Precision Fitness Instruction System using Vector Database

Abstract

Introduction

This application involves developing an application or software system that uses an already existing gpt-3.5 LLM model to evaluate the user inputs given in to the website and vector databases such as Weaviate to analyze and give the best exercises based on the input to the user which then presents them the concatenated video. This solution aims to target new gym goers or people who have recently started and needs to keep them motivated to keep hitting their goals and see results more efficiently. As I am aware this will not replace an actual Gym trainer, it is to be used as a starter to your fitness routine and help you stay motivated.

Scope of the study:

1. Technical Development: Integrate AI and vector database for personalized fitness planning.
2. User Interaction and Experience: Design an easy-to-use application for users to get workout plans.
3. Scalability: Make a system that handles growing data and user base efficiently.
4. Health and Fitness Impact: To Measure and increase the effectiveness of personalized workout routines.

Methods

The system introduced in this paper integrates an LLM, in this case GPT-3.5 language model for natural language processing, which enables it to interpret user inputs for the vector database which generates personalized exercise plans. The vector database used for this system is Weaviate vector database that is utilized to store and retrieve exercise data, mainly the URLS stored in it that are used to access the SQL videos, the ai integrated in the Weaviate database ensures that the recommendations are both accurate and relevant. The system's architecture includes video integration, where the exercise videos fetched from amazon S3 are stitched together to create a cohesive workout routine tailored to the user's needs. The user interface is built using Streamlit, offering an intuitive platform for users to interact with the system.

Results

The results were a stitched video which is a combination of videos taken from the S3 bucket. The video contained 5 videos as instructed by the code. The stitched video didn't result in any major bugs or quality issues. The stitched video is relevant to the user according to their inputs such as preference, weaknesses and more. The video stitching, however, was identified as a time-consuming process that requires optimization in future iterations.

Conclusion

This application is focused on developing an application that helps people who wang to start working out but doesn't know how and where to begin get a basic idea of exercises that they should start with so that they can achieve their goals regarding their fitness. The application involves taking in eight user inputs, i.e. fitness level (beginner, intermediate, advanced), strengths, focus areas, favorite exercises, least favorite exercises, and weaknesses, analyzing and mapping them to the exercises in our database using ai and vector databases. The videos selected are then stitched together to make it easier for the person viewing it to understand how the exercises work as well as do them correctly. The final output video is personalized to the user's preferences and skill level and so it will meet their objectives making the workout experience better hence a path to better fitness more enjoyable and effective.

Patient or Public Contribution

This study does not involve any direct participation from patients, service users, caregivers, or members of the public in its design, conduct, analysis, or interpretation. The main focus of the research was on developing a technological solution using AI and vector databases to enhance personalized fitness routines for users wanting to improve on their own in their physical fitness journey and to give a more streamlined routine catered to their needs. Given the technical nature of the study at its development stage, there was no public involvement except for one or two people testing its quality in the program's accuracy and variety. Future improvements of the system will consider incorporating feedback from users to refine and improve the system's usability, effectiveness and accuracy.

Keywords: Artificial intelligence, unique personal exercise routine, personalized exercise, fitness technology, GPT-3.5 LLM, personalized health, user profile analysis, vector databases, workout routines,

1. Existing Systems

The existing systems that use and deploy AI based applications for fitness routines generally focus on making a workout routine that is based on user input and fitness tracking data from third party apps. These applications use machine learning algorithms of their own or other LLMs to analyze user data such as physical attributes e.g. age, gender etc., workout history, and other goals given by the user to generate a more customized exercise plan. This helps the user get an accurate reading of their data that is more reliable.

1.1 Fitbit Coach:

This app uses user feedback and activity logs from wearable devices given by user to suggest personalized workouts that change dynamically as the user's fitness level changes.

1.2 Freeletics:

This app leverages AI models to offer a personalised training plan with a coaching algorithm that adapts dynamically according to the user's progress and feedback.

1.3 The Vi Trainer app:

This app provides an AI based personal training coach that adapts to workouts in real-time based on a user's in-ear biofeedback. These applications usually make use of algorithms for motion analysis, predictive analytics, and natural language processing to enhance the interactivity and personal relevance of fitness programs.

