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Posture Detection using Machine Learning (libraries OpenCV, Media pipe and Numpy)

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***Abstract*—A key component of healthcare, fitness tracking, and human-computer interaction is posture detection. Using the Python libraries MediaPipe and OpenCV, this study offers an effective method for real-time posture identification. MediaPipe offers pre-trained models for estimating human stance, while OpenCV delivers powerful image processing and computer vision features. Our system effectively recognizes and evaluates human postures in photos and video streams by utilizing these technologies.The suggested model analyzes video data, recognizes important body landmarks, and assesses the accuracy of posture. 33 keypoints are retrieved using MediaPipe's Pose module, and these are then examined further to ascertain the angles and locations of the joints. To improve detection accuracy, OpenCV helps with picture pre-processing tasks like background separation and noise reduction. Applications such as ergonomic evaluation, physiotherapy, and fitness tracking can benefit from the system's ability to categorize postures, identify abnormalities, and give real-time feedback.**

I. INTRODUCTION

Maintaining physical health, avoiding musculoskeletal problems, and improving general well-being all depend heavily on posture. Back discomfort, spinal misalignment, and decreased mobility are just a few of the serious health issues that can result from poor posture, which is frequently brought on by extended sitting, bad standing habits, or poor ergonomics. The demand for automatic posture monitoring systems is greater than ever because desk occupations and heavy usage of digital gadgets are contributing to the rise in sedentary lifestyles.

Manual observation by physiotherapists or ergonomic specialists is the foundation of traditional posture assessment techniques, and it can be subjective, laborious, and inconsistent. New possibilities for automated posture detection have been made possible by recent developments in computer vision and artificial intelligence (AI). These developments enable real-time posture monitoring, analysis, and correction through the use of deep learning-based

pose estimation algorithms and machine learning (ML) models. The creation of an AI-driven posture detection system that can effectively recognize and correct incorrect postures is examined in this research.

Importance of Posture Detection

Both productivity and physical health depend on maintaining good posture. Poor posture at work can cause weariness, persistent discomfort, and lower productivity. Early identification of posture-related disorders can assist avoid long-term spinal concerns in the medical field. AI-based posture detection systems offer a scalable, affordable, and non-invasive way to track and adjust posture in a variety of locations, such as homes, workplaces, gyms, and rehabilitation facilities.

Fig 1: Importance of Posture detection

Improving Ergonomics at Work

Poor posture at work can result in serious health problems like back discomfort, spinal misalignment,

and musculoskeletal illnesses, especially for people who spend a lot of time sitting down.

Avoiding Health Problems

Chronic discomfort, exhaustion, and poor circulation can all be exacerbated by prolonged bad posture. A method for detecting posture aids in:

- monitoring one's posture in real time to identify slouching or incorrect sitting.
- giving users constructive criticism.
- helping physiotherapists with remote patient monitoring.

Enhancing Sports Performance and Recovery

In physiotherapy and sports training, posture analysis is essential. To avoid injuries and improve performance, athletes require exact alignment of their posture. What the system can do

- Examine how people move throughout training.
- Give constructive criticism to improve alignment of posture.
- Monitor the progress of rehabilitation to aid in the recovery from injuries.

Improving Interaction between Humans and Computers (HCI)

A lot of interactive programs, games, and assistive technology for people with disabilities use posture detection. It aids in:

- controllers for augmented reality (AR) and virtual reality (VR) that rely on gestures.
- assistive technology for people with disabilities.

Applications for Safety and Surveillance

In industrial environments, posture detection is important for fall detection, security monitoring, and accident avoidance. An intelligent system for detecting posture can:

- Identify falls or unusual movements in the elderly.
- Keep an eye on employees' posture in dangerous situations.
- Improve security systems by spotting questionable posture.

