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Development of a Mobile IoT Device for Posture Tracking

Pyo-Woong Son[(1,2)], **Jiwon Seo**[(1,2)]

[(1)]***School of Integrated Technology, Yonsei University***
85 Songdogwahak-ro, Yeonsu-gu, Incheon 21983, Korea
Email: jiwon.seo@yonsei.ac.kr

[(2)]***Yonsei Institute of Convergence Technology, Yonsei University***
85 Songdogwahak-ro, Yeonsu-gu, Incheon 21983, Korea

BIOGRAPHY

Pyo Woong Son received his B.S. degree from the School of Electrical and Electronic Engineering, Yonsei University in 2012. He is currently a PhD candidate in the School of Integrated Technology at Yonsei University.

ABSTRACT

Many people experience musculoskeletal disorders such as low back pain or neck pain these days. Previous studies have suggested that a poor posture may cause the disorders. In fact, many people spend significant time of their lives in a static posture such as sitting on a chair. However, it is difficult to accurately investigate and track how a poor posture adversely affects musculoskeletal disorders.

This paper tries to resolve this problem by developing a mobile Internet of Things (IoT) device. The device consists of Inertial Measurement Units (IMUs), a flex sensor, and a microcontroller with a Bluetooth module. The IMUs measure angular velocities and linear accelerations, and the flex sensor measures bending angles. The posture of a user is estimated based on these sensor data. The posture estimation based on the limited sensor data is challenging. Thus, we develop a matching algorithm utilizing the motion capture system which provides the ground truth of the user's posture. The sensor data and the posture data are used together to refine the estimation algorithm.

Two IMUs of the device are attached to the both ends of the flex sensor along the low back and measure the movement of the low back. The flex sensor measures the degree of bending between two IMUs. The microcontroller with a Bluetooth module is attached to one end of the flex sensor. These sensor data contain the information of the spine movement, and the spine movement is connected to the user's posture which is obtained by the motion capture system. Thus, after applying a classification algorithm, the sensor data from the device can be classified into several postures. The estimated posture information is transferred via the Bluetooth communication. This device and classification algorithm can be utilized for the investigation of the correlation between a poor posture and musculoskeletal disorders.

Keywords: Posture Tracking, Mobile IoT Device, Musculoskeletal Disorders, Matching Algorithm, Sensor Fusion

INTRODUCTION

A number of people who experience musculoskeletal disorders have been increased over the past few decades [1]. Many experts have suggested that these diseases can be caused by a poor posture in daily life [2]. However, it is still controversial whether a poor posture in daily life causes such disorders directly because it is difficult to verify the relationship between a poor posture and musculoskeletal disorders [3]. To demonstrate the relationship between a poor posture and musculoskeletal disorders, the system that can track the user's posture in daily life is necessary.

In this paper, we develop a mobile IoT device that can estimate and track user's posture. This device consists of some sensors which sense a user's spinal curve and small board which processes the sensor data and communicates with other external devices. Also we develop a matching algorithm which is important for increasing the accuracy of the estimation. After data processing at the board, the user's spinal curve data is converted to the user's posture and it can be used from anything associated with the device.

SYSTEM ARCHITECTURE

This mobile posture tracking device consists of sensor part, processing part and communication part. Two inertial measurement unit sensors and flex sensor organize the sensor part and microcontroller unit (MCU) and Bluetooth module compose the processing part and communication part.

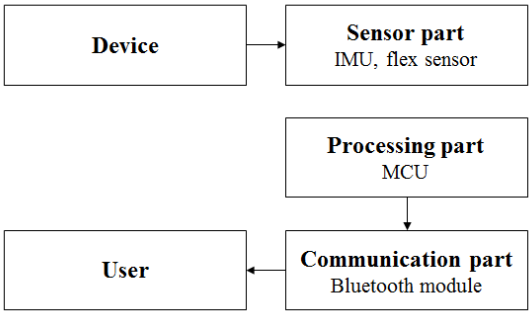

Figure 1. Configuration of the mobile spinal curve detection device

Two IMUs and flex sensor comprise the sensor part of the device. Two IMUs are attached to the end side of flex sensor along the low back and measure gyroscope, accelerometer, gyroscope at the attached point and the flex sensor measures bending angles between two IMUs. The data obtained from the sensors is used to estimate a user's posture.

