

ML Report

On

**Yoga Pose Detection and Correction**

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**ABSTRACT**

The aim of this project is to create a real-time yoga pose sensor and correction system, enabling people to practice yoga in a safe and effective manner, without requiring instructors. The system operates by detecting the user's pose via webcam, analyzing the user's pose in combination with the MediaPipe pose library and OpenCV methods, using computer vision and machine learning methods. The system will correctly recognize specific yoga poses, downward-dog pose, goddess pose, lotus pose, butterfly pose, and easy pose (meditation) determining that the user performed the pose correctly based on the relative positions and angles of key body landmarks. If you did not have the ideal pose, immediate feedback will provide help the user in the correct way. This system is for enabling users to practice yoga without worrying about injuries.

**Keywords:** Yoga pose detection, pose correction, computer vision, MediaPipe, OpenCV, real-time feedback

1. **INTRODUCTION –**

Yoga has become a prominent and growing worldwide practice that incorporates a holistic approach to health and promotes not only physical fitness but mental clarity and spirituality [1]. The heightened levels of personal health and awareness of fitness and mindfulness have contributed to an notable increase in the number of people beginning yoga, including digital and home-based formats. However, one of the ongoing drawbacks of practicing yoga independently is the limited real-time feedback, and the inability to rectify body posture or gilt, often found in traditional classes, taught by a teacher [2]. Wrong posturing can not only lessen the effectiveness of the yoga practice, but can also contribute to body strain or injury over a period of time. There is a need as well as a trend for smart systems which engage the user by identifying incorrect postures and providing timely corrections, as a virtual yoga instructor [3].

The aim of our project, entitled "Yoga Pose Detection and Correction System", is to contribute to a solution to this problem, by providing users real-time visual and textual feedback on their poses through machine learning and computer vision. Although similar pose estimation systems exist, which estimate body posture, our model primarily focuses on correcting poses and correcting gold-classified yoga poses, by utilizing landmark detection and checking for angles [4].

We created a custom dataset created specifically for six beginner-friendly but foundational yoga poses: Tree Pose (Vrikshasana), Downward Dog Pose (Adho Mukha Svanasana), Goddess Pose (Utkata Konasana), Lotus Pose (Padmasana), Butterfly Pose (Baddha Konasana), and Easy Pose (Sukhasana) [5]. Each pose image in our dataset is annotated with 33 body landmarks defined by the MediaPipe Pose library, with a focus on the joints and angles of limbs of importance for correcting a pose [6]. Our dataset is different from other generalized fitness datasets that depict a variety of activities, as our dataset is specific to improving accuracy for both pose detection and correction involved in yoga practice [7].

Using MediaPipe Pose and OpenCV, skeletal data was extracted from the live webcam input and in real-time to quantify joint angles and relations between landmarks. Then, joint angles and relations were compared against thresholds for each pose to determine if the yoga posture was correct [8][9]. If the pose did not meet the required threshold of accuracy, corrective feedback was given instantaneously on-screen, so that the user was aware of their posture deviation. If the pose was correctly aligned, a confirmation message would appear, and the pose was logged as valid [10].

The feedback loop is designed to be rapid, intuitive and low-intervention, and has the intention to emulate a real-time coach without requiring the user to wear any sensors or any other advanced device [11]. Using a learner's poses imagery to run the feedback loop meant that the system was simple to use and could be developed as a scalable home practice system focusing on beginner poses, which only needed reference images to run feedback [12]. The overall goal of this type of software is to guide practitioners not only to accurately engage with poses, but also to develop proper technique and a muscle memory experience over time.

1. **PROBLEM STATEMENT –**

With the growing popularity of home workouts and virtual training, many yoga practitioners, particularly beginners, don't have access to adequately trained instructors which results in improper postures and potential injuries. In-person classes and training may not be some available option in rural locations or in times of health crisis. In this supplement, we propose an AI-powered, real-time Yoga Pose Detection and Correction system based on MediaPipe Pose for web camera-based Yoga practice. The system gathers video stream information of the participant, analyzes the pose of the participant against the correct pose and then, provides instant visual feedback which can facilitate a safe, effective and enjoyable yoga practice.