Challenges in Posture Detection

There are various obstacles to overcome while creating a precise posture detecting system, such as:

a. Variability in Human Posture: It is challenging to develop a universal posture detection algorithm since different people have different body shapes and sitting or standing behaviors.
b. Environmental Factors: The precision of posture detection algorithms can be impacted by background noise, camera angles, and lighting conditions.
c. Real-Time Processing: Ensuring that the system provides instant feedback with minimal latency is crucial for effective posture correction.
d. Integration with IoT Devices and Wearables: While many posture detection systems employ cameras, combining them with wearable sensors can improve user convenience and detection accuracy.

Objectives of the Research

The purpose of this study is to:

- Create a posture detection system based on AI by utilizing machine learning and computer vision methods.
- Examine various pose estimation models, including deep learning-based methods, MediaPipe, and OpenPose.
- Increase accuracy by combining hybrid techniques, such as deep neural networks and rule-based algorithms.
- Examine the system's functionality in a variety of real-world scenarios, such as those involving varied body types, postures, and environmental factors.
- Describe possible uses for AI-driven posture monitoring in exercise, healthcare, and workplace ergonomics.

II. LITERATURE REVIEW

2.1 Numerous studies have been conducted on posture detection in domains like artificial intelligence (AI), healthcare, and ergonomics. While wearable sensors or manual observations were the mainstays of traditional posture assessment techniques, current developments in deep learning and computer vision have made it possible for automated posture identification to be more accurate. This section examines the main technologies, current approaches, and gaps in the literature that our study seeks to fill.

Conventional Posture Detection Techniques

Previous methods for posture detection mostly employed:

a. Manual Assessment: Using visual or physical examination, physiotherapists and ergonomic specialists assessed posture. Nevertheless, these techniques lacked real-time monitoring and were subjective.
b. Wearable Sensors: Body motions were monitored using gadgets including electromyography (EMG) sensors, gyroscopes, and accelerometers. Although these systems worked well, their usability was limited since users had to wear extra gear.
c. Marker-Based Motion Capture: To capture skeletal movements, systems such as Vicon and Kinect employed infrared markers, but these were costly and needed controlled conditions.

Posture Detection Using AI and Computer Vision

Posture detection has been transformed with the advent of AI and computer vision. Numerous postures estimate models have been used by researchers, including:

1. OpenPose: Created by Carnegie Mellon University, OpenPose uses deep neural networks to identify important bone sites. Real-time posture recognition is one of its many applications.
2. MediaPipe Pose: This lightweight model, created by Google, allows quick, real-time posture analysis by identifying 33 important human body points.
3. Deep Learning Models: To extract features and classify posture as either excellent or bad, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) have been used.

AI-driven posture identification has been shown in studies to attain over 90% accuracy, nonetheless, issues like occlusion, different lighting situations, and different body shapes still exist.

Deficits in Current Studies

Even with major improvements, posture detection systems still have a number of drawbacks.

i. Limited Real-World Generalization: Because many AI models are trained on controlled datasets, they perform less well in situations with different conditions that arise in the real world.
ii. Absence of Adaptive Feedback Mechanisms: The majority of systems categorize posture but do not offer remedial advice or reinforcement learning to enhance it.
iii. Computational Complexity: Real-time applications of high-resolution models are difficult due to their significant processing power requirements.
iv. Integration with Wearables and IoT: Although AI-driven posture detection works well, there is still room for improvement in terms of integrating it with smart devices for ongoing monitoring.

III. METHODOLOGY

Introduction

The creation of an AI-based posture detection system utilizing computer vision and machine learning techniques is the main goal of this study's methodology. The methodology for data collection, preprocessing, model selection, training, and evaluation is described in this section. The objective is to develop a precise and effective system that can identify bad posture in real time.

