Project Phase II Report On

AI Yoga Tutor

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

in

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CERTIFICATE

This is to certify that the project report entitled ***"AI Yoga Tutor"*** *is a bonafide record of the work done by* ***Mr. George Jose (U2003084), Mr. Midhun Mohan K. M. (U2003134), Mr. M. S. Rahul (U2003125), Mr. Naman Mathew George (U2003141)****, submitted to the Rajagiri School of Engineering & Technology (RSET) (Autonomous) in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology (B. Tech.) in Computer Science and Engineering during the academic year 2023-2024.*

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Abstract

This project introduces a revolutionary real-time yoga pose detection and correction system, leveraging artificial intelligence and computer vision technologies. The system's core functionality lies in its ability to accurately identify and classify diverse yoga poses through analysis of live webcam footage. Unlike traditional methods, our system provides immediate, personalized audio feedback to guide practitioners toward optimal alignment and form during their yoga practice. The user interface is designed for seamless integration, ensuring a positive and engaging experience. The proposed system addresses the limitations of existing manual approaches by offering scalable, technologically-driven feedback, thereby enhancing the overall quality and effectiveness of yoga sessions. This project not only contributes to the advancement of AI applications in health and wellness but also represents a transformative step towards redefining the intersection of technology and mindful physical activities.

Contents

List of Abbreviations

HPE - Human pose Estimation

FCN - Flowing ConvNets

CPM - convolutional pose machine

CNN - convolutional neural network

AI - Artificial Intelligence

CV - Computer Vision

ML - Machine Learning

C3D - Convolution 3D network

LogRF - logistic regression Recursive Feature elimination

SMPL - Skinned Multi-Person Linear

CNN - Convolutional Neural Network

PCA - Principal Component Analysis

NLG - Natural Language Generation

NLP - Natural Language Processing

GPT - Generative Pre-Trained Transformers

BART - Bidirectional and Auto-Regressive Transformers

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Chapter 1

Introduction

This chapter explores the key components that characterise the research landscape and provides the study's fundamental structure. The background part establishes the topic matter's evolution and offers historical context. The problem definition that follows then clarifies the particular difficulties and gaps in the present knowledge, laying the groundwork for the research to solve relevant topics.

The limits and importance of the study are described in the scope and motivation section, which also clarifies the reasons for the research's relevance and necessity. The desired results and contributions are then articulated through clearly stated objectives, which lead the reader through the investigation's overall goals. Furthermore, the study's assumptions are made clear, recognising the fundamental ideas around which the investigation is based.

1.1 Background

In the evolving landscape of health and wellness, the intersection of technology and ancient practices like yoga is gaining prominence. Traditional methods of yoga instruction often lack immediate, personalized feedback, hindering practitioners' progress and potentially leading to incorrect postures. Our project addresses this gap by introducing a real-time yoga pose detection and correction system powered by artificial intelligence and computer vision.

The significance of this project lies in its potential to revolutionize how individuals engage with yoga, offering immediate, intelligent feedback for optimal alignment and form. In a digital age where fitness technology plays a crucial role, our system caters to the modern practitioner's need for dynamic, tech-driven guidance during yoga sessions. This endeavor aligns with the broader trend of integrating AI into health and wellness applications, contributing to the synergy of ancient practices and cutting-edge innovations.

Recognizing the limitations of current methodologies, our project aims to enhance overall well-being by providing a transformative tool for individuals practicing yoga. Subsequent sections will delve into the technical intricacies, objectives, and potential societal impact of our innovative real-time yoga pose detection and correction system

1.2 Problem Definition

Traditional yoga practice often lacks the necessary real-time feedback mechanisms, leaving practitioners to rely solely on their own perception of form and alignment. Without immediate guidance, individuals may unknowingly perform poses incorrectly, increasing the risk of injury and hindering progress. This absence of feedback can impede practitioners from fully realizing the potential benefits of their yoga practice, both physically and mentally.

1.3 Scope and Motivation

The scope of this project extends to the development of a comprehensive real-time yoga pose detection and correction system. This encompasses the creation of advanced algorithms capable of recognizing and classifying a diverse range of yoga poses through analysis of live webcam footage. The system aims to provide practitioners with immediate, personalized audio feedback for optimal alignment and form during their yoga sessions. It also includes the design of an intuitive user interface for seamless integration into practitioners' routines. Scalability, adaptability to different environments, and ethical considerations in data handling are integral aspects within the project's scope. The system's potential integration with existing platforms further broadens its applicability within the fitness and wellness industry.

The motivation behind this project arise from the need to enhance the practice of yoga by leveraging the capabilities of artificial intelligence. Traditional methods lack the instantaneousness and customization required for effective feedback during yoga sessions, hindering practitioners' progress. The motivation is to introduce a transformative solution that not only addresses these limitations but also aligns with the evolving trends in health-tech. By providing real-time, personalized feedback, the system aims to motivate and guide practitioners towards optimal poses, thereby improving the overall quality and effectiveness of their yoga practice. The project's motivation extends beyond individual well-being to contribute to the broader dialogue on integrating technology and mindfulness in the pursuit of a healthier lifestyle.

1.4 Objectives

1. **Yoga Pose Recognition**: Develop algorithms capable of accurately identifying and classifying a diverse range of yoga poses through analysis of live webcam footage.
2. **Real-time Feedback**: Implement a responsive feedback mechanism that provides immediate, personalized audio feedback to users, guiding them toward optimal alignment and form during their yoga practice.
3. **User Interaction**: Design an intuitive user interface to enhance user engagement, allowing practitioners to seamlessly integrate the AI system into their yoga routines.
4. **Scalability**: Ensure the system's scalability to accommodate a variety of yoga poses, catering to practitioners with different skill levels and preferences.
5. **Accuracy and Reliability**: Strive for high accuracy in pose detection and correction, minimizing false positives and negatives to enhance the overall effectiveness of the system.
6. **Adaptability**: Create a system that adapts to various environments and lighting conditions, ensuring robust performance during diverse yoga sessions.

1.5 Challenges

The project faces challenges related to the complexity of developing accurate algorithms for real-time yoga pose detection, accommodating diverse user movements and variations. Additionally, ensuring seamless user engagement, addressing privacy concerns, and achieving low-latency processing for immediate feedback pose significant challenges that require meticulous attention and innovative solutions.

1.6 Assumptions

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1. **User Cooperation**: The project assumes user cooperation and engagement, as the effectiveness of the system relies on practitioners actively participating and following the feedback provided.

2. **Consistent Lighting Conditions**: Assumption of consistent lighting conditions during yoga sessions to ensure reliable performance of the computer vision algorithms for pose detection.

3. **Access to Webcam**: The project assumes that users have access to a webcam, as the system relies on live footage for real-time pose detection

4. **Diverse Yoga Poses**: The system assumes a diverse range of yoga poses and postures, accommodating various styles and difficulty levels commonly practiced by users.

1.7 Societal / Industrial Relevance

The project holds substantial relevance for both society and the industry. In the societal context, the real-time yoga pose detection and correction system addresses a growing need for accessible and personalized fitness solutions. By offering immediate, AI-driven feedback during yoga practice, the system contributes to individual well-being, promoting healthier lifestyles in the broader community.

In the industry, the project aligns with the evolving landscape of health-tech and fitness technology. The system's potential integration with existing platforms opens avenues for collaboration with fitness apps, yoga studios, and wellness organizations. This relevance positions the project at the forefront of innovative applications in the intersection of artificial intelligence and mindful physical activities, contributing to the ongoing transformation of the fitness and wellness industry.

1.8 Organization of the Report

The report begins with an introduction that provides context, outlines the problem and the scope and motivation for the project. It also underscores the assumptions and challenges undertaken and the significance of the AI Yoga Tutor. The second chapter then delves into a comprehensive review of existing literature and research in the field, providing a foundation for understanding the project's context within existing knowledge. The third chapter then details the implementation prerequisites in hardware and software. Following this, the fourth chapter details the system design illustrating the architecture and modules involved in the project, as well as the project execution plan using Gantt chart and work schedules. Finally, the concluding chapter summarizes the key findings and outcomes of the project. The references and appendices are then provided to offer a comprehensive resource base for the report

1.9 Summary Of Chapter

To sum up, this chapter gave a thorough review of the state of the research, including the study's background, problem definition, scope, and motivation. The outlined goals and recognised difficulties prepared the groundwork for the discussion of important topics in the sections that followed. We emphasised the work's industrial importance while detailing the study process's underlying assumptions. The reader is guided towards a fuller comprehension of the research objectives and the context in which they are pursued by this foundational chapter, which also establishes the platform for the discussions and analyses that follow.

Chapter 2

Literature Survey

2.1 The Progress of Human Pose Estimation: A Survey and Taxonomy of Models Applied in 2D Human Pose Estimation [1]

2.1.1 Introduction

A vital part of computer vision, human posture estimation (HPE) involves precisely detecting important body points in images. This allows for a variety of applications, such as tracking, gaming, human-computer interaction, sign language recognition, and video monitoring. The goal of this thorough survey paper is to close the knowledge gap in the area of 2D human posture estimation. The introduction is brief and classifies posture estimate as single or multi-person depending on how many people need to be tracked. After that, the paper methodically examines many techniques for estimating human stance, highlighting its uses and addressing typical problems.In this survey, we mainly focus on two widely used algorithms: Deeppose and HR-Net. Deeppose offers a robust framework for human pose estimation, while HR-Net, with its high-resolution architecture, presents an alternative approach

2.1.2 DeepPose [2]

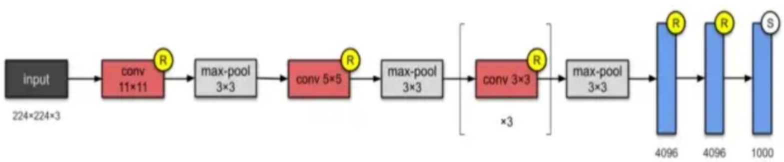

Figure 2.1: ALEX-NET

DeepPose is a notable research study that applies deep learning to human pose estimation, employing a three-stage cascade of regressors to estimate an individual's pose in a picture. The job of determining body joints for an individual was framed by DeepPose as a regression task using CNNs.The impacts of simultaneously training a multi-staged architecture with recurrent intermediate supervision have been examined by the authors using AlexNet as the backbone architecture. Images are trimmed around joints predicted by DeepPose cascaded regressors so that they can feed into the subsequent stage. Because higher resolution images lead to increased precision, this enables the subsequent regressors to learn features for finer scales.

A posture vector, denoted as y = (..., yiT,...)T, encodes the locations of all k body joints to describe a pose. Here, i is a member of 1,..., k, and yi holds the x and y coordinates of the ith joint. An image with labels is indicated by (x, y). The human body, or portions of it, are bounded by box B in the normalisation process. The box may indicate the entire image in a simple scenario. Such a box has a centre (bc), width (bw), and height (bh) that define it.

b = (bc, bw, bh)

$$N(\mathbf{y}_i; b) = \begin{pmatrix} 1/b_w & 0 \\ 0 & 1/b_h \end{pmatrix} (\mathbf{y}_i - b_c)$$

DeepPose has limitations in regressing to a location, which makes learning complex and weakens generalization. Firstly, its computational intensity can limit real-time performance on devices with constrained processing power. Additionally,it has the need for large datasets for training poses challenges in terms of time and resources

2.1.3 HRNet [3]

It is Simliar to deepose and it is much more advanced and has higher accuracy. It predict human keypoints using a convolutional network, which is composed of a stem , a main body and a regressor .Stem is initial part of a neural network architecture. It consists of a series of convolutional layers designed to process the input image, extract basic features, and reduce the spatial dimensions (resolution) of the image,these convolutional layers use

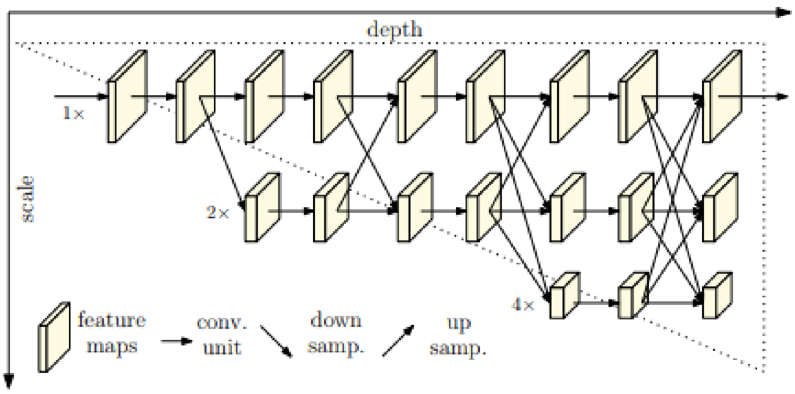

Figure 2.2: HRNet

a larger stride value, which reduces the size of the feature maps.

The stem is followed by the network's main body. It processes the stem's output feature maps while preserving the input feature maps' spatial resolution. This segment of the network is in charge of extracting higher-level and more intricate elements from the data. One part of the model in charge of calculating certain output values is the regressor.The regressor may use the feature maps produced by the main body to forecast heatmaps, each of which shows the probability of a specific keypoint.

HRNet processes the input image at its original high resolution in its first stage, which is a high-resolution subnetwork. The network's depth and the feature maps' scale are represented by the horizontal and vertical directions, respectively. HRNet gradually adds more stages as it goes further into the network, each of which processes data at a different resolution. Next, information is exchanged across the parallel multi-resolution subnetworks over the course of repeated multi-scale fusions. Exchange units are introduced across parallel subnetworks for recurrent multi-scale fusion, guaranteeing that each subnetwork receives information from other parallel subnetworks on a regular basis.

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2.1.4 Conclusion

The base paper provides a comprehensive survey and taxonomy of models applied in 2D HPE, with a specific focus on comparing the DeepPose and HRNet algorithms. DeepPose, known for its detailed pose estimation capabilities through deep CNN , exhibits strengths in adaptability to diverse poses but faces challenges in real-time applications due to its computational intensity and sensitivity to occlusions. On the other hand, HRNet, a cutting-edge algorithm, excels in high-resolution and multi-resolution approaches, demonstrating robustness in complex scenarios but introducing increased computational demands. Despite their respective advantages and limitations, both algorithms contribute significantly to advancing human pose estimation techniques.

The referenced papers further expand the understanding of pose estimation. FCN [9] excel in capturing temporal dependencies for dynamic scenarios, offering advantages in accuracy for applications like action recognition. However, the added complexity and computational demands must be carefully considered. CPM [10] contribute to sophisticated pose estimation techniques but may face challenges in high-resolution predictions and resource-intensive implementations. DC's deep learning foundation provides advantages in hierarchical representation learning but is sensitive to data quality and diversity, posing challenges in real-world generalization. SHN offer advanced capabilities in pose estimation through hierarchical multi-scale processing but come with computational demands, data dependencies, and interpretability challenges. In summary, these algorithms contribute valuable insights and capabilities to the evolving field of HPE, each with its unique strengths and considerations for practical deployment.

2.2 LogRf Approach to Human Pose Estimation Using Skeleton Landmark[4]

2.2.1 Introduction

An effective approach for estimating human stance is presented in the research. It uses a multi-class workout dataset based on human skeletal movement points and presents a novel method for feature selection called Logistic Recursive Feature Elimination (LogRF). The major goal is to recognize and resolve possible bad postures, and poor movement patterns—all of which are critical for preventing injuries and maximizing the benefits of exercise. With a high-performance score of 0.998, the suggested strategy exceeded the most recent research.

