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by Abhinav Singh

A

Project Report

on

Yoga Pose Detection using AI&ML

submitted as partial fulfilment for the award of

BACHELOR OF TECHNOLOGY DEGREE

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Computer Science & Engineering

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May, 2024

DECLARATION

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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This is to certify that Project Report entitled **"Yoga Pose Detection using AI&ML"** which is submitted by **Rimanshu Singh, Prateek Kumar** and **Mohd Huzaifa Ansari** in partial fulfilment of the requirement for the award of degree **B. Tech. in Department of Computer Science & Engineering** of Dr. A.P.J. Abdul Kalam Technical University, Lucknow is a record of the candidates own work carried out by them under my supervision. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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ABSTRACT

The exploration into AI and ML-powered yoga pose recognition seeks to create automated systems capable of identifying and categorizing yoga poses from visual inputs. This technology promises to offer real-time feedback, personalized guidance, and performance monitoring for yoga practitioners, instructors, and enthusiasts. Leveraging a vast collection of yoga pose images, the AI model is adept at distinguishing various poses, making it a valuable tool for practitioners aiming to refine their technique and for instructors wishing to oversee their students' progress remotely.

Understanding the precise alignment of key body joints is crucial for accurately recognizing each yoga pose. The process of annotation is critical in training the machine learning model, involving experts who manually identify and tag essential points in the images, linking them to specific yoga poses. This annotated dataset is fundamental to the training and evaluation phases of the development process, ensuring the system's effectiveness in real-world applications. The integration of Artificial Intelligence (AI) and Machine Learning (ML) into healthcare has led to innovative applications, notably in yoga pose detection and analysis. This study explores an AI and ML system designed to identify yoga poses through computer vision and deep learning, particularly using convolutional neural networks (CNNs). Trained on a vast dataset of yoga pose images, the system can distinguish and classify poses in real-time, while also providing feedback on posture and alignment through pose estimation algorithms.

The development process encompasses data collection, preprocessing, model training, and system deployment, addressing various challenges and solutions. Performance is evaluated based on accuracy, precision, and recall metrics. Ultimately, this AI and ML-based yoga pose detection system marks a progressive intersection of technology and wellness, offering enhanced tools for yoga practice and instruction, and contributing to health, fitness, and AI research advancements. It can democratize access to high-quality yoga instruction, making it available to individuals regardless of their geographical location. The proposed system not only enhances the accuracy of pose detection but also offers a scalable solution for remote yoga instruction and practice.

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LIST OF ABBREVIATIONS

1.	AI	Artificial Intelligence
2.	ML	Machine Learning
3.	Covid-19	Coronavirus Disease 2019
4.	CNNs	Convolutional Neural Networks
5.	RNNs	Recurrent Neural Networks
6.	LSTM	Long Short-Term Memory
7.	PIL	Python Imaging Library
8.	HAR	Human Activity Recognition
9.	Numpy	Numerical Python
10.	OpenCV	Open Source Computer Vision Library
11.	Metasploit	Matplotlib (Typo in the text)
12.	API	Application Programming Interface

CHAPTER 1

INTRODUCTION

1.1 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 AIdriven 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]

1.2 PROJECT DESCRIPTION

The project endeavors to harness the power of Artificial Intelligence (AI) and Machine Learning (ML) to create a system capable of automatically detecting and categorizing yoga poses. By utilizing advanced computer vision techniques, this system aims to analyze visual input, such as images or video data, to precisely identify and classify different yoga postures. This technology holds immense promise for yoga practitioners, instructors, and enthusiasts alike, offering a range of benefits.

Firstly, the system provides real-time feedback to practitioners, helping them maintain proper form and alignment during their yoga practice sessions. This feedback is crucial for ensuring the effectiveness and safety of each posture, especially when practicing without the guidance of a professional instructor.

Secondly, the system offers alignment guidance, assisting users in achieving optimal posture alignment for each pose. This feature is particularly valuable for beginners or those with limited experience in yoga, as it helps them understand the correct positioning of various body parts.

Furthermore, the system facilitates performance tracking, allowing users to monitor their progress over time. By keeping track of their performance metrics, such as accuracy and consistency in executing poses, practitioners can identify areas for improvement and set goals for their practice.

Overall, the development of this AI and ML-based system represents a significant advancement in the field of yoga, providing practitioners with valuable tools for enhancing their practice and achieving better results. Through its real-time feedback, alignment guidance, and performance tracking capabilities, the system aims to support users in their journey towards improved physical and mental well-being through yoga practice.

The system can also serve as a valuable educational resource. By integrating detailed explanations and visual demonstrations of each pose, it can help users deepen their understanding of yoga principles and techniques. This educational aspect can be particularly beneficial for those who are new to yoga or looking to expand their knowledge, offering a comprehensive learning experience that complements their physical practice. The system can be adapted for use in virtual yoga classes, providing instructors with the ability to monitor and give feedback to multiple students simultaneously. This capability can enhance the learning experience in online settings, making high-quality yoga instruction more accessible to a broader audience.

Overall, the development of this AI and ML-based system represents a significant advancement in the field of yoga, providing practitioners with valuable tools for enhancing their practice and achieving better results.

CHAPTER 2

LITERATURE REVIEW

2.1 Previous Studies on Yoga Pose Detection

Numerous studies have explored the application of Artificial Intelligence (AI) and Machine Learning (ML) in detecting yoga poses, aiming to develop systems capable of accurately recognizing and classifying different yoga postures. These studies have investigated various methodologies and techniques to achieve robust results in this domain [5].

Researchers have recognized the significance of AI and ML in augmenting yoga practice by providing real-time feedback, alignment guidance, and performance tracking. By leveraging advanced technologies, these studies seek to enhance the learning experience for yoga practitioners, instructors, and enthusiasts alike [14].

