DESIGN OF A HEADSET-COMPATIBLE WEARABLE NECK POSTURE MONITORING DEVICE

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Abstract— In these days, neck diseases related to bad daily posture has risen to be one of the major symptoms that people are suffering from. Not to mention, the best method to deal with such ailment is staving it off by keeping desirable posture in a daily routine. Acknowledging the difficulties of maintaining correct posture for a long period, we suggest an original way not only to help people do it but also to let people check their neck condition in terms of muscle contraction. This paper reports a neck monitoring device which monitors neck postures and state of surrounding muscles to alert the user of bad posture. By Integrating electromyography(EMG) and inertia measurement unit(IMU) with Bluetooth headset, we found that neck posture and myotonus of neck muscles could be faithfully monitored without significantly increasing inconvenience. Moreover, a rubber sheet attached to the system greatly increased practicality by eliminating the needs to keep EMG pad adhesive. When it comes to data processing, real-time data obtained from both sensors is processed through Arduino, and visualization is implemented with Processing.

Index Terms— Electromyography, Forward head posture, Inertia measurement unit, Neck posture monitoring device.

I. INTRODUCTION

The advent of personal monitor including PC and smart phone has greatly increased the occurrence of orthopedic diseases, especially forward head posture. Unlike conventional reading materials, ever-changing contents presented by monitor make people easily preoccupied with it for a long time, causing them to stay in one position even without noticing it. This catchy feature of personal monitor in turn give rise to a fair necessity of "an alarm" to constantly remind people of their bad postures in their daily lives. As a result, many types of wearable devices that monitors the posture of wearer in real time has been introduced recently. [1] and [2] suggests a way to estimate body posture using sensors attached to body. When it comes to commercialized products, [3] and [4] measures neck angle and alert the wearer by mild vibration if posture goes bad. This function is primarily implemented by acceleration sensor which measures tilted angle from a default state. If the deviated angle exceeds a certain threshold value, the device gives signal to the wearer. However, none of them seems to go further than that. We assumed that in order to completely monitor the state of neck, conditions of ambient muscles as well as posture should be taken into account. Since existing monitoring devices mainly focus on measuring physical angle, they give no information on internal state of wearer's body. In view of this marginal utility, we made up an integral system to measure both external and internal condition of neck by using both acceleration and EMG sensors.

To begin with, we selected Bluetooth headset as an 'infrastructure' of monitoring device. It not only presents a fair convenience in that Bluetooth headset is widely used besides for the sake of monitoring, but also lets the device take advantage of Bluetooth functions embedded in the headset for sending measured data to smart phone. We attached one IMU sensor in the midst of headset, and two EMG sensors on the both sides. One concern here is defining location of EMG pad. As will be discussed, the locations of muscle measurement are chosen to obtain electric signal of trapezius and splenius capitis. To fix the location of each pad, a rubber sheet whose holes' locations correspond to those of EMG pads is attached to the device.

Upon processing data, Arduino and Processing is utilized. Real-time data obtained by Arduino is transferred to Processing by serial port communication, and then visualized. These processes result in a monitoring system that surveils neck condition in the true sense of health care.

II. DESIGN AND RESULT

The system takes advantage of two types of sensor techniques. First, in order to measure slope and tilted angle of head with regard to backbone, IMU sensor has been applied. In particular, MPU-9250 from InvenSense which measures acceleration in 3 orthogonal orientations is utilized. It is laid parallel to back of neck so that it faithfully shows direction in which neck is leaned. Next, electromyography sensor is used to measure stress of muscle, or myotonus, at trapezius and splenius capitis, which are the two dominating muscles surrounding the cervical vertebral. Typical movement that results in the contraction of trapezius is laterally tilting head with

eyes fixed on one spot. If head is tilted to the left, then left trapezius would contract, resulting in an increased value of data from EMG sensor at left side. On the other hand, rotating head with backbone as an axis is related to contraction and relaxation of splenius capitis. If head rotates to the left, then the left splenius contracts while the right one relaxes. These simple and direct relationships between external movements and muscle behavior has made the two muscles most suitable target of measurement for EMG sensor. In this regard, 3 pads of EMG sensor, one of which represents the ground and the others electrical potential, are placed to keep in touch with both trapezius and splenius capitis. In order to fix the position of each of the pads and improve adherence of the device to human skin, a perforated rubber sheet is attached to the system. In conventional usage of EMG sensors, adhesive has been always accompanied by adhesive[5]. However, sticky but not adhesive nature of rubber sheet largely contributed to a stable contact of EMG sensor. Also, it provides the system with a fair insulator by its nature, rubber. Its discretely located 6 holes capably separated each of them in terms of electric signal. Fig. 1 shows the completed system which mainly consists of Bluetooth headset, 1 IMU, and 2 EMG sensors along with a rubber sheet.

