An Image Recognition-Based System for Correcting Body Posture

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ABSTRACT: *In this study, a novel system for correcting posture was developed through the application of wearable sensing technology. This system comprises three subsystems, namely, a smart necklace, smart phone, and notebook computer. The smart necklace houses an MPU- 6050 sensor that can collect and analyze gravitational acceleration data when the necklace is worn, and use that data to determine a user's upper body posture. When the necklace detects poor posture, it will send a reminder to the user's smart phone, which is able to receive such messages from the necklace via a mobile app that was developed in this study. This app can also be used to set parameter values such as the standard values (base values for posture assessment) of the necklace and the timing of reminders, and to activate the posture image calibration function on the notebook computer. The notebook computer is used to read the relevant data via a depth camera, identify the user's skeletal structure and joint reference points, and perform reference point computations, after which signals will be sent to the necklace in order to calibrate the necklace's standard values. This proposed system allows for: 1) the self-correction of posture to be carried out without the use of corrective clothing that is heavy, thick, and stuffy; 2) the quick calibration of the necklace's standard values through the use of posture imaging; and 3) the elimination of complex wiring and the effective application of the Internet of Things through the implementation of wireless communication between the interfaces of the smart necklace, smart phone, and notebook computer.*

Keywords: Wearable, Sensor, Posture Correction, Image Recognition, Internet of Things,Mobile App

Received: 29 February 2022, Revised 8 March 2022, Accepted 26 March 2022

DOI: 10.6025/dspaial/2022/1/2/93-99

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1. Introduction

In 2008, Apple unveiled the world's first 3G capable phone, the iPhone3G, and ushered in a 3G revolution that changed our lifestyles and created hordes of mobile phone addicts. When an individual spends prolonged periods of time looking down at his/her phone and maintaining a slouched back, he/she may develop bone spurs in the cervical vertebrae. As a result, the average age of patients suffering from cervical degeneration is becoming increasingly younger. In addition to the cervical vertebrae, the thoracic, lumbar, and caudal vertebrae, as well as the pelvis, will all also be affected, which may lead to scoliosis, functional leg length discrepancies, and distended stomachs. Traditionally, there are two approaches to posture correction, and one of the two approaches is used based on the severity of a patient's condition. For patients with mild kyphosis, kyphosis correction exercises and kyphosis correction belts (which are made of highly elastic fabrics used to support the back) are utilized. As for patients with severe spinal diseases, rigid back braces made of aluminum alloys are used to support the body and keep it straight.

In recent years, information communication technologies relating to newly developed wearable sensing devices have been touted as key technologies that can be applied in the health care field, and the use of these advanced technologies to address the aforementioned issues will become a trend going forward. For example, in 2007, Veari unveiled a smart neck ring that utilized wearable device technologies [1], claiming that it could track the number of steps walked by a user, record the user's neck movement data, and alert the user to poor posture. However, as the company was unable to meet its fundraising target on a public fundraising platform, the project was subsequently cancelled in 2015.

To our knowledge, few studies have examined the use of wearable sensing devices to effectively integrate information communication technologies and apply them to health care issues (particularly those pertaining to posture correction). Thus, in this work, a novel system for correcting posture was developed through the application of wearable sensing technology.

The rest of this paper is organized as follows. Section 2 presents the hardware architecture and system design. Section 3 demonstrates the experimental results. Section 4 provides the conclusions.

2. System Sturcture

The proposed overall system hardware architecture is shown in Fig. 1. This system consists of three subsystems, namely, a smart necklace, smart phone, and notebook computer. The hardware specifications of the subsystems are described below. Smart necklace: A Raspberry Pi 3 connected to an IT Training I/O board, and subsequently, to an MPU-6050 sensor (equipped with a gyroscope and triple axis accelerometer). Smart phone: A Sony Xperia Z with an Android operating system. Notebook computer: A Micro-Star International GP62 notebook computer connected to a Kinect [2] camera. Data transfers between these three subsystems are carried out via the TCP/IP network protocol. The mobile app developed in this study enables signal transmissions between the mobile phone and the necklace and notebook computer.

After a new user wears the necklace, its internal parameters need to be recalibrated. The overall system is first activated, after which the mobile app is used to activate the notebook computer's image recognition function, which will then perform an automatic calibration of the necklace's internal parameters. Next, the user may choose to perform fine manual adjustments to the necklace's internal parameters, in which case he/she may do so via the mobile phone. If the user chooses not to make the above adjustments, the necklace's program for determining the user's posture will start. Subsequently, the mobile app is used to activate the function of receiving reminder signals from the smart necklace. The necklace will simultaneously be continuing its assessment of the user's posture. In the event that bad posture is detected, a reminder signal will be sent to the mobile phone. Once the system reaches its set operating time, its operations will end.

