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Department of Computer Science and Engineering
Data Science

An Application based Data-Driven AI Fitness Trainer integrating Deep Learning Algorithms and Computer Vision

Group No. 15

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Project Guide

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Contents

Abstract

Generic workout routines, lack of personalized advice, and time management issues often lead to ineffective workouts and frustration. The AI Fitness Trainer addresses this issues by offering personalized recommendations through Deep Neural Networks (MLP), tailored to each user's fitness goals. It combines Mediapipe, CVzone, and CNN for advanced pose estimation with real-time feedback from a voice assistant. Additionally, users can track progress and performance through a dashboard and leaderboard, ensuring an engaging and effective fitness experience.

Introduction

- Modern fitness enthusiasts seek personalized guidance to achieve their unique health and fitness goals, but traditional programs often lack the adaptability to cater to individual needs, leading to decreased motivation and inconsistent results.
- Existing fitness solutions, such as mobile apps and wearable devices, typically offer generic workout plans and manual tracking, failing to deliver the personalized, real-time feedback necessary for effective workouts and goal achievement.
- Inadequate personalization, lack of real-time feedback, and low user engagement are persistent challenges in current fitness solutions.
- A dynamic and interactive fitness solution is needed to address these limitations and provide precise, personalized guidance.

Motivation

- Traditional fitness programs offer generic advice and manual tracking, lacking personalization for individual health conditions, goals, and progress.
- The AI Fitness Trainer uses artificial intelligence and real-time data analysis to provide personalized recommendations and instant feedback, improving user engagement and fitness outcomes.

Objectives

1. To provide real-time feedback on exercise form, gesture, posture, and accuracy percentage, as well as to detect and track exercises performed, calculate calories burned, and address user slacking off during workouts using deep learning-powered human pose estimation, computer vision technologies and convolutional neural networks (CNNs).

2. To provide personalized workout routines based on the user's health conditions, age, fitness - based goals using a deep learning-based Multilayer Perceptron network.

3. To create a dynamic and customizable diet plan tailored to the user's health conditions, age, preferences, height, weight, and allergies using a deep learning-based Multilayer Perceptron network.

4. To generate comprehensive weekly performance reports by integrating data from workouts and diet recommendations using data aggregation, descriptive statistics, and data visualization techniques, and to enhance user engagement and motivation through a system that allows users to log their progress and participate in leaderboards.

Literature Review

The literature review is presented in the sequence illustrated in the figure: AI Fitness Trainer, Recommendation Engine, and Subscription Model with Payment Integration.