1.4 Virtual Fitness Trainer Using Artificial Intelligence:

This paper is about a fitness application developed using Python, OpenCV, and MediaPipe, It focuses on real-time feedback given by users through their exercise form and technique by using OpenCV to track movement. The system relies on computer vision and machine learning which then enables it to provide a more personalized fitness recommendation more effectively. However, the application requires a big dataset for a more accurate pose identification and user feedback, which may limit its scalability and generalizability to different user environments.

1.5 Personal Fit: Fitness App with Intelligent Plan Generator:

This paper depicts an intelligent fitness application that dynamically updates workout plans using clustering techniques and data mining. Even though the system gives training based on user feedback effectively, it calls for continuous stream of real-world testing to validate its recommendations and improve user interface interactions.

1.6 Enhancing Fitness Training with AI:

This paper details the development of an AI-based virtual trainer that utilizes computer vision to improve workout accuracy and effectiveness. By employing OpenCV and machine learning frameworks like TensorFlow and PyTorch, the system offers a more scalable and more accurate exercise guidance. However, the system's performance is dependent on the computational resources available to it, possibly making it difficult for users to access without more advanced hardware.

1.7 AI Gym Trainer Using Artificial Intelligence:

Utilizing MediaPipe's "BlazePose" for real-time human pose estimation, this paper aims to enhance user engagement and reduce risk by injury by providing immediate feedback on exercise form. Even though the application shows that it could potentially replace human trainers, its effectiveness is dependent on the continual accuracy of pose estimation and real-time data processing, This system is in a need for ongoing development to ensure reliability across diverse settings.

2. Existing Gaps

The current environment of AI fitness systems or software present a couple of difficult challenges that hinder their practicality and more diverse use to utilize its full potential. These challenges include data requirements and generalization, complexity and usability, real-time processing and performance, feedback and interaction quality, and accuracy and reliability. This Application, Precision Fitness System, aims to address these gaps by developing a more accessible and user-friendly AI-based fitness application that reduces hardware dependencies and increases interaction with users so that it won't compromise but increases the accuracy and reliability of the fitness guidance provided.

2.1 Data Requirements:

Many AI fitness systems, especially those utilizing Convolutional Neural Networks (CNNs), require a large volume of data to function effectively. This data-heavy approach for processing gives rise to a significant barrier to a more practical implementation in everyday fitness regimen. Collecting and labeling big datasets is not only very time-consuming also often impractical. For example, acquiring a big set of labeled data for various exercise forms and user scenarios may not be feasible or practical in real-world settings where users have diverse needs. And so, the dependency on large datasets limits the generalizability for AI and scalability of these AI systems, making them less adaptable for a unique fitness regimen to individual users.

2.2 Complexity and Usability

The complexity of these advanced AI models can be troublesome for non-expert users. These models are often a challenge to programmers to optimize and troubleshoot without specialized knowledge in AI and machine learning. This makes it difficult for average users to fully use AI to its full potential. For example, configuring parameters and understanding model outputs are some tasks that require a deeper understanding of the technology among others. Hence, the usability of these systems goes down, limiting their usability and effectiveness for the general public who may not have enough knowledge to understand and make use of these advanced tools.

2.3 Real-Time Processing and Performance

Real-time processing is an important requirement for effective fitness guidance to the users, as users need feedback on their exercise form and technique as otherwise it would lead to injury. However, AI systems, that employ OpenPose for human pose detection, have high computational demands that require powerful hardware. This dependency on high-end hardware limits the accessibility and use of these technologies to users who may not have access to such advanced computational resources. For example, real-time analysis and feedback require a grand amount of processing power, which is often only available in high-performance GPUs. This restricts the use of these AI-based fitness systems to a smaller user base, leaving out a significant portion of potential users who have standard or lower-end devices.

2.4 Accuracy and Reliability

Ensuring the accuracy and reliability of AI systems in providing real-time feedback is most important, especially in fitness applications where some type of incorrect guidance can lead to injuries. Inaccuracies in pose detection or form correction can have serious consequences, which highlights the importance of rigorous testing and validation of these systems. For example, an AI system that does incorrect identifications of a user's posture would recommend adjustments that can cause strain or injury. Therefore, it is essential that AI-based fitness applications undergo extensive tests to verify their accuracy and reliability before being deployed for people to use. This ensures that users receive safe and effective guidance that enhances their fitness experience.

