ISSN 2278-3091
Volume 8, No.4, July – August 2019
International Journal of Advanced Trends in Computer Science and Engineering
Available Online at http://www.warse.org/IJATCSE/static/pdf/file/ijatcse77842019.pdf
https://doi.org/10.30534/ijatcse/2019/77842019

The Human Spine Health Application Based on Deep Learning

Guohua Li[1], WooLim Kim[2], and Sang Boem Lim[3,*]
[1]National Institute of Supercomputing and Networking, Korea Institute of Science and Technology Information, Daejeon, Korea, ghlee@kisti.re.kr
[2]Department of Smart ICT Convergence, Konkuk University, Seoul, Korea, kwl930521@konkuk.ac.kr
[3,*]Department of Smart ICT Convergence and Social Eco-Tech Institute, Konkuk University, Seoul, Korea, sblim@konkuk.ac.kr ([*]corresponding author)

ABSTRACT

Sitting in postures other than the good one for a long time can not only cause spinal diseases but also diabetes or heart stroke and may increase death risk. Also, the longer the sitting time becomes, the greater the back pain gets. Remaining in a bad posture for a considerable amount of time can cause strain on the spine, which might bring spinal diseases such as scoliosis and other musculoskeletal diseases.

This study uses data measured from posture measuring smart cushion from 10 participants. Furthermore, our group aims to use the designed application to provide real-time experience and statistical data to suggest good posture and improve the spinal disease. Our application also provides a stretching program to help to treat the spinal disease. In this research, we focus on user group from the young to the elderly to prevent diseases such as spinal disease and diabetes.

Key words: Deep Learning, Spine Health, Smart Device Application.

1. INTRODUCTION

The human spine is S-shaped and composed of four major sections which are cervical (7), thoracic (12), lumbar (5), and sacral (4). It supports bodily weight, buffers physical shocks, and act as a passing highway for nerves. The good posture for this spine is unbiased, not leaning to any direction when examined up, below, left, right, front and back. Especially, when one is using one's personal computer or is studying, person's head and neck must be straight from the side, shoulders pulled out, and waist perpendicular to the thigh. Additionally, the thigh should be put parallel to the floor, knee at the same height as the buttock with sole entirely touching the floor. [1]

When a spinal disease takes place, it affects back and enlarges the pain range [2]. Spinal disc herniation and straight neck syndrome which many suffer from is also widely affected by the posture. Forward head posture (FHP) is the most frequented modern disease that breaks the curvature of the cervical spine makes what is originally C-shaped into a straight line. When such symptom occurs, other bones are also affected, and finally, the S-shaped spinal curvature collapses, making it even more susceptible to shock and weight, leading to appreciate disc herniation risks [3]. Nonetheless, it is impossible to maintain good posture while sitting and most people enjoy wrongful posture with their bodily center pointing to one side [4]. Previous studies have classified wrongful postures into four categories. The first is when one's head is pulled straight forward to the monitor. The second is when one is seated deep, burying oneself in the chair. Sitting with one leg crossed is the third wrongful posture, and the fourth is sitting with one arm support, making the overall posture tilted to a side. Each wrongful posture causes disorders or diseases which hinders ordinary life. Correcting and also maintaining good posture can prevent several diseases beforehand [5]. However, it is deceivingly difficult to maintain good posture just by one's will and therefore there is a need for a device that can help correct and maintain good posture.

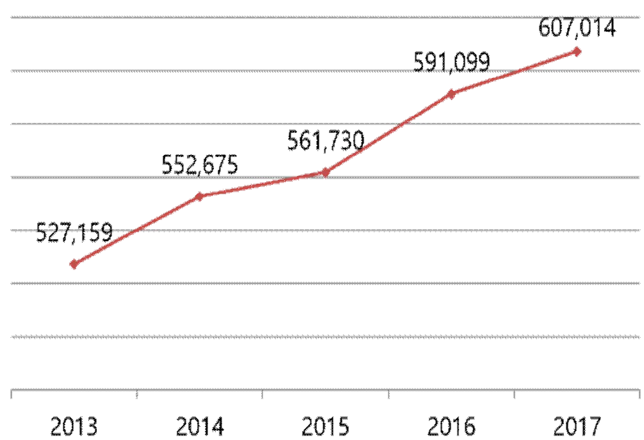

Figure 1: the number of spinal disease patients in their 20s [6]

