Article

A Smart System for Continuous Sitting Posture Monitoring and Assessment

David Faith Odesola1, Janusz Kulon1 and, Shiny Verghese1

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1 Faculty of Computing, Engineering and Science, University of South Wales, Pontypridd, CF37 1DL, UK; 30025293@students.southwales.ac.uk; j.kulon@southwales.ac.uk; shiny.verghese@southwales.ac.uk

2 Affiliation 2; e-mail@e-mail.com

**\*** Correspondence: e-mail@e-mail.com; Tel.: (optional; include country code; if there are multiple corresponding authors, add author initials)

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

**Keywords:** sitting posture classification, smart-sensing chair, machine learning, 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 affecting 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 can detect 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. Furthermore, an overall accuracy between 79% to 96% was achieved. Subsequently, a lot of research studies were being published which followed a similar approach.

2.1 Sensor Technology

The sensor being integrated is one of the key components in the development of smart sensing systems, as it plays a key role in capturing one’s sitting pattern which would subsequently be processed and classified by a detection algorithm. Furthermore, across the research studies found, there are 2 categories of sensors in which sitting postures can be detected which are wearable and non-wearable. Those under the wearable category involved the use of sensors such as accelerometers, gyroscopes, and inertial measurement units. On the other hand, there are the non-wearable systems which do not require the individual to directly put on or wear the sensor, promoting its non-invasive nature. These types of sensors mostly used which are pressure sensors, load cells, cameras, flex sensors and distance sensors. According to a study by Odesola et al. in 2024 [4], the pressure sensor was seen as the most popular option among related studies.

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2.2 Machine Learning Techniques

The ability for a smart sensing chair in the detection multiple sitting postures significantly lies in the posture detection algorithm being employed. Hence, various types of machine learning tool and statistical models are being evaluated in hopes to achieve high classification accuracy among a wide range of sitting postures.

2.3 Feedback Mechanism

There is no doubt that achieving high posture classification accuracy is crucial among smart sensing chair systems. However, this alone doesn’t bring any value back to the end user. What is also needed is a feedback mechanism that would both inform and encourage the end user to adopt “proper” sitting postures while also providing valuable insights that would improve their overall sitting pattern. Whenever a bad sitting posture is detected for a long duration of time, the user should be alert in one way or another to correct it. Within the current research landscape, there are multiple ways that a user could be alerted. Mobile phones have been emerging as a popular medium for collecting and displaying useful feedback back to the end user. Cai et al. [6] developed a smart sensing chair system which relayed the detected posture via a mobile app. Additionally, Cho et al [7] also developed a similar mobile app which provided statistical insights along with recommended YouTube videos largely based on the sitting postures being adopted.

There are also other ways that the end user could be notified or alerted whenever an incorrect sitting posture is being adopted. Ran et al. [8] and Ishac et al. [9] integrated haptic motors into the seating cushion which vibrated whenever an improper sitting posture is being detected which continues until an upright posture has been achieved by the individual. Ren et al. [10] incorporated the use of a RGB led light strip which changed in color whenever the individual needed to change their sitting posture and taking microbreaks.

Overall, it was seen that the feedback mechanism implemented among existing studies were severely lacking mainly in its informative elements and valuable insights which ideally should encourage the adoption of proper sitting postures among individuals. Most systems simply just focused on displaying the current posture being adopted without any form of valuable feedback mechanism. While most smart-sensing systems can detect and identify various sitting postures, there are some feature sets that are absent such as real-time feedback and posture scoring mechanism which would rate and provide a score on the current posture being adopted. From the end user’s perspective, is there any certainty that the implemented feedback system has achieved its goal of inciting adopting of proper sitting postures? Furthermore, with the lack of comprehensive feedback of such systems, a lot of questions can be raised in regard to both its usability and effectiveness in a real-life environment. Hence, there is a need for a comprehensive system in place to access whether the implemented feedback mechanism as achieved its desired expectations.

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

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

* 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.

