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Detection and Analysis of Sitting Posture in Real Time Based on Keras Framework

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Abstract - Sustaining proper sitting posture is crucial in the contemporary era of sedentary lifestyles to prevent musculoskeletal problems and promote general well-being. Using the Keras framework, this study proposes a tailored method for the instant identification and evaluation of sitting positions. The suggested approach uses a pre-trained DenseNet201 model with frozen layers and custom layers on top to train a specialized model for identifying sitting postures. The method accurately categorizes sitting postures as good, bad, or undefined by using a wide dataset of sitting posture photos and transfer learning. The system's ability to analyze and monitor seated postures in real time is improved by the integration of YOLOv3 for person detection and MediaPipe Holistic for pose estimation. The system provides immediate visual feedback, using color-coded indicators (green for good, red for bad, and blue for undefined postures), to assist users in self-assessing and correcting their sitting postures. Furthermore, the system incorporates notification alerts to prompt users when a bad posture persists, motivating them to make necessary adjustments. Experimental results demonstrate the effectiveness of the system in promoting healthy postural habits and reducing the risk of musculoskeletal issues associated with improper sitting posture. Future work involves exploring posture analysis techniques and expanding the system's capabilities for a comprehensive analysis of sitting postures. This innovative approach addresses the growing concern of sedentary behavior by providing real-time posture monitoring and feedback, contributing to long-term postural health and well-being.

Key Words: DenseNet201, YOLOv3, MediaPipe, Real-Time, Notification alert, Health.

I. INTRODUCTION

The modern lifestyle has made prolonged sitting increasingly prevalent, which can lead to a number of musculoskeletal and health issues. In addition to bringing about pain and suffering, a bad sitting position can also lower productivity. This problem needs to be resolved in order to promote better workplaces and prevent long-term health issues. Due to advancements in technology, particularly in the fields of machine learning and deep learning, computer-based solutions are now a practical solution to the problem of detecting and analyzing sitting positions. The demand for sitting posture detection and analysis has arisen as a result of an increase in sedentary lifestyles and desk employment, raising awareness of the harmful effects of prolonged sitting. Employee health and safety risks include excessive laptop use while sitting incorrectly, the use of incorrect workstation heights, and a lack of suitable desk chairs. Spinal dysfunction, headaches, neck pain, back pain, and even back discomfort may result from this. The number of people who have back issues rises over time but never falls. Furthermore, given that these ailments affect 20% of the population. As a result, there is an increasing need for automated systems that can accurately identify sitting situations and provide objective analysis and feedback. This report emphasizes the significance of treating issues linked to sitting posture and provides an innovative approach to tackle this problem. The suggested method makes use of the Keras framework, a potent deep learning technology, to detect and analyze sitting posture in real-time. The technology intends to give users precise and quick feedback on their sitting postures by utilizing cutting-edge techniques like transfer learning, object identification, and pose estimation. This essay lays the groundwork for a revolutionary method of real-time seated posture analysis while highlighting the value of proactive posture correction and personalized feedback. To give readers a thorough knowledge of the proposed system's effectiveness and possible influence on postural health, the next sections of the study will examine review work, system architecture, methodology, experimental findings, conclusions, and future work.

II. REVIEW WORK

1. Sitting Posture Recognition Based on OpenPose.[2]

This paper proposed a sitting posture recognition system based on OpenPose, which uses the monitor in the classroom to detect the sitting posture of the students, and uses OpenPose to extract the posture feature. Keras deep learning framework is used to construct the convolutional neural network, which is used to train the datasets and recognize the sitting posture of students.

2. A Deep-Learning Based Posture Detection System for Preventing Telework-Related Musculoskeletal Disorders.[3]

In this work, a system based on the postural detection of the worker is designed, implemented, and tested, using a specialized hardware system that processes video in real-time through convolutional neural networks. This system is capable of detecting the posture of the neck, shoulders, and arms, providing recommendations to the worker in order to prevent possible health problems, due to poor posture.

3. Design and Development of a Sitting Posture Recognition System.[5]

This paper focuses on body posture monitoring, by acquiring the pressure distribution of a sitting person with thirteen piezoresistive sensors placed on a seat. The measurements from the sensors passing through a microcontroller unit fed several machine learning techniques in order to discriminate among five sitting postures (upright, leaning left, leaning right, leaning forward, and leaning backward).

