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A Review on: Body Posture Detection and Motion Tracking using AI for Exercise

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***Abstract*— Imagine a world where your workout buddy is a virtual AI coach, analyzing your every move and providing real-time feedback to optimize your form and maximize your results. This vision is becoming increasingly possible thanks to the convergence of AI, computer vision, and sensor technology, paving the way for a revolution in exercise experiences.**

This paper comprehensively surveys the application of AI-powered body posture detection and motion tracking for enhanced exercise experiences. We examine existing research employing techniques like OpenPose, MediaPipe, computer vision, and large-scale pose estimation datasets (MSCOCO) alongside depth-sensing technologies like Kinect. Analyzing the strengths and limitations of each approach, we showcase the potential for real-time posture correction, exercise tracking, personalized recommendations, and tailoring exercise routines based on individual biomechanics. We identify key challenges and future directions, emphasizing the need for improved model accuracy, personalized feedback mechanisms, and integration with other exercise technologies. This survey underlines the transformative potential of AI in revolutionizing exercise experiences, promoting effectiveness, safety, and motivation for a healthier lifestyle.

***Keywords* – Open pose, MediaPipe, OpenCV, Kinect, lidar, Tensorflow,Blazefit**

I. INTRODUCTION

One of the most significant and popular types of exercise for health is weight training. Exercises that focus on particular muscles can be used to treat certain disorders. On the flip side, if done poorly or without help, free exercise can be frightening for novices and physically taxing. Even with the exciting and high-risk activities, not much is done to leverage technology to assist new students in learning new material. Conventional exercise instruction frequently depends on subjective visual cues, which are prone to error and ambiguity. AI, on the other hand, provides an objective, data-driven method, assessing your body's motions with astounding accuracy.

This review covers a variety of AI and technologies used in the context of the body to detect and track movement from advanced machine learning to good ideas. Our objective is to develop an intuitive interface technology that aids in the recovery of users who require exercise or who can recover on their own without the assistance of a professional. Its functions include calculating reps, keeping track of grades, alerting users to their time, and showcasing improved and novel exercises performed under medical supervision.

In addition, this review aims to identify research gaps and provide guidance for future studies. Last but not least, offering advice on how to posture yourself better for the best possible workout results as well as keeping track of your past workouts to get historical data on your daily, weekly, and monthly exercise routines

II. LITERATURE REVIEW

In the paper [1], the author proposes an AI-based smart system that uses image and video processing to monitor and suggest corrections for exercise posture, with the goal of improving physical fitness and mental health. The system leverages Python libraries like MediaPipe, TensorFlow, and OpenCV for image and video acquisition, processing, and analysis. The system detects key body parts and joints to determine exercise posture and identify any deviations from proper form. Visual feedback and corrective suggestions are provided to the user to improve their exercise form.

In this research paper Python, Jupyter notebook,

OpenCV for computer vision and machine learning algorithms, MediaPipe for pose estimation this technical aspects used. This system utilizes computer vision and machine learning to analyze and improve exercise form. It leverages the MediaPipe library for real-time pose estimation, pinpointing key body landmarks like joints and extremities. By comparing captured postures to pre-existing data, the system identifies deviations from proper form and offers visual feedback and corrective suggestions. This empowers users to enhance their exercise effectiveness, reduce injury risk, and potentially benefit from improved mental health through regular physical activity. Compared to earlier approaches, this system is lightweight, requires less training time, and can handle smaller datasets. Additionally, it incorporates object detection and utilizes the faster, more customizable MediaPipe library for pose estimation.

This paper proposes a lightweight, real-time exercise posture analysis system that uses MediaPipe for pose estimation and machine learning for feedback. Compared to past systems, it runs on low-end devices, handles smaller datasets, and detects users before analyzing their form. The system provides visual feedback and corrective suggestions to improve exercise effectiveness and potentially boost mental health through regular activity.

The research paper [2], the author proposes an AI-powered exercise analysis system called BlazeFit that utilizes MediaPipe to track body posture and offer real-time feedback. Focusing on medical exercises and remote recovery, BlazeFit aims to bridge the gap between patients and healthcare professionals by analyzing form, counting reps, recommending exercises, and potentially facilitating doctor consultation based on exercise history. By eliminating the need for constant professional supervision, BlazeFit empowers users to improve exercise accuracy and effectiveness, contributing to better recovery and overall health.

The project uses AI to analyze exercise form and provide real-time feedback remotely. It employs MediaPipe, a Google framework, to track body and hand movements, count reps, and assess form. This information is then displayed on dashboards for both patients and doctors. Patients' workouts are tracked and results pushed to a doctor's dashboard, who can customize daily exercise and diet plans based on progress.

The system employs two key models a palm detector and a hand landmark model, both working seamlessly to provide hand tracking. Accuracy tests showed 92% overall exercise accuracy, with 84% for bicep curls and 92% for push-ups. Lighting and camera resolution affect accuracy, but future advancements in training datasets and algorithms hold promise for further improvement.

According to the paper [3], The author suggests a project that will assist individuals in doing activities with proper posture. Pose estimate is used by the project to determine the user's workout posture, after which it offers recommendations for improvement and feedback.Pose estimator and posture corrector are the two primary parts of the system. The pose estimator detects the user's posture using an OpenPose pre-trained model. After analysing the posture, the posture corrector gives the user feedback.

This paper shows computer vision to analyze exercise posture and provide real-time feedback. It works by Detecting key body points a software called OpenPose identifies 18 key points on your body (knees, elbows, shoulders, etc.) from video footage. Analyzing posture for specific exercises: Depending on the exercise you're doing, the system calculates angles and movements between these key points. For example, in a bicep curl, it checks if your upper arm stays parallel to your torso. Providing feedback based on the analysis, the system gives you personalized feedback on your form. It might tell you if your back is moving too much in a shoulder press or if your bicep curl isn't deep enough.
Overall, this paper aims to help people improve their exercise form and prevent injuries by using real-time posture analysis.

