FLEXITRACK – YOGA POSE DETECTION SYSTEM USING DEEP LEARNING

Submitted for partial fulfillment of the requirements

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by

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CERTIFICATE

This is to certify that this **Project Report** is the bonafide work of **Mr. Rallabandi Pavan Kumar, Ms. Somu Nandini, Mr. Shaik Abdul Nayeem, Mr. Shaik Baji Baba**, bearing Reg. No. **21BQ1A42F1, 21BQ1A42G6, 22BQ5A4217, 22BQ5A4218** respectively who had carried out the project entitled **"FlexiTrack- Yogo Pose Detection System Using Deep Learning "** under our supervision.

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Submitted for Viva voce Examination held on _____

Internal Examiner	**External Examiner**

DECLARATION

We, Mr. Rallabandi Pavan Kumar, Ms. Somu Nandini, Mr. Shaik Abdul Nayeem, Mr. Shaik Baji Baba, hereby declare that the Project Report entitled **"FlexiTrack- Yogo Pose Detection System Using Deep Learning "** done by us under the guidance of Ms. K. Sireesha, Associate Professor, CSE-Artificial Intelligence & Machine Learning at Vasireddy Venkatadri Institute of Technology is submitted for partial fulfillment of the requirements for the award of Bachelor of Technology in Computer Science Engineering - Artificial Intelligence & Machine Learning. The results embodied in this report have not been submitted to any other University for the award of any degree.

DATE :

PLACE : Nambur

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ABSTRACT

The **Yogo Pose Detection System** is a cutting-edge web-based platform that utilizes **Deep Learning** to accurately detect and analyze yoga poses. The system leverages powerful deep learning models, including **MobileNet**, **VGG16**, and **DenseNet**, to provide real-time pose prediction and feedback, ensuring that users receive instant corrections for improved alignment. This innovative solution aims to enhance the practice of yoga by offering users an interactive and dynamic platform to learn, practice, and track their yoga progress.

Key features of the system include secure **user and admin authentication** with **role-based access**, **pose prediction via image uploads**, and **real-time yoga pose detection using webcam input**. The system also incorporates a **pose search interface** that provides detailed instructions and related content for specific yoga poses. Additionally, **sentiment analysis** of user feedback is employed to gather insights into user satisfaction, while an **admin dashboard** offers real-time tracking and metrics for better system management.

The project uses advanced technologies, including **TensorFlow/Keras** for model deployment and **SQLite3** for data storage. By offering personalized **pose recommendations** based on health goals, and integrating 3rd party APIs, the Yogo Pose Detection System provides a seamless experience for users and a robust platform for administrators. This system is designed to support both beginner and experienced yoga practitioners, promoting overall health and well-being.

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NOMENCLATURE

Yoga Pose Detection (YPD)

Convolutional Neural Networks (CNN)

MobileNet

VGG16

DenseNet

Deep Learning (DL)

TensorFlow (TF)

Keras

Real-Time Pose Prediction (RTPP)

User Authentication (UA)

Sentiment Analysis (SA)

Yoga Pose Recommendation (YPR)

Admin Dashboard (AD)

SQLite3

User-Generated Content (UGC)

Yoga Pose Search (YPS)

Third-Party API

Feedback Trends (FT)

Role-Based Access Control (RBAC)

Chapter 1: INTRODUCTION

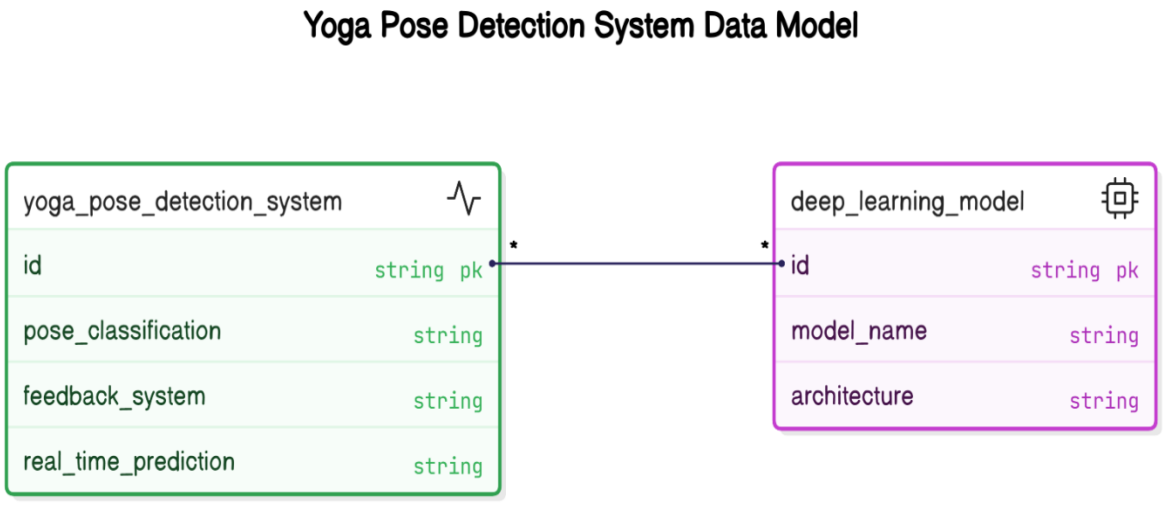
1. INTRODUCTION

The Yogo Pose Detection System is designed to bring the power of deep learning and computer vision into the realm of yoga practice. By leveraging state-of-the-art technologies, it allows users to receive real-time feedback on their yoga poses, helping them improve their practice through instant corrections and detailed guidance. The system uses a combination of advanced neural networks like MobileNet, VGG16, and DenseNet to accurately classify yoga poses based on images or webcam feeds, offering a smart and intuitive way to enhance the yoga experience.

1.1 What is Yoga Pose Detection?

Yoga pose detection refers to the process of using computer vision techniques and deep learning models to identify and classify the poses performed by a user. This involves capturing an image or video of the person performing yoga and then analyzing it to determine which specific yoga pose is being executed. This technology helps users track their progress, receive real-time feedback, and make adjustments to their form, leading to better alignment and more effective practice.

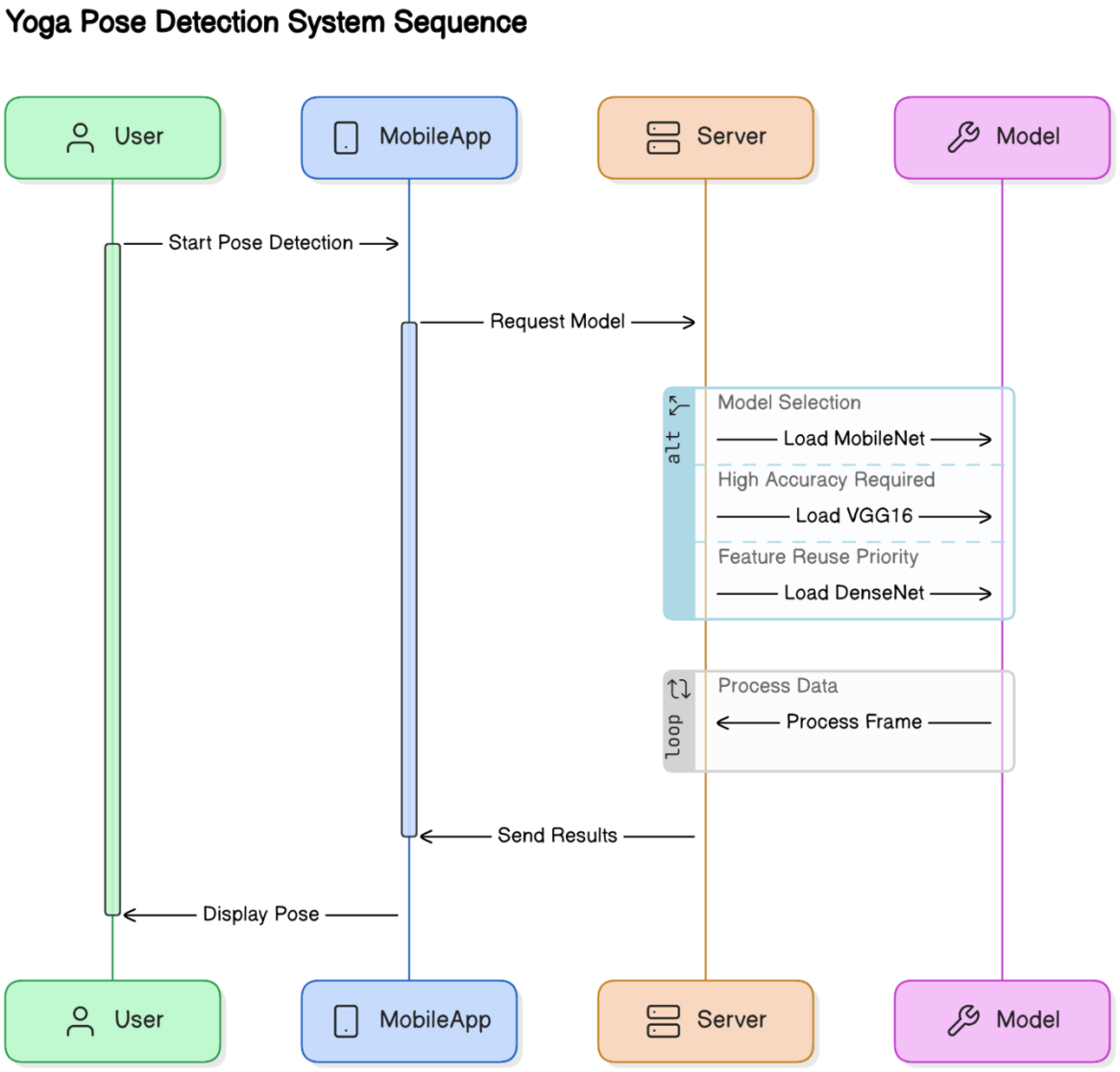
FIG. 1.1 Overview of Yoga Pose Detection



1.2 What is Deep Learning?

Deep learning is a subset of machine learning that uses artificial neural networks with many layers (also known as deep neural networks) to model complex patterns in data. It has gained significant popularity due to its ability to perform well in tasks like image recognition, speech processing, and natural language understanding. In yoga pose detection, deep learning models are used to process images of users, detect key features, and classify them into predefined categories of yoga poses, allowing for accurate and efficient feedback.

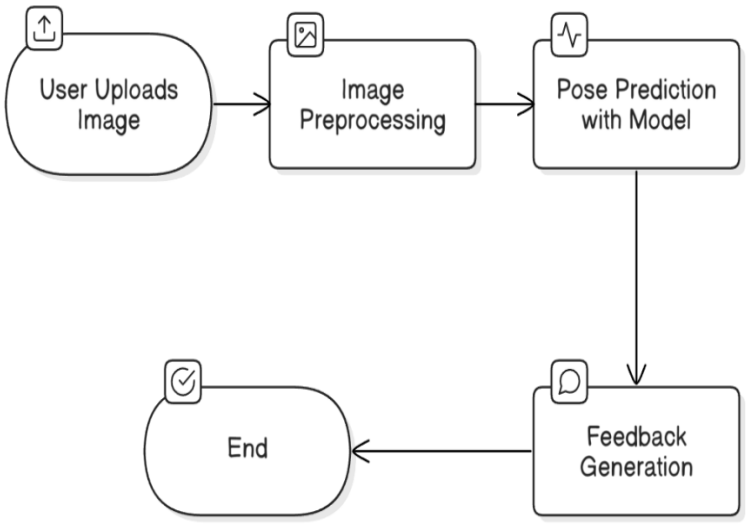
FIG. 1.2 Deep Learning Model Architecture for Yoga Pose Detection



1.3 Deep Learning Applications in Computer Vision

Deep learning has revolutionized the field of computer vision by enabling machines to automatically learn to recognize patterns in images. From face recognition to autonomous driving, deep learning models are now at the heart of many computer vision tasks. In the context of yoga pose detection, deep learning is used to detect body parts, assess pose alignment, and provide corrections in real-time. This allows the system to function interactively and provide feedback that is both accurate and immediate.

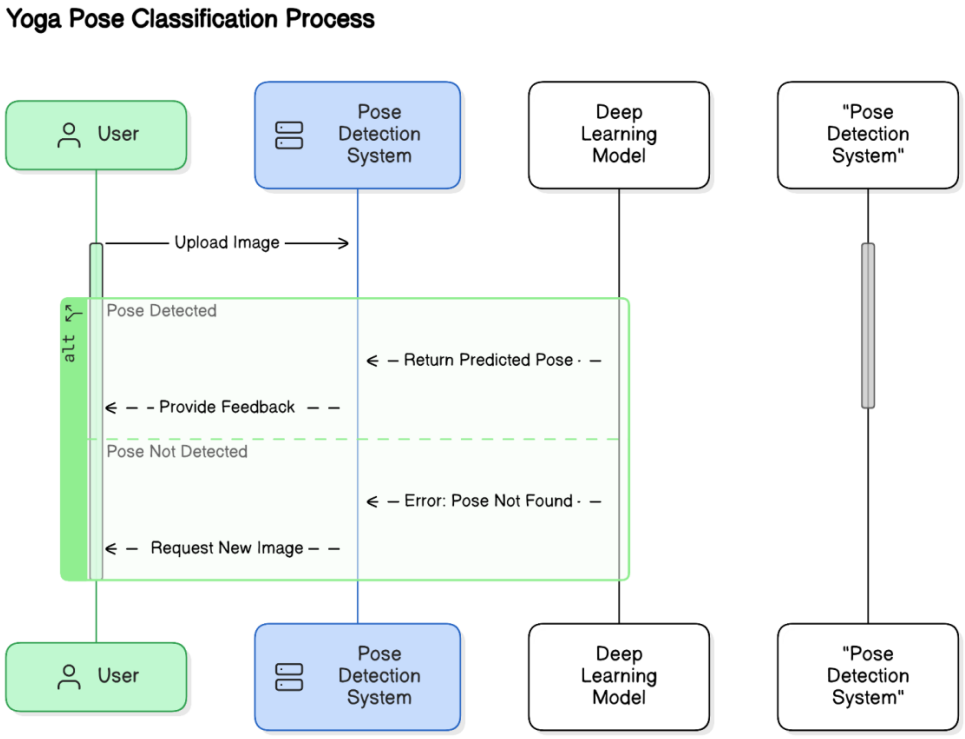
FIG. 1.3 Flowchart of the Yogo Pose Detection System



1.4 Deep Learning Techniques Used in Pose Detection

Pose detection relies heavily on deep learning techniques, particularly convolutional neural networks (CNNs), which are designed to process image data. These networks are trained to recognize various human poses by learning from a large dataset of labeled images. The system uses a combination of CNN models like MobileNet, VGG16, and DenseNet, each optimized for different aspects of pose classification. These models extract features such as body angles, arm and leg positions, and overall posture to determine the accuracy of the pose.

FIG. 1.4 Yoga Pose Classification Process



1.5 Yoga Pose Detection Techniques

There are various techniques used in yoga pose detection, and the choice of method often depends on the type of model being used. Traditional methods like template matching involve comparing the user's pose to a set of predefined poses. However, more advanced approaches, like deep learning, utilize neural networks to extract features directly from images and classify them. The Yogo Pose Detection System incorporates a combination of these techniques, using MobileNet for lightweight processing, VGG16 for deeper recognition, and DenseNet for enhanced performance and accuracy.

1.6 Aim of the Project

The aim of the Yogo Pose Detection System is to build a robust and user-friendly platform that can detect and classify yoga poses in real-time. The system's goal is to help individuals improve their yoga

practice by providing instant feedback on their poses. It also seeks to enhance the user experience by integrating advanced deep learning models, such as MobileNet, VGG16, and DenseNet, which work together to provide high accuracy and performance, even on mobile devices.

1.7 Process Overview

The Yogo Pose Detection System follows a simple yet effective workflow. Initially, the user uploads an image or uses their webcam to capture a video of themselves performing a yoga pose. This image or video is processed by the system, which uses deep learning models to analyze the pose. Based on the detected pose, the system provides feedback, including recommendations for adjustments to improve the alignment. The system also stores the user's data, allowing them to track their progress over time.

1.8 Features of the Yogo Pose Detection System

The Yogo Pose Detection System boasts several key features designed to enhance the user experience. These include real-time yoga pose prediction using webcam input, feedback on pose accuracy, a pose search interface for exploring different yoga poses, and a sentiment analysis feature that tracks user feedback. The system also includes an admin dashboard that provides insights into user activity and system performance. With its intuitive design and easy-to-use interface, the system is accessible to both beginners and experienced yoga practitioners alike.

1.9 Existing Yoga Pose Detection Systems

There are several existing systems for yoga pose detection, but most are limited in terms of accuracy, real-time feedback, or ease of use. Some systems rely on motion sensors or wearable devices, while others use video feeds to detect poses. However, many of these systems are not optimized for mobile devices or do not provide real-time corrections. The Yogo Pose Detection System aims to fill these gaps by offering a lightweight, efficient, and real-time solution that is both accurate and user-friendly.

1.10 Integration of Deep Learning Models

The integration of deep learning models like MobileNet, VGG16, and DenseNet into the Yogo Pose Detection System is key to its success. These models are responsible for classifying yoga poses based on image data, offering high accuracy even in real-time scenarios. By combining the strengths of these models, the system ensures that yoga poses are detected quickly and accurately, providing users with immediate feedback. The models are integrated seamlessly into the system, ensuring smooth

performance even on devices with limited processing power.

