Posture Detection Using MoveNet

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Abstract: **Posture detection plays a critical role in applications such as fitness tracking, ergonomic assessment, and rehabilitation. Traditional methods for posture evaluation often demand intricate hardware setups and specialized software, posing challenges for broad adoption. This project introduces MoveNet, a cutting-edge machine learning model designed to serve as the core of a real-time posture detection system. MoveNet efficiently estimates human poses using a single camera, identifying key body landmarks with high precision. Tensor Flow Lite powers the system and leverages Python for real-time processing in machine learning applications, ensuring cross-platform compatibility without the need for specialized hardware. By providing accurate posture detection and feedback on body alignment, MoveNet demonstrates adaptability to a wide array of use cases, including fitness coaching, rehabilitation exercises, and ergonomic monitoring.**

I. INTRODUCTION

Posture detection plays a key role in current applications such as fitness tracking, ergonomic assessment, and rehabilitation. However, existing approaches for analyzing and monitoring human posture sometimes need more support due to their reliance on complicated hardware setups and specialized software. These approaches can be expensive, difficult to apply at scale, and tough for users who lack access to specialized equipment. Moreover, many posture detection systems struggle to offer real-time feedback, making them less useful in dynamic, real-world contexts.

To solve these obstacles, the invention of a lightweight, precise, and efficient posture-detecting system is needed. This research proposes the usage of MoveNet, a state-of-the-art machine learning model designed for real-time human position prediction. By employing a single camera and integrating TensorFlow Lite with Python,

MoveNet.equipment-light option for identifying breast cancer biomarkers in clinical development investors or backers, thus preventing unauthorized use of resources.

II. LITERATURE SURVEY

Researchers have focused a lot of effort on human body posture recognition because of its many applications and important challenges. It can be used for everything from simple posture detection to sophisticated behavior analysis in surveillance systems. These results are essential for refining methods for identifying and expressing body position. The applications and basic framework of human body posture identification are examined in this study. It offers a TensorFlow-based posture detection technique to track people's proper posture while they're doing different tasks.P. Kaushik et al. [1] also compare two well-known posture estimation techniques and discuss their benefits and drawbacks**.**

Hua-Tsung, Chen, et al. [2] demonstrate in this study employs computer vision techniques to analyse images or videos of yoga practitioners and identify the different poses they are performing in order to identify and categorise yoga positions using machine learning and neural networks. This technology could be useful in many contexts, including yoga. Internet studios, fitness centres, and yoga classes. A large collection of annotated images of people in various yoga poses is gathered, used to train a machine learning or neural network model, and then used to automatically recognise and classify yoga poses in new images or videos.
With an emphasis on both 2D and 3D human pose estimation, Hruthika, Jupalle, et al[3] investigate developments in human pose estimation through deep learning techniques. It presents a unique video-based 2D posture estimate technique employing a multi-scale Temporal Consistency Encoding (TCE) module and draws attention to the difficulties presented by occlusion, depth ambiguity, and a lack of training data in real-world situations. This module enhances temporal consistency and performance by utilizing spatial pyramids and learnable offset fields. The article suggests a self-supervised 2D-to-3D lifting model for 3D pose estimation that uses transform re-projection losses and geometric priors to do away with the necessity

for large amounts of 3D ground truth data. Findings show competitive performance on common datasets, highlighting the model's efficacy and generalisability for practical uses in fields such as augmented reality, sports analysis, and human-computer interaction.

Upadhyay A et al. [4] discuss a deep learning-based model, Y_PN-MSSD, designed to recognize seven yoga poses with 99.88% accuracy. The model combines Pose-Net for feature point detection and Mobile-Net SSD for human detection. The process is divided into three stages: data collection, model training, and pose recognition. The model helps users track and correct their yoga posture in real-time, outperforming the Pose-Net CNN model in accuracy. Future work will focus on training with more yoga poses, addressing challenges like occlusion and lighting, and adding features like audio alerts for correct posture, aiming to build a professional real-time yoga trainer application.

