Advanced Mediapipe Enabled Sitting Posture Detection and Correction Model

Vaibhav Krishna S, Deepak Kumar R
KPR Institute of Engineering and Technology

Abstract— **Poor sitting posture has become a significant contributor to musculoskeletal disorders, developing into long-term spinal issues due to the rise of remote work, digital learning, and sedentary lifestyle. This paper presents "Slouchometer," a real-time, vision-based posture monitoring system to address this challenge. The proposed system uses computer vision and AI to extract 33 body landmarks from a standard webcam feed using the MediaPipe BlazePose model. It measures ergonomic angles between major joints to detect slouching and sends dual-modal notifications-visual and aural-to raise awareness for correction in behavior. Slouchometer is non-intrusive and easy to deploy on ordinary computers or mobile devices, unlike existing intrusive wearable-based solutions. The proposed system also offers session-wise insights through an integrated Power BI dashboard. An experiment conducted with 15 participants resulted in significantly improved user posture awareness and behavior over time, backed by excellent classification accuracy of 93.2% with less than 0.2 seconds of feedback latency. This study demonstrates how affordable, scalable, AI-powered ergonomic interventions can be designed and deployed to improve digital wellness across learning, work, and personal contexts.**

Keywords— Posture Monitoring, Computer Vision, BlazePose, Real-Time Feedback, Ergonomics, Deep Learning, Human–Computer Interaction, Slouch Detection, AI in Healthcare, Power BI.

1. Introduction

Spending too much time in front of screens is inevitable for students, gamers, and IT workers today due to society's day-to-day technological advancements. Poor sitting postures are now becoming common due to this kind of sedentary lifestyle and have become a prime cause of spine deformities, chronic back pain, and other musculoskeletal diseases. Remedial solutions for posture correction are badly needed because these problems affect not only physical health but also productivity. Traditional approaches, such as manual reminders and ergonomic chairs, often fail since most of them can't adapt in real time to the small progressive changes of a user's posture [1].

To meet this demand, a new generation of innovative, wearable IoT-based devices have recently been developed that track one's spinal posture and provide immediate remedial input. These devices track the posture of a user throughout the day by means of sensors and send notifications when it deviates from the optimum position. While these wearables are effective, they cannot serve practical purposes for continuous long-term use because of various issues regarding user comfort, maintenance, and the presence of an obtrusive physical device. [2]

Simultaneously, advances in machine learning and computer vision have introduced non-invasive methods of posture detection. These image-based model systems track body landmarks without the need for physical sensors and, in real time, can provide insightful feedback. Because they require no more than a basic camera, these methods are non-intrusive, scalable, and adaptable to environments. The use of deep learning models has further enhanced their accuracy in assessing intricate postural patterns, such as shoulder alignment and spinal curvature.

Some high-end systems incorporate a series of multi-modal inputs such as wearable sensors, smart cushions, and even video inputs for the purpose of posture correction with highly personalized models. Over time, this feedback system helps users change their posture to avoid health problems in the long run [4].

This emerging body of research forms the foundation for Slouchometer. Our proposed solution is a non-invasive, camera-based technology utilizing AI to detect, classify and immediately correct bad posture. Slouchometer is easily scalable and can be used on existing devices, such as laptops and webcams, unlike hardware-specific solutions, making it accessible for a wide range of users. [5]

The AI-powered posture correction model is going to revolutionize the way we handle sitting posture problems in a variety of contexts by providing a more flexible and scalable alternative to traditional methods. Our solution will offer real-time posture analysis and feedback using advances in computer vision and machine learning that assure customers can maintain healthy sitting behaviors throughout the day. These solutions are important in light of an increasing dependence on digital technologies and remote work, which may contribute to reducing health risks associated with long sitting and poor posture. [6]