The incidence of these various diseases is most frequent in the elderly population, yet the number of young patients is increasing. Figure 1 shows that the number of spinal disease patients in their 20s has been steadily increasing since 2013. The number of these patients increased by 70,985, from 527,159 in 2013 to 60,701 in 2017. Within five years, it appreciated 15%. The number of patients in their 50s who accounted for the largest proportion of patients with spinal diseases is 1,934,701 last year, yet its growth rate at the same year is only 8%, half of that of the 20s. Since spinal diseases are caused by long-exposure of strenuous posture, correcting and preventing pain-causing postures from the earlier period is much more helpful.

Figure 2 illustrates the prevalence of spinal disease by age group for a three-year period. The age group of 18 or lower is shown as the least prevalent age group from 1996 to 2011. Only 8% had the spinal disease during the most recent period, from 2009 to 2011. On the other hand, the most prevalent age group is, generally, between ages 18 to 65 which accounts for more than 75% of the whole. Among them, those from 45 to 65 have 32% more prevalence than that of 18 to 45, with the most rapid growth rate from 1996 to 2011. People over 65 had a prevalence of 24.5%, 19% and 56% lower than 18 to 45, 45 to 65 respectively.

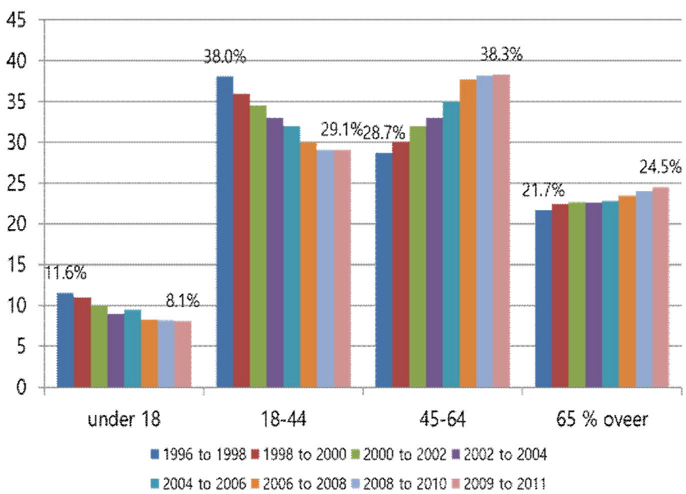

Figure 2: The prevalence rate of musculoskeletal disease by age [7]

2. RELATED WORKS

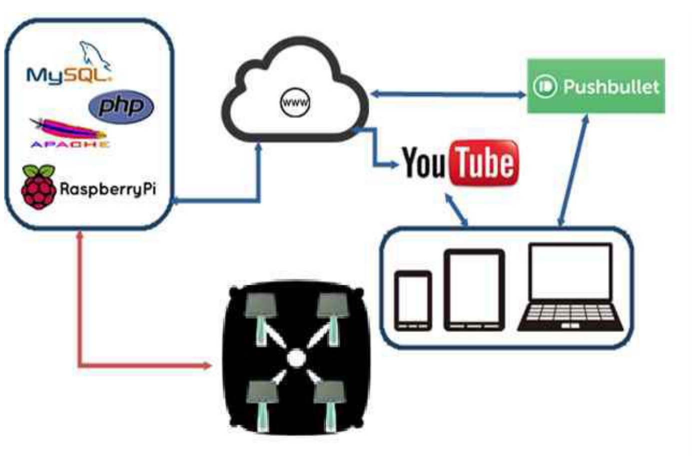

Figure 3: System Architecture [10]

To use pressure sensor for research [8][9][10], their group use OP-AMP for signal amplification, MCUs for analog signal processing and digital signal transmission, and Bluetooth modules for wireless communication between smartphones and MCUs. The users can monitor the application in real time by clicking the analysis button, and the user's posture or accumulated habitual posture data is analyzed and displayed on the screen. and Blueno and Bluetooth 4.0 are used to send data to the Android application. The data comprises the current posture, elapsed time after the start of Bluetooth connection and the special letter that tells the end of data transmission. Previous research delves in the methods where pressure difference between each hip joint are noted as bad posture and alarmed user for correction. The most resembling research that is previously conducted to our own study of this paper had monitored and analyzed the posture of the seated person.

