Article

A Smart System for Continuous Sitting Posture Monitoring and Assessment

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**Abstract: <<**TO BE FILLED>>.

**Keywords:** sitting posture classification, smart-sensing chair, posture monitoring

1. Introduction

1.1 Background and Motivation

In this present day and age, prolonged sitting has become a fundamental component of one’s lifestyles, especially among office workers. These individuals often find themselves confined to a desk for an extended period; a pattern that has proven to be detrimental to one’s health [1,2]. Additionally, the added combination of adopting improper sitting posture further increases the risk of several health issues, ultimately negatively impacting one’s quality of life.

The adoption of awkward sitting postures has been a prevalent issue among individuals across different age ranges [3]. Over a long-term period, this could thereby lead to the development of chronic health issues such as lower back pain and other musculoskeletal conditions. Hence, it is normally advised by doctors and healthcare professionals to consistently maintain an upright sitting posture by constantly having your back in a straight position. In addition to maintaining an upright sitting posture, it is also recommended to avoid sitting for a long period of time irrespective of the sitting posture being adopted. It is advised to take a few walking breaks after a given period.

Furthermore, to help combat this issue, various researchers have explored the use of smart sensing chair systems which are capable of detecting various sitting postures. So far, various methods have been found to be adopted in the development of such systems ranging from different classification methods, sensor placement configuration, and senor types. Furthermore, a recent study by [4] highlighted a research gap that a vast majority of the studies primarily focus just on the detection of different sitting postures and achieving classification accuracy. However, there is more that can be done in providing valuable objective insights back to the end user that would encourage and motivate them to adopt proper sitting postures.

1.2 Objective of the Study

The aim of this study is to develop a robust machine-leaning model capable of detecting different sitting postures as well as creating a comprehensive posture monitoring system that not only classifies different sitting postures, but also intelligently scores them. Additionally, this study also looks provide real-time feedback system which would display relevant statistical insights based on the posture dataset back to the end-user.

2. Related Works

Over the recent years, there has been a rise in the number of research studies conducted on smart seating systems, which can identify various sitting postures. Across some the research studies found, it was apparent that there are various methods being employed ranging from the classification algorithms to the sensor types. Furthermore, one of the first research paper published that pioneered the idea of a smart sensing chair system was by Tan el. [5] back in 2001. They were able to classify 14 different siting postures using their developed PCA (Principal Component Analysis)-based which integrated with pressure sensor array module placed the both the back rest and the sitting area of the chair. They were able to achieve an overall accuracy somewhere between 79% to 96%. From there, a lot of research studies were being published, which adopted a

2.1 Sensor Technology

The sensor being used is one of the most critical components in developing smart sensing systems some of the commonly used sensors are pressure sensor load cells camera flex sensor and distance sensors.

2.2 Machine Learning Techniques

2.3 Feedback Mechanism

**Table 1.** Summary of related studies.

|  |  |  |
| --- | --- | --- |
| **Sensor** | **Title 2** | **Title 3** |
| entry 1 | data | data |
| entry 2 | data | data 1 |

The sensor being used

* Review existing technologies and methodologies used for posture detection and correction.
* Discuss current state-of-the-art solutions, including wearable devices, camera-based systems, and pressure mats.
* Summary of machine learning techniques previously applied to posture detection.
* Analysis of the advantages and limitations of these methods.
* Identification of shortcomings in current posture monitoring systems, such as lack of real-time feedback, limited scope in posture types, and absence of scoring mechanisms.
* Discussion on the need for comprehensive systems that integrate posture detection, evaluation, and feedback.

3. Methodology

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

4. Results and Discussion

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

3.1. Subsection

3.1.1. Subsubsection

Bulleted lists look like this:

* First bullet;
* Second bullet;
* Third bullet.

Numbered lists can be added as follows:

1. First item;
2. Second item;
3. Third item.

The text continues here.

3.2. Figures, Tables and Schemes

All figures and tables should be cited in the main text as Figure 1, Table 1, etc.

