A PROJECT REPORT ON

"YOGA POSE DETECTION using DEEP LEARNING"

SUBMITTED TO

SHIVAJI UNIVERSITY, KOLHAPUR

IN THE PARTIAL FULFILLMENT OF REQUIREMENT FOR THE AWARD OF DEGREE BACHELOR OF TECHNOLOGY IN COMPUTER SCIENCE AND ENGINEERING

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UNDER THE GUIDANCE OF

PROF. DR. S. K. SHIRGAVE

DKTE

Promoting Excellence in
Teaching, Learning & Research

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

DKTE SOCIETY'S TEXTILE AND ENGINEERING INSTITUTE, ICHALKARANJI

2022-2023

D.K.T.E.SOCIETY'S

TEXTILE AND ENGINEERING INSTITUTE, ICHALKARANJI
(AN AUTONOMOUS INSTITUTE)

DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

CERTIFICATE

This is to certify that, project work entitled

"YOGA POSE DETECTION using DEEP LEARNING"

is a bonafide record of project work carried out in this college by

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DECLARATION

We hereby declare that, the project work report entitled “Yoga Pose Detection using Deep Learning” which is being submitted to D.K.T.E. Society’s Textile and Engineering Institute Ichalkaranji, affiliated to Shivaji University, Kolhapur is in partial fulfillment of degree B.Tech. (CSE). It is a bonafide report of the work carried out by us. The material contained in this report has not been submitted to any university or institution for the award of any degree. Further, we declare that we have not violated any of the provisions under the Copyright and Piracy / Cyber / IPR Act amended from time to time.

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Thank you,

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ABSTRACT

In recent years, the popularity of yoga as a holistic practice for physical and mental well-being has grown significantly. Proper posture and form are crucial for maximizing the benefits of yoga exercises and minimizing the risk of injury. However, it can be challenging for individuals, especially beginners, to accurately perform yoga poses without guidance. To address this issue, we present a novel approach to yoga pose detection using deep learning techniques.

The project focuses on the development of a Yoga Pose Detection system using deep learning techniques. The objective of the system is to provide users with real-time feedback on their yoga poses to ensure correct posture and enhance the effectiveness of their yoga practice. The system utilizes live video input from a webcam and employs image segmentation and pose detection models to analyze the user's posture. A web-based interface allows users to select from a list of predefined yoga exercises, and the system continuously monitors their performance. When a correct pose is detected, a timer begins, and any incorrect posture resets the timer.

The project involves the creation of a custom yoga pose dataset and the implementation of deep learning algorithms for pose detection. The system's architecture, algorithms, and modules are described in detail, along with the implementation and testing procedures. The report also discusses the performance analysis, including response time, resource utilization, scalability, and optimization techniques. Additionally, the report presents the future scope of the project, potential applications, and references to relevant literature. The Yoga Pose Detection system holds promise for personal yoga training, fitness centers, rehabilitation centers, remote training programs, research, and assistive technology applications. The project contributes to the advancement of pose detection and human activity recognition, offering users a valuable tool for improving their yoga practice and overall physical well-being.

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1. INTRODUCTION

In today's fast-paced world, the convenience of technology has led to a sedentary lifestyle for many individuals who spend their days glued to screens. However, instead of blaming technology, we can leverage it to address this issue. By combining technology with activities like yoga, we can encourage people to learn and exercise simultaneously.

Yoga, as a physical practice, involves various postures and breathing exercises that provide numerous mental and physical benefits. It can improve body image, aid in weight loss and fitness, enhance focus and concentration, and reduce anxiety. To make yoga more accessible and convenient, we propose the development of an application that combines yoga with technology.

Our application allows individuals to exercise anywhere and anytime without the need for a personal instructor. Users can refer to images of yoga poses provided by the app, mimic the postures, and the app will analyze their posture using computer vision technology. A countdown timer starts once the user achieves the correct posture, and they need to hold it until the timer ends.

The increasing popularity of yoga as a holistic practice has created a demand for tools that can assist individuals in performing yoga poses correctly, especially for beginners without access to a qualified instructor. To address this, we propose an innovative approach that utilizes deep learning techniques for yoga pose detection.

Our system is a web-based application offering a selection of six different yoga exercises. When a user chooses an exercise, the system captures live video from their webcam for processing. Deep learning algorithms are applied to each frame of the video, enabling the system to detect and analyze the yoga pose being performed.

The backend processing consists of two stages: image segmentation and pose detection. Image segmentation extracts the human figure from each frame, isolating the relevant regions of interest and improving pose detection accuracy. In the second stage, a pose detection model is applied to the segmented image to determine if the user's posture aligns with the correct form for the selected yoga pose.

Real-time feedback is provided to the user based on the detected pose. If the posture is correct, a timer starts to track the exercise duration. If an incorrect posture is detected, the timer resets, prompting the user to correct their form and maintain proper alignment.

By developing a yoga pose detection system using deep learning, we aim to enhance the practice of yoga, particularly for individuals practicing at home or without access to an

instructor. The system's real-time feedback and accurate assessment of poses can promote correct posture and improve the overall quality of yoga sessions.

Human posture recognition using skeleton data is an active research area in the field of human-computer interaction. In this context, a novel algorithm based on multiple features and rule learning is proposed in this paper. The algorithm defines a 219-dimensional vector that includes angle and distance features, capturing both local joint relationships and global spatial locations. During human posture classification, rule learning, Bagging, and random subspace methods are utilized to enhance classification performance across different samples.

In addition, techniques such as granular computing can be explored to extract features at multiple levels of granularity and fuse different features. These approaches can reduce dimensionality and sparsity in feature sets. It is also crucial to investigate how the extraction of multiple features can enhance the diversity among classifiers trained using different feature sets or learning algorithms, leading to further improvements in human posture recognition performance.

Yoga pose detection using deep learning techniques has gained popularity due to its ability to provide personalized guidance, accessibility, convenience, and versatility in yoga practice. These systems utilize computer vision and machine learning algorithms to offer real-time feedback, ensuring correct posture alignment and reducing the risk of injuries. With yoga pose detection apps, individuals can practice yoga at their own convenience without the need for a physical instructor, and a wide range of poses and exercises are available to cater to different skill levels. The apps also include features for progress tracking, allowing users to monitor their improvements over time. Additionally, these systems promote continuous learning by providing feedback and opportunities for users to deepen their understanding of proper alignment and form. Some apps even offer social features that foster community engagement and support among practitioners. By leveraging technology, yoga pose detection enhances the overall yoga experience and enables individuals to improve their physical and mental well-being.

1.1 Problem Definition

Creating a Yoga Pose Detection system using deep learning techniques to automatically analyze and evaluate user poses in real-time. By utilizing live video input from a webcam and applying image segmentation and pose detection models, the system will determine the correctness of the user's posture. It will provide immediate feedback, initiating a timer for correct poses and resetting the timer for incorrect postures.

- The goal is to develop a web application for real time Yoga pose detection.

1.2 Aims and Objectives

The aim of this project is to develop a yoga pose detection system using deep learning techniques that can provide real-time feedback to users about the accuracy of their yoga postures. By leveraging computer vision and deep learning algorithms, the system aims to assist individuals in practicing yoga correctly, improving their posture and maximizing the benefits of each exercise.

Objectives:

- To develop a custom yoga pose dataset.
- To develop a pose detection model.
- To evaluate posture correctness.
- To implement a timer system.
- To develop a user-friendly web-based interface.

1.3 Scope

Development of a Yoga Pose Detection system using deep learning techniques. Real-time feedback and guidance to users on their yoga poses. Utilization of live video input from a webcam for pose analysis. Implementation of image segmentation and pose detection models for posture evaluation. Web-based interface for users to select from a list of predefined yoga exercises. Continuous monitoring of user performance, with a timer starting for correct poses and resetting for incorrect postures. Creation of a custom yoga pose dataset for training the deep learning models. Implementation and integration of the system's architecture, algorithms, and modules. Testing and evaluation of the system's performance, including response time and resource utilization. Contribution to the field of pose detection and human activity recognition. Improvement of users' yoga practice, posture correctness, and physical well-being.

1.4 Limitations

1. Limited Pose Variation:
   Our system is specifically designed to detect and assess a predefined set of six yoga poses. It may not accurately detect poses outside of this set or variations within the poses. To expand the range of detectable poses, additional training data and model enhancements would be necessary.

2. Lighting and Background Constraints:
   The accuracy of pose detection can be influenced by lighting conditions and the complexity of the background. Poor lighting or cluttered backgrounds could affect the system's ability to accurately segment the human figure and detect poses reliably.

3. Dependency on Webcam Quality:
   The quality of the user's webcam directly impacts the clarity and resolution of the captured video. Lower quality webcams may result in degraded image quality, potentially affecting the accuracy of pose detection.

4. Two-Dimensional Analysis:
   Our system analyzes yoga poses based on two-dimensional images captured from the webcam. This approach may have limitations in accurately capturing three-dimensional aspects of pose alignment, such as depth and rotation, which are crucial for some advanced yoga poses.

5. Individual Body Variations:
   The system may encounter challenges in accurately detecting poses for individuals with unique body proportions, body shapes, or physical limitations. The model's generalization to diverse body types and abilities might be limited, requiring additional customization and adaptation.

1.5 Timeline of the project

We have mentioned the timeline for our project below:

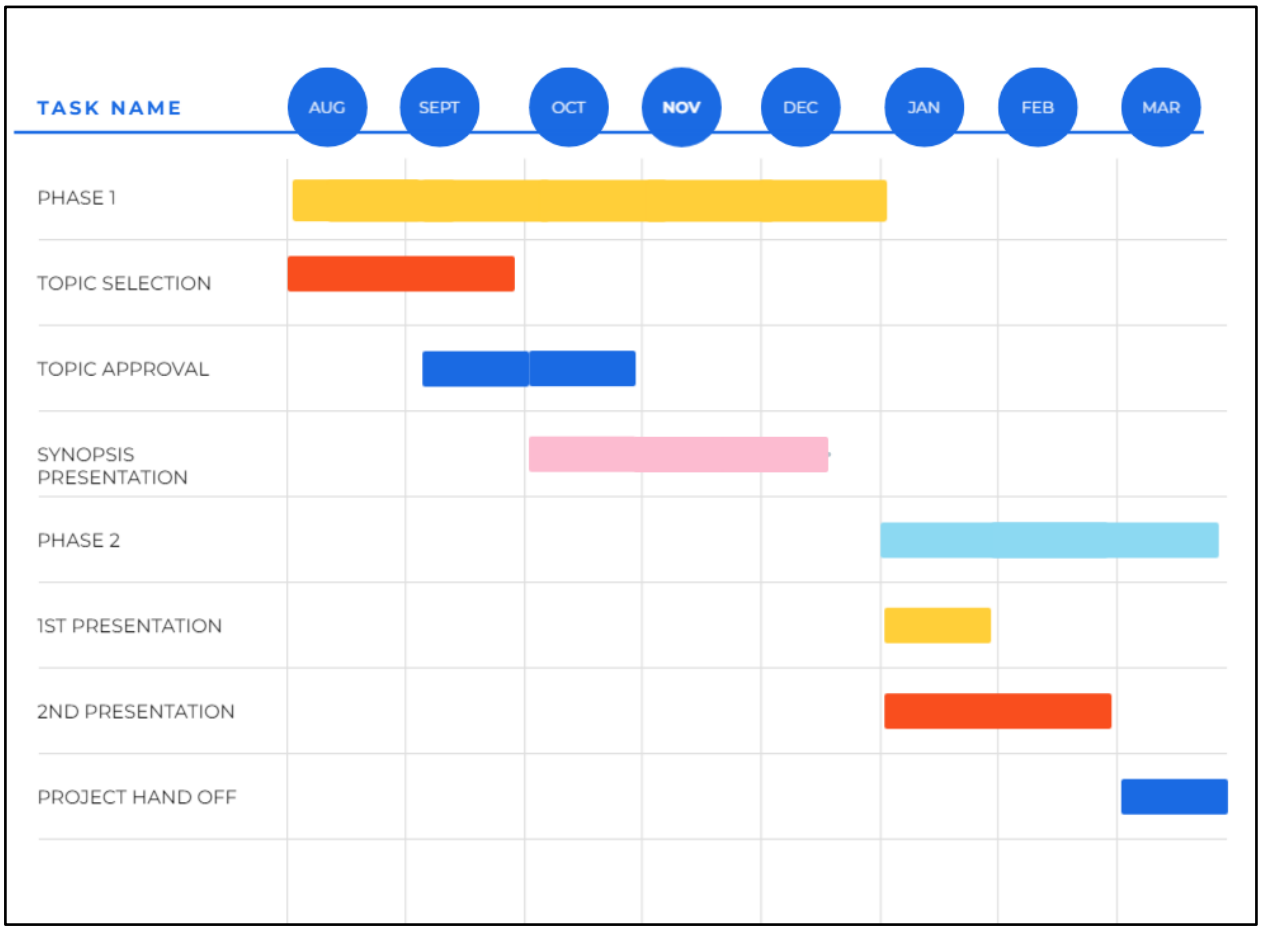


Fig. 1.1 Timeline of the project

1.6 Project Management Plan

Task Name	**Duration**	**Start Date**	**End date**
Domain Selection	2 days	28-07-22	29-07-22
Domain Finalization	2 days	30-07-22	31-07-22
Selection of Problem Statement	3 days	1-08-22	3-08-22
Finalization of Problem Statement	3 days	4-08-22	6-08-22
Study on Research Paper	25 days	7-08-22	1-09-22
Requirement Analysis	15 days	2-09-22	17-09-22
System Requirement	7 days	18-09-22	23-09-22
System Architecture	52 days	24-09-22	15-11-22
Stage 1 Implementation	85 days	20-01-23	15-04-23
Stage 2 Implementation	19 days	15-04-23	04-05-23
Testing	8 days	04-05-23	12-05-23