2.2.2 Methodology

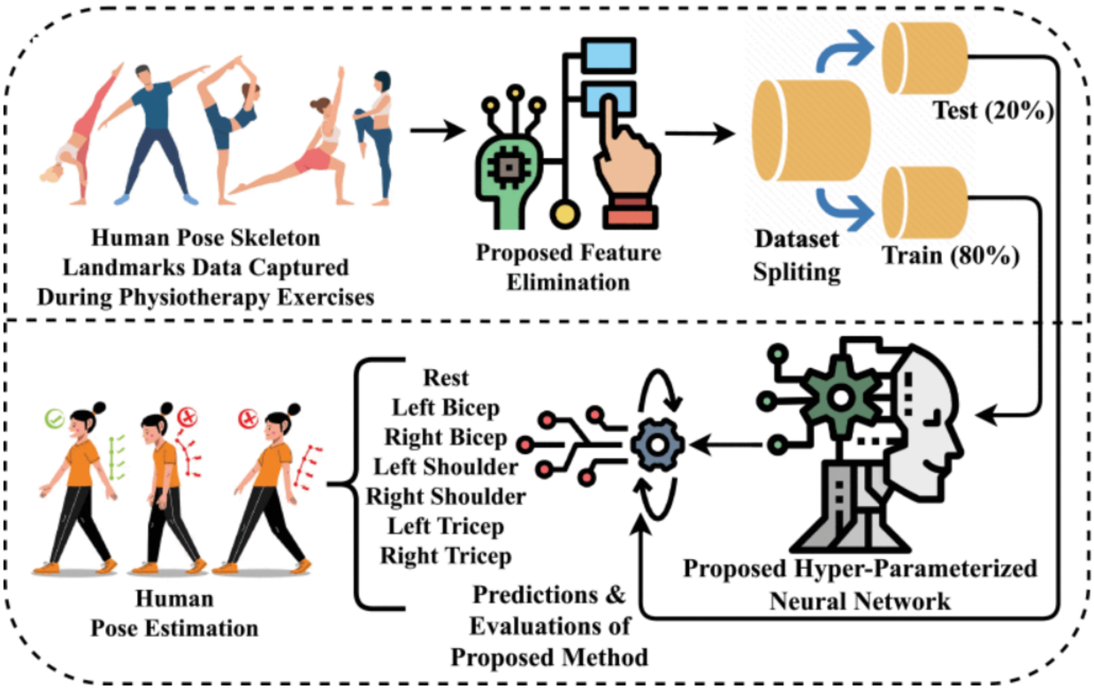


Figure 2.3: Methodology

The research methodology utilized in this study is a thorough way to estimating human position during different exercises. A publicly accessible dataset was used in the study to conduct trials with human positions during various exercises. In the initial processing of the dataset, a novel feature selection method was introduced with the goal of keeping only those features that provide a significant contribution to the estimation of human posture. Following the division of the chosen feature set into training and testing subsets, a number of sophisticated AI techniques were trained and evaluated. The technique that performed the best was then applied to the estimation of human position.

The study uses a multi-class workout dataset with seven different goal classes that is based on human skeleton position data. Furthermore, a novel feature elimination method called LogRF was put out and examined. This method helps deal with a huge number of characteristics by iteratively selecting and removing features to find a subset that contributes the most to the model's prediction capacity.In addition, the research utilized k-fold cross-validation techniques to verify the effectiveness of every implemented approach. With a high k-fold accuracy score of 0.99, the suggested LogRF approach was successfully validated for human posture estimations.In order to determine the best strategy for human pose estimation during physiotherapy fitness exercises, the methodology included feature selection, dataset processing, model training and testing, and performance validation.

2.2.3 Conclusion

The study concludes that, with a high accuracy score of 0.998, the suggested LogRF technique beat state-of-the-art studies for human position estimation during physiotherapy fitness exercises. The study shows that the LogRF approach may be applied in real-time to posture estimation and improves human pose estimation ability.

The reference papers also provide different methodology like Defining and annotating keypoints on equipment full body poses in collected images. Trained three deep learning networks (Hourglass, Cascaded Pyramid, Ensemble of Hourglass and Cascaded Pyramid) using our annotated pose dataset.[11].In the second paper model the body joint guided feature pooling is conveniently formulated as a bilinear product operation.[12].The third paper proposed to use the Skinned Multi-Person Linear (SMPL) model, which uses Principal Component Analysis (PCA) coefficients to represent human body shapes and poses.[13].The fourth paper extracted joint coordinates and angles using tf-pose algorithm, utilizing the angles as features for machine learning models. Tested various models, and Random Forest classifier demonstrated the highest accuracy.[14]

2.3 iYogacare: Real-Time Yoga Recognition and Self-Correction for Smart Healthcare[5]

2.3.1 Introduction

The yoga posture recognition and self-correction methodology comprises a set of. steps that focus on feature extraction and comparative analysis. First, the tf-pose algorithm is used to record and separate many coordinates indicating various parts of a human body key joint positions of the body during a yoga pose. These coordinates are considered to be basic data for further analysis.

2.3.2 Methodology

The obtained coordinates are used to calculate various angles, distances and slopes between specific points on the body, which served as important evaluation values in determining the correctness of yoga poses. Mathematical computations, using these parameters is done using of the Cosine rule and Euclidean distance. The Cosine rule helps to compute joint angles and Euclidean distance calculates distances between joints or body parts.

Once these parameters are extracted, a critical stage involves comparing the computed values with pre-defined results. This comparative analysis is useful in determining the pose alignment and accuracy. The goal is to assess if the extracted parameters fits into an acceptable range or within a deviation from what is expected.

2.3.3 Conclusion

Using this comparison, it is possible to determine the correctness of the yoga posture based on which conclusion was drawn. If the taken parameters match very well with what had been defined previously it shows a proper and correct attitude when standards. Conversely, significant deviations might indicate faulty alignment, requiring potential adjustments or corrections for the pose.

The reference papers also provide different methodologies to find the angle between the joints. The different methodologies include using Cosine similarity to find the angle between joints[15][16], Using Cosine Similarity to find the relative angle between trainer and trainee between each body part[17] and finally computing the angle between joints by adding their relative inclination with respect to the horizontal plane[18]. In all these methods the idea is to obtain the angle between the extracted keypoints.

Cosine Similarity

The similarity between a vector pair of each body part of the instructor ($\vec{u}$) and the trainees ($\vec{v}$) is determined by the mathematical equation:[17]

$$cos(\theta) = \frac{\vec{u}.\vec{v}}{|u||v|}$$

To estimate angle between 2 joints of a trainee $\vec{u}$ and $\vec{v}$ are taken as neighbouring joints.[16][15]

Relative Inclination With Respect To Horizontal[18]

Given three key-points angle can be easily calculated which is made between the two lines using analytic geometry. Let A(x1, y1), B(x2, y2) and C(x3, y3) be the three points:
$angle = math.degrees(math.atan2(y3 - y2, x3 - x2) - math.atan(y1 - y2, x1 - x2))$

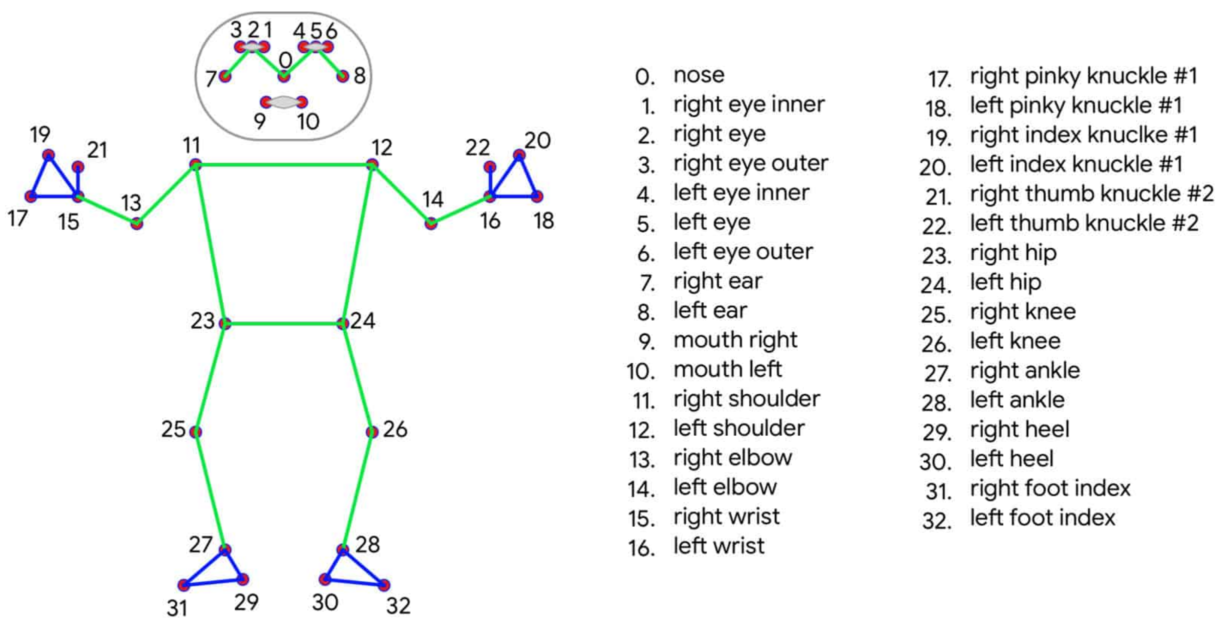
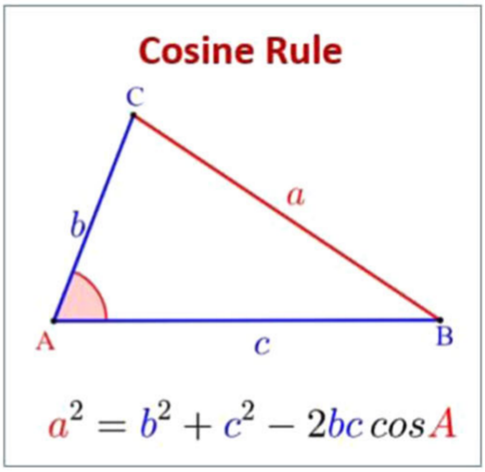
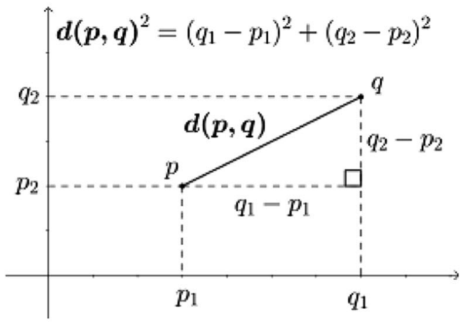


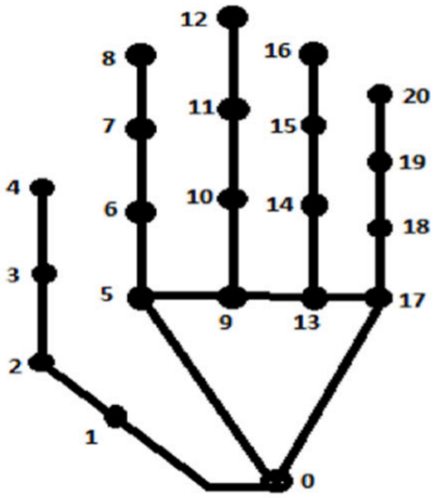
Figure 2.4: Keypoints



(a) Cosine Rule.



(b) Euclidean Distance.



(c) Palm Skeleton.

Figure 2.5: Pose Correction.

2.4 LOGEN: Few-Shot Logical Knowledge-Conditioned Text Generation With Self-Training [6]

2.4.1 Introduction

Researchers have been interested in natural language creation from structured data for a long time, and this has led to numerous practical applications. Nevertheless, producing high-fidelity text with limited training pairings for table-to-text creation is a difficult task.Previous research uses logical forms to aid in the generation of logical knowledge-conditioned language; but, due to their data-hungry nature, its application to real-world scenarios with little data is challenging. To tackle this challenge, this research proposes a unified framework for self-training few-shot logical knowledge-conditioned text production.

2.4.2 Methodology

The methodology proposed in the paper involves the LOGEN framework, which addresses The text creation issue conditioned by few-shot logical knowledge. With just a few seeded training cases, the framework's many essential elements and methods may produce text with more efficiency and reasoning assistance.The evaluation is carried out using the benchmark dataset LOGIC2TEXT, which comprises samples for testing, validation, and training as well as seven different kinds of frequently used logics. The evaluation metrics include BLEU-1, BLEU-2, ROUGE-1, ROUGE-2, and ROUGE-L. The logical rationality estimator based on general rules is used by the content consistency module of the LOGEN framework to guarantee that the generated text is consistent with the input logical form and table content. The structure-consistency module determines which generated logical forms are of high quality and involves iterative training in these forms by calculating their quality score. The framework makes use of samples and self-training pseudo-logical forms according to structure and content constancy to improve few-shot performance. The model is trained iteratively, and the self-training process continues until no unlabeled data remain. The authors conducted an error analysis of their approach and observed the model's behavior in choosing easy and hard instances during different stages of training. Additionally, an investigation on ablation was conducted to confirm how well certain components of the framework works, and a human evaluation was performed to assess the generated answer summaries from the aspects of informativity, logicalness, and readability. In summary, the LOGEN framework addresses the text creation issue using few-shot logical knowledge conditioning by leveraging self-training, content consistency, structure-consistency,

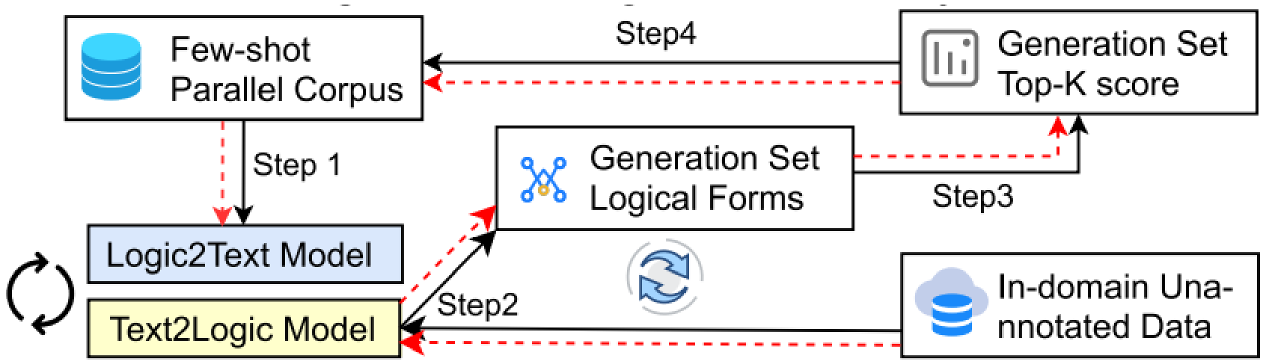


Figure 2.6: LOGEN: Few-shot learning framework

and iterative improvement to surpass baselines on the benchmark dataset in terms of performance.

2.4.3 Conclusion

LOGEN demonstrates promising results in generating high-quality text with limited logical knowledge input. Its self-training capability allows for continuous learning and refinement, making it a valuable tool for various NLG applications. However, challenges remain in mitigating potential biases and ensuring factual accuracy. Future research can focus on enhancing interpretability and adapting LOGEN to diverse real-world data domains. The reference articles include a wide range of techniques for improving text generation, from TableGPT's[19] sparse tables to Seq2Seq's attention[20] focus, BART's denoising[21], and GPT-2[22] baseline effectiveness. To improve text creation and possibly break new ground, think about adding denoising techniques, improved attention, and sparse architectures to your Logen framework.Based on experimental data, the LOGEN framework outperforms baselines in few-shot performance. It shows its promise for practical applications with less data and tackles the data-hungry characteristic of earlier methods.

2.5 YOLO-Pose: Enhancing YOLO for Multi Person Pose Estimation Using Object Keypoint Similarity Loss[7]

2.5.1 Introduction

The YOLO-position framework, which incorporates pose estimates into the YOLO (You Only Look Once) object detection framework, is presented in this study. To overcome issues including scale variation, occlusion, and the non-rigidity of the human body, YOLO-pose makes use of advances in object detection. This approach overcomes the limits of conventional heatmap-based approaches. Pose estimation becomes more precise and efficient with the help of this unified solution, which enables end-to-end training and optimisation of the Object Keypoint Similarity (OKS) measure. YOLO-position, in contrast to conventional methods, does not require post-processing processes to put keypoints into skeletons because every bounding box has a corresponding posture. With no test-time augmentation methods required, YOLO-pose demonstrates cutting-edge performance on the COCO dataset, demonstrating its superiority over current bottom-up approaches in terms of complexity and accuracy.YOLO-position opens the path for combined task solution of object recognition and pose estimation, enhancing the accuracy of human pose estimation.