As shown in Figure 3, They install four pressure sensors to the chair cushion, and each sensor sensed the imbalance of the body according to the state of the seating posture, transmitting information to the controller which pops an alarm when the posture is defined as improper. Also, by clicking the alarm, the user can watch stretching video on YouTube. The user may also connect to the internet and retrieve data of a selected period of time in the form of graphs. However, such research only demonstrates what is received from the pressure sensor in real-time or gives an alarm for the wrong posture. It fails to provide the user of quality information and the range of measurable posture is narrow with a correction solution being too superficial. Moreover, there is a difficulty in measuring posture due to data fluctuation depending on the users' body type and sex.

3. METHODS

The pressure distributions are visualized only for the essential sensors. It excluded the unnecessary portions where the pressure values are lower or not the same in all 10 experimental groups. The pressure distribution is expressed by one sensor only when pressure higher than a predetermined value of data is detected based on the sensor value. In the pressure distribution diagram, the first part is the front part of the cushion, the second part is the middle part of the cushion, and the third part is the end part of the cushion.

Figure 4 demonstrates the pressure distribution of the pressure sensor measured data on the bottom of the smart cover. Of all seven postures, five postures are characterized in pressure distribution: sitting up straight, leaning left or right, sitting with left or right leg crossed.

It can be noted from the sitting up straight position that the pressure is evenly distributed to all the sensors. The distribution of the left-leaning posture is weak on the right pressure sensor and strong on the left. On the contrary, the distribution of the right-leaning posture shows a weak signal on the left and strong on the right. For the pressure distribution of the sitting posture with the left leg crossed, the pressure sensor at the front and the center of the cushion of no.2 and no.3 has a strong signal, whereas the No.1, the left end part has weak value. This is also true for the sitting posture with the right leg crossed, where the signal of no.2 and no.3 pressure sensor had a strong signal and the right end part, the no.1 sensor had the weak signal.