Table 1.1 Project management plan

1.7 Project Cost

A. Hardware Cost

Components	Name	Pricing
Graphics Card	Nvidia GEForce	45750
Processor	Intel i5 7 gen	8999
RAM	16 GB	3845
Total		58594

B. Software Cost

Lines of Code (LOC):195

Effort = a * (LOC) ^ b

Time = c * (Effort) ^ d

Persons Required = Effort / Time

For COCOMO model parameters:

a = 2.4 (constant for organic projects)

b = 1.05 (exponent derived from historical data)

c = 2.5 (constant for organic projects)

d = 0.38 (exponent derived from historical data)

Calculate Effort:

Effort = 2.4 * (295) ^ 1.05

Effort = 2.4 * 343.191

Effort = 823.6574 Person-Hours (approximately)

Calculate Time:

Time = 2.5 * (823.6574) ^ 0.38

Time = 2.5 * 28.7737

Time = 71.9343 Hours (approximately)

Calculate Persons Required:

Persons Required = Effort / Time

Persons Required = 823.6574 / 71.9343

Persons Required = 11.448 (approximately)

Therefore, based on the given 295 lines of code, the estimated cost using the COCOMO model is:

Effort: 823.6574 Person-Hours

Time: 71.9343 Hours

Persons Required: 11.448 (approximately)

2. BACKGROUND STUDY & LITERATURE OVERVIEW

2.1 Literature Overview

Yoga has gained significant attention in recent years as a practice for physical and mental well-being. With the advancements in computer vision and deep learning, researchers have explored the application of these technologies to assist individuals in performing yoga poses correctly. Several studies have been conducted in the field of pose detection and activity recognition, which are relevant to the development of the Yoga Pose Detection system. The following references provide valuable insights into the existing work in this domain:

[1] Cao et al. (2017) proposed a real-time multi-person 2D pose estimation method using part affinity fields. Their approach achieved accurate pose estimation even in crowded scenes with multiple individuals. This work serves as a foundation for our pose detection model, which utilizes similar concepts of body part association for accurate key point localization.

[2] He et al. (2017) introduced Mask R-CNN, a state-of-the-art framework for instance segmentation. Their work combines object detection and pixel-level segmentation, providing precise masks for each detected object. We leverage their approach for image segmentation to isolate the human body from video frames, enabling accurate pose detection.

[3] Lin et al. (2017) proposed the Focal Loss, a novel loss function for dense object detection. Their method addresses the issue of class imbalance in object detection tasks, improving the detection accuracy of rare poses or challenging postures. We draw inspiration from their work to handle pose detection with varying levels of difficulty and class imbalance.

[4] Newell et al. (2016) introduced stacked hourglass networks for human pose estimation. Their model employs a stacked hourglass architecture to capture multi-scale features and achieve precise pose estimation. We consider their approach as a reference for our pose detection model, adapting the architecture to suit the requirements of yoga pose detection.

[9] Wei et al. (2019) presented Mask rcnn-benchmark, a modular reference implementation of instance segmentation and object detection algorithms. Their work provides a flexible and extensible framework for efficient instance segmentation. We refer to their implementation as a valuable resource for developing our image segmentation module.

2.2 Critical appraisal of other people's work

The following literature overview provides a summary of key studies related to yoga pose detection and related areas:

Pose Estimation and Human Activity Recognition:
Several studies have focused on pose estimation and human activity recognition, which form the foundation for yoga pose detection. Techniques such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have been used to analyze human body joint positions and movements in real-time. These studies have demonstrated the potential of deep learning models in accurately recognizing and tracking human poses.

Image Segmentation and Background Removal:
Image segmentation plays a vital role in isolating the human figure from complex backgrounds. Various algorithms, such as Mask R-CNN and U-Net, have been applied to segment the human body from images or video frames. These techniques enhance the accuracy of subsequent pose detection by eliminating background noise and focusing on the relevant regions of interest.

Yoga Pose Datasets and Annotations:
The availability of large-scale annotated datasets is crucial for training and evaluating pose detection models. Existing datasets, such as MPII Human Pose, COCO, and Yoga-82, have been widely used in the field. These datasets provide labeled images or videos of individuals performing various yoga poses, enabling researchers to train deep learning models for accurate pose detection.

Real-Time Feedback and Pose Correction:
Real-time feedback mechanisms have been explored to guide individuals in achieving correct yoga poses. Studies have proposed visual cues, skeletal representations, or overlayed guidance to indicate the correct alignment of body joints during yoga exercises. This feedback helps users in adjusting their postures and improving their form.

2.3 Investigation of current project and related work

In this section, we investigate the current project on yoga pose detection using deep learning, as well as related work in the field. We review the methodology, contributions, and limitations of the project, as well as key findings from related studies.

A. Current Project Investigation

Methodology:

The current project aims to develop a web-based application for yoga pose detection using deep learning techniques. The system captures live video from the user's webcam and applies image segmentation to isolate the human figure. A pose detection model is then employed to determine the correctness of the user's posture. Real-time feedback is provided, and a timer is initiated when the correct posture is detected.

Contributions:

The project contributes to the field of yoga pose detection by providing a user-friendly web application that assists individuals in performing yoga exercises correctly. The integration of deep learning techniques allows for real-time assessment of posture and timely feedback, enhancing the user's yoga practice experience.

Limitations:

The project has certain limitations that need to be considered. These include the dependency on webcam quality, potential challenges with lighting and background constraints, and the limitations of 2D image analysis in capturing three-dimensional aspects of pose alignment. Additionally, the system's accuracy may be influenced by individual body variations, and the current set of detectable poses is limited.

B. Related Work Investigation

Methodologies and Approaches:

Several studies have explored yoga pose detection using deep learning techniques. These methodologies include the use of CNNs, RNNs, and graph convolutional networks for pose estimation. Image segmentation techniques, such as Mask R-CNN and U-Net, have been employed to extract the human figure from images or video frames. Some studies have also incorporated depth information to improve the accuracy of pose detection.

Contributions and Findings:

Previous work has made significant contributions to the field by developing systems that provide real-time feedback and guidance for correct yoga postures. Studies have shown promising results in recognizing and tracking human poses, and the effectiveness of real-time feedback in improving posture alignment. However, challenges related to occlusions, complex poses, diverse body shapes, and limited datasets still need to be addressed.

Limitations and Future Directions:

The related work also highlights limitations, including the need for diverse and comprehensive datasets, addressing occlusions and complex three-dimensional poses, and considering variations in body shapes and sizes. Future research directions involve exploring advanced pose estimation techniques, incorporating multimodal data, and developing personalized systems that cater to individual needs.

3. Requirement analysis

3.1 Requirement Gathering

In this section, we outline the requirements for the development of the yoga pose detection system using deep learning techniques. These requirements serve as a basis for designing and implementing the project. The requirements include functional and non-functional aspects of the system.

A. Functional Requirements:

a. Pose Selection:
The system should provide a user interface that presents a list of six different yoga exercises. Users should be able to select a specific pose from the provided list.

b. Video Capture:
The system should capture live video from the user's webcam, ensuring real-time input for pose detection.

c. Image Segmentation:
The system should utilize image segmentation techniques to extract the human figure from each video frame. This step should enhance the accuracy of subsequent pose detection.

d. Pose Detection:
The system should employ a deep learning-based pose detection model to determine the correctness of the user's posture. The model should analyze the segmented image and provide accurate pose detection results.

e. Real-Time Feedback:
The system should provide real-time feedback to the user regarding the correctness of their posture. Visual cues or overlays should indicate correct alignment or deviations from the desired pose.

f. Timer Functionality:
The system should incorporate a timer that starts when the correct posture is detected. If the user deviates from the correct pose, the timer should reset, encouraging users to maintain proper alignment.

B. Non-Functional Requirements:

a. Dataset:
The system should utilize a custom-created dataset of yoga poses, captured by our team. The dataset should encompass a variety of individuals performing the six selected yoga exercises, ensuring diversity in body shapes, sizes, and yoga styles.

b. Accuracy:
The pose detection model should achieve a high level of accuracy in recognizing and assessing yoga poses. The system should strive for reliable detection, minimizing false positives and false negatives.

c. Performance:
The system should be capable of processing video frames in real-time, ensuring prompt pose detection and feedback. It should be efficient and responsive, providing users with seamless interaction.

d. Usability:
The user interface of the system should be intuitive, making it easy for users to select poses, view feedback, and track their exercise duration. The system should be user-friendly, catering to individuals with varying levels of familiarity with technology.

e. Reliability:
The system should be reliable and robust, capable of handling different lighting conditions, camera angles, and variations in user appearances. It should exhibit stability and consistent performance throughout usage.

3.2 Requirement Specification

The following table provides a comprehensive overview of the functional and non-functional requirements for the yoga pose detection system:

Requirement Id	**Requirement**	**Description**	**Priority**
FR-01	Pose Selection Interface	Users can select from a list of six yoga exercises	Essential
FR-02	Video Capture	The system captures live video from the webcam	Essential
FR-03	Image Segmentation	Image segmentation extracts the	Essential

		human figure	
FR-04	Pose Detection Model	Deep learning model detects correct posture	Essential
FR-05	Real-Time Feedback	System provides feedback on posture correctness	Desirable
FR-06	Timer Functionality	Timer starts when the correct posture is detected. Timer resets if incorrect posture is detected.	Desirable
NFR-01	Dataset	Custom-created dataset of yoga poses	Essential
NFR-02	Accuracy	High accuracy in recognizing and assessing poses	Essential
NFR-03	Performance	Real-time processing of video frames. Efficient and responsive system.	Essential
NFR-04	Usability	Intuitive user interface and easy pose selection. User-friendly system for varying skill levels.	Desirable
NFR-05	Reliability	System handles different lighting and appearances. Stable and consistent performance.	Desirable

Table 3.1 Requirement specification

3.3 Use case Diagram

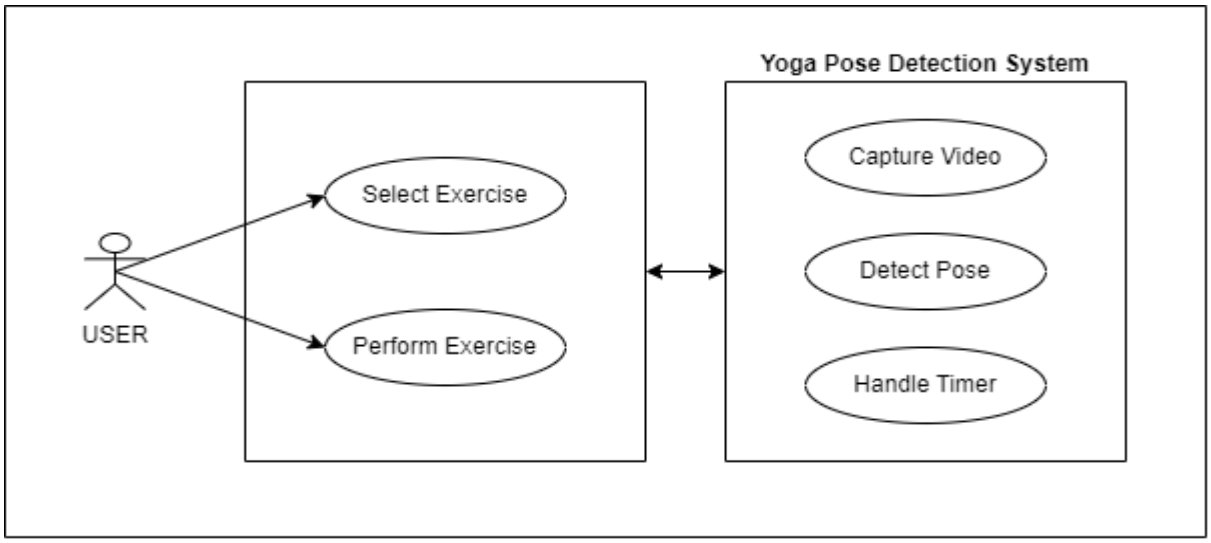


Fig. 3.1 Use case diagram

The "User" actor interacts with the "Yoga Pose Detection" system, performing the following use cases:

- Select Pose: The user selects a specific yoga pose from a list of available exercises provided by the system.

- Perform Pose: The user performs the selected yoga pose while being captured by the system's video feed.