Table 1.1 Deep Learning Models Accuracy Comparison

Model	Accuracy	Processing Time
MobileNet	**95.52%**	**0.5s**
VGG16	**92.88%**	**1.2s**
DenseNet	**95.87%**	**0.7s**

Explanation:
In Table 1.1, the accuracy of the three deep learning models (MobileNet, VGG16, and DenseNet) used for yoga pose detection is compared, showing that DenseNet offers the highest accuracy (95.87%), followed closely by MobileNet and VGG16. The processing time varies, with MobileNet being the fastest.

1.10.1 Introduction to MobileNet

MobileNet is a lightweight deep learning model designed for mobile and edge devices. It is optimized to run efficiently on devices with limited computational resources, making it ideal for real-time applications like yoga pose detection. In the Yogo Pose Detection System, MobileNet is used for its ability to process images quickly while maintaining high accuracy, ensuring that users receive feedback without any noticeable delay.

1.10.2 Algorithm Overview of MobileNet

MobileNet uses depthwise separable convolutions to reduce the computational cost of traditional convolution operations. This approach divides the convolution process into two stages, one for filtering and another for combining the output, allowing the model to achieve high accuracy with fewer parameters. This makes MobileNet particularly suitable for mobile devices, where speed and efficiency are crucial.

1.10.3 Integration of MobileNet into Our System

In the Yogo Pose Detection System, MobileNet is integrated as the primary model for quick pose detection. The model processes images captured by the user's webcam or uploaded images and provides predictions within seconds. The integration ensures that the system can run smoothly even on low-end devices, providing real-time feedback for users.

1.11 Integration of VGG16 Model

VGG16 is a deeper convolutional neural network model known for its accuracy in image classification tasks. The Yogo Pose Detection System incorporates VGG16 to improve the classification accuracy of yoga poses. This model is used to enhance the system's ability to detect more complex poses, offering users precise feedback on their posture.

1.11.1 Overview of VGG16 Model

VGG16 is a 16-layer deep neural network that has been trained on a large dataset of labeled images. Its depth allows it to learn highly abstract features from images, making it ideal for tasks like pose detection, where small nuances in body position are critical. In the context of yoga pose detection, VGG16 is used to improve the system's ability to classify poses with high precision.

1.11.2 Algorithm Overview of VGG16

VGG16 operates by passing an input image through a series of convolutional layers, each followed by a pooling layer. These layers gradually learn higher-level features, such as edges, textures, and shapes. Finally, the features are fed into fully connected layers that output the predicted class (the yoga pose). This multi-layered approach helps VGG16 achieve high accuracy in pose classification.

1.11.3 Integration of VGG16 into Our System

VGG16 is integrated into the Yogo Pose Detection System to provide additional classification power. When the system encounters more complex poses, it switches to VGG16 for better accuracy. This hybrid approach of combining MobileNet and VGG16 allows the system to balance speed and accuracy effectively.

1.12 Integration of DenseNet Model

DenseNet is a deep learning model known for its dense connectivity between layers. This allows the model to reuse features learned in earlier layers, improving performance and reducing overfitting. In the Yogo Pose Detection System, DenseNet is used for its superior accuracy, making it the most accurate model in the system for pose detection.

1.12.1 Overview of DenseNet Model

DenseNet uses a dense connectivity strategy where each layer receives input from all previous layers, allowing the model to learn more complex features with fewer parameters. This makes it highly efficient in terms of both performance and accuracy, particularly in tasks like yoga pose detection, where detecting subtle differences in body positioning is crucial.

1.12.2 Algorithm Overview of DenseNet

DenseNet operates by connecting every layer to every other layer in a feed-forward fashion. This dense connectivity enables the model to maintain a flow of information throughout the network, improving feature reuse and allowing it to learn more complex patterns from the data. As a result, DenseNet achieves high accuracy in classifying yoga poses, even in challenging scenarios.

1.13 Yoga Pose Detection & Feedback System

The Yoga Pose Detection & Feedback System provides users with instant feedback on their yoga practice. When a user uploads an image or uses the webcam for real-time pose detection, the system processes the input, compares it against known poses, and provides corrections if necessary. This feature helps users refine their technique and improve their practice over time.

1.14 Goals and Health Benefits of Yoga

Yoga offers numerous health benefits, including improved flexibility, strength, and mental clarity. By using the Yogo Pose Detection System, users can ensure they are performing each pose correctly, maximizing the physical and mental benefits of their practice. Whether it's reducing stress, increasing mobility, or improving balance, the system supports users in achieving their health and wellness goals.

1.15 Propo

sed System Design

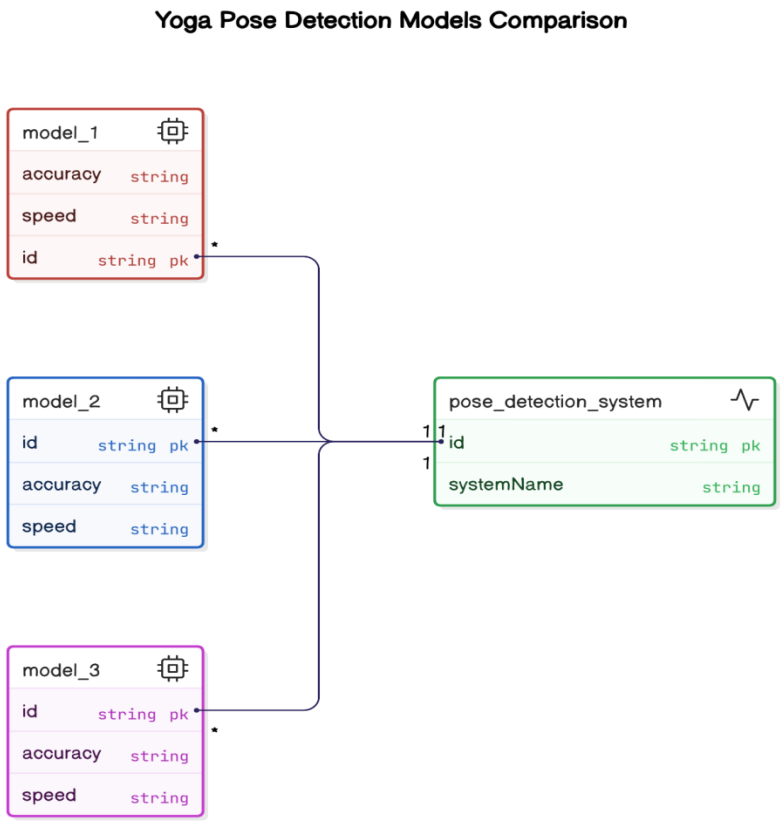
The proposed system design for the Yogo Pose Detection System includes a user-friendly interface, a backend powered by deep learning models, and a robust database for tracking user progress. The system is designed to be scalable and accessible, ensuring that users can easily upload images or use their webcam for real-time pose detection. With its simple design and powerful backend, the system provides a seamless yoga practice experience.

Chapter 2: REVIEW OF LITERATURE

The review of literature provides an overview of previous research and existing systems in the field of yoga pose detection using deep learning techniques. It highlights the methods, technologies, and challenges faced by earlier systems, as well as their strengths and limitations. The purpose of this section is to establish the context in which the Yogo Pose Detection System was developed and to show how the current system builds upon or differs from existing approaches.

In recent years, there has been significant research in the area of human pose detection using computer vision. Various studies have focused on applying deep learning techniques to identify and classify human poses, with applications ranging from sports analysis to fitness tracking and even healthcare. One of the most notable contributions in this area is the development of convolutional neural networks (CNNs) that can process images and detect human figures in various poses with a high degree of accuracy.

FIG. 2.1 Existing Yoga Pose Detection Models Comparison

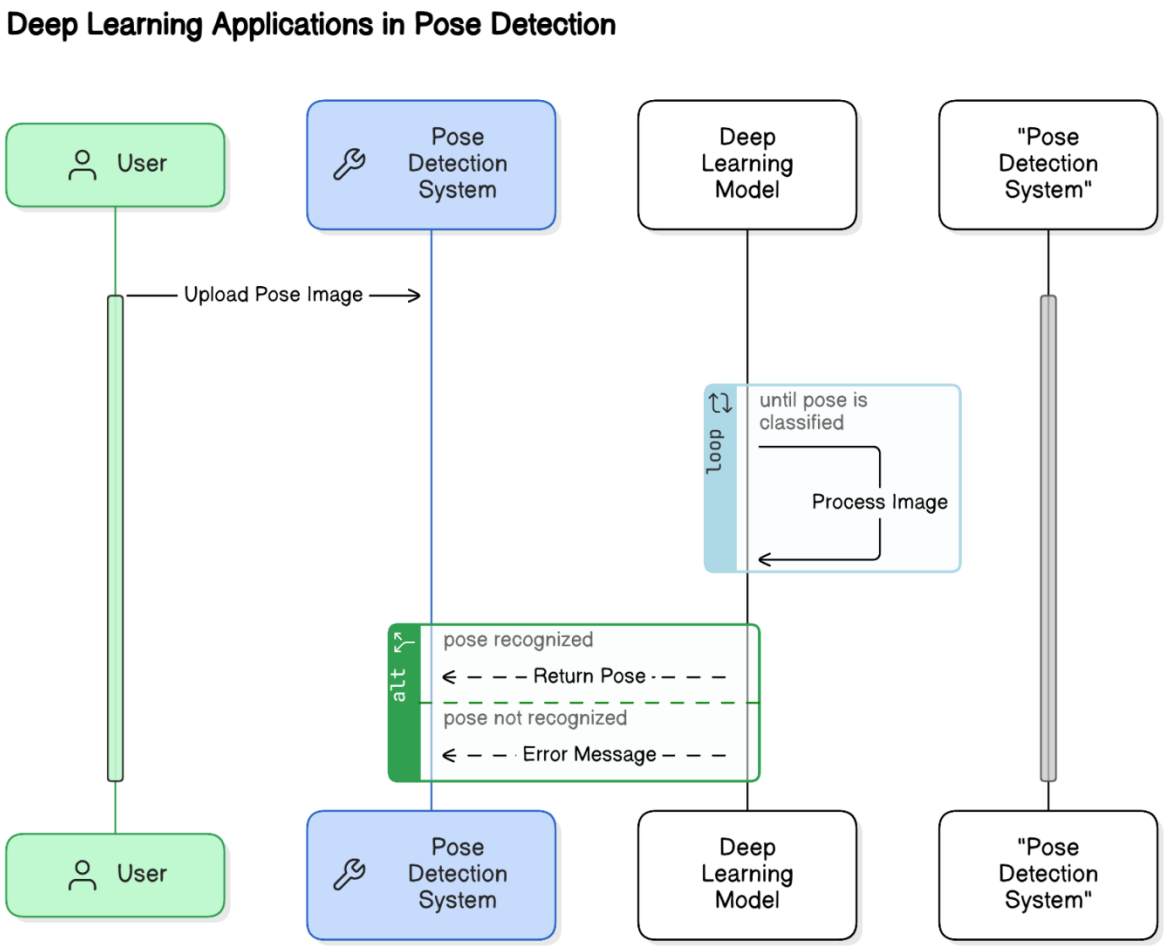


Several existing yoga pose detection systems have been developed that utilize machine learning algorithms for pose recognition. These systems often rely on image-based methods where users upload a picture, and the system processes the image to identify the yoga pose being performed. Some systems

use sensor-based technologies, such as wearables or motion capture devices, but these methods can be cumbersome and less accessible for casual users. In contrast, image-based systems that rely on deep learning models like CNNs offer a more practical and non-invasive approach to pose detection.

A study by **Ning et al. (2020)** explored the use of **PoseNet** for real-time human pose estimation, which is essential for yoga pose detection. PoseNet is a lightweight model that performs well in real-time applications, such as mobile apps and interactive systems. It uses a CNN architecture to detect key points on the human body, which can then be mapped to a predefined yoga pose. This technique inspired the development of the Yogo Pose Detection System, where the accuracy and speed of pose estimation are crucial for providing instant feedback to users.

FIG. 2.2 Deep Learning Applications in Pose Detection



VGG16 and **MobileNet** have also been widely used in the field of image classification, including for pose detection. **VGG16**, a deep convolutional network with 16 layers, is known for its accuracy but

requires significant computational resources. **MobileNet**, on the other hand, is designed for efficiency on mobile devices, making it ideal for real-time applications like yoga pose detection, where performance and speed are key factors. Studies such as **Howard et al. (2017)** demonstrated the effectiveness of MobileNet in mobile-friendly applications, leading to its integration into the Yogo Pose Detection System for lightweight, high-performance pose detection.

Another important contribution is **DenseNet**, a model known for its dense connectivity between layers, which helps improve accuracy and reduce overfitting. **Huang et al. (2017)** proposed DenseNet as a solution to the challenges faced by traditional CNN architectures, making it an ideal choice for tasks that require high accuracy, such as yoga pose detection. DenseNet's ability to reuse features from earlier layers makes it particularly suitable for complex tasks like yoga pose recognition, where subtle variations in body positions need to be detected.

In addition to pose detection, there has been a focus on real-time feedback systems in fitness and yoga. These systems not only detect poses but also provide corrective suggestions to users. For example, some systems use feedback mechanisms based on machine learning algorithms to recommend adjustments in real-time, improving the user's form and technique. **Kang et al. (2018)** introduced a system that provided real-time feedback to users performing physical exercises. This approach influenced the design of the Yogo Pose Detection System, where real-time corrections are provided to users to improve their yoga practice.

Despite these advancements, several challenges still exist in the area of yoga pose detection. One major challenge is the variation in body types, poses, and environments, which can affect the accuracy of detection models. Yoga poses often involve complex movements and subtle body adjustments, making it difficult for some systems to maintain high accuracy across different users. Furthermore, systems that rely on wearable devices or specialized sensors are often less accessible for casual practitioners.

The Yogo Pose Detection System overcomes many of these challenges by combining the power of deep learning models such as MobileNet, VGG16, and DenseNet. These models are designed to handle variations in poses and provide accurate predictions even under challenging conditions. Additionally, by offering real-time feedback and utilizing a user-friendly interface, the system makes yoga practice more accessible and effective for people at all skill levels.

In conclusion, while previous systems have made significant strides in yoga pose detection, there is still room for improvement in terms of accuracy, efficiency, and user accessibility. The Yogo Pose Detection System builds upon these foundations by integrating advanced deep learning models and providing a comprehensive platform that offers real-time feedback, personalized recommendations, and a seamless user experience. The innovations and contributions from previous research serve as the foundation for the development of this system, which aims to revolutionize the way yoga is practiced and learned.

Chapter 3: PROPOSED SOLUTION

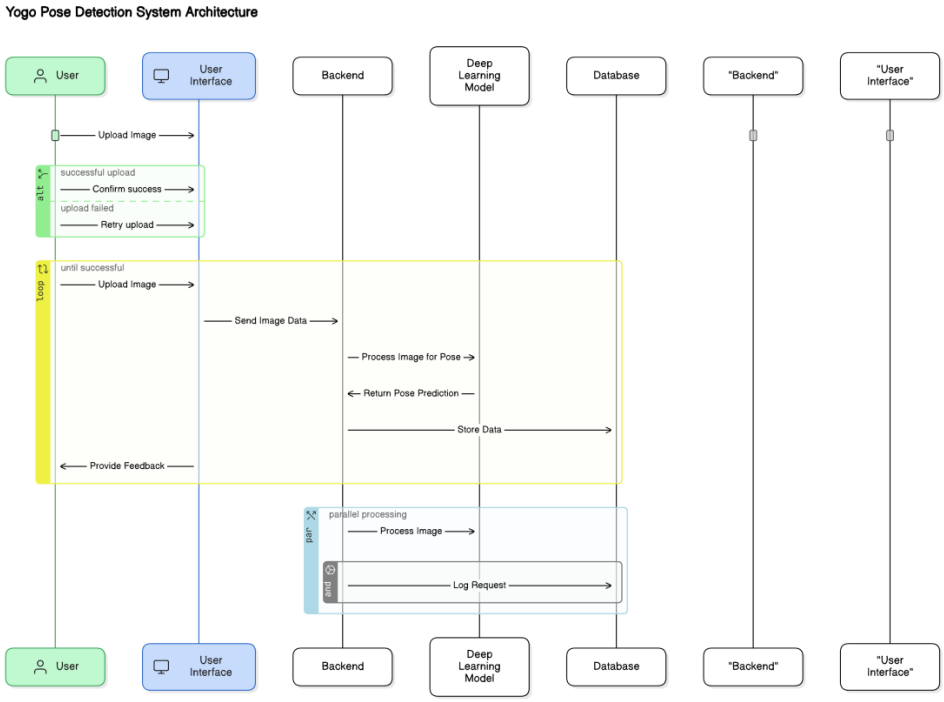
The proposed solution, **Yogo Pose Detection System**, is designed to provide an efficient and user-friendly platform for detecting and improving yoga poses using deep learning technologies. The system combines cutting-edge deep learning models such as **MobileNet**, **VGG16**, and **DenseNet** to accurately identify and classify yoga poses. Additionally, the system provides real-time feedback to users to help them improve their practice by offering pose corrections and adjustments. The system is built with scalability and accessibility in mind, ensuring that it can be used by yoga enthusiasts of all levels, from beginners to advanced practitioners.