Samkari E et al. [5] analyze deep learning techniques for 2D human pose estimation (HPE) from images and videos, summarizing 107 articles from 2014 to 2023. It categorizes methods into single-person vs. multiple-person pose estimation and image vs. video-based approaches, highlighting models like HRNet, OpenPose, and Stacked Hourglass that improve accuracy. Challenges remain in multi-pose estimation, particularly in crowded scenes and occlusion. For video, offline methods are accurate but slow, while online methods balance accuracy and efficiency, though real-time performance is still difficult. The review emphasizes the need for more research on video-based HPE, real-time applications, smaller networks, and methods to handle occlusion and crowd scenes.

Parashar, D. et al. [6], a deep learning model based on MoveNet and MediaPipe is used to automatically detect yoga positions. The suggested technique skeletonizes input yoga photos using key points and MediaPipe. MediaPipe is used to extract the main features and skeletons of people, and the MoveNet model processes the generated images to precisely determine the right yoga positions. The LDY yoga dataset was used to assess the model's performance, and MoveNet's deep learning architecture produced an accuracy of 99.50%. We tested the method using four different models to determine its robustness, and the findings showed that the suggested method performed better in yoga pose detection than the current methods. Furthermore, an accuracy comparison revealed that our strategy outperformed alternative techniques.

P. . Daphal et al.[7] focuses on human position detection techniques used in robotics, sports, fitness, fall detection, human-computer interface, and motion analysis, among other surveillance applications. It looks into how well-suited the current single-person and multi-person pose detection methods are in terms of efficiency and real-time compatibility. The goal of the project is to enhance pose detection-based systems, especially for applications like fall detection that can save lives. The survey also covers the creation of an effective deep learning model for human pose identification that is tailored for machine learning-based single-person pose estimation and can be used with both photos and videos.

Parashar et al.[8] presents an automated technique for identifying yoga poses that makes use of the MoveNet deep learning model and the MediaPipe methodology. The suggested method uses MediaPipe to skeletonize input yoga images using key points. MoveNet then processes the images to identify yoga positions precisely. When tested on the LDY yoga dataset, the model's accuracy was 99.50%. The MoveNet and MediaPipe combo performed better than the current approaches, according to testing with four distinct models. Better alignment and participation in yoga practice are encouraged by this method's useful applications in real-time pose correction, progress tracking, and personalized virtual yoga instruction.

Roggio,Federico et al.[9] presents a novel machine-learning technique for postural analysis that offers clear classification and less subjectivity, with substantial therapeutic promise. This effective, non-invasive technique may improve individualized physical therapy and ergonomic care. Our study provides normative data, confirming its reliability and relevance in evaluating healthy adult posture. We identified sex-related differences and very reliable postural metrics. Crucially, postural features like limb length and variations in shoulder-hip width that are not influenced by sex were identified using cluster analysis. These results point to possible new directions for ML-driven posture classification.

Using MediaPipe and a deep learning model based on MoveNet, Parashar et al. [10] presented a novel automated method for identifying yoga postures. For critical point-based skeletonization in the performance of the proposed model, the MediaPipe approach is employed. The MediaPipe technique is utilised to process input yoga images in order to extract each person's key characteristics and skeletons within the suggested framework. The normalised and skeletonised images are then loaded into the MoveNet model, which enables accurate identification of suitable yoga poses. The LDY yoga dataset has been used to evaluate the performance of the proposed model. they achieved a 99.50% accuracy rate using MoveNet's deep learning architecture.To test the suggested method's resilience, they selected four distinct models. The collected findings demonstrate that the suggested approach, which used MediaPipe and MoveNet, performed better for yoga posture detection than the current approaches. Furthermore, they evaluated the accuracy of the results against the current approaches and discovered that the suggested approach performed better for detecting yoga poses. Real-time position correction, progress tracking, and personalized virtual yoga instruction are all made possible by yoga pose identification, which promotes better alignment and practice participation.

