# A framework for the biomechanical analysis of Lateral Angle and Stance Width Ratio Error

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***Abstract*—Competitive sports like basketball necessitate rapid and intense movements, such as jump landings, which can make athletes susceptible to injuries from neuromuscular control and joint mechanics. Biomechanical features during landings are closely related to the importance of proper movement execution and postural stability. The study provides a novel image analysis framework to evaluate the comprehensively jump-landing biomechanics in athletes, aiming to identify irregular movements and incorrect postures. It can provide recommendations to coaches regarding injury prediction and athlete training requirements. This framework offers a unique approach to understanding lateral flexion and stance width ratio errors. This feature contributes to a deeper understanding of Injury Mechanisms and Prevention Strategies and provides personal training.**

***Index Terms*—Pose Estimation, Landing Error, Supervised learning, Training, MediaPipe, Roboflow, Basketball, Computer Vision, Machine Learning, Sports Analytics.**

## I. Introduction

In many sports, high-intensity activities done for a long time may lead to the risk of injury. The injury could result from incorrect posture and movements while playing the game, reducing neuro-muscular control. The injuries can affect the performance of players and the team. Therefore, it is essential to identify the wrong postures and movements. This project aims to identify such postures and movements that may help in the early detection of such errors. Thus, to detect the incorrect posture, the ratio of the distance between the shoulder key points and the distance between the ankle key points is employed. Similarly, lateral flexion, the angle made by the midpoint of the distance of shoulders, the midpoint of critical points of the hip, and the midpoint of critical points of the ankle, is used to recognise incorrect movements.We used Google's media pipe pose and Roboflow for detection and annotation purposes and further develop a model to predict such errors made by players.

## II. Methodology

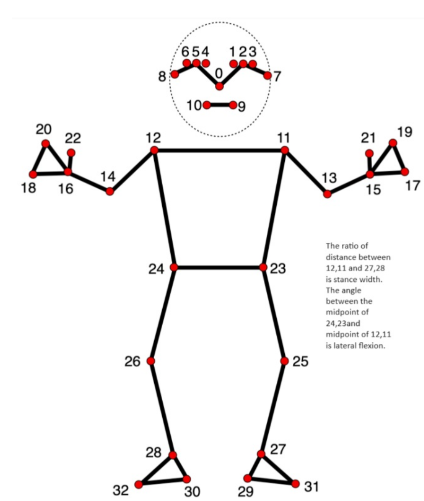
The video is first segmented into individual frames, and each frame is converted from BGR to RGB format to maintain compatibility with MediaPipePose.It utilizes ML and BlazePose to estimate 2D coordinates of movements and posture. From 33 body landmarks, we are evaluating four landmarks (11,12,27,28) for kinematic feature estimation. The coordinates obtained are first normalized (x*960,y*544) with the respective image. Using the Euclidean distance and Cosine angle, we compute kinematic features for each frame – a mixture of angles between body landmark key points and ratios between distances. In the next step, we calculate the hip midpoint, shoulder midpoint, and top frame midpoint(the image's center point) to calculate the lateral flexion angle.

**Algorithm 1** Error Detection Algorithm

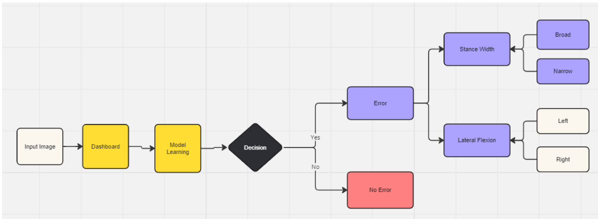
1: 1. Load the input image from a file.
2. Initialize an empty list to store the details obtained from the detection and processing steps.
3. For each pose landmark point to be detected:
3.1. Determine the approximate location of the landmark point in the image based on its index.
3.2. Record the pixel coordinates of the landmark point.
4. Calculate the distance between the shoulder points and the ankle points using the Euclidean distance formula.
5. Calculate the stance ratio by dividing the shoulder distance by the ankle distance.
6. Determine the stance error based on the stance ratio:
6.1. If the stance ratio is within the range [0.8, 1.2], mark as "no error".
6.2. If the stance ratio is less than 0.8, mark as "wide stance error".
6.3. If the stance ratio is greater than 1.2, mark as "narrow stance error".
7. Calculate the midpoint of the hips and the top of the frame.
8. Compute the lateral angle formed by the top of the frame, hips, and shoulders.
9. Determine if the lateral angle indicates an error:
9.1. If the lateral angle is within the range [0, 3.1] or [176.9, 180], mark as "no error".
9.2. Otherwise, mark as "error". And based on the points left or right lateral flexion is also provided.
10. Save all the details obtained from the detection and processing steps.

