# Technical Report: Rule-Based Yoga Pose Detection for Marjaryasana

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## Objective

This project aims to implement a rule-based system to detect Marjaryasana (Cat Pose) using keypoint data extracted from MediaPipe. The system uses geometric rules and thresholds to classify the pose based on angles, distances, and alignments between body landmarks.

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## Overview

Marjaryasana is characterized by a rounded back, lowered head, and a specific alignment of hands and feet. The detection system processes input images, extracts body landmarks, and applies mathematical rules to identify the pose. The implementation demonstrates the ability to analyze pose geometry systematically and highlights technical and analytical skills relevant to the internship role.

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## Implementation

### 1. Tools and Libraries

- **MediaPipe Pose:** To extract 33 skeletal landmarks from images.
- **OpenCV:** For image processing and visualization.
- **NumPy:** For mathematical calculations (e.g., vector operations and angle computation).

### 2. Functional Approach

#### a. Keypoint Extraction

MediaPipe was used to extract normalized keypoints. These were scaled to pixel coordinates based on the input image dimensions for further analysis.

#### b. Geometric Rules

The detection logic was based on the following:

- **Curved Back:**
  - The angle between the left shoulder, left hip, and left ankle was computed. An angle between **130° and 160°** indicated a properly curved back.
- **Head Down:**
  - The vertical distance between the nose and left shoulder was checked. A threshold of **greater than 10 pixels** indicated the head was sufficiently lowered.
- **Hands and Feet on Ground:**
  - Wrist and ankle positions were compared with hips and shoulders to confirm ground contact.
- **Straight Hand-Knee-Foot Lines:**
  - The angles between the wrist, knee, and ankle were calculated for both sides. Angles in the range **170° to 190°** indicated alignment close to a straight line.

#### c. Visualization

Input images were annotated with body landmarks and detection results using MediaPipe and OpenCV utilities.

#### d. Final Pose Classification

The pose was classified as Marjaryasana if all conditions were met:

1. Curved back.
2. Head pointing downward.
3. Hands and feet touching the ground.
4. Alignment of hand-knee-foot in straight lines on both sides.

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## Results

- **Detection Accuracy:**
  - The system reliably detected Marjaryasana in well-framed images with clear poses.
- **False Negatives:**
  - Occurred when the back curvature was less pronounced or the head position slightly deviated.
- **False Positives:**
  - Rarely, poses with similar configurations (e.g., tabletop pose) were incorrectly identified.

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## Challenges and Solutions

**1. Noisy Landmarks**

Landmark predictions occasionally fluctuated, affecting angle calculations. This was mitigated by setting reasonable thresholds and ranges for conditions.

**2. Pose Variability**

Variations in pose execution (e.g., back curvature, head position) made rigid thresholds ineffective. Flexible angle and distance ranges were introduced to accommodate natural variations.

**3. Image Quality and Occlusion**

Low-quality images or occluded landmarks (e.g., hands not visible) posed challenges. A fallback mechanism handled missing landmarks by assigning default values.

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## Key Insights

- **Rule-Based Systems Are Effective:** A well-defined set of geometric rules can detect structured poses without complex models.
- **Threshold Tuning is Crucial:** Setting appropriate ranges for angles and distances was key to handling variability in human poses.
- **Visualization Enhances Usability:** Annotated images provide immediate feedback on detection success and help debug inaccuracies.

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## Future Scope

1. **Enhanced Robustness:**
    - Test with a larger, more diverse dataset of yoga poses to improve accuracy.
2. **3D Analysis:**
    - Incorporate depth data to improve detection in three dimensions.
3. **Real-Time Processing:**
    - Extend the system for real-time video analysis during yoga sessions.
4. **Feedback Mechanism:**
    - Add suggestions to guide users in correcting their pose.

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## Conclusion

This project successfully implemented a rule-based system to detect Marjaryasana using geometric properties derived from MediaPipe landmarks. The approach demonstrated a clear

understanding of pose geometry and proficiency with tools like MediaPipe, OpenCV, and Python. While the system performed well under controlled conditions, future enhancements can address limitations to make it more robust and scalable.

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## Attachments

1. **Code Implementation**
2. **Report**

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