Yoga Pose Detection using Artificial Intelligence and Machine Learning

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***Abstract*— The study of yoga pose detection with the help of AI and ML aims to develop automatic structures that are capable of spotting and classifying yoga poses solely based on visible input. This age can help yoga experts, teachers, and fans by introducing ongoing criticism, customized direction, and, in general, execution checking. The site's artificial intelligence model can accurately identify various stances thanks to its extensive dataset of yoga poses. The proposed web application can help yoga professionals who need to improve their accuracy and educators who need to remotely monitor their students' progress.**

The crucial elements encompassing the positions of significant body joints are vital for a comprehensive understanding of each pose. Annotation plays a pivotal role in educating the machine learning model, where experts manually label key factors within the dataset and associate them with specific yoga poses. This annotated dataset serves as the cornerstone for education and evaluation in the development process.

Keywords—yoga, detection, artificial intelligence, machine learning, accuracy, dataset, checking.

I. Introduction

Yoga is a famous exercise that promotes bodily and intellectual wellness via diverse postures or poses. With the improvements in synthetic intelligence (AI) and system learning (ML), there may be an possibility to broaden structures which could mechanically locate and classify yoga poses from visible input. This era can help yoga practitioners, instructors, and fans through supplying real-time feedback, alignment guidance, and overall performance tracking.

Historically, yoga has been traditionally guided by skilled instructors, but this may not be financially feasible for the majority. The growing awareness of yoga and the constraints imposed by Covid-19 have prompted individuals to engage in solo yoga sessions at home. Without professional guidance, there is an elevated risk of executing poses inaccurately. Practitioners must adhere to specific steps and guidelines to optimize the benefits of each pose. Neglecting these instructions can potentially lead to severe consequences, including prolonged incorrect practices causing joint pain and various health issues.

Yoga pose detection the use of AI and ML entails schooling a version to apprehend and classify extraordinary yoga poses primarily based totally on pics or video data. The manner starts off evolved with the gathering of a categorised dataset that consists of a various variety of yoga poses finished with the aid of using people from diverse angles. Pre-processing strategies are implemented to standardize the data, inclusive of resizing pics, normalizing pixel values, and extracting frames from videos.[1]

Pose estimation algorithms or libraries, along with Open Pose, Pose Net, or Alpha Pose, are applied to pick out key factors or landmarks in every photo or frame. These key factors constitute the places of considerable frame joints, imparting an in depth illustration of the pose being performed.

Iterative refinement of the version and experimentation with one-of-a-kind architectures, hyper parameters, and education strategies can be essential to acquire foremost overall performance.[2]

Computer vision and data science methodologies have been harnessed to develop AI-driven software tailored for instructional purposes. This software elucidates the benefits associated with yoga poses and assesses the precision of their execution. Consequently, individuals can engage in yoga practice autonomously, without necessitating the presence of a human instructor.

Recognizing humans poses a significant challenge in the field of computer vision. The task involves pinpointing the locations of various joints in an image or video to create a skeletal representation. Automatically identifying a person's movements in an image proves to be challenging due to factors such as image scale and resolution, changes in lighting, background clutter, diverse poses, and the interaction between humans and their surroundings. The issue becomes even more critical when applied to yoga, as, like any other form of exercise, it is crucial to execute it correctly. Incorrect postures during a yoga session can be counterproductive and potentially harmful. This underscores the importance of having an instructor to oversee the session and ensure proper form.

Utilizing pose estimation techniques enables the precise recognition of yoga postures.[5] These algorithms mark key points and create a skeletal representation on the human body in real-time images, aiding in the selection of the most effective algorithm for comparing poses. The complexity of posture estimation tasks lies in the necessity to generate datasets that facilitate the estimation of real-time postures.[6]

II. REVIEW OF LITERATURE

They propose a novel method for assessing yoga poses using pose detection technology. Their approach aims to facilitate self-learning of yoga by introducing a Performance Evaluation System as part of a Yoga Pose Training System. This innovative system employs pose detection to assist individuals in better understanding and mastering yoga postures [10].