The "Yoga Pose Detection" system performs the following use cases:

- Capture Video: The system captures live video from the user's webcam for pose detection.

- Detect Pose: The system employs a deep learning-based pose detection model to determine the correctness of the user's posture.

- Handle Timer: The system initiates a timer when the correct pose is detected and resets the timer if the user deviates from the correct posture.

4. System design

4.1 Architectural Design

The following system architecture diagram illustrates the components and their interactions in the yoga pose detection system:

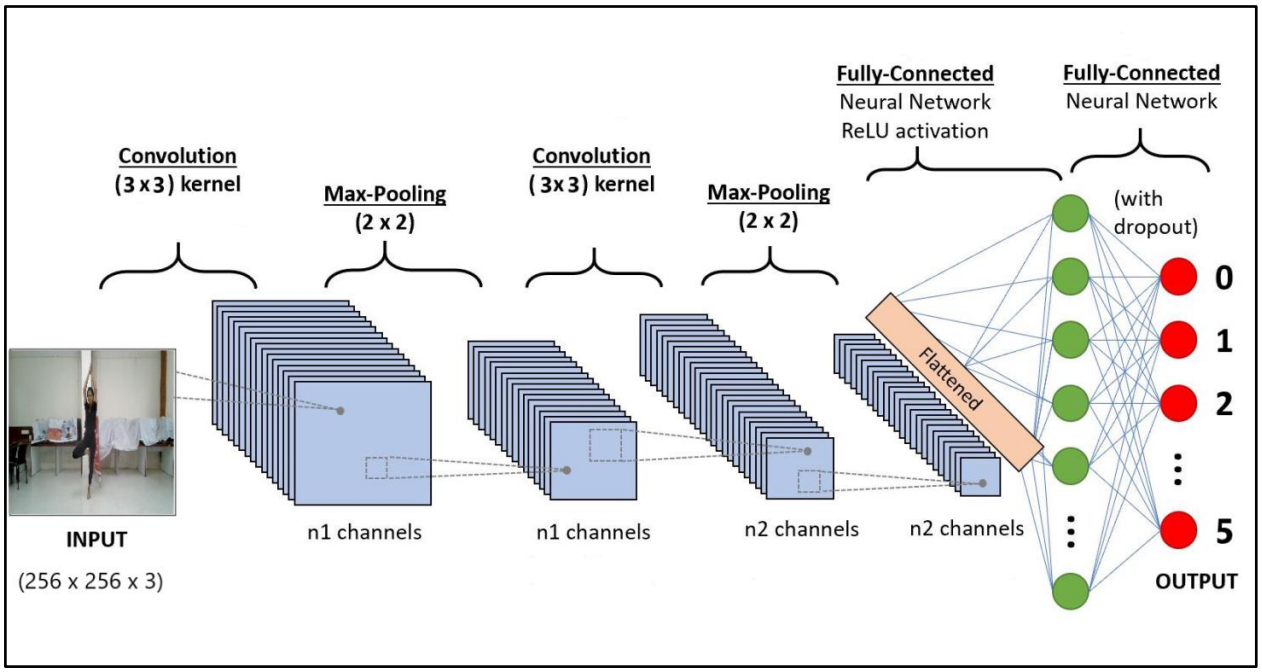


Fig. 4.1 Software Architecture Diagram

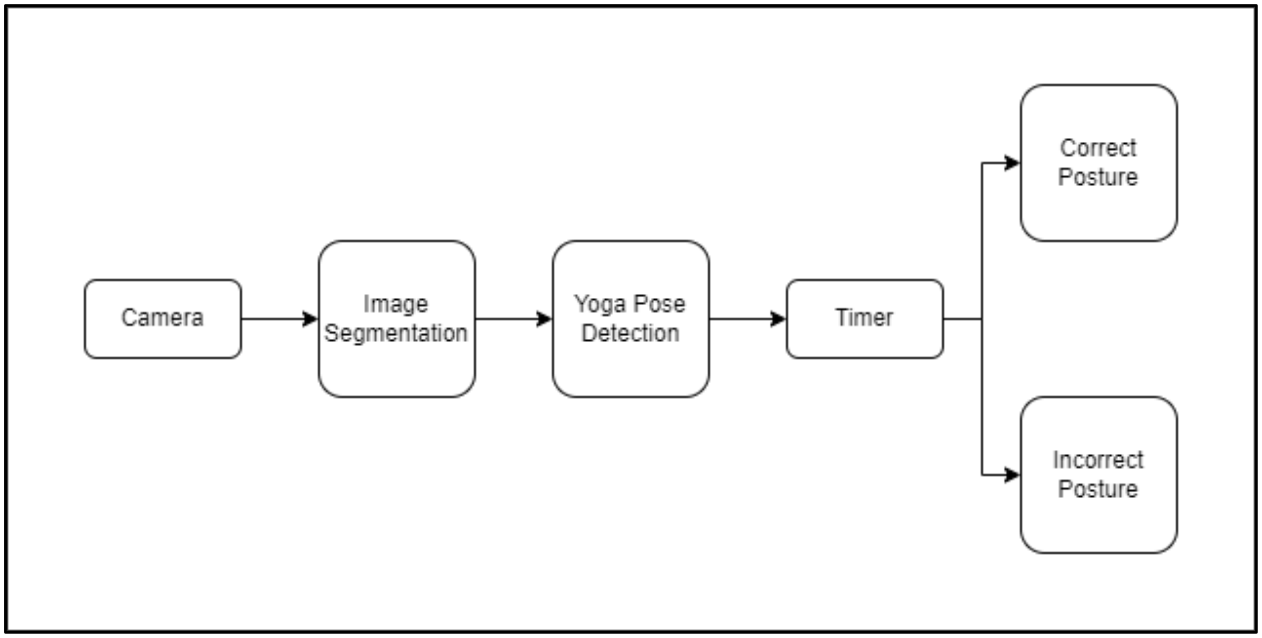


Fig. 4.2 System Architecture Diagram

The system architecture consists of the following components:

1. User Interface:
   Provides a graphical user interface for users to interact with the system and select yoga poses from a given list.

2. Pose Selection:
   Allows users to choose a specific yoga pose from the provided list.

3. Backend Server:
   Handles the processing and logic of the system.

4. Video Capture Module:
   Captures live video from the user's webcam to be used for pose detection.

5. Image Segmentation Module:
   Applies image segmentation techniques to extract the human figure from each video frame.

6. Pose Detection Module:
   Utilizes a deep learning-based pose detection model to analyze the segmented image and determine the correctness of the user's posture.

7. Feedback Generation Module:
   Generates real-time feedback to the user regarding the correctness of their posture.

8. Timer Handling Module:
   Manages the timer functionality, starting the timer when the correct pose is detected and resetting it if the user deviates from the correct posture.

Architecture Components:

1. Image Segmentation:

   The process of image segmentation involves dividing an image into distinct regions or segments based on its content or characteristics. This is done to identify and group pixels or regions that belong to the same object or exhibit similar properties. Image segmentation can be achieved using various approaches, including traditional methods and deep learning-based methods.

   Traditional methods encompass techniques such as thresholding, edge detection, and region growing. Thresholding separates pixels based on predetermined intensity or color values. Edge detection focuses on detecting and connecting boundaries between objects. Region growing groups pixels based on criteria like color similarity or texture.

   Deep learning-based methods utilize neural networks like Fully Convolutional Networks (FCNs), U-Net, or Mask R-CNN. These models are trained on labeled datasets, consisting of input images and corresponding segmentation masks. Through optimization, the models learn to map input images to their respective segmentation masks.

Following segmentation, post-processing techniques such as morphological operations or filtering can be applied to refine the results. Evaluation involves comparing the predicted segmentation masks with ground truth masks, utilizing metrics like Intersection over Union (IoU) or pixel accuracy.

2. Yoga pose classification:

Yoga pose classification involves several steps, including data collection, data preprocessing, selecting an appropriate deep learning model architecture such as Convolutional Neural Networks (CNNs), applying transfer learning using pre-trained weights, training the model on the dataset, and evaluating its performance using metrics like accuracy, precision, and recall.

CNNs (Convolutional Neural Networks) are a specific type of neural network widely used in image recognition tasks. Inspired by the human brain's visual cortex, CNNs consist of multiple layers that learn to extract features from input images. The network consists of an input layer, convolutional layers, pooling layers, fully connected layers, and an output layer. Each layer performs specific operations, such as convolutions and pooling, to gradually learn and extract complex features from the input data.

By utilizing CNNs, the model can effectively learn and recognize patterns in the yoga pose images. The advantage of using pre-trained weights and transfer learning is that the model can leverage knowledge learned from a large dataset in a related domain, such as ImageNet, to improve its performance on the specific task of yoga pose classification. The model is then trained on the collected dataset, and its performance is evaluated using standard evaluation metrics, such as accuracy, precision, and recall, to assess its effectiveness in correctly classifying yoga poses.

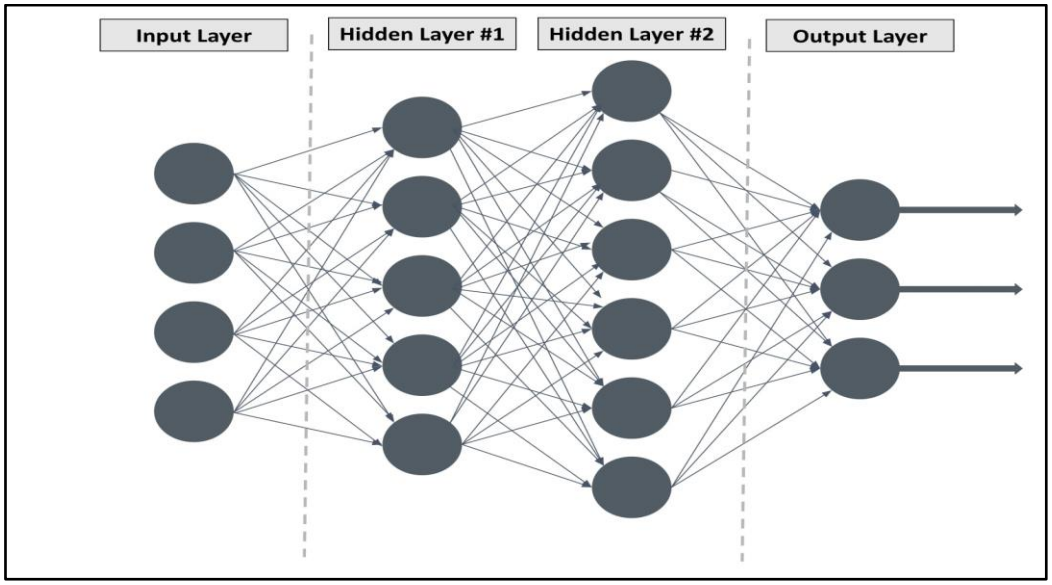


Fig. 4.3 Skeleton of neural network

In a neural network, the leftmost layer is known as the input layer, and the rightmost layer is referred to as the output layer. The layers in between, known as hidden layers, are not directly observable in the training set and play a crucial role in the network's functioning. These hidden layers enable the network to perform complex

computations and learn intricate patterns. The depth of a neural network is determined by the number of hidden layers it possesses.

An essential characteristic of neural networks is their ability to learn and improve over time. If the network's predictions are inaccurate, it can learn from its mistakes and update its parameters accordingly. This process allows the network to continually refine its predictions and enhance its performance. Neural networks that employ this self-learning capability are a part of the field of Deep Learning.

Image classifiers, which utilize deep neural networks, are particularly effective in tasks involving image analysis and recognition. Through the layers of the network, these classifiers can extract meaningful features and make accurate predictions based on the learned representations.