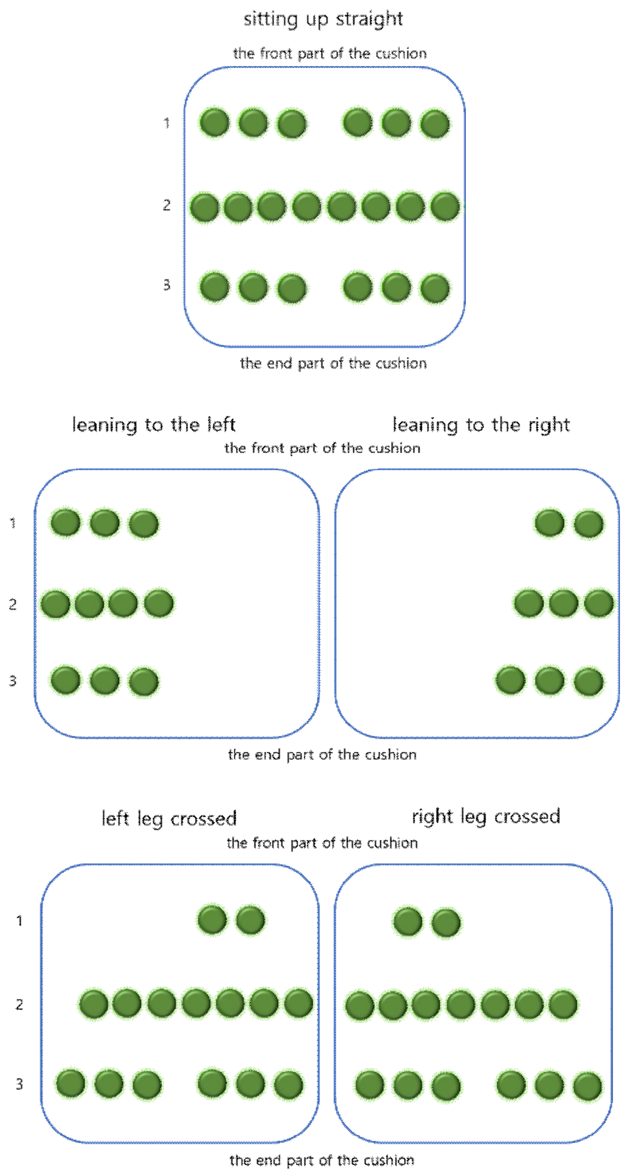

Figure 4: Pressure distribution on the seat side of the smart cushion

Figure 5 shows the pressure distribution diagram of the backrest part. During the sitting up straight posture, the pressure of the backrest part is intense only at the end of the no.3 pressure sensors. For this reason, as described above, the head and neck should be straight when viewed from the side, and the waist should be perpendicular to the thigh so that the entire spine is unattached to the chair, but the waist is floated. In the leaning backward posture, it can be perceived that the pressure values are mostly evenly distributed except for the one or two pressure sensors. Conversely, when we look at the distribution of the leaning forward posture, weakness in the signal is detected in all sensors. When the pressure of the backrest is checked, the bottom part revealed a similar distribution as that of Figure 4. When measured solely at the bottom, confusion could occur due to the similarity of the proper posture with leaning back and the forward posture. To tackle this matter and clearly distinguish three from each, our group additionally installed the backrest parts.

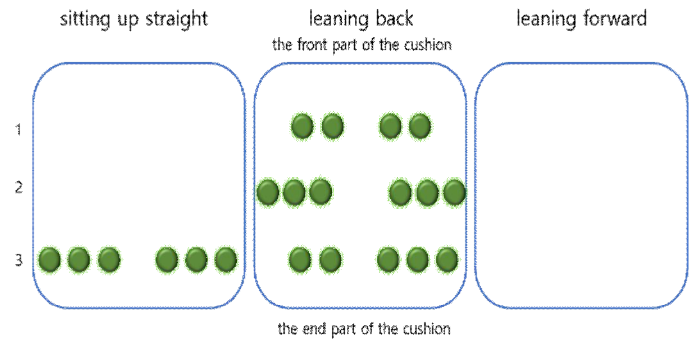

Figure 5: Pressure distribution on the back side of the smart cushion

4. ANALISIS AND RESULTS

4.1 Deep Learning Results

Table 1: Learning result of a deep learning test model

	P1	P2	P3	P4	P5	P6	P7
A	96	89	89	85	90	96	93
B	77	91	87	92	90	89	91
C	92	90	97	96	93	87	83
D	88	96	93	82	89	98	96
E	85	88	95	94	88	95	87
F	92	97	89	91	90	87	90
G	90	92	85	90	97	95	93
H	95	93	90	98	94	92	89
I	97	95	90	89	67	90	93
J	96	88	90	93	90	87	98

* Description of Position:
- P1: sitting up straight
- P2: leaning right
- P3: Leaning left
- P4: Right leg crossed
- P5: Left leg crossed
- P6: Leaning back
- P7: Leaning forward

We infer that accurate result could be derived regardless of one's body type or sex and continued to use deep learning to evaluate the system suggested in this paper [12].

Table 1 shows the learning result of the deep learning model based on ten experiment participants. The number designates accuracy of each posture. For deep leaning process, approximately a hundred data are collected for a total of five times per posture per person. Of all 500 data collected, 400 are used for leaning and the other 100 are selected randomly for the learning model development, which repeated 100 times. Eventually, the accuracy is confirmed by testing datasets. As a result, it is confirmed that the accuracy of each posture of all ten participants is generally high. The average accuracy of posture is 90.8%. For each group, it is 91.9% in leaning right position, 90.5% in leaning left position, 91% in sitting with the right leg crossed, 88.8% with the left leg crossed, 91.6% in the leaning back posture and 91.3% for leaning forward. It can be concluded that the seven kinds of postures can be accurately classified through our suggested system. As described in Table 1, A to J represent Participants 1 to 10.