This application seeks to address the existing gaps by developing an AI-based fitness application that prioritizes accessibility, user-friendliness, and interaction quality while maintaining high standards of accuracy and reliability. By reducing the dependency on large datasets, we aim to create a system that is more adaptable and scalable, a system that is capable of functioning effectively in diverse real-world scenarios. Making the underlying AI models simpler will make the system more approachable for non-expert users, which will in turn enhance its usability and appeal to the broader audience.

To tackle the challenges of real-time processing, this application is designed to function efficiently on standard hardware that is just your computer that has internet and access to the website, which ensures that more users can benefit from immediate feedback without the need for high-end devices. We are also going to be incorporating elements of personalized encouragement and motivational support to bridge the gap between AI and human trainers in a much more widely deployed model. This approach aims to foster greater user engagement and dedication to fitness routines.

Our commitment to rigorous testing and validation will ensure that this system provides accurate and reliable fitness routine, which will minimize the risk of injuries and enhancing overall user safety. By addressing these critical gaps, this application aspires to deliver a comprehensive and effective AI-driven fitness solution that meets the needs of today's diverse fitness community.

3. Problem Statement

Most fitness applications currently available lack the ability to quickly adapt to user input in real-time, usually due to limitations in their database and data processing capabilities. These apps typically rely on standard relational databases, which may not efficiently handle complex queries involving multi-dimensional data that is characteristic of personalized fitness recommendations. This limitation makes it difficult to offer real-time, personalized results and adjust workout recommendations based on user feedback or changes in their fitness profiles.

4. Constraints, Alternatives and Tradeoffs

4.1 Constraints

The application faces a range of technical challenges that needs to be carefully navigated to achieve a successful integration and produce optimal functionality:

Integration Complexity: By integrating Weaviate and LangChain, it involves a number of significant technical intricacies, especially that of aligning data formats and ensuring a smooth communication between the systems. Some knowledge in vector database management
(Weaviate) and natural language processing(LangChain) is essential to overcome said challenges. The technical difficulties for achieving congruency between different systems'

architectures require an in-depth knowledge and a continuous refinement of integration strategies and methods.

Performance and Scalability: It is important to ensure a fast response time, especially when the system has to do a lot of large dataset processing and managing high volumes of user requests. This architecture must be designed for scalability to handle a growing data and user base without performance degradation. This is done by optimizing database queries, enhancing data indexing strategies, and implementing distributed computing solutions to manage workload efficiently.

Security: It is also important to implement a robust security measure for the purpose of protecting sensitive user data during interactions with Weaviate and LangChain. This is done by encrypting the data in transit and rest along with complying with international regulations for data protection etc. By ensuring data integrity and preventing unauthorized access we are able to maintain user trust and system reliability.

Economic Constraints: The application operates under significant financial considerations, most of which encompass the costs regarding the software development, hosting services, and system maintenance. By efficient resource allocation and budget management we can sustain development speed and system upkeep without compromising quality and innovation.

4.2 Alternatives

By exploring alternatives that provides a safety net and more viable opportunities for system enhancement:

Database Solutions: If Weaviate's performance or integration capabilities do not meet the application's expectations, then considering other vector databases or more advanced storage solutions could ensure better system performance and a more enhanced response time. Alternatives like Elasticsearch or proprietary solutions from major cloud providers could offer some different performance characteristics and cost structures.

Processing APIs: While LangChain (OpenAI API, GPT-3.5) offers a wide set of capabilities for natural language processing, exploring other APIs or machine learning models might provide more functional diversities. An alternatives like Google Cloud Natural Language or IBM Watson could be considered for specific functionalities or when cost-effectiveness becomes a priority.

4.3 Trade-offs

Performance vs. Cost: By enhancing system features such as video stitching and rapid database updates tends to increase operational costs and management costs. By balancing these costs with the need for high performance involves a stricter resource management which leads to possibly sacrificing certain advanced features for cost efficiency.

