A Sitting posture recognition system based on 3 axis accelerometer

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***Abstract*—According to a recent study poor sitting posture of the spine has been shown to lead to a variety of spinal disorders. For this reason, it is important to measure the sitting posture. In this study, we proposed a system that sitting posture classify using 3-axis accelerometer. We retrieved acceleration data from single tri-axial accelerometer attached on the back of the subject's neck in 5-types of sitting posture. 6 subjects without any spinal disorder were participated in this experiment. Acceleration data were transformed to the feature vectors of principle component analysis. Support vector machine (SVM) and K-means clustering were used to classify sitting posture with the transformed feature vectors. To evaluate performance, we calculated the correct rate for each classification strategy. Although the correct rate of SVM in sitting back arch was lower than that of K-means clustering by 1.9%, SVM's correct rate was higher by 0.8%, 4.7%, 15.5%, 6.9% in a normal posture, sitting front arch, sitting cross-legged, sitting leaning right, respectively. In conclusion, the overall correction rates were 95.33% and 89.35% in SVM and K-means clustering respectively, which means that SVM have more advantage than K-means method for classification of sitting posture.**

Keywords—sitting posture, accelerometer, principle component analysis (PCA), support vector machine (SVM), K-means clustering

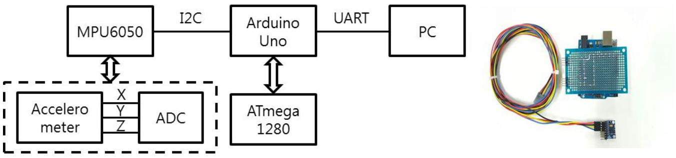
I. INTRODUCTION

Most of modern people spend on most of their time sitting at a desk. This causes disorders of the spine. Upright sitting posture is the best way to prevent spinal disorders. Upright sitting posture doesn't lean the center of gravity to one side. The body is observed to the sagittal plane, frontal plane and horizontal plane. However, They are disturbed their posture within a few seconds after sitting on a chair[1-3]. Poor posture causes various diseases, which from spinal disorders to psychological stress[4]. The system for maintaining correct posture of the user has been developed in order to prevent for poor posture[5-7]. But, the system is inefficient in terms of cost and space limitation. Recently, the study was carried out to classify the posture using accelerometer[8]. In particular, through the data of acceleration sensors attached to the four joint, the study was classified as normal and abnormal sitting posture. However, this method can't be used in everyday-life. Also, poor posture is very various. The type of poor posture is different from that in case of spinal disorders.

In this study, we proposed the system that's sitting postures classified as the five types using single-accelerometer. Five types are defined as one correct posture (posture A) and four poor postures (posture B-E). Four poor postures are a cause of lumbar herniated intervertebral disc. The four postures include sitting front arch (posture B), sitting back arch (posture C), sitting cross-leg (posture D), sitting learning writing (posture E). We retrieved acceleration data from single tri-axial accelerometer attached on the back of the subject's neck in 5-types of sitting posture. A feature vectors are extracted by principle component analysis (PCA) from the acceleration data. Support vector machine (SVM) and K-means clustering were used to classify sitting posture with the transformed feature vectors. To evaluate performance, we calculated the correct rate for each classification strategy.

II. SITTING POSTURE RECOGNITION SYSTEM

In this study, MPU6050 is used to measure the data of sitting postures measure. The accelerometer was set in the range of the ±2g. And it was possible to human activity recognition (HAR). Also, The analog-to-digital convertor (ADC) transmits the data in the -32768 ~ +32767 range. Sampling rate was set to 100Hz. And the +1g has been mapped to a value of 16,384. The size of the accelerometer is very small in a 20*15mm value. It gives only a few restrictions on the sitting posture of the subject and is possible with data acquisition. Arduino uno is used for collection of acceleration data. The accelerometer is connected to the MCU (microprocessor unit) through the i2c communication. The PC and arduino uno were connected by the serial communication via USB and it was set up to 38400



(a) (b)

Figure 1. (a) The developed hardware device, (b) The real system

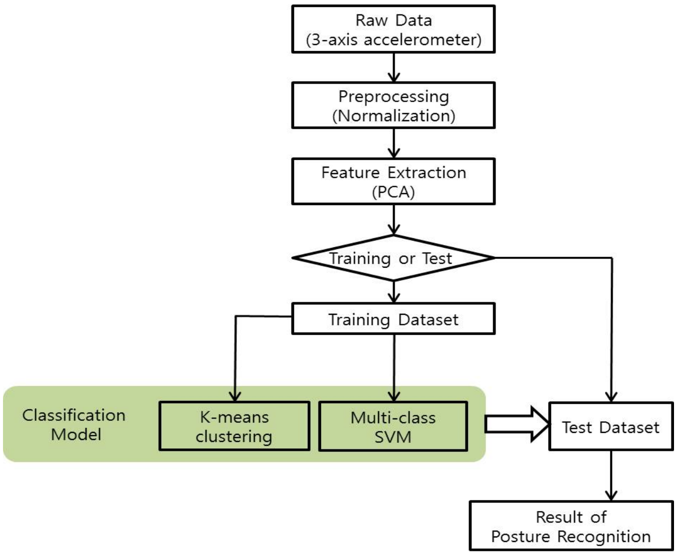


Figure 2. Flow chart of the proposed algorithm

baudrate. As shown in figure 1, acceleration signal of sitting posture is collected by the configured hardware.