1. **MOTIVATION –**

Although Yoga provides a plethora of advantages for physical and mental well-being, success in yoga practice relies on the delivery of accurate postures. Practitioners need to be conscious of accuracy in order for results to happen and for them to prevent injury. Unfortunately, the majority of practitioners - especially beginners or practitioners in exclusively remote areas - lack access to qualified instructors and may be executing incorrect posture resulting in long-term health concerns [1][3]. From an instructor perspective, it is simply unreasonable to manually correct each individual practitioner's pose in both solo and home practice - especially during timeframes where participants are engaging in live classes [2][6].Recent advances in artificial intelligence and computer vision have provided the opportunity to develop a real-time posture detection system. Specifically, posture detection systems that can compare a user's pose to an ideal position of the body. Feedback can be provided in real-time and when users execute a technique incorrectly, they can be reinforced in order to reduce the likelihood of performing poorly or improperly [4][7]. The inclusion of OpenCV, MediaPipe, and deep learning models like MoveNet have expedited the development and accessibility of pose estimation on consumer-level hardware [5][11].

By employing these technologies, yoga practitioners will have access to real-time guidance, like having a personal coach, which offers a better learning and retention of poses [8][10]. Similar systems have demonstrated effectiveness in previous studies in areas to include physical therapy and sports training which shows it is possible to influence the end health outcomes for them [9][13]. Using similar technology in yoga makes practice more inclusive and accessible, while also promoting the more contemporary notion of personalized digital health technology [12][15]. This project aims to amalgamate a traditional yoga practice with developing AI technology to offer a supportive and intelligent correction system for users as they practice with safety and consistency [14][1].

1. **OBJECTIVES –**

* To build a system for detecting and correcting yoga poses in real-time, using MediaPipe and computer vision technology.
* To provide real-time feedback by analyzing the position and angles of body joints.
* To allow for self-directed, enjoyable yoga that utilizes intelligent correction knowledge with logic.
* To develop a user interface that promotes usability and preserves efficacy for beginners.

1. **LITERATURE REVIEW –**

The [1] paper proposed a machine learning-based technique for estimating yoga postures, showcasing how body pose classification can be improved through feature extraction and prediction models. Similarly, [2] implemented a machine learning-based yoga pose correction system, focusing on aligning users' postures with ideal ones in real time.

The integration of real-time video processing has become a crucial element in enhancing user interactivity. [3] leveraged OpenCV and MediaPipe libraries to detect yoga poses with high accuracy and real-time performance, demonstrating a practical approach for webcam-based detection. [4] extended this by applying machine learning models for yoga pose classification and recognition using labeled datasets, contributing to the field with pose-specific learning.

The importance of keypoints detection is emphasized [5], who used deep learning with MediaPipe for accurate pose recognition. Their model capitalized on joint landmark extraction to classify specific yoga poses. [6] also explored detection and correction techniques, combining classification models with feedback mechanisms for improved learning. [7] focused on pose validation using OpenCV and MediaPipe, especially for maintaining body alignment during complex poses. This aligns with [8] deep learning approach for yoga pose recognition, which enhanced accuracy through neural networks trained on pose-specific datasets.

In terms of practical applications for health and physiotherapy, [9] discussed pose estimation models used for therapeutic purposes, particularly in rehabilitation and injury prevention. [10] supported this direction by implementing machine learning methods to create assistive systems for yoga pose guidance. [11] proposed a corrective system capable of identifying misalignments in posture, offering suggestions for improvement. Similarly, [12] utilized AI-based human pose estimation for real-time detection and correction, showcasing a robust system with feedback loops.

Finally, [13] designed an AI posture trainer using MediaPipe and OpenCV, providing a seamless user experience for pose detection and correction in real time. Their work emphasizes the usability and low-latency design of such applications for everyday users.

1. **DATASET DESCRIPTION –**

The dataset applied in our Yoga Pose Detection and Correction project is a constructed dataset of labeled yoga pose images. Each image contains pose images of six different types: Tree, Downward Dog, Goddess, Lotus, Butterfly, and Easy (Meditation) Pose. All images include keypoints identifying easily identifiable body landmarks, which are critical for pose detection and correction. The background and angle of images differ, which will help in generalizing the model for other real-world use cases. The dataset can be used to classify any unaided images and can also be used to validate if a pose is correctly attained. The dataset is critical to the model-training and testing stages of the pose estimation pipeline we build in MediaPipe and OpenCV.

1. **YOGA POSES –**

This project uses six yoga poses for real-time detection and correction using MediaPipe's 33-keypoint model. The poses are selected both for popularity, representing the wide range of differences with alignment, and importance in beginner to intermediate levels of yoga. The six poses used in the system are listed below in both English and Sanskrit, coupled with a detailed description:

1. **Tree Pose (Vrikshasana):** A standing balance pose in which one foot rests against the opposite inner thigh or calf and the arms are brought together overhead. This pose builds balance and strength through the legs, and aids with focus. Keypoints focus includes the hips, knees, ankles, and shoulders for alignment checking.

