Prevention System of Forward Head Posture Using IMU and Infrared Distance Sensor

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Abstract : Forward head posture (FHP) is representative bad habit causing neck pain, shoulder pain, back pain, dental occlusion, headache etc in modern society. Approaches to prevent FHP were researched by camera sensors such as Kinect and Webcam, which has cost and space limitation caused by installation of the sensors. To compensate the limitations, we proposed wearable device to put it behind user's ear to provide comfortable, feasible, cost-effectible advantages. Prevention system of FHP composed of three sensors such as IMU, IR distance and vibration sensors. IMU sensor is used to detect sensor positions, and IR distance sensor is used to measure distance between the tragus of the ear and the torso. Vibration sensor gives vibration warning when the system detects FHP. Challenge to detect FHP is that threshold of FHP decision changes to the variables such as sensor position. Result showed that different thresholds depending on sensor positions could detect the FHP by considering IMU sensor and IR distance sensor.

Keywords : Forward head posture, turtle neck syndrom

I. Introduction

These days, a computer is one of the most common stuffs in modern society. Along with the developments of computer networks and communications, it has had a lot of effects on people`s since the computer was to be seen anywhere. Especially, to use the computer is not confined to the specific age. To be specific, many workers use computers in workplaces to spend time efficiently or make their tasks easy [1]. Moreover, the computer is also utilized for children's or students' education [2]. In South Korea, computer classrooms are installed obligatorily and many internet cafes are easily seen anywhere. As a result, people are naturally exposed to the circumstance of computers. Computers have brought lots of conveniences and fun to people's life: telecommunicating, web conference, e-mail service, computer game, etc. However, there is no only bright side from computers. Many problems can be caused such as privacy issues, security issues, social relations, health problems, etc. Especially, the health problems are usually issued these days because people spend a lot of time in front of computers [1]. When people use computers, they tend to maintain the bad posture which is moving the head forward with curved spine because people feel that the posture is comfortable. If they do not pay attention to their posture, they will naturally keep the harmful postures when they use computers, and then they will feel uncomfortable or painful. These factor causes or forward head posture (FHP). FHP has badly effects on people's health. It causes neck pain, shoulder pain, back pain, dental occlusion, headache, etc [1, 3, 4]. Moreover, the ordinary postures would be changed to the bad one like a turtle.

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So, it is also called turtle neck syndrome. It is one of the most common health problem that modern people suffer because people are living in the environments extremely expose them to using computers. Therefore, it is necessary to detect FHP to prevent people from doing bad posture when they use computers.

Some methods to detect the FHP have been suggested. One is to detect FHP and let the user notice his bad posture via neckband which is equipped with vibration motors [5]. It suggested that FHP can be detected by measuring distance between the head and the torso. Kinect camera and webcam were used to detect the distance. If the distance is over specific threshold, the vibration motors will be operated to let the user notice his bad posture. The other is to detect FHP by measuring the cranio-vertebral (CV) angle through body sensors [6]. CV is the angle between the horizontal line passing through CV which is part of the cervical spine and a line extending from the tragus of the ear to CV [7]. If CV is over the 45 degree, it is judged that the user has FHP. The approaches to detect the FHP which are used in [5] and [6] are good ways, but there are some problems about price or convenience. That is because the user in [5] needs to prepare the expensive equipment, the Kinect camera and webcam, and the user should attach the sensors to his body inconveniently in [6]. To relieve the problems about the cost and the uncomfortableness, we suggest the different approach to detect FHP.

Our approach is to measure the vertical distance between the tragus of the ear and the torso. If the posture is correct, the vertical line will be the shortest because it passes between the tragus and the shoulder. However, if people have a bad posture, the distance will be longer than the counterpart. Moreover, the degree of distance refers to the degree to which the people have bad postures.

II. Method

1. Sensor System and Challenge

We designed for prevention of FHP and proposed a new healthcare function in smart earphone. The system uses three sensors such as IMU, Infrared (IR) distance sensor and vibration motor sensor. IMU sensor module is MPU-6050 containing 3-axis accelerometer and 3-axis gyroscope sensors. GP2Y0A51SK module which was made by SHARP was used to measures vertical distance from ear and distance range is from 2cm to 15cm. The IR distance sensor was pointing outward of head because of radiation angles. The three sensors are controlled by Tinyduino which is a miniature version of Arduino Uno and uses Atmega328P processor. Sensing data from the three sensors are transmitted to smartphone via Bluetooth. The system is attached to Ear-guide as shown in Fig. 1-(a). Challenges of our system are categorized into two cases as follows.

Firstly, IR distance is sensitive to the sensor position. IR distance sensor measures only one directional distance information structurally. The measurement distance value is meaningful when IR distance value is discriminable between normal posture and FHP. Secondly, head direction causing the FHP depends on sitting direction. The FHP is mainly occurred when we stares a monitor. Although the IMU sensor tracks head direction, finding head direction looking at the monitor in sitting situation is difficult.

III. Experimental Results

1. Forward Neck Decision Threshold

Turtle neck threshold should be considered in many variables such as sensor position and diverse postures. We tested distance sensor data in these variation conditions to check challenges and extract appropriate threshold in accordance with the variables. Fig. 2. Table 1 shows median value of distance value in challenging conditions. Normal sensor position

that we desired shows the distribution of data in correct posture, and normal position are clearly different to the distribution in the FHP. False wearing upward is exceptional data that shows distribution data is smaller than correct and normal postures. It means FHP is occurred when small distance value is detected. False wearing downward shows exceptional case that the sensor is needed to modify the sensor position physically, which is not compensated by software.