2.5.2 Methodology

In YOLO-Pose, the anchor-based multi-person pose formulation is a cornerstone. Anchors, predefined bounding boxes positioned across the image, serve as reference points for detecting human poses. When an anchor is matched with a person, it captures the entire 2D pose alongside bounding box data. To ensure consistent representation, the coordinates of keypoints and bounding boxes are transformed relative to the anchor center. This transformation, expressed by equations like $x_{new} = \frac{x - x_{anchor}}{anchor\_width}$ and $y_{new} = \frac{y - y_{anchor}}{anchor\_height}$, allows for standardized interpretation of positions within the anchor's context.

The YOLOv5 object detection framework serves as the backbone of YOLO-Pose, renowned for its accuracy and complexity. YOLOv5 specializes in detecting 80 classes of COCO objects and predicts 85 elements for each anchor. These elements include bounding box coordinates (x, y, w, h), objectness score, and class probabilities. By predicting these elements for each anchor across the image grid, YOLOv5 ensures comprehensive coverage and accurate detection of humans, laying the foundation for precise pose estimation.

Bounding box supervision in YOLO-Pose relies on the CIoU (Complete Intersection over Union) loss function. CIoU loss represents an advanced variant of IoU loss, incorporating additional terms to penalize deviations in center point distance and aspect ratio between predicted and ground truth boxes. By optimizing the evaluation metric directly, CIoU loss enhances the robustness and accuracy of bounding box predictions, aligning them closely with ground truth annotations.

During inference, the YOLOv5 model leverages its object detection capabilities to detect humans in the image. For each detected human, the corresponding anchor is identified. Within the region defined by the anchor, keypoints are extracted, and pose estimation proceeds based on their relative positions within the anchor's coordinate system. This integrated approach, combining object detection and pose estimation within a single-shot framework, enables efficient and accurate detection of human poses in images, making YOLO-Pose a powerful tool for various applications.

2.5.3 Conclusion

The YOLO-Pose framework presented in this paper marks a significant advancement through the use of object detection's advantages in the realm of multi-person pose estimation. By unifying these two domains, YOLO-Pose overcomes challenges such as scale variation and occlusion, leading to robust and accurate pose estimation results. The end-to-end training approach, coupled with the use of Object Keypoint Similarity loss, eliminates the need for complex post-processing steps, making the framework efficient and effective. With superior performance on the COCO dataset and competitive results compared to state-of-the-art bottom-up approaches, YOLO-Pose demonstrates the potential of joint detection and pose estimation. This work paves the way for further exploration and integration of object detection techniques into human pose estimation, promising exciting possibilities for future research and applications in computer vision.

2.6 Existing Methods

2.6.1 Real Time Virtual Yoga Tutor[8]

The current existing method of AI Yoga platform is an website developed with HTML,CSS for frontend and Python Django for backend. The website works by taking input through a webcam and is pre-processed using MediaPipe to extract the keypoints for each frame. The same frame is sent to pre-trained ML model which is trained to recognize 3 yoga poses: Vrikshasana, Virambhadrasana and Utkata Konasana. Based on this prediction the static image is send to MediaPipe to get keypoints of actual yoga pose. The angle estimation for comparing two poses is done by calculating the relative angle of body parts with respect to horizontal and then adding the corresponding joints to get the angle between 2 joints.

Given three key-points angle can be easily calculated which is made between the two lines using analytic geometry. Let A(x1, y1), B(x2, y2) and C(x3, y3) be the three points:

$$angle = math.degrees(math.atan2(y3 \text{ - } y2, x3 \text{ - } x2)\text{- } math.atan(y1 \text{ - } y2, x1 \text{ - } x2))$$

Figure 2.7: Web Interface

Fig. 1. Warrior pose (Virabhadrasana)

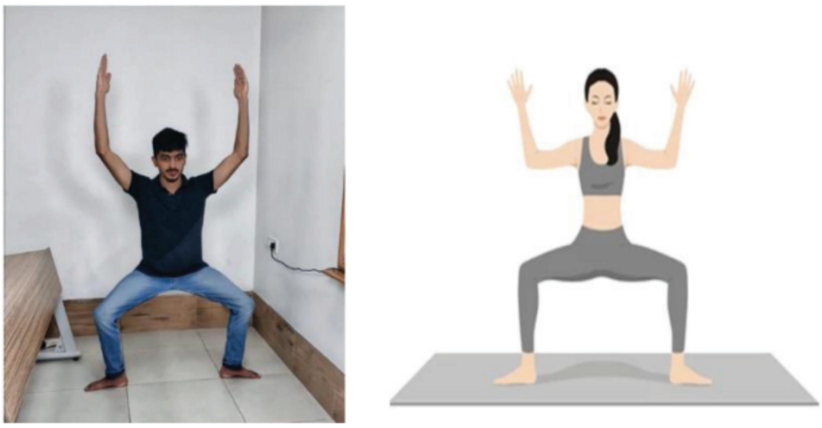


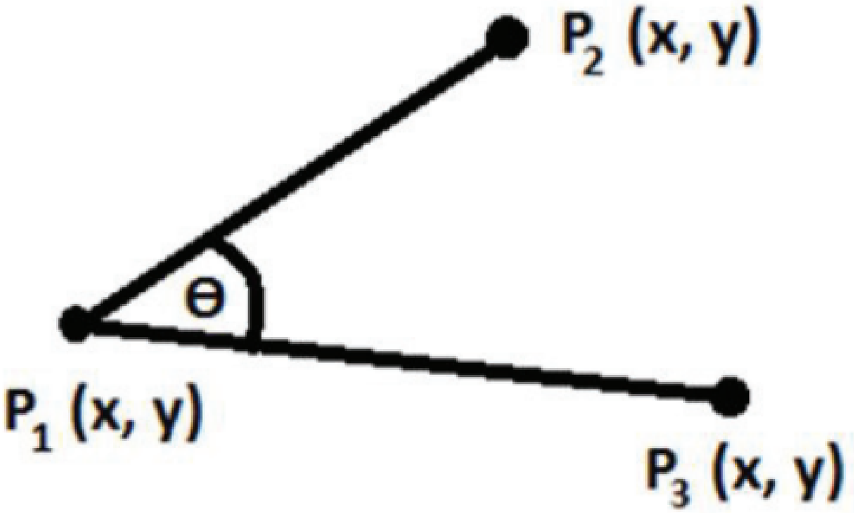
Fig. 2. Goddess pose (Utkata Konasana)

(a) Pose 1 and 2

(b) Pose 3

Figure 2.8: Poses Recognized

(a) Sequence Diagram



(b) Pose Correction

Figure 2.9: Pose Correction

2.7 Summary of the Chapter

Table 2.1: Summary of chapter

Paper Name	**Advantages**	**Disadvantages**
T. Munea, Y. Jembre, H. Weldegebriel, L. Chen, C. Huang, and C. Yang, "The progress of human pose estimation: A survey and taxonomy of models applied in 2d human pose estimation," IEEE Access, vol. 8, p. 133330–133348, 2020[1]	The algorithm exhibit high precision and accuracy in generating skeletal representations, providing an accurate representation of the human body's pose. The algorithm is designed for real-time processing and can efficiently generate skeletal structures in near real-time, making it suitable for applications requiring quick responses.	The algorithm can struggle with accurately generating skeletons for complex or uncommon poses, limiting its generalization to a wide range of movements. It might be sensitive to noise in the input data, leading to inaccuracies in skeleton generation, especially in scenarios with incomplete or noisy image information.
A. Raza, A. M. Qadri, I. Akhtar, N. A. Samee and M. Alabdulhafith, "LogRF: An Approach to Human Pose Estimation Using Skeleton Landmarks for Physiotherapy Fitness Exercise Correction," in IEEE Access, vol. 11, pp. 107930-107939, 2023[4]	The LogRF approach demonstrated its usefulness in estimating human position estimation, outperforming state-of-the-art research. By selecting and keeping characteristics that make a significant contribution to human pose estimation, the LogRF technique presents a novel feature selection process that improves model performance.	One of the main drawback is its large feature dimensionality, which can have an impact on how well machine learning and deep learning techniques perform when estimating a person's stance. In addition, deep learning models' computational complexity is also a setback.

Paper Name	**Advantages**	**Disadvantages**
iYogacare: Real-Time Yoga Recognition and Self-Correction for Smart Healthcare[5]	Comparing angles in yoga poses simplifies assessing their similarity without complex math. It's user-friendly, offering immediate feedback on pose differences, aiding adjustments for better alignment These methods enables precise analysis and targeted corrections, using fewer resources for real-time feedback during sessions..	These methods primarily focuses on angular differences, potentially disregarding essential elements like body proportions or flexibility crucial for pose correctness and comfort. While angles detail joint alignment, they might not capture overall pose similarity
S. Deng et al., "LOGEN: Few-Shot Logical Knowledge-Conditioned Text Generation With Self-Training," in IEEE/ACM Transactions on Audio, Speech, and Language Processing, vol. 31, pp. 2124-2133, 2023[6]	Offers a novel approach to few-shot logical knowledge-conditioned text generation. Demonstrates improved performance compared to baselines. Iterative training process and components like the content consistency module contribute to ensuring the quality and consistency of the generated logical forms, enhancing the overall effectiveness of the approach.	Faces challenges in generating text with certain logic types, indicating potential struggles with numerical logic reasoning

Paper Name	Advantages	Disadvantages
Maji, Debapriya, et al. "Yolo-pose: Enhancing yolo for multi person pose estimation using object keypoint similarity loss." Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition. 2022.[7]	Performs multi-person pose estimation and joint detection in a single forward pass, eliminating the need for multiple inference steps. This efficiency results in faster processing times and lower computational complexity. Allows for end-to-end training, enabling the optimization of the Object Keypoint Similarity metric directly. This leads to improved model performance and better alignment with evaluation metrics.	YOLO-Pose is tailored to the YOLOv5 object detection framework, which may limit its adaptability to other architectures or datasets. This lack of flexibility could hinder the framework's applicability in diverse scenarios or research settings. May introduce challenges in scenarios where anchor points do not align well with the distribution of keypoints. This dependency could impact the model's ability to generalize effectively across diverse datasets or pose variations.

2.7.1 Gaps identified

1. **Customized Feedback**: AI yoga instructors may offer customized feedback based on the particular body type, degree of flexibility, and proficiency of each student.

2. **Continuous Learning**: Using machine learning to update and improve the AI model over time to make it more responsive to user preferences and input.

3. **Adaptability**: It may dynamically modify exercise regimens in response to advancements or unique user requirements.

4. **Language Options**: Providing support for several languages so that consumers worldwide may utilize the AI.

2.8 Conclusion

In conclusion, the area of human pose estimation has really developed over recent years demonstrated by an array of different models that have been considered in this review. The landscape of research from the traditional 2D pose estimation methods to the innovative LogRf approach based on skeleton landmarks and real time yogacare recognition system like iYogaCare is changing rapidly. The novelty of state-of-the art technologies like LOGEN, in which the features of few shot logical knowledge conditioned text generation are coalesced with self training highlights how interdisciplinary applications such as pose estimation can be. Efficiency in human pose estimation will undoubtedly depend on the combined efforts of different research methodologies and technologies, thereby opening up additional opportunities for progress toward enhancing computer-human interaction experiences from both societal and healthcare perspectives.

Chapter 3

Requirements

3.1 Hardware and Software Requirements

1 Hardware

- I5 Processor Computer
- Device with a Camera Unit
- GPU Unit

2 Software

- React (Front-End)
- Django (Back-End)
- Visual Studio Code
- Python
- Database-Mysql

Chapter 4

System Architecture

In this chapter, comprehensive overview is given that includes its architecture, design, module division, and a visual representation of the planned timeline through a Gantt Chart. The System Overview section provides a bird's-eye view, outlining the core components and their interactions. Following this, the Architectural Design section delves into the structure and organization of the system, elucidating the principles guiding its construction.

The Module Division segment breaks down the system into distinct modules, elucidating their specific functions and interconnections. To provide a tangible sense of project progression, the chapter concludes with a Work Schedule presented in the form of a Gantt Chart. This chart serves as a roadmap, detailing the planned timeline for the various project activities, ensuring a clear understanding of the anticipated milestones and their interdependencies.

4.1 System Overview

The proposed system aims to enhance the yoga practicing experience by seamlessly integrating advanced computer vision methods and machine learning algorithms for real-time pose estimation, detection, correction, and feedback generation. Leveraging the YOLOv8x-pose-p6 model, an extension of YOLOv8, the system enables accurate detection of 17 key points corresponding to various body parts crucial for yoga poses. This model serves as the cornerstone for subsequent processes, including pose detection, where a custom dataset of annotated images is utilized along with the YOLOv5 architecture for effective training and generalization. The pose correction module utilizes camera technology to detect and track key points or joints, facilitating the estimation of pose angles. By comparing these angles with standard ideal angles stored in the system's database, errors in the user's posture are identified, enabling targeted feedback generation. The Feedback Generation Module employs four fundamental components to provide rapid, tailored instruction for practitioners. This includes organizing and structuring incoming data, comparing detected angles with ideal angles, generating textual feedback, and converting it into audio format for seamless communication. Together, these components form a comprehensive framework that ensures a methodical flow of information, analysis, and communication, empowering practitioners to refine their postures with instantaneous corrections and subtle coaching, thereby enhancing their yoga practice.