The application our group designed also provided a stretching routine based on the results of the deep learning process. It is to induce user-driven posture correction. For the stretching content, our group selected one that can be done while seated and that reduces muscle tension and relieves stress [11]. Using the previously defined pressure sensor value, the application determines the user's posture by coordinating real-time posture and pressure distribution information as shown in Figure 4 and Figure 5. Thus, the app distinguishes whether the user did the stretching routine. After it concludes that the user has done the routine, it moves to the next stretch.

4.2 Smart Device Application

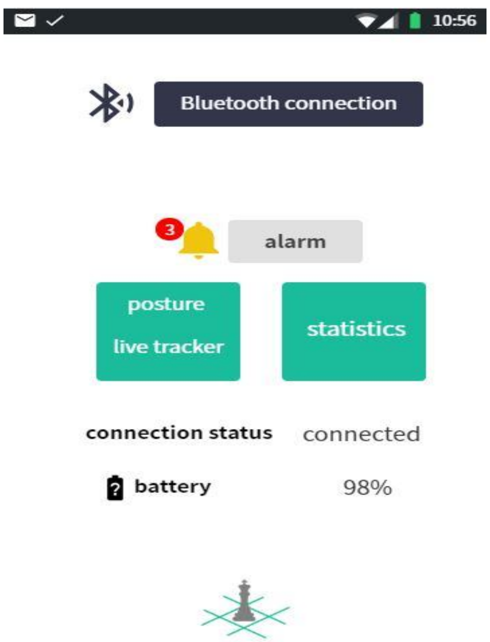

Figure 6: The main page of the application

Figure 6 shows the main screen of the application. The Bluetooth connection button on the main screen connects the Bluetooth with the pressure sensor of the cushion and tells the user whether the application and the smart cushion is connected. The main screen clearly shows either state where Bluetooth connection is made or has been disconnected. When the application and the smart cushion are associated via Bluetooth, the user can also know the remaining battery capacity of the smart cushion sensor. Also, when the user does not sit properly or in good posture for a certain period of time, the application files an alarm and the user can check it at any time through the notification button on the main screen. Real-time posture live tracker and the statistics for previous data are also seen on the screen. User may use posture live tracker to understand one's posture in real time basis and use statistics to learn overall summary by daily, weekly and monthly basis.