A mobile application designed to serve as a yoga assistant. This application offers a personalized experience where yoga instructors can guide and supervise their students remotely through video chat sessions, enhancing the overall yoga learning process [11].

The focus is on machine learning techniques for recognizing yoga poses within video sequences. The approach involves analyzing extensive datasets of regular yoga movements using various data sources and minimal manual intervention. To achieve this, the authors propose the use of autoencoders for efficient pose recognition, reducing the need for extensive manual labeling [13].

Since the COVID epidemic, there has been a significant increase in the popularity of remote yoga activities, as Nagalakshmi's research has shown. In addition to treating musculoskeletal diseases and promoting a healthy lifestyle, remote yoga has gained attention. Notably, researchers have made valuable contributions to the field of human pose estimation by developing yoga posture recognition techniques. This was done to address the lack of remote yoga pose estimation studies [14].

AI methodologies often heavily rely on heuristic extraction of human elements in everyday tasks for identifying social activities. However, this reliance is constrained by human spatial awareness. To mitigate this limitation, researchers have explored various techniques such as deep learning methods. These approaches enable the automatic extraction of specific features from raw sensor data during the preprocessing stage, followed by the presentation of low-level temporal characteristics with significant high-level abstractions. The widespread application of deep learning techniques, including image classification, voice recognition, natural language processing, among others, has emerged as a novel research avenue in pattern detection, extending into human activity recognition. Table 1 illustrates several current AI models alongside their respective accuracy in Human Activity Recognition (HAR). We highlight methods that yield the highest accuracy across a broader range of subjects. Notably, the accuracy may vary depending on the subject count, potentially improving with fewer subjects. [25]

No.	Keypoint	No.	Keypoint
0	Neck	**9**	Right Knee
1	Nose	**10**	Right foot
2	Left Wrist	**11**	Right hip
3	Left Shoulder	**12**	Right knee
4	Left Wrist	**13**	Right foot
5	Right Shoulder	**14**	Left eye
6	Right elbow	**15**	Right eye
7	Right Wrist	**16**	Left ear
8	Left hip	**17**	Right ear

Table 1

Agarwal conducted experiments using various Machine Learning methods to achieve this objective. They created a dataset consisting of 5,500 photos depicting 10 different yoga positions. By utilizing the estimated pose technique, they were able to extract skeletal images instantly. Through their experimentation, Agarwal and their team found that classifiers employing random forests outperformed other methods when working with their dataset [15].

A dynamic coding method is introduced for real-time detection in crowded areas. This unsupervised approach is designed to identify unusual activities in video footage by constructing query alerts from dictionaries of learned events, enabling the monitoring of crowded environments for security and safety purposes.

A deep learning technique was utilized to train the model in recognizing yoga poses. Using Keras multi-use pose estimation, we extracted features, and the model classified the poses into 6 categories: Corpse pose Tree pose Mountain pose Triangle pose Lotus pose Cobra pose Based on the angles between 12 key points, we used Multilayer Perceptron to classify the poses with 99.58% accuracy [19].

Yoga could potentially contribute to the recovery of the heart and can be integrated into cardiovascular rehabilitation programs. This study proposes a way to categorize and measure the efficacy of yoga exercises. To assess the quality of asanas in yoga, the study uses ConvNet and the deep belief network model to calculate quality scores for input movements. Remarkably, the precision of their yoga practice was found to be 99.99% accurate [16].

Mustafa extracts 136 significant places dispersed throughout the body using transfer human learning position estimators in order to construct random forest classifiers for yoga asana assessment. Using the popular pose estimation method Alpha Pose in the first step, they switch to random forest classifiers in the second stage. They developed a novel dataset that emphasizes various viewpoints for the classification of yoga positions. 91.21% of the data is accurate. It depends on precise key point identification and posture estimation. [17].

III. METHODOLOGY

A. Methods

1) Data Collection: Gather a dataset of yoga pics or movies that cowl a extensive variety of poses, angles, lighting fixtures conditions, and people with special frame types. You can create your personal dataset with the aid of using recording movies or pics of humans appearing numerous yoga poses, or you may leverage current yoga pose datasets if available.