Convolutional layers

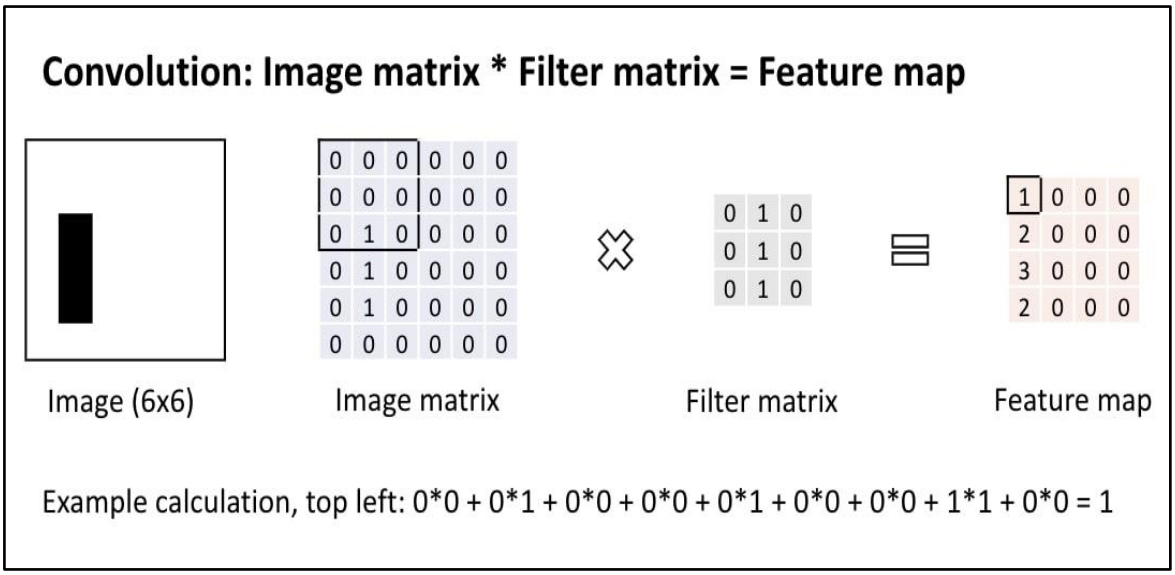
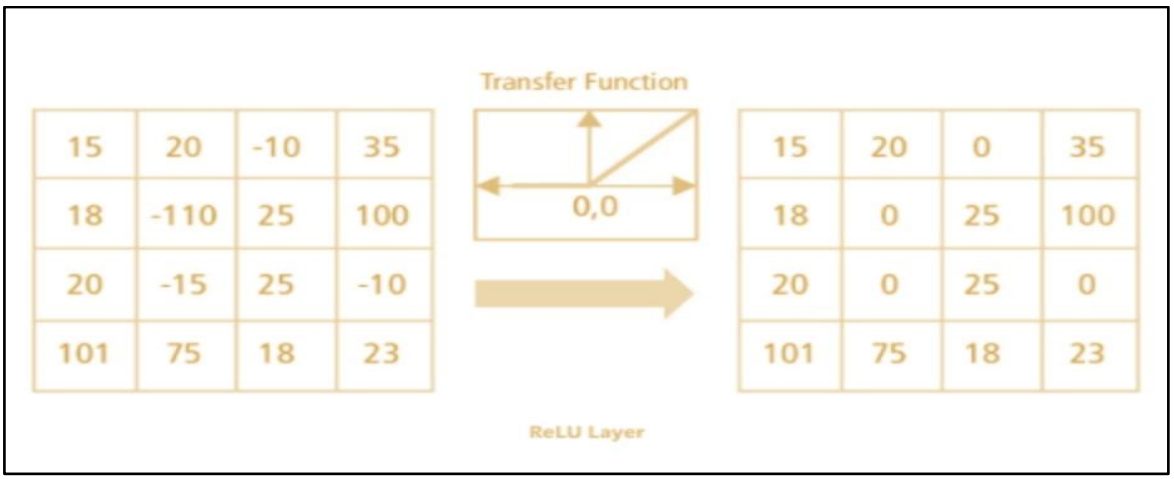
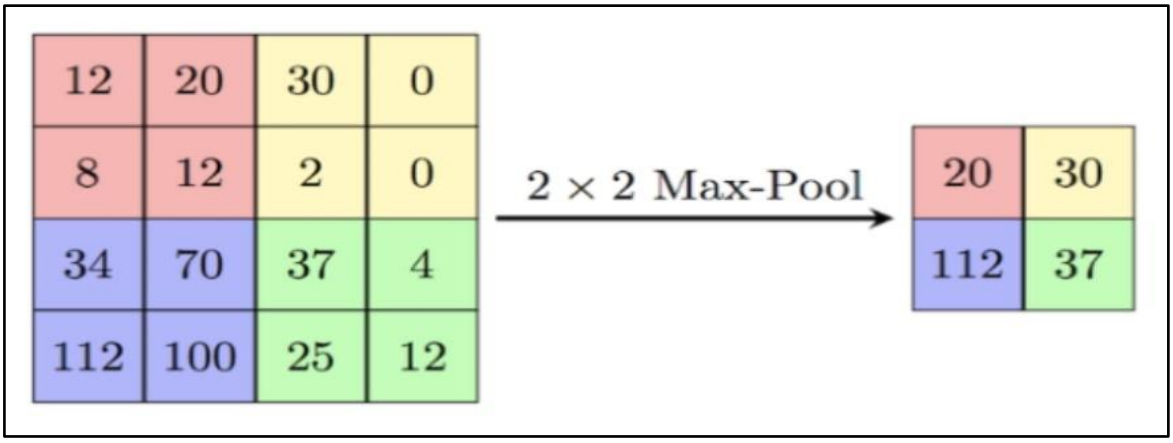


Fig. 4.4 Convolutional layer

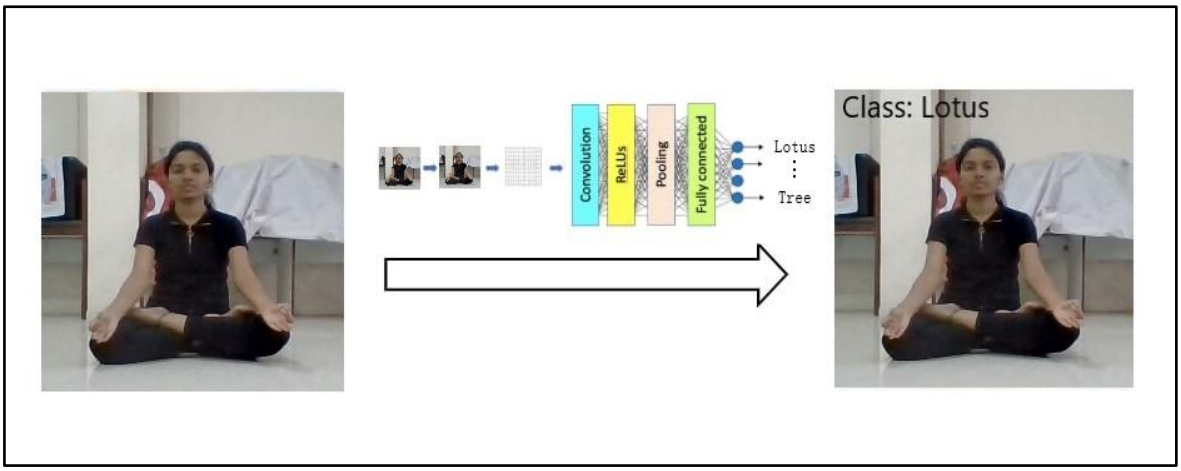
ReLU layers



Pooling layers



Fully connected layer (the final layer)



4.2 USER INTERFACE DIAGRAM

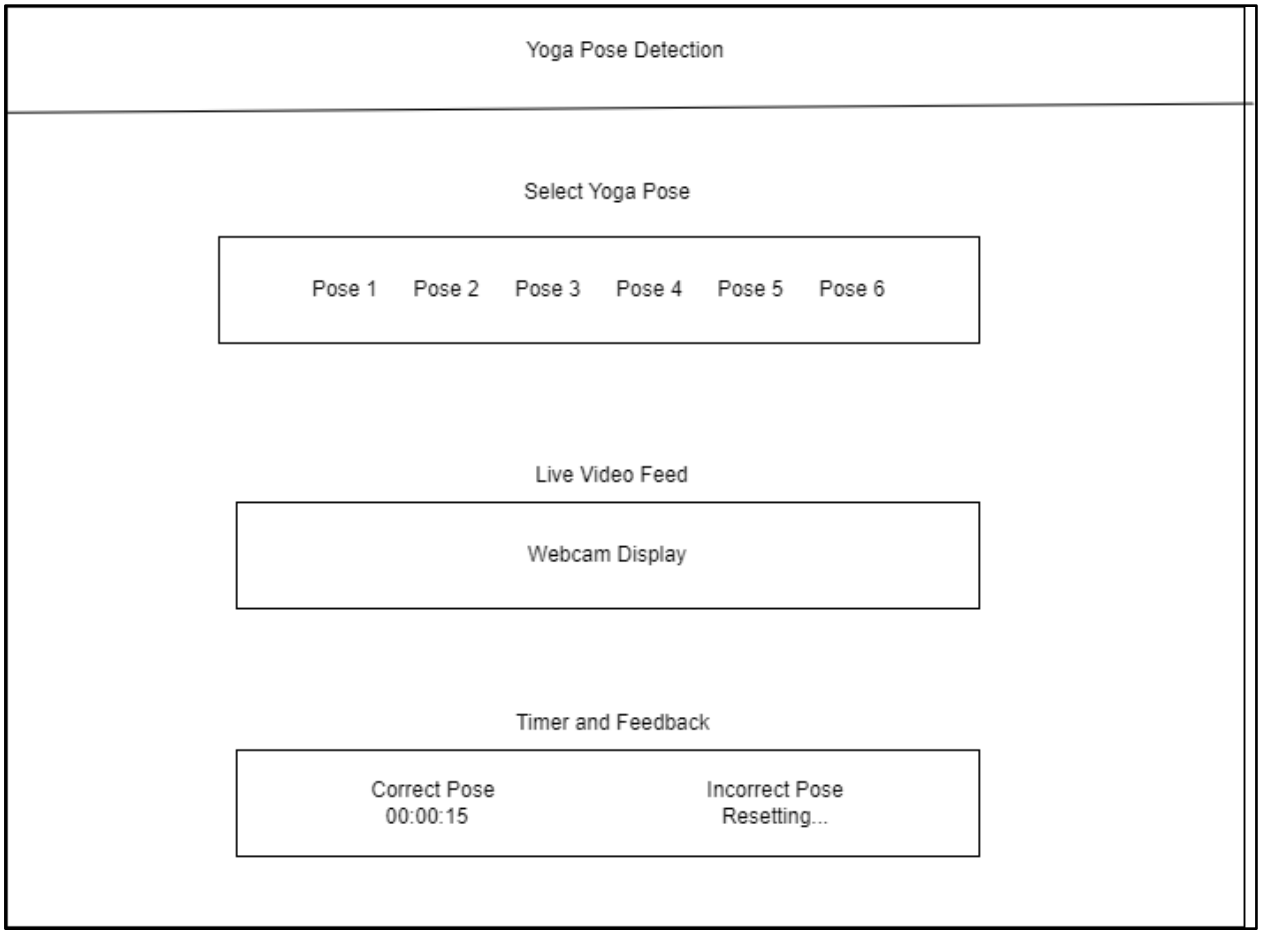


Fig. 4.5 User Interface Diagram

The User Interface (UI) for the Yoga Detection program includes the following components:

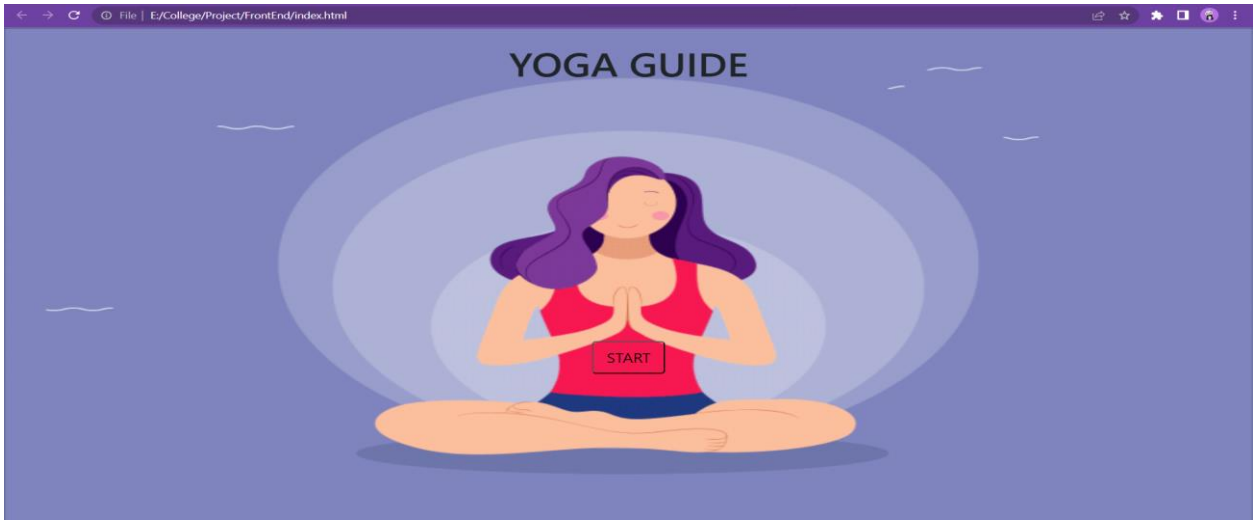
Home Screen: It displays the logo or title of the system and provides a navigation menu and exercise selection options.