Fig. 2 shows a program when a new user uses the notebook computer's image recognition function to perform an automatic calibration of the necklace's internal parameters. The user first activates the mobile phone's automatic calibration function, which then activates the notebook computer's skeletal structure image recognition function. Among the considerable number of methods used to detect human skeletal structures, the method proposed by Shotton et al. [3] was selected for this study. This method involves the use of the Kinect device to obtain depth image data, which are then analyzed using random decision trees and forests [4] to identify joint points.

Next, the notebook computer assesses the user's side posture by determining if the line connecting his/her head- and neck-

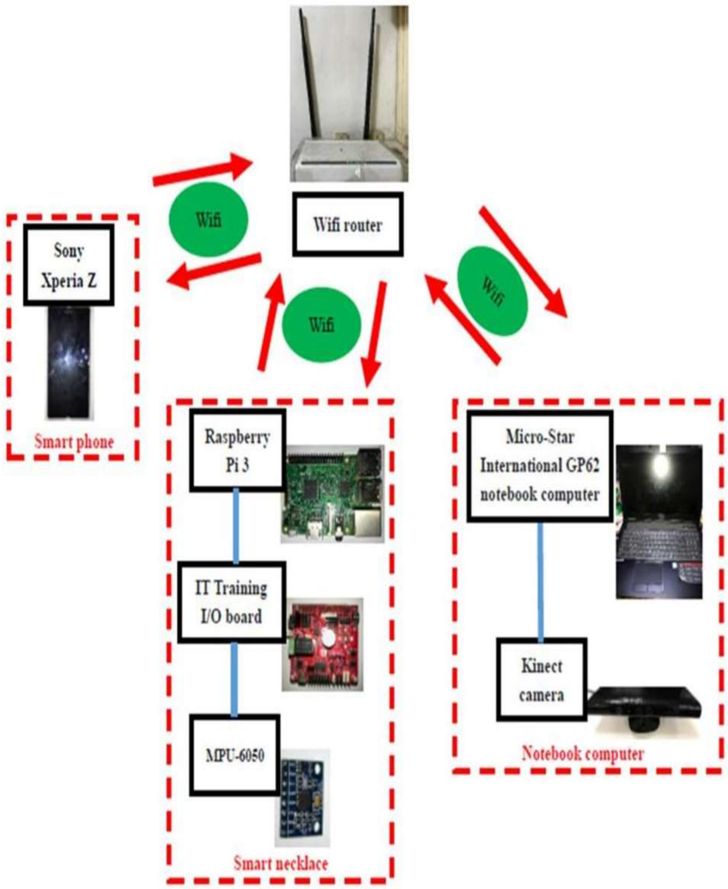

Figure 1. Overall system hardware architecture

based reference points is perpendicular to the ground. When the line is not perpendicular to the ground, the notebook computer will continue with the image assessment process. When the line is perpendicular (indicating proper posture), the notebook computer will send a signal to the necklace, where the triple axis accelerometer's x-axis value will be digitally filtered (the current value and the previous values are averaged) and designated as the standard value Sx for determining the user's forward tilt.

Following that, the notebook computer will assess the user's frontal posture to determine if the line connecting the reference points on the user's left and right shoulders is parallel to the ground. If the line is not parallel to the ground, the image assessment process will continue. Conversely, if the line is parallel to the ground, the notebook computer will send a signal to the necklace, where the triple axis accelerometer's y-axis value will be digitally filtered and designated as the standard value Sy for determining the user's left/right tilt.

After the internal parameters of the necklace have been successfully calibrated, the mobile phone will receive a message informing the user of the successful calibration. At this point, the program running on the notebook computer will close.

The smart necklace allows for the posture analysis of the gravitational acceleration data recorded by the MPU-6050 and allows for reminder signals to be sent to the phone when bad posture is detected.

The App Inventor 2 [5] is used in this study as it does away with the need to use Java to open up Blocks Editor (which is integrated into the website and can be used immediately) and makes it easy for developers to write Android apps. This app can be used to set parameter values such as the standard values of thenecklace and the timing of reminders, and to activate the posture image calibration function on the notebook computer, etc. Fig. 3 illustrates the app interface and functions.

