Yoga Pose Estimation Using Rule-based Approach

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***Abstract*—Due to high computing requirements and a lack of available datasets, precise pose detection in yoga is a challenging task. Since even small modifications can have negative effects, suggestions should be made precisely[1-2]. Pradhan is a rule-based technique which is used to guide people who practice yoga at the convenience of their homes. Pose estimation's primary goal is to foretell human poses by identifying key points like elbows, knees, wrists, and so on. In this paper, we have proposed a system which uses rule-based techniques on every frame that was processed by the Mediapipe Framework. In this technique, the user can either upload images or perform a yoga posture in front of a camera which is then used to classify the posture from a set of 10 pretrained postures. The yoga poses used are Dolphin Pose, Half-Moon Pose, High Lunge Pose, Mountain Pose, Side Plank Pose, T-Pose, Tree Pose, Upward Salute Pose, Warrior-II Pose and Warrior-III Pose. When the work is put into practice, a real-time video feed from the user's computer's webcam is collected, and the yoga pose's estimation is done. This research work used angle heuristics to categorize various yoga postures for pose detection, and we were able to achieve a combined accuracy of 93%.**

***Index Terms*—yoga, angle heuristics, accuracy.**

I. Introduction

The Indus-Sarasvati civilization, which thrived in the Indian subcontinent around 5000 years ago, is believed to have contributed to the development of the yoga practice[3-4]. The term "yoga" refers to a close connection and integration of the mind and the body. Through asana, meditation, and other practices, it is utilized to keep the body and mind in balance throughout all of life's ups and downs [5]. Due to the growing stress levels in the modern lifestyle, yoga has recently attracted interest on a global scale. Many people choose self-learning in fast-paced environments because resources such as Internet, books, recorded clips, and personal tutors might not always be accessible. Nowadays most people practice yoga at the convenience of their homes[6].

Like any workout, it is crucial to perform yoga poses correctly because any incorrect posture is counterproductive and often harmful. AI-based technology assists in recognizing yoga poses and offers users feedback or recommendations. These guidelines assist users in making their poses more advantageous rather than harmful [7].

The integration of AI technology in the yoga industry has also opened new opportunities for research and development. For example, researchers can use AI algorithms to analyze large datasets of yoga practitioners and identify patterns in their behavior and performance. This data can be used to improve the effectiveness of yoga training programs and optimize the design of yoga equipment and accessories [8].

Intelligent yoga trainers have recently benefited from the development of posture measurement techniques. A real-time position estimation-based yoga training system is what this research wants to create. The proposed method was compared to several state-of-the-art methods and was found to have less computational complexity. Experimental results show that this method can show high real-time performance on home computers and high accuracy on real data sets [9].

II. Proposed Methodology

In this paper, a rule-based yoga pose estimation system is proposed to detect yoga poses from a set of 10 pre-trained poses as shown in Figure 1. The proposed approach consists of the following steps:

1) **Feature Extraction:** Videos or images are given as input to the system, and frames are extracted at regular intervals from videos using OpenCV[12] Python Module. These frames are then sent to Mediapipe Pose Estima- tion Python Framework to extract key points. From these key points, 8 joint angles are calculated[13-15].

2) **Pose Estimation:** The above calculated angles are then fed into a rule-based system to estimate the pose among a set of 10 poses[16].

To estimate the 3D coordinates of human body keypoints, the Pose Estimation module in MediaPipe employs a multi-stage pipeline that includes a detector network with a keypoint regression network. The keypoint regression network then calculates the 3D coordinates of the body keypoints once the detector network first detects the presence of a human body in an input image or video frame.