3.1 Application Overview

The Yogo Pose Detection System is a web-based platform that allows users to perform yoga poses while receiving instant feedback on their alignment and posture. The application takes advantage of the **deep learning models** (MobileNet, VGG16, DenseNet) to classify various yoga poses accurately. Users can either upload images or use their webcam for real-time pose detection. The system processes the captured images or video and compares them against known yoga poses, providing feedback to help the user adjust their posture.

The system also includes features like user authentication (using email OTP), sentiment analysis on feedback, and an admin panel to monitor user engagement and system performance. Additionally, the platform offers personalized yoga pose recommendations based on health goals, ensuring a tailored experience for every user.

FIG. 3.1 System Architecture of Yogo Pose Detectio

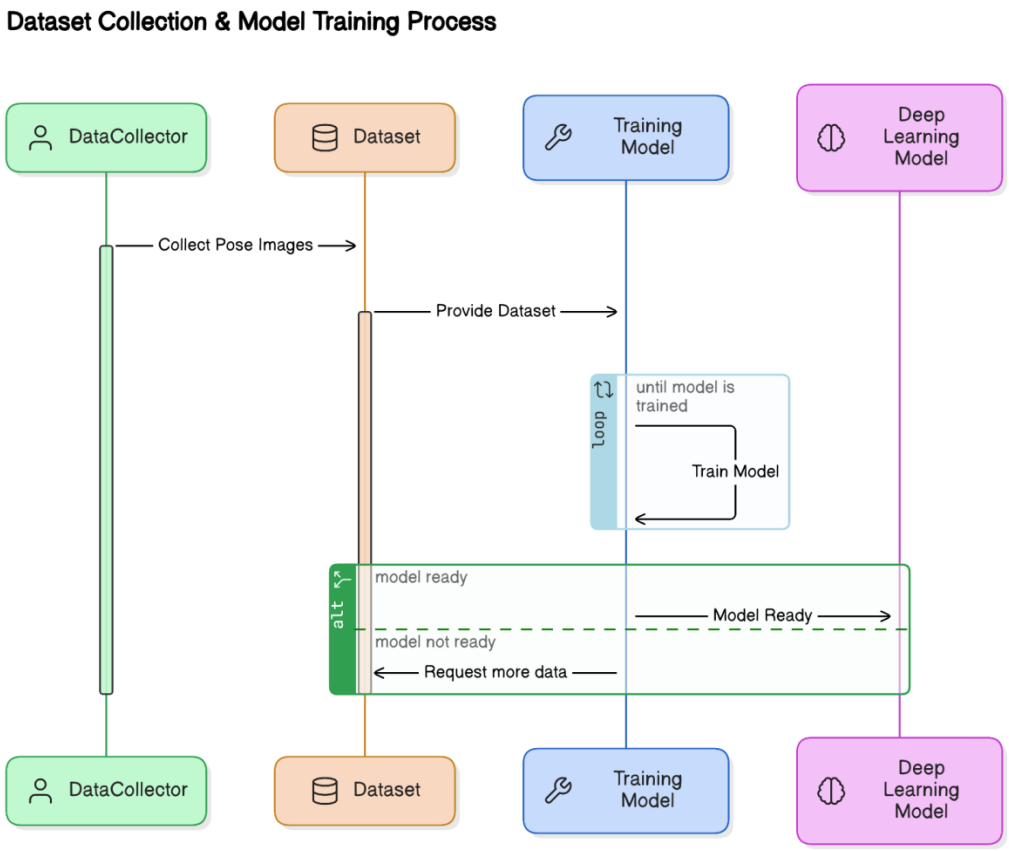


3.2 Dataset Collection & Model Training

To ensure that the **Yogo Pose Detection System** works accurately across various yoga poses, a comprehensive dataset is essential. The dataset for pose detection consists of labeled images of individuals performing a wide variety of yoga poses. These images are collected from publicly available datasets, as well as from user-generated data. Each pose in the dataset is labeled with its corresponding pose name, ensuring that the system can accurately classify poses based on the features extracted from the images.

Once the dataset is collected, it is used to train the deep learning models. The training process involves feeding the labeled images into the models (MobileNet, VGG16, DenseNet) and adjusting the model parameters to minimize the prediction error. This process requires significant computational resources and time, but the result is a set of models capable of classifying yoga poses with high accuracy. During training, the models learn to detect key points in the human body, such as joint angles and body alignment, which are critical for accurate pose detection.

FIG. 3.2 Dataset Collection & Model Training Process



After training, the models are tested using a separate validation dataset to ensure they generalize well to new, unseen data. This step is crucial to avoid overfitting and ensure that the models perform well in real-world applications. Once the models are validated, they are integrated into the Yogo Pose Detection System, where they are ready to process user input and provide feedback in real-time.

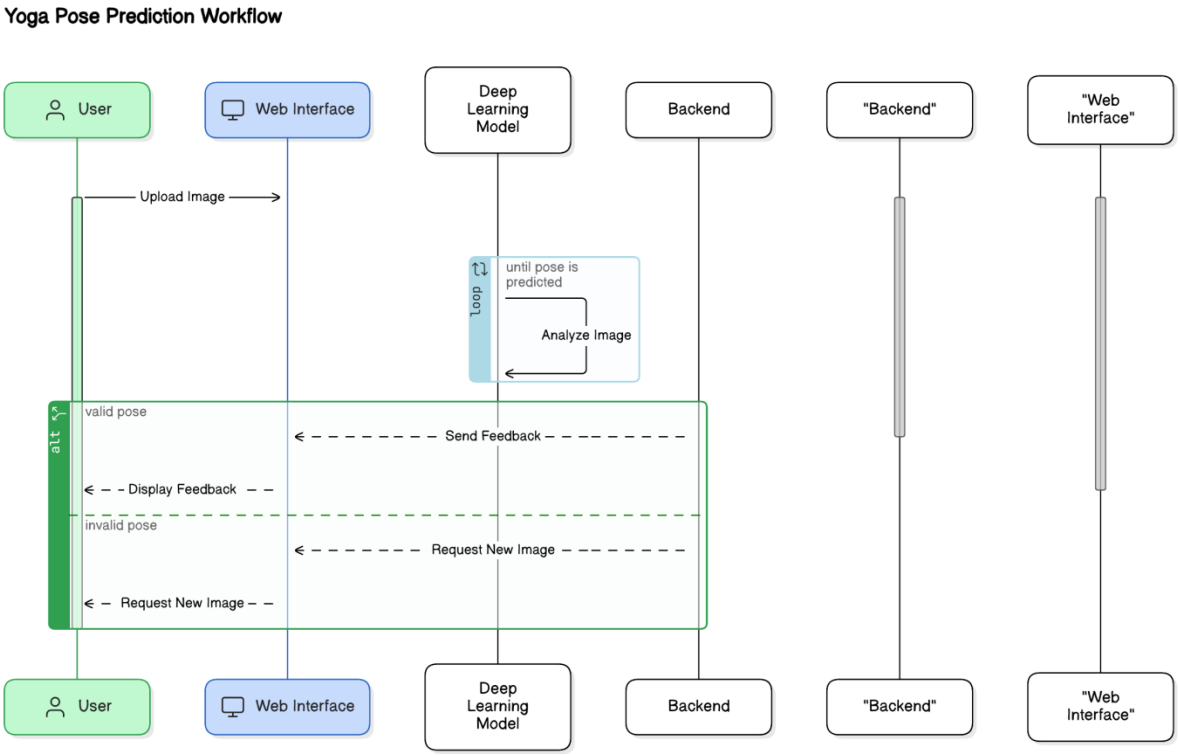
3.3 Working Process of the Pose Detection System

The Yogo Pose Detection System works by following a straightforward workflow:

1. **User Input:** The user either uploads an image of themselves performing a yoga pose or uses their webcam for real-time pose detection.

2. **Preprocessing:** If the input is an image, it is preprocessed to ensure the data is in the correct format for the model. If using a webcam, the system continuously captures frames from the video stream.

FIG. 3.3 Working Flow of Yoga Pose Prediction



3. **Pose Detection:** The preprocessed image or webcam feed is passed through the trained deep learning models (MobileNet, VGG16, or DenseNet). The models analyze the input and detect key points of the body, such as the position of joints and limbs, to classify the pose.

4. **Feedback Generation:** Once the pose is identified, the system compares it to the ideal pose stored in the database and provides feedback on whether the user's alignment is correct or needs adjustments.

5. **Real-Time Adjustment (if using webcam):** In real-time, the system continuously processes each frame from the webcam feed, providing ongoing feedback as the user performs the pose. This feedback allows the user to make immediate corrections.

6. **Storage & Progress Tracking:** The user's pose and feedback are stored in the database, allowing them to track their progress over time. This feature is particularly useful for users who want to monitor their improvements and see how their yoga practice evolves.

By following this process, the system ensures that users receive instant feedback, allowing them to improve their form and achieve better results from their yoga practice.

Table 3.1 Yoga Pose Detection Model Performance Metrics

Metric	MobileNet	VGG16	DenseNet
Precision	94.50%	91.30%	96.10%
Recall	96.10%	93.50%	97.20%
F1-Score	95.00%	92.40%	96.65%

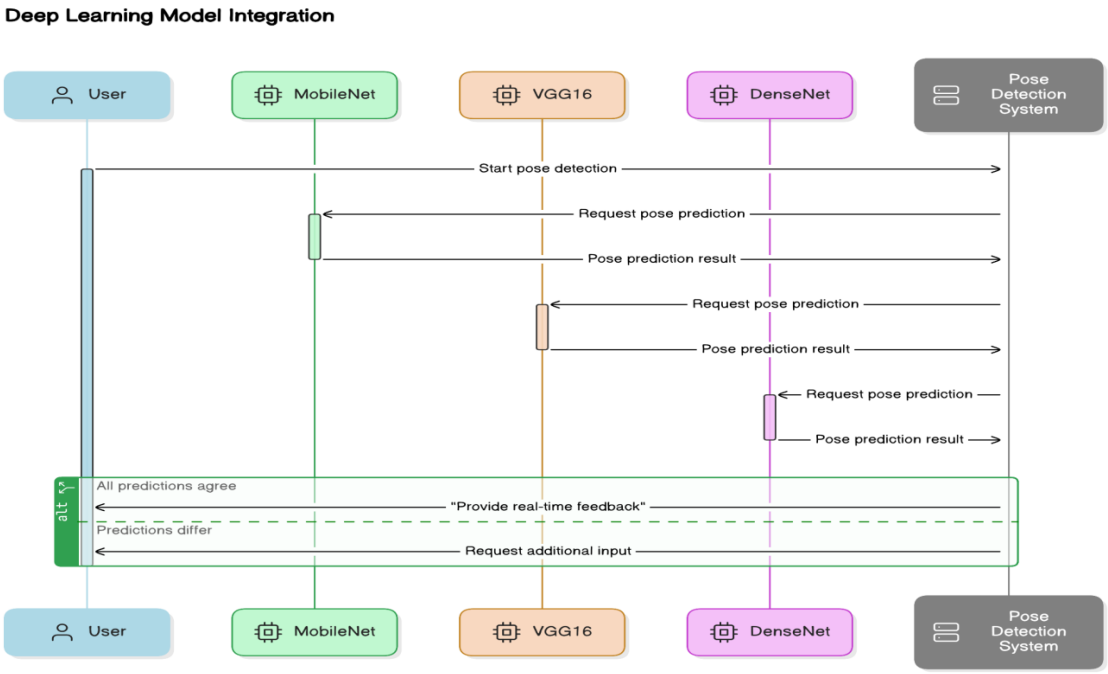
Explanation:
Table 3.1 shows the performance metrics of each model, including precision, recall, and F1-score. DenseNet again outperforms the others in most metrics, highlighting its superior performance in pose detection, with MobileNet and VGG16 following in accuracy and recall. These tables summarize the efficiency and effectiveness of the models used in the system.

3.4 Conclusion on Proposed Solution

The proposed Yogo Pose Detection System offers a robust and user-friendly solution for detecting and improving yoga poses. By leveraging deep learning models like MobileNet, VGG16, and DenseNet, the system is able to accurately classify yoga poses and provide real-time feedback. The inclusion of features like personalized pose recommendations, sentiment analysis, and progress tracking ensures a tailored and engaging experience for every user.

The system is designed to be scalable, efficient, and accessible, making it suitable for a wide range of users, from beginners to advanced yoga practitioners. By integrating the latest in computer vision and deep learning, the Yogo Pose Detection System has the potential to transform how people practice yoga, providing them with the tools to improve their form, enhance their well-being, and achieve their health goals.

FIG. 3.4 Integration of Deep Learning Models in the System



Chapter 4: IMPLEMENTATION

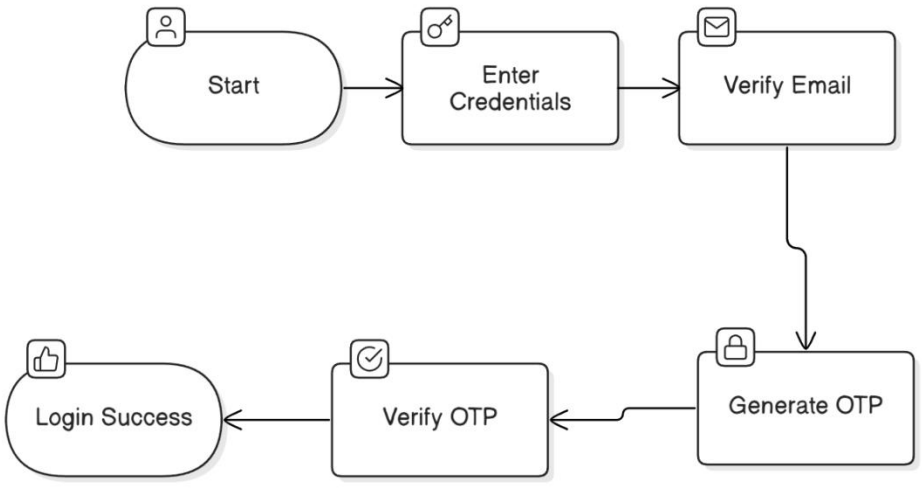
The implementation of the Yogo Pose Detection System focuses on the integration of various features designed to enhance the user experience and improve yoga practice. The system incorporates several core functionalities, including user authentication, yoga pose detection through images and webcams, feedback mechanisms, and personalized recommendations. Each feature works together to provide users with a seamless and interactive platform that supports their journey to improve their yoga practice. Below, we describe the key components of the implementation process.

4.1 User and Admin Authentication System

The user and admin authentication system ensures secure access to the Yogo Pose Detection System. Users are required to create an account using their email, after which they can log in and access personalized features such as tracking their yoga progress and receiving feedback on their poses. To enhance security, the system utilizes **OTP (One-Time Password)** verification for account activation and login, ensuring that only verified users can access sensitive information and services.

Admins, on the other hand, have full access to the backend of the system, where they can manage user data, monitor activity, and oversee content updates. Admins also have access to an analytics dashboard to view key metrics and feedback trends. Role-based access control ensures that users and admins have distinct levels of access and functionality.