4.2 Architectural Design

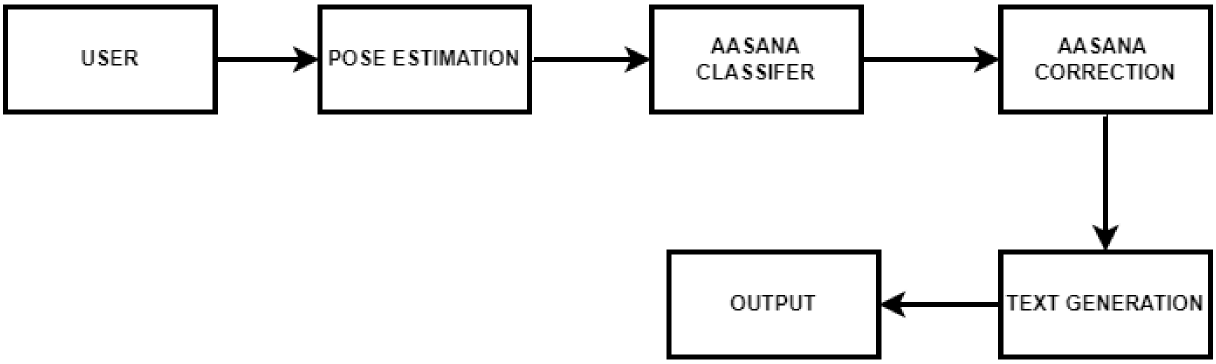


Figure 4.1: Architecture Diagram

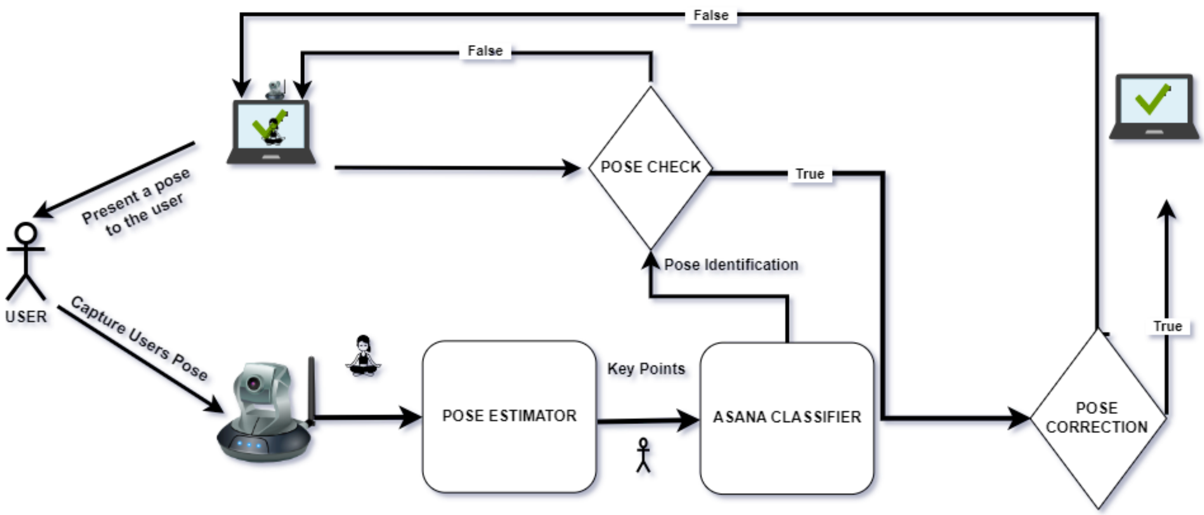
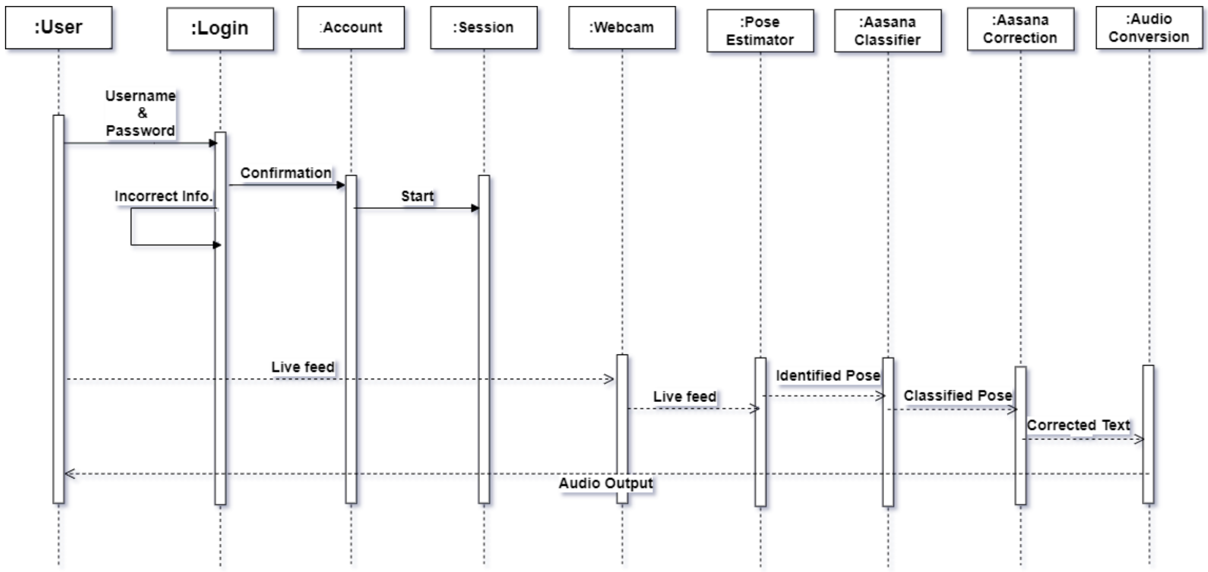
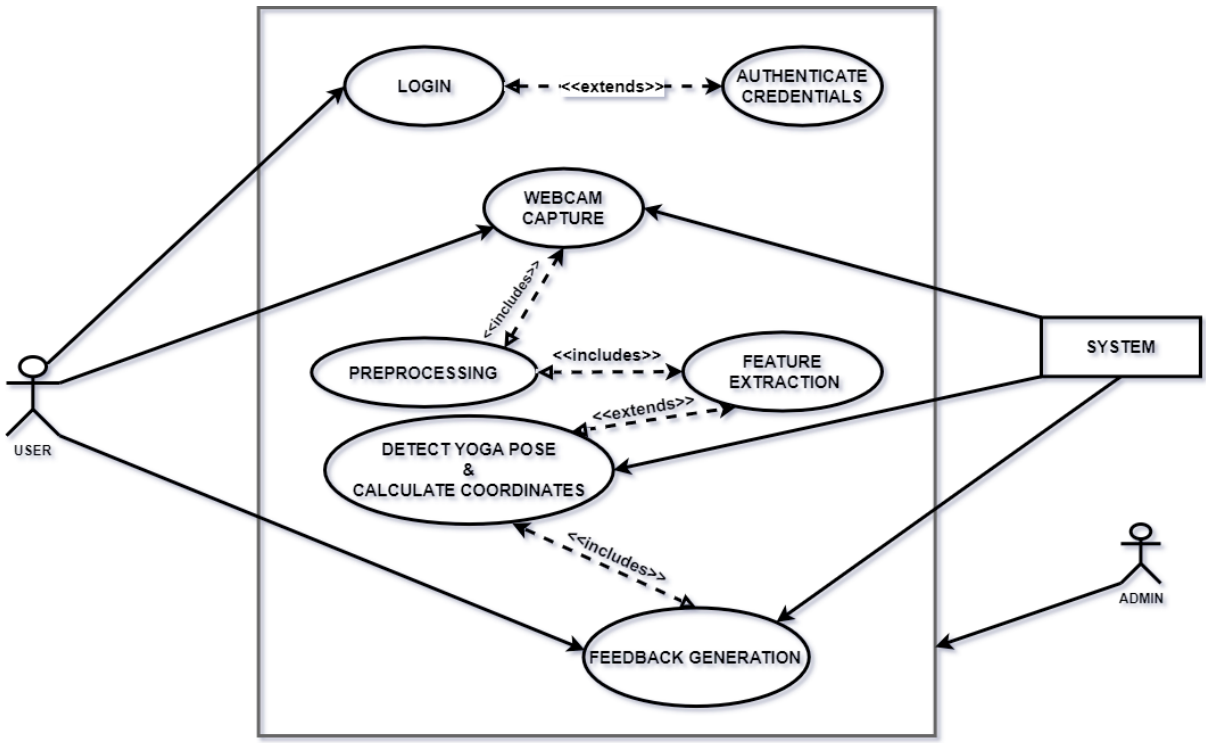


Figure 4.2: Workflow Diagram



(a) Sequence Diagram



(b) Use Case Diagram

Figure 4.3: Architectural Design

4.3 Module Division

4.3.1 Pose Estimation

Figure 4.4: Pose Estimation

The core methodology used in pose estimation lies in adoption and integration of YOLOv8x-pose-p6 model. This ar- chitecture, is an extension of YOLOv8, which integrates pose estimation capabilities into YOLO object detection model. This model helps in 17 keypoint detection of different body parts of the trainee. The keypoints including nose, eyes, ears, shoulders, elbows, wrists, hips, knees, and ankles. These keypoints would be further used for pose correction and com- parisons.In summary, our proposed methodology integrates the power of YOLOv8x-pose-p6 for pose estimation by seamlessly integrating object detection and keypoint estimation to deliver an accurate and efficient solution for real-time yoga pose estimation applications.

4.3.2 Pose Detection

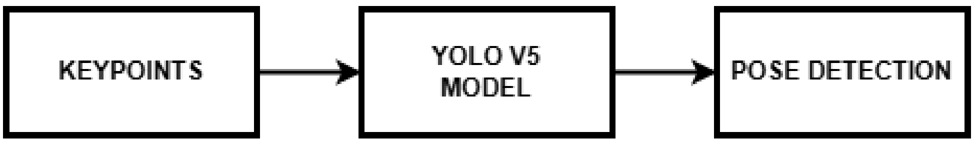


Figure 4.5: Pose Detection

For pose detection we collected a custom dataset consisting of images depicting individuals in various poses relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sir- sasana, Lolasana, Makara adho mukha svanasana, Mar- jaryasana, Mayurasana, Natarajasana, Padangusthasana, Pad- masana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation. . This division ensured that the model could generalize effectively to unseen data while being trained on a sufficiently diverse range of poses. We employed the YOLOv5 architecture, a state-of-the-art object detection framework, for pose detection tasks. The model was trained over 240 epochs using the training subset of our custom dataset. YOLOV5 architecture was chosen due to its speed in training such large datasetsof user movements and postures in the context of yoga practice.

4.3.3 Pose Correction

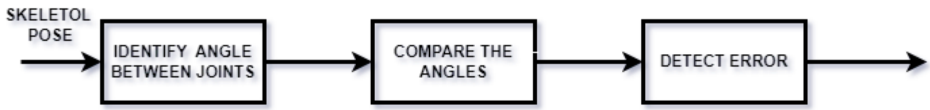


Figure 4.6: Pose Correction

The pose correction module works through the first step of detecting and tracking key points or joints of the user's body by either using camera technology. These keypoints detected include joints such as shoulders, elbows , hips and so forth . They form the basis with which they can estimate what pose certain body parts or angles between these parties. Later, the app compares these angles to standard ideal angles for different yoga positions stored in its database. Inorder to generate feedback based on the necessary correction, certain keywords and the degree to which correction has to be made is sent to feedback generation module

4.3.4 Feedback Generation

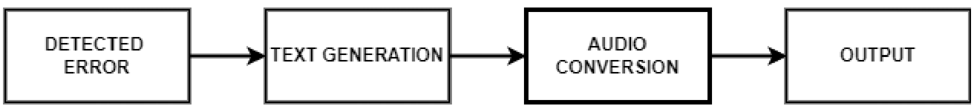


Figure 4.7: Feedback Generation

Four fundamental building pieces comprise the Feedback Generation Module, which aims to improve the user experience while practicing yoga. The Pose Correction Module provides keypoint and angle data to the module in the Input Block, which is where the module gets important information regarding recognized errors in yoga postures. The incoming data is then arranged and structured during the Preprocessing phase, readying it for in-depth examination. By comparing the received angles with the actual angles of the keypoints.In the Text Generation block the corresponding text will be returned by the function. In order to provide practitioners with rapid, tailored instruction, the Audio Conversion Block transforms the text-based feedback into an audio format. Yoga practitioners may refine their postures with instantaneous corrections and subtle coaching thanks to this all-inclusive framework, which ensures a methodical flow of information, analysis, and communication.

4.4 Work Schedule - Gantt Chart

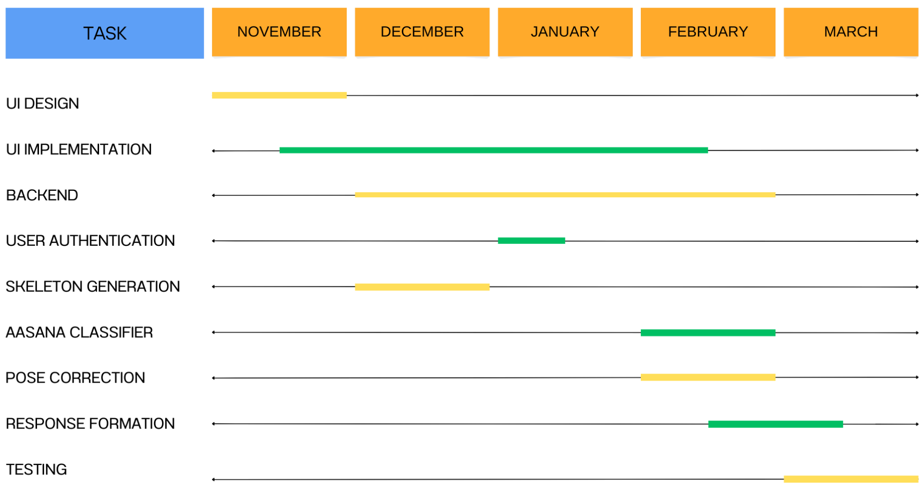


Figure 4.8: Gantt Chart

To sum up, this chapter thoroughly examined the important facets of our project, starting with a thorough System Overview that offered understanding of the overall design and operation. The section on Architectural Design examined the system's architecture and clarified the fundamental design ideas that influenced its creation. By breaking the system down into smaller, more manageable parts, Module Division clarified the functions and relationships between them.

The Gantt Chart ensures transparency and a clear execution roadmap by graphically outlining our tasks and deadlines. The foundation established thus far prepares the reader for a thorough examination of each component in the next sections.

4.5 Summary Of Chapter

This chapter outlines a system design, first providing a general overview of its purpose and functionalities. It then dives into the system's architecture and how its different modules will work together. The chapter further details the four main modules that the system will be divided into: Pose Estimation, Pose Detection, Pose Correction, and Feedback Generation . Each module's specific function is briefly explained.

Chapter 5

System Implementation

The system for real-time pose correction relies on a few main parts. Firstly, chose the right data to train our model. Next, we used YOLOv5 to estimate poses from images. A simple user interface is designed. Finally, set up a database to store information. To get good data, process images ahead of time. Our method combines deep learning with computer vision tricks. The interface lets users interact easily. The database keeps things organized. By combining these pieces, our system works well and keeps users engaged.

5.1 Datasets Identified

For pose detection we collected a custom dataset consisting of images depicting individuals in various poses relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sir- sasana, Lolasana, Makara adho mukha svanasana, Mar- jaryasana, Mayurasana, Natarajasana, Padangusthasana, Pad- masana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation.

5.2 Proposed Methodology/Algorithms

The method proposed for MatYogi is for user to send real-time yoga poses via the front-end interface. The live poses received at the backend system will then be processed and analyzed in real-time. The backend system seamlessly integrates four key functionalities: Pose Estimation, Pose Detection, Pose Correction, and Feedback.

5.2.1 Pose Estimation

The core methodology used in pose estimation lies in adoption and integration of YOLOv8x-pose-p6 model. This architecture, is an extension of YOLOv8, which integrates pose estimation capabilities into YOLO object detection model. This model helps in 17 keypoint detection of different body parts of the trainee. The keypoints including nose, eyes, ears, shoulders, elbows, wrists, hips, knees, and ankles. These keypoints would be further used for pose correction and comparisons.In summary, our proposed methodology integrates the power of YOLOv8x-pose-p6 for pose estimation by seamlessly integrating object detection and keypoint estimation to deliver an accurate and efficient solution for real-time yoga pose estimation applications.

5.2.2 Pose Detection

For pose detection we collected a custom dataset consisting of images depicting individuals in various poses relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sirsasana, Lolasana, Makara adho mukha svanasana, Marjaryasana, Mayurasana, Natarajasana, Padangusthasana, Padmasana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation. . This division ensured that the model could generalize effectively to unseen data while being trained on a sufficiently diverse range of poses. We employed the YOLOv5 architecture, a state-of-the-art object detection framework, for pose detection tasks. The model was trained over 240 epochs using the training subset of our custom dataset. YOLOV5 architecture was chosen due to its speed in training such large datasets.

5.2.3 Pose Correction

For pose detection we collected a custom dataset consisting of images depicting individuals in various poses relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sirsasana, Lolasana, Makara adho mukha svanasana, Marjaryasana, Mayurasana, Natarajasana, Padangusthasana, Padmasana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation. . This division ensured that the model could generalize effectively to unseen data while being trained on a sufficiently diverse range of poses. We employed the YOLOv5 architecture, a state-of-the-art object detection framework, for pose detection tasks. The model was trained over 240 epochs using the training subset of our custom dataset. YOLOV5 architecture was chosen due to its speed in training such large datasets.

In context of pose correction we utilised basic trignometric formulas to compare the angles of different joints between trainee and a standardised image used for comparison of different poses. The basic formulas utilized includes,

$angle = math.degrees(math.atan2(y3 - y2, x3 - x2) - math.atan(y1 - y2, x1 - x2))$

where (x1,y1) , (x2,y2) and (x3,y3) represent 3 adjacent key-points forming a joint.

5.2.4 Feedback

For feedback, we compare the angles between trainee and the standard image used for comparison which act as a trainer and corresponding text is returned by the correction module. The text returned by the module is converted into audio format by means of an API, which finally provides the output to the user as audio format.The correction is visible to the user through the screen.

