AI-Powered Virtual Yoga Coach for Real-Time Surya Namaskara Posture Correction and Personalized Yoga Trainer

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***Abstract*— Yoga is an ancient practice that brings harmony to the body, mind, and spirit through physical postures (asanas), breathing techniques (pranayama), and meditation. It is practiced worldwide for its many health benefits, including improved flexibility, increased muscle strength, better posture, stress relief, and enhanced mental well-being. Among the various sequences in yoga, Surya Namaskara, or the Sun Salutation, is particularly significant. This dynamic series consists of twelve linked postures performed in a continuous flow, promoting cardiovascular health, muscle strength, spinal flexibility, and respiratory efficiency. Correct execution of each posture in Surya Namaskara is essential for maximizing these benefits and preventing injuries. Misalignment or improper posture can lead to unnecessary strain on joints, muscles, and ligaments, which may reduce both effectiveness and safety. This research analyzes key body points to monitor posture and ensure accurate alignment during Surya Namaskara. It evaluates joint angles in real time and provides corrective feedback to guide practitioners through smooth pose transitions. By offering instant audio feedback and adapting to user movements, the system helps maintain proper form, enhancing the effectiveness and safety of the practice. Therefore, this research emphasizes the importance of real-time posture detection and correction, which play a critical role in helping practitioners achieve proper form and alignment.**

***Keywords*—Body Keypoints Analysis, Real-Time Feedback, Surya Namaskara, Yoga, Yoga Posture Correction.**

I. INTRODUCTION

In the fast-paced world of the present day, diseases are becoming more common across the various age groups. Lack of physical activity, improper diet, and increased stress are the major factors responsible for lifestyle diseases, such as obesity, diabetes, high blood pressure, and cardiovascular diseases. The World Health Organization (WHO) has identified physical inactivity as one of the major risk factors for deaths worldwide, causing millions of early deaths annually. In addition to physical ailments, mental health problems, such as stress, exhaustion, anxiety, and depression, are becoming more common among students and working individuals.

As a response to these issues, there has been a large scope for health practices such as yoga. Thousands of years old exercise in ancient Indian tradition, yoga offers a spiritual approach towards physical, mental, and good health. As opposed to traditional exercises that focus mostly on physical fitness, yoga focuses on the integration of body, mind, and spirit through physical postures (asanas), breathing exercises (pranayama), and meditation (dhyana). Yoga is now firmly rooted not only as a physical program but also as a therapeutic treatment for various psychological diseases [2], [4], [11].

Scientific studies validate that regular yoga practice significantly improves flexibility, muscular strength, cardiovascular health, respiratory function, and metabolic balance [5], [13]. It also reduces cortisol levels which is a stress hormone, improves emotional resistance, and improves general mental concentration and focus. This set of physical and psychological benefits makes yoga a useful activity for stress management, quality of life improvement, and long-term health improvement [6], [7].

Fig. 1. Surya Namaskara Steps

Yoga comprises three constituents - asanas or bodily postures intended to develop flexibility, balance, strength, and alignment of posture. Special asanas involve contracting muscles to enhance the flexibility of the joints and improve circulation of the blood. The second constituent is pranayama or breathing practice, which deals with mastering the breath in order to master the nervous system, enhance the oxygen intake, and relax the mind state. The third one is dhyana or meditation, which works on the development of awareness, consciousness, and inner calm by using attention and mental will power. Collectively, the above components coalesce to cover physical illness and mental derangements, hence making yoga a preventive and restorative medicine.

A. Importance and Benefits of Surya Namaskara

Among the various sequences in yoga, Surya Namaskara, or Sun Salutation, stands out as a series of twelve linked postures performed in a flow. It is should be practiced at the beginning of a yoga session so that it warms up the entire body and prepares it for deeper practice. The steps are shown in Fig.1. Each of the twelve postures serves a specific physical function:

1. Pranamasana (Prayer Pose): Brings a state of mental focus and calmness.
2. Hastauttanasana (Raised Arms Pose): Stretches the spine, opens the chest, and improves lung capacity.
3. Padahastasana (Standing Forward Bend): Improves flexibility of the spine helping in digestion of food in the body.
4. Ashwa Sanchalanasana (Equestrian Pose): Opens up muscles in the hip and strengthens the legs.
5. Dandasana (Plank Pose): Builds arm and core strength.
6. Ashtanga Namaskara (Eight-Limbed Pose): Multiple muscles work together for stability and strength.
7. Bhujangasana (Cobra Pose): Improves spinal flexibility and energizes the heart region.
8. Adho Mukha Svanasana (Downward-Facing Dog): Provides a full-body stretch, improving blood circulation.