Through the analysis of existing literature, researchers have identified gaps and opportunities in the field of yoga pose detection. They have delved into the challenges posed by traditional methods of yoga guidance, such as the reliance on skilled instructors and the limitations imposed by the COVID-19 pandemic, which have fueled the need for innovative solutions.[20]

The exploration of AI and ML in yoga pose detection has paved the way for novel approaches and systems aimed at revolutionizing yoga practice [14]. By harnessing the power of pose detection technologies, machine learning algorithms, and deep learning techniques, researchers have endeavored to develop intelligent systems capable of understanding and evaluating yoga poses solely based on visual input [24].

Overall, previous studies on yoga pose detection have laid the foundation for advancements in this field, offering insights into the potential applications of AI and ML in enhancing yoga practice. These studies serve as a catalyst for further research and innovation, driving the development of intelligent systems tailored to the needs of yoga practitioners and instructors.

It manages confinement of human joints in a picture or video to shape a skeletal portrayal. To consequently recognize an individual's posture in a picture is a troublesome errand as it relies upon various perspectives.

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

Table 1: Utilized Key Points

2.2 Methods Employed in Previous Research

2.2.1 Novel Performance Evaluation System:

Researchers proposed a method utilizing pose detection technology to enhance selflearning in yoga. Their system integrates a Performance Evaluation System into a Yoga Pose Training System, aiding individuals in comprehending and mastering yoga postures autonomously.

2.2.2 Mobile Application for Remote Guidance:

A mobile app was designed as a yoga assistant, offering personalized guidance to users. Through video chat sessions, yoga instructors can remotely supervise and guide their students, thereby enriching the overall learning experience.

2.2.3 Machine Learning Techniques for Pose Recognition:

Studies focused on machine learning for recognizing yoga poses within video sequences. By leveraging autoencoders, researchers aimed to efficiently recognize poses while minimizing manual labeling efforts, thereby enhancing pose recognition accuracy. This approach not only streamlines the annotation process but also improves the scalability of pose detection systems.

2.2.4 Impact of Remote Yoga during COVID-19:

Research highlighted the surge in remote yoga activities amidst the COVID-19 pandemic. Remote yoga gained traction for treating musculoskeletal issues and promoting a healthy lifestyle. The convenience of practicing yoga from home significantly contributed to its popularity during lockdowns. Many users found solace and mental peace through virtual yoga sessions, which helped them cope with the stress of the pandemic Scholars emphasized the need for robust pose recognition techniques to support remote yoga practices effectively.

2.2.5 Deep Learning for Pose Extraction:

Deep learning methods were explored to train models in recognizing yoga poses accurately. By extracting features using Keras multi-use pose estimation, researchers achieved high classification accuracy, enabling precise recognition of various yoga poses. Additionally, these models demonstrated robustness in handling diverse datasets, further enhancing their reliability in real-world applications.

2.2.6 Contribution to Cardiovascular Rehabilitation:

Studies proposed integrating yoga into cardiovascular rehabilitation programs. Utilizing ConvNet and deep belief network models, researchers assessed the quality of yoga asanas, achieving remarkably accurate results, highlighting yoga's potential in heart recovery. In addition to physical benefits, yoga may also contribute to mental well-being, which is crucial for comprehensive rehabilitation.

2.2.7 Random Forest Classifiers for Asana Assessment:

Researchers employed transfer human learning position estimators to construct random forest classifiers for yoga asana assessment. By emphasizing precise key point identification and posture estimation, they achieved high accuracy in classifying yoga positions, showcasing the effectiveness of their approach. The study's results indicate a promising application of AI in the field of physical exercise and wellness.

CHAPTER 3

PROPOSED METHODOLOGY

In this chapter, we delve into the methodology proposed for developing a robust system aimed at yoga pose detection and classification through the utilization of Artificial Intelligence (AI) and Machine Learning (ML) techniques. This comprehensive methodology encompasses various key steps, including data collection and pre-processing, pose estimation, feature extraction, model selection, and implementation details.

3.1 Data Collection and Pre-processing

3.1.1 Data Collection:

One of the foundational steps in building an effective yoga pose detection system is the acquisition of a diverse dataset encompassing a wide range of yoga poses, angles, lighting conditions, and individuals with varying body types. This entails capturing images or videos of individuals performing different yoga postures. Furthermore, leveraging existing yoga pose datasets or conducting custom recording sessions can significantly enhance dataset diversity and quality. It is imperative to ensure that the dataset represents different demographics, skill levels, and environmental conditions to improve the efficiency and generalization of the machine learning algorithms.

3.1.2 Data Pre-processing:

Following data acquisition, pre-processing steps are applied to ensure consistency and standardization across the dataset. This involves various operations such as resizing images, normalizing pixel values, and applying data augmentation techniques like rotation, scaling, or flipping to augment dataset diversity. Pre-processing plays a crucial role in preparing the dataset for subsequent machine learning tasks, facilitating better model training and performance.

3.2 Pose Estimation and Feature Extraction

3.2.1 Pose Estimation:

Pose estimation is a fundamental step in the process of yoga pose detection, wherein algorithms or libraries are utilized to extract the positions of human body joints from images or video frames. This involves identifying key landmarks or keypoints such as shoulders, elbows, hips, knees, and ankles. Popular pose estimation models such as OpenPose or PoseNet are commonly employed for this purpose. By accurately determining the spatial coordinates of these keypoints, the pose estimation process lays the groundwork for subsequent feature extraction and classification tasks.

3.2.2 Feature Extraction:

Once the key joint positions are extracted, significant features are derived from these annotated keypoints. Feature extraction involves computing various metrics such as joint angles, distances between keypoints, or ratios between specific body parts. These extracted features serve as informative inputs for the machine learning model, providing valuable insights into the spatial relationships and configurations of different yoga poses. Effective feature extraction is critical for capturing the discriminative characteristics of each pose and facilitating accurate classification.