* Analysis of Tree Pose:

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| Fig 1(a) : Tree Pose  An ideal Tree Pose reference image used for real-time pose validation comparison. | Fig 1(b): User’s Image  User's initial frame displaying pose captured via webcam before doing the actual pose. |
| Fig 1(c): Wrong Tree Pose  System detected wrong limb placement and a message displaying the user has an invalid Tree Pose. | Fig 1(d): Correct Tree Pose  User achieves correct Tree Pose and system confirmed and validated the pose while showing a progress bar and a confirmation message. |

1. **Downward Dog Pose (Adho Mukha Svanasana):** A foundational pose where the body is in an inverted "V" shape. The hands and feet are grounded on the base while hips are lifted high. This pose provides a stretch through the spine, hamstrings, and calves. Detection is focused on alignment between the wrists, shoulders, hips, and ankles.

* Analysis of Downward Dog Pose:

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| Fig 2(a): Downward Dog Pose  This image depicts the conventional Downward Dog Pose used as the proper reference in pose comparison. | Fig 2(b): User’s Image  The first image of the user prior to the introduction of the pose detected by the webcam to be analyzed. |
| Fig 2(c): Wrong Downward Dog Pose  The system detects the angles of the user's body are incorrect and, therefore, the pose detected is wrong. | Fig 2(d): Correct Downward Dog Pose  The user successfully performed the Downward Dog Pose again and the system responds positively by reporting with an acknowledgement and completed progress bar. |

1. **Goddess Pose (Utkata Konasana):** A powerful standing pose where the knees will be bent and opened wide apart while the arms are elevated with a "cactus" shape. This pose creates openness in the hips and chest while building strength through the lower body. Key points monitor and center on the knees, hips, elbows, and shoulders for symmetrical and structure cues.

* Analysis of Goddess Pose:

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| Fig 3(a): Goddess Pose  This represents a correct Goddess Pose; used as the benchmark for comparison against the system. | Fig 3(b): User’s Image  The initial photograph logging by the webcam before the user begins the Goddess Pose. |
| Fig 3(c): Wrong Goddess Pose  The system recognizes that the user has made an error (joint angle and spacing), and denoted this invalid pose and provided recommendations for correction. | Fig 3(d): Correct Goddess Pose  The user successfully completed the Goddess Pose and the system identified this pose as valid with a success message and visual output. |

1. **Lotus Pose (Padmasana):** A traditional seated meditative pose where each foot is placed on the opposite thigh. This pose encourages relaxation and spinal alignment. Pose checking focuses on symmetry of hip and knee joints along with upright positioning of the spine.

* Analysis of Lotus Pose:

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| Fig 4(a): Lotus Pose  The reference view of the correct Lotus pose the system will use for reference during the pose validation. | Fig 4(b): User’s Image  An image taken of the user before the user starts to pose, no active pose detection. |
| Fig 4(c): Wrong Lotus Pose  The system sees that the users foot placement is incorrect and flags the pose as invalid with help identifying for correcting. | Fig 4(d): Correct Goddess Pose  The user holds the Lotus pose correctly and the system verifies the pose as valid and displays validate the "Hold Pose" message. |

1. **Butterfly Pose (Baddha Konasana):** This pose is practiced sitting down with the feet soles joined and the knees dropped to the sides, which promotes flexibility in the inner thigh and encourages calmness. Ensure general distance between the knee and the floor is equal and the spine is upright.

* Analysis of Butterfly Pose:

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| Fig 5(a): Butterfly Pose  This image is considered the standard reference for the proper Butterfly Pose, and is used for comparison throughout the evaluation. | Fig 5(b): User’s Image  The user is not yet in pose and the system detects a neutral pose and waits for the user to initiate the pose. |
| Fig 5(c): Wrong Butterly Pose  The pose is detected, but the user has not properly aligned their feet, thus the system flags this as invalid and immediate supports or instructional notifications appear. | Fig 5(d): Correct Goddess Pose  The pose is a perfect match for the reference image and the system flags this as correct and prompts the user to hold the pose. |

1. **Easy Pose / Meditation Pose (Sukhasana)**: In this seated pose, the legs are in a simple crossed-legged position that is naturally used for seated meditation. This is a restful and alert seated position. Checking for a straight spine the knees are even height from the floor and relaxed through the shoulders.