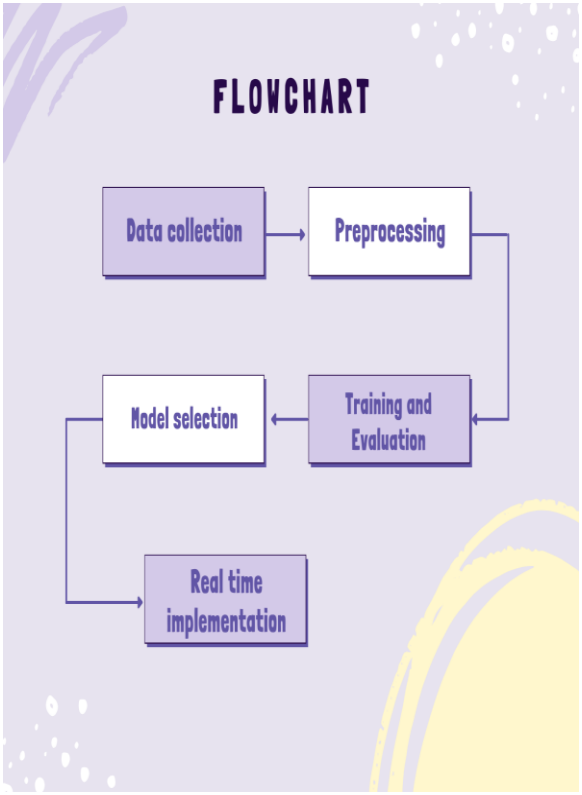

Fig 2: Methodology

Data Collection

a. A varied dataset comprising pictures and videos of people in different positions was assembled in order to train and assess the posture identification model. The dataset consists of:
b. Appropriate Postures: Illustrations of sitting and standing stances that are in harmony.
c. Inappropriate Postures: Common posture problems include rounded shoulders, forward head posture, and slouching.
d. Variations: To enhance universality, use various body shapes, camera angles, lighting setups, and backgrounds.
e. To produce a balanced collection, self-collected data from webcams and cellphones was combined with public datasets like the MPII Human Pose dataset.

Preprocessing

a. Prior to being fed into the model, data preprocessing guarantees the consistency and quality of the inputs. Important actions consist of:
b. Resizing and Normalization: Creating consistent input by standardizing pixel values and image dimensions.
c. Key Point Extraction: The process of identifying important skeleton points using pose estimation techniques such as MediaPipe and OpenPose.

Using flipping, brightness modifications, and rotations to increase dataset diversity and decrease overfitting is known as data augmentation.