In addition, dataset quality and diversity play an important role in the efficiency and generalization of machine learning algorithms, so it’s important to pay attention to details during data collection, making sure that different demographics, skill levels, and environment conditions are represented. Annotation of the dataset with precise labels and metadata also plays an important role in supervised learning tasks, helping the model learn efficiently from the data. By carefully curating a large dataset, scientists and developers can build a strong base to train robust and robust yoga pose detection systems with higher accuracy and performance.

2) Data Pre-processing: Pre-process the accumulated facts to make certain consistency and standardization. This can also additionally contain resizing the images, normalizing pixel values, and making use of facts augmentation strategies together with rotation, scaling, or flipping to growth the dataset's diversity.*Selection:* Highlight all author and affiliation lines.

3) Pose Estimation: Utilize a pose estimation set of rules or library to extract the human frame joint positions from the pix or video frames. This step includes figuring out key frame landmarks or key points which include the shoulders, elbows, hips, knees, and ankles. Popular pose estimation fashions encompass Open Pose, Pose Net, or human- pose-estimation. pytorch.

4) Feature Extraction: Extract significant functions from the annotated joint positions. This can contain calculating joint angles, distances, or ratios among precise frame keypoints. These functions can be used as inputs for the gadget gaining knowledge of model.

5) Model Selection: Choose the ideal device gaining knowledge of set of rules or version for pose classification. Convolutional Neural Networks (CNNs) are normally used for image-primarily based totally tasks, even as Recurrent Neural Networks (RNNs) or Long Short-Term Memory (LSTM) networks are appropriate for sequence-primarily based totally tasks. You may recollect pre-educated fashions along with ResNet, Inception, or VGGNet.

B. *Implementation Details*

Python Modules: Importing essential libraries, including: Numpy, Tensorflow, Matplotlib, pillow, OpenCv, Seaborn etc

a) Numpy: NumPy is a versatile programming library that empowers the utilization of advanced mathematical functions on extensive, multi-dimensional arrays and matrices.

b) OpenCV: OpenCV serves as a robust software framework that finds applications in computer vision, machine learning, and image processing. It offers compatibility with various programming languages, such as Python, C++, Java, and more.

c) Pillow: Pillow, also known as the Python Imaging Library (PIL), is a valuable Python library for opening, manipulating, and saving images. It boasts support for a wide range of image formats.

d) Metasploit: Matplotlib is a portable data visualization library in Python. It plays a pivotal role in creating visually appealing plots and charts to present data effectively.

