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Research paper

Implementation of Unconstrained Chair-Type Smart Health Management Monitoring System

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Abstract

Modern people spend many hours of daily life, such as study and work, to the sitting position with chairs and sofas. If you sit for a long time with a wrong posture, musculoskeletal system disorder can occur and distraction due to low concentrations. In this research, we implemented the chair-type smart health management monitoring system which provides the user with the traditional functions of the chair more effectively and also enables various health management functions. For this reason Three load cells (SB S - beam load cell, 100 kgf) were arranged in an equilateral triangle shape between the top plate and the lower plate of the chair to construct a control section. In addition, we designed a measuring section composed of a filter and an amplifier so that we can simultaneously measure weight signal and BCG. We implemented an information-based posture discrimination algorithm of weight information and a distraction estimation method and implemented a PC and Android-based smartphone monitoring system. We conducted two experiments to evaluate the performance of the implemented system. First of all, in order to evaluate the performance of the posture discrimination algorithm, nine postures were obtained for 10 test subjects in an arbitrary order. As a result of comparing arbitrary posture and posture discrimination results, it showed discrimination performance of 97.9%. Finally, experiment was conducted to confirm the usefulness of the discrimination of distraction in daily life. The experimenter checked the change of the indicator according to the posture change during audiovisual data appreciation. Distraction continued changing posture as a result of confirming the image of the section where the numerical value is high, and confirmed that it is not concentrating on the image. The implement system can help not only health care function in daily life, but also to induce proper posture and improve sitting habit. In future studies, we intend to conduct a research to objectively demonstrate the usefulness of the Distraction estimated index.

Keywords: *Posture correction, BCG, Distraction, Bio-Signal, Real-time monitoring*

1. Introduction

Modern people send many hours of daily life, such as study and work, to the sitting position with chairs and sofas. However, if you sit for a long period of time you lose activity and you may cause serious diseases such as cardiovascular disease, diabetes, obesity, etc. and if you sit for a long time with a wrong posture, musculoskeletal system disorder can occur. Especially from early childhood in which the musculoskeletal structure is formed, adolescents are required to have a focused learning posture through correct posture. Continuing wrong posture that will be taken frequently from early childhood to adolescent will cause musculoskeletal structure Impossible and develop into a musculoskeletal disorder, leading to a distraction due to low concentrations. In the case of students who maintain such a high degree of distraction, the immersion of learning is insufficient and the result of learning is low. In typical musculoskeletal system disorder, diseases such as spinal scoliosis, turtle neck, pelvic part occlusion and Distraction related diseases are attention deficit hyperactivity disorder (ADHD). Therefore, in addition to the health management function in daily life, a health management system for the continuous correct posture induction and seat habit improvement is necessary. Conventional research conducted research to measure bio-signals non-restrained for continuous health monitoring in daily life. A method of measuring electrocardiogram using a non-restrained electrode and a method of measuring BCG by incorporating various sensors such as an EFMi sensor and a load cell in a chair, a bed and a toilet have been research. Chair and bed type health monitoring systems have attracted posture as modern people mainly spend a lot of time in a sitting posture. In particular, chairs have traditionally developed through ergonomics for the purpose of preventing and proofing spinal diseases. Therefore, we conducted a research on the chair-type smart health management system which can effectively provide the user with the traditional functions of the chair and enable various health management functions. In this research, in addition to monitoring health condition through BCG measurement in everyday life, it is important not only to prevent musculoskeletal system disorder caused by inappropriate posture and to distract the state of distraction occurring due to lack of concentration we implemented the Chair-type Smart Health management System for estimation.

2. Overall System

In this research, we implemented the unconstrained chair-type smart health management system for estimation of distraction.