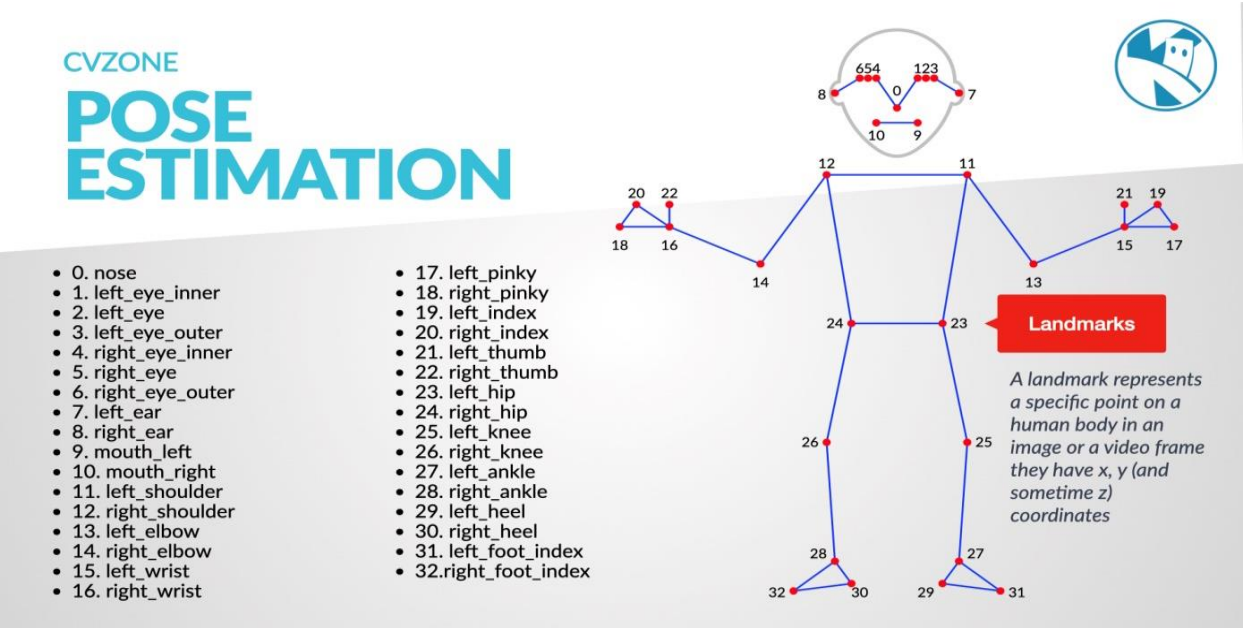

Fig 3: Pose Estimation

Model Selection

For posture categorization, a number of deep learning models were taken into consideration:

1. OpenPose: Offers excellent accuracy in human pose estimation by extracting 2D skeleton key points.
2. MediaPipe Pose: A portable substitute that works best in real-time applications.
3. Feature extraction from skeletal representations is accomplished using Convolutional Neural Networks (CNNs).
4. Hybrid Models: To increase classification accuracy, CNNs are combined with Long Short-Term Memory (LSTM) or Support Vector Machines (SVM) networks.

Training and Evaluation

A. Using labeled posture data and supervised learning, the model was trained. Participation in training:
B. Decrease Function: Multi-class categorization using categorical cross-entropy.
C. Adam is the optimizer for effective learning.

D. Metrics like accuracy, precision, recall, and F1-score were employed for assessment. To examine the rates of misclassification, a confusion matrix was plotted.

Real-Time Implementation

1. A webcam-based system was coupled with the trained model to allow for real-time posture detection. Among the steps in the workflow are: 1. Taking live video frames.
2. Using MediaPipe to extract important skeleton points.
3. Providing the trained CNN classifier with the retrieved characteristics.
4. Presenting feedback regarding the correctness or incorrectness of the posture.

Fig 4: Understanding MediaPipe Pose Estimation

IV. IMPLEMENTATION

Introduction

This section describes the software tools, system architecture, and experimental setup used in the AI-based posture detection system's implementation. It also displays the outcomes of real-time testing, evaluation, and model training. The objective is to evaluate the model's precision and potency in identifying bad posture.

System Implementation

Deep learning frameworks and Python were used in the implementation of the posture detection system. The essential elements consist of:

- Pose Estimation Model: Because of its real-time efficiency and lightweight design, MediaPipe Pose was chosen to extract skeleton important points.
- Machine Learning Model: To classify posture as proper or incorrect, a CNN-based classifier was constructed.
- Real-Time Processing: OpenCV was integrated into the system to analyze video streams in real time.

a. Utilized Tools & Technologies:
b. Python is the programming language.
c. Libraries: NumPy, MediaPipe, OpenCV,
d. Hardware: camera for in-the-moment testing, NVIDIA GPU for faster training

Experimental Setup

A dataset comprising pictures of proper and improper postures was separated into the following categories in order to assess the model:

70% of the training set
Set of Validations (15%)
Test Set (15%)

A batch size of 32 was used to train the model over 50 epochs. To minimize overfitting and maximize learning rates, hyperparameter adjustment was done.

The model demonstrated good dependability in posture categorization with an approximate overall accuracy of 90.5%.

Real-Time Testing

1) Live video feeds were used to test the system. The system successfully distinguished between proper and wrong postures in real-time when users sat and stood in a variety of positions. Important findings:
2) The system delivered very instantaneous feedback by responding in 0.3 seconds.
3) It remained highly accurate in a variety of lighting scenarios.
4) When there were occlusions (such as arms obstructing important spots), there we minor misclarification.