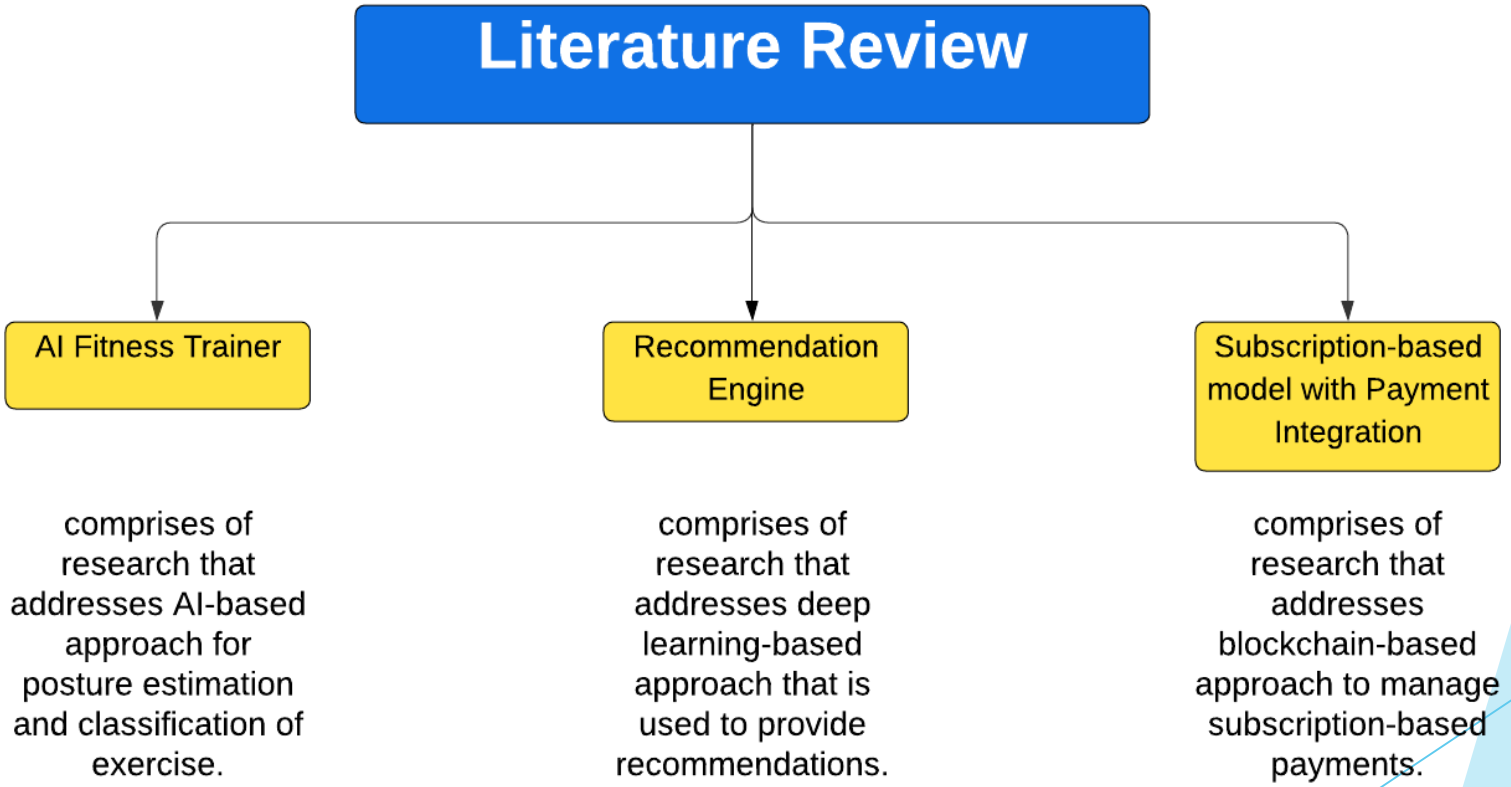


Figure 1: Categorized literature review

Literature Review

Sr.no	Title	Author(s)	Year	Methodology	Drawback
1	Robust Intelligent Posture Estimation for an AI Gym Trainer using Mediapipe and OpenCV [1]	Venkata Sai P Bhamidipati Ishi Saxena Mrs. D. Saisanthiya Mrs. D. Saisanthiya Dr. Mervin Retnadhas	2023	The paper presents an AI-based approach for posture estimation in gym workouts. It utilizes a combination of real-time video processing, keypoint detection, and pose estimation techniques. The system was tested on various exercises to evaluate accuracy.	Limited to predefined exercises: The system may not perform well with exercises or movements outside the trained dataset. Dependence on good lighting and camera quality: Performance may degrade in poor lighting or with low-resolution cameras.
2	AI Trainer: Autoencoder Based Approach for Squat Analysis and Correction [2]	Mukundan Chariar Shreyas Rao Aryan Irani Shilpa Suresh C S Asha	2023	This paper presents a method for classifying squat types and recommending the right squat version. This study uses MediaPipe and a deep learning-based technique to decide if squatting is good or bad.	Limited to squats: The system may not perform well with exercises or movements outside the trained dataset.
3	A Framework for Recognition and Prediction of Human Motions in Human-Robot Collaboration Using Probabilistic Motion Models [3]	Thomas Callens, Tuur van der Have Sam Van Rossom Joris De Schutter Erwin Aertbeli	2020	This paper presents a framework for recognition and prediction of ongoing human motions. The predictions generated by this framework could be used in a controller for a robotic device, enabling the emergence of intuitive and predictable interactions between humans and a robotic collaborator.	The performance of the phase speed estimation module was rather low. Limited to certain domain only considering the aspects of the paper revolve around robotic devices.
4	Real-Time Short-Range Human Posture Estimation Using mmWave Radars and Neural Networks [4]	Han Cui Naim Dahnoun	2022	The system can provide an accurate posture estimate of the person in real-time at 20 fps, with a mean localisation error of 12.2 cm and an average precision of 71.3%.	Hardware requirements limit the system from exploring the software specifications that may be more widely used.