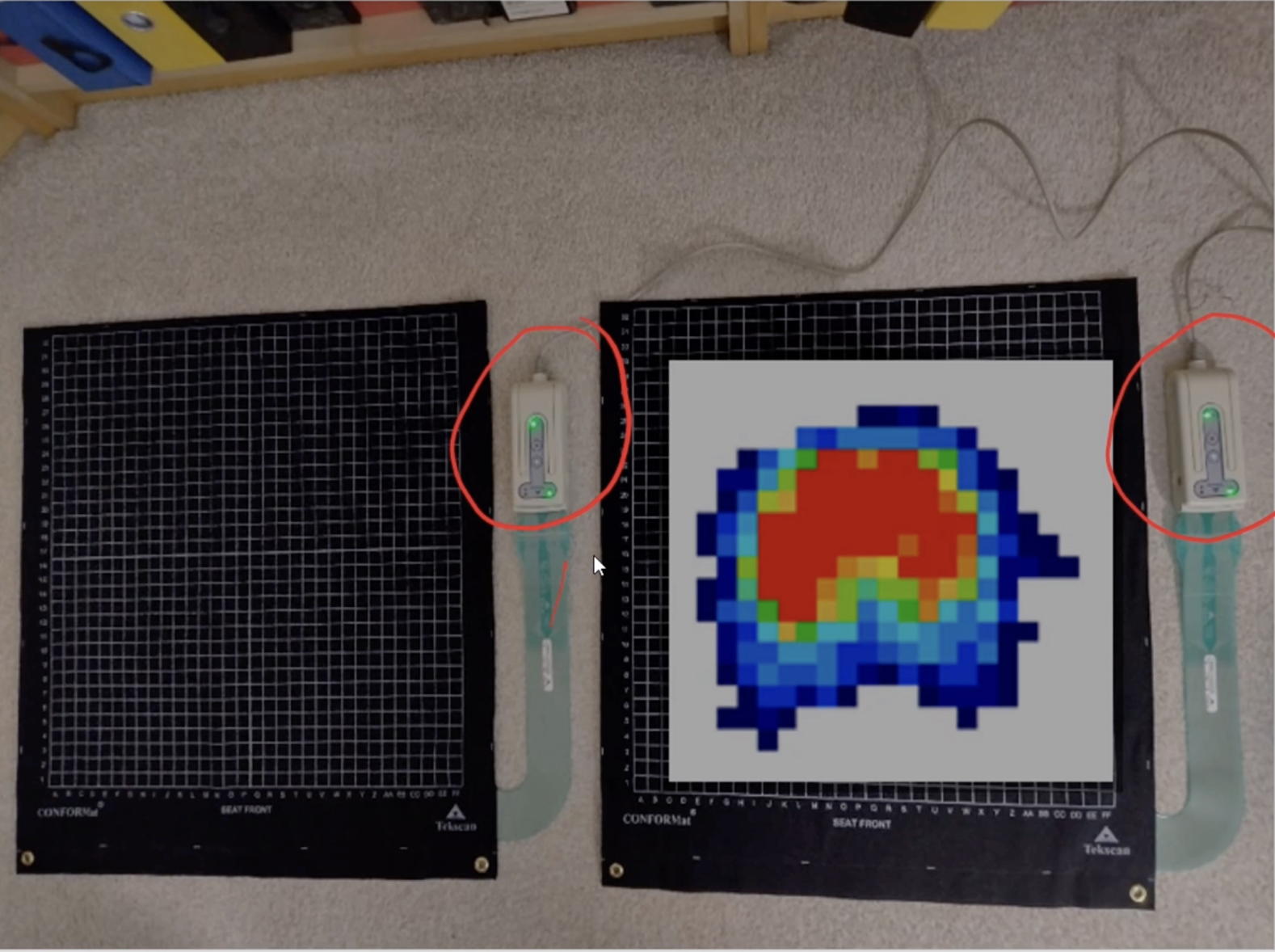
3. Methodology

In this paper, a smart sensing chair system is developed classify different sitting postures using a FSR pressure sensor array. This study will be focusing on 5 sitting postures with are upright, slouching, leaning right, leaning left, leaning back as shown in Figure 1. Additionally, a novel feedback software application will be developed to provide valuable health insights which aims to encourage the end user to adopt proper sitting postures.

In order to capture the entire sitting posture of an individual, 2 (32x32) CONFORMat pressure sensor arrays which will be placed on the backrest and the seating cushion of the chair. The pressure sensor mat was developed by a company called Tekscan which specializes in the manufacturing of pressure measure sensor units [11].



