Smart Yoga: Machine Learning Approaches for Real-Time Pose Recognition and Feedback

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ABSTRACT:
Yoga is an ancient science and discipline with a long history associated with India. It helps in maintaining a person's physical fitness as well as providing mental harmony at the same time. Due to the stress levels in modern life, yoga has recently acquired international attention. Although there are many ways to learn yoga and a variety of materials available, doing yoga without proper instruction can result in major problems like acute pain and long-term chronic issues. To overcome all these major issues, we have proposed an app that identifies yoga poses, which are performed by the user and outputs voice feedback, about the current pose of Asan. Since finding the correct relevant dataset was the major issue, we used web scraping to scrap multiple images from the web and made our dataset to train our model. The proposed model in this study is a KNN binary classifier that classifies whether the asan is correct or not, through this it allows real-time pose estimation to detect the error in a person's pose, thereby allowing them to correct it. The proposed model has shown an accuracy of 0. 836 % and an F1-Score of 82.3% for yoga pose detection and estimation.

KEYWORDS: Yoga, K-NN, Classification, Media, Pipeline, Yoga Pose, Machine Learning, Data Structures, Asanas, Pose Prediction.

INTRODUCTION :

Yoga is one of the most popular forms of exercise that improves the overall health and has some benefits like stress management, flexibility, and vigor. However, practicing yoga incorrectly will lead to some undesirable effects on ones body and mental health. Perhaps the saddest outcome of wrong practice of yoga involves the likelihood of getting injured in the process. The most common injuries are muscle strains sprains, torn ligaments or even fractures can occur with improper setting up of the body, over stretching the body or putting the body in positions that it cannot handle. Yoga poses if practiced in wrong manner leads to increase stress hormones in the body. If the intensity is too high we can stimulate the fight or flight response and stimulate the production of such stress hormones which as cortisol when present in high levels have negative health impacts on you.

Besides, there are specific postures which are contraindicated for people with various sorts of health ailments including hypertension, sprain or strain in spine or neck. It means that practicing yoga inappropriately results in improper posture and hence dysfunctional habits which if maintained in the long-term could culminate into deep pain, limited movement, and less flexibility. overtraining could be defined as an exercising situation where an individual is pushed to the limit, beyond which he or she cannot train anymore, within the shortest period of time[1]. Over training has negative effects on the athlete, these include such things as; One would expect that improvement would increase as the level of practice did; however, the research also showed that athletes who over-practiced actually performed worse on the task. The last piece of advice is to stay attentive to the degree of fatigue and to take a break if the conditions require it. To prevent these ill effects, asana should be done with caution and correctly in the right manner accompanied by a competent yogic trainer. Before practicing any kind of yoga mentioned in this article, a person who has any kind of medical condition should consult his/her doctor.

Investigators have become especially involved in employing artificial intelligence to identify human behavior for decades because of its vast potential [2]. Human activity identification has the potential to impact a variety of fields, including robotics, user interfaces for computers, video game play, camera surveillance, fingerprint authentication, disturbance identification, sports surveillance, and fitness monitoring. Although there has been many possibilities for utilising recognition technologies over the course of time, their application for identifying yoga position is an emerging and understudied area with tremendous opportunity for improving the welfare and health of society through fostering this centuries-old Indian tradition, as well as serving as a watershed moment for investigators in the growth of this field of activity recognition. Relatively brought into the world from India, yoga is today a prestigious regime in the universe due to its versatility in its ability to shape health, physically, mentally and spiritually.

Yoga's exceptional healing properties in a range of bodily disorders, including respiratory difficulties heart ailments, musculoskeletal issues, and many more, should be credited for growing significance in medicine [5, 6].However, there is a knowledge and awareness gap among the younger generation regarding the benefits of yoga, which has led to a number of health problems related to the fast-paced lifestyle of today that can be readily resolved by incorporating yoga into everyday life. The lack of appropriate direction is one of the main causes of the myths surrounding yoga, which ultimately contribute to people's reluctance to include Yoga into their life. As technology advances, it may be possible to address this lack of access to appropriate tutoring through a real-time self-learning tool that can identify different yoga postures using activity recognition tools. This would make the tool a useful tool for instruction and would contribute to the desired level of popularity for the form. The capability of humans to identify and analyse the behaviour of others is a major study topic in the academic disciplines of computer vision and deep learning. Recognition of actions is a vast field research that aims to recognise any number of individuals activities and goals based on an array of evaluations of their actions and environments. The element of understanding human behaviour associated with modelling the way a person moves is used to recognise the individual's unique movement and behaviour employing data from detectors or vision-based approaches. The actions that must be detected could be straightforward movements such as sitting, standing, chatting, or jogging, or more complicated movements such as dynamic yoga positions or specific sports stands [7].