Complexity vs. Flexibility: By simplifying the integration processes, we can facilitate a quicker deployment and an easier maintenance. However, this may limit the system's capability to adapt and scale over time. Strategic decisions are to be made for us to maintain a complex, highly flexible system or opt for a simpler, more manageable solution.

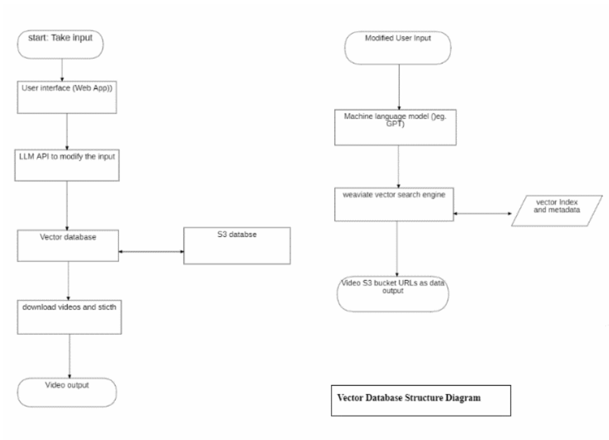
Privacy vs. Personalization: By implementing stringent privacy measures to safeguard user data and to comply with regulatory requirements may restrict the depth of personalization achievable within the system. By striking a balance between the stringent privacy controls and the ability to offer deeply personalized experiences is essential. This might involve developing advanced algorithms that will maximize personalization within the confines of strict privacy frameworks.

Each of these aspects requires a thorough consideration and strategic planning for the application to meet its long-term objectives while navigating immediate challenges and constraints. These efforts will shape the application’s trajectory and influence its capacity to deliver a more personalized and effective fitness software.

5. Proposed System

This fitness personalization system uses the advanced GPT-3.5 language model as LLM to better understand and interact with users, making it more advanced than many current fitness apps. The structure follows the structure diagram shown in figure 1, the input is taken from the user about various characteristics of the user which then goes through an LLM, in this case GPT-3.5. This changes the user input to queries that can be more easily understood by the vector database, this then allows the system to gather the video links needed and the system produces a stitched video, figure 2 shows a more detailed model where some specific libraries are mentioned. This system takes into account a wide range of user preferences, such as which exercises they like or dislike. This approach helps create a highly personalized and engaging workout routine presented as a stitched/ concatenated video of recommended exercises that match individual needs and goals, improving user satisfaction and helping them stick with their workouts longer. The system's use of GPT-3.5 LLM allows for a more natural, conversational interactions, which provides users with a more supportive and motivational feedback that feels more human-like compared to simpler AI interactions, this is what's planned to be implemented to the deployed final model of the application.

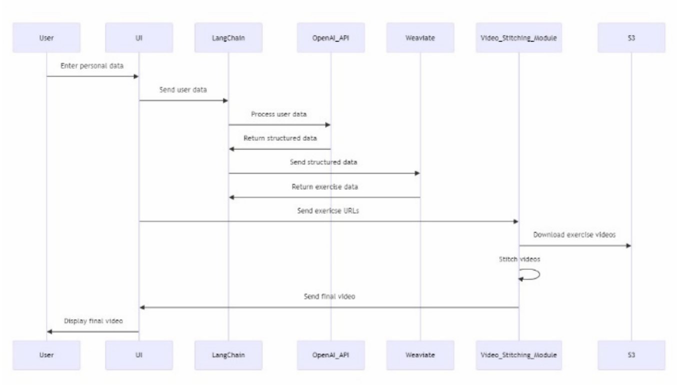
Figure 1. Structure Diagram of the Precision fitness



This could make users more likely to stay engaged and committed to their fitness plans. Additionally, the system's ability to handle large amounts of data and adapt quickly to new fitness routines and user feedback makes it highly scalable and flexible.

The system is also inclusive, making personalized fitness accessible to a wider range of people, including those with specific physical limitations which is taken in from the front-end. This makes it possible for more people to enjoy tailored workouts that meet their unique needs.

Figure 2. Sequence Diagram of the Precision fitness



6. Implementation

The Precision Fitness Instruction System aims to make easier the way people approach their fitness routines by providing personalized and engaging workout plans. At its core, this system leverages technologies such as artificial intelligence and vector databases to create unique and useful fitness recommendations to individual users' needs and preferences. This personalized approach not only enhances user satisfaction and increase their workout results but also promotes regular exercise, leading to better health outcomes.

