CNG 491Senior Project Proposal

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Co-advisor:	Enver Ever
Title:	**AI-Powered Fitness Coach: Realtime Posture Tracking and Performance Optimisation**
Type:	Development project
Team Size:	Four Students

Description

With the increasing adoption of artificial intelligence (AI) in fitness and healthcare, this project aims to develop an AI-powered physical training application that uses realtime video input to perform posture tracking and provide realtime feedback to users [1]. This application will assist users in performing exercises more accurately and efficiently, helping to prevent injury and optimise performance. By offering personalised guidance, the system adapts to individual fitness levels and goals, ensuring a customised workout experience for each user.

The application will leverage computer vision and pose estimation techniques to track users' posture during exercises [2]. It will continuously analyse movement patterns, identify deviations from optimal form, and provide real-time corrective feedback [3]. Additionally, the system will monitor performance over time, offering users insights into their progress through visual reports and recommendations [4]. This continuous feedback loop enhances the user's form and promotes long-term improvements by identifying areas for correction and growth in their fitness journey.

This AI-based solution will integrate advanced deep learning models, such as Vision Language Models (VLMs) and lightweight pose estimation frameworks, to ensure efficient realtime tracking and feedback. The application will be user-friendly, intuitive, and scalable, capable of running on devices with limited computational resources, such as mobile phones or laptop computers.This part of the project will require a full stack development which considers:

- A useful front end with all the necessary interfaces to help users keep track and details of their exercises.
- A database to keep the profiles as well as the exercises performed, exercises performed accurately etc.
- An interactive interface to specify information needed from a state of the art fitness tracking application

The user friendly interface and interactions will make the application accessible for users to train anytime, anywhere, while maintaining high levels of accuracy and responsiveness, even in resource-constrained environments. Furthermore, the application can evolve with new fitness trends and exercises by continuously learning from user interactions and feedback.

Figure 1 Real-time AI-Powered Posture Tracking: Enhancing Exercise Performance with Realtime Feedback

The potential applications of the AI-Powered Fitness Coach:

1. The application can serve as a virtual personal trainer, guiding users through workouts with realtime posture correction and feedback, helping them perform exercises safely and effectively.
2. In medical and rehabilitation settings, the system can assist patients in performing therapeutic exercises correctly, tracking their progress and ensuring they follow prescribed movements for optimal recovery.
3. Athletes can use the application to fine-tune their form during training, improving efficiency, strength, and agility by receiving precise feedback on their posture and movement mechanics.
4. For users who prefer exercising at home, the application can offer an accessible and affordable way to achieve professional-level workout guidance without the need for a personal trainer or gym visit.

5. The application can help seniors engage in safe, low-impact exercises while monitoring their form, reducing the risk of injury or falls by ensuring proper posture and movement patterns.

Figure 1 illustrates a realtime posture tracking setup, which could be an example of the AI-Powered Fitness Coach project. In this setup, a person is performing a physical exercise while a camera or smartphone mounted on a tripod captures the individual's movements. The camera is connected to an AI-driven system that uses computer vision and pose estimation techniques to track the key joints of the body, represented by dots connected through lines over the 'person's figure. On the smartphone screen, a skeletal representation of the 'person's posture is visible in realtime. This visual feedback allows the system to sanalyse and assess the user's posture during exercise, providing immediate insights and corrections. Such a setup showcases the core functionality of the proposed project helping users perform exercises accurately while monitoring their form and movements with realtime feedback to enhance performance and prevent injury.

Objectives

The objectives can be listed as follows:

1. sA user friendly interactive fitness tracking system
2. AI-based pose estimation models to track the user's body movements during physical exercises and assess the accuracy of their posture.
3. Design an intuitive feedback mechanism that alerts users when they deviate from the correct form, allowing immediate corrections.
4. Create a system that logs user performance, offering insights into progress, improvement areas, and exercise efficiency.
5. Ensure the application performs efficiently on low-power devices, leveraging edge AI technologies and lightweight models such as OpenPose or BlazePose.
6. The system will maintain data privacy by processing all data locally on the 'user's device, ensuring no personal information is stored or transmitted externally.

Deliverables:

1. A fully functional AI-based physical training application capable of realtime posture tracking and performance feedback.
2. Pre-trained lightweight models fine-tuned for posture tracking and realtime inference.
3. An interactive user interface that provides immediate alerts and feedback during exercise sessions.
4. A dashboard that allows users to view their exercise history, performance analysis, and personalised improvement recommendations.
5. A detailed report on the development process, system architecture, model selection, and performance evaluations.

Tasks to be Accomplished:

1. Review state-of-the-art AI-based posture tracking and fitness applications. Identify appropriate machine learning and computer vision models for posture tracking. (5 Weeks)
2. Collect and annotate video data of various exercises for model training and testing. Explore available datasets like MHealth and PoseTrack for benchmarking. (5 Weeks)
3. Integrate pose estimation algorithms such as OpenPose or BlazePose with realtime video inputs. Train and fine-tune models for accurate posture recognition and error detection. (5 Weeks)
4. Development of the interactive system and,integration and realtime processing development. (5 Weeks)
5. Testing and validation in controlled environments. (4 Weeks)
6. Final testing in real-world scenarios, results analysis, and deliverables preparation. (3 Weeks).

Hardware and Software Requirements

Hardware Requirements:

1. Mobile or desktop devices with camera input for realtime video processing.

Software Requirements:

1. TensorFlow, PyTorch, or any suitable machine learning framework for model training.
2. OpenCV or MediaPipe for realtime video processing.
3. Pose estimation libraries like OpenPose or BlazePose.

References

1. Ji Haoran, K. Githinji, T. Kenji, and R. Reetzke. "AI Fitness Coach at Home Using Image Recognition." (2022).

2. Zhe Cao, Tomas Simon, Shih-En Wei, and Yaser Sheikh. "Realtime multi-person 2d pose estimation using part affinity fields." In *Proceedings of the IEEE conference on computer vision and pattern recognition*, pp. 7291-7299. 2017.

3. Hao-Shu Fang, Jiefeng Li, Hongyang Tang, Chao Xu, Haoyi Zhu, Yuliang Xiu, Yong-Lu Li, and Cewu Lu. "Alphapose: Whole-body regional multi-person pose estimation and tracking in realtime." IEEE Transactions on Pattern Analysis and Machine Intelligence 45, no. 6 (2022): 7157-7173.

4. Yuan Yang, and Yangang Wang. "Realtime Multi-View Human Pose Estimation System." In *2024 39th Youth Academic Annual Conference of Chinese Association of Automation (YAC)*, pp. 2181-2186. IEEE, 2024.