The scientific community continues to struggle with appropriately identifying yoga postures, prompting additional investigations in this field. whichever of what methods are employed, the classification issue must always be examined in two stages: initially the identification part, followed by the localising challenge, that relates to the definition of what is happening that has to be identified and the precise positioning of the subject that is relevant in a sequence of immediate form actions. The total method consists of three distinct types of depiction: lower-level fundamental technological advances, intermediate behaviour identification, and higher levels execution [9]. The subsequent phase of the procedure involves retrieving distinct object features such as colour, structure, outline format, and actions and then representing them into attributes, that can be categorised into four forms: frequency change, regional indicators, temporal space data, and body demonstrating information. The final phase of the procedure involves event recognition and categorization approaches that distinguish various human postures and motions according to the characteristics gathered in the preceding phase. Identifying human activities is a difficult task due to the obstacles faced at each one of these levels below as a result of a number of situations, such as lack of illumination, variations in the quality of the footage, incomplete exposure, proximity surrounding chaos, position concerned, and so on [10].

Motivation:

The reason for establishing the intention to build a system that can recognize yoga poses with voice feedback is to make it easier for people to get the positive effects of yoga exercise, at the same time being able to have the best practice sessions. The purpose of this technique is to increase the possibility of embracing yoga by the largest population possible through the use of a technological tool that gives prompt identification of poses besides offering voice guidance to the users, regardless of the region or level of fitness. The approach fulfills functional demand for good postures and alignment as it offers instant feedback to avert injuries. In addition, it allows them to access progressiveness and learn it on go; helpful for the raw beginners and experienced yoga practitioners. The combination of technology and the traditional yoga technique relates to contemporary societal realities and helps individuals embrace consciousness and proper health in societies inundated with the use of technology.

Contribution of work:

- This paper proposes a system for pose recognition and correction of yoga poses in real-time, which mimics the entire feel and environment of a yoga class at home.
- This study responds to the objective of identifying yoga classes which are inexpensive as well as easily accessible yet lacks real-time tutorial.
- Model evaluation measures are also presented and creating the user feedback procedures is described in the paper.

Benefits of yoga:

Yoga offers a holistic approach to well-being, with several physical and emotional benefits as shown in figure no. 1. On a physical level, consistent practice promotes flexibility, muscle strength, and general body awareness. Yoga positions that emphasize balance and coordination contribute to enhanced stability and a better aligned posture. Yoga's careful, controlled breathing practices promote enhanced respiratory function, increased lung capacity, and relaxation. Yoga, with its emphasis on mindfulness, is a strong stress management strategy, assisting individuals in cultivating a peaceful and centered state of mind. This mental clarity, combined with increased focus and attention, carries over into daily life, positively influencing daily living and increasing emotional well-being. Yoga's integration of physical postures, breathwork, and meditation generates a perfect synergy that not only heals the body but also promotes inner peace and harmony [1-5].