5.3 User Interface Design

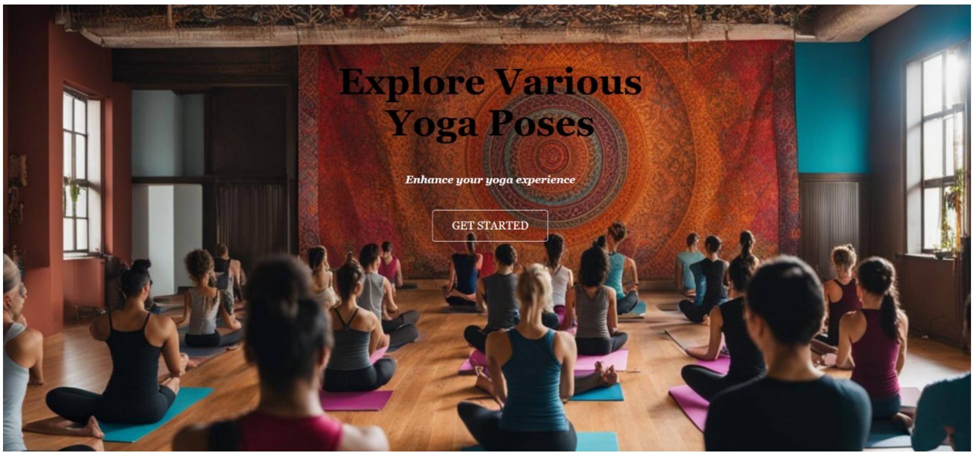


Figure 5.1: Landing Page

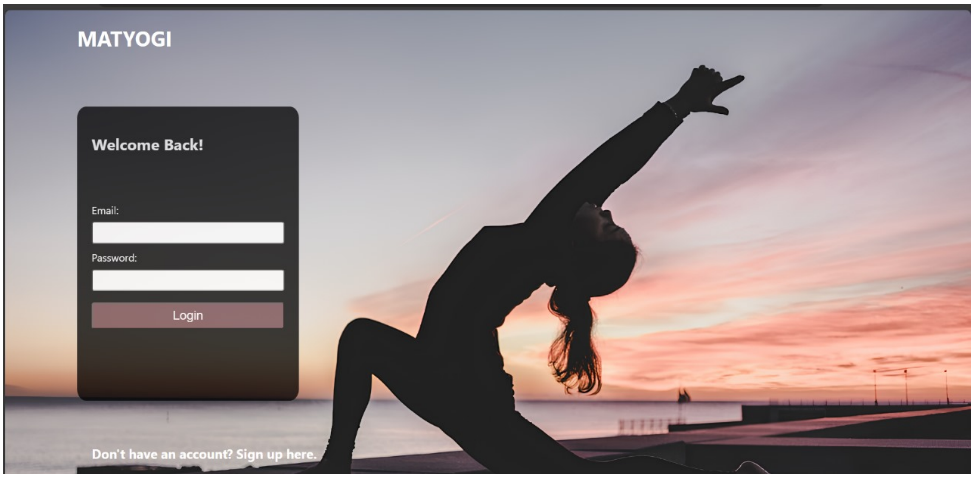


Figure 5.2: Authentication Page

Figure 5.3: Pose Selection

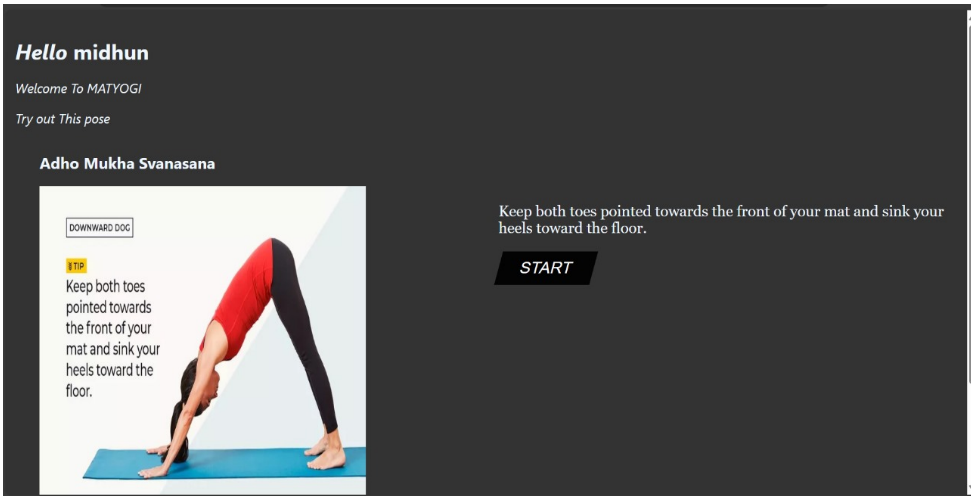


Figure 5.4: Pose Instruction

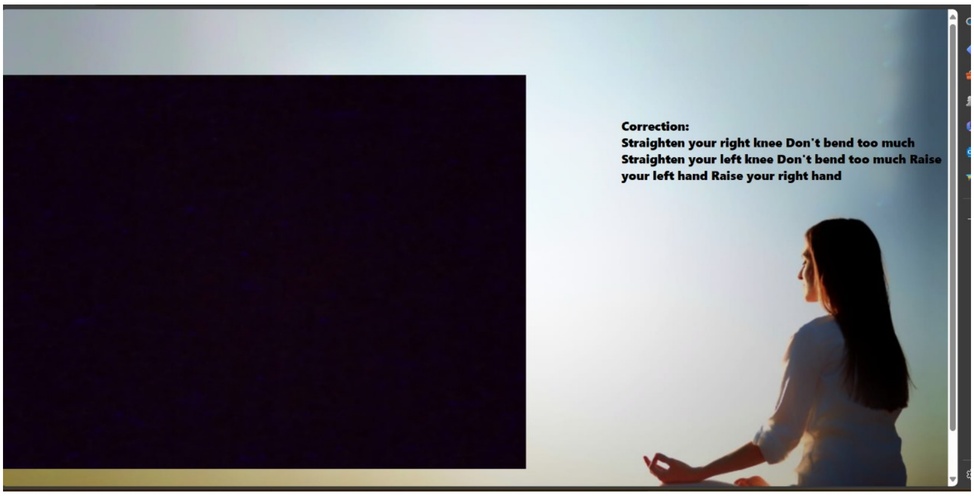


Figure 5.5: Pose Execution

5.4 Database Design

Noting its lightweight design, ease of installment, and python's compatibility is why SQLite is selected. SQLite has no need for a separate server process, allowing you to store the database in one single computer file, thus, making it very manageable for smaller applications. It is the best choice for apps with small to average traffic, simple data models, as this yoga related app appears to be. On top of this, SQLite is embedded in Django, thus, it facilitates the overall development cycle and eliminates the need of separate database management software during deployment.

- **UserSignup**: This table stores user signup information. Each user is identified uniquely by their email (`signupemail`). Other details such as name, password, and date of birth are also stored.
- **UserStatus**: This table maintains user status information. It tracks the user's level and whether they are a beginner. Each entry is associated with a user's email (`mail_id`).
- **Userpose**: This table stores information about different yoga poses. Each pose has a unique name (`poseName`). Other details such as image, description, level, and index number are also stored.

5.5 Summary Of Chapter

This section covers the system's implementation details. It starts by discussing the datasets identified for training the system . Then, it details the proposed methodologies and algorithms for each module: Pose Estimation, Pose Detection, Pose Correction, and Feedback Generation . Finally, it outlines the design for the user interface and the database .

5.6 Conclusion

Our system can fix your pose in real-time – here's how it works. Carefully chose the right data to train our model. Then, use an advanced technique called YOLOv5. This lets the system accurately recognize your pose. Also design an easy-to-use interface. And we built a solid database to store information. With these key parts working together, our system corrects posture effectively. You get a smooth experience and all the functionality you need.

Chapter 6

Results and Discussions

The system for fixing poses in real-time was built and tested. We checked its work using different data sets. The results and analysis are shown here and measured the system against some key metrics. This chapter talks about how well it did, where it struggled, and ways to make it better. Looking at this tech's pros and cons helps understand using it in the real world.

6.1 Overview

Highlighted the system's effectiveness in identifying and correcting user poses, supported by quantitative metrics such as accuracy, precision, and recall. Additionally, further analysis identifies trends and areas for improvement, providing valuable insights into the system's performance and potential enhancements.

6.2 Testing

6.2.1 Correct Yoga Pose Testing

The correct yoga pose testing phase validates the system's proficiency in accurately identifying and evaluating yoga postures,showcasing the system's ability to detect key body points such as shoulders, hips, and knees, and assess their alignment against predefined ideal angles.

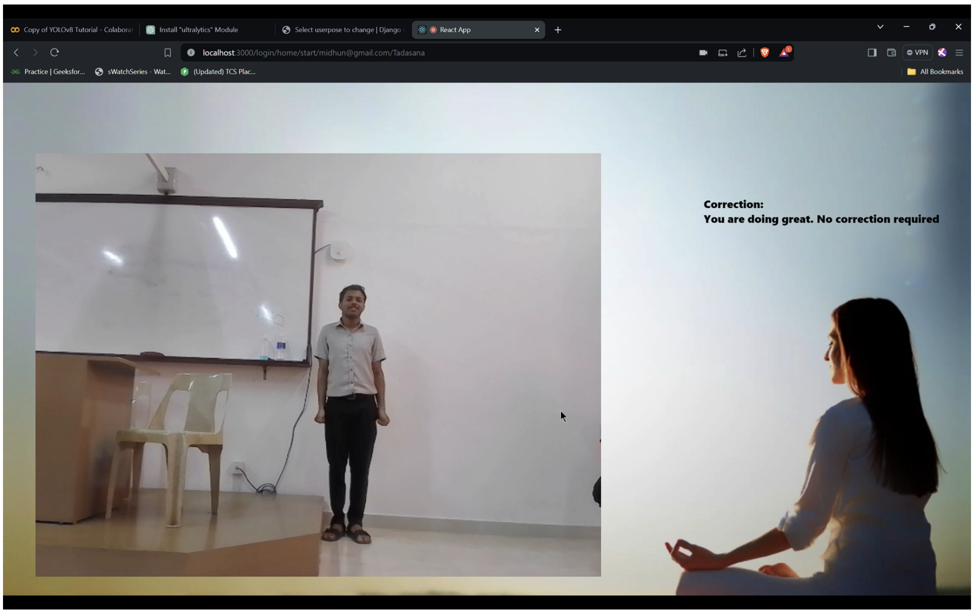


Figure 6.1: Correct Yoga Pose Testing

6.2.2 Incorrect Yoga Pose Testing

The incorrect yoga pose testing phase evaluates the system's ability to detect and address deviations from proper alignment in yoga postures. It portrays a scenario where the user's posture deviates from the ideal alignment, resulting in misalignments of key body points or angles.

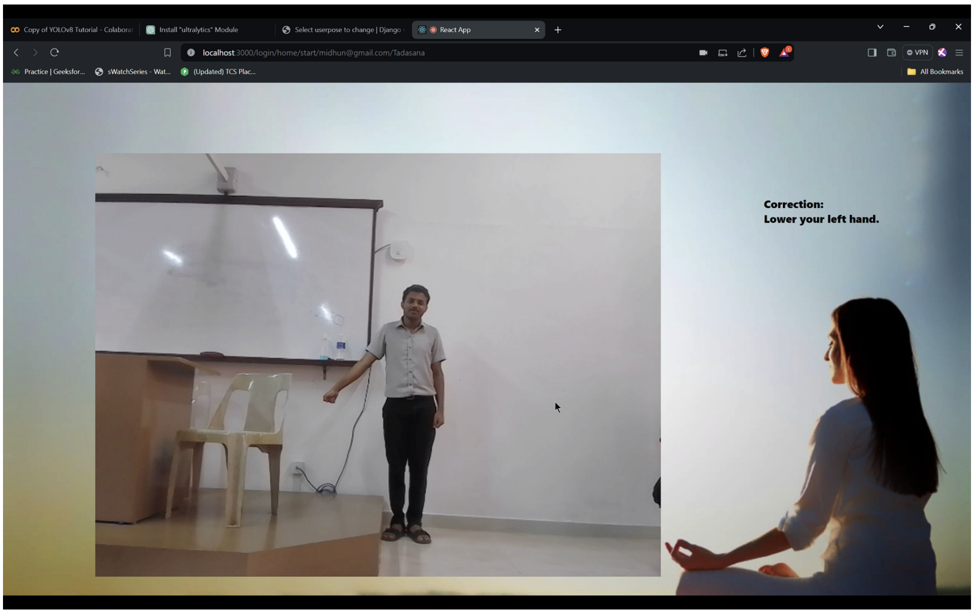


Figure 6.2: Incorrect Yoga Pose Testing

6.3 Quantitative Results

6.3.1 Confusion Matrix

The confusion matrix is a valuable tool for assessing the performance of our yoga pose detection model. It helps to gain insights about model's strengths and weaknesses, enabling us to make informed decisions for future iterations and improvements.The confusion matrix of model comprising of 50 classes are shown above. Most of the poses have been correctly identified by the model.

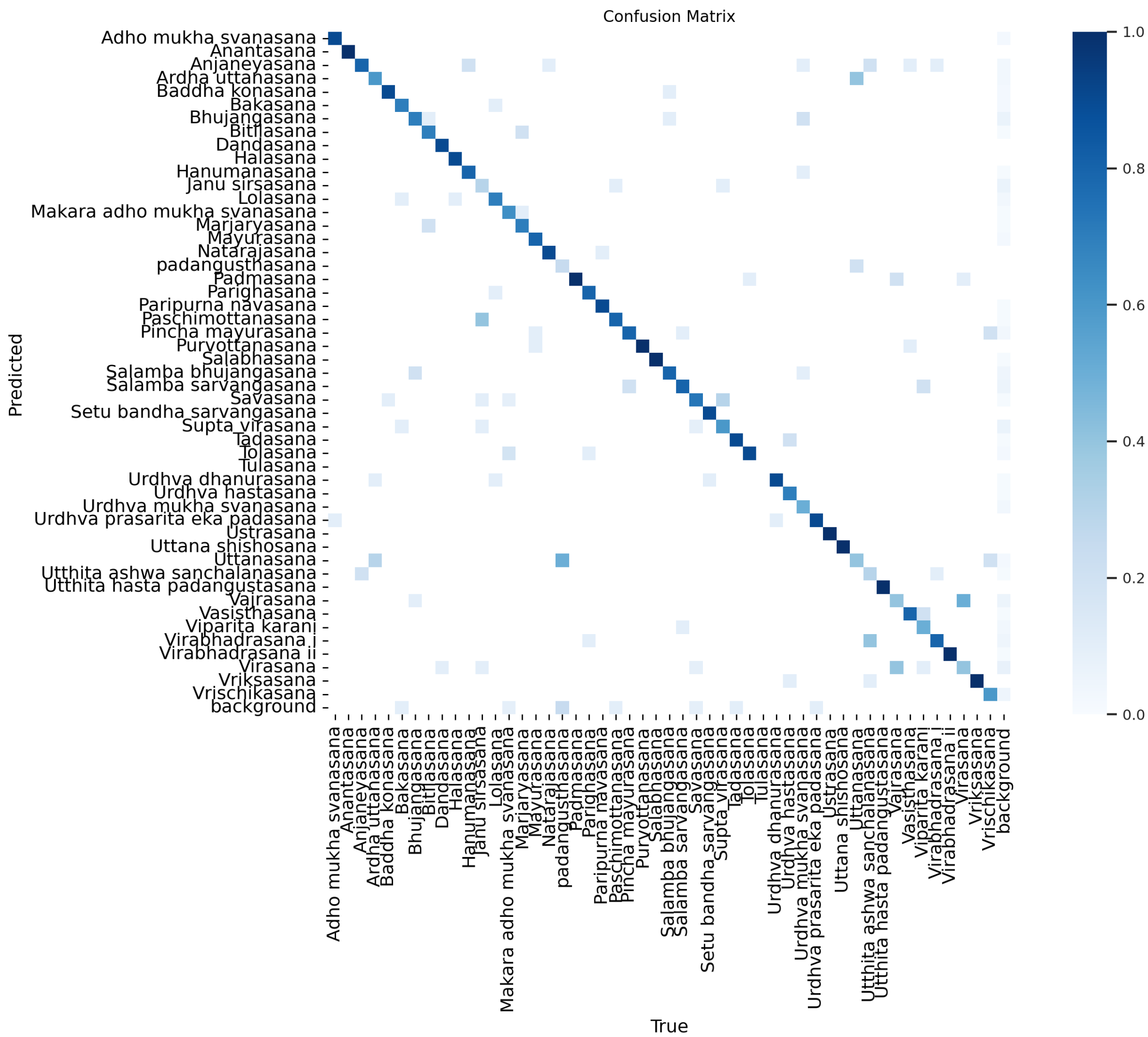


Figure 6.3: Confusion Matrix

6.3.2 F1 Curve

The F1 curve assists in selecting an optimal threshold value based on specific requirements such as, if precision and recall are of equal importance, we may choose the threshold that maximizes the F1 score.