4. A Smart Chair Sitting Posture Recognition System Using Flex Sensors and FPGA Implemented Artificial Neural Network.[6]

This paper reports a novel posture recognition system on an office chair that can categorize seven different health-related sitting postures. The system uses six flex sensors, an Analog to Digital Converter (ADC) board, and a Machine Learning algorithm of a two-layer Artificial Neural Network (ANN) implemented on a Spartan-6 Field Programmable Gate Array (FPGA).

5. Sitting posture analysis by pressure sensors.[4]

In this paper, a system uses a pressure sensor seat on a chair for identifying sitting postures. In the experiments, a system is classified into nine postures, including leaning forward/backward/right/left and legs crossed. In this paper, “stable part” frames are only used for sitting-posture classification.

6. Sitting Posture Monitoring System using Image Classification.[7]

This system does not need additional infrastructure and can be used only via the system webcam. The proposed project helps to solve all these problems by providing a web interface solution that can detect the user’s posture in real-time and based on the image classification model the system gives a visual result. By making use of MediaPipe API we are able to detect the faces easily and the CNN algorithm is used for the image classification.

7. Sitting Posture Detection using Fuzzy Logic.[8]

In this paper, an approach is developed based on how the classification algorithm handled lateral postural changes and identified stability and instability zones. To differentiate between intermediate trunk flexion and extension an approach based on integrating Fuzzy logic into the existing Neural Network-based Classification Algorithm that was capable of classifying 6 standard sitting positions.

8. Machine Learning Algorithms Application for The Proposed Sitting Posture Monitoring System.[9]

This paper studies the application of machine learning algorithms for the prediction of the sitting posture. We implement a smart belt equipped with inertial sensors for the data collection of the sitting posture. Then seven machine learning algorithms are trained for posture prediction. The machine learning algorithms are compared based on three main metrics: Accuracy, Precision, and Prediction Time.

9. Detection of sitting posture using hierarchical image composition and deep learning.[10]

In this paper, the system proposes a novel deep recurrent hierarchical network (DRHN) model based on MobileNetV2 that allows for greater flexibility by reducing or eliminating posture detection problems related to a limited visibility human torso in the frame, i.e., the occlusion problem. The DRHN network accepts the RGB-Depth frame sequences and produces a representation of semantically related posture states.

III. SYSTEM DESIGN

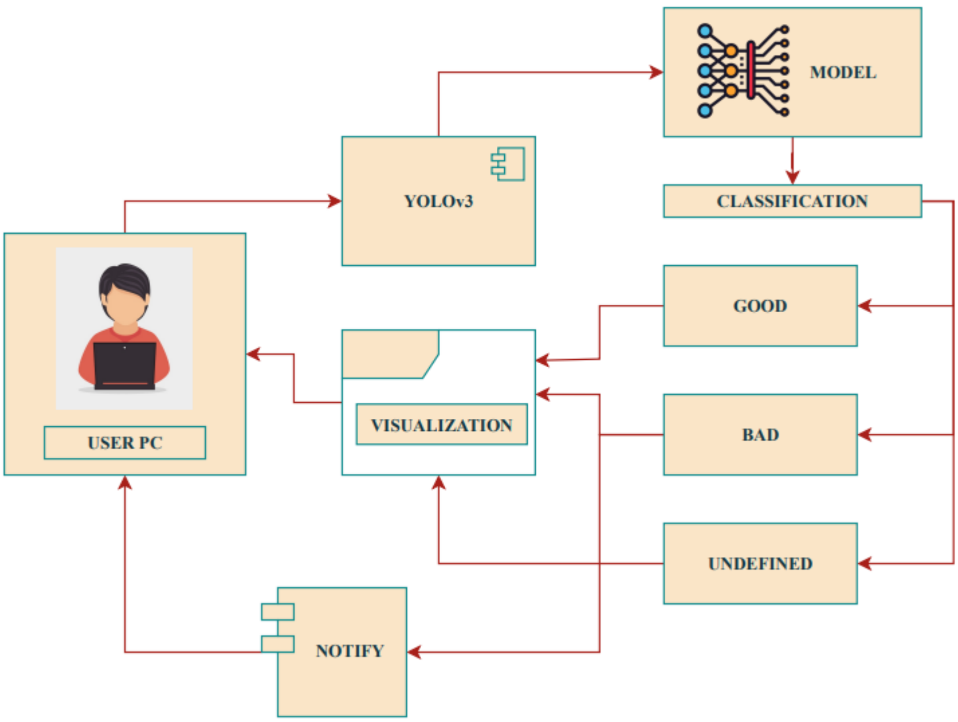

Figure 1. System design.

