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# Ensemble Analysis for Yoga Poses

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**ABSTRACT**
Yoga is a remarkable form of physical activity due to its most promising uses in personal health care. Several studies show that yoga can help with cancer, muscular, skeletal disorders, depression, parkinson's disease, and respiratory and cardiac illnesses. The entire body is the core focus for the practice of yoga. For ideal posture, the muscles, ligaments, and joints are to be aligned mechanically. Postural-based yoga improves flexibility, energy, and total brain activity while decreasing stress, blood pressure, and anxiety. Through the practice of body postural alignment techniques in yoga, key and common grievance such as back ache is critically addressed by practicing yogasanas regularly. Bending forward or backward is necessary in yogic asanas such as uttanasana, kurmasana, ustrasana, and dhanurasana. In addition, improper executed asanas can cause strain in the joints, ligaments, and backbone can create issues in human body joints. It is therefore important to monitor the correct yoga postures when performing the various asanas. The prediction of yoga postures and automatic movement analysis are now possible thanks to advances in computer vision algorithms and sensors. This research explores an in-depth analysis of improper yogasanas recognition and collectively summarizing the ensemble of yogic postures using computer vision, machine learning and deep learning techniques. (not doing the correction of postures in this research)

## INTRODUCTION

Yoga is a health-promoting activity that integrates physical postures, breathing techniques, and meditation. Because of its various health related advantages for the body, mind, and spirit, it has gained popularity all over the world. An individual's experience can be enhanced by including yoga positions into one's everyday practice since it promotes self-awareness, relaxation, and focus. This article wills to teach some fundamental yoga positions that the reader may incorporate into daily writing regimen, regardless of one's level of experience. Yogasanas that are to be performed with minimal help are Mountain Pose (Tadasana), Child's Pose (Balasana), Downward Facing Dog (Adho Mukha Svanasana), Warrior II (Virabhadrasana II), and Seated Forward Bend (Paschimottanasana).

While, Tadasana enhances body awareness, balance, and posture; Balasana, encourages reflection and relaxation. Adho Mukha Svanasana, is a restorative pose that stretches the entire body. And, Virabhadrasana II is a powerful standing pose that builds strength, stability, and focus. This pose cultivates a sense of confidence and resilience. Lastly, Paschimottanasana stretches the back of the body, including the hamstrings, calves, and spine.(No need of explaining the asanas)

## REVIEW OF LITERATURE

Research papers, Online Journal, there are several sizable databases that offer details on various yoga positions. Several well-liked choices consist of:

The Yoga Journal comprises of instructions, modifications, and advantages for every posture, the Yoga Journal website provides an extensive pose directory. The website provides search either through several categories present or pose specific as well. Similarly, the Yoga International organization offers an extensive collection of yoga positions along with detailed instructions, adaptations, and variants. For a deeper knowledge of each position, they also provide articles and videos. To cater to the modern audience as well, an internet resource named Gaia provides a database of yoga positions along with other yoga-related materials. For each stance, they offer thorough instructions, pictures, and videos. Yoga Anatomy can be practiced and perfected with a personal touch these days. Renowned yoga instructor Leslie Kaminoff is the creator of the website Yoga Anatomy. It provides alignment clues, anatomy details, and an extensive library of yoga poses. Also, Yoga.com website offers a variety of yoga positions along with thorough explanations, pictures, and advantages. To make their pose database easily accessible, they also provide a smartphone app.

Considering ARUN KUMAR RAJENDRAN's study which investigates the uses of Yogic Posture Recognition(YPR) in several industries, including gaming, fitness, security, and healthcare. Because of their affordability and compact size, it highlights the potential of wearable sensors and vision-based detectors for gathering yogic postures. The study uses deep learning, machine learning from data gathered using sensing devices to examine current advancements in the evaluation of yoga posture. It includes information from publications on kinetic models and sensor placements on the human body; and characteristics of vision- and sensor-based devices as well as key point estimation techniques.

The accuracy of commonly used deep learning and machine learning algorithms in recognizing yoga postures is suggested by the research in yoga posture classification and grading systems. It emphasizes the potential of multi-sensing sophisticated textiles and the function of sensing devices in intelligent healthcare. The study emphasizes the use of E-textiles and smart textiles and suggests that yoga, pranayama and exercise might aid towards advances in healthcare applications, particularly in times of the COVID-19 pandemic.

The study notes that despite improvements, there are still issues with current yogic posture recognition algorithms, especially when it comes to managing intricate positions and hidden body parts during practice. For applications like as an automated Yoga trainer, it is stressed how important it is to have models that are robust from different camera angles.

