Advanced interdisciplinary approaches for bad posture detection using computer vision and IoT

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Abstract. Addressing the widespread problem of poor posture and its far-reaching health implications, our innovative solution employs advanced interdisciplinary approaches and IoT technology for real-time bad posture detection. By integrating smart sensors and wearables strategically placed to monitor body positioning continuously, our system goes beyond conventional methods. The gathered posture data undergoes analysis by processing units, incorporating advanced algorithms that draw insights from fields like biomechanics and human-computer interaction. This holistic approach not only identifies instances of poor posture with heightened accuracy but also provides immediate feedback to users through visual cues or notifications, fostering self-awareness and encouraging posture correction. The versatility and scalability of our solution make it applicable to diverse settings, including offices, healthcare, and education. This paper delves into the design, implementation, and challenges of our IoT-based system, emphasizing its potential to mitigate health risks linked to prolonged poor posture. By embracing advanced interdisciplinary approaches, we contribute to a more comprehensive understanding of posture-related complexities, paving the way for future advancements in public health through the promotion of better posture habits.

1 Introduction

In the contemporary landscape, the pervasive influence of technology and the increasing prevalence of sedentary lifestyles have given rise to a concerning health issue—poor posture. As individuals spend prolonged hours engaged in digital activities, particularly in the context of office work, the adverse effects on musculoskeletal health become more pronounced. Problems such as back pain, neck strain, and decreased overall mobility are becoming

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increasingly common. Recognizing the substantial impact of technology on human well-being, this research endeavors to address the critical need for effective posture monitoring. The rise of digital devices and the associated sedentary behaviors necessitate a shift in our approach to postural health. Traditional methods of manual correction or periodic reminders have proven inconsistent and lack real-time insights. In response to this challenge, our research explores the integration of cutting-edge technologies to create a robust and automated bad posture detection system.

The primary objective of this research is to design and implement a posture monitoring system that utilizes the Internet of Things (IoT) devices and Google's Media Pipe library for accurate and real-time detection of poor posture. By combining the power of connected sensors and advanced pose estimation algorithms, our goal is to develop a system that not only identifies bad posture but also provides timely feedback to users, promoting awareness and encouraging corrective actions. This study holds significant implications for both individual users seeking to enhance their well-being and organizations aiming to foster healthier work environments. The proposed solution goes beyond traditional methods by providing continuous monitoring, personalized feedback, and actionable insights into improving posture-related habits. In addressing the pervasive issue of poor posture through the lens of computer vision and IoT, this research advocates for an advanced interdisciplinary approach to enhance the effectiveness of posture detection systems. Recognizing the multifaceted nature of posture-related challenges, our methodology integrates insights from diverse fields such as biomechanics, human-computer interaction, and health sciences. This approach aims to cultivate a holistic understanding of posture, acknowledging that it is influenced by physiological, psychological, and behavioral factors. The collaboration of experts from these various domains is anticipated to yield innovative algorithms, surpassing traditional methods and resulting in a more accurate and robust posture detection system. Furthermore, the user-centric design of our approach incorporates expertise from behavioral psychology and human-computer interaction, ensuring not only precision in detection but also user-friendly feedback mechanisms for encouraging corrective behavior. By adopting an advanced interdisciplinary approach framework, this research not only strives to overcome the complex challenges associated with poor posture but also seeks to pioneer a more nuanced and comprehensive approach to posture detection technology.

2 Literature Survey

The approach of "Human Activity Recognition Using an IoT-based Posture Corrector and Machine Learning" represents an innovative fusion of technology aimed at enhancing human well-being. In this method, a wearable device, designed as a posture corrector and equipped with sensors like accelerometers and gyroscopes, captures intricate data regarding users' body movements and postures. Leveraging Internet of Things (IoT) technology, this data is seamlessly transmitted to a central system for real-time processing. Continuous improvement is achieved through user feedback, which informs periodic retraining of the machine learning model, ensuring adaptability across diverse users and environments. This holistic approach not only recognizes and categorizes human activities but also actively contributes to promoting healthier and more ergonomic postures.[1]

