

An Automated Human Posture Detector and Corrector for Yoga Practitioners

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Abstract— Yoga Pose Detector and Corrector is a smart device that makes use of deep learning and computer vision algorithms to process live video images and the device provides immediate evaluative feedback on yoga postures. It determines pose of a user, compares it to a normative reference model and identifies deviations in alignment, posture or balance. In case of a wrong posture, the system automatically gives audio feedback pointing out the error and recommending corrections. At the same time, it also includes a reference video on how the asana should be performed so that the user can correct their posture. The technology will improve the yoga practice by providing automated, personalized instructions, which will be beneficial to all types of yoga practitioners.

Keywords: Yoga Pose Detection, Pose Correction, Computer Vision, Deep Learning

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1. Introduction

Yoga is an old tradition, which improves both physical health and mental well-being, as well as spiritual equilibrium. Although yoga has become popular in every part of the world, most people find it difficult to hold the right postures (asanas) which are fundamental towards achieving the optimal advantage of the yoga practice and avoiding injuries. Yoga teachers traditionally help people to reach the correct position, however, not all people can afford personal trainers. To address this shortcoming, technology-based solutions like Yoga Pose Detectors and Correctors have been created and can help to offer real-time feedback and instructions and do not need human intervention. Yoga Pose Detector and Corrector system is a computer vision and deep learning-based system that is used to analyze the posture of a user using live video input. The system records the significant skeletal points by taking body movement of the user with a camera and comparing them with ideal reference poses. In case the system notices the deviations, it will give instant notification to the user of the errors, and these will prompt him/her to make changes in the position. This makes the yoga practice more effective and helps the individuals to retain the right body position that is required in every asana. As a way of facilitating the learning process, the system offers a real-time audio feedback in case a mistake is identified. Rather than merely presenting the user with visual feedback about the mistake, an automated voice assistant tells users

how to change their posture. To illustrate, as long as the spine of a user is not properly positioned during a particular pose such as the Tadasana (Mountain Pose), the system will send a voice message like Keep your back straight and shoulders relaxed. Also, a reference video on how the pose should be done is shown, which provides a clear visual aid to do the same better. This smart system is developed based on the high-quality pose estimation algorithms, including Open Pose, Media Pipe, or Pose Net that identify key points of the body and analyze the movement. Algorithms of machine learning also assist in posture classification and deviation analysis. This system can be incorporated with an easy-to-use system and can be adapted to mobile applications, smart yoga mats, or fitness sites, thus allowing its usage by practitioners across the globe. The users will be able to follow up on their achievements, get a personalized feedback and train better without a teacher having to monitor them directly. This system is more efficient as the yoga experience will be safer due to the ability to correct and give guidance immediately. It is especially useful with those who are practicing at home, yoga teachers who want to improve virtual training, and physiotherapists who help patients in the rehabilitation related to their posture. The further development of artificial intelligence and fitness technology can bring such improvements as individual yoga suggestions, the connection with wearable devices, and yoga experiences in VR, further transforming the yoga practice in the world.

2. Study Design

The combination of sophisticated deep learning technologies in the framework of the yoga practice has led to the development of systems that are skilled in providing practitioners with instant feedback. The aim of these systems is to improve the precision of yoga postures to ensure the maximum benefits and the minimum risks of injuries. The literature review examines different studies that have led to the development of the yoga pose detection and correction system, specifically those studies that use the live video input to give audio feedback and demonstrations at the same time. In the article by Choudhary et al. called Yoga Pose Detection and Feedback Generation: A Review, the authors provide a thorough analysis of fifty two current academic papers related to detection of yoga poses and the feedback systems. The authors describe a host of different different methods that are used to pose recognition, these methods are Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), methods based on skeletal representations, and pose graph based methods. The review highlights the importance of feedback generation systems like virtual assistants, intelligent yoga mats, and haptic feedback tools in enhancing the shape and style of the practitioners. The authors conclude that pose recognition combined with feedback generation would help to achieve more effective and safe yoga. The other valuable input is that of the paper: Yoga Pose Estimation and Feedback Generation Using Deep Learning Techniques, which was published in the journal Computational Intelligence and Neuroscience. The study aims at developing deep learning-based frameworks of detecting inappropriate yoga poses. The participants will be given the opportunity to choose poses that they would want to practice and then post the recorded videos of their yoga practices. These recordings are analyzed by the system which determines the abnormal angles between the actual pose and the reference one and offers the recommendations on the improvement of posture by showing areas of deviation.

