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AI-BASED VIRTUAL FITNESS TRAINER WITH REAL-TIME POSE ESTIMATION AND INTELLIGENT DIET RECOMMENDATION SYSTEM

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Abstract: The growing popularity of home-based fitness training has increased the demand for intelligent systems that can guide users during workouts without requiring professional supervision. However, many individuals performing exercises at home struggle to maintain correct posture, which can reduce workout effectiveness and increase the risk of injury. This paper presents a Virtual Fitness Trainer, an intelligent system that utilizes computer vision and pose estimation techniques to monitor exercises and provide real-time feedback. The proposed system captures video using a standard webcam and detects key body landmarks to analyze joint movements during exercises such as bicep curls, push-ups, planks, and yoga poses. By evaluating joint angles and motion patterns, the system automatically recognizes exercises, counts repetitions, and identifies posture deviations. In addition to exercise monitoring, the system integrates a diet recommendation module that provides nutritional suggestions based on user fitness goals such as weight loss, muscle gain, or general health improvement. Unlike traditional fitness monitoring solutions that rely on wearable sensors or specialized hardware, the proposed approach operates efficiently on standard computing devices using camera-based pose estimation. Experimental evaluation demonstrates that the system provides reliable exercise detection and real-time feedback while also supporting personalized dietary guidance. The proposed Virtual Fitness Trainer offers a cost-effective and accessible solution for promoting safe workouts and balanced nutrition in home-based fitness environments.

Index Terms - Computer Vision, Pose Estimation, Human Pose Detection, Exercise Recognition, Real-Time Feedback, Fitness Monitoring System, Diet Recommendation System.

I. INTRODUCTION

In recent times, there has been increased consciousness about one's physical well-being and health, thus resulting in people developing their own fitness routines. Many have adopted exercising from the comfort of their homes due to their convenience, ease, and the availability of online exercises. However, doing exercises unsupervised by professionals often results in wrong posture and poor workout efficiency. Wrong posture while working out does not maximize the effectiveness of exercising and can even lead to injuries of the muscles or strain of certain body parts. In addition, maintaining proper nutrition is necessary for good workout results but is lacking among many people.

The evolution of AI and computer vision technology has allowed the creation of intelligent systems able to analyze human motion in real time. Pose estimation algorithms allow computers to recognize certain landmarks on the human body, such as shoulders, elbows, hips, knees, and ankles from images or videos. With the help of these landmarks, scientists can study body positioning and determine patterns of human motion during physical exercises. Therefore, these innovations make it possible to design automated fitness tracking tools that will help people exercise without human coaches.

Classic techniques to track fitness often use wearable sensors like accelerometers and gyroscopes or smart fitness gadgets to estimate activity levels. While sensor-based tracking offers precise results, it demands extra equipment and might be inconvenient for daily use. In addition, the need for specific devices makes such systems more expensive and less accessible to people opting for home workouts.

In response to this problem, computer vision methods using camera input and algorithms to recognize the body movement were introduced. Such programs analyze video data to determine the exercises performed by the user and his or her posture during the activity. However, most existing methods focus only on the identification stage and lack other features that would provide workout instructions and nutrition tips.

The paper presents a solution to develop an intelligent Virtual Fitness Trainer using Computer Vision technology, which aims to guide users when working out at home. The system captures video through a webcam in real-time and uses pose estimation technique to detect body joints and their movement trajectories while performing different exercises like push-ups, squats, and bicep curls. Using movement trajectories detected from video footage, the system is capable of recognizing different exercises, counting repetitions, and providing feedback on posture.

In addition to exercise monitoring, the proposed system incorporates a diet recommendation module that provides nutritional suggestions aligned with user fitness goals. By combining exercise analysis with dietary guidance, the system offers a more comprehensive fitness assistance platform that supports both physical activity and healthy nutrition.

The main contributions of this research are summarized as follows:

1. Design of a real-time exercise monitoring system using computer vision algorithms.
2. The use of pose estimation technique for identification of body parts during workout routines.
3. Detection of specific exercises performed by the user and the automatic counting of repetition numbers by analyzing joint movements.
4. Integration of a diet recommendation module providing nutritional advice according to fitness needs of the user.
5. Lightweight architecture capable of working efficiently in standard computers without any wearable sensors.