IV. METHODOLOGY

1. Data collection: Sitting posture images are gathered into a dataset that includes both instances of good and bad postures. The dataset is varied and supplemented to boost its size and variety, ensuring thorough coverage of sitting positions in various situations and people.

2. Model Training: A posture classification model is trained using transfer learning. The feature extractor is a pre-trained DenseNet201 model with its weights frozen to preserve the learned features. To enable posture classification, more customized layers are put on top. With the proper loss and optimization functions included, the model is trained using the gathered dataset. Cross-validation techniques are used to assess model performance.

3. System Setup: The system is configured to incorporate the learned posture classification model, the notification module, and the YOLOv3 object identification algorithm for human detection. The required frameworks, libraries, and dependencies have been installed and set up. For face and position assessment, MediaPipe Holistic is used, supplying markers for each person that is found. Real-time video stream capture is configured on a webcam or other camera.

4. Real-time Posture Classification: Using a video capture object, the system extracts frames from the video stream. To find people in each frame, YOLOv3 is used. Using non-maximum suppression, duplicate detections are eliminated. A region of interest (ROI) is extracted for posture analysis for each person that is detected.

5. Posture Analysis: The extracted ROI is processed to classify each observed person's posture as either good or terrible if they are seated, or as undefined otherwise. This judgment is based on features retrieved from the ROI using the trained posture classification model. Based on the collected features, the posture is classified using established criteria or models with predefined thresholds.

6. Monitoring of Bad Posture: Using a timer, the system continuously tracks the length of time spent in bad posture. The notification module is activated if someone continues to stand awkwardly for a predetermined amount of time.

7. Notification: A notification is generated when the notification module is activated to warn the user about their continued poor posture. A visual indication, aural alert, or a message that appears on the screen can all serve as notifications. The notification's goal is to draw the user's attention to their posture and motivate them to make appropriate adjustments.

8. Visualization: By overlaying the posture categorization findings and bounding boxes on the video frame, the system offers real-time visualization. The user can assess their posture and make any modifications thanks to the visual feedback. It facilitates posture correction and fosters self-awareness.

9. Evaluation and Optimization: The real-time posture classification system is tested using a variety of people in a variety of seating situations. To evaluate the system's efficacy and accuracy, user feedback and performance indicators are gathered. Based on the evaluation results, the model and system parameters may be adjusted to improve posture categorization performance.

V. EXPERIMENTAL RESULTS

The system's experimental results showed encouraging outcomes, which were illustrated through color-coded feedback. The outcomes are as follows:

Result 1: Green was chosen to symbolize a good sitting posture, as illustrated in Figure 2, demonstrating that the user maintained a correct and healthy posture. Users were made aware of their ideal posture thanks to this feedback, which also helped to perpetuate good behaviors.

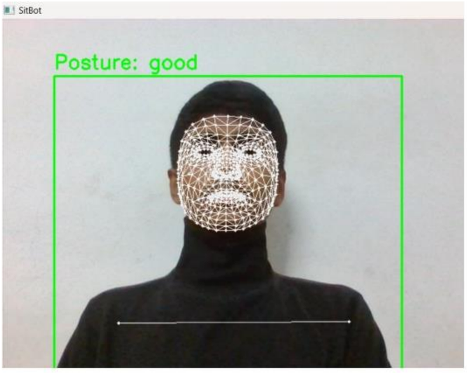

Figure 2. Good sitting posture.

Result 2: Red was designated to denote bad posture, as demonstrated in Figure 3, indicating that the user was seated in an unnatural or harmful manner. Users were urged to rectify any variations in their posture by the rapid visual feedback, which encouraged better sitting habits and decreased the risk of musculoskeletal problems.