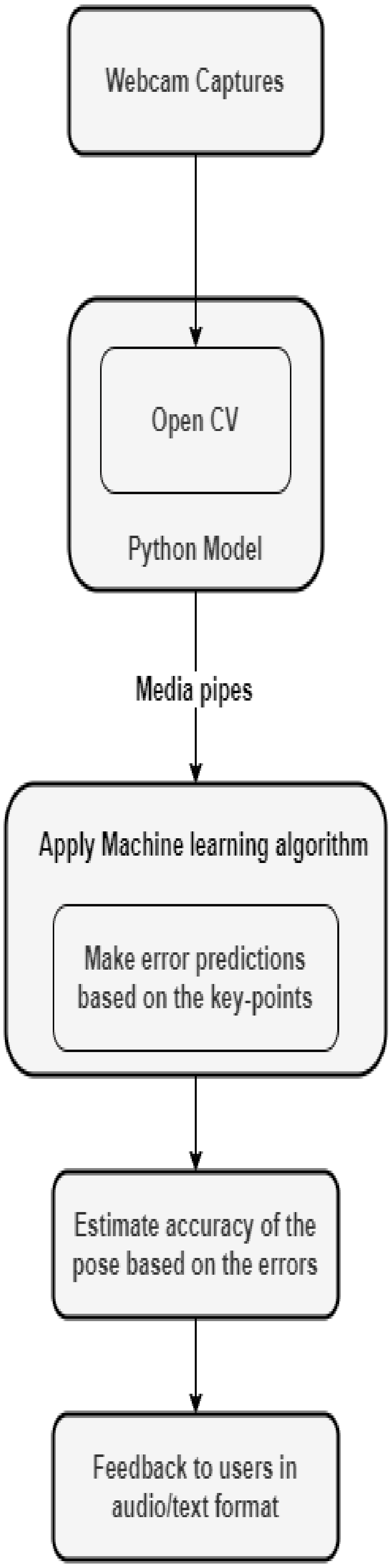

Fig 2. flow chart of process

e) Tensorflow: TensorFlow, a pivotal component, is essential for implementing machine learning models. It leverages tensors, data structures in linear algebra, to facilitate complex computations and build machine learning algorithms.

By integrating these libraries, the implementation details of the project are fortified, enabling efficient data processing, image manipulation, data visualization, and machine learning tasks.

C. Error free work flow

The model's primary goal is to evaluate the user's key observations by comparing them to a set of predetermined reference standards. Its goal is to figure out the best way to hold a particular yoga asana. In the event that any imperative point examination reveals an error or irregularity, the client will expeditiously get notices as messages and voice messages. The user is guided by these alerts to make any necessary adjustments as quickly as possible, preserving correct posture and correcting any errors.

Furthermore, the model has the capability to integrate machine learning algorithms in order to enhance its recommendations by adapting and improving them over time. This is achieved through the analysis of user feedback and performance data, as well as the examination of patterns in user behavior and the effectiveness of suggested adjustments. As a result, the system can continuously refine its guidance to better cater to individual needs and preferences. This iterative and refined approach allows the model to dynamically evolve, providing ongoing support to users in maintaining proper form and maximizing the benefits of their yoga practice. Additionally, the incorporation of user feedback into the learning process promotes a collaborative approach between the model and the user, fostering a sense of partnership in achieving optimal performance and overall well-being.

IV. Results

Researchers continuously strive to enhance the methods for teaching and evaluating machine learning. The thesis extensively examines diverse machine learning training and testing procedures, subjecting them to rigorous testing within a sample application. Several critical factors were considered in this application, including classifiers, dataset size, feature selection algorithms, sampling strategies, training and testing frequencies, among others. In the modified approach, a more comprehensive data set was employed as the training set, contributing to a richer training experience for the model. The training loss, indicative of the cumulative error rates across all samples in the training set, was closely monitored after each training batch. This process enabled the construction of a loss curve during training, revealing insights into how training performance evolved over time.

Different methods were used to perform pose estimation for the four yoga postures, as depicted in Figure 1. Once the model was validated, a total of 8 sample images were captured in real time and fed individually to the model to estimate the accuracy of each posture. The summarized average accuracy values can be found in Table 1.

Here is sample images:

