Yoga Pose Estimation using Angle Heuristic Approach

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***Abstract*—Pose estimation plays vital role in various applications related to fitness. Yoga aims to development of all-round personality. In the past, it is used to be performed under the supervision of expert. In this fast and continuously changing world, yoga asanas can be performed utilizing the presented solution in this paper. We have classified yoga asanas using Mediapipe and Angle heuristic approach. Mediapipe employs Blazepose model which can identify 33 body keypoints which are more than the determined by conventional approaches of keypoint detection methods.**

Keywords—Pose Estimation, Yoga, Classification, Angle Heuristic, Mediapipe, BlazePose, Keypoints

I. Introduction

Yoga is a spiritual practice that is centered on a very sensitive science that aims at bringing the mind and body into balance. A healthy lifestyle is indeed an art and science [1]. The word 'Yoga' is originated from the Sanskrit word 'Yuj,' which denotes 'to join.' Because of its numerous health advantages, the United Nations General Assembly has recognized June 21st as the "International Day of Yoga."

Pose estimation is a method for spotting human poses in photos or videos. It plays an essential role in body tracking and various pose estimation applications [2]. Yoga should be performed under the supervision of specialists because any inaccurate or terrible stance can bring about medical conditions like a lower leg sprain, muscle pulls, etc. [3]. In recent days computer-assisted training systems growing day by day and it also improves the performance of the user and reduces injuries [4].

In this paper, the concept of Angle Heuristic approach and MediaPipe framework has been applied to estimate the Yoga asanas. MediaPipe is a lightweight framework that can give real-time performance on low-end devices. It employs the lightweight convolutional neural network architecture, the BlazePose model for human pose estimation that detects 33 human key points such as the arms, face, feet, and hands [5]. The existing models (OpenPose, PoseNet, and DeepPose) follow COCO topology which can identify only 17 human keypoints.

The following are the major aspects of this paper:

- The MediaPipe framework has been used for the identification of the body keypoints from the input frame.
- Estimation of Yoga asanas is done using Angle Heuristic approach which classifies the asanas based on the angles calculated among the body keypoints.
- The estimation of yoga asanas from images and real-time input feed has been 3 presented.

The remainder of the paper is organized as follows:

Section 2 discusses an overview of relevant research activity. Section 3 describes the detailed methodology of pose estimation, while Section 4 discusses the outcome analysis. Section 5 outlines the conclusion and future orientation.

II. Related Work

There is a significant amount of research work has been carried out for the estimation of human pose. These semiautomated systems serve in the analysis of exercise and sports activities including the push-up counters, yoga pose categorization, and etc. In this section, research efforts in human pose estimation or yoga pose estimation have been discussed briefly.

Santosh Kumar Yadav and Jagdish Raheja [6] have proposed an approach for effectively categorizing Yoga asanas that incorporates a hybrid deep learning model, convolutional neural network (CNN), and long short-term memory (LSTM) . They implemented the CNN layer to extract features from the keypoints of each frame obtained through OpenPose, followed by LSTM, and achieved test accuracy of 99.04 % and 98.92 % in real-time testing.

S. Sankara Narayanan et al [7]. implemented OpenPose for detecting human body keypoints. They have compared the results of 2D and 3D points of the image and noticed if there is a need of adding more features that will lead to an increase in accuracy or not. Further, they have added a simple neural network that analyses the input images and coneys if the pose performed is correct or not.

Josvin Jose and Shailesh S. [8] presented different approaches, they have developed a system using convolutional neural network (CNN) along with transfer learning. They utilized photos of ten distinct asanas to train and assess the prediction accuracy. The model, which is supported by transfer learning, achieves a prediction accuracy of 85 %.

Mayben Chan Thar and Khine Zar Ne Winn et al. [9] used an angle heuristic approach to estimate the yoga Pose and OpenPose to detect the keypoints. The model measured the difference in given body angles between an instructor's and a user's pose and proposed a correction if it was more than the threshold. They evaluated the model upon three individuals by performing three distinct easy and basic yoga asanas.

Yash Agrawal and Yash Shah et al. [10] applied a tf-pose estimation algorithm to generate a human body skeleton in real time. Angles of human body joints are retrieved using the tf-pose skeleton and utilised as a feature in several machine learning models. Furthermore, they investigated several Machine Learning classification models and attained about 99.04 % accuracy using a Random Forest classifier.