* Analysis of Easy/Meditation Pose:

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| --- | --- |
| Fig 6(a): Easy Pose  Perfect reference image for Easy Pose to reflect users’ performance when comparing. | Fig 6(b): User’s Image  User standing detected as invalid Easy Pose; prompting feedback requested sitting with crossed legs. |
| Fig 6(c): Wrong Easy Pose  User has incorrectly seated position; pose invalidated upon cross of legs, or hands not positioned correctly. | Fig 6(d): Correct Easy Pose  Easy Pose seated position detected accurately, with guidance to breathe and hold pose; 'Hold' sensed to reflect pose held. |

1. **METHODOLOGY –**

The steps are as follows:-

1. The system receives live video input from a standard webcam located on a laptop as the user completes the yoga poses.
2. MediaPipe Pose extracts 33 accurate keypoints from the human body in each frame, including shoulder, elbow, hip, knee, and ankle coordinates and movement.
3. Angles between selected body joints are calculated to comprehend body alignment and pose structure.
4. The detected pose is compared to previously recorded correct poses, stored as a labeled dataset of six yoga asanas, which uses angle thresholds.
5. If the pose falls out of the accepted threshold, poses detected are labeled incorrect, and the system will provide real time corrective error feedback through an on-screen error message.
6. This provides the user with corrected feedback that indicated the user is correct and the system will be generated in real time as the user corrected their posture in real time.

8.1 Architecture Diagram/Block Diagram:



**Fig 1: Architecture Diagram**

**Fig 1** describes detecting and correcting yoga poses in real-time. The poses are compared from the user activity (video/image) to the correct pose using OpenCV & MediaPipe with feedback whether the pose is valid or not.

1. **TECHNIQUES & ALGORITHMS –**

The Yoga Pose Detection and Correction system uses MediaPipe Pose and OpenCV to provide accurate feedback in real-time on yoga poses without the complicated and heavyweight deep learning models. MediaPipe Pose identifies 33 body keypoints in each frame, including important joints like shoulders, elbows, hips, knees, and ankles, to measure pose accuracy [2][6]. These keypoints then allow the angle between joints to be calculated which is at the center of the pose comparison algorithm. This system does not utilize Convolutional neural networks (CNN) or ensemble learning which would need powerful equal computers with high-end GPUs, increasing overall computational costs [5][12]. This is a lightweight algorithm compares the angles of a user's pose with its pre-defined reference pose, calculating the angular difference to define its correctness. Once the angular difference values pass a defined threshold, the system can classify the pose as incorrect and provide real-time feedback to correct this pose on the screen [1][4][13]. OpenCV allows for rapid video capture and frame processing for an efficient visualization of the labelled keypoints [3][14]. The angular difference algorithm reduces overall complexity while providing speed and responsiveness, which is critical for immediate feedback during active yoga practice [7][11].

While previously existing systems have used deep learning models such as MoveNet in conjunction with pose classification convolutional neural networks (CNNs) to assist pose detection and correction, the flexibility of using angular measurements with the built environment has advantages over a dedicated deep learning pose detector when trying to balance motion and real-time performance on typical hardware [8][9][10]. The overhead of complex model training software can be avoided, while ultimately meaningful performance can be achieved with beginner and intermediate yoga practices. Overall, combining the landmark detection capabilities of MediaPipe and the processing pipeline of OpenCV, and a rule-based technique to compare angular differences, creates an effective, lightweight, and fast system for yoga pose correction in real-time [15].

1. **HARDWARE & SOFTWARE REQUIREMENTS –**

* Laptop used - no GPU necessary & has built-in webcam for real-time input.
* Built in VS Code (Visual Studio Code) & core programming language is Python.
* MediaPipe Pose detects 33 keypoints.
* OpenCV is used to capture video and view video.
* NumPy is used for angle and joint calculations.
* The system is lightweight and does not heavily consume CPU resources.
* Can be used on multiple platforms and easily deployable.

1. **EXPERIMENTAL ANALYSIS –**

The system was assessed on a custom dataset of six particular yoga poses: Tree, Downward Dog, Goddess, Lotus, Butterfly, and Easy Pose (Meditation). The poses had several samples of images in order to define reference angles for the key joints. The MediaPipe Pose tracked the user in real time with standard laptop webcam using 33 keypoints. The correctness of posture was determined by calculating the joint angles and comparing them to current pose with original poses in images.

Measures of performance included:

* Accuracy in detection of keypoints and angle calculation.
* Ability of the system to identify the deviation from the ideal posture.
* Latency of feedback (i.e., how quickly the system provided correction alerts).
* Stability of performance in both conditions of lighting and body type.]Responsiveness of the system while maintaining real time feedback loop.

User testing was performed with individuals who executed all six yoga poses. The data provided immediate and consistent feedback on angles that were incorrect (e.g., knee-bending or arms in the wrong position).