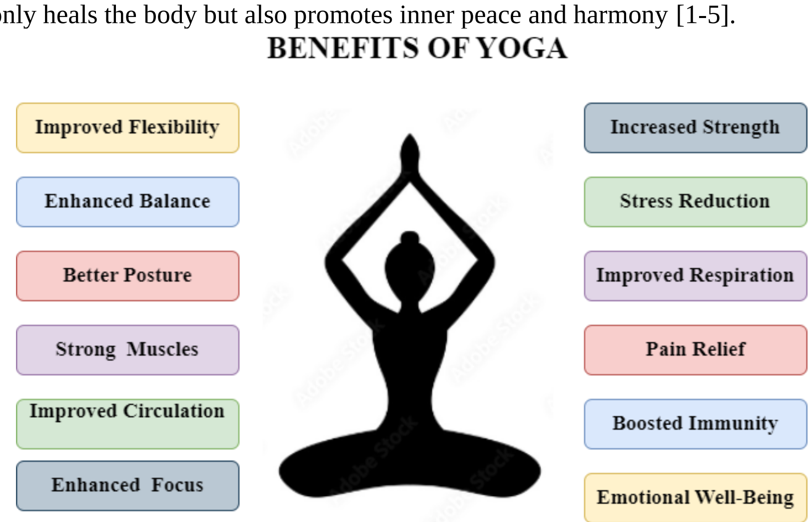


Figure 1: Benefits of practicing yoga

Yoga has been found to help to larger elements of health in addition to its physical and mental benefits. Regular practice may help to improve cardiovascular health, lower the risk of chronic diseases, and increase the immune system. Yoga's thoughtful and introspective character stimulates self-reflection, which aids people in managing and navigating their emotions. Many yoga practitioners discover that including yoga into their practice improves their entire quality of life by encouraging a sense of connectedness between mind, body, and spirit. Yoga, as a diverse and approachable practice, has the ability to benefit people of all ages and fitness levels, making it a wonderful tool for those looking for a holistic approach to health and wellness [6,7].

Pitfalls of Incorrect Yoga Practice:

Incorrect yoga practice can result in a variety of difficulties that jeopardise the holistic advantages that have historically been linked with this ancient discipline. One of the main concerns is the increased risk of physical harm. Misguided postures and incorrect alignment during asanas (yoga poses) can strain muscles, ligaments, and joints, resulting in sprains, strains, and even more serious disorders over time. The adage "no pain, no gain" does not apply to yoga, as pushing the body beyond its limits in pursuit of advanced poses might cause long-term harm rather than advancement[] .In addition to physical implications, poor practice can have a negative impact on the mental and emotional components of yoga. Yoga is designed to be a mindful and meditative activity that promotes the connection of the body and mind. However, if poses are performed incorrectly or without sufficient breath awareness, the intended mental clarity and stress reduction may be jeopardized. Incorrect breathing practices, in particular, can contribute to increased stress rather than the relaxation and centeredness essential to yoga practice. To build a safe, sustainable, and truly helpful experience on their yoga journey, practitioners must first grasp the inherent risks of wrong yoga practice [4-6].

Need for yoga pose detection and voice feedback:

The development of an app with yoga stance identification and voice feedback answers a growing desire for personalized and accessible wellness solutions as shown in figure no. 2. Such an application functions as a virtual yoga instructor in today's digital age, as health-conscious consumers seek handy ways to include physical activity in their daily life. The pose detection technology guarantees that users maintain perfect form during their practice, lowering the risk of injury and increasing the effectiveness of their yoga sessions [5-9]. The accompanying vocal feedback not only gives real-time assistance but also motivational cues, encouraging a sense of accomplishment.