**Figure 1.** This is a figure. Schemes follow the same formatting.

**Table 1.** This is a table. Tables should be placed in the main text near to the first time they are cited.

|  |  |  |
| --- | --- | --- |
| **Title 1** | **Title 2** | **Title 3** |
| entry 1 | data | data |
| entry 2 | data | data 1 |

1 Tables may have a footer.

The text continues here (Figure 2 and Table 2).

|  |  |
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| (**a**) | (**b**) |

**Figure 2.** This is a figure. Schemes follow another format. If there are multiple panels, they should be listed as: (**a**) Description of what is contained in the first panel; (**b**) Description of what is contained in the second panel. Figures should be placed in the main text near to the first time they are cited.

**Table 2.** This is a table. Tables should be placed in the main text near to the first time they are cited.

|  |  |  |  |
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| **Title 1** | **Title 2** | **Title 3** | **Title 4** |
| entry 1 \* | data | data | data |
| data | data | data |
| data | data | data |
| entry 2 | data | data | data |
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| entry 3 | data | data | data |
| data | data | data |
| data | data | data |
| data | data | data |
| entry 4 | data | data | data |
| data | data | data |

\* Tables may have a footer.

3.3. Formatting of Mathematical Components

This is example 1 of an equation:

|  |  |
| --- | --- |
| a = 1, | (1) |

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

This is example 2 of an equation:

|  |  |
| --- | --- |
| a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z | (2) |

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

**Theorem 1.** Example text of a theorem. Theorems, propositions, lemmas, etc. should be numbered sequentially (i.e., Proposition 2 follows Theorem 1). Examples or Remarks use the same formatting, but should be numbered separately, so a document may contain Theorem 1, Remark 1 and Example 1.

The text continues here. Proofs must be formatted as follows:

**Proof of Theorem 1.** Text of the proof. Note that the phrase “of Theorem 1” is optional if it is clear which theorem is being referred to. Always finish a proof with the following symbol. □

The text continues here.

4. Discussion

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Conclusions

This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

6. Patents

This section is not mandatory but may be added if there are patents resulting from the work reported in this manuscript.

**Supplementary Materials:** The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

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**Appendix A**

The appendix is an optional section that can contain details and data supplemental to the main text—for example, explanations of experimental details that would disrupt the flow of the main text but nonetheless remain crucial to understanding and reproducing the research shown; figures of replicates for experiments of which representative data is shown in the main text can be added here if brief, or as Supplementary data. Mathematical proofs of results not central to the paper can be added as an appendix.

**Appendix B**

All appendix sections must be cited in the main text. In the appendices, Figures, Tables, etc. should be labeled starting with “A”—e.g., Figure A1, Figure A2, etc.

References

1. Daneshmandi, H.; Choobineh, A.; Ghaem, H.; Karimi, M. Adverse Effects of Prolonged Sitting Behavior on the General Health of Office Workers. *J Lifestyle Med* **2017**, *7*, 69–75, doi:10.15280/jlm.2017.7.2.69.

2. Keskin, Y. Correlation between Sitting Duration and Position and Lumbar Pain among Office Workers. *Haydarpasa Numune Med J* **2019**, doi:10.14744/hnhj.2019.04909.

3. Susilowati, I.H.; Kurniawidjaja, L.M.; Nugraha, S.; Nasri, S.M.; Pujiriani, I.; Hasiholan, B.P. The Prevalence of Bad Posture and Musculoskeletal Symptoms Originating from the Use of Gadgets as an Impact of the Work from Home Program of the University Community. *Heliyon* **2022**, *8*, e11059, doi:10.1016/j.heliyon.2022.e11059.

4. Odesola, D.F.; Kulon, J.; Verghese, S.; Partlow, A.; Gibson, C. Smart Sensing Chairs for Sitting Posture Detection, Classification, and Monitoring: A Comprehensive Review. *Sensors* **2024**, *24*, 2940, doi:10.3390/s24092940.

5. Tan, H.Z.; Slivovsky, L.A.; Pentland, A. A Sensing Chair Using Pressure Distribution Sensors. *IEEE/ASME Trans. Mechatron.* **2001**, *6*, 261–268, doi:10.1109/3516.951364.

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