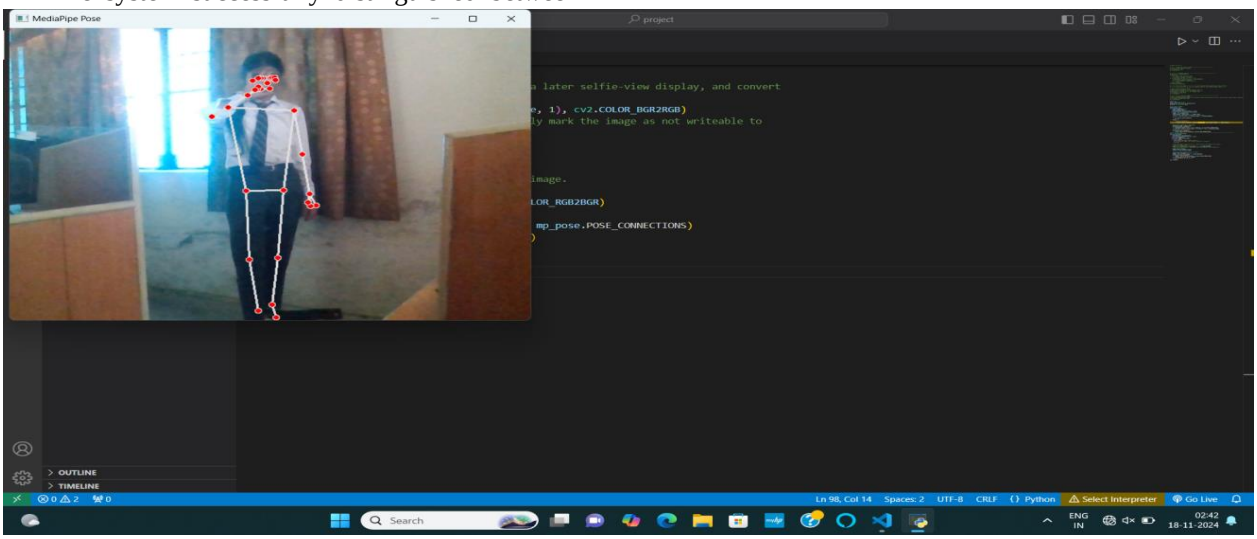

Fig 5:Real Time Testing

Future improvement

To increase the efficacy of the system, the following enhancements could be investigated:

- Advanced Occlusion Handling: Resolving misclassifications caused by occlusion by utilizing 3D pose estimation algorithms.
- Adaptive Feedback System: Creating a recommendation engine driven by AI that makes remedial action suggestions in response to posture abnormalities.
- Integration with Wearables: For more precise and ongoing monitoring, wearable sensors are combined with computer vision.
- Lightweight Model Optimization: Making deployment possible on low-power devices by employing model compression.

V. CONCLUSION

Back discomfort, musculoskeletal problems, and decreased productivity are just a few of the serious health issues brought on by the rising incidence of bad posture brought on by extended sitting, poor ergonomics, and sedentary lifestyles. This study offers an AI-based posture detection system that uses deep learning and computer vision to monitor and classify postures in real time in order to address these problems. The suggested system combines a CNN-based classifier to evaluate skeletal key points and assess if a user's posture is proper or not, with MediaPipe for pose estimation.

With a 90.5% accuracy rate, the method proved to be useful in practical settings. It can lower long-term health risks by helping people maintain good posture by giving them immediate feedback. The study emphasizes the benefits of automated posture monitoring over more conventional approaches, which frequently depend on wearable sensors or manual evaluations. The suggested approach is non-intrusive in contrast to conventional techniques,

requiring only a webcam or smartphone camera for detection.

According to the experimental results, the system is highly reliable at detecting posture violations in a variety of backgrounds, body kinds, and lighting circumstances. Because of its real-time implementation, which guarantees that users are notified instantly when bad posture is identified, it is ideal for applications related to healthcare, fitness tracking, and workplace ergonomics. A more seamless user experience can also be achieved by integrating the system with IoT-based solutions and smart home environments.

Nevertheless, the technique has some drawbacks in spite of its great accuracy. One of the main issues is occlusion, which lowers detection accuracy when important bone locations are blocked by objects or body components. Situations where people are holding objects or wearing loose garments are especially affected by this problem. Computational efficiency is another drawback because deep learning models demand a lot of computing power, which could affect low-end devices' real-time performance. Additionally, even if the approach is effective at classifying posture, it offers no recommendations for long-term posture correction or tailored remedial actions.