Using this framework, the image is transformed into a set of 33 coordinates, which include the x, y, and z points as well as the visibility of the object in focus in each frame as shown in Figure 2. The keypoints include the shoulder, hip, elbow, and knee on both the left and right sides of the body. By analyzing the changes in the position and visibility of these keypoints

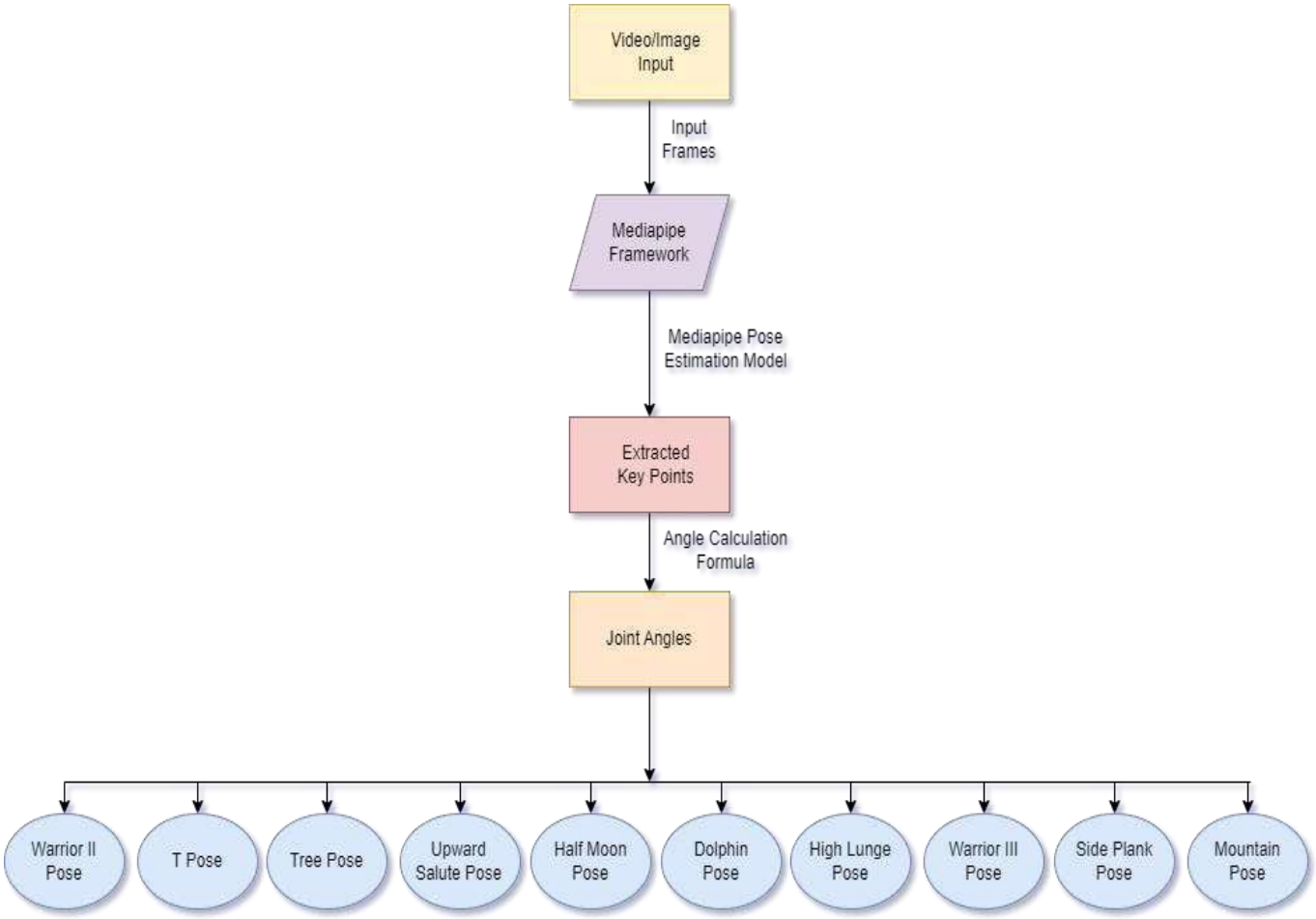

Fig. 1. Proposed System Flow.

over time, the module can determine whether the yoga posture is being performed correctly or not [10].