In way to provide a customized yoga experience, this paper attempts to suggest novel pairings of wearable technology and machine learning techniques, such as a yoga mat that integrates with smartphones and optional wearables to enhance health during the epidemic, it also suggests creating effective mobile applications for self-assessment yoga and gaming tools. Finally, the study proposes a unique method for amputee image-based yoga posture prediction.

Also considering data by Amira Samy Talaat the text discusses the ancient practice of yoga, highlighting its physical, mental, and spiritual benefits. Emphasizing the importance of correct posture to avoid health issues. It suggests that yoga should ideally be practiced under the guidance of an expert. However, recognizing the growing trend of people practicing yoga at home, the text proposes the use of computerized reasoning-based programs, aided by computer vision, to analyze practitioners' postures and offer personalized advice.

Beyond yoga posture recognition, L G Deep's concepts and methods can be adapted to address classification issues in various fields, including fitness tracking, physical therapy, and sports performance analysis. The paper suggests that the versatility of the recommended technique extends its applicability to different domains.

The future direction of research and development involves expanding the dataset to incorporate more postures, variants, and body types, enhancing the model's generalizability and robustness. Additionally, the paper proposes the inclusion of a user-friendly interface in the Yoga posture recognition system to improve accessibility, allowing users to interact with the system, visualize their positions, and track their progress over time.

| Features | OpenCV [118], [154], [164], [175] | OpenPose [57], [102], [176] | Mask R-CNN [57], [61], [102], [168], [169], [177] | MediaPipe [170]–[174], [178] |
|---|---|---|---|---|
| Author | Intel | Gines Hidalgo, Zhe Cao, Tomas Simon, Shih-En Wei, Yaadhav Raaj, HanbyulJoo, and Yaser Sheikh | Kaiming He, Georgia Gkioxari, Piotr Dollar, and Ross Girshick. | Google |
| Released Year | 2000 | 2019 | 2017 | 2020 |
| Pro's | OpenCV runs on both desktop and mobile.<br>Google, Yahoo, Microsoft, Intel, IBM, Honda, Toyota, and Sony using this library.<br>Most favoured computer vision library midst embedded vision engineers.<br>For businesses it's easy for utilizing and modifying the codes.<br>It contains more than 2500 optimized algorithms.<br>Automatic memory management. | OpenPose documents updated regularly.<br>Good technical support and issue tracking.<br>Speedup and RAM/GPU memory reduction.<br>It won the COCO keypoint challenge in 2016. | Simplicity<br>Easy to train and implement<br>Performance<br>Outperform all the single model entries in every tasks.<br>Good inference speed and accuracy.<br>Efficiency<br>Compared with Faster R-CNN, its very efficient.<br>Flexibility<br>Easy to reuse.<br>Outperforms the winners in segmentation challenges of COCO2015 and 2016. | Fast.<br>Reusable.<br>Free to use.<br>Multi-platform support.<br>Windows, Mac & Ubuntu.<br>Best solution for deploying neural network on mobile and desktop. |
| Con's | Lack of Documentation.<br>Without knowing any C++ programming skills it's not easy to work on.<br>It has only a small set of ML algorithms. | Not yet provided any support for mobile devices.<br>It does not provide the background mask.<br>It couldn't be used in Sports activities.<br>Worse accuracy and less detected number of faces | False Alerts<br>Missing Labels | Slightly complicated.<br>Lack of documentation. |
| Approach | Bottom-Up | Bottom-Up | Top-Down | Bottom-Up |
| No. of Keypoints in Body Estimation | 15 or 18 | 15, 18 or 25 | 17 | 33 |
| No. of Keypoints in Hand Estimation | 42 | 42 | - | 42 |
| No. of Keypoints in Face Estimation | 68 | 70 | - | 468 |
| No. of Keypoints in Foot Estimation | - | 6 | - | - |
| Software Compatibility | Linux, MacOS, Windows, FreeBSD, NetBSD, OpenBSD, \ iOS, Android. Maemo, and BlackBerry10. | Ubuntu (14, 16, 18, 20), Windows (8, 10), Mac OSX and Nvidia TX2. | Linux, MacOS, and Windows | Debian Linux, Ubuntu Linux, MacOS, Android, and iOS. |
| Hardware Compatibility | CUDA and OpenCL based GPU | CUDA, OpenCL, and non-GPU versions. | CUDA and CPU | Web, Modern mobile phones, Desktop/server, and embedded devices like, Raspberry Pi and Jetson Nano. |
| Written in | C++ | C++ | Python | C++ |
| Interfaces | C++, Python, Java, and MATLAB. | C++ and Python | Python | C++, Python, and Java |
| License | BSD 3-Clause | Caffe | Massachusetts Institute of Technology | Apache 2.0 |
| GitHub Ranking | 63743⋆ | 24922⋆ | 22170⋆ | 18697⋆ |
| Applications | Intrusion, Text, Vehicle and Lane Detection.<br>Face Recognition.<br>Augmented Reality.<br>Tracking Peoples.<br>Background Segmentation.<br>Social Distance Alerting.<br>Medical Image analysis and Robotics. | Vehicle Detection.<br>Single person tracking.<br>2D multi-person and 3D single person keypoint detection in real-time.<br>Assisted Living and Gaming. | Self-Driving Car and Drone Image Mapping. | Selfie Segmentation.<br>Hair Segmentation.<br>Human, Hand, and Object Tracking. |