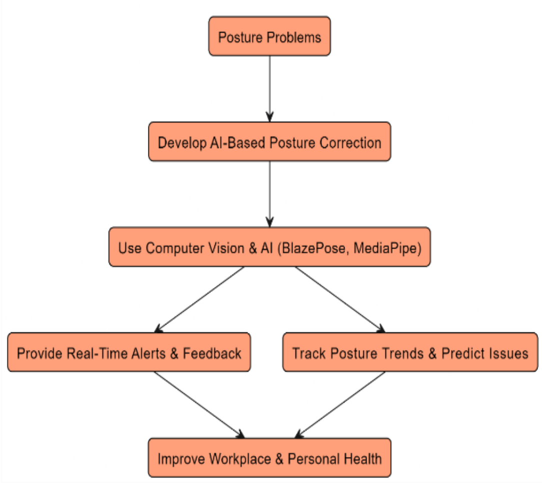

Fig 1: flow of slouchometer model

2. Literature Survey:

Simple ergonomic tools have given way to complex, AI-powered systems in recent years for posture monitoring.In order to track spinal alignment, early systems mostly used wearable sensors. To correct spinal posture, for example,Hafeez et al. (2021) created a system that used sensor-based alerts. It proved beneficial, but its application was constrained by user comfort and maintenance requirements [7].

The ability to track in real time made IoT-based posture detection popular. In 2019, Bairagi and Kamble presented a pressure sensor-driven Internet of Things system for spinal curvature analysis. These technologies still necessitate physical interaction, though, which may hinder user convenience and adoption rates. [8]

In order to get around wearables' drawbacks, computer vision-based technologies have become a potent substitute.Although it was frequently computationally demanding, Rathore et al. (2024) created a model using OpenPose to track head, shoulder, and spine angles. This method was less invasive and more scalable [9]

Researchers started incorporating multimodal data sources to improve accuracy. In order to give highly customized feedback, Bi et al. (2022) integrated smart cushion sensor data with picture recognition[10], while Marques-Villarroya et al. (2022) used Convolutional Neural Networks (CNNs) for real-time video analysis[11].

Makkar et al. (2024) highlighted the feasibility of camera-only solutions by proposing an AI-driven ergonomics model that uses common cameras to identify bad sitting postures, reflecting the requirements of a remote workforce. System application and robustness have been the topic of additional research [12].

For dynamic situations, Khan et al.(2023) created a hybrid model that used visual and inertial data[13], and Li et al. (2023) investigated posture detection for medical rehabilitation[14]. Finally, to take into consideration a person's posture behaviors over time, temporal models utilizing LSTMs have been constructed (Amiri et al., 2023) [15].

Collectively, these findings indicate a definite shift away from hardware-dependent systems and towardsoftware-based, AI-powered solutions. Slouchometer is a vision-based, AI-enabled tool that can be deployed on common consumer devices and is scalable and non-intrusive.This evolution helps its development

3.Methodology

A continuous monitoring pipeline that makes use of readily accessible technologies for accessibility and real-time performance forms the foundation of the Slouchometer system.

3.1. Real-Time Video Capture and Processing

The pipeline starts with real-time video capture, which uses the OpenCV library to access the user's webcam. Every video frame is processed separately so that surveillance can continue without interruption. The MediaPipe BlazePose model, which is the main part of the analysis, can find 33 different body parts, like the shoulders, hips, and important points along the spine. BlazePose is great for real-time apps on devices with limited resources because it is very accurate and works quickly [16].

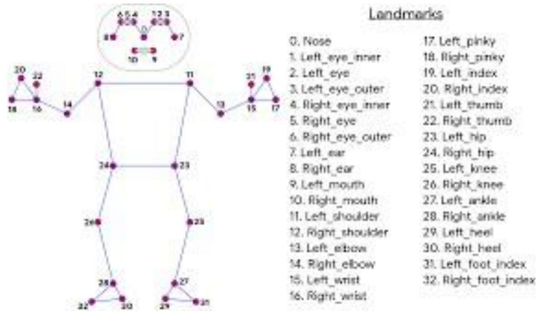

Fig 2: BlazePose Keypoints map, Source: Mediapipe Doc.

3.2 Posture Angle Computation

After finding landmarks, the system uses vector math to do geometric analysis and figure out the user's posture.The posture angle θ is determined by utilizing the dot product formula to calculate the angle between the shoulder–hip–neck vectors. If θ is outside of the ideal ergonomic range of 150°–180°, which was found through experimentation and validation, then the posture is considered slouched. [2].

$$\theta = \cos^{-1}\left(\frac{\vec{AB}\cdot\vec{BC}}{|\vec{AB}||\vec{BC}|}\right)$$

Where:

- $\vec{AB}$ is the vector from shoulder to hip
- $\vec{BC}$ is the vector from hip to neck
- θ denotes the ergonomic posture angle

3.3 Real-Time Decision Engine

Compared to older models like OpenPose, BlazePose has better landmark accuracy, fewer false positives, and faster processing speeds. When the system's decision engine sees someone slouching, it sends them dual-modal alerts:

• Auditory Alert: A short beep is played to stress that changing your posture is important.