Precision

Precision: Precision measures the proportion of true positive predictions out of all positive predictions made by the model. It is calculated as the ratio of true positives to the sum of true positives and false positives.

$Precision = \frac{TP}{TP+FP}$

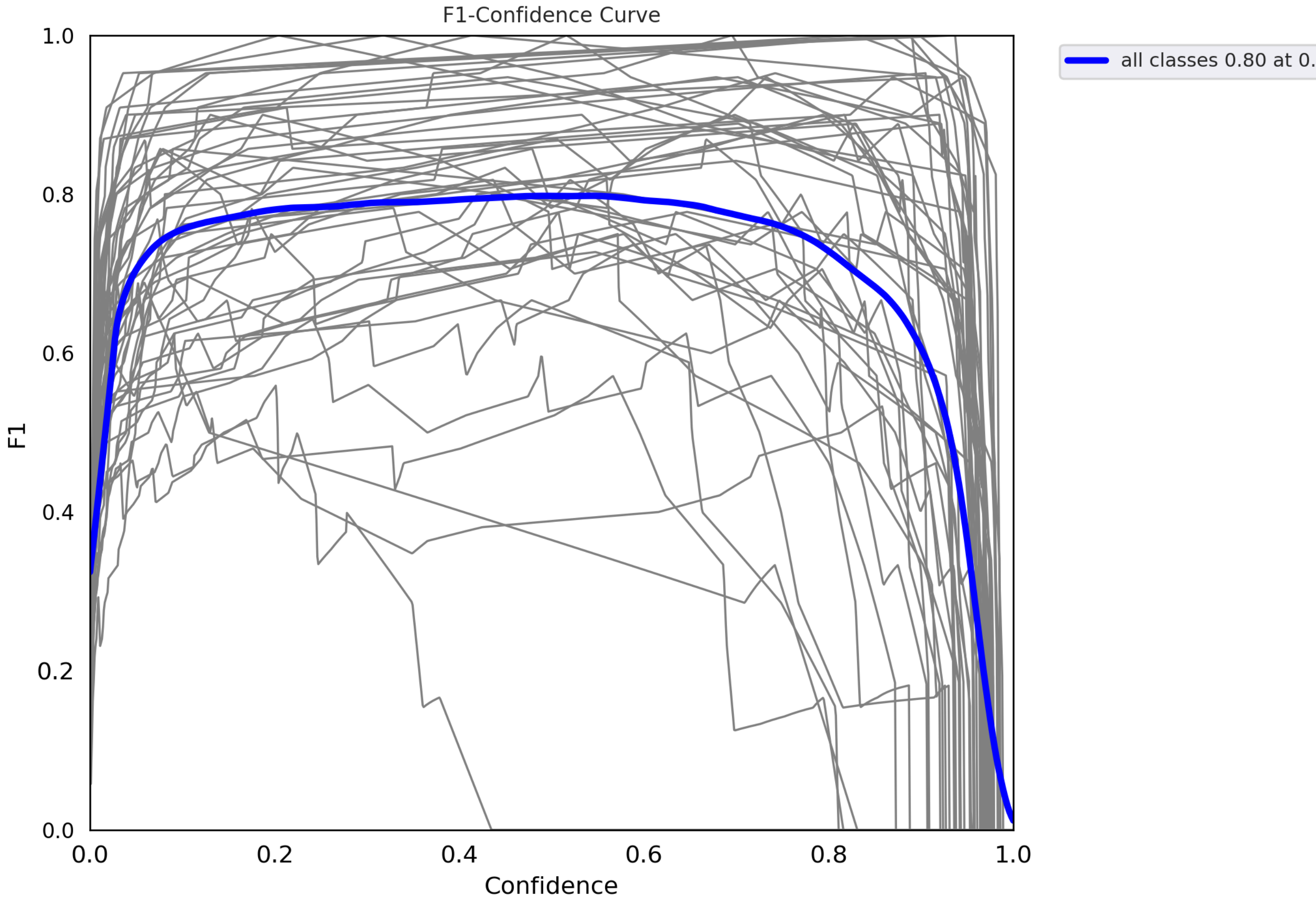


Figure 6.4: F1 Curve

Recall

Recall quantifies the model's ability to identify all relevant instances, capturing the proportion of true positives out of all actual positives. It is calculated as the ratio of true positives to the sum of true positives and false negatives.

$Recall = \frac{TP}{TP+FN}$

6.4 Summary Of Chapter

This section focuses on testing the system's effectiveness . It covers different testing procedures, including testing how well the system recognizes both correct and incorrect yoga poses . The expected outcome likely involves presenting quantitative results such as confusion matrices and F1 curves to analyze the system's accuracy .

6.5 Conclusion

To sum up, we have shown how great our real-time pose correction system works. We used numbers like accuracy, precision, and recall to prove it can identify and fix user poses. Looking closer, we found ways to make it even better. The main point is our results show how promising this system is for building healthy posture habits.

Chapter 7

Conclusions & Future Scope

The AI Yoga Tutor project, in summary, is an innovative combination of state-of-the-art technology designed to transform the yoga learning process. The system embodies a comprehensive and intelligent approach to yoga training with its carefully developed four-part architecture: Natural Language Processing (NLP)-driven Audio Feedback, Asana Classifier, Yoga Pose Correction, and Human Pose Estimation.

The project's core module, Human Pose Estimation, uses cutting-edge computer vision algorithms to accurately record and analyse users' yoga positions in real-time. Adding to this, the Asana Classifier makes use of machine learning algorithms to classify and identify the particular yoga poses being executed, guaranteeing a comprehensive comprehension of the practitioner's practice.

One important feature that stands out is the Yoga Pose Correction component, which produces insightful keywords that contain practical advice for improving the user's technique. By offering precise and tailored corrections, this cutting-edge function distinguishes the AI Yoga Tutor and enables users to perfect their positions.

By utilising Natural Language Processing, the system converts these produced keywords into grammatically correct and contextually aware sentences. This linguistic change improves the feedback's interpretability and harmonises with the user's natural understanding, resulting in a more productive and captivating learning environment.

Finally, the system creates an auditory feedback that translates these linguistically precise corrections into a conversation that is unique to the user. In addition to accommodating various learning methods and promoting a feeling of connection between the user and their AI yoga tutor, this dynamic audio interaction offers an intuitive way to convey corrections.

The AI Yoga Tutor project offers a comprehensive response to the difficulties associated with yoga education, capturing the spirit of intelligent and user-centric design. Beyond its technological capabilities, the project prioritises accessibility to enable people with different skill levels to take advantage of artificial intelligence's transformative potential on their path to better physical health and mindfulness. This project paves the way for a time in the future when artificial intelligence acts as a competent and encouraging guide in the pursuit of holistic health by representing a major step towards the harmonious fusion of technology and traditional wellness techniques.

In charting the future course of the AI Yoga Tutor, exciting enhancements promise to reshape the user experience.Social elements will create a friendly community where users can interact, exchange accomplishments, and take part in interesting challenges. By incorporating Virtual Reality (VR), the mindfulness experience is elevated through immersive yoga classes and guided meditations. Real-time feedback and tactile cues are provided by smart wearable integration, which improves the correcting process. Flexibility is ensured by the introduction of an offline mode, and ongoing accessibility enhancements accommodate a range of user abilities. The AI Yoga Tutor is being propelled into a dynamic realm of personalised wellbeing by these forward-thinking initiatives, which together provide users with a rich journey towards holistic health and mindfulness.

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Appendix A: Presentation

AI YOGA TUTOR

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George Jose
Midhun Mohan K.M
Naman Mathew George
....
GUIDE: Ms. Jisha Mary Jose

RSET

April 28, 2024

Contents

Problem Definition

- To address the challenges of ensuring proper postures, personalized guidance, and real-time corrections during yoga sessions, catering to the diverse needs of practitioners in a convenient and accessible manner there is a need for a real time AI Yoga tutor to provide a proper guidance and feedback for the people.

Project Objective

- **Yoga Pose Detection**:Utilizing state-of-the-art computer vision algorithms to track and identify the user's body positions.
- **Yoga Pose Analysis**: Employing machine learning models to assess the alignment, balance, and correctness of the user's poses.
- **Personalized Feedback:** Offering real-time feedback to the user, suggesting adjustments to enhance their yoga practice.
- **Progress Tracking**: Allowing users to monitor their improvement over time, setting achievable goals, and tracking their yoga journey.
- **User-Friendly Interface**: Developing an intuitive web application for easy accessibility and usability

Novelty Of Idea and Scope Of Implementation

User-Friendly Interface: An intuitive interface simplifies the user experience, accommodating individuals with varying levels of technical proficiency.

Wide Range of Poses: The application supports detection and correction of a diverse array of yoga poses, accommodating practitioners of various styles and difficulty levels.

Real-time Pose Detection and Correction: The application offers immediate feedback on yoga poses by detecting and correcting them in real-time during practice sessions.

Audio Feedback: Corrections are delivered in audio format, enhancing the user experience during live yoga sessions

Literature Survey

Algorithm	Architecture	Single/Muti-Person	Top-down/Bottom-up
DeepPose[1]	AlexNet	Single person	Top-down
HRNet[1]	ResNet	Multi-person	Bottom-up
ConvNets [2]	VGGNet	Single person	Top-down
Convolutional Pose Machines[3]	VGG structure	Single person	Top-down
DeeperCut[4]	ResNet	Single person	Bottom-up
Stacked Hourglass Networks [5]	ResNet	Multi-person	Bottom-up

Literature Survey-Pose estimation

Reference papers	Insights
LogRF Approach to Human Pose Estimation Using Skeleton Landmarks[6]	Proposed LogRF for feature selection, achieving top-tier results. Random forest with the top 20 features outperformed, yielding a high score of 0.998, surpassing state-of-the-art studies.
Pose estimation of construction equipment using computer vision and deep learning techniques[7]	Defined and annotated keypoints on equipment full body poses in collected images. Trained three deep learning networks (Hourglass, Cascaded Pyramid, Ensemble of Hourglass and Cascaded Pyramid) using our annotated pose dataset.
Body Joint Guided 3-D Deep Convolutional Descriptors for Action Recognition[8]	In this model the body joint guided feature pooling is conveniently formulated as a bilinear product operation.
Shape-Aware Human Pose and Shape Reconstruction Using Multi-View Images[9]	Proposed to use the Skinned Multi-Person Linear (SMPL) model, which uses Principal Component Analysis (PCA) coefficients to represent human body shapes and poses.
Implementation of Machine Learning Technique for Identification of Yoga Poses[10]	Extracted joint coordinates and angles using tf-pose algorithm, utilizing the angles as features for machine learning models. Tested various models, and Random Forest classifier demonstrated the highest accuracy.

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Literature Survey-Pose Correction

Research Paper	Insights
iYogacare: Real-Time Yoga Recognition and Self-Correction for Smart Healthcare[11]	Different mathematics formulas are used,such as Cosine rule and Euclidean distance.
Real-time Pose Estimation for Human-Robot Interaction[12]	Any joint of the human body is represented by three key points. The cosine angle between two vectors a, b is calculated by Cosine Similarity. The two vectors are the body part of the individual
A Comparison of the Instructor-Trainee Dance Dataset Using Cosine similarity, Euclidean distance, and Angular difference[13]	The similarity between a vector pair of each body part of the instructor and the trainees was then determined using Cosine similarity
Yoga Correction Using Machine Learning[14]	The angle between joints is calculated using their individual slope with respect to horizontal and their sum is added
Yoga Pose Estimation using Artificial Intelligence[15]	The angle between the joints are computed using the cosine inverse of cosine similarity.

Literature Survey-Text Generation

Models	Insights
TableGPT [17]	Poor performance observed without logic guidance Highlights the crucial role of logical forms for accurate and logical text generation
Seq2seq+att [19]	Utilizes sequence-to-sequence model with attention mechanism Tends to generate low-quality text, especially in few-shot settings
BART [18]	Not easily adaptable for generation tasks Limitations due to bidirectional encoder and autoregressive
GPT-2 [20]	Outperforms other methods in all few-shot settings Challenges in informativity and logic may lead to lower scores
LOGEN [16]	Integrates content and structure for effective logical and high-quality text generation Consistently outperforms in informativity, logic, and readability

Proposed Method

- A responsive web app utilizes live webcam video input to detect yoga postures.
- The video is converted into frames and processed by a skeletal generator, which creates a pose format.
- This format is then classified using a trained model, and angles are analyzed to offer corrective suggestions.
- Users receive guidance through audio prompts for a seamless experience.