Three load cells (SB S - beam load cell, 100 kgf) were arranged in an equilateral triangle shape between the top plate and the lower plate of the chair to construct a control section. In addition, we designed a measuring section composed of a filter and an amplifier so that we can simultaneously measure weight signal and BCG. For estimation of distraction, we implemented an information-based posture discrimination algorithm of weight information and a distraction estimation method and implemented a PC and Android-based smartphone monitoring system. The overall configuration diagram of the implemented system is shown in Figure 1.

Fig. 1: Overall configuration diagram

3. Distraction Estimation Method

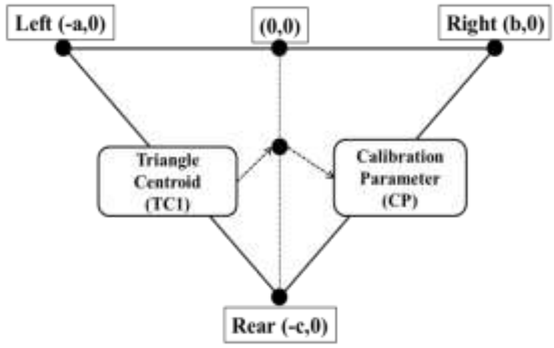
3.1. Triangular Center Algorithm

In this research we implemented triangle center algorithm of weight information base for distraction estimation. First, as shown in Equation 1, the center of gravity of the weight signal output from the three load cells (left-load cell = a, right-load cell = b, rear-load cell = c) was calculated. In Equation 2, the difference of the previous coordinates was found based on the center point on the coordinate, and the movement value was determined.

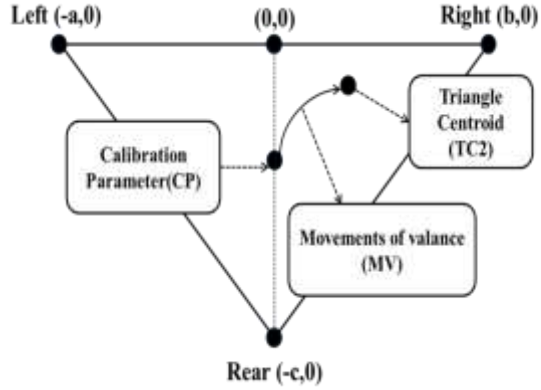
$$\mathrm{TC}(x, y) = \left(\frac{-a+b+0}{3}, \frac{0+0-c}{3}\right) - (X_{cp}, Y_{cp}) \quad (1)$$

$$\mathrm{MV} = \mathrm{TC}_2 - \mathrm{TC}_1 \quad (2)$$

TC is used at the setting position of the central coordinate reflected at the time of seating at the beginning, and initializes the coordinates generated by subsequent posture change. In equation (1), the value is set according to the posture change after it is set to the first (0, 0) coordinates. The previous TC uses the current coordinates and the difference to return the amount of change on the x axis and the y axis to the MV. Also, reflected at the time of monitoring represent the current position and make stepwise expression to green - orange - red according to the distance from the center point. The following Figure 2 shows how to identify the center of the triangle and calculate the movement value. (a) Shows the center point (TC_2) that is continuously detected after the initial center point (TC_1) determined via the center algorithm of the triangle and the criterion it is shown at a point (CP). (b) Shows information of(TC_2) which is the center point changed reflecting the initial center(TC_1). The proposed triangle center algorithm detects the posture change of the seated person through the movement of the position with the occurrence of the movement based on 3 load cells.



(a) First triangle center discrimination and Standard parameters



(b) Movement value generation and center point movement

Fig. 2: Triangular center algorithm

3.2. Posture Discrimination Method

Using the triangular center algorithm, it is possible to confirm the strength of motion reflecting the detection of the center of gravity movement, the information of posture change and the distance value. In order to measure the strength size of motion, the distance between the current center on the coordinate and the previous center was calculated, and the value of the distance was reflected in the strength of the posture change. Applying the Equation 3 to calculate the distance between two center points, Figure 3 shows the distance calculation in the coordinate. For posture discrimination, apply the current center point to (x_1, y_1) apply the previous coordinates to (x_2, y_2)set the straight line value of the shortest distance between both centers to calculated and applied.