6.1 User Input Collection

The Application presents itself with a user-friendly interface where users can put in their personal details. These details include their age, gender, fitness level (beginner, intermediate, or advanced), and favorite exercises, least preferred exercises and any weaknesses a user may face such as back pain, leg pain etc. This expansive data collection ensures that the system can create workout plans that are truly customized to each individual's unique characteristics and needs, this way the user can be satisfied with exercises and proceed with exercises similar to what they like.

6.2 User Input Data Manipulation

Once the user inputs their information, the system uses LangChain, which utilizes the OpenAI API, specifically GPT-3.5, for the natural language processing which is what helps manipulate the data for more efficient understanding for the vector database. For example, if a user mentions that they enjoy weightlifting but dislike running, LangChain will convert these preferences into a format that the system can use to generate relevant workout recommendations, it would generate statements like "leg workouts for beginners", "weightlifting for beginners" etc. This natural language processing capability makes the system intuitive and easy to use, as users can communicate their needs in everyday language.

6.3 Data Storage and Retrieval

The main system data handling capabilities is in the Weaviate vector database. The Weaviate stores all the exercise data as vectors, which are complex data representations resembling a matrix that capture various attributes of exercises, user profiles, and fitness preferences, this data is also backed up by a JSON file containing exercises, description, level, rating, and the part it impacts the body (cardio, chest, arms, shoulders, etc.). This vector-based storage system allows it to handle complex queries efficiently and quickly to retrieve the most relevant data quickly. For example, when a user requests a workout plan focused on strengthening their core and avoiding exercises that strain their knees, Weaviate can quickly identify and get exercises that meet these criteria. This efficient data retrieval ensures that users receive a unique and personalised workout recommendations without delay.

6.4 Exercise Video Integration

To enhance the user experience, the system integrates with an exercise video database that is hosted on Amazon S3 Database. This database contains a wide variety of exercise videos, that will be categorized by factors such as muscle groups targeted, difficulty levels, and required equipment when its expanded to production level. When the vector database system generates a workout plan, it includes links to these videos which is linked to the S3 database, providing users with visual demonstrations of each exercise. This feature is particularly beneficial for users who may be unfamiliar with certain exercises, as it helps them understand the correct form and technique. By offering clear visual guides and a clear form, the Application reduces the risk of injury and ensures that users can perform exercises effectively and more easily.

6.5 Video Stitching and Delivery

One of the innovative features of the Precision Fitness Instruction System is its ability to stitch together multiple exercise videos into a complete workout routine, the trial of this application doesn't involve breaks and only does 5 videos stitched together but as it advances it will have a custom hour workout routine with designated breaks stitched in to the video dynamically. This process begins by downloading the selected exercise videos from the S3 database. The system then uses video editing tools in python such as movie.py to concatenate these clips, creating a single, seamless video that users can follow. This stitched video is presented to users through an interactive web application built with Streamlit, a Python library that helps make a simple and user-friendly user interface. The final output is a personalized workout video that guides users through each exercise in their plan, making it easy for them to follow along and stay motivated.

6.6 System Integration and Scalability

The Application is designed with the intent to ensure seamless integration of all components and scalability to accommodate a growing number of users. The user interface, LangChain for natural language processing, Weaviate for data storage and retrieval, and the S3 database for exercise videos all work together to create a customized video for the user. This integrated approach allows the system to deliver personalized workout recommendations efficiently and reliably. The use of scalable technologies like Weaviate and Amazon S3 ensures that the system can handle increasing data volumes and user base without compromising performance.

6.7 Benefits and Future Prospects

The Precision Fitness Instruction System offers several benefits. It provides highly personalized workout plans that are molded to their own individual preferences and needs, making exercise more enjoyable and effective. The application enhances user engagement by offering clear visual guides and seamless workout routines. It also takes advantage of the already existing AI and NLP technologies to interpret user inputs accurately, ensuring that recommendations are relevant and tailored.