The sequence then reverses to balance both sides of the body, ensuring symmetrical development. Repetition of Ashwa Sanchalanasana on both sides helps promote muscular and skeletal balance, reducing postural asymmetry [10], [13].

B. Yoga Injuries and Need for Guidance

Although the physical and mental benefits of yoga are well established, improper performance of these steps particularly in the absence of professional guidance can result in injuries. Misalignment, improper stretching, and maintaining improper postures for prolonged periods of time are the most common reasons for yoga-related injuries,

particularly among beginners. Injuries most commonly affect the knees, lower back, shoulders, and wrists. These injuries mostly occur due to overstretching, lack of body awareness, or inadequate instruction [6], [9]. A research study by Kasture et al. [6] brought to light that yoga injuries could be minimized by increased posture awareness and corrective feedback mechanisms. Yoga has been practiced on a large scale at home for the last few years, particularly after the pandemic, and most of the practitioners have no access to trained professionals to teach them. Therefore, the likelihood of injury is increased by self-practice.

C. Role of Real-Time Posture Estimation in Yoga

Computer vision and artificial intelligence advancements have opened up new avenues in yoga posture correction. Technologies such as pose estimation can detect and track major human body landmarks, examine joint angles, and verify posture alignment in real-time. Tools such as Google ML Kit, MediaPipe, and OpenPose offer an avenue of application of these features on mobile devices [1], [3]. "Utilizing pose estimation for yoga correction systems enables pose alignment recognition and automatic correction, particularly without a physical instructor" — Kotte et al. [1]. These systems not only identify what posture the user is performing but also identify whether the posture is being performed correctly and provide real-time feedback. If utilized with software like Flutter TTS, they can provide real-time audio feedback for correction or provide feedback on the next posture to be performed. Practitioners can receive real-time guidance, reduce the risk of injury, and improve the overall safety and efficiency of their yoga practice with this system.

II. LITERATURE REVIEW

This section of the paper outlines some of the latest research work in computer vision-based posture recognition and yoga posture correction, with specific reference to real-time systems in the area of enhancing physical exercise through intelligent feedback control. The growing emphasis on applying machine learning and deep learning techniques to posture analysis has initiated a whole new set of approaches to the health and wellbeing arena.

Kotte et al. [1] proposed a computer vision system for gym workouts that not only estimates pose but also exercises error classification and performance feedback. Their system integrates CNNs for pose estimation and feedback mechanism, making the workout very effective. Their model is not, however, generalizable to yoga asanas.

Bhosale et al. [2] had suggested a light-weight PoseNet-based yoga pose detection system having a K- Nearest Neighbors (KNN) classifier. They were aiming to provide pose correction to make it compatible with mobile platforms with light computation. The system is light-weight and efficient, but the complexity of the keypoints restricts the accuracy of intricate postures detection.

Sinha et al. [3] introduced a rule-based method of angle estimation for yoga pose detection and correction. They applied joint keypoint mapping for static pose estimation. It is a good basis on which to build a yoga assistant system. It is not interactive and does not provide real-time feedback.

Kulkarni et al. [4] used the deep learning structures, the convolutional neural networks (CNNs), for image- based recognition of a wide variety of yoga postures with accuracy. Their system is effective in high-quality image-based recognition but the computational complexity limits its usage in real time on mobile systems.

Rokade et al. [5] built a yoga aid tool that utilizes computer vision and angle computation to detect poor posture and offer correction suggestions. Their model is appropriate for basic yoga poses and straightforward interaction. However, the model's generalization is limited and may be inadequate to handle complex or transition postures.

Kasture et al. [6] introduced a posture detection system based on OpenCV and body landmark detection for the estimation of joint angles. Real-time performance is an added advantage, although accuracy of the posture detection suffers when dealing with complex asanas, indicating the requirement for better models with higher sensitivity to body orientation.