**Figure1:** Surveyed Data from Rajendran etal

The increasing incidence of illnesses linked to age, bad food, and lifestyle choices is discussed in the text. It highlights the move toward integrative and preventative medicine, emphasizing the importance of exercise for general health. Yoga is emphasized as an effective integrative treatment that improves mental and physical qualities as well as reduces stress and increases muscular strength and flexibility.

The study examines current approaches to stance identification, specifically as they relate to yoga, referencing CNN, computer vision and accelerometer sensors. The epidemic has made yoga more well-liked as a practical and reasonably priced choice for at-home workouts. With an accuracy of 94.91%, the deep learning-based model that the authors present can identify five different yoga positions, beating conventional picture classification algorithms.

The Book by Sinha, Anurag Kumar Deepak explores the difficult field of computer vision-based human posture evaluation, concentrating on its use in the context of fitness and exercise, with a focus on the intricacies of yoga poses. It emphasizes how vital it is to practice yoga correctly because doing so might be harmful or ineffective. To help people improve their yoga form, the idea promotes the use of artificial intelligence-based applications that use real-time yoga posture detection to provide individualized feedback. Recognizing recent advances in human posture evaluation, particularly in deep learning, the main goal of the study is to investigate different methods for classifying yoga poses. Using a variety of sources, including published papers, technical reports, conference proceedings, and journals, the research aims to offer light on how contemporary technology are used to evaluate yoga postures.

The importance of human posture evaluation is emphasized in the second paragraph along with its potential to improve exercise performance and avoid injuries in the larger context of fitness and sports. The paper cites studies showing that yoga self-guidance systems have the potential to make yoga more widely practiced while guaranteeing proper form. Deep learning methods are acknowledged as promising as they have proven to be highly successful at correctly identifying six yoga postures. One such method is the use of a hybrid CNN and LSTM model using Open Pose data. The book also mentions how well a simple CNN and SVM perform in comparison to expectations. The use of SVM emphasizes how machine learning algorithms may be effective for motion identification and posture evaluation. Moreover, SVM's simplicity and efficiency in comparison to neural networks are emphasized, since it takes less training time, which makes it a notable choice in this situation.

**METHODOLOGY**

There are several choices to take into consideration when it comes to effective classifiers for yoga position categorization. The choice of classifier is influenced by several aspects, including the task's unique needs, processing resources, and dataset size. Each classifier has pros and cons of its own. The following are a few well-liked and effective classifiers for identifying yoga poses:

1. Support Vector Machines (SVM)
2. Random Forests
3. Convolutional Neural Networks (CNNs)
4. K-Nearest Neighbors (KNN)
5. Gradient Boosting Techniques (such as Light GBM and XG-Boost)

It is noteworthy to emphasize that the choice of features and hyperparameters, as well as the dataset, might affect how well these classifiers perform. To choose the best classifier for your yoga poses classification problem, try out a variety of classifiers and assess their performance using relevant evaluation metrics (e.g., accuracy, precision, recall, F1-score).