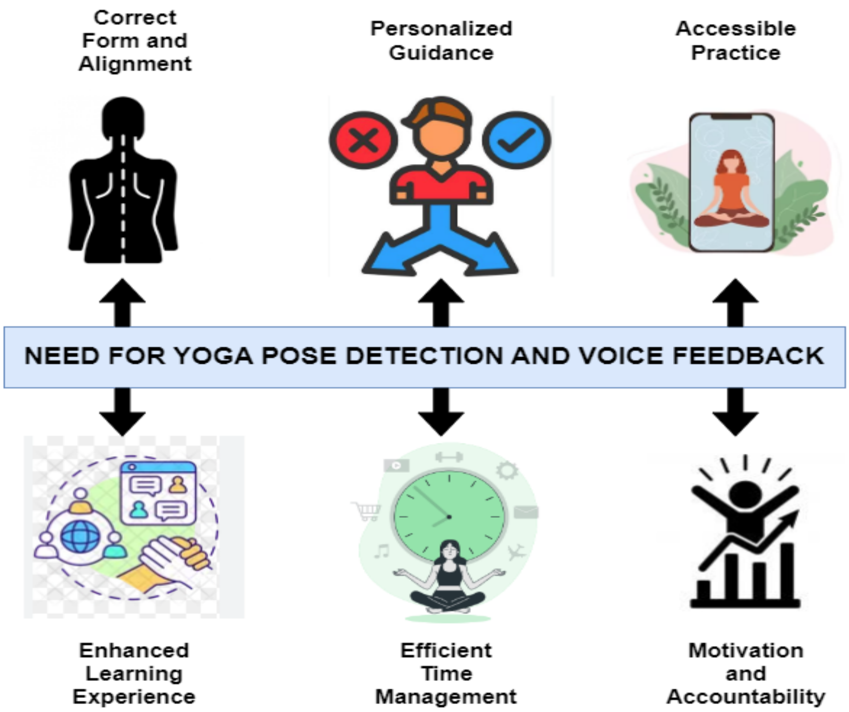


Figure 2 : Need for yoga pose detection and voice feedback

Additionally, the app helps to meet the needs of the current society with its intensified rhythm and globalization, when people can barely attend classical yoga classes or invite a yoga teacher to their homes. Especially, the voice feedback option allows users to do yoga set without leaving their homes and at any time, thus, it transforms spaces into yoga studio. This not only makes Yoga more accessible to everyone and helps in its propagation, but also it is well suited for our fast-paced modern world where even 20-30mins of practice can be squeezed into one's schedule. This programme is more useful for fortifying Mental and Physical Health and awareness through mixing of Technology with Yoga, and expanding the benefits of Yoga for a large number of people and from all around the world.[7-11]

General framework for yoga pose detection:
Figure no. 3 shows the detailed and well-structured format to detect all forms of yoga positions, which requires a systematic approach for data collection, building the model, training the model, and input from the user. To maintain reliability, large pool of data of different yoga positions is used, which goes through pre-processing stages for consistent data. A suitable posture estimation model is then selected or developed to estimate the main body joints into the high degree of accuracy and is typically reliant on deep learning approaches. The model is trained on the preprocessed dataset to minimize the parameters' configuration when the model is tested in backpropagation of different yoga positions recognition. Subsequently, the relations from the body keypoints to the particular yoga poses are established, contributing to the rough framework of posture identification[4].

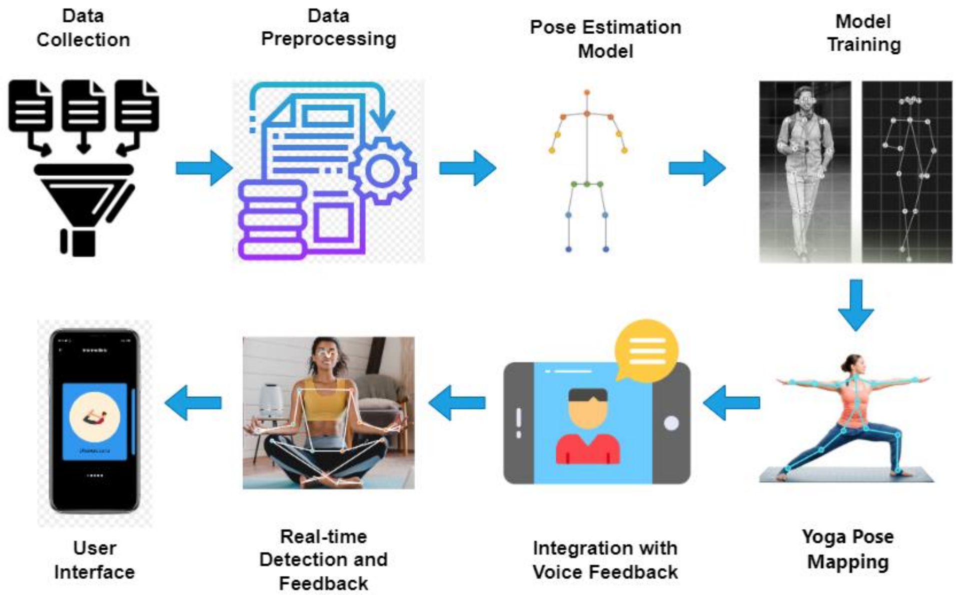


Figure 3: General pipeline for Yoga pose detection and generation of voice feedback

The final stage is integration which involves establishing a response system that incorporates pose detection with voice comments in real time. Supported by the identified postures, voice messages are fed back to participants, giving quick directions about correct body positioning, correct breath control, and other subtle aspects of the asanas. The layout of the app is quite clear with the detected poses and is complete with a box where input can be made directly. The testing methodologies market often includes thorough testing and assessment, to ensure the accuracy of the model and its responsiveness to deployment in the final application across multiple platforms. Constant feedback from the users of the YouTube application and tweaking of the model is employed in the enhancement of the yoga position identification framework adding to its effectiveness indicated by the fact that it presents a wide coverage for users in different circumstances [4-8].