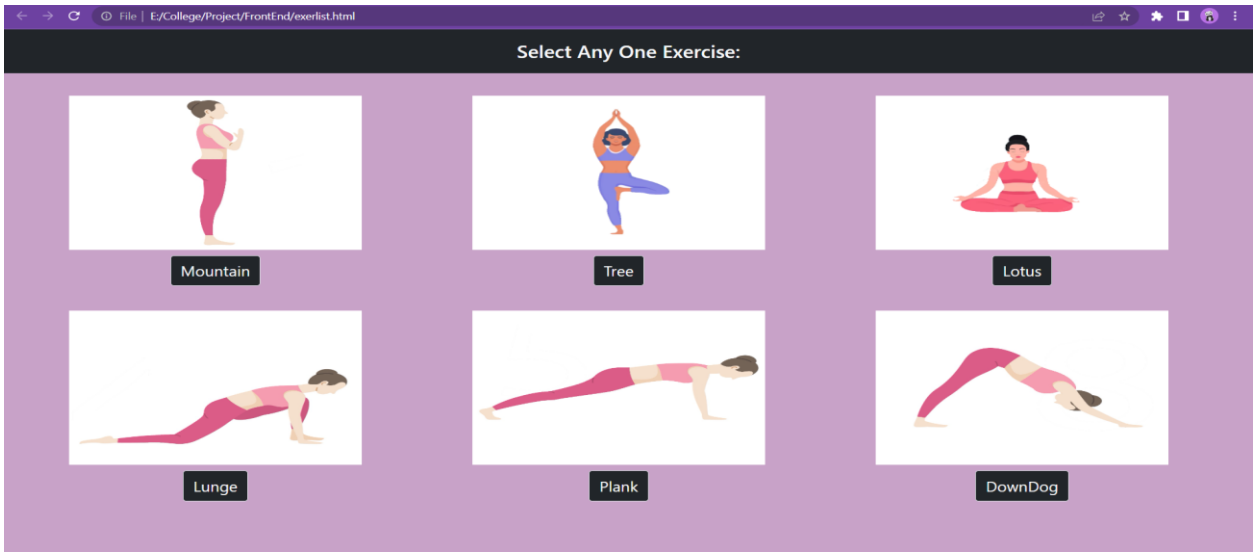
Webcam Display: It shows the live video feed from the user's webcam and provides visual feedback on the correctness of their pose.

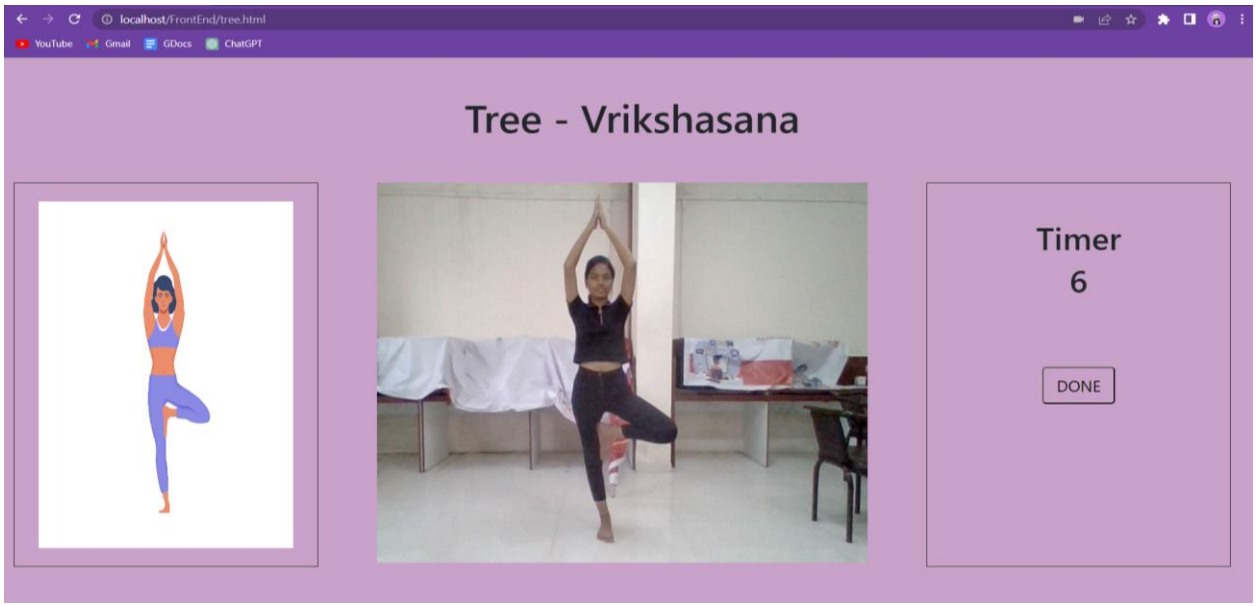
Timer Display: It includes a timer that tracks the duration of correct posture during the exercise. There is also a reset button to restart the timer if the user's posture is incorrect.

Instruction Panel: It provides a description and instructions for the selected exercise, along with a visual reference of the correct pose.

Additional Features: The UI may include features such as user profiles for customization, progress tracking to monitor improvement, and settings for personalizing the system's behavior.


File | E:/College/Project/FrontEnd/index.html
YOGA GUIDE
START


File | E:/College/Project/FrontEnd/exerlist.html
Select Any One Exercise:
Mountain
Tree
Lotus
Lunge
Plank
DownDog


localhost/FrontEnd/tree.html
YouTube
Gmail
GDocs
ChatGPT
Tree - Vrikshasana
Timer
6
DONE

4.2 Algorithmic description of each module

In this section, we provide algorithm descriptions for each module in the yoga pose detection system. These algorithms outline the processes and computations performed within each module.

A. Video Capture Module Algorithm:

Input:
Realtime image frame from the webcam.

Procedure:
1. Initialize the webcam and video capture settings.
2. Start the video stream from the webcam.
3. Read each frame from the video stream.
4. Preprocess the frame, if necessary (e.g., resize, normalize).
5. Pass the preprocessed frame to the Image Segmentation Module.
6. Repeat steps 3 to 5 until the video stream is ended.

Output:
Preprocessed image frame.

B. Image Segmentation Module Algorithm:

Input:
Preprocessed image frame obtained from the video capture module
Procedure:
1. Receive the preprocessed frame from the Video Capture Module.
2. Apply an image segmentation algorithm (e.g., Mask R-CNN, U-Net) to the frame.
3. Extract the human figure by segmenting the image based on predefined criteria.
4. Return the segmented image to the Pose Detection Module.

Output:
Segmented image obtained after the segmentation algorithm

C. Pose Detection Module Algorithm:

Input:
Segmented Image frame

Procedure:
1. Receive the segmented image from the Image Segmentation Module.
2. Apply a deep learning-based pose detection model (e.g., OpenPose, PoseNet) to the segmented image.
3. Analyze the pose estimation results to determine the correctness of the user's posture.
4. Return the posture analysis result to the Feedback Generation Module.

Output:
Probability resulting after applying deep learning model

D. Timer Handling Module Algorithm:

Input:

Result of the pose detection model

Procedure:

1. Receive the posture analysis result from the Pose Detection Module.
2. If the correct posture is detected and the timer is not running, start the timer.
3. If the user deviates from the correct posture, reset the timer.
4. Continue monitoring the user's posture and timer status.
5. Update and display the timer value in real-time.
6. Return the timer status to the user interface for display.

Output:

Timer status Start/Stop to user interface.

4.4 System Modeling

A. Data Flow Diagram

The following data flow diagrams illustrate the flow of data within the yoga pose detection system:

Level 0 DFD:

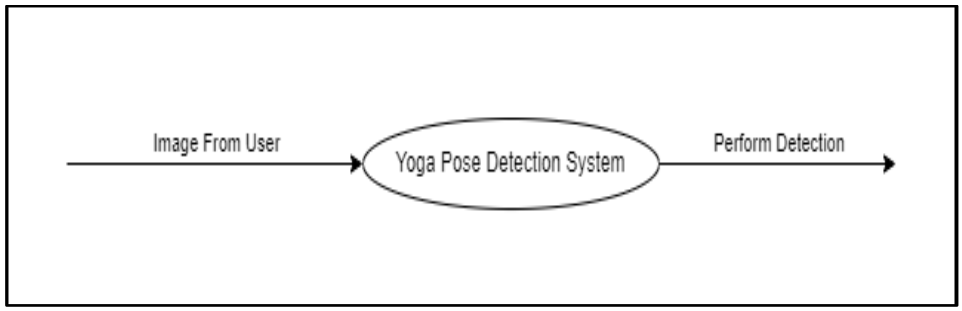


Fig. 4.6 Level 0 DFD

Level 1 DFD:

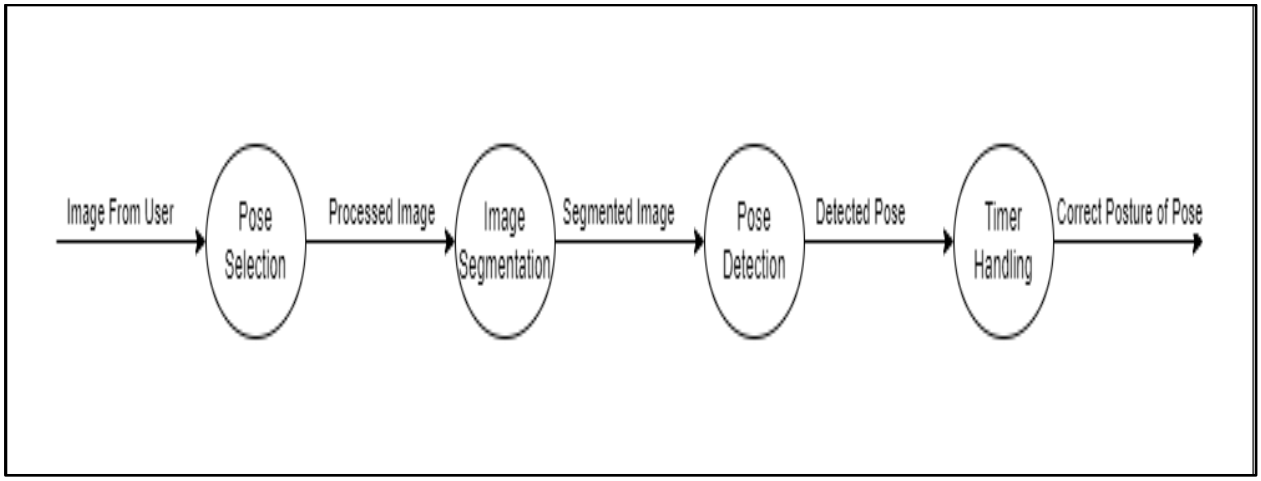


Fig. 4.7 Level 1 DFD

The provided Data Flow Diagram (DFD) summarizes the data flow and processing steps in the Yoga Detection system:

User interacts with the User Interface (UI). Live video input is captured from the user's webcam. Pose Detection module analyzes video frames to detect the user's pose. Detected pose is evaluated against the correct reference pose. Real-time feedback is provided through the UI, and the timer is controlled based on pose correctness. The timer outputs the duration of correct posture.

B. Sequence Diagram

The following sequence diagram illustrates the interactions and message exchanges between the components in the yoga pose detection system:

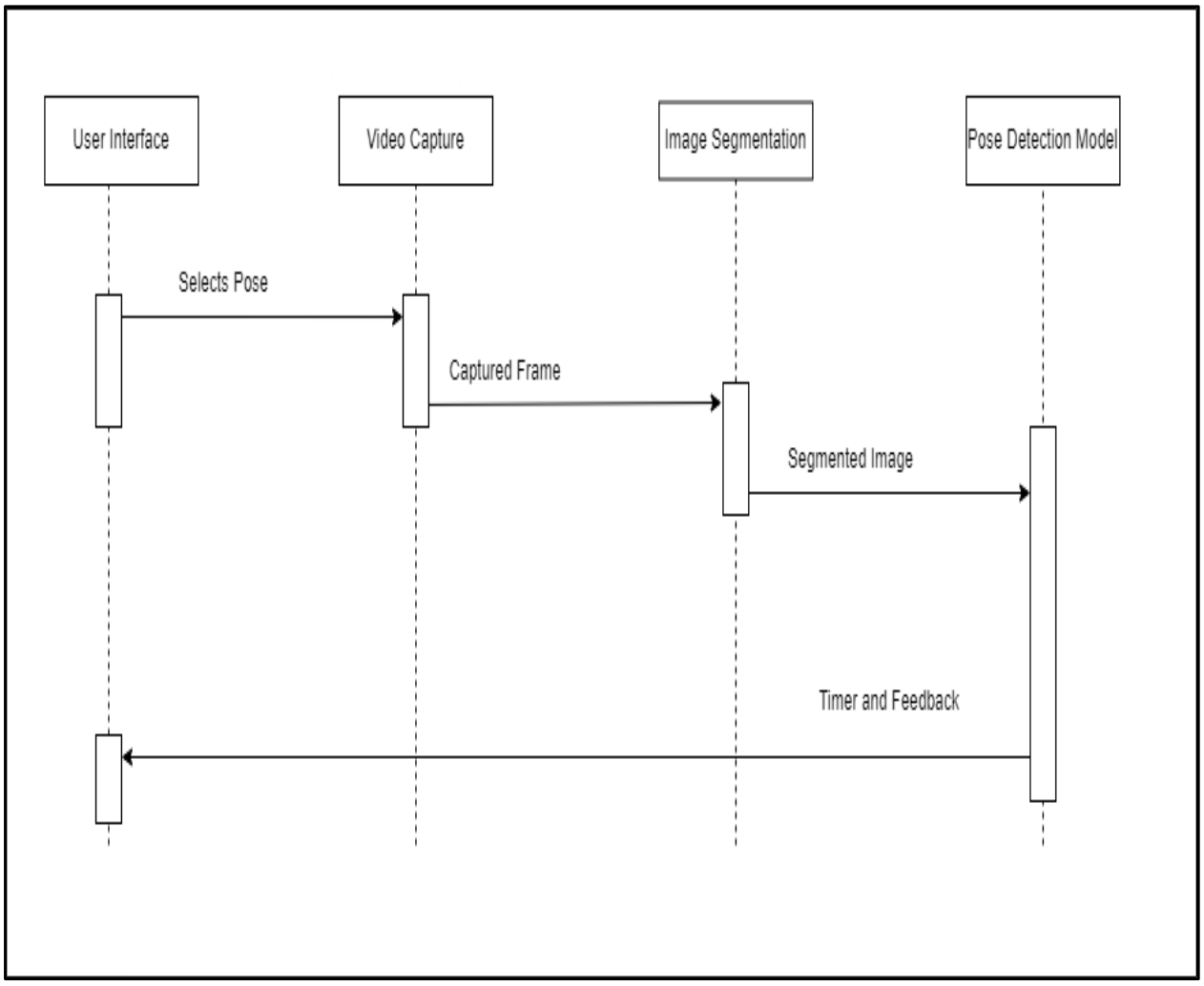


Fig. 4.8 Sequence Diagram

The sequence diagram summarizes the flow of events in the Yoga Detection program as follows:

The user selects a specific yoga exercise. The webcam captures live video of the user performing the exercise. Each video frame is sent to the pose detection module for analysis. The pose detection module identifies key points and determines the user's pose. The system evaluates the correctness of the user's pose compared to the reference pose. Real-time feedback is provided to the user through the user interface, indicating correctness. The timer starts or resets based on the pose correctness. The process repeats as the webcam captures new frames, and the system continuously analyzes the user's poses, provides feedback, and updates the timer.