The angles which are fed into the rule based system can be calculated, once the keypoints or joints are detected. For example, let's consider calculating the angle formed by three joints: A, B, and C. Each joint is represented by a 2D coordinate, denoted as (x, y), where 'x' and 'y' represent the horizontal and vertical pixel coordinates in the image, respectively. Trigonometry is used to calculate the angle between joints A, B, and C. The angle between the y-axis and the lines resulting from the points B-A and B-C is determined by the arc tangent function. The angle in degrees is then calculated by multiplying the absolute value of this difference by a conversion factor. If the calculated angle is greater than 180 degrees, it is converted to the complementary angle (360-angle) to ensure it always represents the smallest angle between the two line segments [11].

III. Poses With Psuedo Code

Remove the last 2 lines and replace with the following: The different yoga poses estimated in this work are Dolphin Pose, Half-Moon Pose, High Lunge Pose, Mountain Pose, Side Plank Pose, T-Pose, Tree Pose, Upward Salute Pose, Warrior-II Pose and Warrior-III Pose and is shown in Figure 3.

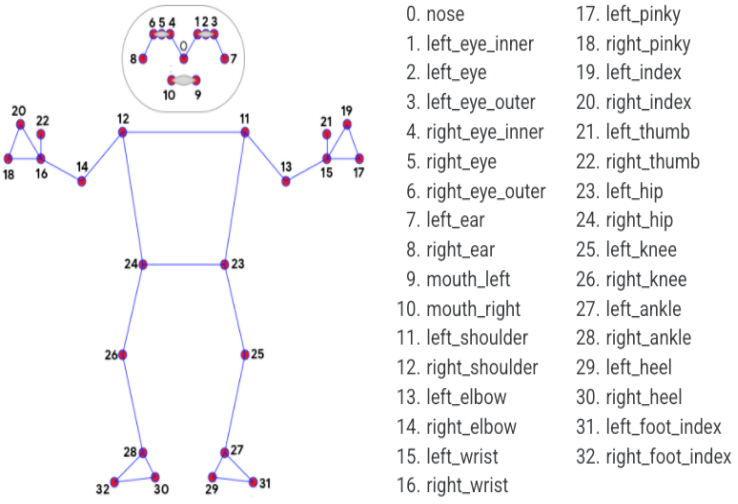

Fig. 2. Mediapipe 33 Pose Landmarks

Pose1: Dolphin Pose

Pose2: Half Moon Pose

Pose3: High Lunge Pose

Pose4: Mountain Pose

Pose5: Side Plank Pose

Pose6: T Pose

Pose7: Tree Pose

Pose8: Upward Salute Pose

Pose9: Warrior II Pose

Pose10: Warrior III Pose

Fig. 3. Ten different Yoga Poses

Listing 1. **Code Snippet for Classifying Yoga Poses:**

```
if left_elbow_angle>a1 and left_elbow_angle<a2 and
right_elbow_angle>b1 and right_elbow_angle<b2:
    if left_shoulder_angle>c1 and left_shoulder_angle<c2 and
    right_shoulder_angle>d1 and right_shoulder_angle<d2:
        if left_hip_angle>e1 and left_hip_angle<e2 and
        right_hip_angle>f1 and right_hip_angle<f2:
            if left_knee_angle>g1 and left_knee_angle<g2 and
            rightknee_angle>h1 and right_knee_angle<h2:
                label = "YOGA POSE"
```

Pose1 - Dolphin Pose: To correctly perform the dolphin pose in yoga, certain conditions should be met. These include maintaining angles of both left and right shoulders between 150 to 180 degrees, angles of both left and right elbows between 70 to 130 degrees, angles of both left and right hips between 20 to 70 degrees, and angles of both left and right knees between 160 to 180 degrees. However, it is important to note that these criteria are not the only factors to consider in identifying the pose. Each individual's body is unique, and their yoga practice may vary.

Pose2 - Half Moon Pose: The Half Moon pose, is an intermediate level standing yoga pose that involves balancing on one foot with one arm extended towards the ground and the other arm extended towards the ceiling. The Half Moon yoga pose can be identified by meeting the following criteria: the angle of the left shoulder should fall between 80 to 140 degrees, and the angle of the right shoulder should be between 65 to 120 degrees. Additionally, the angles of both the left and right elbows should fall within the range of 165 to 195 degrees, and the angles of both the left and right hips should fall within the range of 20 to 70 degrees. Finally, the angles of both the left and right knees should fall within the range of 160 to 180 degrees[17].