Sr.no	Title	Author(s)	Year	Methodology	Drawback
5	DAN: a deep association neural network approach for personalization recommendation [5]	Xu-na WANG Qing-mei TAN	2020	This paper propose a feedforward deep neural network recommendation method, called the deep association neural network (DAN), which is based on the joint action of multiple categories of information, for implicit feedback recommendation.	The research predicts the interaction between all features by matrix decomposition. Yet, in actual situations, there is no interaction between some features.
6	Deep learning for recommendation systems [6]	Badiâa Dellal-Hedjazi Zaiai Alimazighi	2020	This paper proposes a deep learning-based recommendation system using MLP, combining demographic and content-based filtering to improve accuracy and speed.	The algorithm used in the research paper provides recommendations but they may not be personalized due to the increased computational complexity.
7	An Embedding-based Deep Learning Approach for Movie Recommendation [7]	Ram Murti Rawat Vikrant Tomar Vinay Kumar	2020	This paper proposes a recommendation system using deep learning and embedding techniques. The system is evaluated using RMSE and MAE metrics.	MLP can solve more complex tasks by adding a large number of neurons and layers for processing. However, it will increase the computation time.
8	An Efficient Hybrid Recommendation Model With Deep Neural Networks [8]	Zhenhua Huang Chang Yu Juan Ni Hai Liu Chun Zeng Yong Tang	2019	The paper introduces a Deep Metric Factorization Learning (DMFL) model combining deep learning, factorization machines, and metric learning, using SDAE-FM and DNN to generate personalized recommendations.	Struggles with sparse datasets, affecting effectiveness. Increased computational demands reduce real-time efficiency.
9	A hybrid recommender system using Multi Layer Perceptron Neural Network [9]	Didar Divani Sanandaj Sasan H. Alizadeh	2018	This paper proposes a hybrid recommender system combining collaborative filtering and content-based filtering with an artificial neural network (ANN) to address the cold-start problem.	Due to the use of ANN with hybrid recommendation system it affects the accuracy of the model, which can be improved further.

Sr.no	Title	Author(s)	Year	Methodology	Drawback
10	Subscription-Based Data-Sharing Model Using Blockchain and Data as a Service [10]	Fahad Ahmad Al-Zahrani	2020	The paper proposes a data-sharing model that uses blockchain for secure, transparent transactions and a subscription-based system for data access. It combines blockchain technology for decentralized data management with a Data as a Service (DaaS) model to provide on-demand data access, addressing privacy, ownership, and trust issues in digital data-sharing.	Integrating blockchain technology with existing data-sharing infrastructures. Blockchain systems can face scalability issues due to their consensus mechanisms and the need to process and store large volumes of data across decentralized nodes.
11	State of the Art: Secure Mobile Payment [11]	Wenzheng Liu Xiaofeng Wang Wei Peng	2019	The paper "State of the Art: Secure Mobile Payment" presents a comprehensive review of secure mobile payment technologies. It analyzes various security protocols and techniques employed to protect mobile transactions, including encryption methods, authentication mechanisms, and secure communication protocols.	Advanced security protocols can be complex and may require significant changes to existing systems.
12	BlockSubPay - A Blockchain Framework for Subscription-Based Payment in Cloud Service [12]	Yustus Eko Oktian Elizabeth N. Witanto Sandra Kumi Sang-Gon Lee	2019	The "BlockSubPay" methodology involves establishing a blockchain network to manage subscription-based payments in cloud services. It utilizes smart contracts to automate payment agreements and ensure secure, transparent, and traceable transactions.	Implementing blockchain and smart contracts requires technical expertise, making it challenging for organizations without prior experience.
13	BPDS: A Blockchain based Privacy-Preserving Data Sharing for Electronic Medical Records [13]	Jingwei Liu Xiaolu Li Lin Ye Hongli Zhang Xiaojiang Du Mohsen Guizani	2018	The methodology involves blockchain framework to securely and privately share electronic medical records. It uses a decentralized ledger for tamper-proof access management, incorporates encryption and zero-knowledge proofs for privacy, and utilizes smart contracts for automated access control and auditing.	Adoption of blockchain-based systems may be slow due to the need for stakeholders to adapt to new technologies and processes.

Research Gap (Limitations of existing systems)

- Limited Exercise Variety: Existing systems, like those using Mediapipe, are often restricted to specific exercises, limiting their ability to handle diverse workouts.
- Environmental Dependence: Current posture estimation systems rely on factors like lighting and camera quality, reducing effectiveness in varied conditions.
- Challenges in Real-Time Feedback: While real-time posture correction exists, integrating it with accurate exercise tracking and feedback remains a challenge.
- High Computational Demand: Deep learning models, such as MLP, face issues with scalability and real-time application due to high computational requirements.
- Limited Personalization: Many systems lack dynamic, real-time personalization based on user preferences and evolving fitness levels.
- These gaps in the existing systems present opportunities that the AI Fitness Trainer addresses by providing dynamic progress tracking, real-time feedback, and enhanced personalization. This results in a more engaging and effective fitness solution.

Problem Definition

The goal of the Data-Driven AI Fitness Trainer project is to develop a comprehensive fitness solution that leverages artificial intelligence to provide personalized workout and diet recommendations, track user progress, and offer real-time feedback. The system aims to enhance user engagement and motivation through data-driven insights and advanced technologies while integrating secure subscription-based access to manage various service tiers.