METHOD:

A machine learning based yoga posture identification and voice feedback software has been created to tell the user whether he or she is doing the right or wrong yoga pose. The Yoga82 database, which includes a large number of labelled photographs of people engaged in different yoga practices, serves as a useful resource for preparing datasets for yoga pose recognition. The dataset was carefully selected to contain different poses that are usually seen in multiple yoga practices. This results in each image being tagged with the correct name of a particular yoga position thus making it possible to develop well-structured model for recognizing positions. In addition, Yoga82's database helps ensure sound and resilient models by factoring in the intricacies associated with various Asanas for effectiveness of the subsequent system on this topic.
The block diagram of proposed model is demonstrated with the help of figure no. 4 which help to give us step wise pictorial view. Raw photos from the Yoga82 database are scaled, normalised, and transformed to bitmap

format in the image preprocessing stage for yoga pose detection to ensure compatibility with following processing processes. Following that, the BlazePose model from Google ML Kit is added into the system to conduct precise pose detection. BlazePose analyses preprocessed pictures and returns keypoint coordinates for various joints in recognised postures. This stage is critical because it establishes the groundwork for extracting features that record the spatial arrangement of body parts, which will serve as the foundation for later steps in the yoga posture identification pipeline. Image preprocessing and BlazePose work together to guarantee that the input data is properly prepared and that detailed posture information is collected for subsequent analysis.