Pose3 - High Lunge Pose: To determine whether a yoga pose is the High Lunge, specific conditions must be met. These conditions include having the left and right shoulder angles between 150 to 180 degrees, as well as the left and right elbow angles between 150 to 180 degrees. The left hip angle must be within 110 to 150 degrees, while the right hip angle should be between 110 to 160 degrees. Moreover, the angles of both the left and right knees must either fall between 90 to 130 degrees or 160 to 180 degrees or the reverse of these ranges. In addition, the High Lunge pose can be modified to suit different levels of practice or physical abilities by using props, such as blocks or blankets, or adjusting the depth of the lunge.

Pose4 - Mountain Pose: The Mountain pose is a foundational posture in yoga, often used as a starting position for other asanas. It can be identified by meeting certain requirements. Specifically, the left and right shoulder angles should be in the range of 0 to 30 degrees, while both the left and right elbow angles should be in the range of 165 to 195 degrees. Additionally, the left and right hip angles should fall within the range of 165 to 195 degrees, as should the angles of both the left and right knees. Additionally, the Mountain pose is a great way to practice mindfulness and deep breathing, which can help reduce stress and increase relaxation[18].

Pose5 - Side Plank Pose: In order to categorize a particular yoga, pose as the Side Plank, a set of conditions must be fulfilled. These conditions dictate that the angle of the left shoulder and right shoulder must fall between either 60 to 100 degrees or 90 to 150 degrees (or vice versa). Additionally, the left and right elbow angles must be in the range of 150 to 180 degrees, while the left and right hip angles should be between 150 to 180 degrees. Finally, the left and right knee angles must also fall within the range of 150 to 180 degrees. To achieve the correct alignment in this pose, it is important to engage the muscles of the arms, core, and legs while maintaining a steady breath. With practice, this pose can help to build strength and endurance in the entire body[19].

Pose6 - T Pose: To classify a particular yoga pose as T pose, the following criteria have to be met: The practitioner's left shoulder and right shoulder angles should fall within the range of 165 to 195 degrees, indicating that the arms are raised perpendicular to the body. The left elbow and right elbow angles should be between the range of 80 to 110 degrees, indicating that the arms are bent at the elbows. The left hip and right hip angles should also be between the range of 165 to 195 degrees, indicating that the legs are straight and hip- width apart. Finally, the left knee and right knee angles should be between the range of 160 to 195 degrees, indicating that the knees are slightly bent. These specific joint angles allow the practitioner to achieve the T pose, which is

an essential foundation for many yoga poses.

Pose7 - Tree Pose: The Tree yoga pose can be identified by satisfying certain conditions. These conditions state that the angle of both the left and right shoulders should be between 210 to 240 degrees, as well as the angle of both the left and right elbows. Moreover, the angles of both the left and right hips should fall within the range of 165 to 195 degrees, while the angles of both the left and right knees should fall within the range of 165 to 195 degrees, or something similar. In addition to meeting the specific angle ranges for the shoulders, elbows, hips, and knees, there are some other important factors to consider when performing the Tree pose. These include maintaining a strong core and a steady gaze, as well as focusing on your breath to help maintain balance and stability.

Pose8 - Upward Salute Pose: In order to identify the Upward Salute yoga pose, certain conditions need to be met. Specifically, the angles of both the left and right shoulders, elbows, hips, and knees should all fall within the range of 165 to 195 degrees. In addition to meeting the angle requirements for the shoulders, elbows, hips, and knees as mentioned above, it is important to focus on proper alignment and posture while performing this pose. This includes engaging the core muscles, keeping the spine straight, and lifting the chest towards the ceiling while maintaining a steady breath.

Pose9 - Warrior II Pose: The Warrior II yoga pose can be identified by fulfilling specific conditions. These conditions require that the angle of both the left and right shoulders fall within the range of 165 to 195 degrees, while the angle of both the left and right elbows should be between 80 to 110 degrees. Moreover, the angles of both the left and right hips should be in the range of 165 to 195 degrees, while the angles of both the left and right knees must fall within the range of 90 to 120 degrees. Warrior II pose is a popular yoga pose that can help build strength, flexibility, and endurance. In addition to the criteria mentioned above, proper alignment and form are important in performing this pose safely and effectively[20].