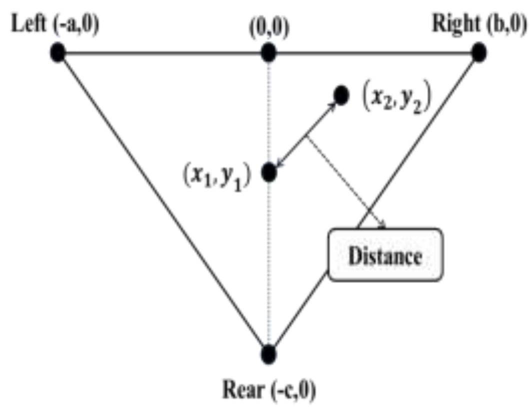


Fig. 3: Calculation of intensity of posture change

$$\mathrm{Distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

Equation 4 was implemented to confirm the orientation of posture. Equation 4 can discriminate the direction by using the function atan 2 to numerically convert the position information corresponding to the four quadrants with the current center coordinates with reference to the first triangular center coordinates as a reference. The defense of the posture computed via the posture discrimination algorithm is divided into four quadrants front, rear, left, right, center coordinates for computation utilized CP (calibration parameter) at the initial center. Figure 4 shows directions with reference to the center.

$$\text{Direction} = \text{atan2}(x.y) \quad (4)$$

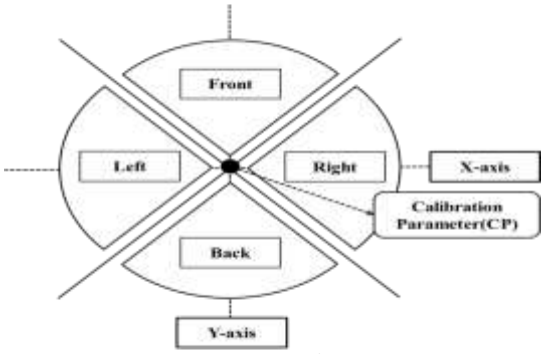


Fig. 4: Determine the directionality of coordinates through posture discrimination

3.3. Distraction Estimated

We tried categorizing postures using triangle center algorithm and posture discrimination algorithm, classified 9 kinds of posture which are made in a lot of everyday life, and discriminated impulsive behavior. The area is calculated by reflecting the distance and the time between two center points caused by the center of gravity movement determined by the implemented algorithm. In Equation 5, the DLE index (distracted-limit estimation index) is expressed, and the distance is reflected in the distance between the center points before and after the motion, and the time domain of the detected peak is reflected in time. The reflection of the time domain computes n areas, which is the cumulative number of occurrences and intensity, and utilizes as a DLE Index.

$$\text{DLE Index}_n = \sum_{k=0}^{n}(\text{Distance} \times \text{Time})_k \quad (5)$$

4. Experiments and Results

4.1. Posture Discrimination Performance Evaluation

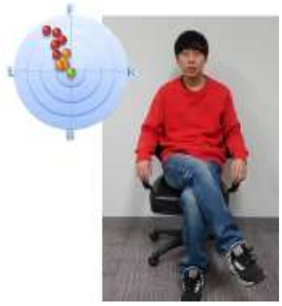
In this research, we evaluated the performance of the posture discrimination algorithm. The standard of posture discrimination analyzed nine postures of everyday situations. Classified posture were classified by front, back, left, right oblique posture, left and right leg trembling posture, left and right leg twisting posture, correct posture. Figure 5 shows the each posture and it is possible to confirm the azimuth and strength of the posture discriminated by the smart health management system. Each posture was taken 100 times for test subject measurement results by posture. The experimental results are shown in Table 1, and the leg tremor posture and leg tremor posture were similar, but showed a high posture differentiation success rate of 97.9%.