III. METHODOLOGY

The proposed approach is explained in this section leveraging the Mediapipe framework and the BlazePose model. Yoga poses are examined using common pre-trained architectures for pose detection models. Using pre-trained pose detection architectures, we use OpenPose, PostNet, and DeepPose to extract visually discriminative and complicated features. CNN, or Convolution Neural Network, is one of the Deep Learning techniques that is mostly used for handling computer vision tasks without identifying handmade features in many pre-trained models. Huge volumes of data are frequently required to train a CNN, however obtaining large amounts of data for classification purposes can be difficult. The full explanation of MediaPipe and the proposed approach have been elaborated further.

A. *Body Keypoints Extraction*

MediaPipe is an elevated body pose tracking solution that uses the BlazePose method to derive 33 2D keypoints and background separation masks on the entire body from RGB video frames. Pose estimate for fitness applications is especially difficult due to the broad range of potential asanas (for example, hundreds of yoga asanas), various degrees of freedom, occlusions of the body or other objects clump limbs as observed from the camera, and a variation of appearances or attire. BlazePose effectively detects more keypoints, making it perfect for fitness applications. Furthermore, existing state-of-the-art methodologies for inference rely mostly on expensive desktop systems, but this method delivers real-time performance on mobile phones using CPU inference.

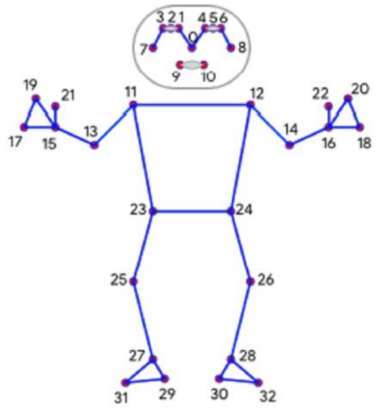

Fig. 1. BlazePose 33 keypoint topology [11]

The COCO topology, which includes 17 markers in the torso, arms, legs, and face, is the current standard for human body posture. But, the COCO keypoints are solely focused on the ankle and wrist points, leaving hands and feet without size and orientation information, which is significant for practical applications such as fitness and dancing. More keypoints are required for the following implementation of domain-specific pose estimation models, such as those for hands, faces, or feet.

We are able to locate an unique topology of 33 human body keypoints employing BlazePose, which is a superset of the COCO, BlazeFace, and BlazePalm topologies. This enables us to determine body semantics based on just pose prediction, which is compatible with face and hand models.

B. *Angle Heuristic Approach*

Angle heuristics methodology is used to classify the asanas, Individual poses have a unique set of angles where they could be classified as asanas, for extracting the angle from a particular Position the mediapipe library is used which creates the keypoints for that particular pose and for consideration of angles keypoint number (elbow, shoulder, hand) similarly for below waist (hip, ankle, leg) is extracted then if a condition is applied for that specific pose and it matches the condition applied the result is displayed showing the name of the asana, similarly such conditions are applied on sitting and standing asanas.

Fig 2. Virabhadrasana Asana

The above asana can be delineated as the outcome of the following angles.

- A shoulder angle of 90 degrees on both sides.
- Both elbows are at 180 degrees.

- The front leg and waist are at a 90-degree angle.
- The rear knee is at a 180-degree angle.
- The waist is at a 135-degree angle.

The angles have been generated using these pose landmarks. The angle at the right front leg and waist, for example, is the angle formed by the lines from the right shoulder to the right hip and the right hip to the right knee.