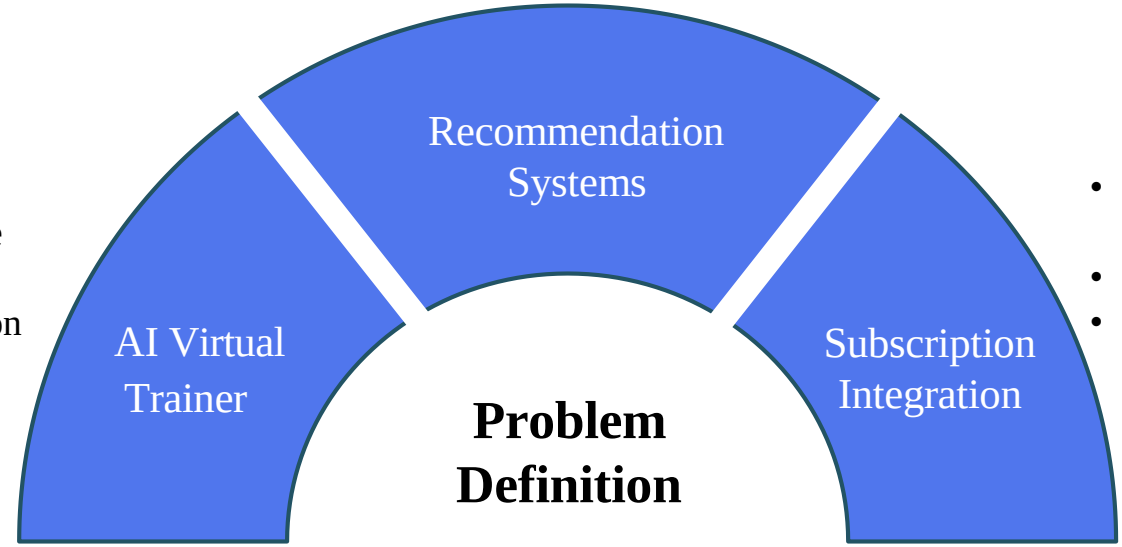
Key points to address:

1. User Progress Tracking
2. Real-Time Feedback
3. Face Detection & Recognition
4. Weekly Performance Reports
5. Diet Recommendation Engine
6. Workout Recommendation Engine
7. Subscription-based model

Problem Definition

- feature interactions
- offers generic suggestions
- struggles with sparse data
- accuracy issues

- predefined exercises
- poor lighting performance
- focus on squats
- low phase speed estimation accuracy
- domain restrictions
- hardware constraints.



- complexity with data-sharing
- scalability issues
- security implementation difficulties

Figure 2: Problem Definition Diagram

Scope

1. The Data-Driven AI Fitness Trainer (AIFT) can be applied in various areas such as fitness centers, home workouts, corporate wellness programs, and more, providing a comprehensive solution for personalized fitness training, workout plans, and nutrition guidance.
2. AIFT caters to a wide range of users, including fitness enthusiasts, beginners, professional athletes, and individuals with specific health needs, offering tailored workout and diet plans for each.
3. The recommendation engines within AIFT are highly customizable, allowing seamless integration with other platforms and ensuring flexibility for different fitness applications and use cases.
4. With its adaptive workout plans, real-time feedback, and personalized recommendations, AIFT enhances the fitness experience, making it a valuable tool for users looking to achieve their fitness goals efficiently and effectively.

Technological Stack

Front-end:

- HTML5, CSS3, JavaScript: For building responsive web interfaces, ensuring cross-device compatibility.
- Flutter 3.7.1: Used for creating cross-platform mobile apps, offering a consistent experience on Android and iOS.

Back-end:

- Firebase 13.21.0: Local data storage for caching real-time interactions.
- AWS DynamoDB: A scalable NoSQL database for managing user data, workout plans, and subscription information.

AI Fitness Trainer:

- MTCNN & FaceNet: For secure face recognition and verification.
- CVZone & MediaPipe: Real-time pose estimation and feedback with improved accuracy for exercise form.
- CNN Model: Detects exercise types in real-time, trained on a custom dataset for robustness.

Technological Stack

Recommendation Engine:

- Deep Learning (MLP): Generates personalized workout and diet plans using user data (age, weight, fitness goals). Combines content-based and collaborative filtering for high relevance.

Subscription, Reports, and Leaderboard:

- Blockchain (Ethereum): Manages subscriptions securely with smart contracts for automation of payments and access control.
- Data Visualization (D3.js, Chart.js, Plotly): Real-time visualizations for user progress and leaderboards.
- Report Generation (ReportLab, jsPDF): Customizable reports on user performance.
- Authentication (Auth0, Firebase, JWT): Provides secure user sessions with 2FA for enhanced protection.
- Payment Processing (Stripe, PayPal, Braintree): Handles subscription payments, integrated with blockchain for real-time updates.
- Database (PostgreSQL, Redis): PostgreSQL for long-term data storage, Redis for real-time leaderboard data.