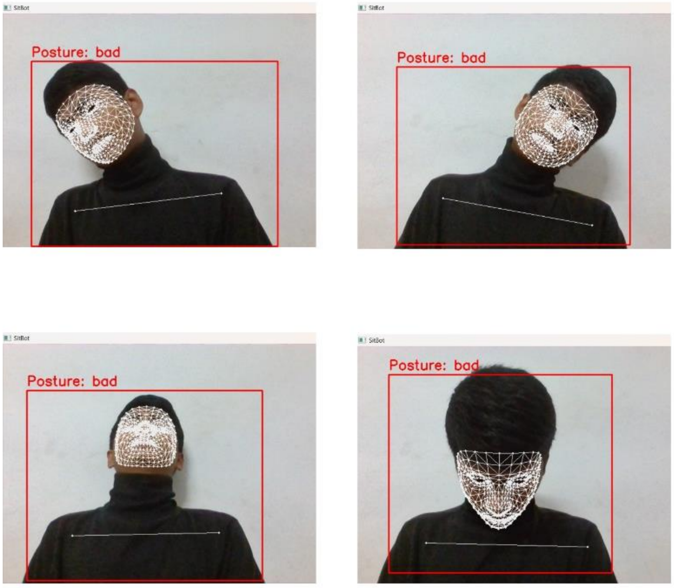

Figure 3. Bad sitting posture.

Result 3: As illustrated in Figure 4, Blue was utilized to indicate an undefinable posture when the system discovered that the user was not seated.

Figure 4. Undefined posture.

Result 4: A notification was sent to the user to warn them of their unhealthy seating habits when they continued to keep poor posture for a predetermined amount of time. The alert sent out a visual notice, as seen in Figure 5, which the user may utilize as a timely reminder to improve their posture and choose a more healthful sitting position.

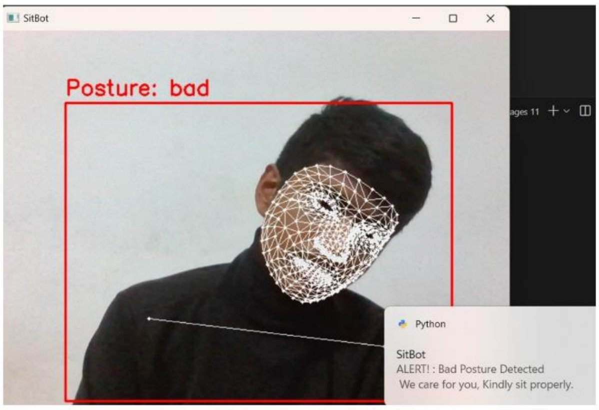

Figure 5. Notification alert.

The system gave users intuitive feedback in real-time, allowing them to self-evaluate and make the necessary adjustments to maintain a good posture throughout their seated activities. This was accomplished by using color coding to represent the testing results. Additionally, users were given both visible and audio cues thanks to the system's integration of notification alerts, which effectively helped them become aware of their sitting position and inspired them to make the necessary corrections. This preventive strategy helped to promote better posture habits and reduce the possibility of long-term problems connected to bad posture.

VI. CONCLUSION

In order to track sitting postures, the current study suggested a real-time posture analysis system that makes use of computer vision and machine learning approaches. The created system exhibits efficient posture classification skills, differentiating between good and unfavorable sitting postures in real time. Each individual in the frame can have their posture accurately and reliably analyzed thanks to the integration of YOLOv3 and the posture classification model. Users receive rapid feedback from the system's visualization component, which helps them become aware of their sitting positions and make the appropriate adjustments. The color-coded feedback (green for good, red for bad, and blue for undefined) improves user comprehension and engagement. The majority of the time, according to experimental results, the system was successful in differentiating between good and bad sitting postures. This indicates a high level of accuracy in posture categorization. A further layer of proactive intervention was provided with the addition of notification alerts, which helped users maintain awareness of their posture and improve it over time. The system performs and functions more efficiently overall when user input is incorporated, as well as when enhancements are made iteratively.

VII. FUTURE WORK

Although the suggested approach shows encouraging results, there are several opportunities for further study and improvement:

1. The posture classification model can be fine-tuned and optimized to increase accuracy and resilience.
2. The system's efficacy can be further increased by incorporating machine learning algorithms to detect musculoskeletal diseases or identify potential health hazards linked to poor posture.
3. Conducting longitudinal studies to evaluate the system's long-term effects on users' postural patterns and prospective health outcomes would offer insightful information and confirm the system's efficacy in encouraging healthy sitting habits.
4. Working together with medical professionals, ergonomic specialists, or physical therapists can take advantage of their knowledge to confirm the system's efficacy and offer suggestions for improving posture correction techniques.

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