## III. Preprocessing of Dataset

The video was initially tilted which was adjusted using Adobe Video Editor. We extracted 210 frames (6 fps) from a 35 sec video of the athletes while jumping; these frames will be further processed for the dataset's annotation (Stance width, Lateral Flexion). Annotations will be done using Roboflow, and this would work as the training dataset for the model.



## IV. Proposed Framework

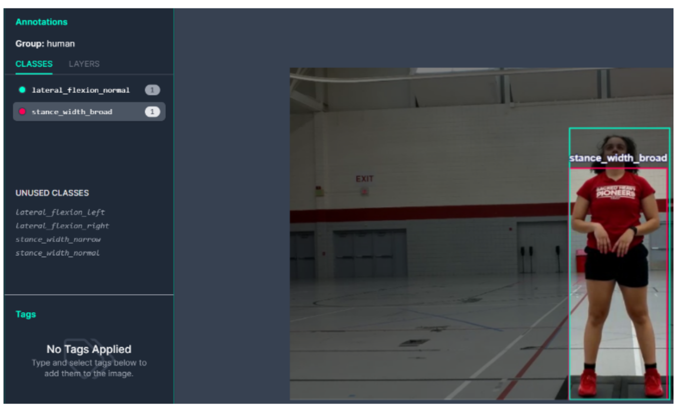


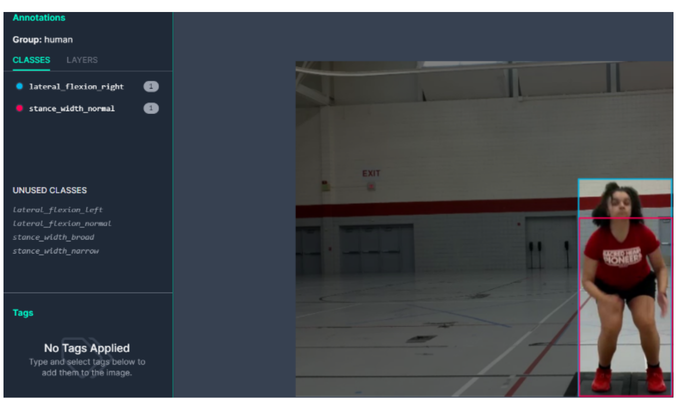

## V. Results

The video dataset has been converted to frames and pose estimation using MediaPipe has been done and then using the keypoints two errors stance width and lateral flexion have been calculated using the results, training dataset has been generated using roboflow which would be further used for the model learning.

## VI. Images

The below image demonstrate how to calculate stance width and lateral flexion from coordinates




## VII. Discussion

In this project, we have used MediaPipe by Google to extract the keypoints on human body. Further, we have processed the extracted keypoints to find the stance ratio by dividing the shoulder keypoint distance by ankle keypoint distance. Furthermore, we have used the midpoint of shoulder keypoints, midpoint of hip keypoints and midpoint of ankle keypoints, to find the lateral flexion. Using the processed data, we annotated the errors with the help of Roboflow software. Next, we aim to develop a model which trains on this annotated dataset. Further, it takes images as input and output's whether error was made or not. Code implementation - colab link

## VIII. Conclusion

The project aims to detect the errors made by athletes while playing high-intensity games like basketball and football. The early detection of such errors will help in preventing the risk of injuries. To achieve this, we first extract keypoints using MediaPipe, calculate whether error was made or not, annotate it using software. We further plan to develop a model which will train on annotated dataset. The trained model will take in the image as input and output error or not.

## IX. References

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