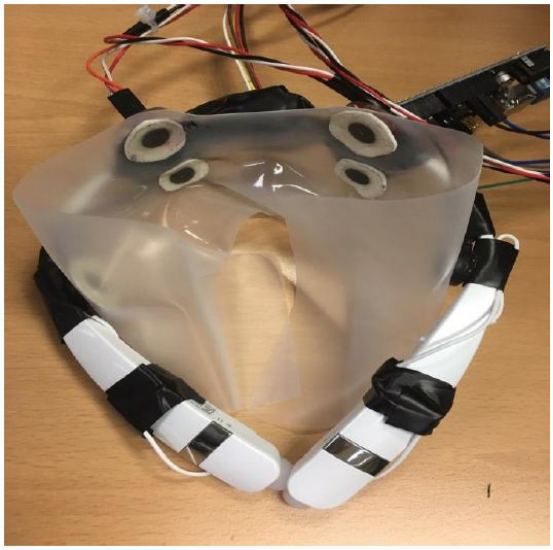


Fig. 1

The algorithm of system, as shown in Fig. 2, begins with calibration step in which wearer is required to stay in a 'good posture' for a certain amount of time. In this step, threshold values get personalized by measuring electric signal and physical feature of neck of initial state. This step is necessary since EMG data greatly varies with people. Thus, what matters in determining state of muscles is not the absolute values but the variation of EMG data. Once calibration is done, the device truly begins to monitor the wearer by checking if the posture deviation exceeds threshold values. If so, it alerts the wearer through user interface as represented in Fig. 3 and induce him or her to regulate the posture. Fig. 3 informs the wearer of several conditions. First, the first region in the figure represents the direction to which the wearer's head is leaned. The result is discretized into three categories: Forward, left, and right. Then, the region marked by 2 visualizes the state of neck in terms of forward head posture. If head is erected, then it gives green sign. However, as head leans forward, the color changes to yellow and red, consecutively. In contrary to the two former regions which primarily deals with geometry of neck and head, the third region gives result obtained by EMG. When either left or right side of neck muscle turns out to be under stressed condition for more than a certain amount of time, either left or right part of shoulder in the picture changes to red, signifying that muscle is overly stressed.

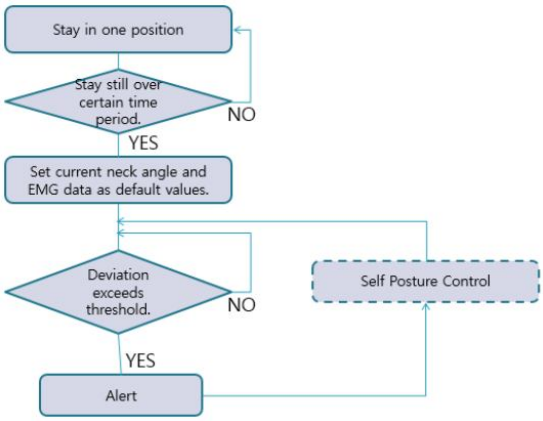


Fig. 2



Fig. 3

CONCLUSION

The newly designed monitoring system suggested in this paper is featured by monitoring of neck posture in way that is more completed. It covers from physical feature of neck posture to tension level of surrounding muscles. In addition, we suggested a new way of applying EMG pad to human skin by using a rubber sheet in place of adhesive. The nature of rubber sheet which is far from being slippery greatly increased friction against human skin, and resulted in a stable contact of EMG pad. All in all, the system is expected to compete with and replace the existing wearable posture monitoring devices if proper optimization process such as introduction of fancy exterior is ensued.

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