Proposed system architecture

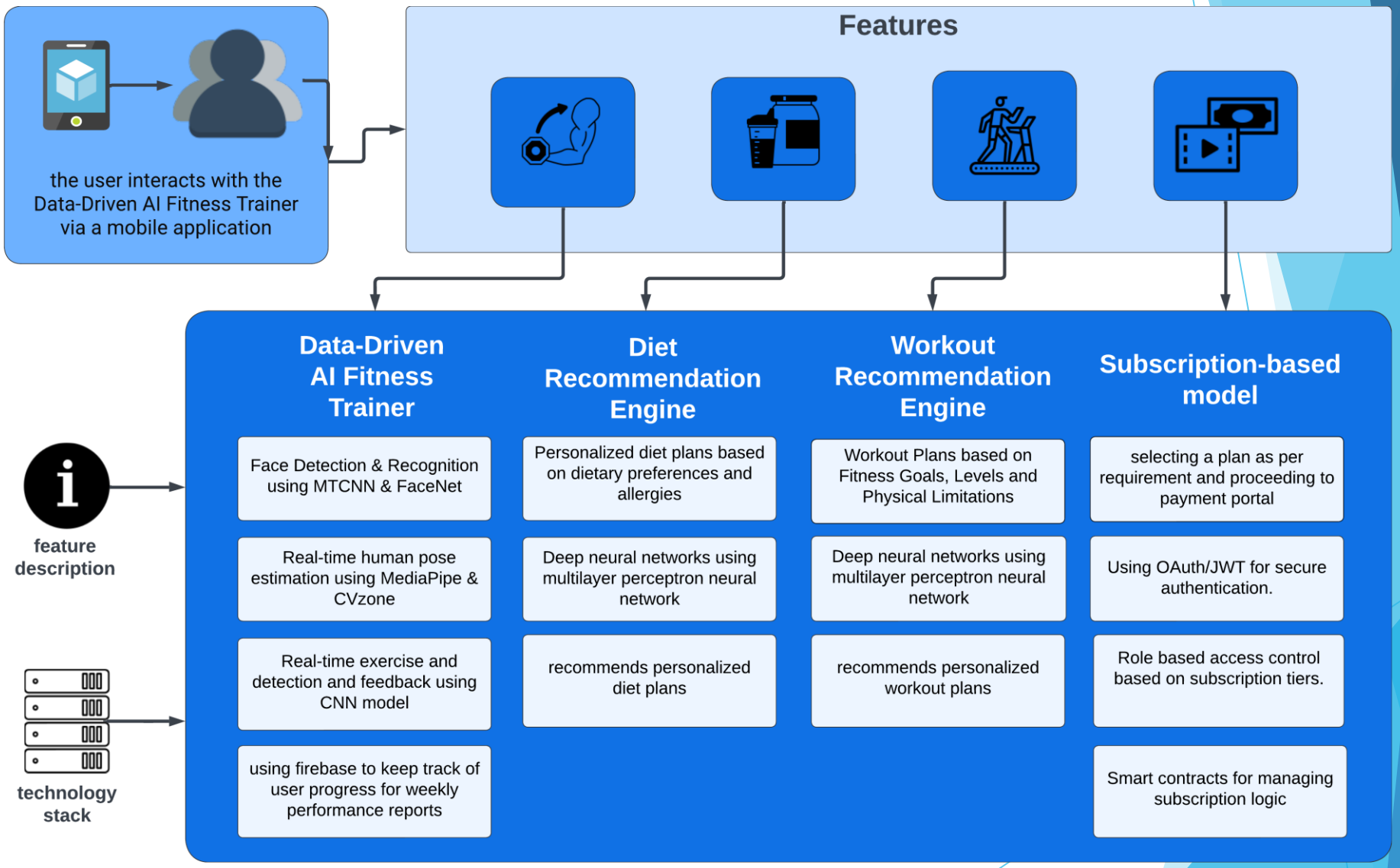
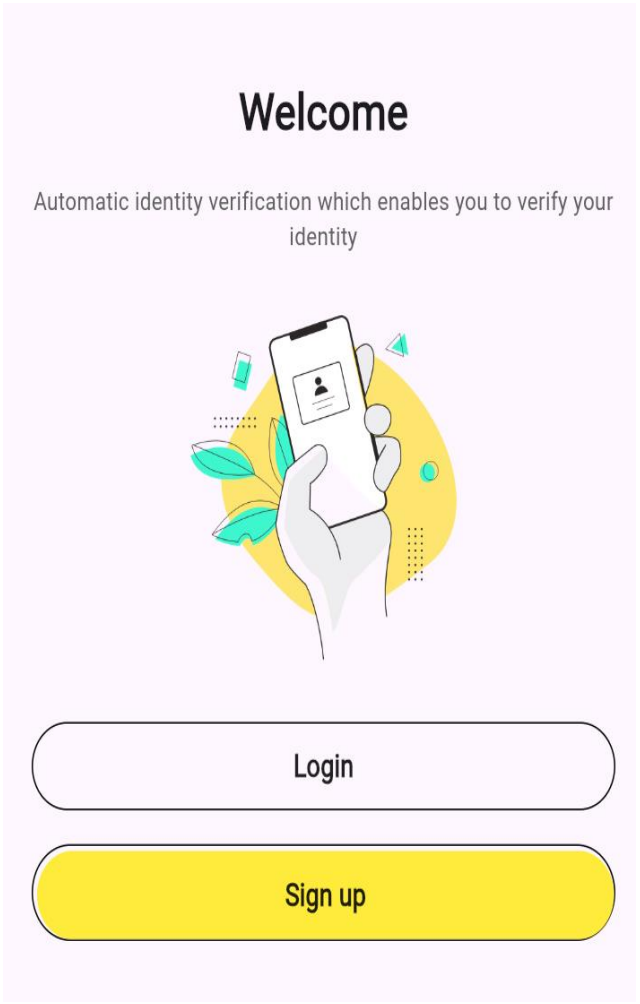