**Figure 1**. 5 different sitting postures. (SP1) Upright, (SP2) Leaning Back, (SP3) Leaning Left, (SP4) Leaning Right, (SP5) Slouching



**Figure 1**. 5 different sitting postures

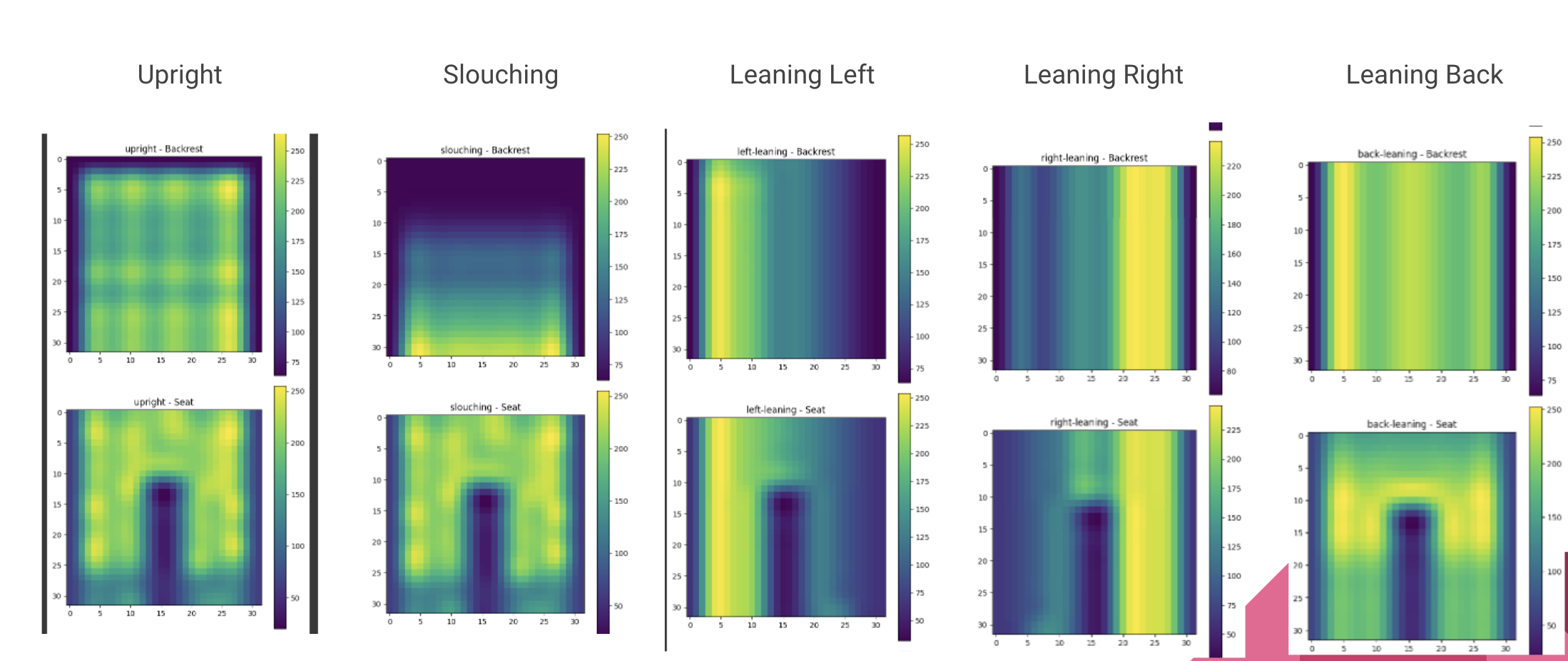
3.1 Data Collection

3.1.1 Participants

3.1.2 Experimental Setup

Java 2 
GORITHMS 

3.2 Machine Learning Algorithm



3.3 Posture Monitoring and Scoring System

4. Results and Discussion

4.1 Performance of the Machine Learning Algorithm

A graph of different models

Description automatically generated

4.2 Effectiveness of the Posture Monitoring System

4.3 Statistical Analysis of Sitting Patterns

4.4 Interpretation of Results

4.5 Limitations of the Study

4. Discussion

5. Conclusions

This is the conclusion section

**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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**Data Availability Statement:** We encourage all authors of articles published in MDPI journals to share their research data. In this section, please provide details regarding where data supporting reported results can be found, including links to publicly archived datasets analyzed or generated during the study. Where no new data were created, or where data is unavailable due to privacy or ethical restrictions, a statement is still required. Suggested Data Availability Statements are available in section “MDPI Research Data Policies” at https://www.mdpi.com/ethics.

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**Conflicts of Interest:** The authors declare no conflicts of interest.

**Appendix A**

Appendix content

**Appendix B**

Appendix content

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