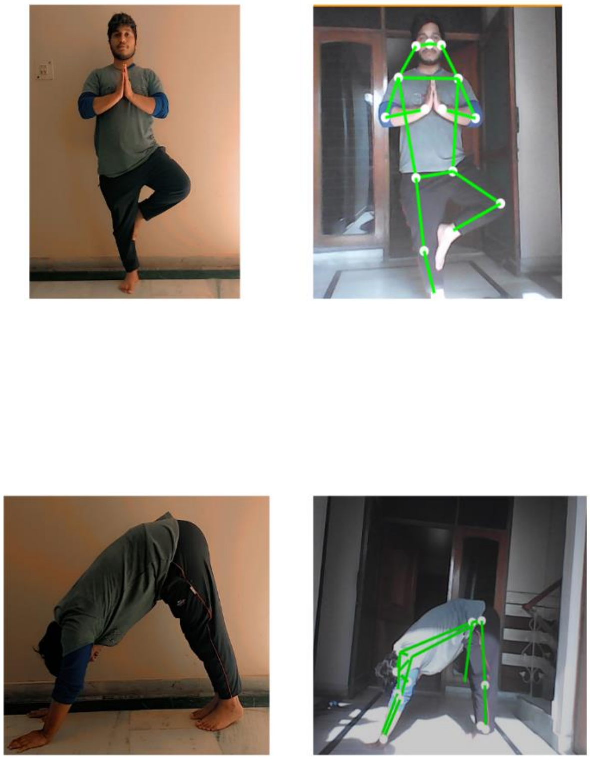

Fig 1. Sample Images

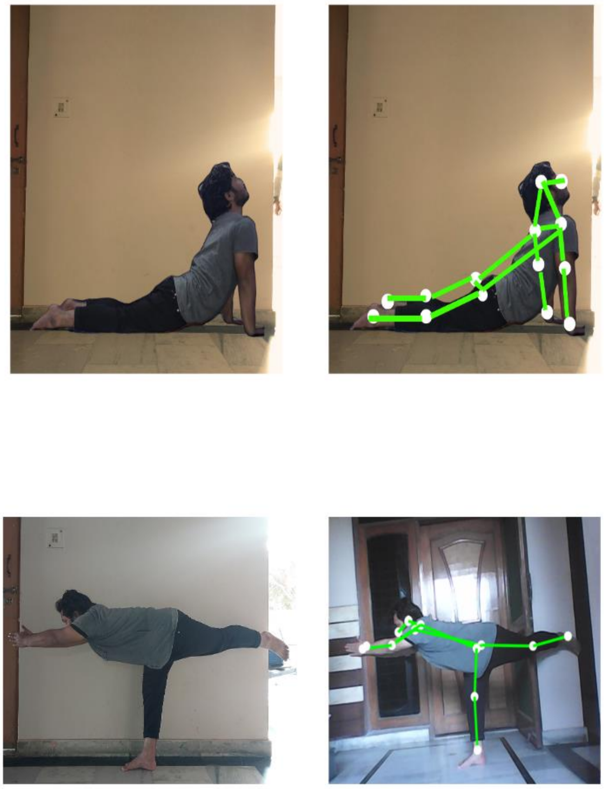

Fig 2. Sample images

Result comparison table

Approach	Base results	Our results
“Traning accuracy”	94.66%	98% Approx.
“Training loss”	0.3312	0.1044
“Test Accuracy”	0.9468	97% Approx.
“Test loss”	0.4132	0.0372
“Epochs”	100	100

Table 2 Results comparison

The accuracy values of pose estimation are influenced by factors such as background light and contrast.

Additional research is required to broaden the application of this method to other complex poses for pose estimation and correction. This can be achieved by employing improved tools that offer enhanced accuracy. These tools can aid individuals in evaluating their yoga postures and provide biofeedback, serving as a valuable self-assessment tool.

V. CONCLUSIONS AND FUTURE WORK

Yoga pose detection using AI and ML is advancing rapidly, offering significant potential to enhance yoga practice and provide real-time feedback. Despite current limitations, such as focusing on only a few poses out of the total 80+, improvements can be made by enriching datasets with key pose points. Technology can evolve to make real-time predictions and self-train on mobile devices, catering to diverse scenarios beyond individual evaluations, like crowded environments. Challenges include accommodating numerous poses and ensuring effective classification, yet advancements in computer vision and machine learning offer promising results.

Moving forward, there's a focus on enhancing accuracy, handling real-time feedback, and personalizing recommendations. Future directions include extending pose detection for multiple individuals, integrating gesture recognition, and developing accessible mobile applications. Wearable devices and remote monitoring can further augment yoga pose detection systems, emphasizing refinement in pose estimation algorithms and machine learning models. By prioritizing personalized feedback mechanisms, we can shape advanced systems that not only refine yoga practice but also contribute to overall well-being.

In the forthcoming stages of our research paper, which focuses on the future implementation of the Yoga Pose Detection project, we plan to incorporate additional features to enhance user experience and functionality. One notable addition will be the integration of a profile section for users, where they can create personal profiles and track their yoga journey. This profile section will include details of their previous achievements in performing yoga poses, such as the duration for which they maintained a perfect pose. By including these features, we aim to provide users with a more personalized and rewarding experience as they engage with the Yoga Pose Detection system.

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