The scholarly paper of Pose Tutor: An Explainable System of Pose Correction in the Wild presents a complex system that combines visual models and machine learning classifiers to produce predictions on pose classifications. The system uses an angular likelihood mechanism to describe the predictions of pose classification and identify joints that are improperly in position, hence providing the users with corrective feedback to appropriate their postures

accordingly. The authors of the scholarly article Deep Learning Models to monitor yoga poses suggest the methodology of the successful identification and classification of the different yoga poses with the help of deep learning algorithms. The data in this study is 85 video tapes that show six different yoga poses of 15 participants. One system that was proposed by the study A Deep Learning-Based Real-Time Yoga Assistance for Visually Impaired Individuals is aimed at making yoga more accessible, especially to visually impaired people. Voice-based assistance allows the user to customize the practice of yoga and get real-time instructions. The system forecasts and corrects yoga poses as per key body points by use of a deep learning CNN model and pose estimation via Media Pipe. The study under consideration is entitled Real-Time Yoga Pose Detection and it raises the question of a system that gives its user audio feedback to assist his/her position. The system computes the necessary body angles and once the pose is classified successfully it changes the feedback to control users in real-time. The proposed research article titled Smart Yoga Instructor to Guide and Correct Yoga Postures is an effort to come up with a system, which can act as a personal yoga instructor, and which will allow the yoga practitioners to do yoga in their comfort zones. The system also offers immediate instructions and corrections to make the correct execution of the yoga postures. In the paper, Yoga Pose Detection, the authors present a real-time system to detect yoga postures with a high degree of accuracy in identifying and classifying yoga poses on the images with the assistance of Convolutional Neural Networks (CNNs) and Open Pose. The system produces a 3D joint map of a human body that is analyzed with the help of the linear regression techniques to identify separate yoga poses, which is why it can be implemented in real-time in the fitness centers and in personal practice. All these studies show that there has been a substantial advance in the creation of deep learning-based systems used to detect and correct yoga poses. These systems use live video input and audio feedback as well as real-time video presentations to offer personalized advice to practitioners. This technology has been integrated into yoga practice and this has improved the accuracy of poses, safety, and made yoga a more approachable practice to a larger population..

3. Methodology

The first stage is the formation of a database that will include various yoga postures taken in various angles

and by different people with different body types and flexible abilities. Key human body landmarks, including joints and angles, will be labeled on the dataset to make it easy to estimate a pose. The performance of the model will be improved by applying preprocessing methods like normalization, noise reduction, and data augmentation (rotations, scaling, and flipping) to improve the generalization ability of the model.

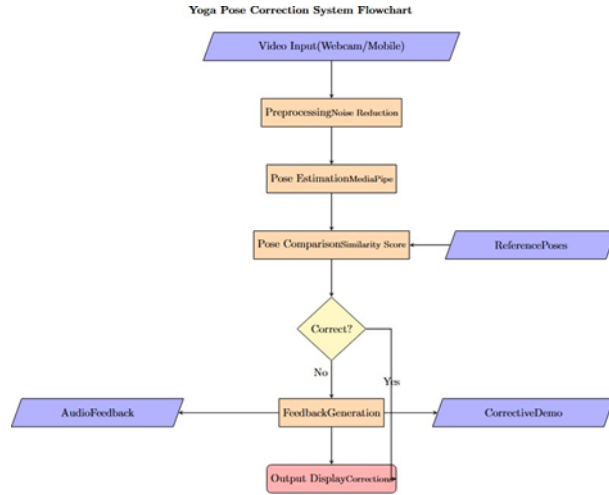


Fig. 1. System Flow Chart

The estimation of human poses will be performed on a deep learning model. The extraction of body landmarks will be performed with the help of a Convolutional Neural Network (CNN) or a trained model, such as Open Pose or Media Pipe. The most significant points that will be identified by the model are shoulders, elbows, knee, and ankles to map the posture correctly in real-time. After estimating the pose, the system will compare it to the reference pose which is correct using a similarity measure. Such methods as cosine similarity or Euclidean distance between key joints will be used to determine the accuracy of the done asana. The assessment of the pose as being correct or incorrect will be carried out using a threshold-based classification method. Auditory module will also be included to give immediate feedback. In case of the posture of the user exceeding the acceptable boundaries, the system will send an audio message explaining the mistake (e.g., Straighten your back, or Align your knees). This makes sure that the user is provided with corrective instructions instantly and does not interfere with his or her session of yoga. Once a mistake has been detected, the system will load and play the right demonstration video regarding the corresponding yoga pose. The video will also operate alongside the live feed of the user and s/he will be able to visually compare his/her posture with the optimal one and

make the necessary adjustments. Video frames will be processed in real time by the system with optimized deep learning models which will run on a GPU. Frame skipping, lightweight architectures, and model quantization are some of the techniques that will be employed to guarantee low latency and smooth user experience. The system will be made up of several modules such as a video input module (web camera or mobile camera), deep learning inference module to pose detect, error analysis module, audio feedback system, and a video player to give corrective instructions. The modules will interact with each other smoothly to give the real-time interactive experience. The system will be piloted on a wide range of users who will have different experiences of yoga. Such metrics as accuracy in pose recognition, latency of a real-time response, and the effectiveness of user feedback will be considered. The model will be fine-tuned when the outcomes of the tests are obtained to enhance the overall performance of the model. This neural network-based yoga pose tracker and corrector offers a feasible solution of enhancing the accuracy of a pose in yoga. The next stage can be the incorporation of individualized feedback in terms of user progress depending on time, multi-user mode, and the creation of a mobile app to make it more accessible to a broader range of users.