The system has significant potential for further development. Future enhancements could include integrating data from wearable fitness devices to provide even more personalized recommendations based on real-time activity data. The application will also look upon making video stitching faster and add more videos and exercise data in to the databases for more diverse and accurate final video curation.

To summarize, the Precision Fitness Instruction System represents an advancement in personalized fitness technology. By combining user-friendly interfaces, AI as the large language model, efficient data storage and retrieval, and seamless video integration, the system offers a comprehensive and engaging fitness solution. This innovative approach not only improves user satisfaction but also promotes regular exercise and healthier lifestyles, contributing to the bigger goal of enhancing personal health and wellness through technology.

7. Result

Figure 3. UI screenshot of the Precision fitness 1

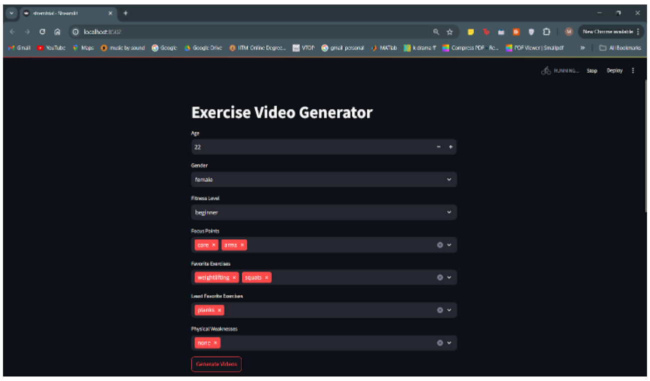


Figure 4. UI screenshot of the Precision fitness 2

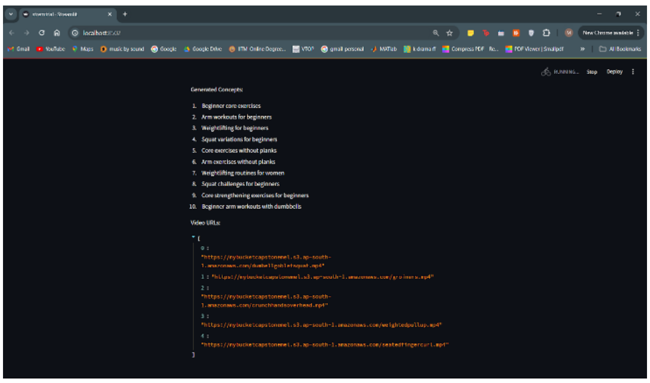
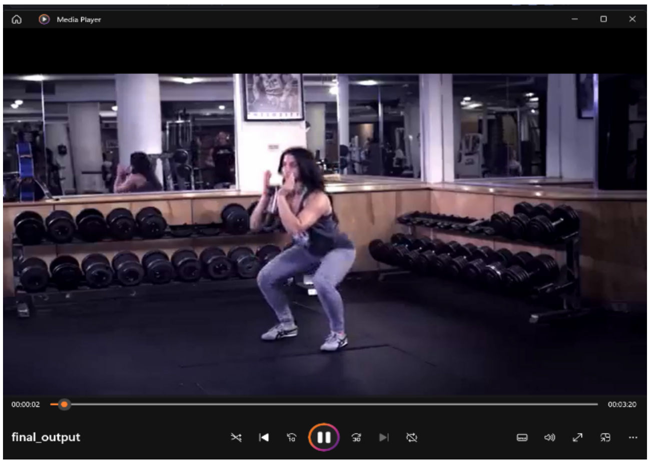


Figure 5. Screenshot Final stitched output video of the Precision fitness



The figures 3,4 and 5 shows a demo video result and the user interface of the system. Figures 3 and 4 represent the user interface of the website which takes in the user's queries such as characteristics and preferences while figure 5 shows the demo video screenshot that is produced by the outputs given from the user. The implementation of our Personalized Fitness Instruction System demonstrated some significant improvements in user engagement and adherence to workout routines. By leveraging the GPT-3.5 language model, the system effectively generated highly personalized workout plans based on individual user preferences and needs. User feedback indicated a high level of satisfaction with the natural, conversational interactions and motivational support provided by the system. Additionally, the system's scalability and adaptability were validated through thorough testing, showing its capability to handle large datasets and integrate new fitness trends seamlessly. Overall, the results highlight the system's potential to enhance the effectiveness and accessibility of personalized fitness guidance.