Thus, combining the capabilities of real-time exercise monitoring and nutritional advice into one solution, the proposed Virtual Fitness Trainer aims to provide a low-cost and convenient method for improving home-based fitness training.

II. LITERATURE SURVERY

Recent breakthroughs in the field of artificial intelligence and computer vision have made it possible to create intelligent systems that can observe and help the user during their workouts. Scientific studies have explored different approaches to monitor fitness levels, which include wearable sensor-based systems, exercise detection using computer vision, and intelligent food recommendation systems.

The earlier versions of physical fitness monitoring technology were mostly based on wearable devices that were used to track the body's movement patterns. The smart gym trainer suggested by Douzas and Mavroudi [1] is another good example of the use of wearable technologies to measure the effectiveness of physical exercises. The downside of the model was its reliance on numerous sensors.

The evolution of computer vision technology has led many scientists to propose camera-based systems for monitoring exercises. Suphanichet et al. [2] suggested a machine-learning technique for identifying exercises using skeletal tracking. In this system, the algorithm analyzed body postures for the detection of different exercises. However, this method mainly focused on the recognition of exercises and did not provide any real-time feedback for the correction of posture during physical activities.

Chang et al. [3] introduced an artificial intelligence-powered fitness trainer for guiding elderly people while exercising. In this system, the developers used deep learning techniques for identifying exercises

and movement patterns. This approach produced encouraging results but was computationally complex and could not be implemented on low-cost hardware.

Besides the monitoring of physical activities, there is research on intelligent diet recommendation systems aimed at helping individuals follow balanced diets. They are based on the analysis of user preferences, health information or fitness goals to provide personal recommendations about meals. Although intelligent diet recommendation systems may improve eating habits, the vast majority of available technologies exist separately from fitness monitoring services and cannot combine physical activity analysis with diet planning.

Nevertheless, despite advancements in the development of intelligent fitness monitoring software, there is still a number of issues. Currently, intelligent fitness applications are based either on wearable technologies or need to process huge amounts of data to perform their functions in real time. In addition, both fitness monitoring systems and diet recommendation systems are designed separately, thus restricting their ability to offer a complete solution to individuals' fitness problems.

The suggested Virtual Fitness Trainer combines computer vision–based exercise analysis with a diet recommendation tool. It uses pose estimation to recognize body movements during exercise performance and gives feedback about posture in real time while at the same time providing personalized suggestions about meals depending on individual fitness goals.

III. PROPOSED METHODOLOGY

The proposed method of the Virtual Fitness Trainer uses computer vision techniques and machine learning algorithms for the purpose of monitoring exercise routines and offering dietary advice to its users. By detecting body positions, the system makes dietary suggestions that are suitable based on user-defined fitness goals. The overall methodology is broken down into several steps.

A. Video Acquisition

The first stage in this process involves the capture of live video through the use of a webcam. The captured video feed is constantly processed and divided into individual frames for processing purposes. Individual frames are then fed into the pose estimation model where body keypoints are detected.

Through the use of webcams, there will be no need for sensors or special equipment, making it suitable for home use.

B. Pose Estimation

The method of pose estimation helps in identifying important anatomical points using video images. These include the major joints of the body, which include shoulders, elbows, hips, knees, and ankles. These anatomical points are used by the software to build a skeleton of the individual.

The coordinates of the points help in determining the angles at these joints. Using the difference in these angles over time between different frames helps analyze the posture and movement patterns during workouts.

C. Exercise Recognition

Exercise identification is carried out by analyzing patterns in movement of joints. Exercise activities create unique patterns in joint angles and posture.

For example:

- **Bicep curls**: involve continuous joint motion in the elbow.
- **Push ups:** involve synchronized joint motions in the shoulder and elbow joints.
- **Squats**: involve joint motion in the hip and knee joints.
- **Planks**: involve static postures for a specified amount of time.

From the above analyses in the video sequence, the exercise carried out can be determined.

D. Repetition Counting

The repetition counter system tracks the change from the starting to the final position for each particular exercise movement. Each full cycle of the movement will prompt an increase in the count of repetitions.

An example of this would be the bicep curl exercise, where one counts a repetition after lifting the weights from a fully extended position to a bent one and going back to the starting point.