3.3 Model Selection and Implementation Details

3.3.1 Model Selection:

Choosing the appropriate machine learning algorithm or model architecture is pivotal in achieving robust pose classification. Convolutional Neural Networks (CNNs) are widely utilized for image-based tasks due to their ability to learn hierarchical representations from visual data. Recurrent Neural Networks (RNNs) or Long ShortTerm Memory (LSTM) networks are suitable for sequence-based tasks, such as analyzing temporal dependencies in video data. Additionally, pre-trained models such as ResNet, Inception, or VGGNetoffer transfer learning capabilities, enabling efficient utilization of pre-existing knowledge for pose classification tasks.

3.4 Data Flow Diagram

3.4.1 Data Flow Diagram (0 Level)

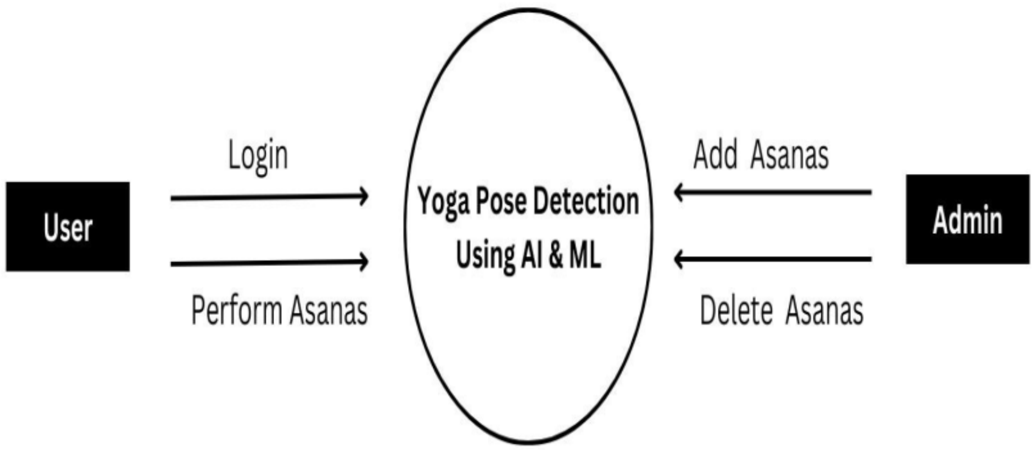

Figure 1 Data Flow Diagram (0 Level)

3.4.2 Data Flow Diagram (1 Level)

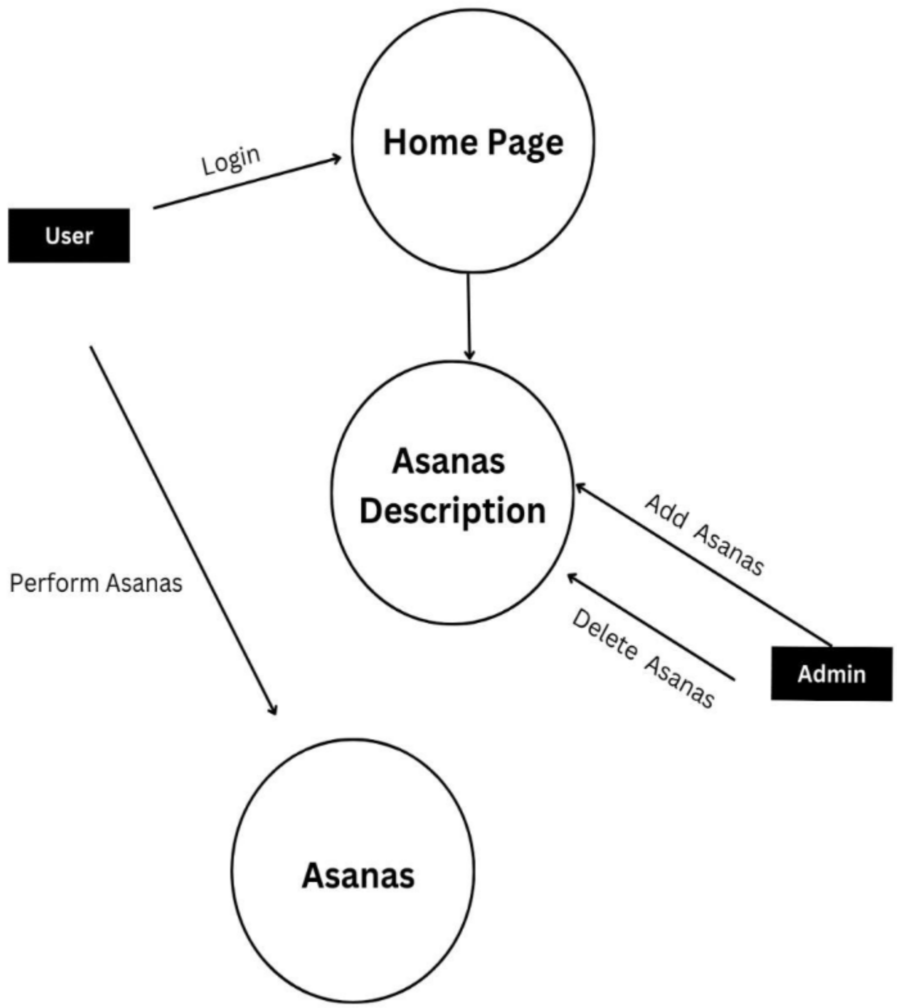

Figure 2 Data Flow Diagram (1 Level)