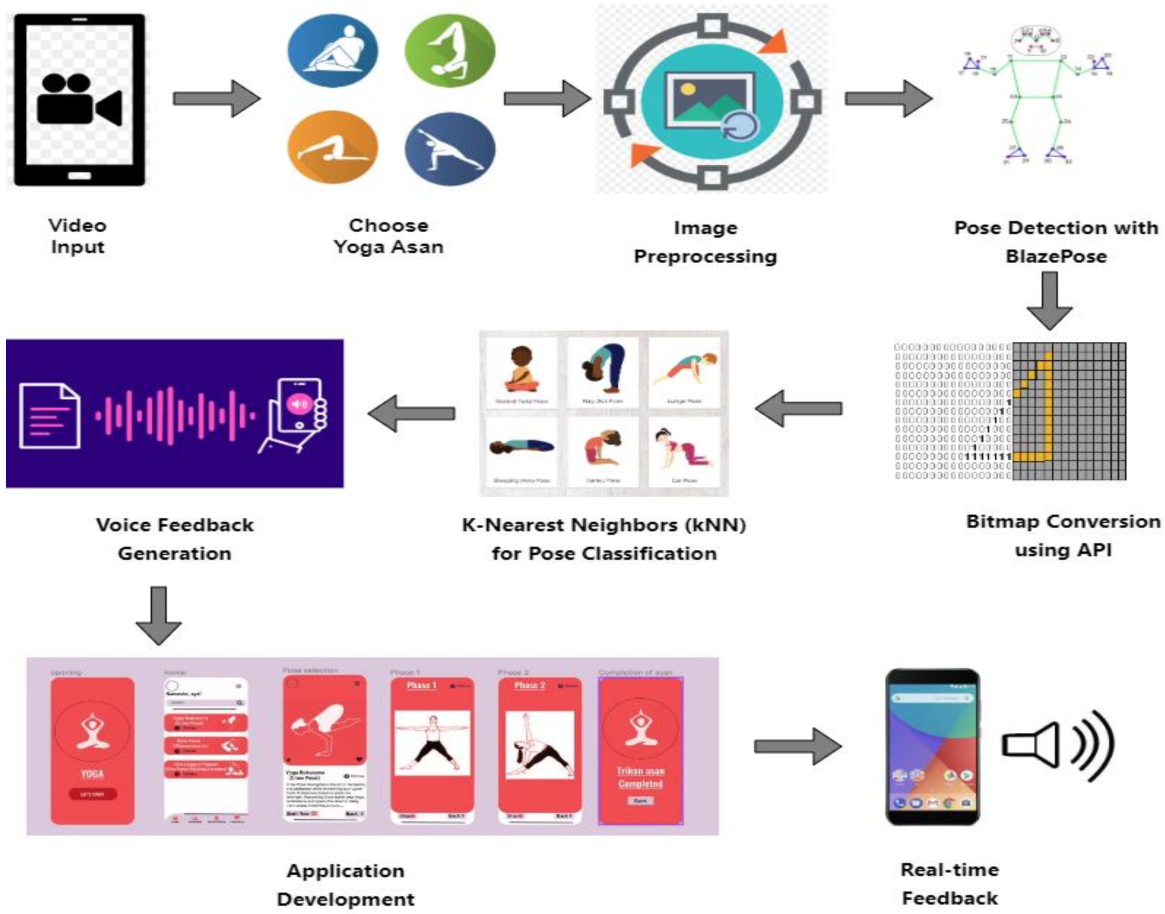


Figure 4: General Block diagram of proposed approach for detecting yoga pose and generating voice feedback

We have used the yoga-82 database for five different asanas namely Chair, Tree, Warrior-1 , Warrior-2 , Warrior-3. To extract key points for posture estimation, we used Google's ml-kit pose detection API, which leverages BlazePose to precisely localise 33 key locations, which makes it suitable for health programmes. The following generates a 33-location full-body skeletal coincide, including scores for the arms, legs, and facial characteristics (ears, eyes, mouth, and nose). An exact replica of the individual using the device with locations gazing through the camera at them. The picture's left side depicts the user's right side. It is necessary for the user's face to be present in order to recognise a pose, but BlazePose can execute subsequent ML models, such face or hand tracking, with super-real-time speed if one uses GPU inference. stance detection can also detect a partial body stance, however it performs better when the subject's full body is visible in the picture. In that situation, coordinates outside of the image are given to the landmarks that are unknown. To normalize the 33 key points returned from the api we have used torso, calculated by midpoint of shoulder(right shoulder + left shoulder)*0.5 and hip(right hip + left hip)*0.5 and using Torso size as the minimum body size. torso_size = (shoulders - hips)*0.5.

Extract features from the keypoints identified by BlazePose. Joint coordinates, relative locations, joint angles, lengths between joints, and other custom features related to yoga posture characteristics are examples of these features. Create equations to compute these characteristics. For example, if (x_i, y_i) represents the coordinates of joint i, the relative distance between joints A and B can be computed as distance_AB = sqrt((x_A - x_B)^2 + (y_A - y_B)^2).

Using the collected features, run the KNN algorithm. Using the labelled dataset, train the KNN classifier. The feature vectors will be used by the classifier to determine the nearest Neighbours and classify the posture accordingly. The Euclidean distance metric can be employed in the KNN algorithm, where the distance between two feature vectors A and B is computed as

distance(A, B) = sqrt(sum((A_i - B_i)^2)) for each feature dimension.

A Text-to-Speech (TTS) API is used in the voice feedback generation stage for yoga pose identification to convert the predicted yoga pose into spoken feedback. The TTS API generates voice feedback through a simple equation:

voice_feedback=TTS_API.generate_text_feedback(predicted_pose)

For pose estimation, we utilize a two-step detector-tracker ML pipeline. This pipeline starts by identifying the pose region-of-interest (ROI) inside the frame using a detector. The tracker then extrapolates the ROI's 33 posture keypoints. Keep in mind that the detector is only executed on the first frame in video use cases. We use the pose keypoints from the previous frame's frame to compute the ROI for following frames. In addition to the two virtual alignment key points mentioned above, the posture estimate part of the pipeline predicts the locations of all 33 key points for individuals with three degrees of freedom (x, y location, and visibility). The predicted model uses a regression technique that is supervised by a combined heat map/offset prediction of all keypoints, in contrast to current approaches that apply compute-intensive heatmap prediction.