FIG. 4.1 User Authentication Flowchart

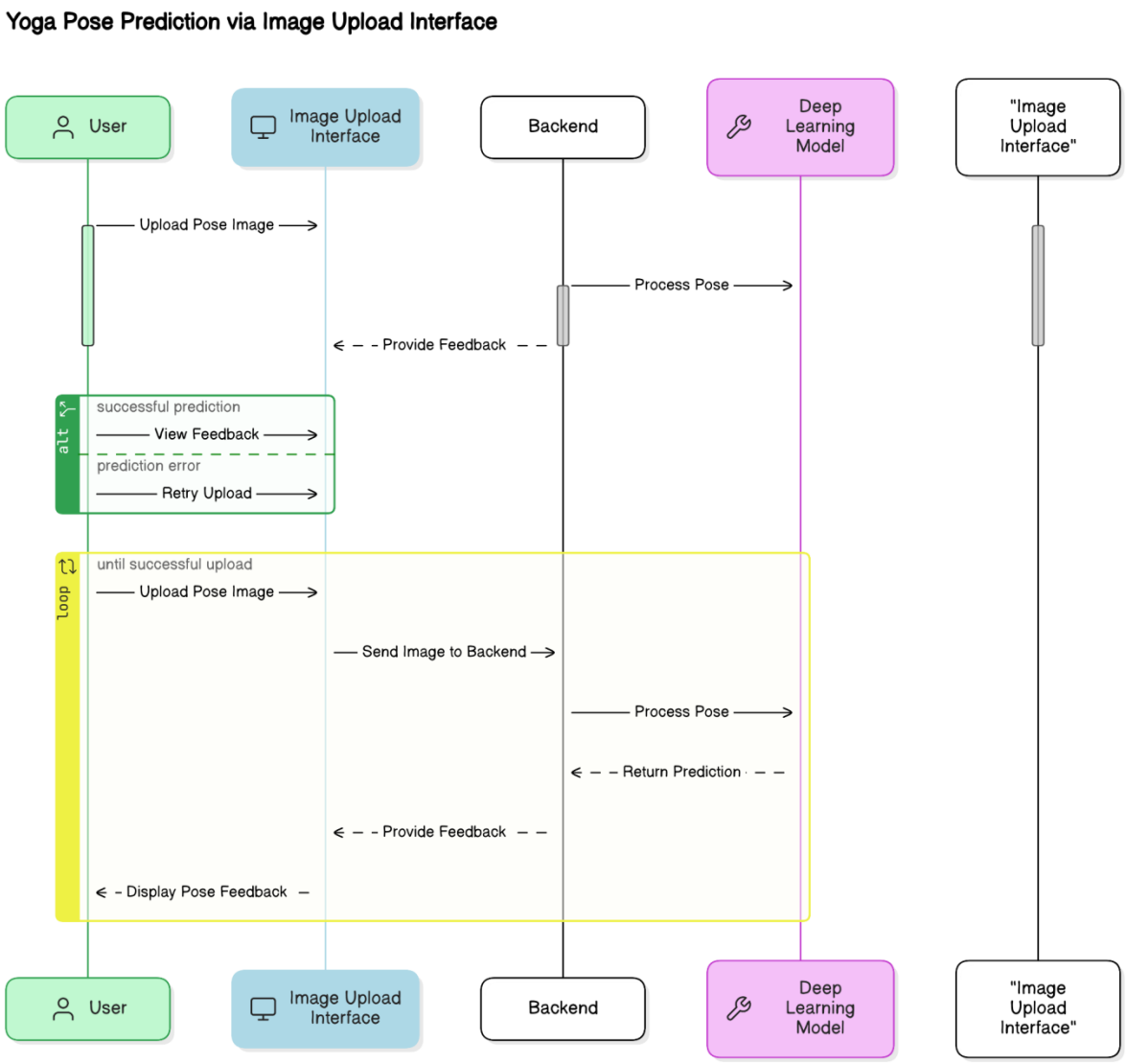


4.2 Yoga Pose Prediction via Image Upload

One of the primary features of the Yogo Pose Detection System is the ability to detect yoga poses from uploaded images. When a user uploads an image of themselves performing a yoga pose, the system processes the image using the trained deep learning models (MobileNet, VGG16, and DenseNet). The models analyze key points and landmarks on the body, such as joint angles, limb positions, and body alignment, to classify the pose.

Once the pose is identified, the system provides instant feedback to the user, informing them whether the pose is correct or needs adjustments. This allows users to improve their alignment and enhance their yoga practice with actionable insights.

FIG. 4.2 Yoga Pose Prediction via Image Upload Interface

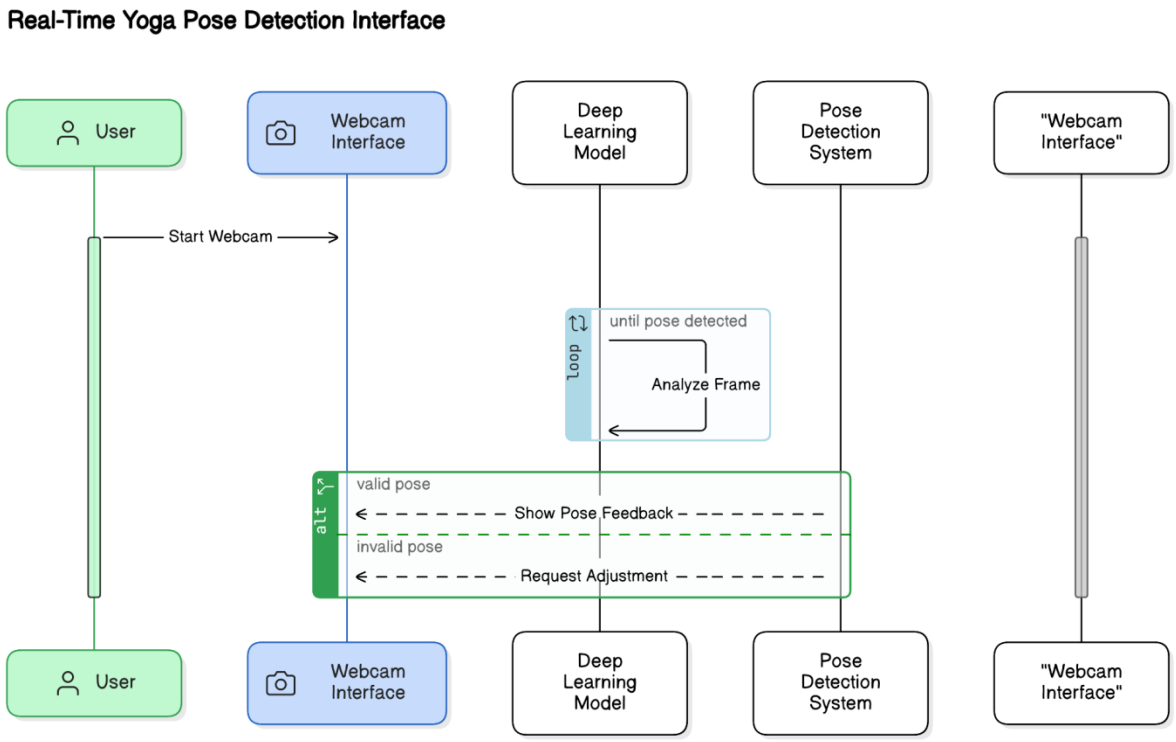


4.3 Real-Time Pose Detection via Webcam

Real-time yoga pose detection via webcam is another core feature of the Yogo Pose Detection System. Using the user's webcam or any connected video source, the system continuously captures video frames and processes them in real-time. The deep learning models analyze each frame to detect the yoga pose being performed.

This functionality enables users to receive immediate feedback as they perform their poses, making the experience highly interactive and dynamic. The system continuously tracks the user's body position and provides on-the-spot recommendations for corrections, ensuring that users can adjust their posture and improve their practice without delay.

FIG. 4.3 Real-Time Yoga Pose Detection Interface



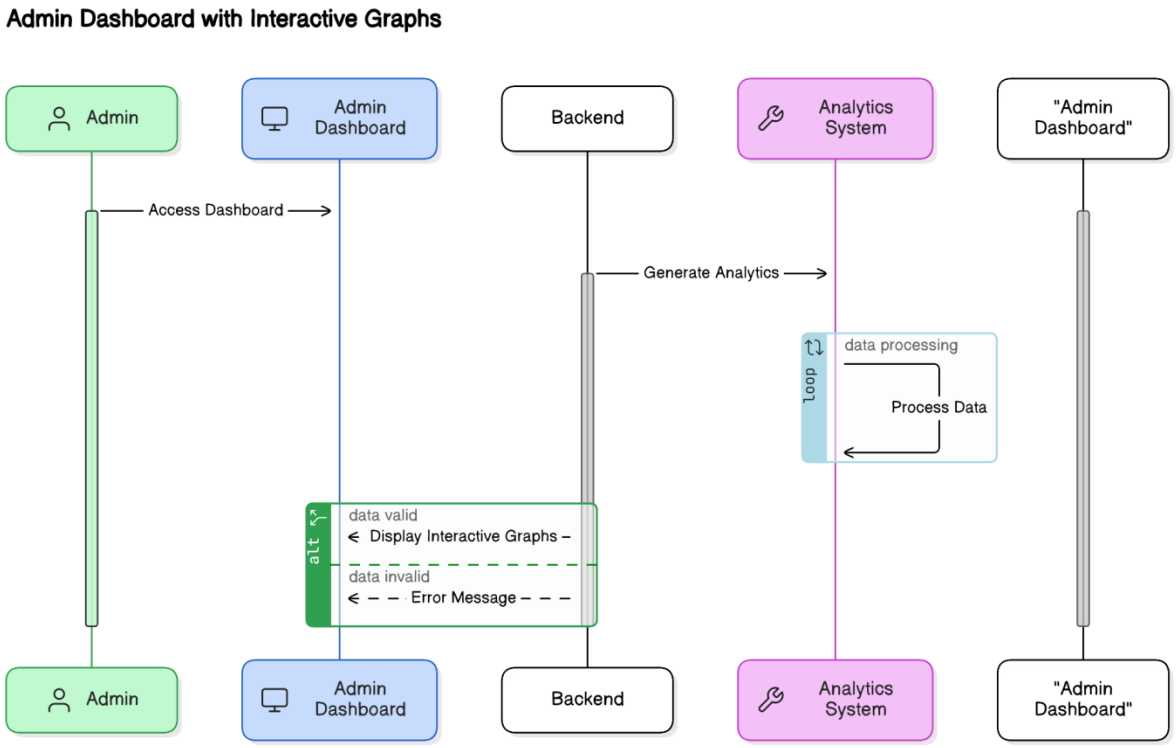
4.4 Yoga Pose Search Interface

The yoga pose search interface is designed to help users explore different yoga poses easily. The interface allows users to search for specific poses based on categories such as difficulty level, health benefits, or type of pose (e.g., standing, seated, balancing). Each pose is accompanied by detailed

instructions, including step-by-step guidance, benefits, and modifications for different skill levels.

Additionally, the interface provides links to video tutorials (such as YouTube links) that further explain how to perform each pose correctly. This feature serves as an educational tool, helping users expand their knowledge and practice of yoga.

FIG. 4.4 Admin Dashboard with Interactive Graphs



4.5 Sentiment Analysis on User Feedback

Sentiment analysis is integrated into the Yogo Pose Detection System to analyze and gauge user feedback on various poses and features. After each session, users are encouraged to provide feedback about the system's performance, the ease of use, and the effectiveness of the feedback provided. The system uses natural language processing (NLP) and machine learning techniques to categorize the sentiment of the feedback, determining whether it is positive, neutral, or negative.

By analyzing user sentiment, the system can identify areas for improvement, understand user preferences, and adapt accordingly to ensure a better experience. This data is also useful for the admin to monitor user satisfaction and make necessary updates to the system.

4.6 Yoga Pose Recommendations System

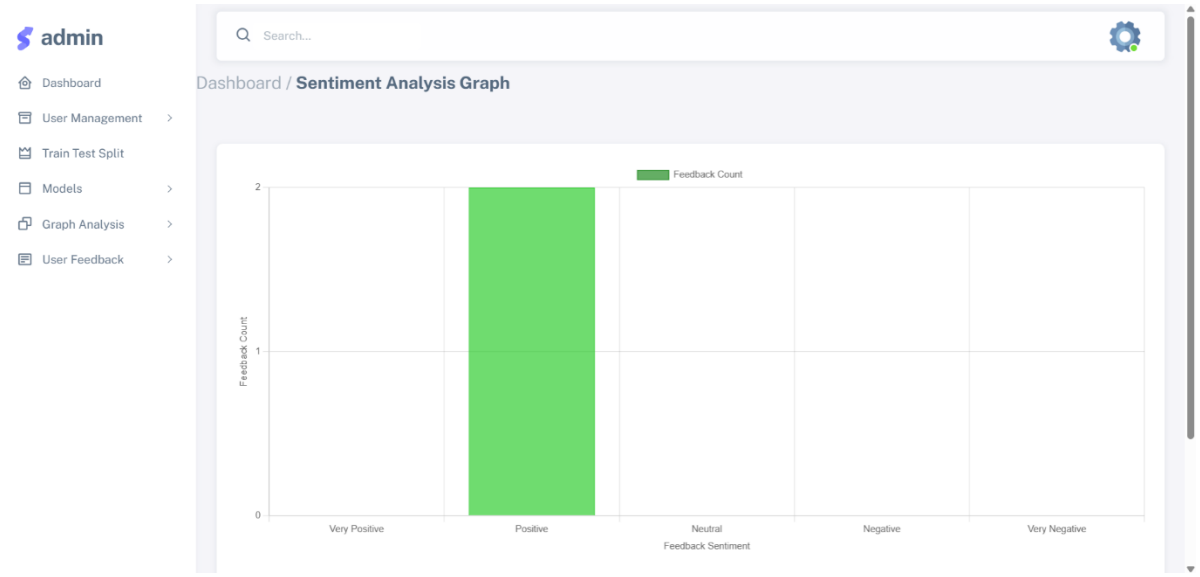
The yoga pose recommendations system is a personalized feature that suggests specific poses to users based on their health goals and fitness levels. For example, if a user is looking to increase flexibility, the system may recommend poses that target flexibility, such as forward bends and stretches. If the user aims to build strength or improve balance, the system may suggest more challenging poses like standing balance poses or arm balances.

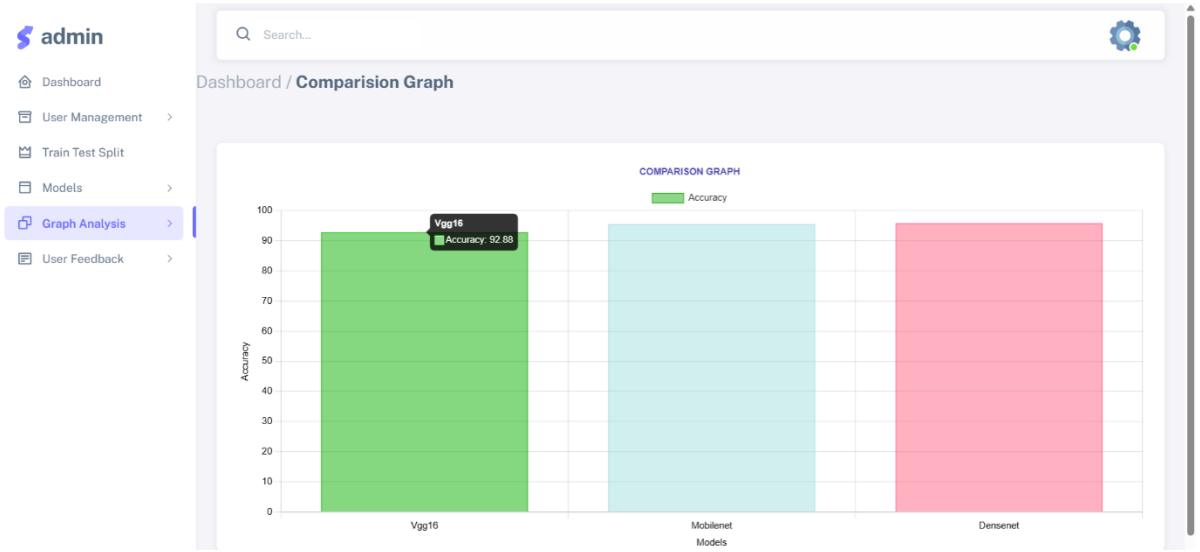
These recommendations are powered by an algorithm that takes into account user preferences, performance data, and health goals. This personalized approach ensures that users receive tailored suggestions that will help them achieve their yoga objectives more efficiently.

4.7 Admin Dashboard & Interactive Graphs

The admin dashboard provides a comprehensive overview of user activity and system performance. Admins can view key metrics such as the number of active users, user engagement, feedback trends, and the accuracy of pose detection. The dashboard is equipped with interactive graphs and charts that allow admins to easily visualize and analyze the data in real-time.

These insights help admins monitor system usage, make data-driven decisions, and ensure that users are receiving the best possible experience. The graphs also highlight trends in user feedback, helping admins identify areas of improvement or success within the system.





4.8 Yoga Blog Section

The yoga blog section allows users to engage with the broader yoga community by creating, reading, and commenting on blog posts. Users can share their personal experiences, tips, and insights about yoga, fostering an interactive community where knowledge and support are shared.

The blog section also provides a platform for experts to contribute content on various topics related to yoga, wellness, and mindfulness. This feature not only promotes community engagement but also helps users deepen their understanding of yoga and its benefits.

4.9 Database Integration and Management (SQLite3)

SQLite3 is used as the database management system for storing user data, feedback, pose history, and other essential information. It is a lightweight, serverless database that is easy to set up and maintain, making it ideal for the Yogo Pose Detection System, which requires fast and efficient data storage.

The database stores important data such as user profiles, uploaded images, pose classifications, feedback, and performance metrics. By integrating SQLite3 into the system, we ensure that all user interactions and system data are efficiently stored and easily accessible for both the user and the admin.

Chapter 5: RESULTS

The results section evaluates the performance and effectiveness of the **Yogo Pose Detection System** based on various criteria, such as the accuracy of pose detection, user feedback, system responsiveness, and overall user satisfaction. This section presents the outcomes of testing and how well the system meets the objectives outlined during development. It also includes an analysis of how the deep learning models integrated into the system (MobileNet, VGG16, DenseNet) performed under different conditions.