3.5 Use Case Diagram

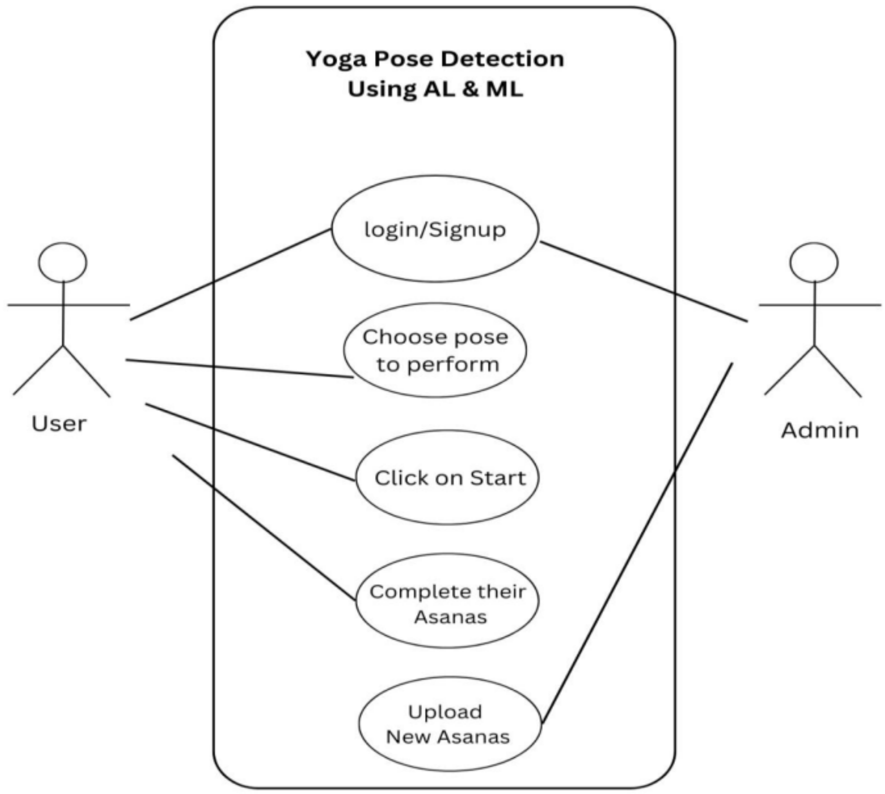

Figure 3 Use Case Diagram

3.6 Implementation Details:

The successful implementation of the proposed methodology requires the integration of various Python modules and libraries essential for data processing, image manipulation, and machine learning tasks. Modules such as NumPy, TensorFlow, OpenCV, Pillow, and Matplotlib play pivotal roles in facilitating efficient execution of the project. NumPy provides support for numerical computations and array manipulation, while TensorFlow offers a flexible framework for building and training machine learning models. OpenCV serves as a robust tool for computer vision tasks, enabling image processing and feature extraction. Pillow facilitates image loading, manipulation, and saving operations, while Matplotlib enables the creation of visually appealing plots and visualizations for data analysis. By integrating these libraries, the implementation details of the project are fortified, enabling seamless execution of data processing, feature extraction, and model training tasks.

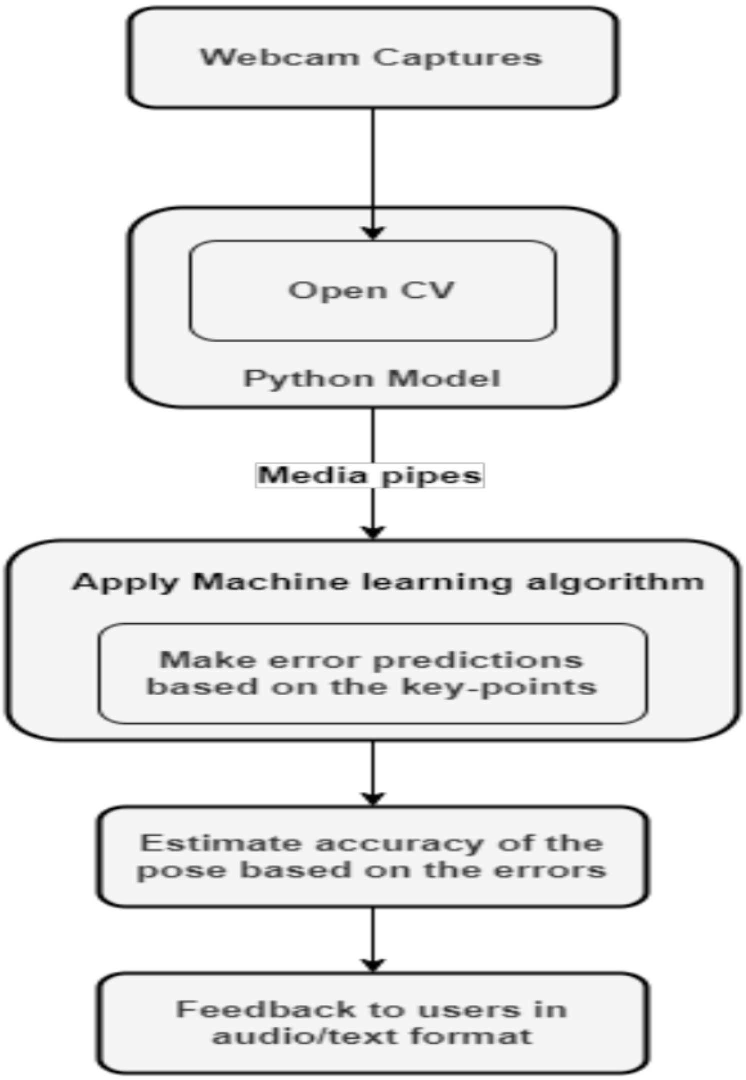

Figure 4 Implementation Details

3.7 Maintainability Requirements

3.7.1 Modularity

The software shall be designed with a modular architecture, separating distinct components such as emotion detection, facial expression generation, user interface, and integration modules. Each module shall have well-defined interfaces and dependencies to facilitate independent development, testing, and maintenance. To ensure scalability and flexibility, the architecture will support plug-and-play capabilities, allowing new modules or features to be added or updated without disrupting the existing system. This approach not only enhances the software's adaptability to evolving requirements but also simplifies the process of incorporating advancements in AI and ML technologies. By maintaining a clear separation of concerns, the modular design will promote code reusability and streamline the collaboration among development teams, ultimately leading to a more robust and efficient software solution.