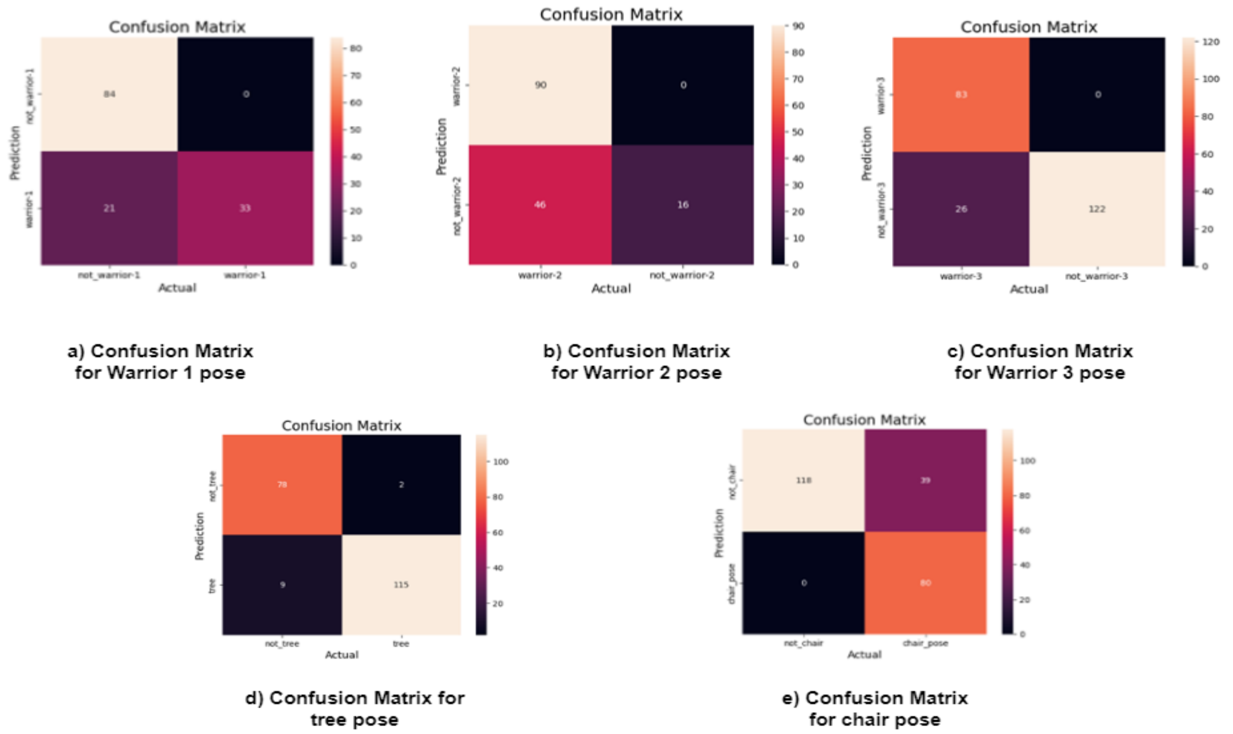
The process of turning the predicted yoga posture label into human-readable text, which is then synthesized into vocal feedback is encapsulated in this equation. The implementation of a TTS API improves the user experience by providing real-time audio cues corresponding to recognized yoga poses, allowing for effective assistance and correction during yoga practice.

RESULT AND DISCUISSION:

The following is a list of parameters signifying the performance of a particular model as highlighted in Table 1. These have been computed for six distinct possessions: the tree, the chair, the two warriors on the left and the third on the right. Score, recall and, precision are the metrics of measurement F1-score is used, whereas, recall and precision are pre-defined parameters. The F1 score for this work ranges from 63 % to 94% where the minimum measure has been achieved by us. The Yoga-82 database has the potential to be a source of useful information in the process of further development of the yoga pose detection. The dataset generally includes a range of labeled images, and thus, cover a broad spectrum of yoga poses and actions, which endows it with versatile representativeness. Every image from the Yoga-82 database also comes with annotations of the yoga poses that were performed link to certain images Therefore the Yoga-82 base dataset provides an ideal environment to train and test the pose detection algorithms. With an emphasis on yoga-specific postures, this dataset allows researchers and developers to construct and fine-tune algorithms that are tailored to the complexities of yoga practice.