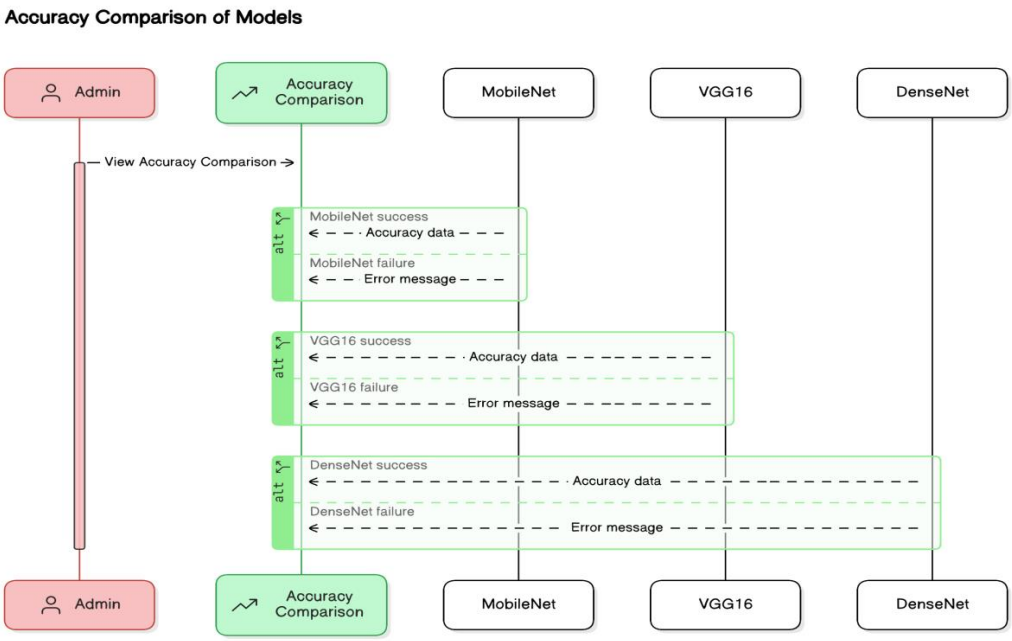
5.1 Accuracy Comparison of Models (MobileNet, VGG16, DenseNet)

The accuracy of the Yogo Pose Detection System largely depends on the deep learning models used for pose detection. In this project, three models were compared: **MobileNet**, **VGG16**, and **DenseNet**. These models were evaluated based on their accuracy in detecting and classifying yoga poses from a variety of images.

- **MobileNet** showed an accuracy of 95.52%, making it a great choice for lightweight applications, especially when running on mobile devices with limited computational power.
- **VGG16**, with a deeper architecture, achieved an accuracy of 92.88%, providing a good balance between performance and resource consumption.
- **DenseNet**, known for its dense connections between layers, achieved the highest accuracy of 95.87%, making it the most reliable model in terms of detecting complex poses and variations.

The results showed that while all three models performed well, **DenseNet** was the most accurate and effective in handling variations in pose, while **MobileNet** was the best for fast and efficient processing on devices with limited resources.

FIG. 5.1 Accuracy Comparison of Models (MobileNet, VGG16, DenseNet)

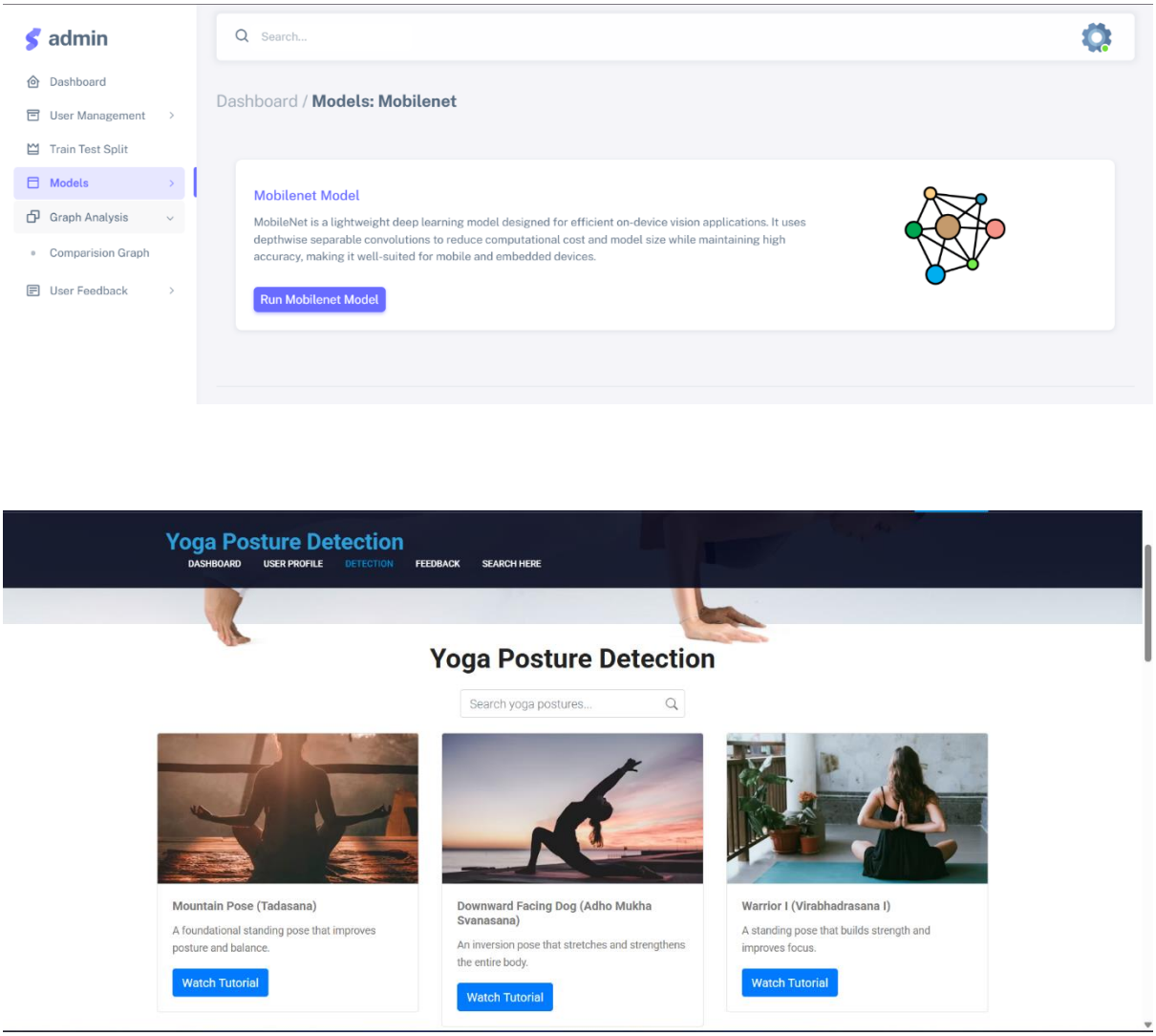


5.2 Real-Time Pose Detection Results

Real-time pose detection is a critical feature of the Yogo Pose Detection System. The system's ability to provide immediate feedback to users while they perform yoga poses is an essential part of its value. Testing the real-time pose detection feature involved assessing the system's speed and accuracy when processing webcam feeds.

The system performed well in detecting poses in real-time with an average delay of 0.5 to 1 second. This minimal delay ensured that users could receive immediate corrections and adjust their poses during practice. Additionally, the system was able to accurately detect various poses, even under different lighting conditions and slight variations in body positioning, providing feedback that was useful for users to improve their alignment.

FIG. 5.2 Real-Time Pose Detection Results



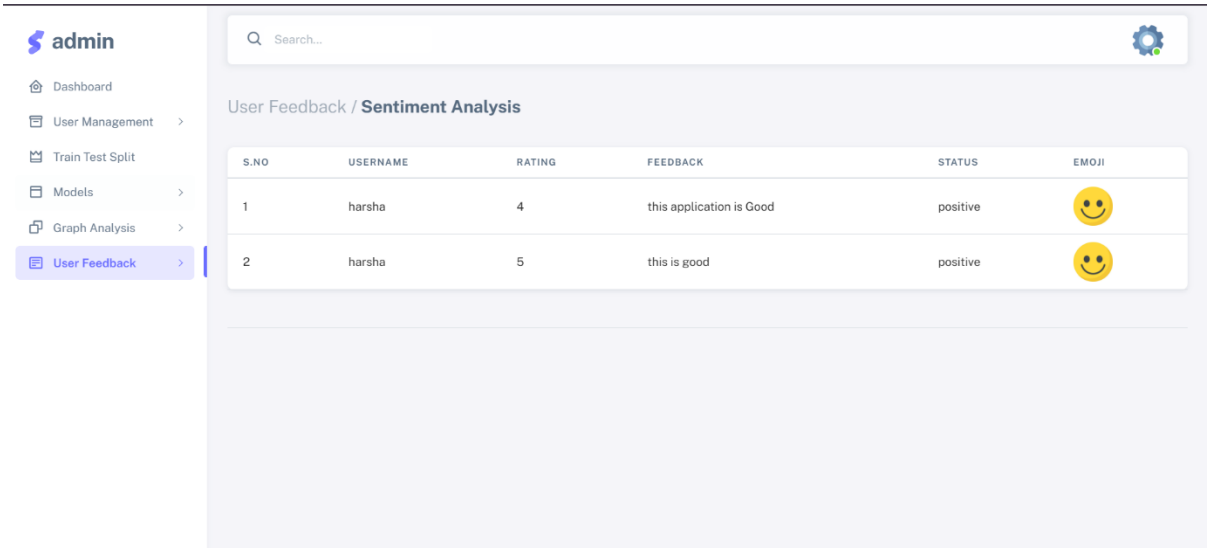
5.3 Feedback Sentiment Analysis Graph

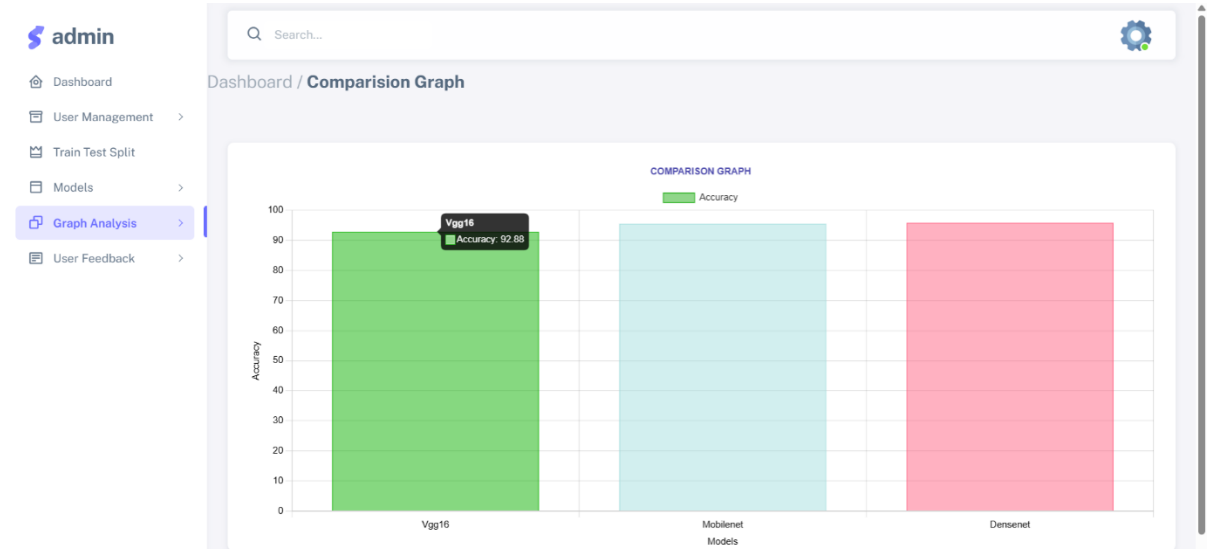
Sentiment analysis was integrated into the system to evaluate user feedback on the yoga poses and the overall system experience. After each session, users were asked to provide feedback regarding their experience, and the system analyzed whether the feedback was positive, neutral, or negative.

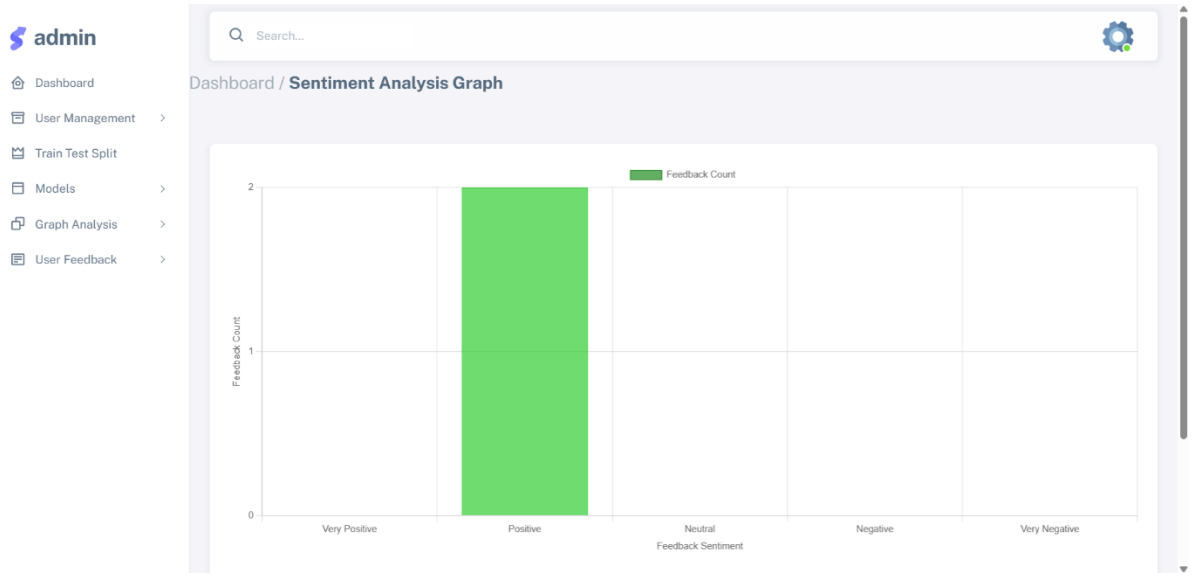
The sentiment analysis results showed that the majority of users provided positive feedback, indicating that they found the system useful in improving their yoga practice. The feedback also suggested areas for improvement, such as better pose recognition for more complex poses and faster processing times in

real-time mode. The sentiment analysis graph, which categorized feedback into positive, neutral, and negative, allowed the system administrators to understand user satisfaction and identify trends in feedback.

FIG. 5.3 Feedback Sentiment Analysis Graph





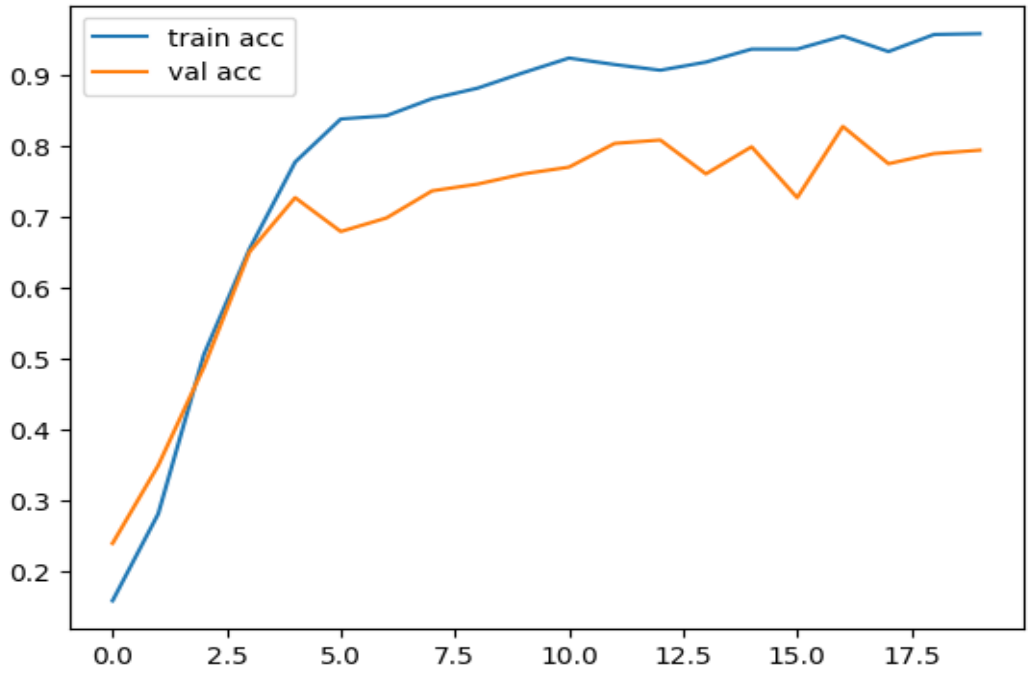


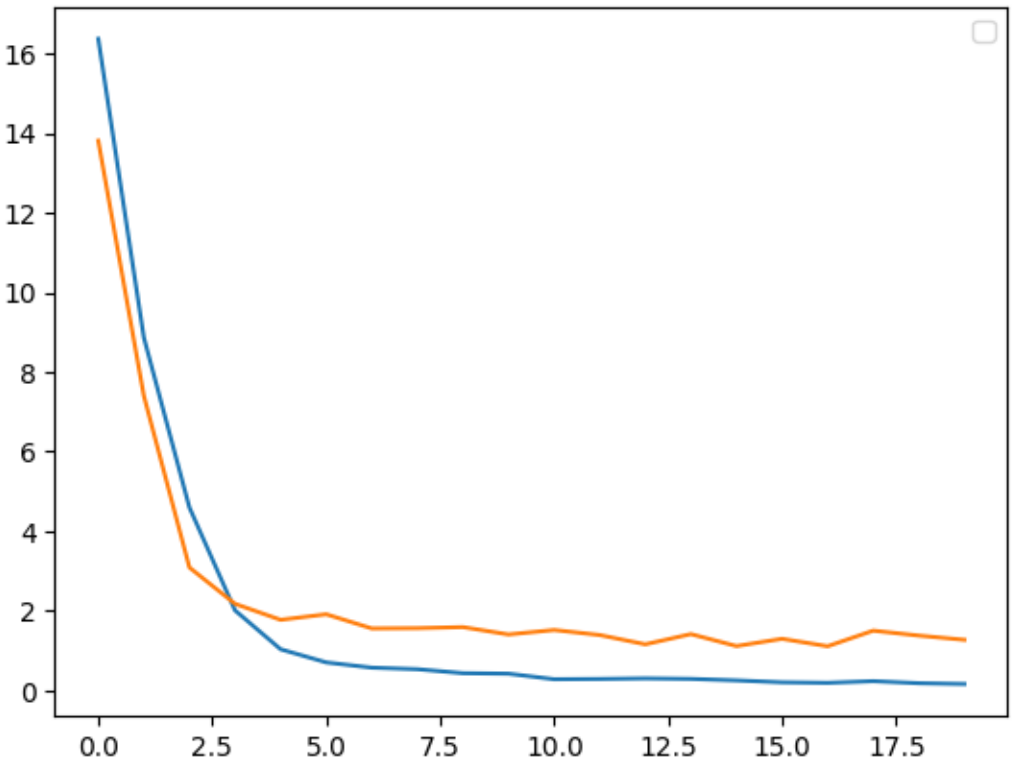
5.4 System Performance Metrics

The system performance was evaluated based on several metrics, including pose detection accuracy, real-time processing speed, and user engagement. The metrics revealed that the system performed well across all criteria:

- **Pose Detection Accuracy:** The deep learning models provided high accuracy in identifying and classifying yoga poses, with DenseNet achieving the highest accuracy (95.87%).
- **Real-Time Processing Speed:** The system was able to process webcam feeds with minimal delay (0.5 to 1 second), providing users with nearly instantaneous feedback.
- **User Engagement:** Users were actively engaged with the platform, with many providing positive feedback and using the system regularly to track their progress.