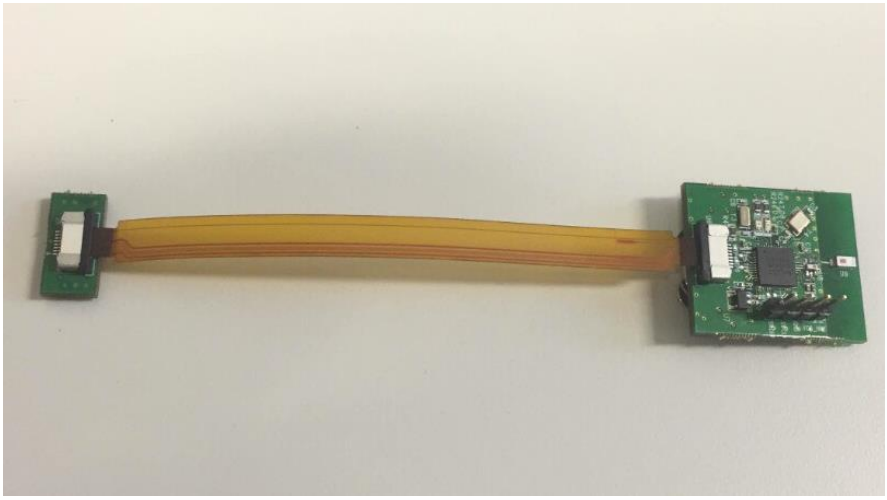

Figure 2. Sensors and the small board of the device

Processing part and communication part are operated in the small board which consists of MCU and Bluetooth module. MCU handles the data from the sensor part to estimate a user's posture. The posture data processed by the matching algorithm can be connected to the external device through Bluetooth module of the small board.

We design for the user to wear the device at the bottom of the back in daily life. Worn with contact-type clothing such as sportswear, the device can sense the user's spinal curvature exactly. Since the user should wear the device for a long time, it is produced in silicon for a convenience for the user.

Figure 3. The design of the mobile posture tracking device

MATCHING ALGORITHM

Generally, a lot of IMU sensors are necessary to verify the spinal curve for posture estimation [4]. However, it is possible that only a few IMU sensors are needed to estimate the spinal curve when the sensor data is processed by the matching algorithm. The matching algorithm in this paper refers to an algorithm using correlation between the posture information obtained from the motion capture system such as VICON and the spinal curve information from the sensor data.

$$\rho_{X,Y} = corr(X,Y) = \frac{cov(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X-\overline{X})(Y-\overline{Y})]}{\sigma_X \sigma_Y}$$

where X and Y are each sensor data and the posture analysis information obtained from motion capture system.

Figure 4. Development of the matching algorithm using motion capture system and the device

DEVELOPMENT RESULT

We develop a posture estimation algorithm by correlation between the sensor data and the information from motion capture system. Based on the database in the development process, the user's motions were classified into several postures. The device may track that how long the user maintains in particular posture and this results are freely used by anyone who is connected to the device.

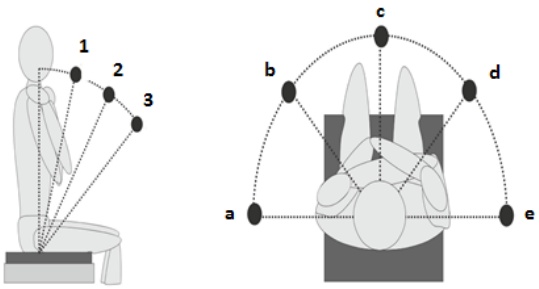

Figure 4. Classified the direction of body

Classified posture	Example
1-c	In use a smartphone
2-c	In use a computer sitting on a desk
2-b,d	Resting chin on hand
1-a	Put weight on the armrests

Table 1. The posture classified by direction of body

CONCLUSION

In this paper, we develop the mobile IoT device which estimates and tracks a user's posture. Using the device, we try to resolve the challenge which measures spinal curve using the sensors of limited number and estimates a user's posture in daily life. To complement the information from the limited number of the sensor, we also develop the matching algorithm which utilizes the motion capture system to refine the classification of a user's posture. We expect that the device and the matching algorithm can be used for the investigation of the correlation between a poor posture and musculoskeletal disorders

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