The IoT System for Real-Time Posture Asymmetry Detection is a pioneering solution leveraging Internet of Things (IoT) technology. By employing wearable devices with embedded sensors, this system continuously captures and transmits posture data to a centralized hub. Advanced algorithms analyze the real-time data, focusing on detecting posture asymmetry. Users receive immediate feedback, enabling prompt adjustments to mitigate musculoskeletal issues. This innovative approach not only facilitates on-the-spot corrections but also contributes to long-term health by offering personalized insights. By addressing posture imbalances in real-time, the IoT System provides a user-friendly and proactive solution for promoting optimal musculoskeletal well-being [2]. The introduction of IoT-based posture detection signifies a paradigm shift in health technology. This approach utilizes connected devices equipped with advanced sensors to monitor and analyze user postures in real time. The underlying sensor technology, such as accelerometers and gyroscopes, enables precise and comprehensive data capture. These sensors work synergistically to provide a nuanced understanding of body movements and positions [3]. By seamlessly integrating IoT and sophisticated sensor technology, this innovative solution lays the foundation for effective posture monitoring, offering insights that contribute to long-term musculoskeletal health. The Posture Detection and Correction System using IoT: A Survey explores advancements in posture-related health technology. This comprehensive study investigates the integration of Internet of Things (IoT) for real-time posture monitoring and correction. Through a survey lens, it evaluates existing systems, sensor technologies, and corrective mechanisms. By synthesizing current research, the survey aims to provide insights into the efficacy and potential improvements of IoT-driven solutions in posture detection and correction, contributing to the evolving landscape of health-focused IoT applications.[4]

The Smart Wearable Sensor System for Real-time Posture Monitoring and Correction represents a breakthrough in health technology. This approach involves wearable devices embedded with advanced sensors that monitor user postures in real time. The system not only detects deviations from optimal postures but also provides corrective feedback to users. By leveraging smart sensors and real-time data analysis, this innovative system offers a proactive solution for promoting better posture habits, ultimately contributing to musculoskeletal health and overall well-being [5]. 1The authors of the [6] Real-time Posture Recognition and Feedback System using Wearable Sensors and Mobile Applications is a groundbreaking solution for promoting healthy postural habits. It employs wearable sensors to continuously monitor user postures in real time. Integrated with mobile applications, the system provides instant feedback to users, guiding them toward optima postures. This approach not only fosters awareness of posture but also facilitates immediate corrective actions. By merging wearable technology and mobile interfaces, this system creates an accessible and user-friendly platform, contributing to enhanced posture awareness and overall musculoskeletal well-being.

The Deep Learning Approach for Real-Time Posture Classification using Wearable Sensors- integrates advanced technology for accurate and instantaneous posture analysis. Employing deep learning techniques, the system utilizes wearable sensors to detect and classify diverse postures in real time. Image processing, including eye blink detection and face tracking, enhances its precision. The inclusion of a flex sensor for hand gestures further refines the system's usability. This innovative approach ensures not only real-time posture assessment but also a comprehensive understanding of user movements, catering to applications ranging from healthcare to fitness monitoring. [7]

In IoT-based Smart Chair for Posture Monitoring and Feedback - The IoT-based Smart Chair for Posture Monitoring and Feedback is an innovative system designed to enhance ergonomic well-being. Equipped with sensors, the chair continuously monitors the user's posture in real-time. Data collected is transmitted to an IoT platform, enabling comprehensive analysis. In response to poor posture, the chair provides real-time feedback, promoting healthier sitting habits. This approach not only fosters awareness of posture-related issues but also contributes to preventing discomfort and musculoskeletal problems by encouraging users to maintain correct and comfortable seating positions.[8]

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3 Component Description

3.1 Flex Sensor

Flex sensors, detecting changes in resistance as they bend, play a pivotal role in bad posture detection through IoT. Placed strategically on body parts, they generate digital data transmitted wirelessly, enabling real-time monitoring, algorithmic analysis, and user feedback to promote healthier posture habits.

Fig. 1. Flex Sensor.

3.2 Buzzer

Buzzer assumes a crucial role as an alert system. When flex sensors identify improper posture, the buzzer is triggered, providing users with immediate auditory feedback, facilitating timely corrections, and promoting better posture habits.

Fig. 2. Buzzer.

3.3 LCD Display

The LCD display has been utilized to keep a tab on and being regularly notified about the reading shown by the flex sensor. We program the threshold value of the flex sensor and we can see these readings and values on the LCD display.

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Fig. 3. LCD Screen.

3.4 Webcam

A high-resolution webcam with a wide field of view and good low-light performance is essential for accurate bad posture detection using Media Pipe. Compatibility, considerations contribute to effective real-time pose analysis.

Fig. 4. Webcam.

3.5 Amplifier PCB Board

In the "Bad Posture Detection using Computer Vision and IoT", an amplifier PCB board plays a vital role in enhancing the functionality of flex sensors.