• Visual Alert: A red overlay appears on the user's screen to show that their posture is off. The goal of this instant feedback system is to work well without getting in the way of the user's ability to focus or get things done [3].

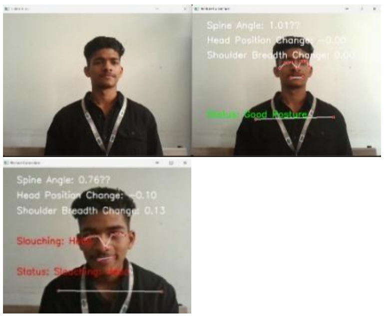

Fig 4: Working of real time decision engine

D. Competitor analysis :

Table I contrasts the proposed Slouchometer system with current posture detection solutions, emphasizing distinctions in hardware reliance, scalability, and personalization features.

3.4 Data Logging and Session Analytics

Every processed frame is recorded in a structured CSV file containing the following information for long-term analysis:

• Posture Angle Calculated

• Posture Classification Label ("Upright" or "Slouched")

• Timestamp

In addition to comprehensive behavioral tracking, this data logging enables the creation of progress reports and personalized feedback.

1	timestamp	sture_stat	pine_angl	position_c	r_breadth	ouching_s	ouching_h	ching_sho	session_id
2	2025-02-2	Good Post	0.08	0.0021	0.0027	0	0	0	2.03E+13
3	2025-02-2	Slouching:	1	-0.0318	-0.0246	0	1	1	2.03E+13
4	2025-02-2	Good Post	0.29	-0.0028	-0.0025	0	0	0	2.03E+13
5	2025-02-2	Slouching:	2.94	-0.0885	0.0745	0	1	0	2.03E+13
6	2025-02-2	Slouching:	1.14	-0.0197	-0.0102	0	1	0	2.03E+13
7	2025-02-2	Slouching:	0.55	-0.043	0.0034	0	1	0	2.03E+13
8	2025-02-2	Slouching:	3.46	-0.0146	-0.0369	0	1	1	2.03E+13
9	2025-02-2	Slouching:	2.91	-0.0207	-0.0224	0	1	1	2.03E+13
10	2025-02-2	Slouching:	0.86	-0.069	-0.0683	0	1	1	2.03E+13
11	2025-02-2	Slouching:	0.12	0.0388	-0.0281	0	0	1	2.03E+13
12	2025-02-2	Slouching:	0.46	0.0245	-0.0286	0	0	1	2.03E+13
13	2025-02-2	Good Post	1.53	0.0297	0.0174	0	0	0	2.03E+13
14	2025-02-2	Good Post	1.54	0.0287	0.0167	0	0	0	2.03E+13
15	2025-02-2	Good Post	0.38	0.0003	-0.0009	0	0	0	2.03E+13

Fig 3: Real time posture data updating in CSV

3.5 Visualization and Insights Dashboard

The structured data from the CSV logs is imported into Power BI to create a personalized analytics dashboard. On this dashboard, users and researchers can view visualizations of the following:

• Total session durations • Posture trends over time • The frequency and duration of slouching • The number of alerts per session

This visual feedback loop is crucial for comprehending long-term posture habits and tracking behavioral improvement and undesirable behavior [6].

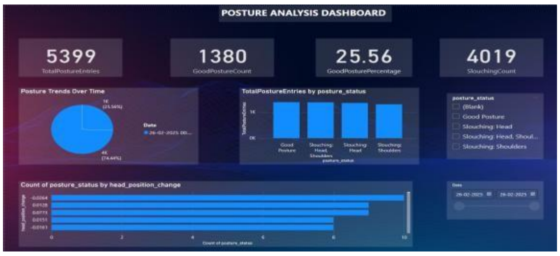

Fig 5: Real-time data storage in Excel Sheet

3.6 System Architecture

With MediaPipe and OpenCV serving as its foundational libraries, the system is fully constructed in Python. Anatomical uniformity among various body types and sizes is guaranteed by the landmark-based angle analysis. The architecture is intended to be:

• Portable: Does not require specialized hardware to operate on typical laptops and desktop computers.