Architecture Diagram

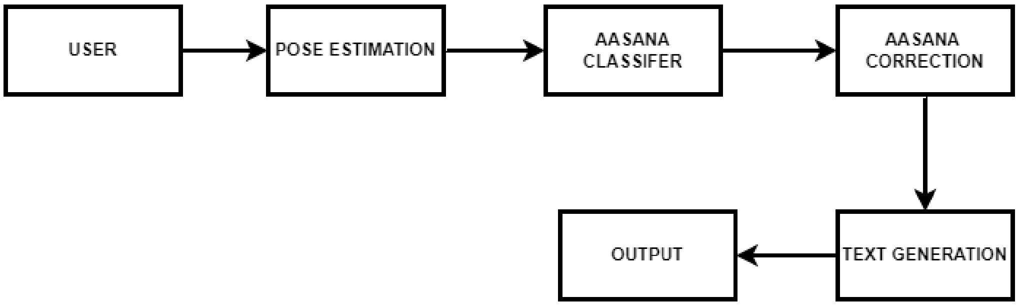

Figure 1: Architecture Diagram

Usecase Diagram

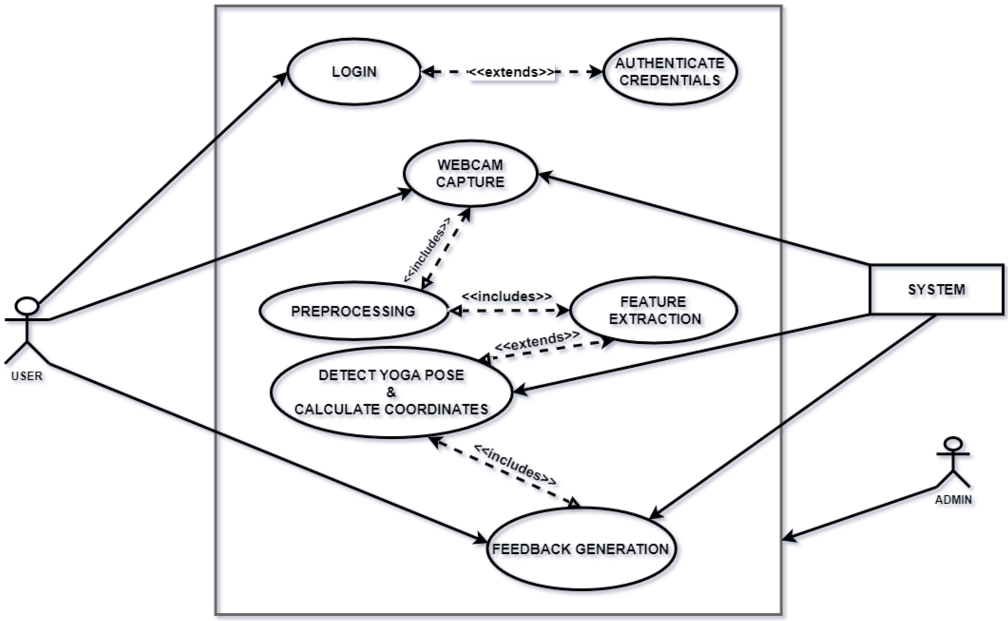

Figure 2: Usecase Diagram

Sequence Diagram

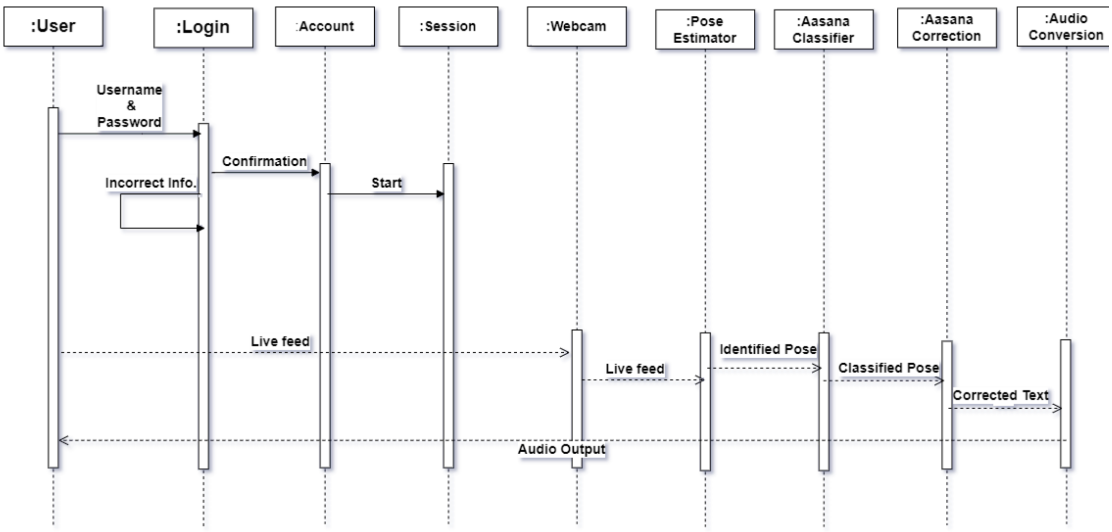

Figure 3: Sequence Diagram

Work Flow Diagram

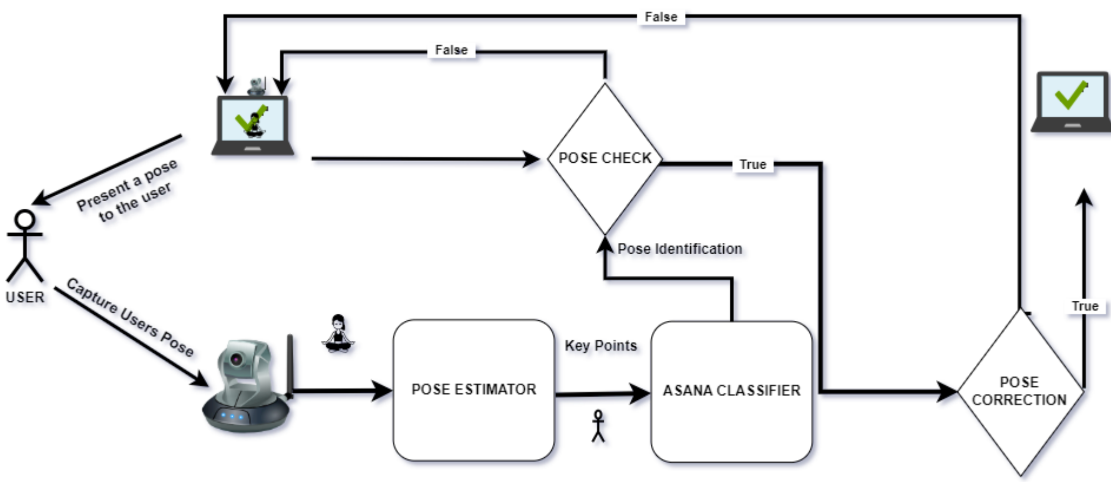

Figure 4: Workflow Diagram

Modules

1 Pose Estimation
2 Pose Detection
3 Pose Correction
4 Feedback

Pose Estimation

Figure 5: Module 1

Pose Detection

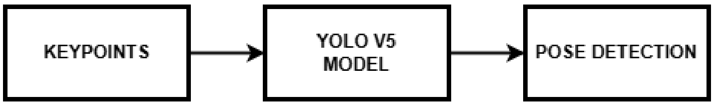

Figure 6: Module 2

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Aasana Correction

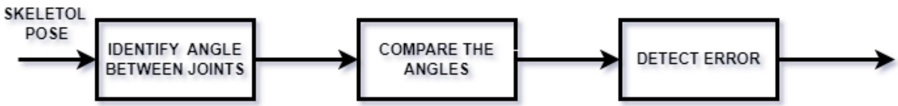

Figure 7: Module 3

Feedback

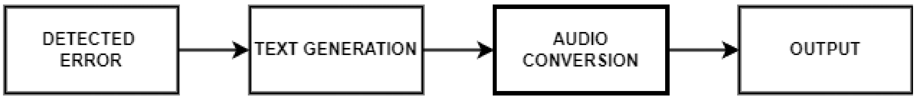

Figure 8: Module 4

Results

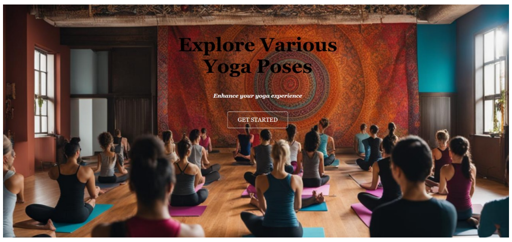

Figure 9: Landing Page

Figure 10: Login Page

Results

Figure 11: Pose Selection

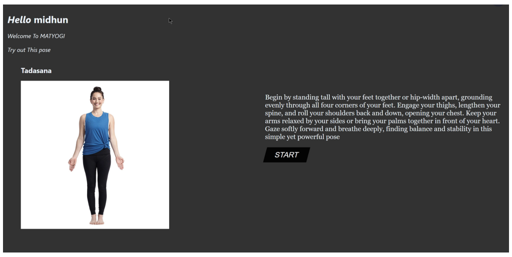

Figure 12: Pose Instruction

Results

Figure 13: Correct Pose

Results

Figure 14: Incorrect Pose

Work breakdown and Responsibility

GEORGE JOSE	NAMAN MATHEW GEORGE	M S RAHUL	MIDHUN MOHAN K M
Database	Assana Classifier	Pose Correction	Text Generation and conversion to audio
API,URL(Django)	UI design	Datasets	React Structure

Figure 15: Work Breakdown

Conclusion

The system proposed to detect and correct yoga poses has to be implemented. The features from the image has to be extracted to obtain the coordinates of each joint and then the angle is obtained using that coordinates.The feedback and guidance has to be provided in audio format.

Future Scope

- **Improved Accuracy:** AI advancements, especially in computer vision and deep learning, could boost the precision of yoga pose detection by understanding human postures across diverse body types and movements.
- **Personalized Recommendations:** AI systems could analyze practitioners' progress and offer tailored suggestions, adjusting poses to meet individual needs or limitations.
- **Enhanced Accessibility:** AI-driven algorithms could adapt yoga poses to make them accessible for individuals with impairments or barriers to traditional classes.

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Thank You

Appendix B: Research Paper

MatYogi: Real-time Yoga Pose Detection and Correction Using CNN Techniques

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***Abstract*—Nowadays the availability of personalised yoga trainers is not practical always. Hence AI based yoga trainers can be implemented. MatYogi is such a system which is based on CNN techniques for real-time yoga posture detection and correction. While most of the existing models have capability to identify limited number of poses, MatYogi is notable for its ability to recognize more than 40 different positions. This broadened range enhances the yoga application's multi-functionality for different types of yoga practice. The system uses YOLOv5 for pose detection because of its fast speed for training and analyzing objects within images. Besides, YOLOv8 is also used in pose estimation that gives you exact pose estimation of yogic postures. The system contains a pose correction mechanism that uses basic trigonometric formulas, comparing sample pose images with the user camera. The MatYogi application uses these techniques of providing instant feedback on yoga poses, therefore enabling the adoption of better form and alignment during practice.**

***Index Terms*—Pose detection, Pose correction , Image Analyzing , Dataset Matching , CNN , YOLO**

I. Introduction

In the realm of human pose correction and detection, the fusion of computer vision techniques with deep learning methodologies [5]has revolutionized the landscape, offering novel solutions for enhancing human-computer interaction and physical performance monitoring. In this context, our research focuses on leveraging Convolutional Neural Network (CNN) techniques for matyogi: pose correction and detection. Yoga is an age old practice from India, is arguably the most prominent method of maintaining fitness for its combination of mental, physical and spiritual approaches. Yoga is evolving its branches and seeping into different cultures and lifestyles as technology evolves. We see modern tech [15]applications such as digital platforms and many other yoga-apps promoting mindful living increase in popularity. In specific, combining the latest computer vision as well as the machine learning approaches open up the possibility of some new levels of the evolution of an individual's engagement with yoga. The modern technology mostly makes the general selection of CNNs for pose detection and assessment. Nevertheless, they finally establish their parameters in most of the recognized postures. Recognizing this small-pit, our work the paper is about MatYogi, an intelligent real-time yoga posture detection and correction tool that solves these problems.That is, MatYogi is a solution capable of detecting more than 40 yoga poses which gives not only a holistic solution for regular practitioners and differently skilled yogis but also for professionals who practice the yoga of all styles. The main principle in designing the system, the utilization of YOLOv5 for pose prediction. YOLOv5 stands out for its efficacy and precision, that is probably the greatest fit of every type of yoga practice with its diversity and specificity. Firstly, MatYogi applies YOLOv8 algorithm for pose detection as well as identification, enabling it to get hold of the exact pose even in complex cases. In addition, it has built-in check of the mechanism following the Law of Sines that allows immediate comparison of two photos taken with different angle to the same aiming point. As such, this mechanism paves the way for yogis to amend the flaws in their postures and body alignment in real-time, thus improving their yoga performance and decreasing the possibility of sustaining injuries.

II. Related Work

The distinctive of MatYogi not only delivering accurate pose detection and correction but also designing games bond with yoga for the purpose of giving attention and motivation to the users to exercise yoga habitually By applying the principles of gamification, MatYogi turns the yoga space into a more engaging and satisfying one through elements such as challenges, rewards, progress tracking, and interactive tutorials. Through this gamification concept, it includes a sense of amusement and enthusiasm and also plays a role in getting you consistent and serious to a daily yoga routine.

Contrarily, other methods [1] emphasize machine learning for pose identification and feedback, while the key difference of MatYogi lies in its holistic and on-the-fly pose detection and correction. The MatYogi not only recognizes a wider range of yoga asanas but also implements a pose correction system which is based on trigonometry formulas aiding users to build-up the correct alignment and positioning. This is how MatYogi stands out with its proactive approach to common concerns in yoga practice by alignment, thus safety and protection of injuries, this is the reason of why MatYogi is a safety reliable companion for yoga effectively.

Likewise, [2]although other methods have vision-based techniques that use features such as Openpose for pose segmentation and identification, MatYogis ability to recognize almost 40 positions of yoga refers to beginners as well as the seasoned yogis. Moreover, gamification components played a role in building user engagement and motivation by means of challenges, rewards, and progress tracking, therefore, providing a cheerful place for individuals regardless of their backgrounds.

One method [3] depends on computer vision technology as a pose estimation tool where the limitation in user interaction and engagement as in MatYogi is not highlighted. The MatYogi's well-designed user interface including game like elements provide the users with the motivation of accomplishment, feedback, as well as progression that further encourage the consistent usage and commitment to daily yoga routine.

In a nutshell, the major distinct feature of MatYogi is the integration of holistic approach, adopting advanced technology, promoting safe practice and improvement, and using innovation design which grants end users a universal platform both enjoyable and useful.

III. Proposed Methodology

The method proposed for MatYogi is for user to send real-time yoga poses via the front-end interface. The live poses received at the backend system will then be processed and analyzed in real-time. The backend system seamlessly integrates four key functionalities: Pose Estimation, Pose Detection, Pose Correction, and Feedback.

A. Pose Estimation

The core methodology used in pose estimation lies in adoption and integration of YOLOv8x-pose-p6 model [8] [10]. This architecture, is an extension of YOLOv8, which

Fig. 1. Pose Estimation

integrates pose estimation capabilities into YOLO object detection model. This model helps in 17 keypoint detection [9] of different body parts of the trainee. The keypoints including nose, eyes, ears, shoulders, elbows, wrists, hips, knees, and ankles. These keypoints would be further used for pose correction and comparisons.In summary, our proposed methodology integrates the power of YOLOv8x-pose-p6 for pose estimation by seamlessly integrating object detection and keypoint estimation to deliver an accurate and efficient solution for real-time yoga pose estimation applications.

B. Pose Detection

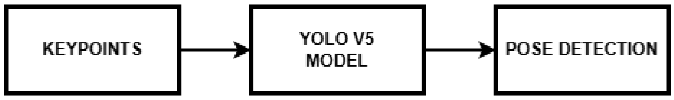

Fig. 2. Pose Detection

For pose detection we collected a custom dataset [4] consisting of images depicting individuals in various poses relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes [7] Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sirsasana, Lolasana, Makara adho mukha svanasana, Marjaryasana, Mayurasana, Natarajasana, Padangusthasana, Padmasana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation. . This division ensured that the model could generalize effectively to unseen data while being trained on a sufficiently diverse range of poses. We employed the YOLOv5 architecture, a state-of-the-art object detection framework, for pose detection tasks. The model was trained over 240 epochs using the training subset of our custom dataset. YOLOV5 architecture was chosen due to its speed in training such large datasets.

C. Pose Correction

For pose detection [11] we collected a custom dataset consisting of images depicting individuals in various poses

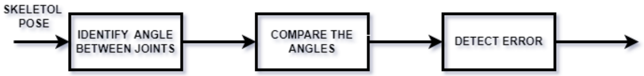

Fig. 3. Pose Correction

relevant to our application domain from kaggle. Each image was meticulously annotated with bounding boxes encompassing the pose regions of interest. The different poses for training includes Adho mukha svanasana, Anantasana, Anjaneyasana, Ardha uttanasana, Baddha konasana, Bakasana, Bhujangasana, Bitilasana, Dandasana, Halasana, Hanumanasana, Janu sirsasana, Lolasana, Makara adho mukha svanasana, Marjaryasana, Mayurasana, Natarajasana, Padangusthasana, Padmasana, Parighasana, Paripurna navasana, Paschimottanasana, Pincha mayurasana, Purvottanasana, Salabhasana, Salamba bhujangasana, Salamba sarvangasana, Savasana, Setu bandha sarvangasana, Supta virasana, Tadasana, Tolasana, Trdhva dhanurasana, Trdhva hastasana, Urdhva mukha svanasana, Urdhva prasarita eka padasana, Ustrasana, Uttana shishosana, Uttanasana, Utthita ashwa sanchalanasana, Utthita hasta padangustasana, Vajrasana, Vasisthasana, Viparita karani, Virabhadrasana i, Virabhadrasana ii, Virasana, Vriksasana, Vrischikasana. There was total of almost 2500 images used for training and almost 500 images used for validation. . This division ensured that the model could generalize effectively to unseen data while being trained on a sufficiently diverse range of poses. We employed the YOLOv5 architecture, a state-of-the-art object detection framework, for pose detection tasks. The model was trained over 240 epochs using the training subset of our custom dataset. YOLOV5 architecture was chosen due to its speed in training such large datasets.

In context of pose correction we utilised basic trignometric formulas to compare the angles of different joints between trainee and a standardised image used for comparison of different poses. The basic formulas utilized includes, [13] $angle = math.degrees(math.atan2(y3 - y2, x3 - x2)\text{-} math.atan(y1 - y2, x1 - x2))$

where (x1,y1) , (x2,y2) and (x3,y3) represent 3 adjacent key-points forming a joint.

D. Feedback

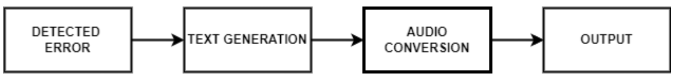

Fig. 4. Feedback Generation

For feedback, we compare the angles [?] between trainee and the standard image used for comparison which act as a trainer and corresponding text is returned by the correction module. The text returned by the module is converted into audio format by means of an API, which finally provides the output to the user as audio format.The correction is also visible to the user through the screen. Highlighted the system's effectiveness in identifying and correcting user poses, supported by quantitative metrics such as accuracy, precision, and recall. Additionally, further analysis identifies trends and areas for improvement, providing valuable insights into the system's performance and potential enhancements.