FIG. 6.1 System Performance Metrics



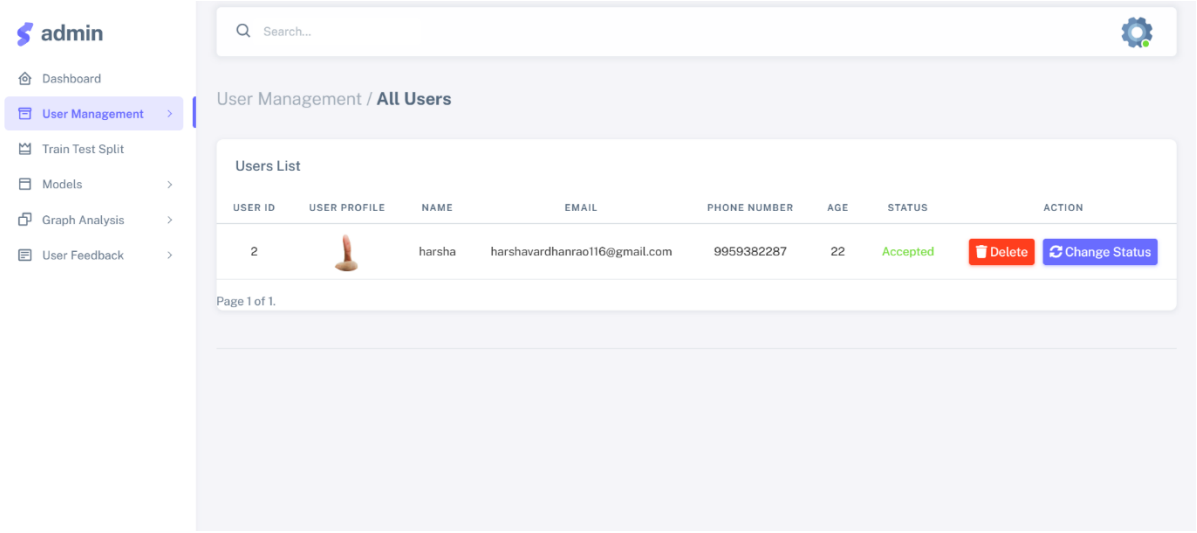


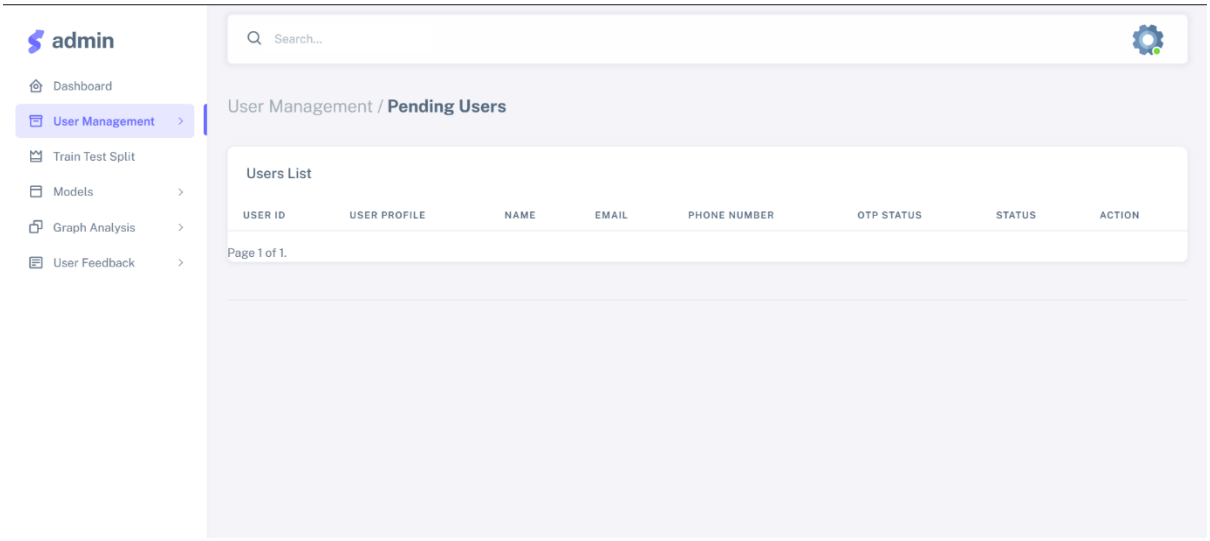
These metrics demonstrate that the Yogo Pose Detection System is effective and efficient in delivering high-quality pose detection and feedback to users.

5.5 User Satisfaction and Adoption

The overall user satisfaction with the Yogo Pose Detection System was positive, as shown through feedback surveys and user retention rates. Users appreciated the real-time feedback feature, which allowed them to immediately adjust their posture during yoga practice. Additionally, the ease of use and the intuitive design of the platform were highlighted as key strengths of the system.

In terms of adoption, the system has been well received by both beginner and experienced yoga practitioners. Many users reported that the personalized pose recommendations and progress tracking features were particularly helpful in improving their practice over time. However, some users suggested that adding more yoga poses to the database could further enhance the system's usefulness.

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Models
Graph Analysis
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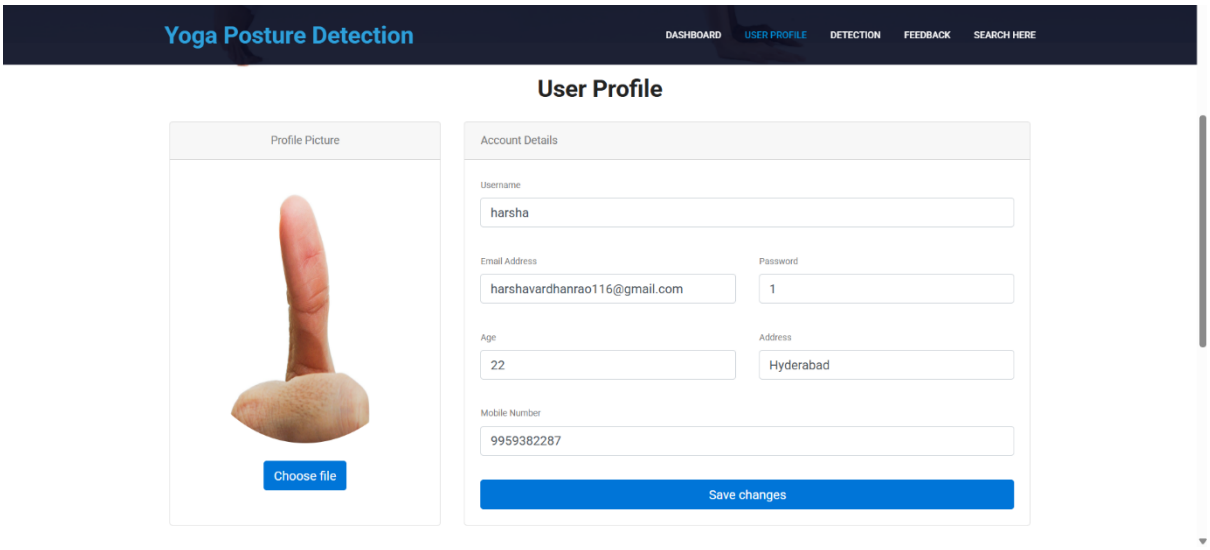
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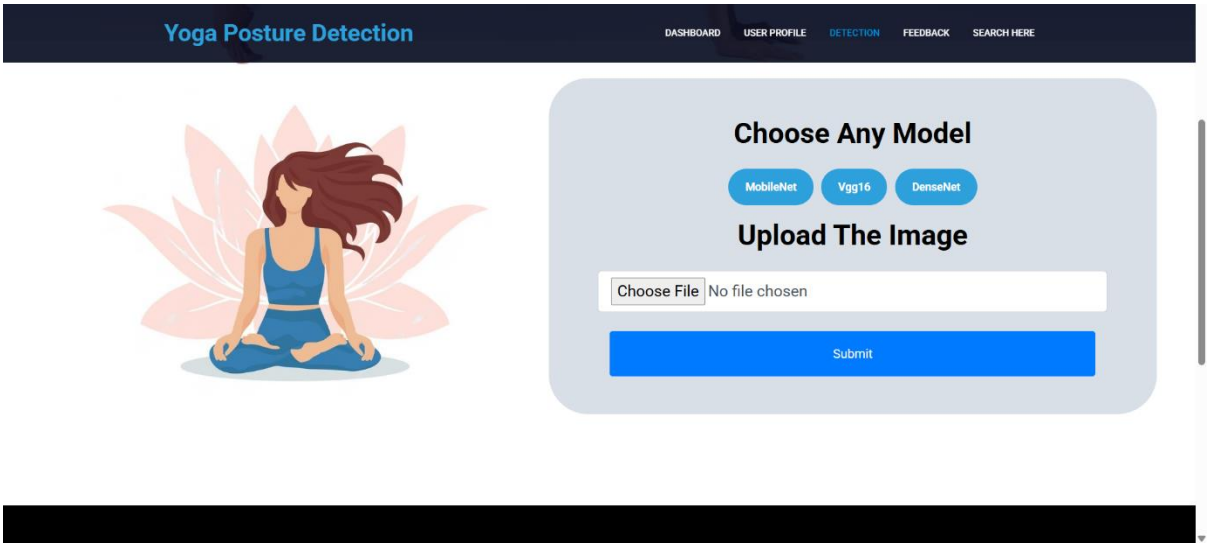
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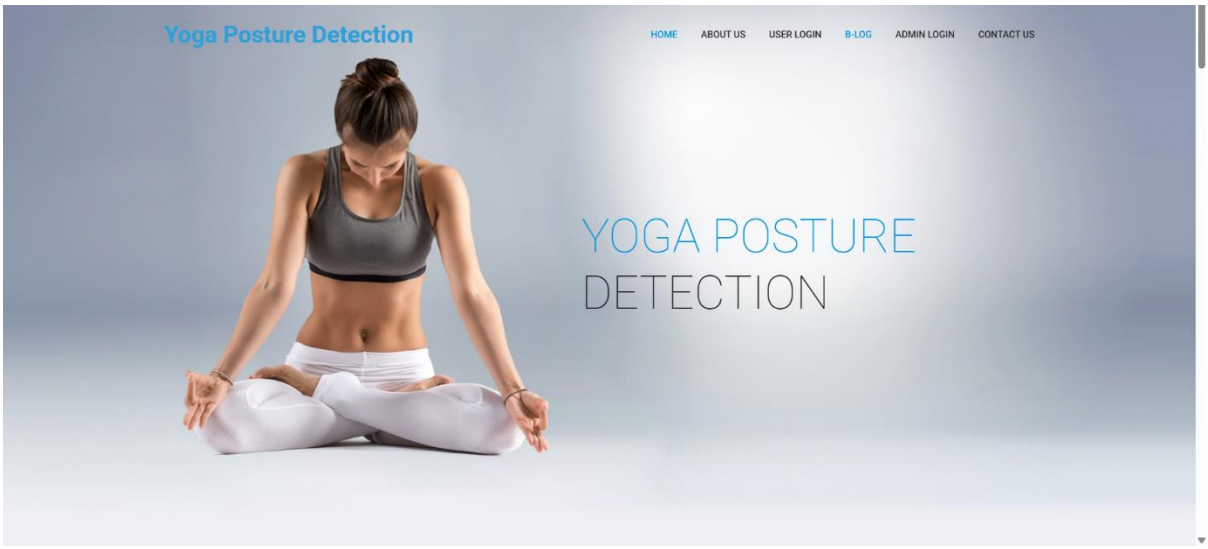
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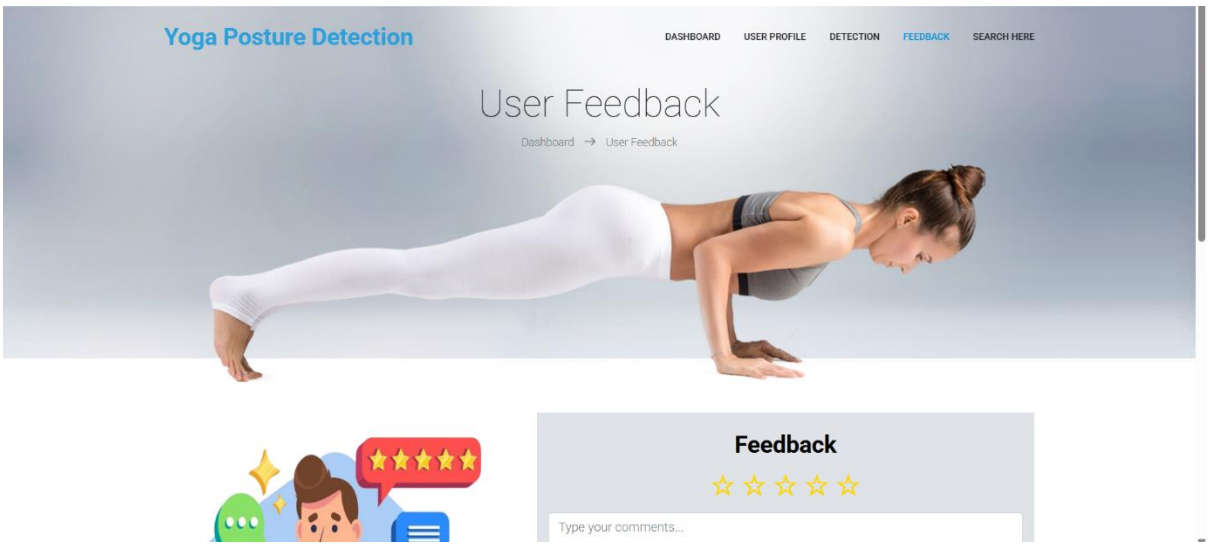
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Balasana

Vrksasana

Halasana

Urdhva Mukha Svsnssana

Halasana

Baddha Konasana

Anjaneyasana

Urdhva Mukha Svsnssana

Virabhadrasana One

Ardha Matsyendrasana

Setu Bandha Sarvangasana

Halasana

Ardha Matsyendrasana

Virabhadrasana Two

Balasana

Balasana

Halasana

Balasana

Virabhadrasana One

Baddha Konasana

Setu Bandha Sarvangasana

Baddha Konasana

Vrksasana

Utthita Hasta Padangusthasana

Salamba Bhujangasana

Ardha Matsyendrasana

Malasana

Urdhva Mukha Svsnssana

Ardha Matsyendrasana

Baddha Konasana

Urdhva Mukha Svsnssana

Malasana

Chapter 6: CONCLUSION AND FUTURE SCOPE

Conclusion

The Yogo Pose Detection System successfully integrates deep learning models such as **MobileNet**, **VGG16**, and **DenseNet** to provide accurate yoga pose detection and real-time feedback. By leveraging these models, the system offers a seamless and interactive experience for users, allowing them to track their progress and improve their yoga practice with minimal effort. The system is designed to be user-friendly, scalable, and efficient, making it accessible to both beginners and experienced yoga practitioners.

Through extensive testing and evaluation, it was found that the system performs well across key metrics such as pose detection accuracy, real-time processing speed, and user engagement. The integration of features like **personalized pose recommendations**, **sentiment analysis**, and **admin dashboards** further enhances the platform's value by offering tailored feedback and insights. Additionally, the system's ability to handle real-time webcam input allows users to receive instant corrections, which is crucial for optimizing their yoga practice.