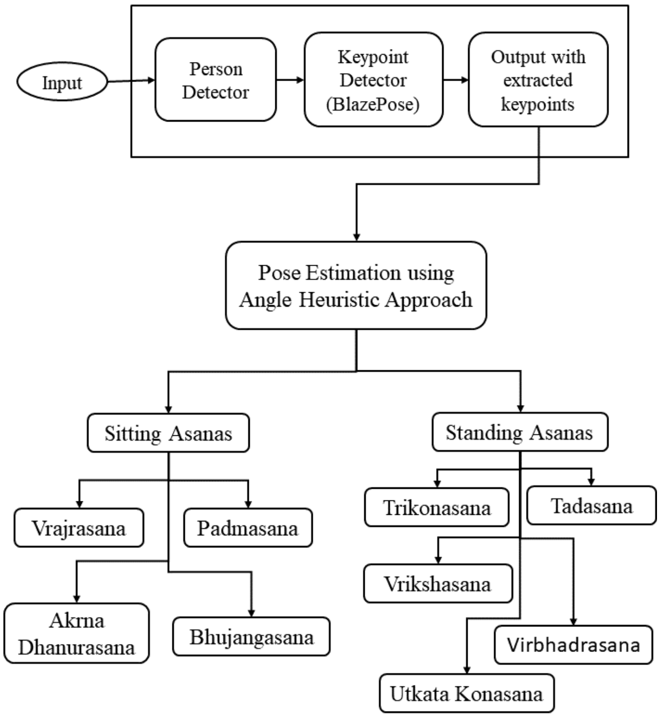

Fig 3 .Workflow of Proposed Work

IV. Result And Analysis

The section contains, our experimental work findings presented. The system on which experiments are carried out consisted of NVIDIA GEFORCE 2GB GPU, 16GB RAM, Intel Core i7 8th generation processor, and 520GB SSD. Python 3.6 programming language and Mediapipe Library were utilized. Self-captured images were used as datasets containing different poses for sitting and standing asanas. In our experiments for each pose, a mean average was taken of each angle obtained from 5 test images for the specific pose, The input data contains 50 samples each further divided into standing asanas and sitting asanas containing 5 classes and 4 classes respectively with 50 images in each class. After Evaluating on various measures on the sample Sitting and standing asanas dataset like using different clothing types still asanas were classified correctly, similarly, two different people with distinguishable height differences the mediapipe library was able to predict the landmarks accurately and classify the given pose for both genders. After performing testing 10 times on 5 individual images for each specific asanas and an +-error of 15 degree is obtained for asanas and the obtained results are presented in Table 1.It can be clearly distinguished after comparison that pose classification using deep learning gives better results because multiple If conditions will be needed for each asana to be added, while in a deep learning model only dataset is required for that specific asanas.

(a) (b)

Fig. 3. Image (a) refers to original image and (b) refers to classified image

TABLE I. TABLE FOR ANGLES OF DIFFERENT ASANAS

	ARM ANGLES				LEGS ANGLE	
ASANAS	RIGHT ELBOW ANGLE	LEFT ELBOW ANGLE	RIGHT SHOULDER ANGLE	LEFT SHOULDER ANGLE	RIGHT KNEE ANGLE	LEFT KNEE ANGLE
Virabhadrasana	> 165 & < 195	> 165 & < 195	> 80 & <110	> 80 & <110	> 165 & < 195	> 90 & <120
Vrikshasana	-	-	-	-	> 165 & <195	> 25 & <45
Trikonasana	> 155 & <195	> 155 & <195	-	-	> 160 & < 195	> 160 & < 195
Tadasana	-	-	> 160 & <195	> 160 & <195	> 160 & < 195	> 160 & < 195
Utkata Konasana	>75 & <105	> 255 & < 285	-	-	> 255 & < 285	>75 & <105
vajrasana	-	-	-	-	>0 & <45	>0 & <45
Bhujangasana	-	-	>0 & <30	>0 & <30	> 160 & < 195	> 160 & < 195
Padmasana	-	-	>0 & <30	>330 & <360	>330 & <360	>0 & <25
Akarna Dhanurasana	-	-	-	-	-	-

Fig. 4 classified output images

Fig. 5. Classified images of Yoga Asanas

V. CONCLUSION AND FUTUREWORK

In this paper, Yoga Pose Classification problem is addressed using the angle heuristic approach. Firstly, 33 body keypoints have been extracted using the MediaPipe framework. After that angle heuristic method is applied to classify the yoga poses. It has been observed that while using this angle heuristic approach , one must be very careful for defining angles of different yoga asanas. Thus this may draw towards low accuracy and misidentification between two similar asanas.

In future, our proposed work of classification of yoga asanas can be coupled with deep learning approaches using different approach for keypoint detection. Along with that classes of yoga asanas can be extended which will provide wide range of asanas.

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Appendix: BlazePose keypoint names

0. Nose	11.Left shoulder	22. Right thumb
1.Left Eye inner	12. Right Shoulder	23. Left hip
2. Left Eye	13. Left elbow	24. Right hip
3. Left Eye Outer	14. Right elbow	25. Left knee
4. Right Eye Inner	15. Left wrist	26. Right knee
5. Right eye	16. Right Wrist	27. Left ankle
6. Right eye outer	17. Left pinky	28. Right ankle
7. Left ear	18. Right pinky	29. Left heel
8. Right ear	19. Left index	30. Right heel
9. Mouth left	20. Right index	31. Left foot index
10. Mouth right	21. Left thumb	32. Right foot index