IV. Results and Dicussions

A. Correct Yoga Pose Testing

The correct yoga pose testing phase validates the system's proficiency in accurately identifying and evaluating yoga postures,showcasing the system's ability to detect key body points such as shoulders, hips, and knees, and assess their alignment against predefined ideal angles.

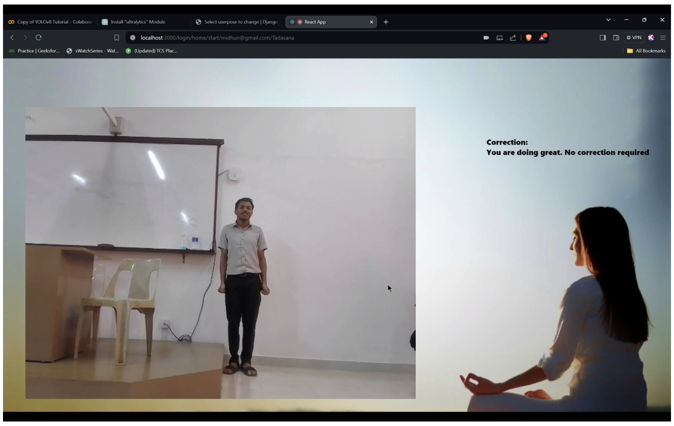

Fig. 5. Correct Yoga Pose Testing

B. Incorrect Yoga Pose Testing

The incorrect yoga pose testing phase evaluates the system's ability to detect and address deviations from proper alignment in yoga postures. It portrays a scenario where the user's posture deviates from the ideal alignment, resulting in misalignments of key body points or angles.

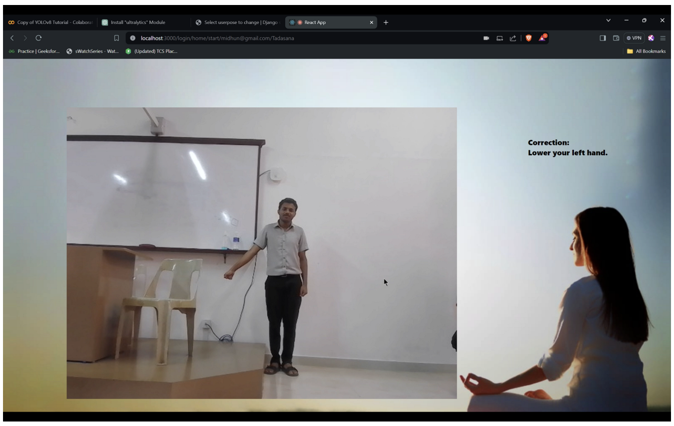

Fig. 6. Incorrect Yoga Pose Testing

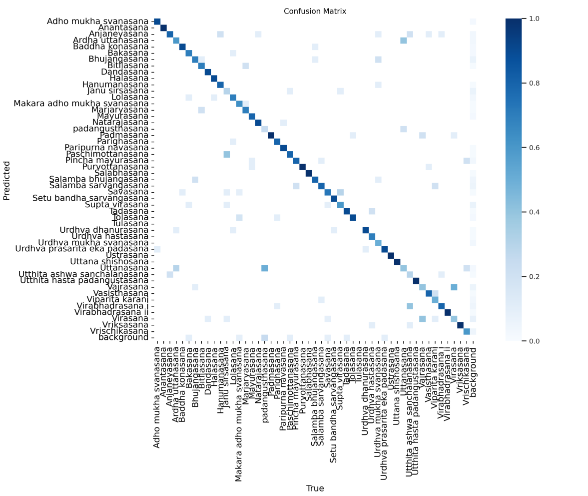

Fig. 7. Confusion Matrix

C. Quantitative Results

1) Confusion Matrix: The confusion matrix is a valuable tool for assessing the performance of our yoga pose detection model. It helps to gain insights about model's strengths and weaknesses, enabling us to make informed decisions for future iterations and improvements.The confusion matrix of model comprising of 50 classes are shown above. Most of the poses have been correctly identified by the model.

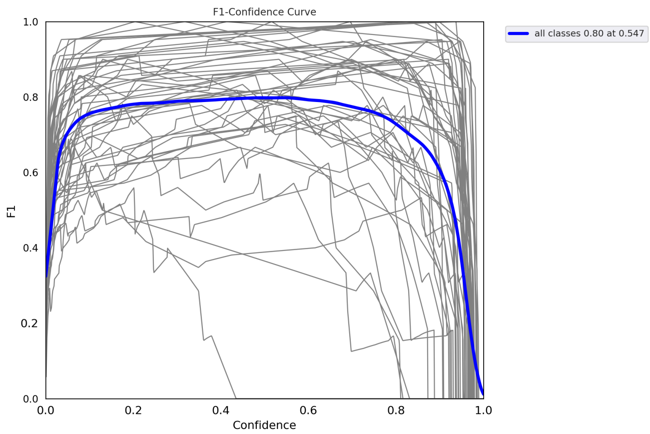

Fig. 8. F1 Curve

2) F1 Curve: The F1 curve assists in selecting an optimal threshold value based on specific requirements such as, if precision and recall are of equal importance, we may choose the threshold that maximizes the F1 score.

3) Precision: Precision: Precision measures the proportion of true positive predictions out of all positive predictions made by the model. It is calculated as the ratio of true positives to the sum of true positives and false positives.
$Precision = \frac{TP}{TP+FP}$

4) Recall: Recall quantifies the model's ability to identify all relevant instances, capturing the proportion of true positives out of all actual positives. It is calculated as the ratio of true positives to the sum of true positives and false negatives.
$Recall = \frac{TP}{TP+FN}$

V. CONCLUSION

In conclusion, the MatYogi system given here shows a drastic advancement in terms of real time yoga pose detection and correction,giving us the capability to recognise a wide range of yoga poses,close to 40 in total.By encompassing and utilizing CNN techniques and integrating YOLOv5 and YOLOv8 architectures,MatYogi provides users with a holistic approach to yoga practice, promoting safe and effective movements. The system's well-designed user interface, incorporating game-like elements, enhances user engagement and motivation, fostering consistent usage and commitment to a daily yoga routine.With the help of pose estimation, detection, correction, and feedback functionalities, MatYogi demonstrates an accurate and efficient solution for real-time yoga pose estimation applications.All together MatYogi stands out with its ability to combine modern computer vision technologies with traditional yoga practices,offering users a universal platform that is both enjoyable and beneficial for improving form, alignment, and overall yoga experience.

VI. FUTURE SCOPE

The future prospect of AI Yoga Tutor goes beyond reformation of yoga education and healthy practices, it paves the path of a new path for the health and well being. Via thoughtful adjustments and forward-looking ideas, the program intends to offer users a whole and unique trip in which they can seek holistic health and being mindful.

The pivotal factor should be labeled social integration in this particular case - In doing so, the Accelerate app helps the users to communicate and collaborate with the like-minded and share about their achievements and also, challenges. In addition to influencing the overall motivation it promotes the creation of an ecosystem that allows for nurture of the aspirations and advancement of people.

VR, i.e., the digital integration of VR, steals the show when it comes to bettering the variety and types of experiences in the immersive yoga experience. Users will have the ability to engage in virtual yoga sessions as well as guided meditation where they will be able to meditate in the real-world while transcending the negative thoughts in their mind. However, VR has the unique ability to do more than just visualize; it gives a profound sensation of being there at the actual event and completely captivates viewer.

Also, integration of smart wearable within the learning ecosystem provides additional and more precise feedback for learners. In comparison to standard activity trackers on your smartphone, real-time data from wearables indeed offers you the chance to accept informative feedback that can facilitate the process of perfecting a new technique and reaching your best performance ever. Wearable devices provide physical cues through tactile cues, making the educational process more practical and interactive. This sensory stimulation should be used in tandem with verbal and visual means of providing feedback.

Along with these technological advancements, the project worker will make all the users capable irrespective of their disabilities and take care of their needs The provision of an offline mode makes it possible for the users to go through the yoga session at any time of day or night, anywhere else. Furthermore, the ongoing accessibility development is thought for the different needs and preferences of the users.

For all, the future of the AI Yoga Tutor project is the uniting of the latest tech with a traditional set-up for the well being and creating a yoga experience with more emotion and transformation.

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Appendix C: Vision, Mission, Programme Outcomes and Course Outcomes

Vision, Mission, Programme Outcomes and Course Outcomes

Institute Vision

To evolve into a premier technological institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

Institute Mission

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

Department Vision

To become a centre of excellence in Computer Science and Engineering, moulding professionals catering to the research and professional needs of national and international organizations.

Department Mission

To inspire and nurture students, with up-to-date knowledge in Computer Science and Engineering, ethics, team spirit, leadership abilities, innovation and creativity to come out with solutions meeting societal needs.

Programme Outcomes (PO)

Engineering Graduates will be able to:

1. Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and Team work: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

10. Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

Programme Specific Outcomes (PSO)

A graduate of the Computer Science and Engineering Program will demonstrate:

PSO1: Computer Science Specific Skills
The ability to identify, analyze and design solutions for complex engineering problems in multidisciplinary areas by understanding the core principles and concepts of computer science and thereby engage in national grand challenges.

PSO2: Programming and Software Development Skills
The ability to acquire programming efficiency by designing algorithms and applying standard practices in software project development to deliver quality software products meeting the demands of the industry.

PSO3: Professional Skills
The ability to apply the fundamentals of computer science in competitive research and to develop innovative products to meet the societal needs thereby evolving as an eminent researcher and entrepreneur.

Course Outcomes (CO)

Course Outcome 1: Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: Apply).

Course Outcome 2: Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: Apply).

Course Outcome 3: Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: Apply).

Course Outcome 4: Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: Apply).

Course Outcome 5: Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: Analyze).

Course Outcome 6: Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: Apply).

Appendix D: CO-PO-PSO Mapping

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	2	2	2	1	1	1	1	2	3		
CO2	2	2	2		1	3	3	1	1		1	1		2	
CO3									3	2	2	1			3
CO4					2			3	2	2	3	2			3
CO5	2	3	3	1	2							1	3		
CO6					2			2	2	3	1	1			3

3/2/1: high/medium/low

JUSTIFICATIONS FOR CO-PO MAPPING & CO-PSO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
100003/ CS722U.1-PO1	M	Knowledge in the area of technology for project development using various tools results in better modeling.
100003/ CS722U.1-PO2	M	Knowledge acquired in the selected area of project development can be used to identify, formulate, review

		research literature, and analyze complex engineering problems reaching substantiated conclusions.
100003/ CS722U.1-PO3	M	Can use the acquired knowledge in designing solutions to complex problems.
100003/ CS722U.1-PO4	M	Can use the acquired knowledge in designing solutions to complex problems.
100003/ CS722U.1-PO5	H	Students are able to interpret, improve and redefine technical aspects for design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
100003/ CS722U.1-PO6	M	Students are able to interpret, improve and redefine technical aspects by applying contextual knowledge to assess societal, health and consequential responsibilities relevant to professional engineering practices.
100003/ CS722U.1-PO7	M	Project development based on societal and environmental context solution identification is the need for sustainable development.
100003/ CS722U.1-PO8	L	Project development should be based on professional ethics and responsibilities.
100003/ CS722U.1-PO9	L	Project development using a systematic approach based on well defined principles will result in teamwork.

100003/ CS722U.1-PO10	M	Project brings technological changes in society.
100003/ CS722U.1-PO11	H	Acquiring knowledge for project development gathers skills in design, analysis, development and implementation of algorithms.
100003/ CS722U.1-PO12	H	Knowledge for project development contributes engineering skills in computing & information gatherings.
100003/ CS722U.2-PO1	H	Knowledge acquired for project development will also include systematic planning, developing, testing and implementation in computer science solutions in various domains.
100003/ CS722U.2-PO2	H	Project design and development using a systematic approach brings knowledge in mathematics and engineering fundamentals.
100003/ CS722U.2-PO3	H	Identifying, formulating and analyzing the project results in a systematic approach.
100003/ CS722U.2-PO5	H	Systematic approach is the tip for solving complex problems in various domains.
100003/ CS722U.2-PO6	H	Systematic approach in the technical and design aspects provide valid conclusions.

100003/ CS722U.2-PO7	H	Systematic approach in the technical and design aspects demonstrate the knowledge of sustainable development.
100003/ CS722U.2-PO8	M	Identification and justification of technical aspects of project development demonstrates the need for sustainable development.
100003/ CS722U.2-PO9	H	Apply professional ethics and responsibilities in engineering practice of development.
100003/ CS722U.2-PO11	H	Systematic approach also includes effective reporting and documentation which gives clear instructions.
100003/ CS722U.2-PO12	M	Project development using a systematic approach based on well defined principles will result in better teamwork.
100003/ CS722U.3-PO9	H	Project development as a team brings the ability to engage in independent and lifelong learning.
100003/ CS722U.3-PO10	H	Identification, formulation and justification in technical aspects will be based on acquiring skills in design and development of algorithms.
100003/ CS722U.3-PO11	H	Identification, formulation and justification in technical aspects provides the betterment of life in various domains.
100003/ CS722U.3-PO12	H	Students are able to interpret, improve and redefine technical aspects with mathematics, science and

		engineering fundamentals for the solutions of complex problems.
100003/ CS722U.4-PO5	H	Students are able to interpret, improve and redefine technical aspects with identification formulation and analysis of complex problems.
100003/ CS722U.4-PO8	H	Students are able to interpret, improve and redefine technical aspects to meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
100003/ CS722U.4-PO9	H	Students are able to interpret, improve and redefine technical aspects for design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
100003/ CS722U.4-PO10	H	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for better products.
100003/ CS722U.4-PO11	M	Students are able to interpret, improve and redefine technical aspects by applying contextual knowledge to assess societal, health and consequential responsibilities relevant to professional engineering practices.
100003/ CS722U.4-PO12	H	Students are able to interpret, improve and redefine technical aspects for demonstrating the knowledge of, and need for sustainable development.

100003/ CS722U.5-PO1	H	Students are able to interpret, improve and redefine technical aspects, apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
100003/ CS722U.5-PO2	M	Students are able to interpret, improve and redefine technical aspects, communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
100003/ CS722U.5-PO3	H	Students are able to interpret, improve and redefine technical aspects to demonstrate knowledge and understanding of the engineering and management principle in multidisciplinary environments.
100003/ CS722U.5-PO4	H	Students are able to interpret, improve and redefine technical aspects, recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
100003/ CS722U.5-PO5	M	Students are able to interpret, improve and redefine technical aspects in acquiring skills to design, analyze and develop algorithms and implement those using high-level programming languages.
100003/ CS722U.5-PO12	M	Students are able to interpret, improve and redefine technical aspects and contribute their engineering skills in

		computing and information engineering domains like network design and administration, database design and knowledge engineering.
100003/ CS722U.6-PO5	M	Students are able to interpret, improve and redefine technical aspects and develop strong skills in systematic planning, developing, testing, implementing and providing IT solutions for different domains which helps in the betterment of life.
100003/ CS722U.6-PO8	H	Students will be able to associate with a team as an effective team player for the development of technical projects by applying the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
100003/ CS722U.6-PO9	H	Students will be able to associate with a team as an effective team player to Identify, formulate, review research literature, and analyze complex engineering problems
100003/ CS722U.6-PO10	M	Students will be able to associate with a team as an effective team player for designing solutions to complex engineering problems and design system components.
100003/ CS722U.6-PO11	M	Students will be able to associate with a team as an effective team player, use research-based knowledge and research methods including design of experiments, analysis and interpretation of data.

100003/ CS722U.6-PO12	H	Students will be able to associate with a team as an effective team player, applying ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
100003/ CS722U.1-PSO1	H	Students are able to develop Computer Science Specific Skills by modeling and solving problems.
100003/ CS722U.2-PSO2	M	Developing products, processes or technologies for sustainable and socially relevant applications can promote Programming and Software Development Skills.
100003/ CS722U.3-PSO3	H	Working in a team can result in the effective development of Professional Skills.
100003/ CS722U.4-PSO3	H	Planning and scheduling can result in the effective development of Professional Skills.
100003/ CS722U.5-PSO1	H	Students are able to develop Computer Science Specific Skills by creating innovative solutions to problems.
100003/ CS722U.6-PSO3	H	Organizing and communicating technical and scientific findings can help in the effective development of Professional Skills.