1. **NOVELTY & RESEARCH CONTRIBUTION –**

This project proposes a new, real-time yoga pose correction system that provides a correction mechanism based on joint angles that goes beyond simply classifying poses. Whereas previous projects have only classified poses, our system assesses the correctness of a particular posture by calculating angular relationships between selected body joints based on the 33 body landmarks detected by MediaPipe.

The system provides feedback only after a pose has been actively initiated, which should reduce false-positive feedback and provide a more stable and accurate pose correction. In addition, another noteworthy feature of this work is the design and creation of a custom dataset for the yoga poses themselves, focused on beginner poses (as opposed to general fitness or posture datasets). Included poses were Tree, Downward Dog, Lotus, Butterfly, Goddess, and Easy Pose (Meditation) - and the structure of each record was intentional to facilitate more accurate pose validation logic.

The correction process is lightweight, and does not invent reliant, on deep learning models so it can run on standard specification machines without requiring GPUs. The system uses rule-based strategies based on threshold-based angular deviations of joint angles to define what is correct. It also considers unstable or noisy keypoints, such as the wrist during the up and down phases of movement, by including logic to ignore values until the pose met stable conditions.

Our interface increases user engagement by providing instantaneous visual and text feedback when an incorrect posture is identified, so practitioners can adjust and refine their pose right away which encourages safer and more effective yoga without needing a human present. This project will ultimately provide a low-cost, non-prohibitive, intelligent system of yoga guidance, that opens pathways for self-paced learning, cites traditional knowledge of yoga postures alongside contemporary computer vision, and supports the energizing area of artificial intelligence and wellbeing.

1. **FUTURE SCOPE –**

The current framework has real-time yoga pose detection and correction based on rule-based angle deviation and lightweight technologies, such as MediaPipe and OpenCV. There are a few paths forward to enhance the system. One key path forward includes integrating deep learning models such as MoveNet or PoseNet to improve real-time accuracy for difficult or complex yoga postures, especially if users are either occluded or in transition [5][12].

These models may also provide support for 3D pose estimation, which would allow more robust feedback along with detailed spatial analysis [1][9]. A noteworthy enhancement would include developing a hybrid model of rule-based and deep learning approaches for classification as well as correction. This ensemble learning strategy would enable the system to use the deep learning model for yoga pose application and ruling based correction logic, and eventually shifting this logic based on changes in user progress and posture difficulty [14][8].

Additionally, a more extensive training and more diverse dataset representing multiple body types, styles of clothing, light, and camera angles would significantly increase the model at testability across conditions that resemble real-life [7][6].

Voice-based, multi-modal feedback systems provide corrective instructions in an audio format in addition to visual cues, thus enhancing user experience and accessibility specifically for low-vision users. The addition of full yoga sequences like Surya namaskar which would allow the system to approve posture to posture transition would make the system even more useful as guidance multiple sequences [2][3].

The use of IoT and wearables, such smart bands or infrared sensors, the user experience could be improved by tracking depth, respiration, and metabolic rate of movement and therefore provide a more holistic evaluation a which would service the full purpose of the system [9][10]. With cloud management for analytics for things like remote monitoring, historical performance tracking, and personalized yoga protocols, could provide benefits to the user but also the trainer [4][11]. As the application of AI expands into healthcare and wellness, a yoga pose-correction system could be a starting point to build smart healthcare and rehabilitation solutions and broaden the reach of intelligent fitness into rural and underserved populations [15][1].

**CONCLUSION –**

The Yoga Pose Detection and Correction system has successfully proven how machine learning and computer vision can be used to improve the practice of Yoga in a safe, accessible, and effective way. The system is able to provide real-time feedback about the correctness of posture based on deviations in joint angles. By using MediaPipe's 33-point pose estimation and OpenCV for real-time video processing, the system has also aided in the calculated cost of close to zero intervention. Unlike many of the current systems that are only able to classify poses, this project sought to offer a new dimension in real-time correction-based on user safety, with a more prescribed and interactive experience as seamlessly connected to tailored anxiety and mindfulness yoga practices for the average user. Using rule-based logic instead of heavy model deep learning techniques allows for efficient and real-time based applications to be run on standard devices without specialized hardware. This project has also incorporated a custom-designed dataset of a survey of beginner-friendly yoga poses and a user-friendly interface, which provides visual and textual feedback for users, will contribute to the usability and educational usefulness of the system.

The project has taken one step closer to identifying a merger of independent self-practice and professional supervision whilst empowering users to have the confidence of independent yoga practice with limited and reduced injury risks. In conclusion, this project provides a promising foreshadow for intelligent yoga instruction, with the potential for alternative implementations as well as the potential for alternative AI-driven wellness footprints.

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