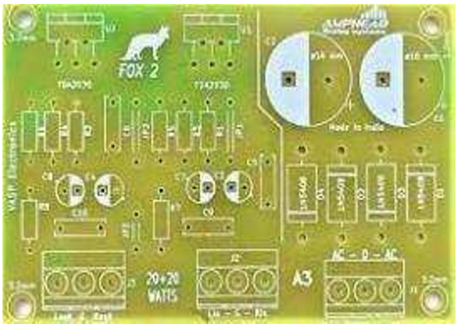

Fig. 5. Amplifier PCB Board.

3.6 Arduino Uno Rev3 SMD

In the "Bad Posture Detection using Computer Vision and IoT ", the Arduino Uno Rev3 SMD (Surface Mount Device) serves as a central component for data processing and interfacing.

4 Proposed Method

4.1 Problem Statement

In today's increasingly sedentary lifestyles, poor posture has become a prevalent issue leading to various musculoskeletal problems. Traditional methods of addressing posture-related concerns often lack real-time monitoring and immediate feedback. Existing approaches to bad posture detection primarily rely on single-sensor solutions, limiting the accuracy and scope of detection. Moreover, the absence of a comprehensive and integrated system combining various IoT sensors hinders the development of effective and user-friendly solutions. This research aims to address these gaps by proposing an innovative IoT-based approach for bad posture detection, leveraging multiple sensors, machine learning algorithms, and cloud-based analytics. The objective is to provide users with real-time feedback and personalized recommendations to foster healthier posture habits and mitigate the long-term consequences of poor posture.

4.2 Architecture Diagram

Mediapipe- The Bad Posture Detection System utilizing MediaPipe is designed to analyze a user's posture through a webcam or camera sensor. The system employs MediaPipe's Pose Estimation model to identify body landmarks, which are then evaluated for deviations from an ideal posture. IoT and sensor- The Bad Posture Detection System employing IoT and Flex Sensors comprises a network of interconnected components designed to monitor and analyze a user's posture. Utilizing Flex Sensors attached to the user's body, the system captures real-time data, which is transmitted to an IoT gateway for processing. The processed information is then sent to a central processing unit where posture deviations are detected, and alerts or feedback are generated, creating a comprehensive and responsive solution for posture improvement.

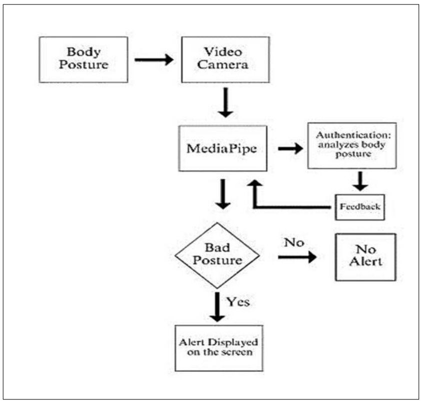

Fig. 6. Architecture Diagram of Bad Posture Detection System Using Media Pipe

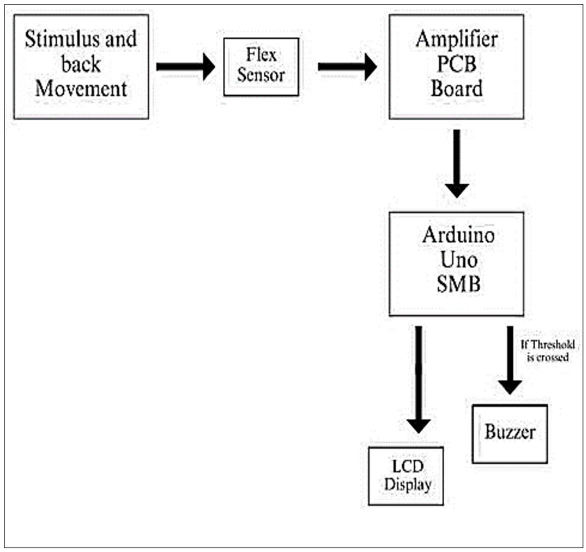

Fig. 7. Architecture Diagram of Bad Posture Detection System Using IoT with Flex Sensor.

4.3 Modules

4.3.1 Data Acquisition

Capturing video and sensor data is crucial for gaining detailed insights into users' body positions and movements, playing a pivotal role in applications like healthcare, fitness, virtual reality, and human-computer interaction. The synergy of video and sensor data allows for a comprehensive understanding of a user's posture, facilitating accurate detection models and enhancing the overall user experience. Employing sensors such as accelerometers and gyroscopes, and continuously monitoring diverse postures, complements the visual representation provided by video data. The collected raw data is transmitted to a Central Control Unit, serving as the system's brain, where sophisticated algorithms and machine learning interpret the data, extracting features, identifying patterns, and offering meaningful insights into the user's posture. This integration yields a robust and accurate posture detection system, adaptable to various environments and user-specific nuances, with applications spanning healthcare monitoring to responsive virtual reality experiences.