Pose10 - Warrior III Pose: The Warrior III yoga pose can be identified by satisfying specific conditions. These conditions require that the angle of both the left and right shoulders should be within the range of 140 to 180 degrees, and the angle of both the left and right elbows should be in the range of 150 to 180 degrees. Furthermore, the angles of both the left and right hips should either be in the range of 80 to 130 degrees or 150 to 180 degrees (or vice versa). Finally, the angles of both the left and right knees must fall within the range of 150 to 180 degrees[21].

IV. Result

The proposed yoga pose estimation model was evaluated on a dataset consisting of 10 users, each performing 10 different yoga poses, resulting in a total of 100 samples. The model's performance was assessed using accuracy, which was calculated as

$$\text{Classification Accuracy} = \frac{\textbf{Total number of Correct Classifications}}{\textbf{Total number of input samples}}$$

The obtained results revealed that the proposed model achieved an accuracy of 93% on the testing set, indicating its ability to accurately estimate yoga poses from the inputs of the 10 users.

The model was tested on 10 different individuals and the observations were noted as in Table 1. Table 1 shows whether the model accurately detected the pose when the user performed it. Poses from 1 - 10 corresponds to Dolphin Pose, Half-Moon Pose, High Lunge Pose, Mountain Pose, Side Plank Pose, T-Pose Tree Pose, Upward Salute Pose, Warrior-II Pose, Warrior-III Pose respectively. Hence after evaluating the results after observing 10 users, the model was found to have a classification score of **93%**. It is essential to remember that a number of variables, including user variances, variations in how poses are executed, and potential inaccuracies in body landmark identification caused by bad lighting or intricate backdrops in the photographs, could affect how accurate the model is. The suggested model, however, has the capacity to accurately estimate yoga positions from inputs of the 10 users, as seen by the accuracy of 93% that was attained. It is noted that the current study has limitations, such as the relatively small sample size of 10 users and the constrained amount of yoga postures that each user performed.

V. Conclusion

The research findings indicate that the proposed yoga pose estimation model has a respectable accuracy of 93%. It should be emphasized, nevertheless, that the estimating procedure may encounter inaccuracies due to several reasons, including inadequate lighting and complicated backgrounds, which could result in inaccurate angle measurements and subsequent pose estimate mistakes.

Furthermore, the precise recognition of body landmarks may be hindered by complicated backdrops in the image frames, which will also negatively impact the performance of the model. Several actions could be taken to resolve these issues and improve the suggested model's accuracy. First off, better illumination during data collection, such as controlled lighting setups or changing camera settings, could help lessen the effect of bad lighting on angle measurements. Additionally, preprocessing methods could be used to improve the visibility of body landmarks, particularly in dim lighting circumstances,

TABLE II
CLASSIFICATION REPORT (YES, IF CLASSIFIED CORRECTLY ELSE NO)

Yoga Pose	Users									
	User 1	User 2	User 3	User 4	User 5	User 6	User 7	User 8	User 9	User 10
Dolphin Pose	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Half Moon Pose	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
High Lunge Pose	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Mountain Pose	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Side Plank Pose	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
T Pose	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Tree Pose	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Upward Salute Pose	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Warrior II Pose	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Warrior III Pose	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

such as contrast enhancement or picture normalization. Utilising advanced computer vision techniques, such as backdrop removal or segmentation, to separate the human body from complicated backgrounds and increase the accuracy of body landmark identification is another potential approach. To further evaluate the model's performance, future study might take into account enlarging the dataset with more participants and a wider variety of yoga positions. Additionally, by employing tactics like controlled lighting setups, preprocessing techniques, and advanced computer vision methodologies, efforts might be made to reduce the impact of potential issues, such as bad lighting or complex backgrounds, on the accuracy of the model. In summary, this study's findings show that the suggested model for estimating yoga positions from inputs of 10 users performs successfully, with an accuracy rate of 93%. The results show that the constraints of sample size and potential affecting factors should be addressed in future study and improvements.

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