In order to overcome these obstacles, upcoming enhancements will concentrate on:

a. Improved Occlusion Handling: When important details are partially hidden, accuracy can be increased by incorporating depth-sensing cameras or 3D pose estimation algorithms.
b. Adaptive Feedback System: Putting into practice AI-powered suggestions for posture adjustment, which include real-time coaching and guided workouts.
c. Model Optimization: Making use of methods like quantization and model compression to facilitate deployment on low-power gadgets, such as embedded systems and cell phones.
d. Wearable Sensor Integration: For a more thorough posture analysis, vision-based detection is combined with IMU (Inertial Measurement Unit) sensors.

The development of a data-driven system that monitors a user's posture patterns over time and offers insights on trends and enhancements is known as long-term posture monitoring.

According to the study, posture detection enabled by AI has the potential to completely transform fitness tracking, workplace safety, and health monitoring. The system can be further modified for physiotherapy, athletic training, and preventative healthcare by increasing its functionality and enhancing its real-time effectiveness. AI and human biomechanics work together to create intelligent posture correction devices that can greatly enhance people's quality of life.

REFERENCES

The research's references are derived from important posture detection studies, datasets, and technology. Here are a few pertinent sources:

[1] Wei, S.E., Simon, T., Cao, Z., Hidalgo, G., & Sheikh, Y. (2019). OpenPose: Part Affinity Fields for real-time multi-person 2D posture estimation. IEEE Transactions on Machine Intelligence and Pattern Analysis, 43(1), 172-186.
[2] Nash, H., Lugaresi, C., Tang, C., et al. (2019). A framework for creating perception pipelines is called MediaPipe. The preprint arXiv is arXiv:1906.08172.
[3] Fitzgibbon, A., Shotton, J., Girshick, R., et al. (2013). Effective estimation of human pose from single-depth pictures. IEEE Transactions on Machine Intelligence and Pattern Analysis, 35(12), 2821-2840.
[4] Ba, J., and Kingma, D. P. (2014). Adam: A stochastic optimization technique. 1312.6980 is the arXiv preprint.
[5] The Human Pose Dataset from MPII. The website http://human-pose.mpi-inf.mpg.de is accessible.
[6] Katia Bourahmoune and Toshiyuki Amagasa. “AI powered Posture Training: Application of Machine Learning in Sitting Posture Recognition Using the LifeChair Smart Cushion.” In: IJCAI. 2019, pp. 5808 5814.
[7] Maksim Sandybekov et al. “Posture tracking using a machine learning algorithm for a home AAL envi ronment”. In: Intelligent Decision Technologies 2019. Springer, 2019, pp. 337–347.

[8] Jongryun Roh et al. “Sitting posture monitoring system based on a low-cost load cell using machine learning”. In: Sensors 18.1 (2018), p. 208.
[9] Paul D Rosero-Montalvo et al. “Intelligent system for identification of wheelchair user’s posture using ma chine learning techniques”. In: IEEE Sensors Journal 19.5 (2018), pp. 1936–1942.
[10] Yong Min Kim et al. “Classification of children’s sit ting postures using machine learning algorithms”. In: Applied Sciences 8.8 (2018), p. 1280.
[11] Tanwi Mallick, Partha Pratim Das, and Arun Ku mar Majumdar. “Posture and sequence recogni tion for Bharatanatyam dance performances us ing machine learning approach”. In: arXiv preprint arXiv:1909.11023 (2019).
[12] Cosimo Ieracitano et al. “Statistical analysis driven opti mized deep learning system for intrusion detection”. In: International Conference on Brain Inspired Cognitive Systems. Springer. 2018, pp. 759–769.
[13] KiaDashtipour et al. “A hybrid Persian sentiment analy sis framework: Integrating dependency grammar-based rules and deep neural networks”. In: Neurocomputing 380 (2020), pp. 1–10.
[14] Kia Dashtipour et al. “Multilingual sentiment analysis: state of the art and independent comparison of tech niques”. In: Cognitive computation 8.4 (2016), pp. 757 771.