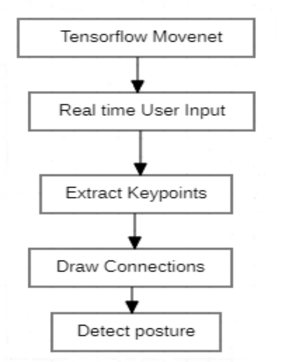
III. PROPOSED METHODOLOGY

This project uses TensorFlow Lite and MoveNet Lightning to construct a real-time posture detection system. Using OpenCV, live video from a camera is captured, and each frame is preprocessed and resized before sending them into the MoveNet model. The model's rendering of important body landmarks on the live video feed shows the user's posture. The posture detection and visualization system is provided with accuracy by establishing linkages between body components based on a confidence threshold. The project is quite flexible since it makes effective use of TensorFlow Lite to allow real-time processing even on low-power devices. This posture recognition system can be utilized for a variety of tasks, such as fitness tracking, rehabilitation activities, and ergonomic assessments because it functions flawlessly across platforms.

pseudo-code:

Pseudo-code Code Steps

1. Bring in required libraries, such as Mediapipe, NumPy, and OpenCV.
2. Resize a picture or video frame before displaying it.
3. Set up the pose detector and sketching tools in Mediapipe.
4. Loop over live camera input or video frames:
5. Adjust the frame's size.
6. To find pose landmarks, use Mediapipe.
7. Draw the identified landmarks on a white background as well as the original frame.
8. Show both the blank image with pose landmarks and the original frame with landmarks.
9. When the video stops or a termination key is pushed, the loop will stop.



IV. PROPOSED WORK

Deep learning techniques (neural networks, computer vision) are required for the difficult task of real-time classification posture detection. This is the first of a series of articles where we will detail how to create an application for posture detection utilizing neural networks and TensorFlow MoveNet.

You can see that the model is a TensorFlow MoveNet Model which is an accurate and fast key point detector for body. It identifies points of the body. This model on TF hub offers two models that are Thunder and Lightning. In real time, they both run quickly and accurately. This means that these models can be effective on modern desktops (like those configured with an NVIDIA 3060 GP) up and modern laptops. The model is popularly used within health and fitness.

Tensorflow moveNet is bottom-up approach, which localise key points from human body with help of heatmap. In this architecture, there are two focused components: a group of prediction heads and extractor points. Prediction schemes (CenterNet which used on it for speed and delicacy) Models are trained using the object detection API of TensorFlow. They extract points from MoveNet and MobileNetV2 which aids in high resolution.

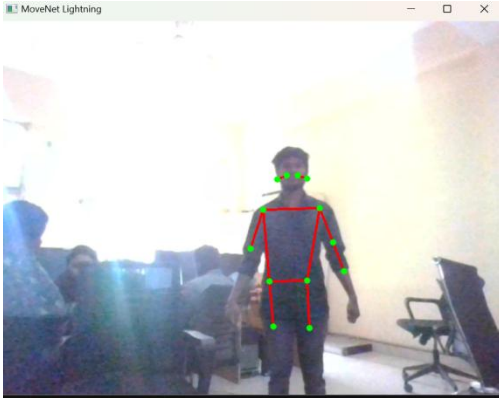
Tensorflow MoveNet is a deep learning library which could discover key factors from snap shots of the human body the use of neural networks. using Tensorflow MoveNet to come across the important thing points from the pictures and then convert these key points to CSV files. The transformed key points (CSV record) are fed into the neural network for type.

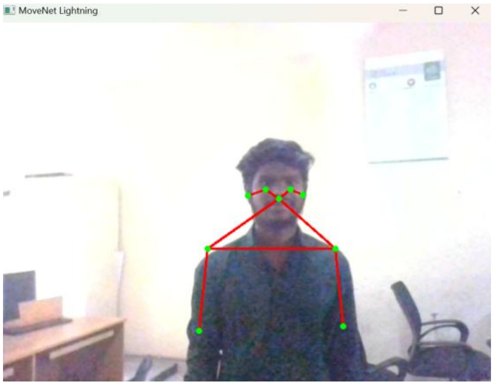
once we have extracted the important thing points from the pics, we can use them to construct a neural community for type. as soon as we have educated the neural community, we can integrate it with our web utility. we will be the use of the React framework to build the internet software. we will start by means of developing an endpoint in our net utility that accepts an photograph as input. we are able to then use TensorFlow MoveNet to extract the important thing points from the photo and feed them to the neural community for classification. eventually, we are able to locate the posture of the person.

V. RESULTS AND ANALYSIS

Result and Analysis: The system's usage of TensorFlow MoveNet for real-time posture detection demonstrates its ability to efficiently extract and classify significant points of the human body. The process begins with data collecting, and input might take the form of image files or real-time video feeds. To ensure that the data meets the requirements of the model, preprocessing techniques like downsizing and normalization are employed to maximize efficiency.