C. Activity Diagram

The following activity diagram illustrates the flow of activities and decision points in the yoga pose detection system:

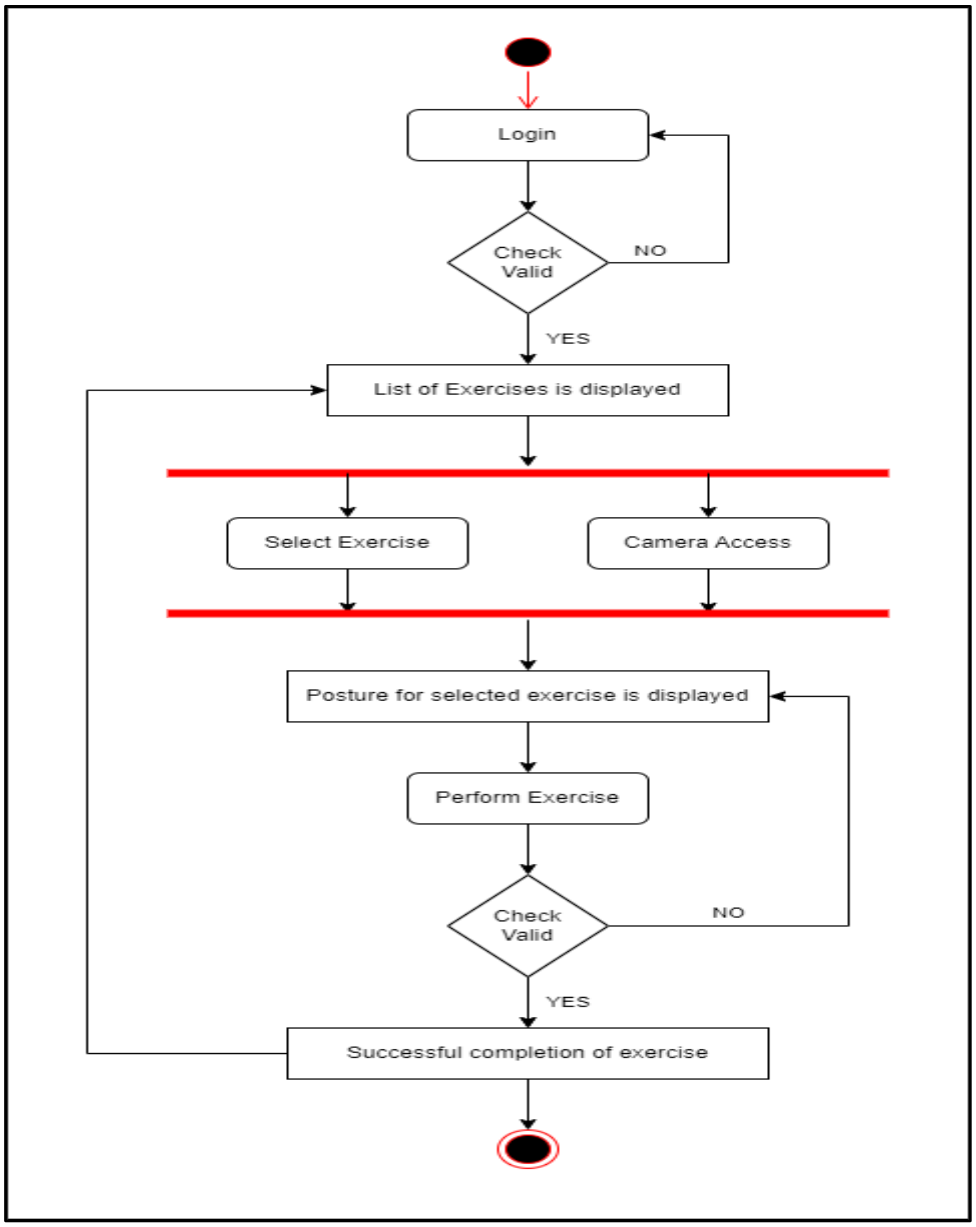


Fig. 4.9 Activity Diagram

The provided Activity Diagram summarizes the sequence of actions and interactions within the Yoga Detection system. It begins with the user selecting an exercise from the available list. The system then captures live video input and applies pose detection algorithms to analyze the user's posture. If the posture is correct, the system starts the timer and continues monitoring the user's posture. If an incorrect posture is detected, the timer resets until the correct posture is resumed. Once the exercise is completed or stopped, the system provides feedback to the user, including the exercise duration and performance. The diagram illustrates the user's interaction, exercise selection, pose detection, posture evaluation, timer control, and feedback generation, showcasing the system's functionality in enhancing the user's yoga practice experience.

D. Component Diagram

The following component diagram illustrates the high-level components and their relationships in the yoga pose detection system:

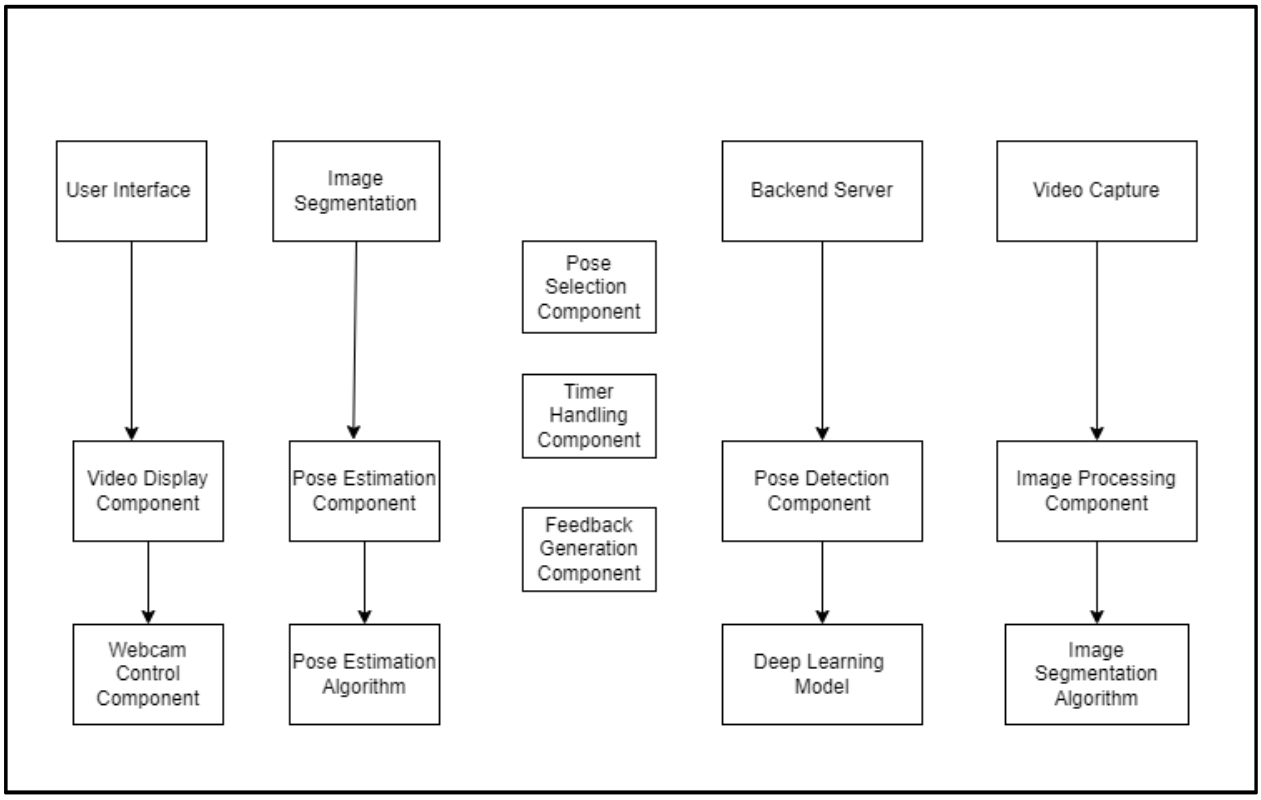


Fig. 4.10 Component Diagram

The provided Component Diagram summarizes the key components and their interactions within the Yoga Detection system:

User Interface (UI) Component: Handles user interaction, exercise selection, feedback display, and timer controls.
Pose Detection Component: Analyzes video frames from the webcam to detect the user's pose using algorithms and models.
Pose Evaluation Component: Compares the detected pose with the correct reference pose to evaluate the correctness of the user's posture.
Timer Component: Manages the timer functionality, tracking the duration of correct posture and controlling its start and reset.
Webcam Component: Captures live video input from the user's webcam.
Exercise Database Component: Stores the dataset of predefined yoga exercises and their corresponding reference poses.

E. Deployment Diagram

The following deployment diagram illustrates the physical deployment of components in the yoga pose detection system:

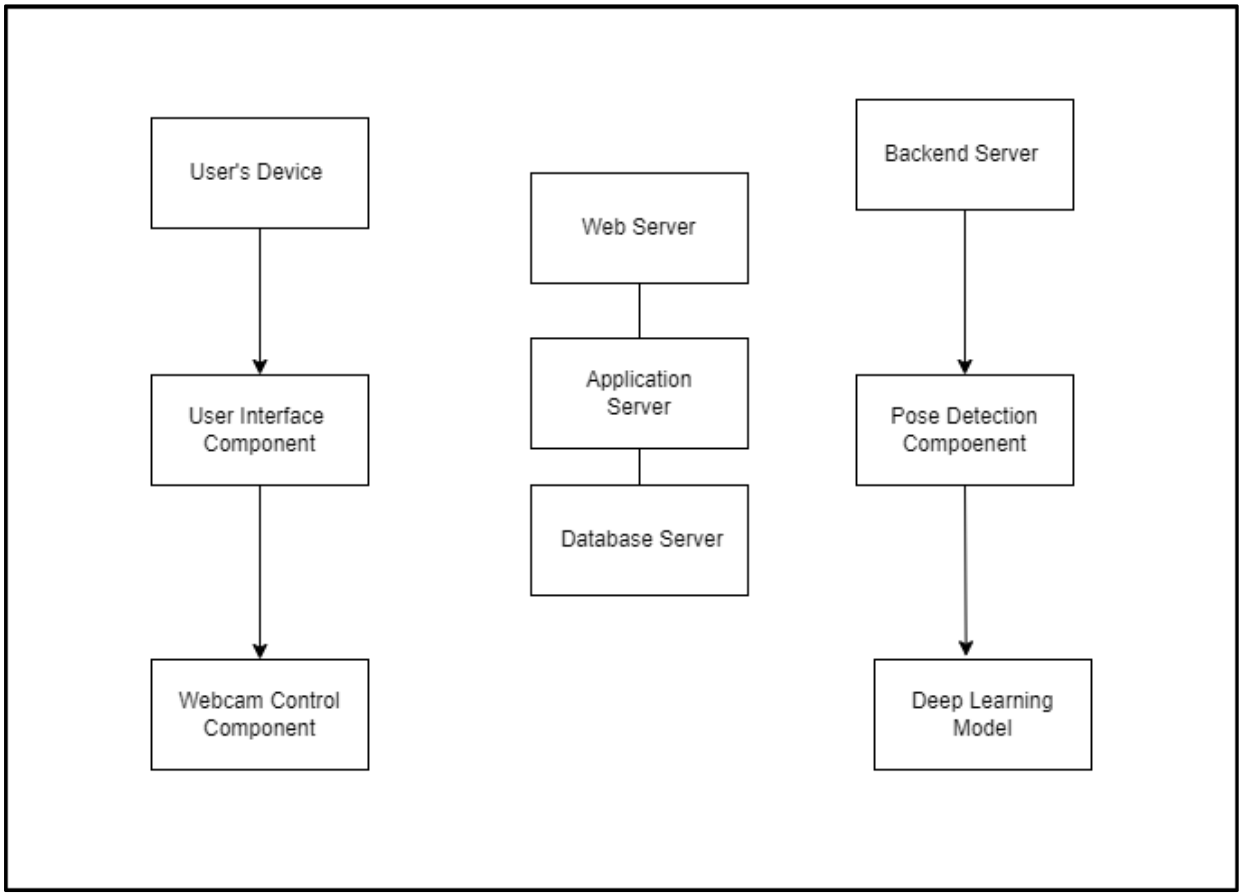


Fig. 4.11 Deployment Diagram

The provided Deployment Diagram summarizes the physical deployment of components in the Yoga Detection system:

User Device: Represents the device used by the user, such as a computer or mobile device.
Web Browser: User interacts with the system through a web browser, accessing the Yoga Detection website.
Web Server: Hosts the Yoga Detection website and handles user requests, serving as the interface between the user and the system.
Pose Detection Server: Hosts the Pose Detection component, responsible for analyzing video frames and detecting the user's pose.
Database Server: Stores the exercise dataset, user profiles, and system data, facilitating data management and retrieval.
Webcam: Physical device used to capture live video input from the user.