• Scalable: Requires little setup and can be widely implemented.

• Tunable: To accommodate different ergonomic requirements and preferences, the slouch detection threshold can be changed using a configurable rule engine [17].

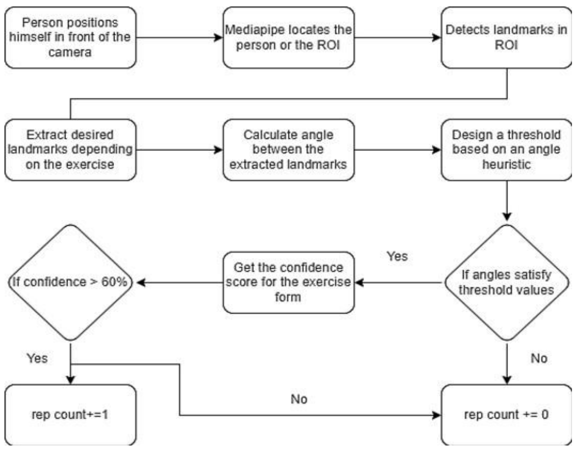

Fig 6: Model Pipeline

4 Results

The Slouchometer prototype was tested with a group of 15 people. Each participant took part in several 30 to 60-minute sessions in different lighting conditions and activity levels, such as typing, reading, and video conferencing.

4.1 Posture Classification Accuracy

To check the model, we manually labeled a dataset of over 10,000 frames as "Slouched" or "Upright." The system reached a classification accuracy of 93.2%. Further analysis showed a precision of 91.4%, which reduced false alerts, and a recall of 94.8%, meaning it successfully identified most slouching instances. These results prove that the model is both sensitive and reliable in detecting

poor posture[18][19].

4.2 Real-Time Feedback Latency

The system had an average latency of less than 0.2 seconds from frame capture to the alert being triggered. This nearly instant response makes sure that correction prompts are given in real-time without interrupting the user's workflow. Performance stayed stable on standard consumer hardware, like an Intel i5 processor and 8 GB RAM, showing its efficiency and ability to work without high-end computing resources [20].

4.3 Usability and Behavioral Impact

User studies showed a significant positive effect on behavior. By the third day of use, participants had a 25 to 30% reduction in the average duration of slouching per session. Post-session surveys indicated positive feedback:

• 86% of users found the dual-modal (visual and auditory) alerts helpful and non-intrusive.

• 71% of users reported being more aware of their posture habits even when not using the system[21].

5) Discussion and Conclusion

The findings of this research provide strong support that Slouchometer represents an effective, non-intrusive, and low-cost option for conducting real-time posture correction. In addition, the accuracy and low latency of the system, along with positive user feedback, corroborate the use of MediaPipe BlazePose for this use case. The average percentage decrease in slouch duration in participants is certainly a promising indication of the systems ability to create long-term behavior change and improve user's digital well-being[22]

The main benefit of the Slouchometer, compared to existing options, is its ease of use. The expense and uncomfortable constraints related to wearable sensors and specialized hardware are removed by utilizing common webcams and open-source libraries. Users may visualize their progress withthe help of the interface with Power BI for data analytics, which highlights improvements and points out recurring problems[23]

Limitations and Future Work

The system has limitations even with its success. Sufficient lighting and an unhindered view of the user's upper torso are essential for its functionality. Additionally, the current study had only a small sample size of fifteen people. Future research should concentrate on testing the system under a greater variety of climatic circumstances and broadening the user study to include a more varied demographic. More advanced machine learning algorithms that can differentiate between short-term, natural actions (such reaching for an object) and persistently bad posture could be developed as further improvements. Additional ergonomic measurements, such as screen distance and head tilt, can also be incorporated into the system, and it may be incorporated into teaching systems or workplace health initiatives.[24]

In conclusion, AI-assisted solutions such as Slouchometer will be vital to reducing the health risks associated with increased dependence on digital technology in society. With the potential to improve wellbeing at home, in businesses, and at educational institutions across the globe, this research provides a realistic and scalable approach to encouraging thoughtful and healthy use of technology

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