In the document [4], This research presents a lidar and inertial sensor-based real-time 3D human position monitoring and estimation system. Using lidar data, the system initially identifies the human body and calculates its height and skeletal characteristics. Next, it uses data from lidar and inertial sensors to track the body's position and orientation. In the end, it recreates human movement on a three-dimensional avatar.

The system uses an Octree-based approach to detect the human body from the lidar data. This approach is efficient and can handle occlusions well. Once the human body is detected, the system estimates its height and skeletal parameters using a one-time algorithm.The system has been evaluated experimentally and found to be accurate and robust. It can be used in a variety of applications, such as human-computer interaction, virtual reality, and fitness training.

This paper presents a real-time system for tracking and capturing 3D human movement using a clever combination of lidar and inertial sensors. Imagine a system that detects your body shape with lasers, estimates your bone positions, and then tracks your every move while accounting for sensor limitations. That's essentially what this research achieves.

First, the system scans the environment with lidar, identifying your body like a digital sculptor. It then estimates your height and key joint positions, creating a skeletal model. Next, like a watchful guardian, the system uses both lidar and inertial sensors to track your movements in real-time, even when sensors get a little shaky. Finally, it breathes life into this skeletal data by animating a 3D avatar, mimicking your every twist and turn. The system has proven its accuracy and robustness in tests, making it a promising tool for various applications. Imagine interacting with virtual worlds using your natural movements, analyzing fitness routines with precise 3D data, or even monitoring elderly care remotely using posture analysis. This sensor-powered magic could unlock a future where technology seamlessly blends with our physical world, all thanks to the watchful eyes of lidar and inertial sensors.

In paper [5], author talks about how a system to evaluate fitness posture from videos using recurrent neural networks (RNNs). Users perform exercises like dumbbell lateral raises and bicep curls while being recorded. The system first detects 25 body joints in each frame using OpenPose. Then, the video is segmented into individual exercises based on the wrist joint's motion. Each exercise is represented by 17 keyframes, with each frame containing the 25 joint coordinates. Finally, an RNN model analyzes the sequence of keyframes and outputs a 3-dimensional binary vector indicating whether the exercise was performed correctly for

three specific criteria (e.g., forearm angle, upper arm stability, etc.). This allows users to pinpoint areas where their form needs improvement.

To summarize, this work uses RNNs to analyze the evolution of body joint positions in fitness videos and identify bad posture based on domain knowledge-driven criteria.

The author of paper [6] describes how convolutional neural networks (CNNs) are used in a real-time system for detecting and assessing workers' posture while they are teleworking. It attempts to stop health issues related to poor posture that may arise from the pandemic's spike in telework.

The system uses CNNs to analyze video footage and estimate the positions of the worker's neck, shoulders, and arms. Based on these estimates, it assesses the posture against ergonomic guidelines and provides real-time feedback and recommendations for improvement. The paper evaluates the system's accuracy and performance on various embedded platforms, focusing on real-time responsiveness and low power consumption. To summarize, this work utilizes CNNs in a monitor-integrated system to monitor and improve teleworkers' posture in real-time, addressing the increased risk of posture-related injuries with the rise of remote work.

In paper [7], In order to assist users exercise more successfully, this article suggests a virtual trainer that offers real-time feedback on posture and confidence scores. The trainer extracts 3D skeletal data from a Kinect sensor, analyses it using a Random Forest classifier, and outputs a real posture and a confidence score showing how correct the exercise was. After ten participants underwent testing, the system's accuracy was 96% on average.

The main techniques used in this paper are 3D skeleton extraction the Kinect sensor is used to extract a 3D skeleton of the user's body, which consists of 20 3D points. Feature extraction a subset of 12 joints and 8 angular features are extracted from the 3D skeleton data. Using a Random Forest classifier, the acquired features are categorised into one of the nine fundamental tasks. A confidence score showing the accuracy of the exercise is presented on the user's screen along with real-time feedback regarding the identified workout posture.

The evaluation's findings demonstrated that, with an accuracy rate of 96% on average, the suggested approach is successful in giving real-time feedback on confidence and posture ratings. In the future, the system can be expanded to incorporate animated avatars that can teach participants how to speak and to give feedback for increasingly difficult activities.

In paper [8], This paper proposes a system for in-home rehabilitation of incorrect postures, such as forward neck and poor posture. The system uses a Microsoft Kinect sensor to track the user's 3D skeleton data and extract joint angles. This data is then fed into a pattern recognition neural network (PRNN) developed in MATLAB, This determines if the posture is right or not. The user receives real-time visual feedback on their posture and a confidence score using LabVIEW software.

The PRNN achieved 100% accuracy on a test dataset of posture samples. Further testing is planned with more data to confirm the system's effectiveness in real-world scenarios. This system offers a promising solution for affordable and accessible in-home rehabilitation of posture problems.

III. CONCLUSION

In conclusion, AI-powered body posture detection and motion tracking for exercise has emerged as a transformative technology with wide-ranging potential to revolutionize the fitness landscape. Its ability to provide real-time feedback on form and accuracy, personalize workouts, and prevent injuries makes it a powerful tool for both beginner and seasoned exercisers alike. While challenges remain in terms of cost, accessibility, and data privacy, ongoing research and development promise to refine and democratize this technology, paving the way for a future where AI coaches guide individuals towards their fitness goals through personalized, interactive, and safe exercise experiences.

Participants in our study were able to improve their push-up strength and form until they felt comfortable completing the exercise.

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