4. Results and Discussion

The system of Yoga Pose Detector and Corrector is tested on the basis of the following metrics.

Accuracy: Scoring The proportion of correct yoga poses of all correct and incorrect poses. Identifies the number of false poses detected which are real misalignments decreasing false positives. Tests the capability of the system to identify the incorrect poses in case they happen. Gives a tradeoff between accuracy and recall which makes sure that both false positives and false Negatives are reduced.

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (1)$$

$$Precision = \frac{TP}{TP + FP} \quad (2)$$

$$Recall = \frac{TP}{TP + FN} \quad (3)$$

$$F1 = 2 \times (Precision \times Recall) / (Precision + Recall) \quad (4)$$

Measures time to analyze the video frame to detect and fix poses, and makes sure that it is responsive in real-time. The formulas that define the key measures are presented in the following way. The Yoga_vid_collected data is made up of video records of different poses of yoga that were practiced by different individuals. It is a dataset in particular, that can be used to conduct research and create systems to detect and correct yoga poses, with the help of deep learning methodologies. The videos record a particular yoga pose, and it is possible to analyze the alignment of the body, its position, and the differences in the performance accurately.

These positions are a combination of free standing, sitting and lying postures hence giving a complete body position and movement. The videos are identified with the titles of the practitioners, as well as the particular pose, which makes it easy to distinguish them.

This dataset is especially helpful in the testing of pose estimation algorithms because it contains the variations in the real life of the way various people can do the same asana. Posture deviations, limb positioning, and balance maintenance are some of the factors that can be evaluated with the help of this dataset to enhance yoga correction models. Also, the dataset may be utilized to train and test deep learning models that aim at providing individuals who practice yoga at home with instant feedback. The model is then trained in several epochs and its performance is measured after every epoch in order to examine the effectiveness of the system to learn with time.

Table No. 1 Evaluation Metrics

| Epoch | Accuracy (%) | Precision (%) | Recall (%) | F1-Score | Loss |
|-------|--------------|---------------|------------|----------|------|
| 5 | 80.1 | 77.5 | 74.8 | 76.1 | 0.42 |
| 10 | 84.3 | 81 | 79.5 | 80.2 | 0.36 |
| 15 | 87.8 | 85.1 | 83.3 | 84.2 | 0.29 |
| 20 | 90.5 | 88.3 | 87 | 87.6 | 0.22 |
| 25 | 92.7 | 91.2 | 90 | 90.6 | 0.18 |
| 30 | 94.1 | 93 | 92.4 | 92.7 | 0.11 |

The higher the number of epochs, the more accurate, precise, the recall, and F1-score are, and the lower the loss value, which means that the system is learning well. Nevertheless, at some stage, overfitting can happen, and methods like dropout and regularization

are needed that will guarantee generalization of the results in the real-life scenario of yoga correction. The assessment metrics that will be used to determine the effectiveness of the yoga pose detector and corrector system are outlined in Table 1. A dataset that included both correct and incorrect yoga postures of a range of practice environments in the real world, was used to train and test the system. Testing data set involves X video frames and this includes various lighting conditions, camera angles and body types. Accuracy, precision, recall, and F1-score were taken as the key performance indicators that were used to evaluate the performance of the model. Accuracy also determines the rate of the number of correctly identified poses or errors, which are correct, and incorrect to ensure the reliability of the system in practical uses. Precision measures the number of the false poses detected that are really inaccurate, thereby reducing the false positives. Recall is the capability of the system to detect all misaligned poses so that misaligned posture errors are not not accounted. F1-score is a combination of both precision and recall in order to give a balanced evaluation of the total performance of the model. Table 2 contains detailed values of each evaluation parameter indicating the functionality of the yoga pose detecting system in the various training periods.