5. Implementation

5.1 Environmental Setting for Running the Project

A. Hardware Requirements

a. User's Device:

Computer or laptop with a webcam
Sufficient processing power and memory to handle real-time video processing
Internet connectivity for accessing the web interface

b. Backend Server:

High-performance server with ample processing power and memory
Sufficient storage capacity for storing the deep learning models and pose dataset
Internet connectivity for communication with the user's device

B. Software Requirements

a. User's Device:

Operating System: Windows, macOS, or Linux
Web Browser: Google Chrome, Mozilla Firefox, or Safari

b. Backend Server:

Operating System: Linux (e.g., Ubuntu Server)
Web Server: Apache or Nginx
Backend Framework: Django, Flask, or Node.js
Deep Learning Framework: TensorFlow, PyTorch, or Keras
OpenCV library for video processing
Additional libraries and dependencies as required

C. Development Tools

a. Integrated Development Environment (IDE):

PyCharm, Visual Studio Code, or any preferred IDE for backend development

b. Version Control:

Git for source code version control

c. Code Libraries and Packages:

Python packages: Django, Flask, TensorFlow, PyTorch, OpenCV, etc.
JavaScript and CSS libraries for frontend development

D. Data and Model Preparation

a. Pose Dataset:

Create self-generated pose dataset with annotated images for training and validation

b. Deep Learning Model:

Training and optimization of the pose detection model using the pose dataset

5.2 Detailed Description of Methods

A. Image Segmentation

Image segmentation is employed to extract the human figure from the captured video frame. The following steps are performed:

a. Preprocessing:The input image frame is preprocessed to enhance contrast and reduce noise using techniques such as histogram equalization and Gaussian filtering.

b. Background Subtraction:A background subtraction algorithm is applied to distinguish the foreground (human figure) from the background. This step involves modeling the background using a reference frame and subtracting it from the current frame.

c. Thresholding:A thresholding technique is employed to convert the grayscale or color image into a binary mask, where the foreground pixels are represented by white and the background pixels by black.

d. Morphological Operations:Morphological operations, such as erosion and dilation, are applied to refine the binary mask and remove noise or small artifacts.

B. Pose Detection

Pose detection is performed on the segmented human figure to determine the correctness of the yoga posture. The following methods are employed:

a. Key Point Extraction:
A deep learning-based pose estimation model is utilized to identify key points or joints in the human body, such as elbows, knees, and shoulders. This model is trained on a large pose dataset and can accurately estimate the pose of a person.

b. Pose Estimation:
Using the extracted key points, the relative positions and orientations of the body parts are analyzed to estimate the overall pose. The pose is compared against the reference pose for the selected yoga exercise to determine if it matches or deviates.

c. Posture Analysis:
Various metrics and algorithms are employed to analyze the posture, including angles between body parts, alignment with predefined guidelines, and spatial relationships between key points. Deviations from the correct posture are identified and flagged.

C. Timer Handling and Feedback

The timer handling and feedback generation components ensure real-time feedback to the user. The following methods are utilized:

a. Timer Start and Reset: When the user selects a yoga pose, the timer starts. If the user deviates from the correct posture, the timer is reset to zero. This is achieved by monitoring the pose detection results and triggering the timer accordingly.

b. Feedback Generation: Feedback messages and visual indicators are generated based on the correctness of the posture. If the posture is correct, positive feedback is provided. In case of incorrect posture, appropriate feedback messages are displayed, such as "Resetting..." or "Incorrect Pose!"

D. Deep Learning Model Training

The deep learning models used for image segmentation and pose detection are trained using a self-generated pose dataset. The following steps are involved:

a. Data Collection:
An extensive dataset of yoga poses is created by capturing images and videos of various individuals performing the poses. Annotations are added to mark the correct pose for each image.

b. Data Preprocessing:
The dataset is preprocessed by resizing the images, normalizing pixel values, and splitting it into training and validation sets.

c. Model Architecture:
Convolutional Neural Networks (CNNs) are utilized for both image segmentation and pose detection tasks. The architecture consists of multiple layers, including convolutional layers, pooling layers, and fully connected layers.

d. Training and Optimization:
The models are trained using the training set and optimized using techniques such as backpropagation and gradient descent. Hyperparameter tuning is performed to achieve optimal performance.

e. Evaluation:
The trained models are evaluated using the validation set to assess their accuracy and performance. The models with the highest accuracy are selected for deployment in the system.

5.3 Implementation Details

A. Web Interface Development

The web interface is developed using HTML, CSS, and JavaScript. The following implementation details are considered:

a. User Interface Design:
The user interface is designed to display a list of yoga poses for selection. HTML elements and CSS styling are used to create an intuitive and visually appealing interface.

b. Pose Selection:
JavaScript event handling is implemented to capture user selection of a yoga pose from the list. Upon selection, the corresponding pose's information is sent to the backend for further processing.

c. Webcam Integration:
The web interface incorporates the webcam functionality to capture live video input from the user. JavaScript APIs such as getUserMedia() and canvas are utilized to access and display the webcam feed.

B. Backend Development

The backend of the system is developed using a Python-based framework (e.g., Django, Flask). The following implementation details are considered:

a. Video Processing:
The backend server receives the live video feed from the web interface. The OpenCV library is used to process each frame of the video, applying image segmentation techniques to extract the human figure.

b. Pose Detection:
The segmented human figure is passed through the pose detection model. The deep learning model, trained on the self-generated pose dataset, analyzes the key points and spatial relationships to determine the correctness of the pose.

c. Timer Handling:
The backend handles the timer functionality. When the user starts a pose, the timer begins counting. If an incorrect posture is detected, the timer is reset to zero. The timer value is updated and communicated back to the web interface for display.

C. Deep Learning Model Integration

The trained deep learning models for image segmentation and pose detection are integrated into the backend. The following implementation details are considered:

a. Model Loading:
   The trained models, stored as serialized files, are loaded into memory during system initialization. The model architecture, weights, and other necessary parameters are loaded for inference.

b. Model Inference:
   The loaded models are used to perform image segmentation and pose detection on the received video frames. The models take the segmented human figure as input and generate the corresponding outputs.

c. Posture Analysis:
   The pose detection model's outputs are analyzed to assess the correctness of the yoga pose. The analysis includes comparing the detected pose with the reference pose for the selected exercise and calculating relevant metrics and angles.

6. Integration and Testing

6.1 Description of the Integration Modules

A. User Interface Module

The User Interface module provides the frontend of the system, enabling users to interact with the application through a web interface. It includes the following components:

a. Pose Selection:
This component displays a list of available yoga poses for the user to choose from. It allows the user to select a specific pose for evaluation.

b. Webcam Integration:
The Webcam Integration component enables the user to access and utilize the webcam to capture live video input. It displays the live video feed on the web interface for real-time feedback.

c. Timer Display:
This component shows the timer value on the web interface, indicating the duration of correct posture. It is updated based on the backend's timer handling functionality.

B. Backend Processing Module

The Backend Processing module handles the processing and analysis of the captured video frames to detect and evaluate yoga poses. It consists of the following components:

a. Video Processing:
This component receives the live video feed from the User Interface module and performs image segmentation using techniques such as background subtraction and thresholding. It extracts the human figure from each frame.

b. Pose Detection:
The Pose Detection component applies a deep learning model to the segmented human figure to estimate the pose. It analyzes key points and spatial relationships to determine the correctness of the pose.

c. Timer Handling:
This component manages the timer functionality. It starts the timer when the user selects a pose and resets it to zero if an incorrect posture is detected. The timer value is updated and communicated to the User Interface module.

d. Feedback Generation:
The Feedback Generation component generates feedback messages and indicators based on the results of pose detection. It communicates feedback messages such as "Correct Pose!" or "Incorrect Pose!" to the User Interface module for display.

C. Deep Learning Model Integration Module

The Deep Learning Model Integration module integrates the trained deep learning models into the backend for image segmentation and pose detection. It comprises the following components:

a. Model Loading:
   This component loads the serialized deep learning models, including their architecture, weights, and parameters, into memory during system initialization.

b. Model Inference:
   The Model Inference component utilizes the loaded models to perform image segmentation and pose detection on the segmented human figure. It generates outputs indicating the segmented image and detected pose.

c. Posture Analysis:
   This component analyzes the outputs of the pose detection model to assess the correctness of the yoga pose. It compares the detected pose with the reference pose for the selected exercise and calculates relevant metrics and angles.

6.2 Testing

Sr. No.	Test Case Title	Description	Expected Output
1	Selection of Yoga pose	Here a list of yoga poses is displayed for a user to choose from. It allows the user to select a specific pose for evaluation.	Pose selection
2	Webcam Integration	The Webcam Integration component enables the user to access and utilize the webcam to capture live video input. It displays the live video feed on the web interface for real-time feedback.	Pop up for camera permission
3	Capture Video	Timer will be set for 10 sec and an image will be captured through the camera.	Video Acquisition
4	Image Segmentation	After the image is captured, the part from the image where the person must be masked properly and that segmented part must be sent as input to a deep learning model.	Detects the person from the captured image.
5	Identification Of Correct Yoga Posture	After image processing, the deep learning model has to identify the correct yoga position.	Identify appropriate yoga positions.
6	Timer value display	It shows the timer value on the web interface, indicating the duration of correct posture. It is updated based on the backend's timer handling functionality.	Timer display
7	Countdown	After identification of the correct pose, countdown will be started.	Countdown start
8	Browse Exercises	Browsing Of Various Exercises Can Be Done.	List Of Exercises With Their Name, Posture And Difficulty Level.

7. Performance Analysis

The performance of the system is assessed through various metrics and measurements to evaluate its efficiency and capability to handle user load. The following performance analysis is conducted:

A. Response Time Measurement

Response time is a critical performance metric that measures the time taken by the system to respond to user actions. The response time is measured from the moment a user selects a yoga pose to the moment the system provides feedback on the posture correctness. It includes the following measurements:

a. Pose Detection Time:
The time taken by the backend processing module to analyze the captured video frames, detect the pose, and provide feedback.

b. Timer Update Time:
The time taken to update the timer value on the web interface after each correct posture is detected.

B. Resource Utilization

Resource utilization refers to the system's consumption of hardware resources during its operation. It is measured to ensure the system operates efficiently and can handle the expected user load. The following resource utilization measurements are considered:

a. CPU Usage:
The percentage of CPU resources utilized by the system during peak load scenarios. It is measured using system monitoring tools.

b. Memory Usage:
The amount of memory consumed by the system under normal and peak load conditions. It is measured to ensure efficient memory management.

c. Network Bandwidth:
The network bandwidth consumed by the system during video streaming and communication between the user interface and backend modules. It is measured to ensure optimal network utilization.