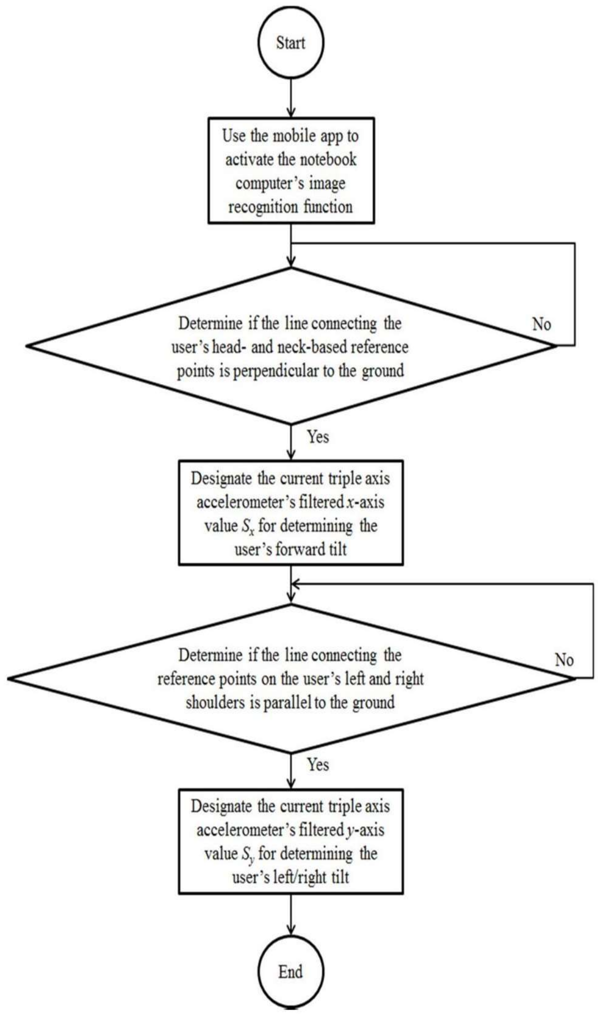

Figure 2. Flowchart of utilizing the notebook computer's image recognition function to calibrate the necklace's internal parameters

3. Experimental Results

Here, we demonstrate a practical test performed on the developed system to show its effectiveness.

The user first activates the notebook computer. Next, the mobile app is activated and the "auto_correct" button (see Fig. 4(a)) is clicked to activate the notebook computer's image recognition function and perform the automatic calibration of the necklace's internal parameters, after which the "Connected" status will be displayed on the phone (see Fig. 4(b)). At this point, the notebook computer will attempt to detect the user's skeletal structure (see Fig. 4(c)) and mark out the head, neck, left shoulder, and right shoulder positions using four pink points. The user first turns to allow the camera to capture his side profile (see Fig. 4(d)), and when the line connecting his head- and neck-based reference points is perpendicular to the ground, the computer will transmit a setting signal to the necklace to calibrate Sx and set it as the standard value for determining the presence of kyphosis. Upon the calibration's completion, the headand neck-based points will disappear (see Fig. 4(e)).

Following that, the user then turns to face the camera frontally (see Fig. 4(f)), and when the line connecting the reference points on the user's left and right shoulders is parallel to the ground, the computer will transmit a setting signal to the necklace to calibrate Sy and set it as the standard value for determining the presence of a left/right tilt. Upon the calibration's completion, the

1. Entering the IP address for the camera linked to the notebook computer
2. Activating the notebook computer's image recognition function and the automatic calibration of the necklace's internal parameters
3. Entering the IP address for the necklace device
4. connect: enabling the phone to connect to the smart necklace and receive reminder signals from the smart necklace

   disconnect: disconnecting the phone and smart necklace (no reminder signals will be received)
5. Adjusting the frequency at which the smart necklace sends reminder signals when poor posture is detected (the higher the value, the higher the frequency)

6.-9. Setting parameters so as to make minor adjustments to the standard values and related values of the smart necklace

Figure 3. App interface and functions

image program closes automatically and the "Correct Finish!!" status is displayed on the phone (see Fig. 4(g)) to indicate that the calibration has been completed.