Jadhav et al. [7] introduced Aasna, a CNN-based yoga posture detection system with kinematic analysis incorporated for improved accuracy. Their system synchronizes by comparing ideal joint angles with real-time ones. It has its advantages but is unable to detect transitions between posture and sequence phases.

Arun Kumar Rajendran and Sibi Chakkaravarthy [8] conducted a comprehensive review of posture

recognition systems and outlined the key trends in the use of machine learning, deep learning, and computer vision in yoga and exercise applications. The paper is a comprehensive review of different methods but does not present any new implementation or methodology.

Pallavi R et al. [9] have presented a comparative analysis on approaches to correction of yoga postures in their survey. They considered other models and frameworks and their demands of immediate feedback and proper joint identification. However, like the conventional survey papers, no system design or experimental setup is presented.

Avinash N Rao et al. [10] developed a real-time posture monitoring and correction system with the help of PoseNet. Their Android app is angle-based rule logic- based and alerts users of poor posture. It is efficient and user-friendly but limited to a basic set of postures and hence unsuitable for more complex sequences.

D. Mohan Kishore et al. [11] highlighted yoga posture estimation using the assistance of traditional machine learning algorithms like Support Vector Machines (SVMs) and Decision Trees. It is computation-friendly and suitable for basic classification. It is not, however, strong when attempted with heterogeneous data sets or with real-world scenarios.

Harshita Gawade et al. [12] came up with pose recognition and correction for the Surya Namaskar sequence using machine learning and computer vision techniques specifically. It records major joint angles for every one of the 12 poses and checks each step. Even though accurate, it greatly relies on the quality of data and the background.

Abhishek Sharma, Pranjal Sharma, and Darshan Pincha [13] also suggested a real-time Surya Namaskar analysis system using deep learning. Their system is capable of pose sequence tracking with time-aligned accuracy and hence most appropriate for full-body movement correction. However, it needs to be implemented in a controlled setting and with fixed lighting to provide the best results.

Yash Agrawal et al. [14] developed a simple yoga posture recognition system from HOG features and SVM classifiers. The system has good classification accuracy on public datasets. Still, it fails to offer posture correction or live feedback, constraining its usefulness.

The overall summary of above explained existing research works are represented in Table 1.

III. RESEARCH GAP

This section presents the research gaps realized after an exhaustive review of the literature on computer vision-based yoga posture detection and correction systems. The major research gaps are as follows:

A. Insufficient support for dynamic yoga sequence: Most of the current systems emphasize static posture detection, in which every asana is regarded as an independent occurrence. Yet Surya Namaskara is a dynamic sequence of 12 interdependent postures performed in a flow-like manner. Few research studies have attempted modeling such sequential series of yoga flows with state-based methods such as finite state machines, leading to compromised accuracy and usability for real-time practice.

B. Lack of real-time corrective feedback: Some posture detection systems can detect keypoints and even pose classify, but without the ability to give real-time voice-based corrective feedback to the user. This limitation restricts the user's capacity to adjust their posture when practicing, which is critical in avoiding injury and enhancing effectiveness.

C. Limited edge-compatible and mobile-native solutions: The majority of recent posture estimation models such as OpenPose or BlazePose need tremendous computational power and are meant for desktop usage. There are few research works that investigate real-time and lightweight solutions through tools such as Google ML Kit that are smartphone- optimized and able to run on-device independent of the cloud.

Table. 1. Summary of Existing Systems

Paper No.	Author(s)	Problem	Technique	Advantage	Limitation
[1]	Kotte et al.	Real-time posture correction for gym	Keypoint detection + classification	Accurate real-time feedback	Not specific to yoga