Key Points Detection and Preprocessing:
TensorFlow Using a bottom-up methodology, MoveNet precisely locates important locations on the human body by using heatmaps. For various application cases, it provides two variations, Thunder and Lightning, that strike a compromise between speed and accuracy. Lightning is optimized for real-time performance on devices with less processing power, whereas Thunder is made for great precision. These devices are appropriate for real-world applications since they can efficiently handle contemporary desktops and laptops.





The identified essential points are taken out and transformed into a CSV file, which is then fed into a neural network. This conversion makes it easier to perform additional analysis, including classifying or assessing posture. The neural network is guaranteed to receive high-quality, structured data for precise predictions thanks to the preprocessing.

Neural Network categorization: The data is placed into a neural network that carries out categorization after the important points have been extracted. The system can recognize particular body poses thanks to this categorization stage, which groups the detected postures into categories. Labeled datasets are used to train the neural network, guaranteeing accurate and dependable predictions. The neural network's integration with TensorFlow MoveNet improves the system's capacity to manage a variety of posture alterations.

Web Application Integration: A web application developed with the React framework is integrated with the system. Users can provide real-time video feeds or submit photographs using an intuitive interface. The web application uses the neural network to identify the posture after processing the input through the MoveNet model and extracting important elements.

Real-Time Performance: The system's real-time feature guarantees that posture identification happens without hiccups, which makes it ideal for applications in fitness tracking, health monitoring, and other fields needing immediate feedback. TensorFlow's Object Detection API in conjunction with the MoveNet model guarantees quick processing without sacrificing precision.

Analysis: The deployed system has several advantages:Accuracy: The exact identification of important locations is guaranteed by the application of heatmaps and deep learning techniques.

Real-Time Detection: Real-time processing of video streams is a big plus, especially for applications like rehabilitation and fitness tracking.

Integration with Web Applications: The system's practical usability is demonstrated by its smooth integration with a React-based frontend.

Scalability: Training the model on more data to identify more intricate postures or movements is one simple extension made possible by the modular approach.

But there are also areas where the system may be improved: Hardware Dependency: Although the models are effective, they only work well if there are enough computational resources available, particularly in Thunder mode.

Generalization: The variety and calibre of the training data affect posture detection accuracy.

In summary, the system successfully illustrates TensorFlow MoveNet's potential for real-time posture detection. It strikes a balance between accuracy, speed, and usability by integrating web applications, neural network-based categorization, and effective preprocessing. This makes it a great tool for practical health and fitness applications, with room for more feature additions and optimization.

VI. LIMITATIONS

There are various issues with the present code. Lighting conditions have a significant impact on posture detection accuracy and can affect performance in overexposed or low-light environments. Since the system depends on visual cues for detection, accuracy is also impacted by frame resolution. Multi-person scenarios are not supported by the code, which is intended for single-person detection. It also doesn't check to see if the video capture object has been successfully initialized and doesn't handle video input errors. Lower-end systems may have processing lag when it comes to real-time pose identification, and the code cannot understand or follow movements over time. Additionally, it needs a camera and enough processing power, which restricts its use in specific settings.

VII. FUTURE SCOPE

There are several approaches to improving the code. Support for multi-person detection and sophisticated pose analysis, including gesture or activity recognition, could be future additions. It would be more functional to incorporate AI models for applications such as gesture-based controls, dance analysis, and fitness tracking. When video input fails or no posture is identified, robust error handling should be put in place to deal with the situation. Real-time processing would be facilitated by efficiency enhancements like GPU acceleration. Additionally, improving background noise filtering and making the application cross-platform and cross-device compatible could increase its usability.

VIII. CONCLUSION

The project effectively uses TensorFlow MoveNet to demonstrate a real-time posture detection system. It efficiently detects and categorizes human body poses by fusing image processing, neural networks, and TensorFlow's pose detection features. Scalable, the technology can be included in more general applications like ergonomics analysis, fitness tracking, or health monitoring systems. TensorFlow MoveNet is a dependable model for real-time human pose estimation applications due to its excellent accuracy and speed. Future research might look into enhancing classification models or extending the use to more subjects at once.

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