Table 1: Performance evaluation of proposed approach based on different metrics

Asan	**Accuracy**	**Precision**	**Recall**	**F1_Score**	**K-value**
tree	0.94	0.94	0.95	0.94	5
chair	0.83	0.89	0.87	0.84	5
warrior-1	0.84	0.87	0.80	0.83	5
warrior-2	0.69	0.79	0.62	0.63	6
warrior-3	0.88	0.91	0.91	0.88	5
Average	0.836	0.88	0.83	0.824	5



a) Confusion Matrix for Warrior 1 pose

b) Confusion Matrix for Warrior 2 pose

c) Confusion Matrix for Warrior 3 pose

d) Confusion Matrix for tree pose

e) Confusion Matrix for chair pose

Figure 5: Confusion Matrix for different yoga pose

Warrior 1 pose

Warrior 2 pose

Warrior 3 Pose

Chair pose

Tree Pose

Figure 6: Detection of different yoga poses

An crucial ability for measuring the performance of a model designed for the identification of yoga poses is a confusion matrix that gives a more profound understanding of the classification results. The confusion matrix classifies the model's predictions in the context of yoga pose detection into four categories: False positives are defined as objects, which were recognized as poses, but indeed they are not poses; true negative means that the object was not a pose, and the program rejected it; true positive means that the program identified an object as a pose, and it was, indeed, a pose. This transfers the advantages and disadvantages of the employed model into an easily assessable graphical format of recall, accuracy, precision, and general performance matrix which can be used to evaluate performance of the model regarding any particular yoga posture. From the confusion matrix, it becomes possible to comprehend the details of the model's functioning, identify some issues that might have arisen and predict some changes to increase the dependability of the model for the identification of numerous kinds of yoga postures. In the figure no. 5 describing confusion matrix for different Yoga poses includes Warrior 1 pose, Warrior 2 pose, Warrior 3 pose, tree pose, chair pose.

Precision, recall, and F1-Score are important measures the field of human yoga posture detection and when taken as These parts alone can provide a layered evaluation of a model's performance. In assessing the findings, the identification of a greater number of patients by the first strategy offered could be compared to the identification of correctly diagnosed The total number of positive predictions to the number of actual positives, whilst precision determine the accuracy of such additional quantities and describe how the model and its capability to decrease the chance of false positives are strengthened by them.Conversely, recall evaluates the model's capacity to capture all positive case occurrences by highlighting the percentage of correctly identified postures out of all real positive case instances. The harmonic mean of precision and recall, or F1-Score, provides a fair evaluation of the model's overall efficacy and is especially helpful in situations when the distribution of positive and negative cases is not uniform.. Performance of KNN classifier for the five asan namely tree, chair, warrior-1, warrior-2 and warrior-3, are as follows tree asan, warrior-1 pose, warrior-3 asan, chair pose, and last warrior-2 pose is shown in figure 6. This is due to the complexity of asana and the relative position of key points the classification becomes difficult as a result of which the performance of KNN gradually decreases from a simple pose such as tree asan to a more complex pose warrior-2.

CONCLUSION:

In conclusion, the developed yoga pose detection technique, incorporating Google ML Kit, BlazePose, bitmap conversion, API integration, K-Nearest Neighbors (KNN), and leveraging the Yoga 82 database, has demonstrated significant efficacy in detecting and providing voice feedback for five distinct yoga poses: Tree, Chair, Warrior 1, Warrior 2, and Warrior 3. The integration of state-of-the-art technologies, such as BlazePose for accurate pose estimation and Google ML Kit for robust machine learning capabilities, has enabled a holistic and real-time yoga guidance system. The classification methods applied using KNN, along with the bitmap conversion techniques and the integration of a Text-to-Speech (TTS) API additionally helps in the clear communication of feedbacks to the users, helping in improving their yogic practice. The achieved average maximum accuracy and F1-Score of 0.94 show that the proposed system is quite reliable and almost equally effective in providing feedback for the particular set of yoga poses discussed in this research, pointing to its feasibility as a tool that can help yoga practitioners practice with more guidance and focus on the most problematic asanas.

As such, it is possible to identify certain points to consider, which can potentially provide directions for improvement in future studies. There are further improvements that could be made in directions for the model in terms of conforming to other body shapes and poses and including more features as components of the system. Moreover, including more painful poses and even more difficult poses, different lighting conditions could be helpful in making the identified technique more universal and applicable to different situations. In total, the provided scheme outlines the possibilities for the implementation of innovative technologies to improve the perception of yoga practice and improve the efficiency of users' exercises, as well as personalizing the process by involving the client in the process..

CONFLICT OF INTEREST:

The authors have no conflicts of interest regarding this investigation**.**

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