Examining the viability of deep learning models for yoga poster categorization entails evaluating the strengths, benefits, drawbacks, and possible uses of these models in this particular field. The viability of classifying yoga posters using deep learning models is thoroughly examined below:

**1. Deep Learning Models' Benefits:**

a. Automatic Feature Learning: By using raw picture data, deep learning models can automatically extract features, doing away with the requirement for human feature engineering.

b. Capacity to Capture Complex Patterns: Deep neural networks, particularly convolutional neural networks (CNNs), are well-suited for identifying various yoga poses and postures because they can capture complex spatial patterns and visual representations in pictures.

c. Transfer Learning: It is possible to refine pre-trained models using sizable datasets (such as ImageNet) for the classification of yoga posters, therefore decreasing the requirement for a sizable, labeled dataset and maybe enhancing performance.

d. Robustness to Variations: Yoga poster variations, such as variations in backdrop, lighting, and picture quality, may be well-represented by deep learning models.

**2. Practical Considerations:**

a. Dataset Availability: It is important to have access to a labeled dataset of yoga posters. Make sure the dataset is varied, representative, and big enough to accommodate a range of poses and variations.

b. Computational Resources: Deep learning model training can need a lot of compute, particularly for big CNN architectures. Examine if the necessary hardware resources (such as GPUs and TPUs) are available for training and inference.

c. Data Augmentation: In situations where the number of labeled samples is constrained, data augmentation techniques can be utilized to artificially increase the dataset. The diversity of the data may be increased by employing techniques like picture rotation, scaling, and flipping.

d. Model Complexity: Take into account how difficult it is to classify yoga posters. For basic position identification, simple designs could be enough, but more intricate models would be required to capture subtler nuances and posture changes.

**3. Deep Learning Architectures:**

a. CNNs: CNNs have demonstrated remarkable efficacy in image classification tasks. They are very good at capturing spatial patterns and characteristics in yoga posters, and they can learn hierarchical representations straight from the raw pixel values of the pictures.

b. Transfer Learning: Make use of CNN models that have already been trained on huge picture datasets, including VGG, ResNet, or Inception. Use the yoga poster dataset to fine-tune these models in order to take use of their learnt features and enhance classification performance.

c. Ensemble Models: To improve classification accuracy and resilience, combine many deep learning models, such as recurrent neural networks (RNNs) or CNNs.

**4. Assessment Measures: Measure the model's overall accuracy in accurately categorizing yoga posters**

a. Accuracy.

b. Accurately categorize distinct yoga poses by evaluating the model's performance on specific courses using the following metrics: precision, recall, and F1-score.

c. Confusion Matrix Analysis: Use this tool to find prevalent misclassifications and problems.

**5. Difficulties:**

a. Limited Labelled Data: It might be difficult to get a sizable, varied, and precisely labelled collection of yoga posters. To efficiently train deep learning models, a dataset unique to yoga positions must be gathered and labelled.

b. Overfitting: When faced with insufficient data, deep learning models are particularly vulnerable to overfitting. It is advisable to use regularization strategies like weight decay and dropout to reduce overfitting.

c. Interpretability: Deep learning models are sometimes referred to as "black-box" models since it might be difficult to understand the assumptions that underlie their predictions. Methods such as Grad-CAM and attention processes can shed light on the model's attention span throughout various sections of the poster.

**6. Applications:**

a. Yoga Pose Recommendation: Deep learning models can be used to recommend yoga poses based on a given poster, helping practitioners find suitable poses for their needs.

b. Virtual Yoga Instructors: Deep learning models can contribute to the development of virtual yoga instructors, providing real-time feedback on posture correctness and guiding users through proper alignment.

c. Yoga Poster Categorization: Deep learning models can be applied to automatically categorize and organize yoga posters based on their pose types or difficulty levels.

**Novel contribution:**

Ensemble Models:

By combining many models, ensemble learning enhances the performance of machine learning. When compared to a single model, this method produces greater predictive performance. The fundamental concept is to teach a group of classifiers (experts) and give them voting rights.

- Statistical Problem: When the hypothesis space is too big for the quantity of data that is accessible, a statistical problem occurs. As a result, just one of the several hypotheses with equal accuracy on the data is selected by the learning process! There's a chance that the selected hypothesis's accuracy on unobserved data will be low!