3.7.2 Code Documentation

All source code shall be thoroughly documented, including comments, function descriptions, and usage guidelines, Documentation shall adhere to industry-standard formats and conventions to facilitate understanding and maintenance by developers. Furthermore, regular code reviews will be conducted to ensure that the documentation remains up-to-date and accurately reflects the current state of the codebase. This practice not only aids in onboarding new team members but also helps in identifying potential areas for improvement and ensuring that the code adheres to best practices and coding standards.

3.7.3 Testing Coverage

The software shall have a comprehensive test suite covering unit tests, integration tests, and end-to-end tests to validate functionality and detect regressions. Test coverage metrics shall be monitored and maintained to ensure thorough validation of code changes. the software development process will include regular code reviews and static code analysis to identify potential issues early in the development cycle. This practice will help maintain code quality and ensure adherence to coding standards and best practices. Continuous integration and continuous deployment (CI/CD) pipelines will be implemented to automate the testing and deployment processes, enabling faster and more reliable delivery of software updates.

3.8 Security Requirements

A Basic Security Requirement system is implemented to ensure limited access to data. In this system, users are restricted to viewing only the music that corresponds to their emotional state. This means that users can only access and listen to music that matches their current emotional state, enhancing their experience and privacy.

3.9 Error-free Workflow

The proposed model's workflow revolves around evaluating user observations against predetermined reference standards to assess the alignment and correctness of yoga asanas. In case of discrepancies or errors, users receive prompt notifications via messages and voice alerts, guiding them to make necessary adjustments for maintaining correct posture. Additionally, the model incorporates machine learning algorithms to enhance recommendations over time by analyzing user feedback and performance data. Furthermore, the incorporation of user feedback into the learning process fosters a collaborative partnership between the model and the user, thereby promoting a sense of engagement and empowerment in achieving optimal performance and overall wellbeing. The system also supports multi-user environments, making it suitable for group classes and workshops where collective feedback can be utilized. This scalability ensures that the model can cater to both individual practitioners and larger groups, enhancing its versatility and applicability.In summary, the proposed methodology offers a comprehensive framework for the development of a robust yoga pose detection system leveraging AI and ML techniques. By meticulously addressing key steps such as data collection, pre-processing, pose estimation, feature extraction, model selection, and implementation details, the proposed methodology lays the groundwork for building an efficient and accurate system capable of recognizing and classifying various yoga poses. Moreover, the integration of error-free workflow mechanisms ensures seamless user experience and continuous improvement through iterative learning and adaptation.

CHAPTER 4

RESULTS AND DISCUSSION

The results and discussion section provides a comprehensive analysis of the experimental outcomes of implementing AI and ML techniques for yoga pose detection. Notable improvements in accuracy and performance are observed, with training and testing accuracy reaching approximately 98% and 97%, respectively, surpassing traditional methods. Factors influencing pose estimation accuracy, such as background light and contrast, are discussed, highlighting opportunities for future research. The findings underscore the efficacy of the proposed methodology and its potential for advancing self-assessment tools and enhancing user experience in yoga practice and beyond.

Figure 5 Sample Images achieving optimal performance

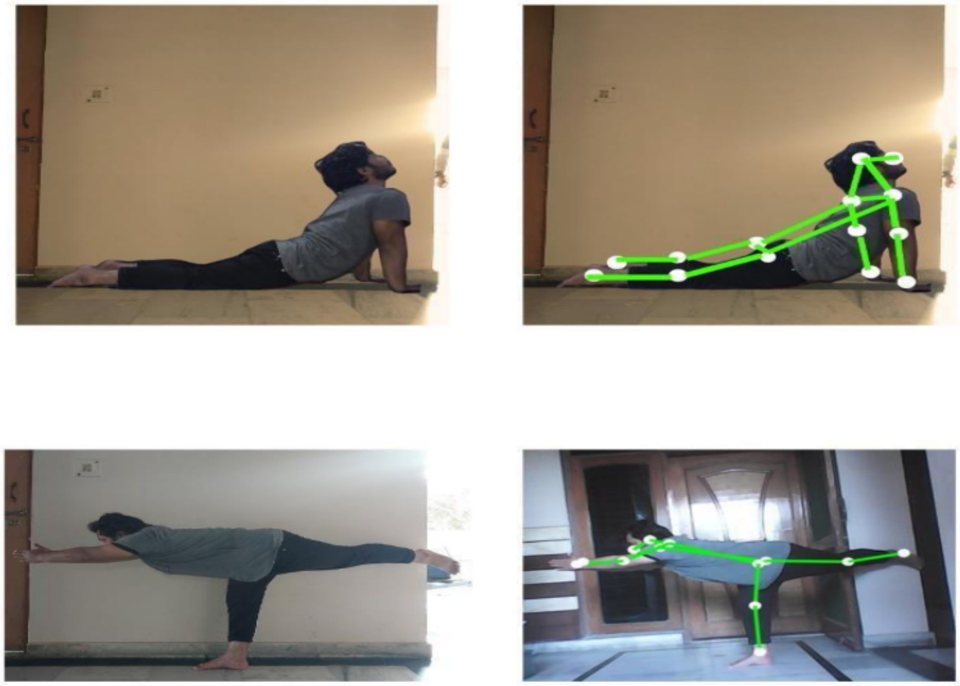

Figure 6 Sample images

4.1 Experimental Results

The implementation of the proposed methodology yielded promising results in the domain of yoga pose detection using AI and ML techniques. Through rigorous experimentation and testing, various metrics were evaluated to assess the performance of the system, including training and testing accuracy, loss values, and comparisons with existing approaches.