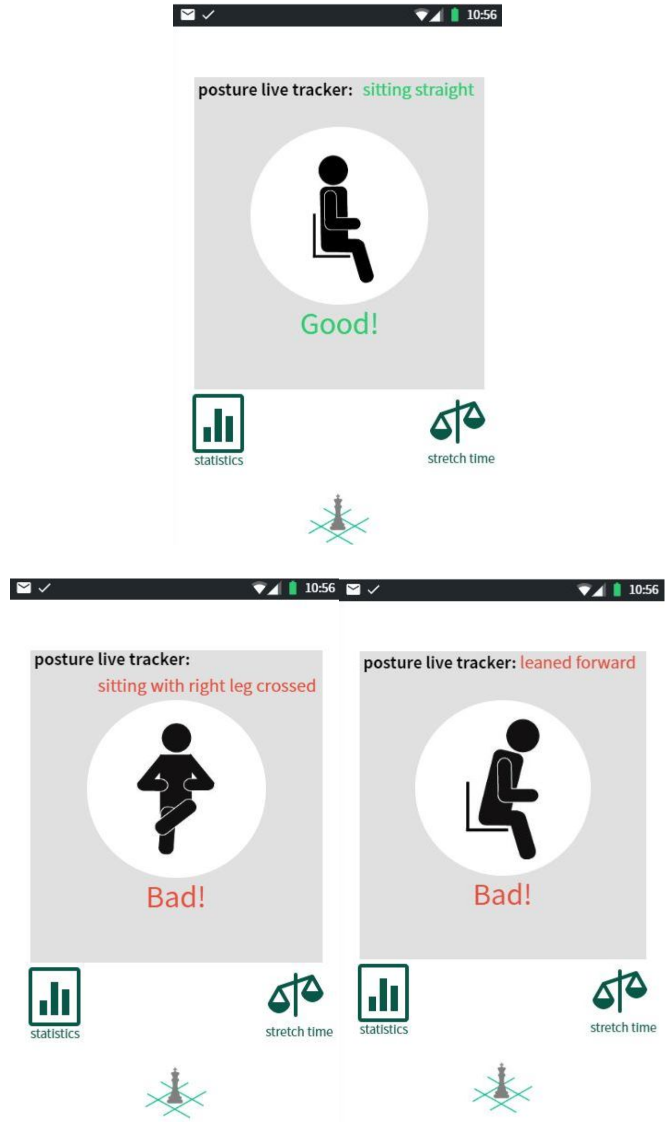

Figure 7: Posture live tracker

Figure 7 demonstrates the real-time, live posture tracking screen of the application. In this section, the user can check and acknowledge the current posture while sitting. If the user is sitting straight up, the green letter ‘Good!' comes out to inform that the user is assuming the good posture whereas the red letter ‘Bad!' comes out to tell that the user should change the posture. Since the users can monitor their posture in real time, the system can influence the user to instantly change the posture. Furthermore, if the user did not maintain proper posture for a certain amount of time, the user can use stretch time button to help correct the posture. Statistics button allows the users to understand their work in a day, a week, and a month.

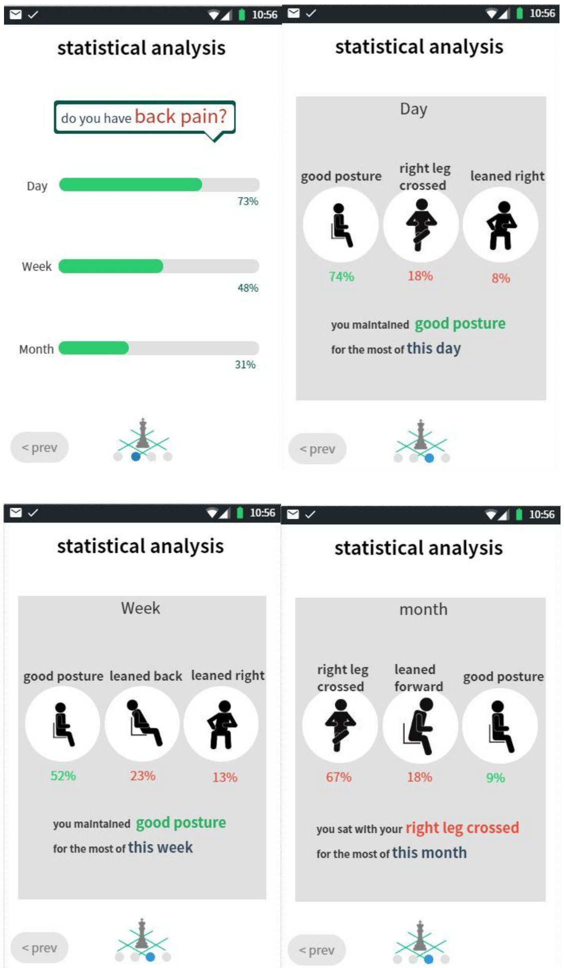

Figure 8: Statistics page

Figure 8 describes a graph of a sitting posture by daily, weekly and monthly basis. It collects and analyzes data gathered from real-time tracking and provides the user of more useful information. Users can see how much they sat properly by a day, a week, or a month. The detail of the statistical screen demonstrates the three most frequently assumed posture and its ratio. If the incorrect posture is too frequently recorded, the application suggests the stretching program for improvement.

The application also provides stretching tools as shown in Figure 9 for user's posture improvement. The screen shows a stretching movement that can be done while sitting, making the user to more freely participate in it regardless of the place one is in for a user set period of time. An application determines by its pressure sensor whether the user has stretched as instructed, and switch to the next stretch so the user can perform the various movement for posture improvement.