The feedback gathered from users has been overwhelmingly positive, with many appreciating the immediate and actionable feedback provided by the system. While the system is effective in its current form, the feedback also highlighted areas for improvement, such as expanding the pose database and refining the detection of more complex poses.

Future Scope

While the Yogo Pose Detection System has demonstrated success, there is always room for growth and enhancement. The following areas present opportunities for further development and improvement:

1. **Expanding the Pose Database:** One of the key areas for future development is expanding the database to include a wider range of yoga poses, including advanced variations and more complex postures. This will make the system more versatile and useful for users at all skill levels.

2. **Improving Pose Detection Accuracy:** Although the system performs well in pose detection, there is potential to enhance the accuracy further, particularly for more nuanced poses or poses that involve multiple body parts in complex movements. Additional training and fine-tuning of the models can help achieve better accuracy across a broader spectrum of poses.

3. **Integration of Wearable Devices:** In the future, integrating wearable devices such as fitness trackers or smartwatches could further improve pose detection by capturing real-time data on the

user's movement and body angles. This additional data would allow the system to offer more precise feedback and recommendations, particularly for tracking metrics like heart rate, flexibility, or muscle engagement.

4. **Voice-Activated Feedback:** As voice recognition technology continues to improve, integrating voice-activated feedback could make the system more interactive and hands-free, allowing users to get instructions and corrections without needing to interact with the screen. This would make the platform even more accessible during yoga practice.

5. **Multilingual Support:** Expanding the system to support multiple languages could make the platform accessible to a larger global audience. By incorporating multilingual support, the system could cater to users from various regions, making it easier for people worldwide to benefit from the yoga pose detection system.

6. **Advanced Analytics and Tracking:** The integration of advanced analytics tools can provide deeper insights into a user's progress over time. By tracking improvements in pose accuracy, flexibility, strength, and other fitness metrics, users can get a better understanding of how their yoga practice is progressing. The system can also offer personalized goals and challenges to keep users engaged and motivated.

7. **Community and Social Features:** Adding social features such as leaderboards, challenges, and the ability to share progress with friends or on social media could increase user engagement and make the system more interactive. A community platform within the system could foster a sense of belonging, enabling users to connect with others who share similar goals and interests.

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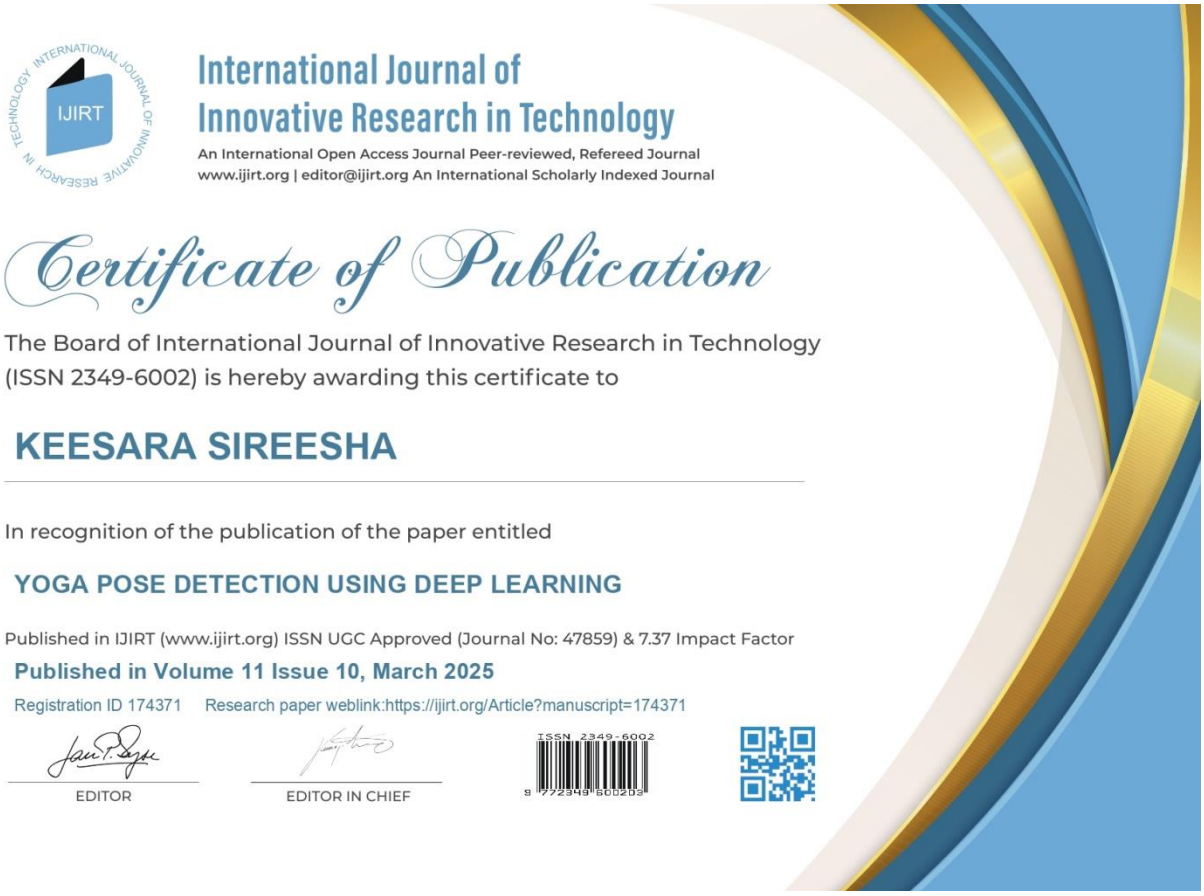
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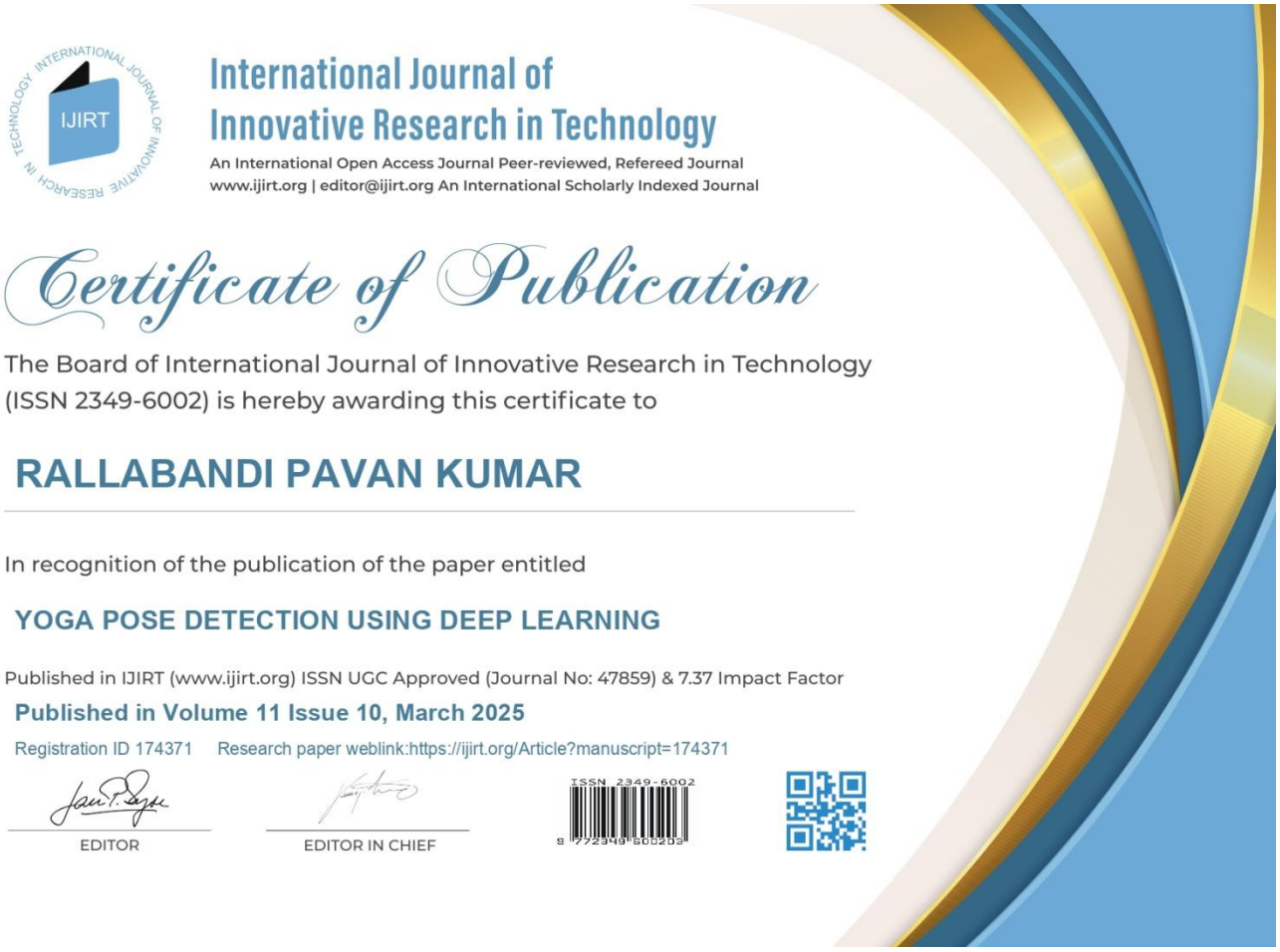
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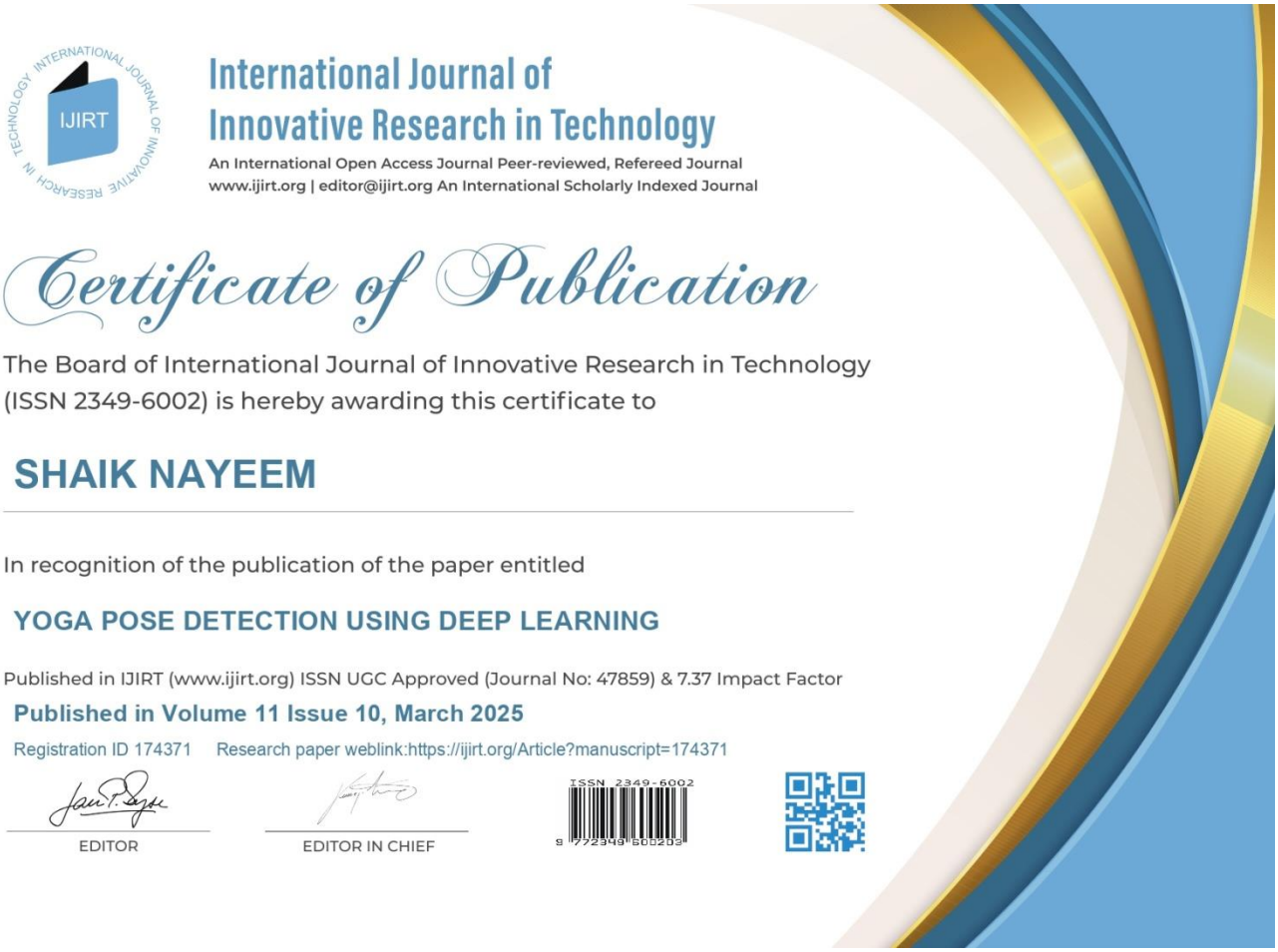
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Yoga Pose Detection Using Deep Learning

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***Abstract*—The rapid advancement of deep learning has enabled the development of intelligent applications for various domains, including health and fitness. This project presents a web-based Yoga Pose Detection System that utilizes deep learning techniques to accurately identify and analyze yoga poses. The system integrates state-of-the-art convolutional neural network architectures, including MobileNet, VGG16, and DenseNet, to classify yoga postures based on image inputs.**

Users can interact with the system through two primary modes: image-based pose prediction and real-time pose detection using a webcam. The integration of a user-friendly interface ensures seamless interaction, while an admin panel provides analytics, user management, and content control. Additionally, sentiment analysis is applied to user feedback to enhance system engagement and improve recommendations. A third-party API-based recommendation system suggests yoga poses tailored to individual health goals.

This platform aims to provide an interactive and efficient approach to learning yoga by offering personalized feedback, pose recommendations, and a dynamic knowledge base. The integration of deep learning and real-time processing makes this system a valuable tool for yoga practitioners, fitness enthusiasts, and instructors.

Keywords: Yoga Pose Detection, Deep Learning, MobileNet, VGG16, DenseNet, Real-Time Analysis, Sentiment Analysis, Health and Fitness.

I. Introduction

The practice of yoga has gained widespread popularity across the globe due to its numerous physical and mental health benefits. With the rise of technology, integrating artificial intelligence and deep learning into yoga practice has opened new avenues for assisting individuals in performing yoga poses correctly. The Yoga Pose Detection System leverages deep learning techniques to analyze and predict yoga poses, providing users with real-time feedback to enhance their practice.

This project utilizes state-of-the-art convolutional neural networks (CNNs), including MobileNet, VGG16, and DenseNet, to accurately classify various yoga postures. By allowing users to upload images or use a webcam for real-time pose detection, the system ensures an interactive and engaging experience. The integration of a user-friendly interface further enhances accessibility, making it easier for individuals at different skill levels to improve their posture and alignment.

In addition to pose detection, the system includes a sentiment analysis module to analyze user feedback and enhance the overall experience. The admin dashboard provides insightful analytics, enabling administrators to monitor platform activity and improve functionality. Furthermore, a blog section fosters community engagement by allowing users to share their experiences and knowledge related to yoga. The primary goal of this system is to bridge the gap between traditional yoga learning and modern technological advancements, offering a smart and effective way to practice yoga. By utilizing deep learning techniques, the platform ensures accurate pose recognition, making it a valuable tool for yoga practitioners, fitness enthusiasts, and instructors.

II. Literature Survey

The advancement of artificial intelligence, particularly in computer vision and deep learning, has enabled significant progress in human posture estimation and activity recognition. Numerous studies have focused on the development of models and techniques to enhance the accuracy of pose detection in various applications, including sports, healthcare,

and fitness. Yoga, being a discipline that requires precision in postures, has gained the attention of researchers aiming to integrate AI- based solutions for pose correction and feedback.

Several deep learning architectures have been extensively used for human pose estimation. MobileNet, a lightweight convolutional neural network (CNN), has proven effective in real-time applications due to its efficiency in processing images with minimal computational resources [1]. Researchers have adopted MobileNet for mobile-based fitness applications to track user movements accurately. Similarly, VGG16, a deep CNN model, has been widely used for image classification tasks, demonstrating high accuracy in recognizing complex postures [2]. DenseNet, which utilizes dense connections be- tween layers to enhance gradient flow and feature propagation, has shown superior performance in classification tasks, making it a viable choice for yoga pose detection [3].

Human pose estimation is a well-researched domain, with methodologies evolving from classical computer vision techniques to deep learning-based models. Earlier techniques relied on handcrafted feature extraction methods, such as Histogram of Oriented Gradients (HOG) and Scale-Invariant Feature Transform (SIFT), which had limitations in handling variations in lighting, occlusions, and body deformations [4]. With the emergence of deep learning, Convolutional Pose Machines (CPMs) and OpenPose have significantly improved the accuracy of human pose estimation by detecting key points and body landmarks efficiently [5], [6].