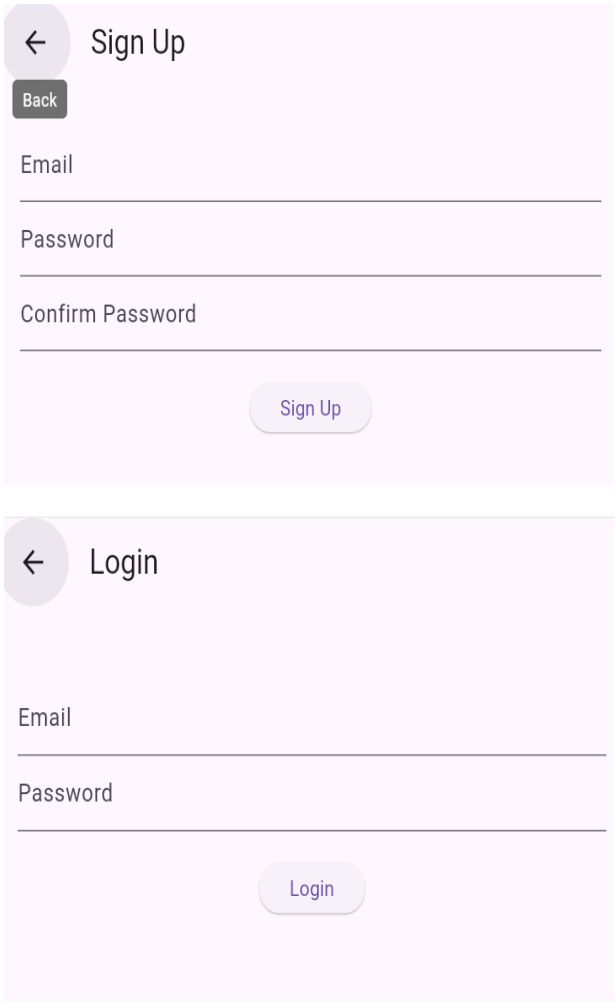
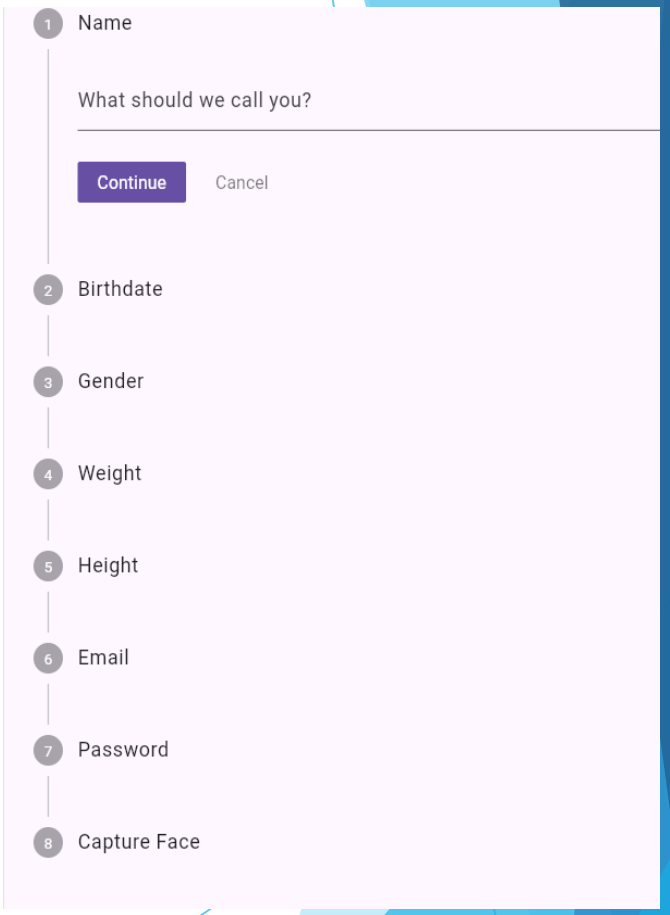