a)Left trembling

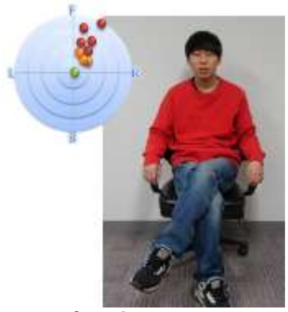
b)Right trembling

c) Left oblique

d)Right oblique



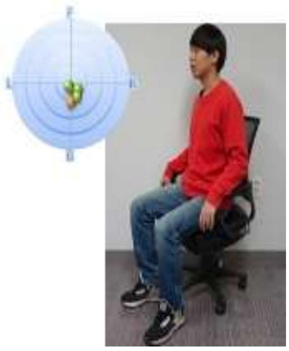
e) Left twisting



f) Right twisting

g) back oblique

h) Front oblique



i) correct

Fig. 5: Nine reference postures

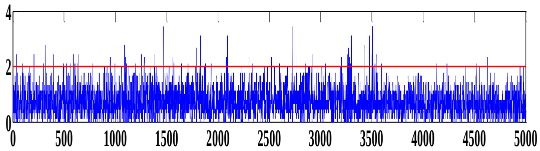
Table 1: Posture determination performance evaluation

		Take Posture								
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
Detection	(a)	100								
	(b)		100							
	(c)			100						
	(d)				97.7			3.1		
	(e)					100				
	(f)						96.8			2.1
	(g)							96.9		
	(h)								100	
	(i)									97.9
Avg.		100	100	100	97.7	100	96.8	96.9	100	97.9

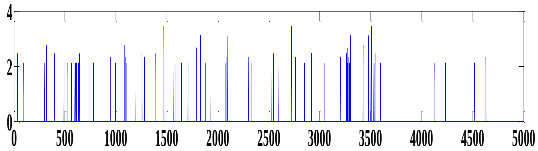
4.2. Distraction Discrimination Performance Evaluation

In this research experiment was conducted to confirm the usefulness of the discrimination of distraction in daily life. The experimenter checked the change of the indicator according to the posture change during audiovisual data appreciation. In order to minimize stimulated by environmental factors, experiments were conducted in a space where temperature and humidity were kept constant and external noise was blocked. In order to evaluate the performance, we presented a movie viewing situation in everyday life and conducted an estimation experiment for long time distraction discrimination for each test subjects with total viewing time of 100 minutes. In (b) shows the change in intensity due to the change in posture. In (c) peak detection in which posture change intensity exceeds the baseline was performed. (d), the amount of change in the distraction discrimination index was shown. Figure 6 expresses information changing with time(s) as a reference. Distraction continued changing posture as a result of confirming the image of the section where the numerical value is high, and confirmed that it is not concentrating on the image.

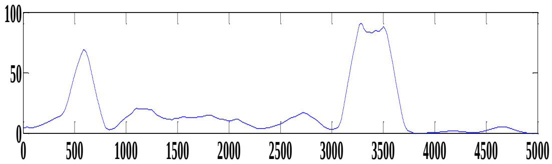
(a) Video recording result



(b) Posture change amount measurement



(c) Peak detection of posture change



(d) Distraction discrimination index

Fig.6: Posture change amount and peak detection for performance evaluation

5. Conclusion

In this research, we implemented a chair-type smart health management system to estimate the distraction state caused by lack of concentration and prevention of musculoskeletal diseases due to wrong posture as well as health status monitoring through measurement of nonrestraint heart rate during daily life. The implemented system monitors the cardiac activity state without restraint and can determine the posture via triangle center algorithm. In addition, frequency and strength were calculated according to user's posture change, and estimated for distraction index. It was confirmed that the posture discrimination performance was excellent by the experiment and the significance of the estimated distraction index was confirmed. In future studies, we will perform comparative evaluation with concentration index using EEG to objectively demonstrate the usefulness of the distractibility index.

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