4.3.2 Pose Analysis with Media Pipe

Media Pipe, a widely embraced library for real-time video and image data processing, simplifies the
integration of pose detection into applications. Noteworthy for its user-friendly APIs and pre-trained models, Media Pipe abstracts away the complexities of deep learning, enabling developers to focus on functionality rather than intricate neural network architectures. Particularly valuable for diverse applications like augmented reality and fitness tracking, Media Pipe’s ease of integration saves developers time and resources. Its pose detection

capabilities, rooted in identifying key body points, enhance applications without the need for developers to delve deeply into complex machine learning models.

4.3.3 Classification Model

Following joint estimation, the posture detection system strategically places reference points and meticulously compares angles, evaluating the alignment and orientation of body parts to gauge the user's posture. Specific joints like shoulders, hips, and knees serve as reference points, enabling targeted assessment. The angles between these points form the basis for detecting deviations from optimal posture, triggering notifications if thresholds are exceeded. The Media pipe library aids accurate joint estimation from video data, facilitating real-time extraction of pose features essential for posture analysis. This, combined with a trained classification model, ensures a sophisticated and accurate posture detection mechanism, promoting healthier habits through real-time feedback.

4.3.4 Results and Performance Metrics:

The bad posture detection system showcases outcomes through a thorough evaluation, visualizing success cases, and presenting quantitative metrics to gauge performance. Utilizing the Media pipe library for joint estimation, the system accurately captures real-time key body points, extracting vital pose features for analysis. Visualized success cases demonstrate effective identification and notification of poor postures. Quantitative metrics, including accuracy, precision, and recall, substantiate the system's performance, offering a comprehensive evaluation. By leveraging Media pipe and a well-selected classification model, the system not only detects bad postures precisely but also provides actionable feedback for improved well-being.

5 Results

5.1 Experimental Results

An experimental setup for detecting bad posture combines Media pipe and flex sensors, merging computer vision with physical sensors for effective body posture analysis. Hardware components include a webcam, strategically placed flex sensors on body points, an Arduino microcontroller for sensor interfacing, and a powerful computer for real-time Media pipe pose estimation.

The initial setup involves calibrating flex sensors by recording readings during a neutral posture. Software integration includes incorporating the Media pipe framework into a chosen programming environment, enabling real-time pose estimation from the webcam feed. Data fusion combines flex sensor output with pose estimation, providing a holistic understanding of user posture.

To identify bad posture instances, a dedicated algorithm analyzes combined data, setting thresholds based on the calibrated baseline. The system offers user feedback through visual alerts, sound signals, or haptic feedback when bad posture is detected.

For ongoing analysis and improvement, the setup includes data logging for recording posture data over time, aiding progress tracking and algorithm refinement. Validation through user studies guides adjustments in an iterative development process focused on continuous enhancement and user feedback incorporation. Future considerations involve

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potential expansions like tracking multiple body parts or providing personalized posture correction recommendations. Throughout development, emphasis is placed on prioritizing user privacy and responsible data handling in compliance with ethical guidelines and regulations.

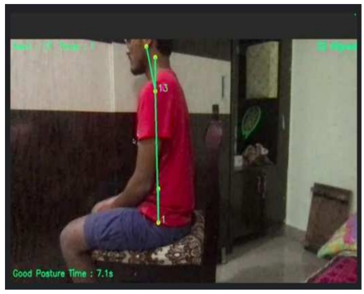

Fig. 8. Good Posture

Fig. 9. Bad Posture.

6 Conclusion and future enhancements

The "Bad Posture Detection Using Media Pipe and IoT", Utilizing advanced computer vision from the Media Pipe library, the system monitors real-time video input, identifying key body points to detect subtle signs of bad posture. Its core innovation lies in seamless IoT integration, enabling continuous posture monitoring and timely user alerts for corrective actions. The goal is to provide immediate, user-friendly feedback through customization options, fostering long-term musculoskeletal health. Beyond detection, enhances the user experience with customization and robust data logging, prioritizing privacy and ethical data handling. By incorporating advanced interdisciplinary approaches, the system leverages not only cutting-edge computer vision from the Media Pipe library but also draws insights from various disciplines. The integration of biomechanics expertise enhances the precision of detecting subtle signs of bad posture, going beyond mere visual cues. The future improvements aim to create a comprehensive and adaptive posture management solution. Integrating a wider range of sensors like accelerometers and gyroscopes would enhance the system's understanding of body movements, enabling a more nuanced posture analysis. The addition of machine learning could personalize feedback by recognizing individual posture patterns and tailoring corrective suggestions.

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