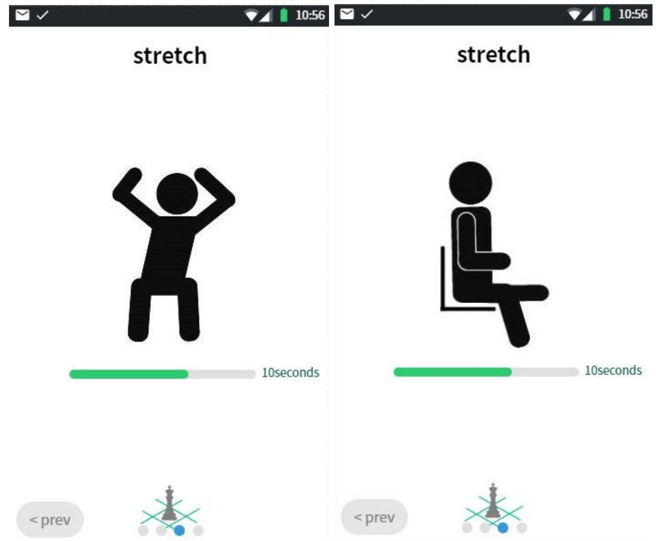

Figure 9: Stretch time service

5. CONCLUSION

This study focused on the rising importance of good posture for people of this modernized era and designed and developed the system in which people can easily monitor posture from the application. Our group used a pressure sensor that is put inside the chair cover and used android studio to build an application. Our suggested system is much more practical and easier to use than that of the hospital posture correcting system. Based on the data value provided from the system, the application provides a visualized image of the data and the statistical analysis of the data and classifies posture through a deep learning process. This study confirmed that our suggested system is applicable system as an efficient posture correcting device.

Our suggested system guides users to assume proper posture through live tracking and statistics so that the users can correct themselves. However, it can be said that the drive for self-correction is limited. Our group will supplement this point by providing disease information on every seven wrongful postures as an update for the application.

REFERENCES

1. J. M. Muscolino. ***Kinesiology: The Skeletal System and Muscle Function***, 3rd ed. Elsevier - Health Sciences Division, 2016.
2. M. Polastri, G. Zagnoni, and A. Loforte. **Basic movements for postoperative exercise in patients with left ventricular assist devices**, *Monaldi Archives for Chest Disease*, Vol. 89, no. 1, pp33-40, 2019. https://doi.org/10.4081/monaldi.2019.995
3. I. A. Kapandji. ***The physiology of the Joints***. 6th ed. Vol. 3, Churchill Livingstone, 2008.

4. P. B. Bruce. **Musculoskeletal disorders and workplace factors**. *U.S. Department of health and human services*, 1997.
5. V. Padmanathan, I. Halim, and T. Y. Wei. **Application of pressure biofeedback unit as part of ergonomics assessment tools for assessing back pain among computer users**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no. 3, pp. 879-882, May-Jun. 2019. https://doi.org/10.30534/ijatcse/2019/83832019
6. Kukmibilbo. Available online: http://kmib.co.kr. (accessed on 10 April 2019).
7. U.S. Department of Health and Human Services. Available online: https://www.boneandjointburden.org. (accessed on 10 April 2019).
8. H. W. Jung, C. W. Wang, and D. M. Se. **Real-time position monitoring system using pressure sensor**. *The transactions of the Korean Institute of Electrical Engineers*, Vol. 64, no. 6, pp. 940-947, Jun. 2015. https://doi.org/10.5370/KIEE.2015.64.6.940
9. Y. J. Shin, K. H. Oh, H. K. Bahn, and H. J. Kang. **A Posture Correction Guidance System Using Arduino and Force Sensitive Resistors**, in *Symposium of the Korean Institute of Communications and Information Sciences*, 2014, pp. 262-263.
10. M. H Lee, S. H. Kim, H. Y. Kim, and E. Y. Byeon. **Sitting Posture Information Services through Smart Cushion.** *The Korean Society of Computer Information Conference*, 2016, Vol. 24, pp. 217-218.
11. S. N. Lee, T. H. Lee, and H. J. Park. **A Study on the Cause and Effect Relationship between Stretch Exercise and Labor Satisfaction**, *Journal of Sport and Leisure Studies*, Vol. 28, pp. 617-625, 2006.
12. S. More and J. Singla. **Machine learning techniques with IoT in agriculture**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no. 3, pp. 879-882, May-Jun. 2019 https://doi.org/10.30534/ijatcse/2019/63832019