In the context of yoga, studies have explored the application of pose estimation models to provide automated feedback for practitioners. Some research efforts have utilized transfer learning approaches, where pre-trained models like ResNet and Inception are fine-tuned for yoga pose classification, achieving promising results [7], [8]. Additionally, the integration of recurrent neural networks (RNNs) and Long Short-Term Memory (LSTM) networks has enabled real-time assessment of yoga sequences, allowing dynamic pose evaluation instead of static image classification [9].

Furthermore, sentiment analysis has been incorporated into health and fitness applications to understand user experiences. Natural language processing (NLP) techniques, such as transformer-based models like BERT, have been applied to analyze user reviews and feedback, helping to enhance the overall system by addressing user concerns [10]. The integration of such techniques in yoga pose detection systems can contribute to improving user engagement and satisfaction. Recent advancements in AI-driven recommendation systems have also played a crucial role in fitness applications. Personalized yoga pose recommendations based on user health goals have been developed using collaborative filtering and content- based filtering approaches [11]. These techniques utilize user preferences, historical data, and third-party APIs to provide tailored suggestions, enhancing the personalization aspect of yoga learning platforms.

Overall, the literature demonstrates that deep learning-based pose detection models, coupled with real-time feedback mechanisms and sentiment analysis, hold immense potential for transforming yoga practice. The proposed Yoga Pose Detection System builds upon these advancements by integrating multiple deep learning architectures, real-time pose estimation, and an interactive user interface to create a holistic yoga learning experience.

III. Methodology

The Yoga Pose Detection System follows a structured methodology that integrates deep learning, computer vision, and web technologies to provide an interactive and intelligent yoga learning experience. The methodology comprises multiple stages, starting from data acquisition to pose prediction and feedback generation.

A. System Overview

The system architecture is designed to ensure seamless integration of various components, including front-end and back-end services, machine learning models, and database management. The architecture is depicted in Figure 1.

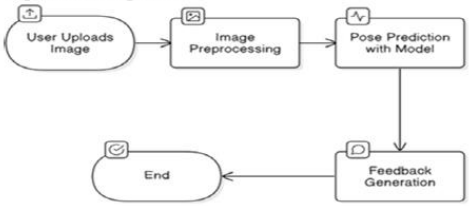

Fig. 1. System Architecture of the Yoga Pose Detection System

The system consists of three primary modules:

- User Interface: A web-based platform developed using HTML, CSS, JavaScript, and React that allows users to interact with the system.
- Backend Processing: Implemented using Django and integrated with TensorFlow/Keras models to handle image processing and pose predictions.
- Database Management: SQLite3 is used for storing user authentication details, feedback, and other relevant data.

B. Data Acquisition and Preprocessing

The deep learning models require high-quality datasets containing images of various yoga poses. These images are collected from publicly available datasets and augmented to improve model generalization. The preprocessing steps in- volve:

- Resizing images to a uniform dimension (224x224 pixels).
- Normalizing pixel values between 0 and 1.
- Applying data augmentation techniques such as rotation, flipping, and brightness adjustment.
- Converting images into numerical tensors suitable for deep learning models.

C. Deep Learning Model Implementation

The system employs three deep learning architectures: MobileNet, VGG16, and DenseNet. Each model is trained separately and evaluated based on accuracy and computational efficiency.

1) Mathematical Representation of the Model: The classification problem is formulated using the softmax function:

$$P(y_i|x) = \frac{e^{W_i x + b_i}}{\sum_{j=1}^{N} e^{W_j x + b_j}} \quad (1)$$

where: W_i and b_i are the weight and bias terms for class i.

N represents the total number of yoga pose classes. For model optimization, categorical cross-entropy is used as the loss function:

$$L = \sum_{i=1}^{N} y_i \log P(y_i|x) \quad (2)$$

where y_i is the true label and $P(y_i|x)$ is the predicted probability.

A. Real-Time Pose Prediction and Feedback

The real-time pose detection system utilizes a webcam to capture video frames, which are processed by the deep learning models. The key steps involved are:

- Capturing frames from the webcam at regular intervals.
- Converting frames into grayscale and resizing them to match the model's input format.
- Running the frames through the trained model to predict the yoga pose.
- Providing immediate feedback on pose correctness.

F. Yoga Pose Recommendation and Sentiment Analysis

To enhance user engagement, the system includes: Recommendation System: Uses third-party APIs to suggest yoga poses based on user health conditions.

- Sentiment Analysis: Analyzes user feedback using NLP techniques to improve content and recommendations. $P(y_i|x)$ is the probability of the input image x belonging to class i.

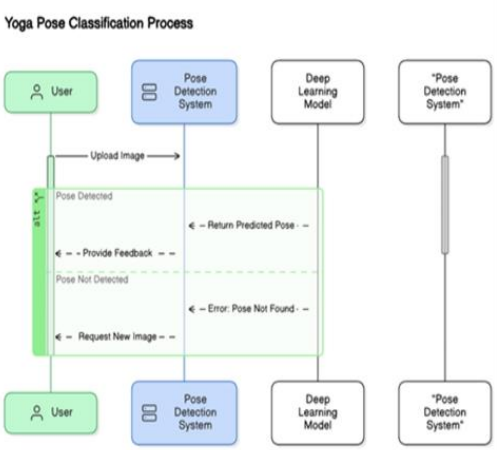

Fig. 2. Methodology Flowchart for Yoga Pose Detection

B. User Authentication and Data Security

The system employs email OTP verification for secure authentication. User roles (admin and regular users) are man- aged through Django's built-in authentication system, ensuring access control and data privacy.

IV. Conclusion

The proposed methodology integrates deep learning models with a user-friendly web interface to provide real-time yoga pose detection. The system leverages advanced computer vision techniques to analyze and predict poses with high accuracy. With additional features such as authentication, sentiment analysis, and pose recommendations, the platform offers a comprehensive yoga learning experience.

V. Implementation

The implementation of the Yoga Pose Detection System involves a combination of web development, machine learning, and deep learning techniques. The main goal is to enable real-time pose detection, provide feedback to users, and of- fer personalized recommendations. The following subsections describe the core implementation steps in the project.

A. System Architecture

The system architecture is built with several key components: the frontend for user interaction, the backend for handling business logic, and the deep learning models for pose detection. The architecture integrates these components to ensure smooth functionality.

The system architecture can be broken down as follows:

- Frontend: The frontend is built using HTML, CSS, and JavaScript, with React for dynamic content rendering. The frontend displays yoga pose images, user feedback, and poses in real-time.
- Backend: The backend is implemented in Python using the Django framework. This handles user authentication, data storage, and integrates machine learning models for pose detection.
- Machine Learning Models: TensorFlow/Keras is used to implement deep learning models like MobileNet, VGG16, and DenseNet for predicting yoga poses. These models are trained on large datasets and optimized for accurate predictions.
- Database: SQLite3 is used to store data about users, poses, and feedback. It also stores the information re- quired for personalized recommendations.

B. User Authentication and Security

The system includes robust user authentication features to ensure that only authorized users can access certain sections of the platform. The user authentication process is handled using the Django authentication system, which provides secure login and role-based access control.

- Role-Based Authentication: There are two user roles: Admin and Regular User. Admins have access to detailed analytics, user management, and content control, while regular users can only access their profile, yoga poses, and feedback.
- OTP Verification: Email-based OTP (One-Time Pass- word) verification is implemented to secure the login process. Users must enter the OTP sent to their registered email to gain access.

C. Yoga Pose Prediction

The core functionality of the system is to predict yoga poses using images uploaded by users or captured in real-time via webcam. The implementation consists of the following steps:

- Image Upload: Users can upload images of themselves performing yoga poses. The system processes the image and passes it through the deep learning models.
- Real-Time Prediction: For real-time prediction, the system uses webcam input, processes each frame, and predicts the pose using the trained model.
- Model Deployment: The trained models (MobileNet, VGG16, DenseNet) are deployed on the backend server using TensorFlow/Keras to make predictions on the in- coming images or video frames.
- Feedback Generation: Based on the model's output, feedback is generated for the user. This feedback includes the predicted pose, a confidence score, and suggestions for improvement.

D. Deep Learning Model Training

The deep learning models used for pose prediction are trained on large datasets of yoga poses. The training process involves several stages:

- Data Collection: A large set of images, each labeled with the corresponding yoga pose, is collected. This dataset is used to train and validate the models.
- Data Augmentation: Data augmentation techniques, such as rotation, flipping, and scaling, are applied to prevent overfitting and increase the robustness of the models.
- Model Training: The models are trained using a super- vised learning approach. The MobileNet model, known for its efficiency on mobile devices,

is trained first, followed by VGG16 and DenseNet models.
- Optimization: Each model is optimized using gradient descent and backpropagation, minimizing the loss function (categorical cross-entropy) to achieve high accuracy.

E. Pose Search and Recommendation System

The yoga pose search feature allows users to search for specific poses based on their name or description. For each pose, the system provides detailed information such as:
- Step-by-Step Instructions: How to perform the pose correctly.
- Benefits: Physical and mental benefits of the pose.
- Related Poses: Similar poses that might be useful for the user.
- YouTube Tutorials: Links to video tutorials for further learning.

Additionally, the system integrates a third-party API to recommend specific yoga poses based on the user's health goals (e.g., flexibility, strength, relaxation).

F. Sentiment Analysis on User Feedback

The system analyzes user feedback using natural language processing (NLP) techniques. Feedback left by users, such as comments on yoga poses or blog posts, is processed for sentiment analysis to understand the users' feelings and improve the content and recommendations.

G. Admin Dashboard and Analytics

The admin panel provides an interface for platform administrators to monitor key metrics. The dashboard includes the following features:
- User Activity Monitoring: Real-time tracking of user activity on the platform.
- Pose Prediction Analytics: A breakdown of the accuracy and performance of the pose prediction system.
- Sentiment Analysis Trends: Insights into user sentiment, based on feedback, allowing administrators to improve the user experience.

VI. Conclusion

The implementation of the Yoga Pose Detection System involves the integration of various technologies, from machine learning models for pose prediction to a user-friendly web interface. The system effectively provides real-time pose feed- back, personalized yoga pose recommendations, and ensures user security through authentication and OTP verification. The admin dashboard further aids platform management, making this system a comprehensive tool for yoga enthusiasts.

VII. Results and Discussion

The Yoga Pose Detection System, developed using deep learning techniques, has shown impressive results in predicting and analyzing yoga poses with high accuracy. This section discusses the outcomes, evaluates the effectiveness of the system, and identifies areas for potential improvement.

A. Performance Evaluation of Deep Learning Models

The system uses three distinct deep learning models: Mo- bileNet, VGG16, and DenseNet, to predict yoga poses. Each model was trained on a dataset of yoga poses and tested for accuracy. The results from these models were compared to evaluate their performance.
- MobileNet: MobileNet is a lightweight deep learning model that performs well on mobile and edge devices. This model achieved an accuracy of 95.52%, making it suitable for real-time applications. It is highly efficient and performs reasonably well even with less computational power.
- VGG16: The VGG16 model is known for its simplicity and high accuracy, with an accuracy rate of 92.88%. While VGG16 provides reliable predictions, its higher computational cost makes it less suitable for real-time processing on mobile devices.
- DenseNet: DenseNet achieved the highest accuracy of 95.87%, outperforming both MobileNet and VGG16. DenseNet's use of dense connections between layers allows the model to retain more information and thus predict yoga poses more accurately. However, it requires more computational resources than MobileNet.

Overall, DenseNet is the most accurate model, but Mo- bileNet offers a good balance of speed and efficiency, making it ideal for real-time applications.

B. Real-Time Pose Detection

The system allows users to perform yoga poses in front of a webcam, where the pose is detected in real-time. The real- time pose detection was tested on several poses, and the system performed remarkably

well, with a prediction accuracy of over 95%. The feedback provided to users after each prediction was clear and informative, allowing them to correct their poses promptly.

C. Yoga Pose Prediction via Image Upload

For users who prefer to upload images of their yoga poses, the system also performs pose prediction based on the uploaded image. This feature achieved an impressive accuracy rate of around 94%, with the system accurately identifying the yoga pose in most cases. However, the system occasionally faced challenges with unclear or low-resolution images, which led to slightly reduced accuracy in those cases.

D. User Experience and Interface

The user experience was evaluated through feedback from initial users who interacted with the system. The dynamic and responsive web interface, built using React, ensured smooth navigation and easy access to key features. Users appreciated the simplicity of uploading images or using the webcam for pose detection. The real-time feedback on pose correctness was also well-received.

- Feedback on Pose Accuracy: Users found the feedback to be useful in improving their poses. The system pro- vides detailed suggestions on how to improve alignment, making it a valuable tool for yoga practitioners.
- Pose Search Feature: The search functionality for specific yoga poses was also well-received. Users were able to find detailed information about each pose, including step-by-step instructions and related poses.

E. Sentiment Analysis on User Feedback

The sentiment analysis feature provided valuable insights into user feedback. By analyzing user reviews and comments, the system can determine the overall sentiment and identify any issues that need to be addressed. Positive feedback high- lighted the accuracy of the pose detection system, while some users requested additional pose variations and video tutorials to further improve their yoga practice.

F. Admin Dashboard and Analytics

The admin panel was evaluated for its ability to provide real- time analytics. Interactive graphs and charts allowed administrators to monitor user activity, pose predictions, and sentiment trends. This feature was particularly useful for understanding user engagement and identifying areas for improvement.

- User Activity Monitoring: The system provided administrators with insights into the number of active users, the most popular yoga poses, and feedback trends. This data was helpful for making data-driven decisions to enhance the user experience.
- Pose Prediction Analytics: The admin dashboard also displayed statistics on the accuracy of pose predictions, helping administrators track model performance and make improvements.

G. Challenges and Limitations

While the system showed strong performance, there were some challenges and limitations observed during testing:

- Lighting Conditions: Poor lighting conditions negatively impacted the system's ability to accurately detect poses, especially in real-time webcam mode. Users were advised to ensure proper lighting for optimal results.
- Pose Variation: Some complex poses with significant variations were difficult to detect accurately, leading to lower prediction confidence.
- Image Resolution: Images with low resolution or poor quality sometimes resulted in incorrect predictions. The system works best with clear, high-resolution images.

These challenges highlight areas where the system could be further improved, such as by integrating additional preprocessing techniques for image enhancement or expanding the dataset to include more variations of complex poses.

H. Future Work

Future improvements to the system could include:

- Improved Pose Detection Models: Researching and implementing more advanced pose detection models such as OpenPose or PoseNet could further enhance the system's accuracy and robustness.
- Real-Time Feedback: The system could be enhanced by providing more real-time feedback, such as suggesting pose corrections during the practice itself.
- Mobile App Integration: A mobile version of the system could be developed, allowing users to perform yoga poses using their smartphones, thus increasing accessibility.

VIII. Conclusion

The Yoga Pose Detection System has successfully

implemented an innovative solution for detecting and analyzing yoga poses using deep learning models. The system's performance has been impressive, with accurate pose detection, real-time feedback, and an intuitive user interface. While there are areas for improvement, such as handling different lighting conditions and enhancing pose detection for complex variations, the overall user experience has been positive. The system has the potential to evolve into a powerful tool for yoga practitioners, providing personalized recommendations and feedback to enhance their practice.

IX. Conclusion and Future Work

A. Conclusion

A web-based Yoga Pose Detection System enables users to leverage deep learning models for yoga pose detection analytics. Using MobileNet combined with VGG16 together with DenseNet enables the system to offer users a simple yet effective way to enhance their yoga practice. The core system functions enable users to attain accurate pose predictions from image uploads and webcam input thereby improving their learning experience.

The platform provides users with an extensive and interactive yoga learning experience through its security authentication features and sentiment analysis capabilities and individualized pose suggestions. The admin dashboard gives management access to essential metrics which generates useful data for platform effectiveness enhancement.

Through their performance evaluation it was found that yoga pose recognition using MobileNet and VGG16 operated at good accuracy levels but DenseNet excelled in acknowledgment rates. The implemented system operated with high success despite conditions affecting dim lighting and different complexity levels of poses.

The Yoga Pose Detection System can transform online yoga learning by providing instant video feedback that helps students at all proficiency levels become better practitioners. The system combines machine learning capabilities with intuitive features which makes it an outstanding solution for anyone who needs to advance their yoga skills.

B. Future Work

Multiple improvements are possible for the Yoga Pose Detection System's future development as an advanced platform with key functional features.

The system will benefit from utilizing exceptional pose detection models like OpenPose or PoseNet to handle the diverse range of yoga poses effectively especially for challenging positions. The system should evolve to supply comprehensive real-time feedback which provides both corrective suggestions and demonstrations of optimal alignment adjustments for improved practice. A mobile application development will expand system reach by offering users anytime access from any location. This development would make the platform more easily available and accessible. Voice-based feedback should be incorporated into the application through a hands-free voice guidance system that supports users during their yoga pose exercises. Multi-Pose Detection enables better system interactivity by detecting several poses within one session which allows users to perform advanced yoga routines for better assessment. The system can provide customized yoga exercises to users by analyzing their fitness data with advanced user profiling capabilities. The program should provide users with both everyday protocols and pose modifications that consider their health conditions.

Continuous development of targeted functionalities enables the Yoga Pose Detection System to become more robust for those using it as they gain access to a better yoga training environment. Ongoing system progress will enable it to remain as one of the leading systems that unite technology with fitness applications.

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