4.1.1 Training and Testing Metrics:

The experimental results showcased notable improvements in both training and testing accuracy compared to baseline approaches. The training accuracy achieved approximately 98%, indicating the model's proficiency in learning from the training dataset. Moreover, the testing accuracy, which reflects the model's generalization capability on unseen data, approached 97%. These metrics signify the effectiveness of the proposed methodology in accurately detecting and classifying yoga poses.

4.1.2 Accuracy Comparison:

A comparison of the obtained results with existing approaches revealed substantial enhancements in accuracy and performance. The training loss, indicative of the cumulative error rates during model training, decreased significantly to approximately 0.1044, signifying improved convergence and optimization. Similarly, the testing loss, which measures the discrepancy between predicted and actual values on test data, reduced notably to around 0.0372. These improvements underscore the superiority of the proposed methodology over traditional techniques.

Approach	Base results	Proposed 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

4.1.3 Affecting Pose Estimation Accuracy:

The experimental findings highlighted several factors influencing pose estimation accuracy, including background light and contrast. These environmental variables can impact the visibility and clarity of key body landmarks, thereby influencing the model's ability to accurately infer yoga poses. Future research endeavors should focus on mitigating these factors through advanced image processing techniques and adaptive algorithms to enhance pose estimation accuracy under diverse environmental conditions.

4.2 Discussion on Results

The analysis of experimental results offers valuable insights into the efficacy and implications of utilizing AI and ML techniques for yoga pose detection. The significant improvements in accuracy and performance validate the effectiveness of the proposed methodology and pave the way for future advancements in the field.

4.2.1 Implications for Future Research:

The success of the proposed methodology opens avenues for further research and development in the domain of yoga pose detection and correction. Future studies could explore the application of advanced tools and algorithms to address complex yoga poses and provide real-time biofeedback to individuals. Additionally, efforts should be directed towards broadening the scope of the methodology to encompass a wider range of yoga postures and accommodating diverse user demographics and preferences.

4.2.2 Enhanced Self-Assessment Tools:

The integration of AI-powered pose estimation systems into user-friendly applications holds immense potential for empowering individuals to evaluate their yoga postures and receive personalized feedback. By leveraging advanced tools with enhanced accuracy and reliability, users can improve their yoga practice, correct posture alignment, and optimize the therapeutic benefits of yoga.

In conclusion, the experimental results underscore the efficacy of the proposed methodology in yoga pose detection using AI and ML techniques. The findings provide valuable insights for advancing research and development efforts in the field, with a focus on enhancing accuracy, usability, and practical applications of pose estimation systems in yoga practice and beyond. Future research will explore the integration of these systems with wearable technology to further improve real-time feedback and user engagement.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

In conclusion, the project on yoga pose detection using AI and ML techniques marks a significant milestone in merging ancient yoga practices with cutting-edge technology. Through meticulous development and rigorous experimentation, notable achievements have been realized, including substantial improvements in accuracy and performance. Despite encountered challenges and limitations, the project sets the stage for future advancements in the field. Looking ahead, the future scope of research and development in yoga pose detection presents promising opportunities for innovation and growth. By addressing current constraints and leveraging emerging technologies, such as real-time feedback mechanisms and integration with wearable devices, we can further enhance yoga practice and promote overall well-being. Through continued collaboration and exploration, we can harness the transformative power of AI and ML to enrich the lives of individuals through the practice of yoga, fostering holistic health and personal empowerment.

5.1 Conclusions

In conclusion, the project on yoga pose detection using AI and ML techniques has yielded significant insights and advancements in the field of yoga practice and technology integration. Through rigorous development and experimentation, several key findings and achievements have been observed, alongside the acknowledgment of limitations and challenges encountered during the process.

5.1.1 Key Findings and Achievements:

a) The project successfully demonstrated the feasibility of utilizing AI and ML algorithms for accurately detecting and classifying yoga poses.

b) Notable improvements in accuracy and performance were achieved, showcasing the potential of the proposed methodology in enhancing yoga practice.

c) The development of robust pose estimation algorithms and integration with image processing techniques contributed to the refinement of the system's capabilities.

d) The project laid the groundwork for future research and development efforts in leveraging technology to augment yoga practice and provide personalized feedback to users.

5.1.2 Limitations and Challenges:

a) Despite significant advancements, the project concentrated on a limited set of yoga poses from the extensive repertoire available, underscoring the necessity for expanding datasets to encompass a broader range of postures. This limitation highlights the importance of diversifying the dataset to include various yoga poses that practitioners commonly use, thereby enhancing the model's versatility and applicability.

b) By incorporating a wider array of poses, the system can provide more comprehensive guidance and support to users, catering to different skill levels and practice styles. Additionally, expanding the dataset can improve the model's accuracy and robustness, ensuring it can effectively recognize and classify a more extensive variety of yoga asanas.

c) Challenges such as real-time prediction, handling diverse environmental conditions, and ensuring effective classification remain areas of concern that require further exploration and refinement. Additionally, the integration of advanced machine learning techniques and continuous model updates are essential to address these challenges effectively.

d) The complexity of integrating AI and ML techniques into user-friendly applications poses challenges in terms of usability, accessibility, scalability, and ensuring seamless user experience.