Figure 3: Proposed system architecture

Prototype Design Demonstration







Prototype Design Demonstration

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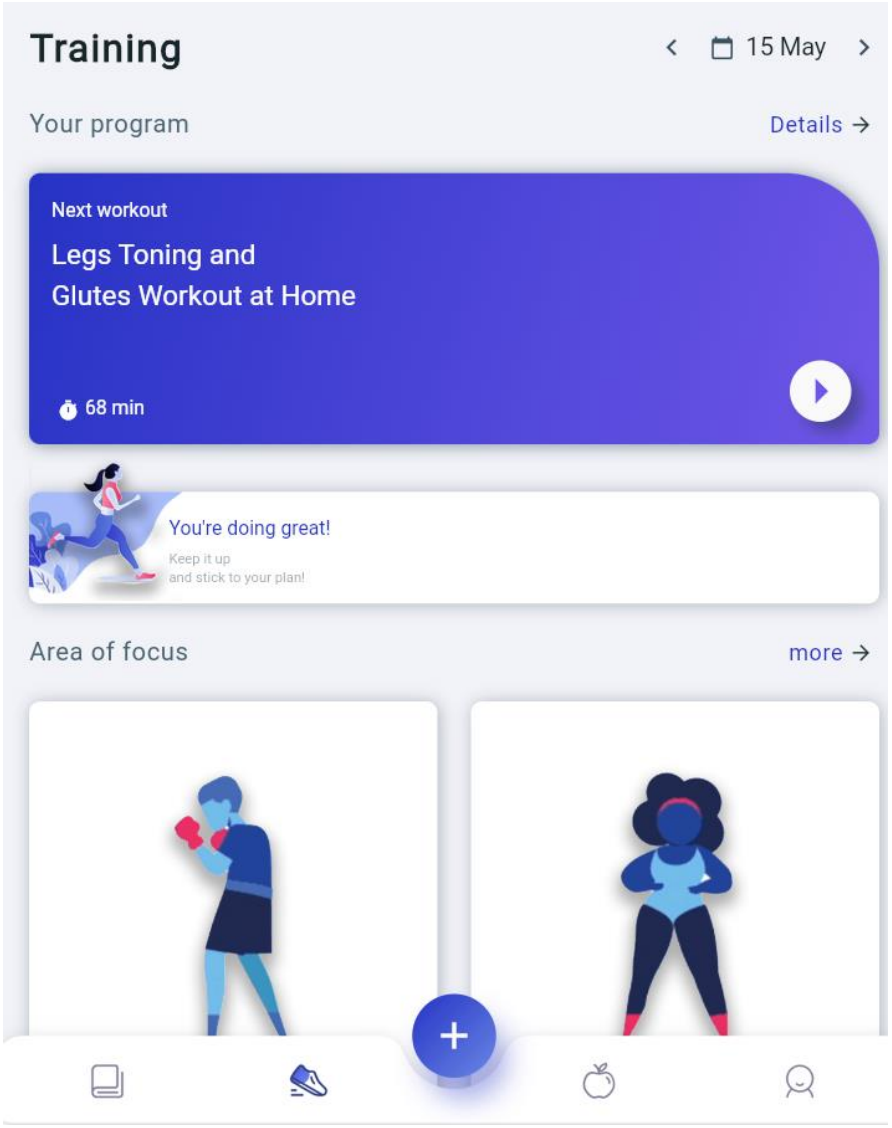

Implementation Status

Objective 1:

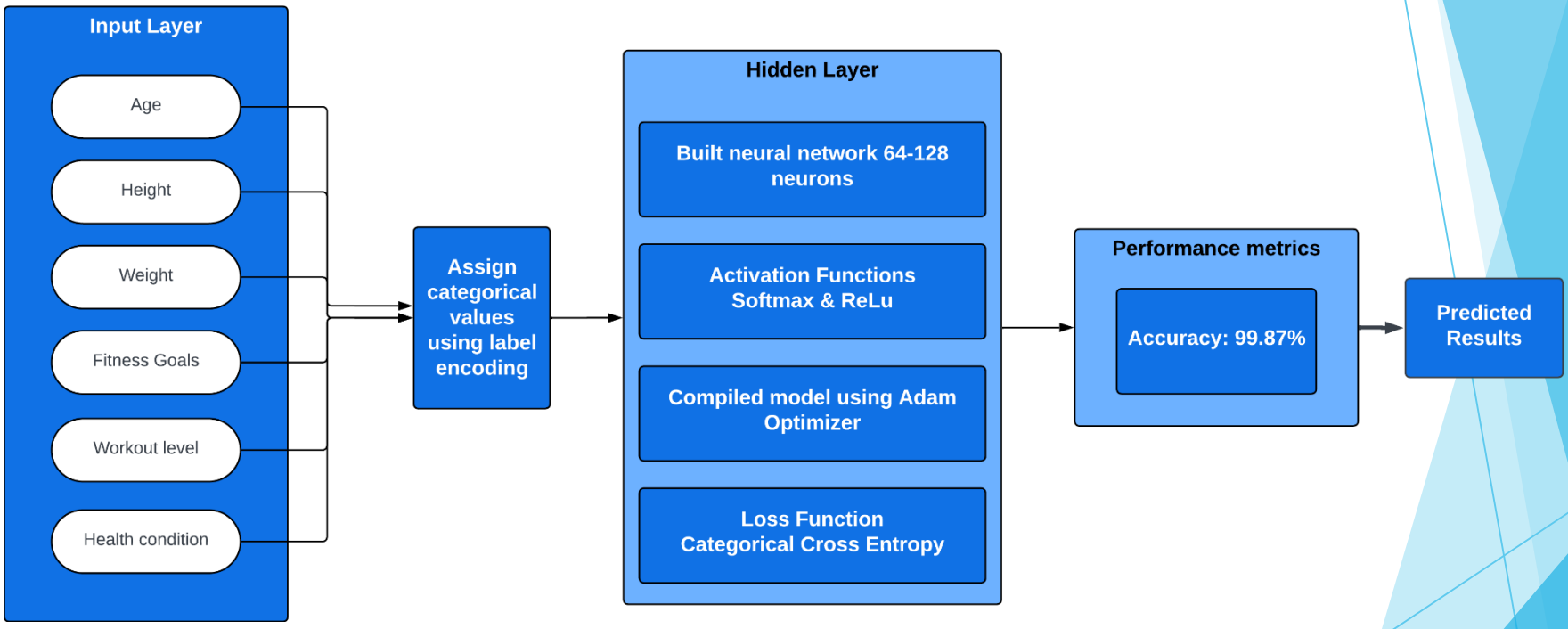

Figure 4: Recommendation Engine using MLP Approach

Implementation Status

Objective 1:

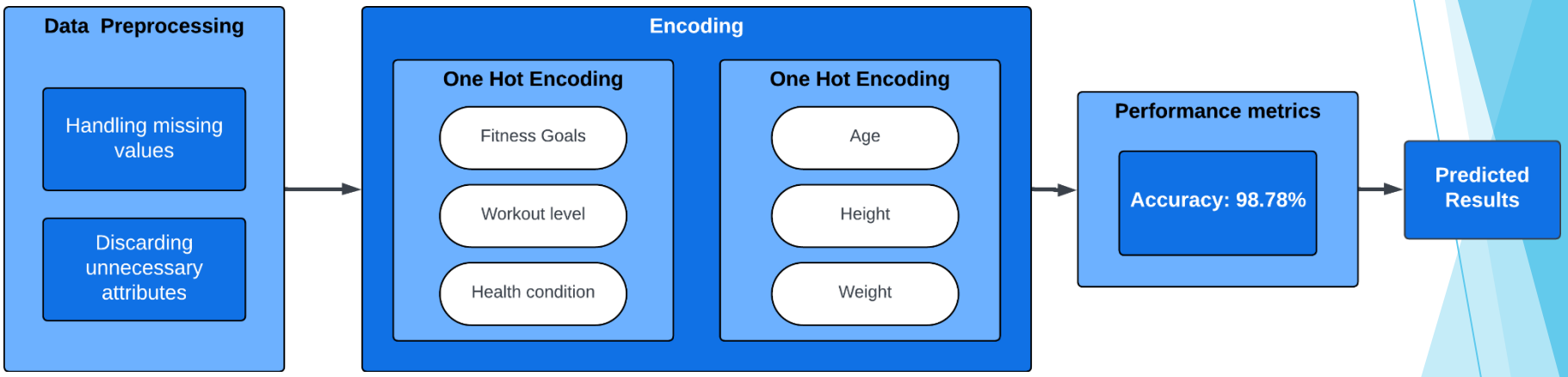

Figure 5: Recommendation Engine using Tensorflow Approach

Review Suggestions (Given in Last meeting)

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Thank You!