[2]	Bhosale et al.	Yoga pose correction	PoseNet + KNN	Good classification with feedback	Limited dataset
[3]	Sinha et al.	Joint angle-based correction	Rule-based + Pose classification	Suitable for home users	Needs accurate angle definitions
[4]	Kulkarni et al.	Yoga pose recognition	CNN	High classification accuracy	No feedback system
[5]	Rokade et al.	Real-time detection and correction	OpenPose + Template matching	Alerts for poor posture	Predefined template dependency
[6]	Kasture et al.	Joint angle comparison	Rule-based	Interpretable system	Limited generalization
[7]	Jadhav et al.	Pose recognition via CNN	CNN-based on images	Effective in structured data	No real-time correction
[8]	Arun Kumar Rajendran, Sibi Chakkaravarthy	Comprehensive review needed on posture recognition methods	Survey of existing CV and DL-based models	Provides a broad understanding of state-of-the-art	Does not propose a novel solution
[9]	Pallavi R et al.	Overview of yoga pose correction techniques	Comparative study of correction models	Highlights importance of error identification	No practical implementation
[10]	Avinash N Rao et al.	Pose tracking and correction in real-time	PoseNet + rule-based angle feedback	Real-time tracking implemented in Android	Only basic postures supported
[11]	D. Mohan et al.	Yoga pose estimation via ML	SVM and Decision Tree classifiers	Fast training and simple implementation	Low precision on complex datasets
[12]	Harshita Gawade et al.	Recognizing and correcting Surya Namaskar postures	ML and vision-based joint angle classification	Specific focus on Surya Namaskar with good results	System is dataset-dependent
[13]	A. Sharma et al.	Real-time correction of Surya Namaskar	Deep learning-based keypoint recognition	Real-time monitoring of all 12 poses	Requires consistent lighting
[14]	Yash Agrawal, Yash Shah, Abhishek Sharma	Identifying yoga poses using ML	HOG features + SVM classifier	Moderate accuracy with simple ML pipeline	Doesn't support correction or real-time use

D. Absence of personalization and user interaction: Current works have limited or no personalized asana suggestions based on user-specific illness or preference.

Further, user experience attributes like voice feedback, progress monitoring, and interactive flow design are underdeveloped or lacking, making such apps less adoptable and impactful in actual usage.

E. Inadequate modeling of posture correctness via there is very little research that systematically determines angle thresholds for correctness particular to Surya Namaskara postures. A mathematical or rule- based model to compute pose accuracy and initiate corrections based on deviations does not exist in most previous methods.

The gaps identified highlight the necessity of an intelligent, real-time, mobile-based yoga posture correction system that can effectively model dynamic sequences, offer intuitive feedback, and engage users with personalized wellness recommendations. Our system proposed is aimed at filling these gaps and helping towards a safer, more effective, and user-centric yoga practice experience. The above studied research gaps are necessary to be considered in any further research towards yoga posture correction, especially Surya Namaskara.

IV. PROPOSED LINE OF RESEARCH

After analyzing the research gap in the previous section, it is evident that the field of real-time yoga posture correction systems is underdeveloped, especially in terms of accurate sequence tracking, user- personalized feedback, and mobile-optimized performance. The subsequent section describes the proposed line of research to address the gaps. The flow of proposed system is as depicted in Fig. 2.

A. Dynamic Real-Time Posture Correction via Pose Estimation and Finite State Machine

The primary goal of this module is to guarantee accurate detection and correction of all phases of the Surya Namaskara set with accurate detection and correction of transitions and full-body keypoints through compact mobile-friendly models.

- *Problem Identified:* The current systems do not have dynamical modeling of the Surya Namaskara time sequence, giving no correct feedback as well as bad posture tracking when there is a steady stream.
- *Proposed Methodology:* A Finite State Machine (FSM) is used to track the transitions between 12 base poses of Surya Namaskara series from 32 in- time body keypoints obtained using Google ML Kit's Pose Estimation. The system calculates accurate joint angles and cross-checks these against ideal threshold angles to detect correctness or anomalies.