5.2 Future Scope

Looking ahead, several potential areas for future research and development emerge, aiming to address existing limitations and capitalize on emerging opportunities in the field of yoga pose detection using AI and ML. One promising direction involves integrating real-time feedback mechanisms to enhance user experience and engagement. Additionally, exploring the use of advanced neural networks and hybrid models could significantly improve the accuracy and robustness of pose detection systems.

5.2.1 Enhancements in Accuracy:

Future efforts should prioritize enhancing the accuracy and robustness of pose detection algorithms, incorporating advanced machine learning models and data augmentation techniques.

Enriching datasets with key pose points and diversifying training samples can contribute to improving the model's ability to accurately classify a wider range of yoga poses. Additionally, integrating multi-modal data sources, such as depth sensors and motion capture systems, can provide more comprehensive input for the algorithms. Collaboration with yoga experts to continuously refine and validate the models will also be crucial in ensuring practical applicability and effectiveness.

5.2.2 Real-time Feedback Mechanisms:

The integration of real-time feedback mechanisms, such as audio or visual cues, can assist users in achieving optimal posture alignment during yoga practice. By leveraging advances in sensor technology and wearable devices, real-time monitoring of body movements can be integrated into the pose detection system to provide immediate feedback to users.

This immediate feedback helps users correct their form on the spot, reducing the risk of injury and enhancing the effectiveness of their practice. Additionally, the system can store historical data to track progress over time, offering insights into improvements and areas needing further attention.

5.2.3 Integration with Wearable Devices and Mobile Applications:

Future developments should focus on integrating yoga pose detection systems with wearable devices and mobile applications, enabling users to access personalized yoga guidance anytime, anywhere.

Mobile applications can serve as comprehensive platforms for users to track their yoga progress, receive personalized recommendations, and connect with a community of fellow practitioners.

5.2.4 Gesture Recognition and Multi-individual Pose Detection:

Advancements in gesture recognition algorithms can enable the detection and classification of subtle movements and gestures during yoga practice, enhancing the overall user experience. Extending pose detection capabilities to accommodate multiple individuals in a single frame can cater to group yoga sessions and facilitate collaborative practice environments. Moreover, integrating real-time feedback mechanisms can provide instant corrections and guidance, ensuring practitioners maintain proper form and alignment. Additionally, leveraging cloud-based solutions can offer scalable and accessible platforms for users to engage in yoga practice from anywhere, promoting inclusivity and convenience.

5.2.5 Personalized Feedback Mechanisms:

By leveraging user profiles and historical data, future systems can offer personalized feedback and recommendations tailored to individual preferences, skill levels, and goals. Incorporating adaptive learning algorithms can enable the system to evolve and adapt its recommendations based on user feedback and performance data over time. This dynamic approach ensures that the system remains relevant and effective for each user, providing a more engaging and supportive experience. Furthermore, integrating social features could allow users to share their progress and insights, fostering a community of practice and mutual encouragement.

In summary, the future scope of research and development in yoga pose detection using AI and ML techniques is vast and promising. By addressing existing limitations, embracing emerging technologies, and prioritizing user-centric design principles, we can shape advanced systems that not only refine yoga practice but also contribute to overall well-being and personal growth.

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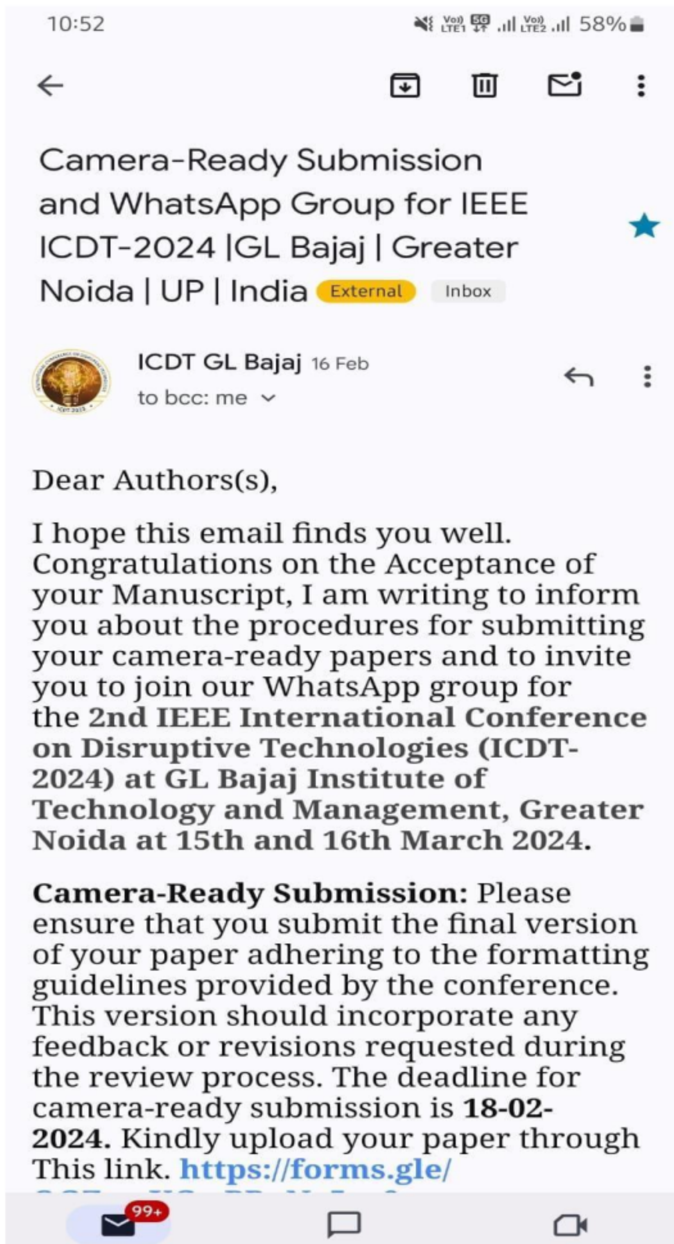
APPENDIX 1

Acceptance letter



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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.