Accuracy:

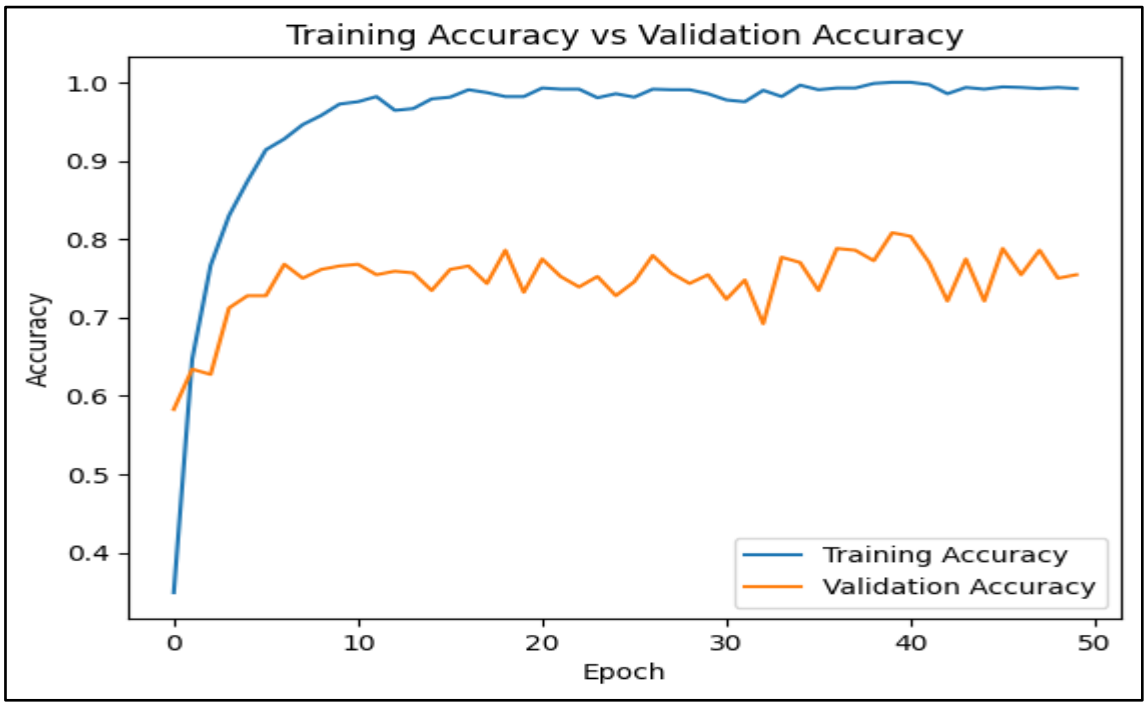


Fig. 7.1 Accuracy

Loss Function:

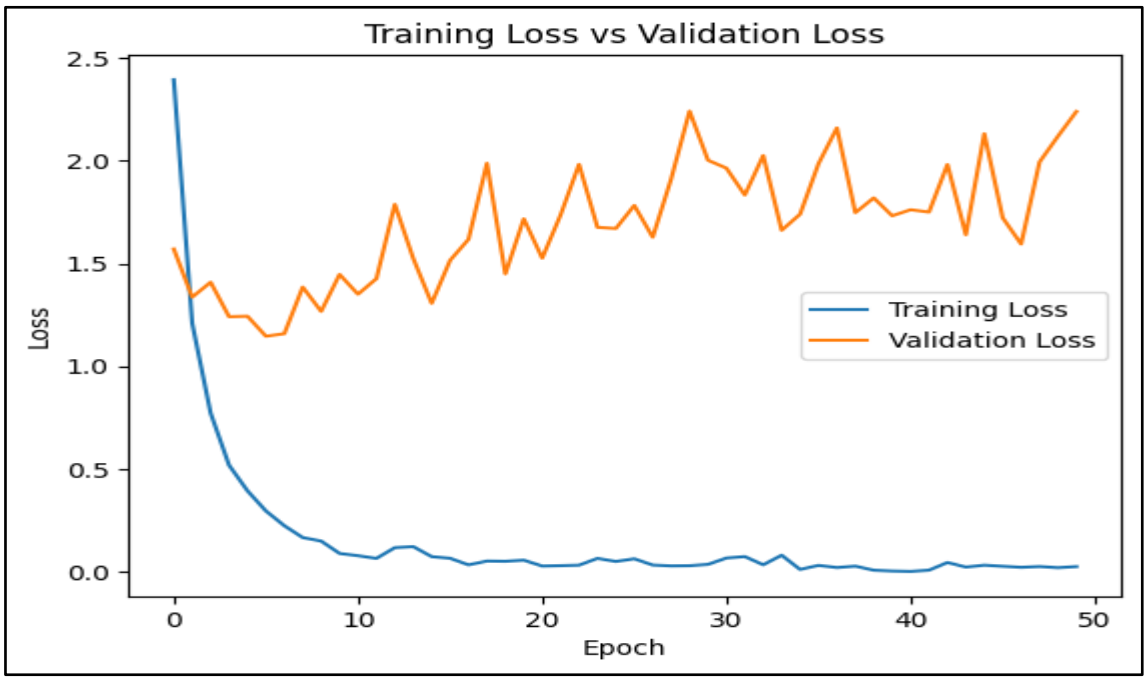


Fig. 7.2 Loss Function

8. Future Scope

The following areas can be explored to further improve and extend the functionality of the system:

A. Enhanced Pose Detection Algorithms

Investigate and implement advanced pose detection algorithms to improve accuracy and robustness. Explore state-of-the-art techniques, such as graph convolutional networks or transformer models, to capture more detailed spatial relationships and achieve better pose estimation results.

B. Mobile Application Development

Develop a mobile application version of the system to provide users with the flexibility to practice yoga anywhere using their smartphones. The application can leverage the device's built-in camera for pose detection and provide feedback and guidance directly on the mobile interface.

C. Gamification and Progress Tracking

Implement gamification elements and progress tracking features to enhance user engagement and motivation. Introduce challenges, achievements, and rewards to encourage users to practice regularly and track their progress over time. This can be achieved through visualizing improvement metrics and setting goals within the system.

D. Integration with Virtual Reality (VR)

Explore the integration of virtual reality technology to create immersive yoga training experiences. Develop a VR-based system that simulates yoga environments, provides real-time feedback, and visualizes correct postures in a virtual setting. This can enhance user engagement and provide a more interactive and immersive yoga practice experience.

9. Applications

The project on yoga pose detection using deep learning has several potential applications in various domains. The following are some key application areas are:

A. Personal Yoga Training

The system can be used by individuals for personal yoga training and practice. Users can receive real-time feedback and guidance on their posture correctness, allowing them to improve their yoga techniques and ensure they are performing the exercises correctly.

B. Fitness Centers and Yoga Studios

Fitness centers and yoga studios can incorporate the system into their training programs. It can serve as an interactive tool for instructors to evaluate and correct the poses of their clients. The system can provide instant feedback and enable personalized training sessions to enhance the effectiveness of yoga classes.

C. Remote Training and Telemedicine

The system can be integrated into remote training programs and telemedicine applications. Users can receive personalized yoga training remotely, with instructors providing feedback and guidance through video conferencing or online platforms. This allows for flexible and accessible yoga training from any location.

D. Research and Development

The project can serve as a platform for research and development in the field of pose detection and analysis. Researchers can utilize the system's architecture and dataset to explore new algorithms, evaluate performance, and contribute to advancements in pose estimation and human activity recognition.

E. Assistive Technology

The system can be adapted for use as an assistive technology for individuals with motor impairments or disabilities. By analyzing and providing feedback on their posture, it can assist users in performing yoga exercises correctly and independently, promoting physical well-being and empowerment.

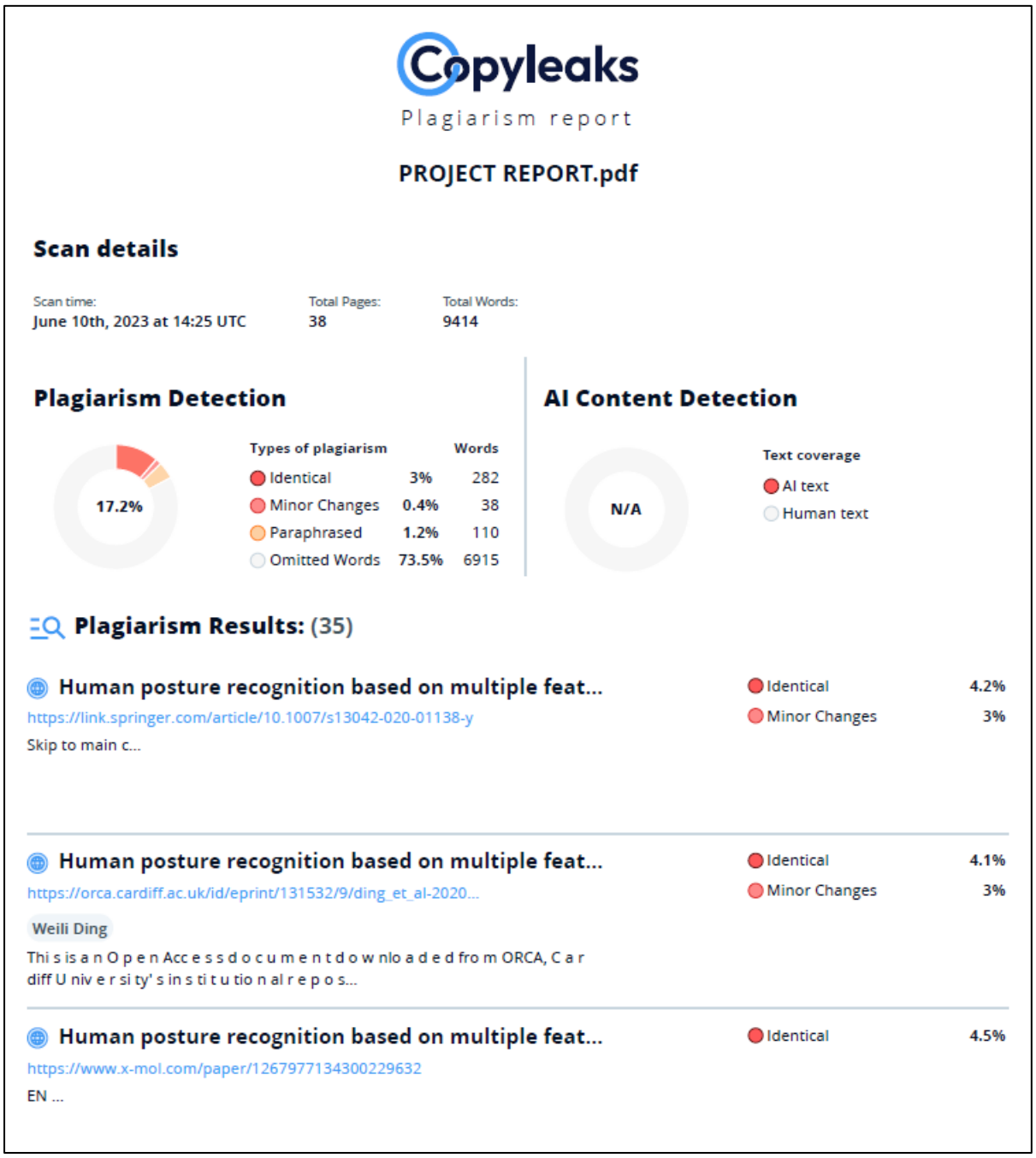
F. Wellness and Healthcare Applications

The system can be integrated into wellness and healthcare applications, such as fitness trackers or health monitoring devices. It can provide personalized yoga recommendations and guidance based on users' activity levels, helping individuals incorporate yoga practice into their daily routines for improved overall wellness.

10. USER MANUAL AND INSTALLATION GUIDE

1. Multiple persons are not allowed to practice yoga simultaneously. At a time only one
2. a person is allowed.
3. The AI can detect a person only if he/she is completely visible to the camera.
4. Sometimes the posture might not be detected at a glance, so the person has to wait until
5. that posture is detected & then the timer will start.
6. The person’s attire must be clearly distinguishable from the background.
7. To detect the user's activity properly, the room must be properly lit.
8. The camera quality for the live video must be good.
9. Stable internet connection.
10. Our system is able to detect and verify yoga asanas with a user-friendly interface.
11. System is able to help users to enhance their performance by clearing different levels.
12. There is no need for a trainer as a user can practice yoga at home on his/her own
13. machine.
14. Users need a good internet connection and any web browser like google chrome,microsoft edge etc.
15. Make sure the application has given camera permissions.
16. Users will see a homepage where there are 6 poses available to perform.
17. If user selects one of these options, user needs to perform respective pose to start the timer
18. Once the user is satisfied by the specific yoga pose, the user can return to the home page.

11. Plagiarism Report



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12. Ethics

The Yoga Detection project incorporates several important ethical considerations. Firstly, user privacy is a paramount concern. To safeguard personal data and video footage, strict confidentiality measures are implemented. Adherence to privacy laws and regulations ensures that user information remains protected from unauthorized access or disclosure.

Secondly, obtaining informed consent from users is crucial. Clear communication about the project's purpose, scope, and potential risks allows users to make an informed decision about participating. This ensures that users have control over their data and understand the implications of their involvement.

Thirdly, data security is prioritized to safeguard user information. Robust security measures, such as encryption techniques, secure storage, and access controls, are implemented to protect against unauthorized use or breaches. Compliance with industry best practices for data security ensures that user data is kept safe and confidential. These measures contribute to building trust with users and demonstrate a commitment to protecting their information.

In conclusion, the Yoga Detection project adheres to ethical principles by prioritizing user privacy, obtaining informed consent, implementing robust data security measures, and addressing fairness and bias. These considerations demonstrate a commitment to protecting user interests, ensuring transparency, and promoting a trustworthy system.

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