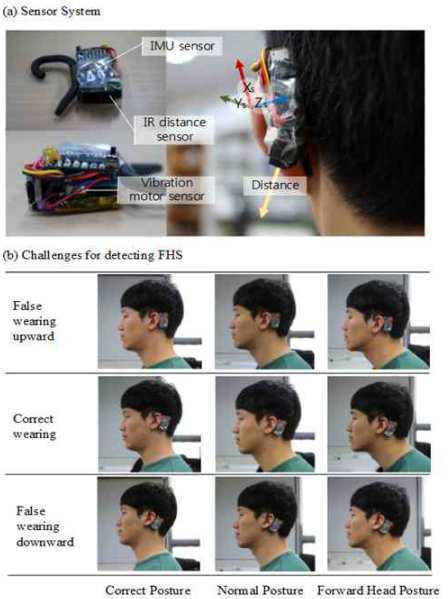

Fig. 1. Sensor System(a), Challenges for detecting FHS(b)

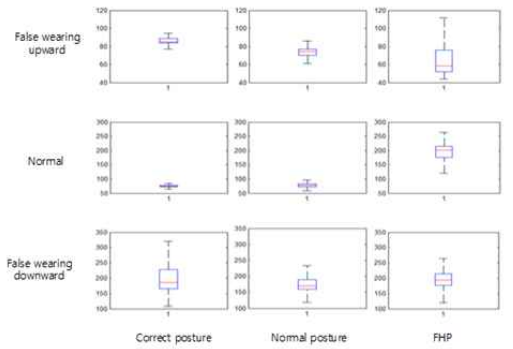

Fig. 2. Distribution of distance value according to sensor position and diverse postures

Table 1. Median of distribution distance

	Correct posture	Normal posture	FHP
False wearing upward	86.39	74.05	65.43
Normal	74.75	78.05	192.68
False wearing downward	186.57	172.60	192.14

To decide the FHP, we make a criterion of the FHP depending on sensor positions, where d indicates distance and th_{CP} means threshold of correct posture. The criterion is follows.

$$False\ waring\ upward: d < th_{CP}$$
$$Normal\ sensor\ position: d > th_{CP}$$
$$False\ waring\ downward: d > th_{CP}$$

2. Performance evaluation

Performance of FHP prediction is evaluated by ROC curve. Performance is evaluated by changing th_{CP} from minimum value to maximum value in distance data from correct posture. In Fig. 3, performance of FHP detection is the best in normal sensor position with high accuracy. In the false wearing upward, the performance is about 65% because there are some overlap data between normal and FHP groups. False wearing downwards shows that the worst performance and it needs to modify the sensor position.

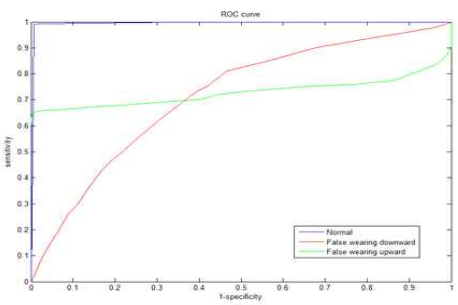

Fig. 3. ROC curve according to sensor positions

IV. Conclusion

We present how to detect the FHP and help people who have the bad posture causing the FHP to correct their posture. To detect the FHP, sensor data from IMU and IR distance sensors is used to detect the FHP. IMU sensor measures sensor positions and IR distance sensors detects FHP depending on the sensor positions. The threshold for decision of the FHP changes depending on the sensor positions. Our results showed that the FHP can be detected by considering two sensors. Prevention system of FHP will be utilized in future smart earphone as a one healthcare function.

References

[1] J.-H. Kang, R.-Y. Park, S.-J. Lee, J.-Y. Kim, . S.-R. Yoon and K.-I. Jung, "The Effect of The Forward Head Posture on Postural Balance in Long Time Computer Based Worker," Annals of Rehabilitation Medicine, vol. 36, no. 1, pp. 98-104, 2012.

[2] M. Ronimus, J. Kujala, A. Tolvanen and H. Lyytinen, "Children's engagement during digital game-based learning of reading: The effects of time, rewards, and challenge," Computers & Education, vol. 71, pp. 237-246, 2014.

[3] P. T. Hakala, A. . H. Rimpela, L. A. Saarni and J. J. Salminen, "Frequent computer-related activities increase the risk of neck - shoulder and low back pain in adolescents," European Journal of Public Health, vol. 16, no. 5, p. 536 - 541, 2006.

[4] M. HW, "The influence of forward head posture on dental occlusion," the Journal of Craniomandibular Practice , vol. 18, no. 1, pp. 30-39, 2000.

[5] J. Lee, E. Cho, M. Kim, Y. Yoon and S. Choi, "PreventFHP: Detection and warning system for Forward Head Posture," in Haptics Symposium (HAPTICS), Houston, 2014.

[6] T. Kim, S. Chen and J. Lach, "Detecting and Preventing Forward Head Posture with Wireless Inertial Body Sensor Networks," in International Conference on Body Sensor Networks, Dallas, 2011.

[7] C. Fernández-de-las-Peñas, C. Alonso-Blanco, M. Cuadrado and J. Pareja, "Forward head posture and neck mobility in chronic tension-type headache: a blinded, controlled study," Cephalalgia, vol. 26, p. 314 - 319, 2005.