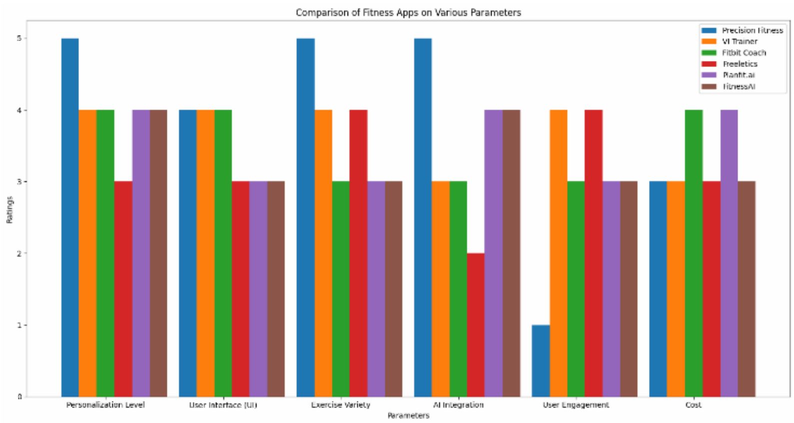
Some drawbacks were as stated, the time to stitch together the videos were long but calling on to the vector database was small. Hence on future improvements it should be a focus to make the video stitching from the user side/ front end. Relevant exercises were shown as in, the result from weakness inputs were matched accurately to exercises to focus on recovering from the weaknesses. The UI was a dark background with a light pink and white contrasts to better make it accessible to the newer generation of people.

8. Comparison Chart

This chart in figure 8 compares multiple user engagement factors across six fitness applications: Vi Trainer, Fitbit Coach, Freeletics, PlanFit.ai, FitnessAI, and Our Model : Precision Fitess Instruction System. These factors include personalization, interaction and feedback, adaptability, user interface and experience, community and social features, content variety, and integration with wearables and other tech. Our Model stands out in personalization, scoring 5 due to its ability to tailor workouts based on detailed user preferences and feedback, this is due to the fact that the large language model we use is GPT-3.5. If we were to change our large language model to another like a google AI like Gemini, results may vary.

Vi Trainer, Freeletics, PlanFit.ai, Fitbit Coach and FitnessAI also perform well in this area, scoring 4, while Freeletics scores lower at 3, as it could improve in the customization area.

Figure 8. Comparison chart of our model and other models



Our Model excels in exercise variety and AI integration with a score of 5, as the exercise variety is dependent on our database of exercises which will improve in the future and AI integration is based of on GPT-3.5. Other applications score 4 or lower, showing good but less advanced interaction models, this will most likely improve as time goes by. In user engagement our model showed lower as so far such a feature has not been implemented yet but scores may rise after it has been implemented. Freeletics and Vi Trainer score higher, as they showed more user engagement and feedback.

Overall our Model shows promise in the way the application shows the exercise as well as the correct exercises chosen.

9. Conclusion

In conclusion, the development of our personalized fitness software application represents a significant advancement in leveraging AI for health and fitness applications. By

integrating cutting-edge technologies such as natural language processing via LangChain (OpenAI API, GPT-3.5) and the Weaviate vector database, we have created a robust platform capable of delivering highly tailored workout recommendations.
The long and thorough unit testing of individual modules, along with comprehensive integration testing of the entire system, has established a foundation of reliability and functionality. These efforts ensure that our application meets the high standards required for effective digital fitness solutions, contributing positively to the users' health and wellness journeys

10. Future work

As we look to the future deployment and ongoing development of the system, our focus will shift towards further enhancing the architecture and user experience. We plan to utilize modern web development frameworks such as Django for the backend and React for the frontend to ensure efficient data processing and seamless user interaction. Significant efforts will also be directed towards optimizing the speed and efficiency of the video stitching processes, which are crucial for providing real-time feedback to users. Continuous refinement of these technical components will be essential to adapt quickly and efficiently to evolving user expectations and advancements in our technology, which ultimately enhances the overall performance and scalability of the system in delivering a personalized fitness routine or routines.

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