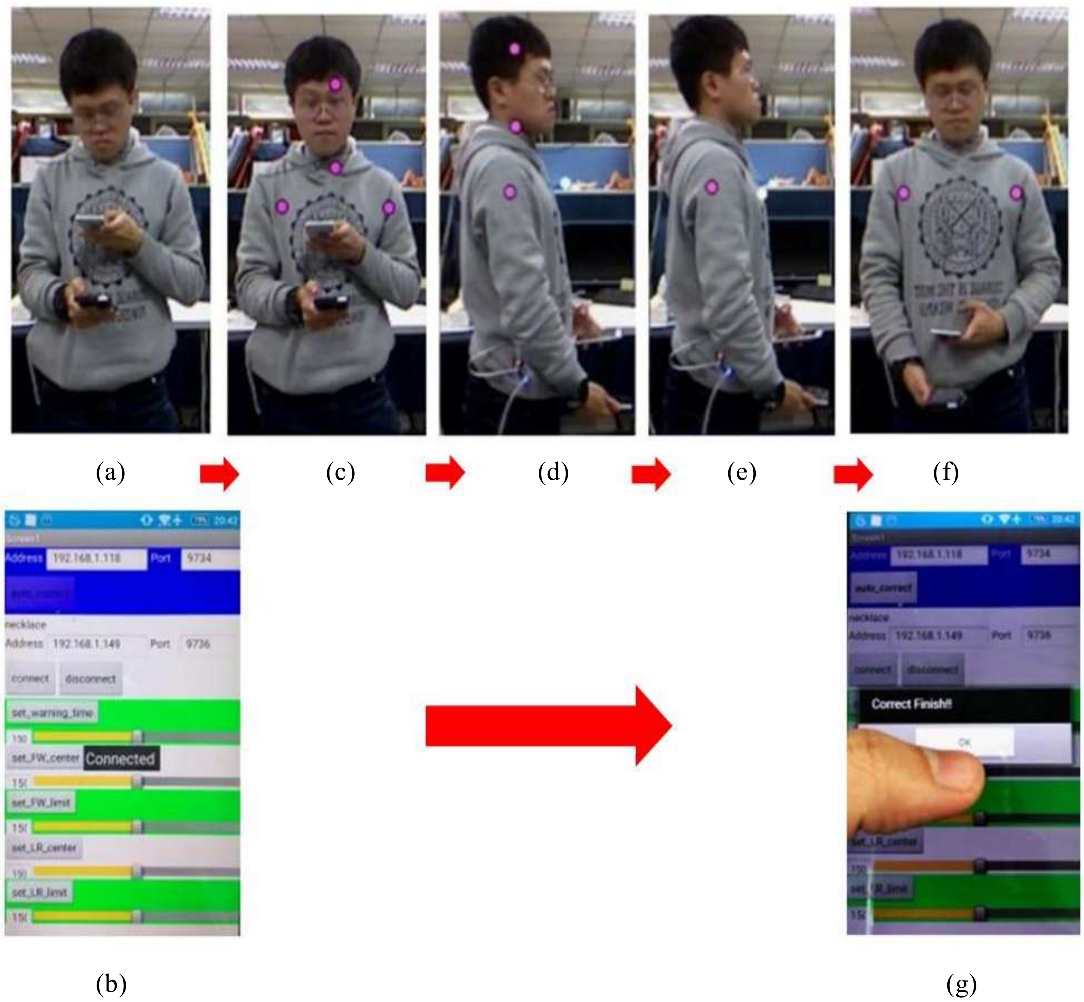

Figure 4. Using the notebook computer's image recognition function to calibrate the necklace's internal parameters

Next, we test a case: the user shifts from a correct posture (see Figure 5(a)) to one with a right tilt (see Figure 5(b)); this change will be detected by the necklace and reflected on the IT Training expansion board's LEDs. That is, the middle LED (indicating correct posture) will turn off while the right LED (indicates a right tilt) will light up (transition from Figure 5(c) to Figure 5(d)). Meanwhile, the necklace will send a reminder signal to the mobile phone, causing the "Too Right!!" reminder to appear on the screen of the mobile phone (see Figure 5(f) (transition from Figure 5(e))). This serves to remind the user that he is displaying a right tilt that requires correction.

4. Conclusions

In this study, wearable sensing, image recognition, and Internet of Things technologies were integrated to create a novel posture correction system that consisted of three subsystems, namely, a smart necklace, smart phone, and notebook computer. Through the combined use of a lightweight smart necklace and mobile phone, a user is able to self-correct his/her posture, prevent spine-related diseases, and, thus, live an effective and hindrance-free life. The notebook computer's posture image recognition function allows a user to quickly calibrate the necklace's internal parameters. Furthermore, with the implementation of wireless communication between the interfaces, a user no longer has to deal with complex wiring and is able to operate the system in a convenient manner. For patients suffering from temporary or mild symptoms of kyphosis, physicians generally do not recommend the use of corrective clothing that is heavy, thick, and stuffy. However, patients who rely solely on their willpower to effect improvements often do not achieve effective results. With these issues in mind, this system was developed to help users detect poor posture, make the necessary corrections, and, thus, effectively prevent the occurrence of diseases arising from the longterm effects of poor posture.

Acknowledgment

The authors wish to thank the financial support of the Ministry of Science and Technology (MOST), R.O.C., under Contract MOST 105-2628-E-019-002-MY3.

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