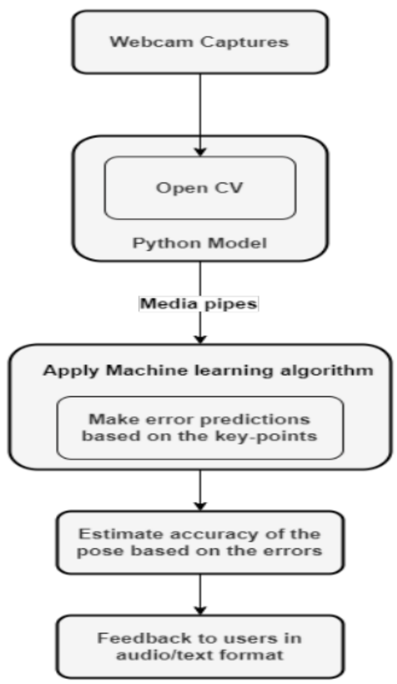

Fig 2. flow chart of process

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:

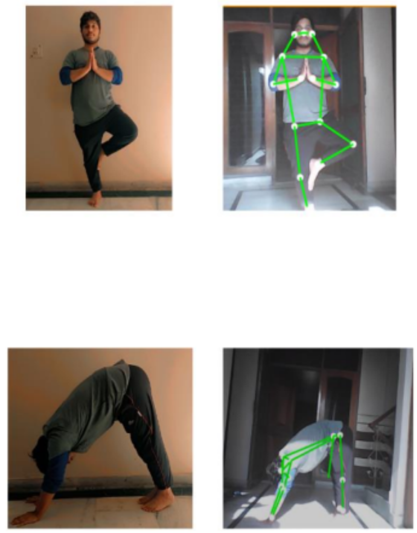

Fig 1. Sample Images

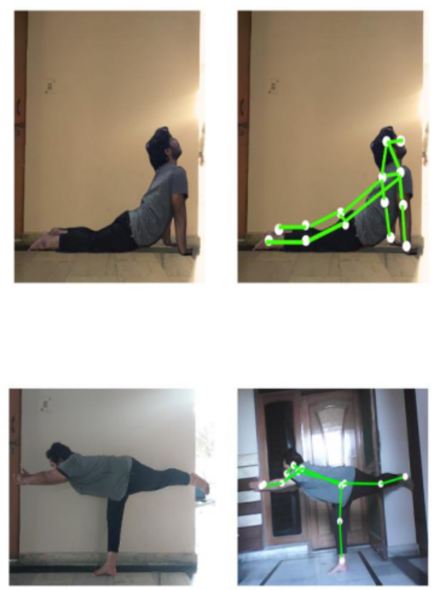

Fig 2. Sample images

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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VII. REFERENCES

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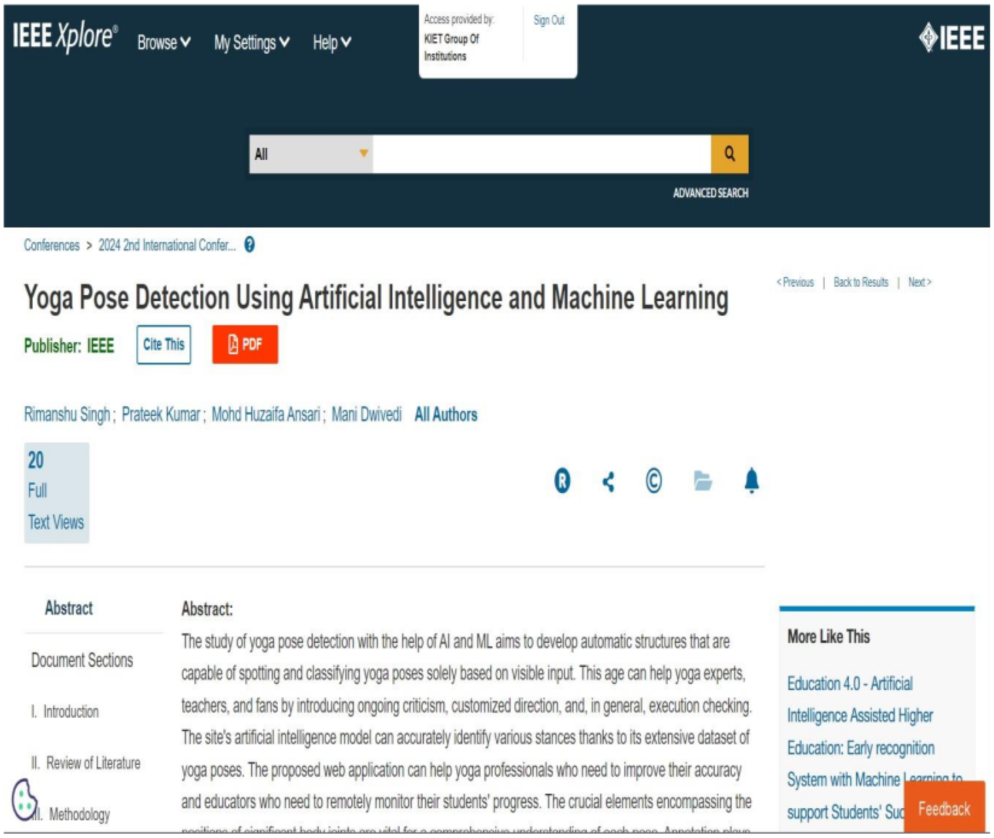

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