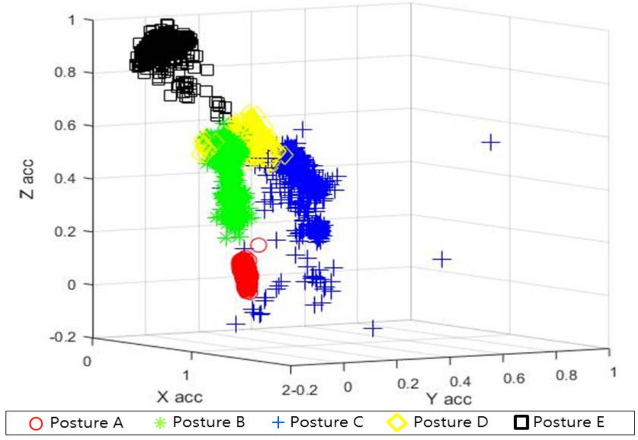
Figure 2 shows a process for classifying the collected data pattern. The signal that 1g is mapped 16384 is normalized to the actual acceleration value. Each sitting posture had sets of three components for principle component analysis (PCA). Two training models were generated; one by K-means clustering algorithm and the other by support vector machine (SVM). To evaluate performance, we calculated the correct rate for each classification strategy.

III. Experiment

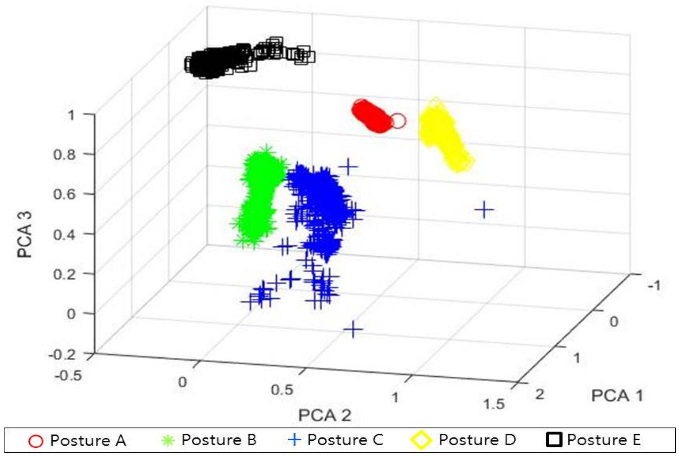
This experiment was carried out on six subjects with no reports of spinal disorders. We retrieved acceleration data from single tri-axial accelerometer attached on the back of the subject's neck in 5-types of sitting posture. The spinal disorders are not present that it forms a straight clavicle and ears when viewed from the lateral. Figure 3 shows the five types posture used in the experiment. Each subjects keeps the five types posture (A-E) for 5 minutes while sitting in a chair. Because of sitting posture easily lose within several seconds after sitting on the chair, data is collected after 1-2 minutes training time.

(a) (b) (c) (d) (e)

Figure 3. The sitting posture recognition ((a) : posture A, (b) : posture B, (c) : posture C, (d) : posture D, (e) : posture E)



(a)



(b)

Figure 4. Data distribution (a) : Raw-data, (b) : PCA-data

IV. Result

Figure 4 (a) shows a map of the Raw-data, and figure 4 (b) shows a map of the PCA-data. The input using raw-data were classified sitting postures each of K-means clustering and SVM. The results have not classified as 54.61% and 61.26%, respectively. Therefore, by using the PCA it was clustering for each type posture. Figure 4 (b) is the result of the PCA and is possible the classification of the sitting posture.

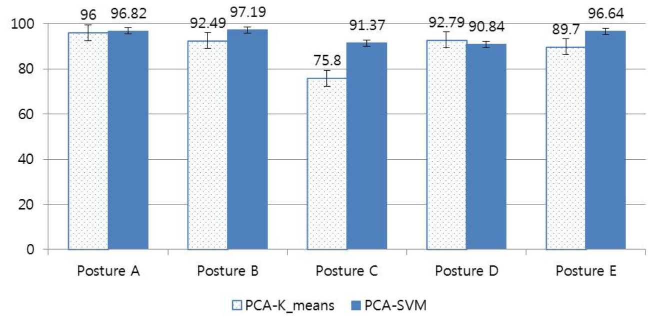


Figure 5. Classification performance for five sitting postures

Figure 5 shows the correct rate of each type posture. Although the correct rate of SVM in sitting cross-leg was lower than that of K-means clustering by 1.9%, SVM's correct rate was higher by 0.8%, 4.7%, 15.5%, 6.9% in a normal posture, sitting front arch, sitting cross-legged, sitting leaning right, respectively. With this result, it was possible that the single-accelerometer classify the five types postures. Via the comparison result of the classification, SVM have more advantage than K-means method for classification of sitting posture.

V. CONCLUSION

In this study, the five types postures can be classified using the single-accelerometer. The correct rate was reduced compared to the previous study[9]. Because the position of the sensor has been changed and the types of sitting posture were increased. Also the subjects are not any spinal disorders and it was difficult to keep the poor postures. Therefore, it decreased the accuracy of the data. But it may be applied to establish a posture coach system without the inconvenience to the user.

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