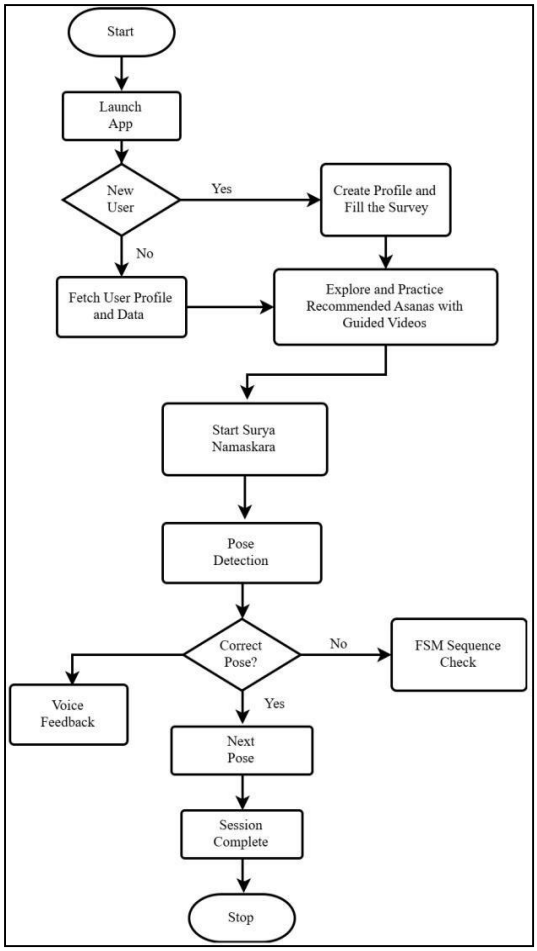

Fig. 2. Flow Diagram for the Proposed System

- *Expected Outcomes:* Accurate pose identification, low-latency feedback, real-time tracking of asana transitions, and a better-organized correction process with clearly defined state management.

B. Audio Feedback Integration using Flutter TTS

The goal of this sub-system is to provide an intuitive, interactive user experience via voice-based correction feedback.

- *Problem Identified:* Most posture systems provide visual feedback only, making it inconvenient during active yoga practice when users cannot keep their eyes on the screen.
- *Proposed Methodology:* Flutter TTS is used to give real-time audio cues and feedback on posture mistakes that are detected. The app alerts users of improper alignments and guides them to adjust their poses during practice, promoting awareness with minimal visual dependency.
- *Expected Outcomes:* Improved user interaction, reduced screen dependency, and easier access for visually impaired or elderly practitioners.

C. Personalized Asana Recommendation System using Rule-Based Filtering

This module is to serve individual needs of the users by offering yoga postures according to their ailments and inclinations.

- *Problem Identified:* Posture correction systems are presently non-personalized, offering each user the same routine without taking into account their body conditions or objectives.
- *Recommended Methodology:* The system follows rule-based logic and maps common afflictions (back pain, worry, diabetes, etc.) into equivalent asanas. On board, the user selects issues for which he will be taking feedback, and on the basis of that, it recommends a sequence of poses or routines.
- *Anticipated Outcomes*: Customized experience for users, higher interest generation, and increased relevance of recommendation leading to greater adherence and wellbeing.

D. Lightweight Mobile Deployment using Google ML Kit and Flutter

This research component ensures that the proposed system runs well on Android mobile phones without cloud computing.

- *Problem Identified:* Excessive computational requirements of existing models limit access to mid-range smartphone users.
- *Proposed Methodology:* Google ML Kit's pose estimation within a Flutter application framework is used to extract body landmarks, processed on the device locally.
- *Expected Outcomes:* Efficient performance on smartphones, real-time feedback without dependence on the internet, improved reach to underserved communities.

V. CONCLUSION

Surya Namaskara, a foundational sequence in yoga, demands precise body alignment and controlled movement, which, if compromised, can lead to reduced benefits or potential injury. This study focused on addressing the limitations in existing posture correction systems, particularly their inability to detect detailed joint movements, track dynamic pose sequences, and offer intuitive feedback. By utilizing Google ML Kit's 32 body keypoints for pose estimation, the developed system identifies body posture in real-time and evaluates each stage of Surya Namaskara using an angle-based scoring mechanism. The use of a Finite State Machine

(FSM) enabled accurate detection of transitions between poses, while the integration of text-to-speech provided immediate audio feedback to guide practitioners. The solution was designed to be lightweight and mobile- friendly, ensuring accessibility without requiring high- end computational infrastructure. This approach addresses key research gaps by combining pose detection, correction, evaluation, and personalization in one cohesive platform. The system contributes to the advancement of smart yoga assistants by leveraging computer vision, mobile AI frameworks, and real-time analytics to enhance safety and precision in self-guided yoga practice. Future scope includes scaling the model to support additional yoga asanas, incorporating feedback loops for long-term user progress tracking, and embedding advanced learning techniques to tailor corrective instructions based on individual biomechanics and historical performance data. This research lays the foundation for intelligent wellness applications that can support healthy lifestyles in a scalable, efficient, and user-focused manner.

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