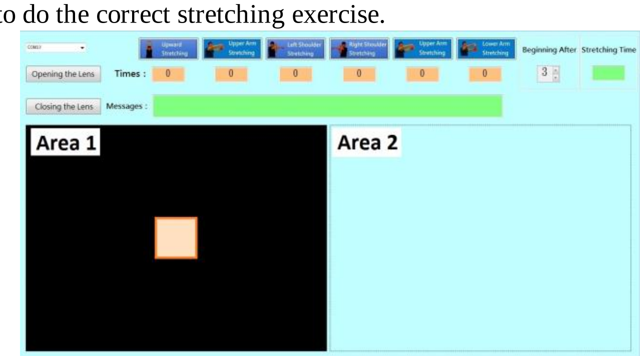


Fig.7 Initial settings of human machine interface of Intelligent Training (i-Training) software

Fig. 8 shows that when the user does the upper back stretching exercise, the system will detect the condition of user's elbow through the flex sensor module and inform users of the bent elbow, so the user has to do the last upper back stretching exercise again 2 seconds later. When the system detects that the user does the correct upper back stretching exercise and stretches the arm to the red area, it will use text messages to inform users about the correct motion, encouraging the user to do the next stretching exercise, as shown in Fig. 9.

Fig. 8 The elbow is bent during upper back stretching, which is incorrect stretching exercise

Fig. 9 Correct upper back stretching exercise

V. Conclusion

In this study, we design Intelligent Stretching Exercise Training System that consists of the Intelligent Training (i-Training) software, the Bluetooth module, and the flex sensors. 6 preset stretching exercises of i-Training can guide the user to do the correct stretching exercise for achieving the best stretching effects. The user can set the type of stretching exercise and the times according to the requirements, and the system can determine if the postures of the user are correct with the webcam and the flex sensor module. Through the visual feedback and the text messages, the user can complete the correct stretching exercise. Hence, the fatigue of neck and back, shoulders, and arm muscle can be reduced, and the muscle tension can be released.

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