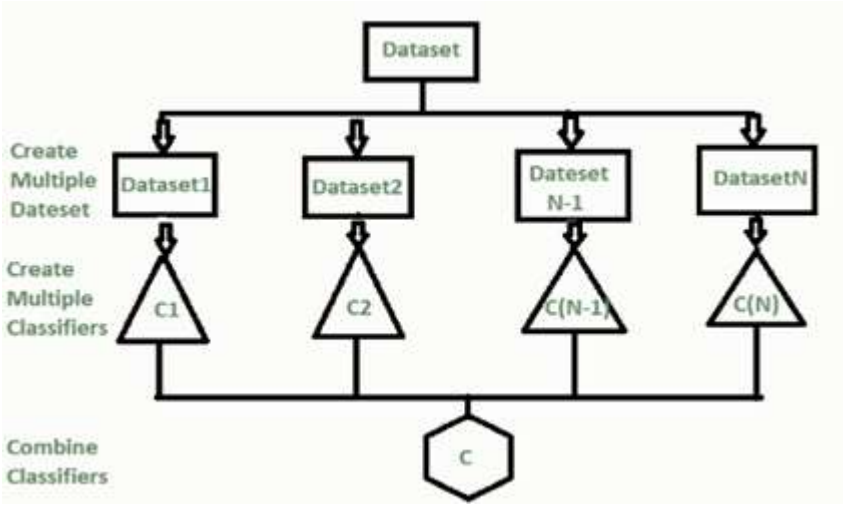


***Figure 1.*** *Ensemble classifier*

- Computational Issue: When the learning algorithm is unable to ensure the identification of the optimum hypothesis, a computational problem occurs.
- Issue of Representation: When there are no accurate approximations of the target class in the hypothesis space, the representational problem occurs. Explanation should be rewrite

**Ensemble models have many issues.**

The primary difficulty is not in obtaining base models with great accuracy, but rather in obtaining base models with various types of faults. For instance, even if the basis classifier accuracy is low, large classification accuracies can be achieved in ensemble settings if distinct base models incorrectly categorize distinct training samples. Which dataset is used for the experimentation?

**RESULTS**

Some explanation should be done about the tables

***Table 1.*** *Confusion matrices of chosen methods*

| Feature extractor | TP | TN | FP | FN |
|---|---|---|---|---|
| Mediapipe | 77 | 70.75 | 0 | 0.75 |
| Movenet | 66.75 | 50.75 | 0.5 | 1.75 |
| Openpose | 67.25 | 75.25 | 1 | 0 |
| Posenet | 68.75 | 68.5 | 3.75 | 1.75 |
| HRNet | 53.25 | 53.25 | 0.25 | 1.25 |

***Table 2.*** *Parameters computed from table 1*

| | Publisher | Language | Accuracy | Precision | Recall |
|---|---|---|---|---|---|
| Media Pipe | Google | C++/Python | 0.8661 | 1 | 0.992086 |
| MoveNet | TensorFlow | Python | 0.7124 | 0.990216 | 0.979333 |
| Open Pose | Gines Hidalgo,ZhenCao,Tomas Simon,Shih-En Wei,Yaadhav Raj 2019 | C++ | 0.7982 | 0.983916 | 1 |
| Pose Net | NVIDIA | Python | 0.8099 | 0.949484 | 0.98101 |
| HR-Net | Peter Sim | ADP | 0.8802 | 0.996753 | 0.977154 |

**DISCUSSION**

Ensemble method computes the advantages of using a particular method for a particular pose. The computation is democratic as the method with the highest parameters for most cases is chosen unanimously. In this case, the method given as the best choice is HR Net with Accuracy of 88%, Precision of 99% and recall of 97%.

**CONCLUSION**

The feasibility of using deep learning models for the classification of yoga posters is promising, given their ability to automatically learn features and capture complex patterns. However, challenges such as limited labeled data

and computational requirements need to be considered. The choice of the deep learning architecture, evaluation metrics, and data preprocessing techniques should be tailored to the specific requirements of the yoga poster classification task. Thorough experimentation and evaluation are necessary to determine the most suitable approach for accurate and reliable classification.

The significance of carefully weighing features, hyperparameters, and dataset properties in selecting the best classifier was underlined in the conclusion. Furthermore, the assessment of deep learning models for the classification of yoga postures brought to light the advantages, realistic considerations, model topologies, evaluation metrics, difficulties, and possible uses of using deep neural networks in this situation; are the advantages, disadvantages, and applicability of each classifier for multiple scenarios.

The conclusion emphasized how important it is to address issues like overfitting, interpretability, and limited labeled data while investigating the various uses of deep learning models in yoga, such as pose recommendation, virtual yoga instructors, and automatic classification of yoga posters. The conclusion emphasized how important it is to address issues like overfitting, interpretability, and limited labeled data while investigating the various uses of deep learning models in yoga, such as pose recommendation, virtual yoga instructors, and automatic classification of yoga posters. The conclusion emphasized how important it is to address issues like overfitting, interpretability, and limited labeled data while investigating the various uses of deep learning models in yoga, such as pose recommendation, virtual yoga instructors, and automatic classification of yoga posters.

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