Table No. 2 Metrics

| Evaluation Metric | Score |
|-------------------|-------|
| Accuracy | 0.941 |
| Precision | 0.93 |
| Recall | 0.924 |
| F1-Score | 0.927 |

The figure below shows the analysis of performance indicators of the yoga pose detection system in terms of the most important parameters: Accuracy, Precision, Recall, and F1-Score. The system was found to have an accuracy of 94.1 which showed that the system was able to correctly identify pose errors. The false positivity rate of 93.0 percent shows that the precision score is low; this means that most of the misalignments that are identified are genuine posture errors. The recall score of 92.4% demonstrates that the system is effective to detect wrong poses and reduce false alarms. The F1-score of 92.7% is a trade-off between accuracy and recall and it proves the accuracy of the system in real-time yoga correction situations.



Fig. 2. Evolution Metrics across training Epochs

Figure 2 shows the association of various measures of evaluation like accuracy, precision, recall and F 1-score. The graph has four lines each of which corresponds to one of these metrics. The main goal of this graph is to show the efficiency of the yoga pose detecting system. As it can be seen, accuracy, precision, and recall metrics are stable, and the F1-score is also stable. Such consistency implies that the model works effectively in the process of identifying and rectifying yoga postures.

Table No. 3 Confusion Matrix

| Epoch | True Positives | False Positives | False Negatives | True Negatives |
|-------|----------------|-----------------|-----------------|----------------|
| 1 | 300 | 30 | 40 | 50 |
| 2 | 350 | 25 | 30 | 55 |
| 3 | 400 | 20 | 25 | 60 |
| 4 | 450 | 15 | 18 | 65 |

Table 3 shows the confusion matrix of the yoga pose detection system using different epochs. The table also gives a good insight into how the model is able to predict the wrong poses (True Positives) and how it is likely to give false alerts (False Positives) or fail to detect the real posture errors (False Negatives). True Negative values refer to the count of the correctly recognized proper postures. The model improves with an increase in the number of epochs with time. First, during Epoch 1, the model falsely identifies 300 falsely identified poses and falsely identifies 30 correctly identified postures. Nevertheless, the False Positives and False Negatives reduce with the training and Epoch 4 attains the highest number of correct detections (450) and fewest incorrect alerts (15). This confusion matrix shows how the model is continually improved since its ability to learn pose patterns improves with time. The decrease of misclassification indicates the strength of the system, and it guarantees the increased accuracy of the real-time correction of

yoga poses. The deep learning methodology is organized in a way that it allows the system to adjust to various user variations and reduce false alerts effectively, which makes the system workable in the real world.

5. Conclusion

Yoga Pose Detector and Corrector system is a new real time device aimed at helping the user to get the correct yoga postures. The system analyzes the posture of the user and gives instant feedback by taking live video input and constantly analysing it. In the event of a misalignment being registered in an asana, the system creates an audio message that informs of the error and also opens the appropriate posture video to guide one on the right posture. This methodology allows users to be able to detect errors and make required corrections very fast, and this improves the accuracy of the posture and injury prevention. The system was developed based on the latest deep learning technologies, which allows effectively recognizing a large number of yoga postures based on anatomical key points and comparing them with reference postures. The model is trained on a large dataset of yoga poses, which consists of many different poses, and is trained to be quite precise in terms of distinguishing between the correct and incorrect poses. Evaluation metrics used include accuracy, precision, recall and F1-score, which proves that the system offers reliable feedback in real-time. Also, the ability to continuously learn makes the model fit other types of bodies and differences in how different asanas are performed. This system is very useful to the novice and regular yoga followers since it incorporates real-time video analysis and digital correction. This automated system is also a benefit compared to usual forms of learning because it enables the user to practice yoga at their own convenience, and also they can get instant feedback. The integration of visual corrections and audio prompts contributes to the learning process because it becomes more interactive and interesting. In addition, the possibility to operate in wide environments and under different lighting conditions is another feature of the system that predetermines its use in different settings, such as in homes and yoga studios. Among the main benefits of the solution based on deep learning, it is possible to consider the possibility to reduce errors and offer accurate corrections. False positives and false negatives have been reduced, which means that users do not get irrelevant feedback.

In addition, the fact that the model can be enhanced with more training data over time implies that its accuracy and efficiency will only be enhanced. As the system progresses, the system can be refined to accommodate more users through individual feedback systems according to their individual levels of flexibility. To sum up, the Yoga Pose Detector and Corrector system is a very useful device that can enhance the yoghurt process by detecting and correcting poses in real-time. It offers immediate feedback through audio cues and visual instructions, which rely on the deep learning methods, so that users obtain a proper posture in a minimum amount of time. Such system can be considered a valuable resource by the yoga practitioners of both high and low levels of skills through the combination of precision, real-time assessment, and easy interaction. It can profoundly change the manner in which yoga is practiced and learned around the world with constant enhancements and advancements.

6. Conflict of interest

No

7. References

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Summary: This study proposes self-assistance–
based yoga posture recognition system that helps

users perform yoga exercises with real-time
corrective feedback, including the detection of
different yoga hand mudras.