E. Diet Recommendation Module

Apart from keeping track of the exercises, the recommended system provides users with meal plans according to their health goals. The dietary plan system generates plans based on goals like loss of weight, gain of muscles, or general fitness maintenance.

Based on the analysis of user preferences and their fitness goals, the system is able to recommend appropriate foods for consumption by the user.

IV. SYSTEM ARCHITECTURE

The intended design of the Virtual Fitness Trainer is an intelligent computer vision-enabled software that aids users during their workouts and provides recommendations for a balanced diet. The software combines movement tracking with a food recommendation module, which helps the users maintain balance in their fitness routines. The software structure combines various components working together to detect body movements, identify exercise routines, and provide feedback and nutritional recommendations.

The architecture of the software is illustrated in Fig. 1 below. It consists of five main modules: the video input module, pose detection module, exercise analysis module, diet recommendation module, and user feedback module.

A. Video Input Module

Live video data is acquired through the use of a normal webcam by the video input module. These videos are continuously processed and separated into frames which are then sent to the pose detection module for further processing.

The use of an input camera provides continuous tracking of the exercise without having to use any type of wearable equipment, thus improving the accessibility of the system to those who conduct their workouts at home.

B. Pose Detection Module

The pose detection algorithm detects the significant body points from the images obtained from the video frames. Such points are associated with the important joints of the body, such as shoulders, elbows, hips, knees, and ankles. Based on such detection, a skeleton of the person is derived.

The positions of the detected body points are used to calculate joint angles and detect any body movements during exercise routines.

C. Exercise Analysis Module

Exercise analysis is carried out using the body landmarks data in order to establish the type of exercise that is being undertaken. Exercise patterns differ depending on the type of exercise and this is identified through changes in the joint angle during successive frames.

Moreover, the module is able to detect both the starting point and the end point of exercise movement in order to establish repetition numbers.

D. Diet Recommendation Module

Apart from tracking workouts, the system provides dietary advice to aid the users in maintaining a healthy lifestyle. The dietary advice generator suggests meals based on the fitness goals of the user, which may include either losing weight, gaining muscles, or becoming generally fit.

The system promotes proper foods for the user, along with dietary advice that would go hand in hand with his/her workout sessions.

E. Feedback and User Interface Module

The feedback component offers instant advice to the user during the workout session. It displays the recognized body position, the name of the exercise being performed, the number of repetitions, and feedback on body positioning.

In case of inappropriate body positioning, the system creates visual notifications to help users adjust their body positions. The interface also offers nutritional advice to help users maintain good nutritional balance during their workouts.

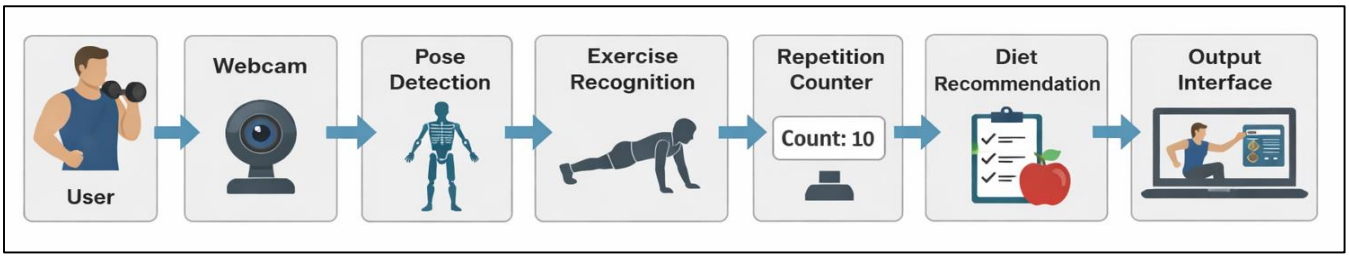

Fig. 1. Architecture of the proposed Virtual Fitness Trainer system.

V. RESULTS AND DISCUSSION

The Virtual Fitness Trainer system was created and tested to evaluate its potential to detect exercises in real-time and provide personalized training advice. The proposed system uses pose detection, exercise identification, repetition counting, and a diet recommendation component to help users perform better during their training sessions. Testing was performed using a regular laptop and a camera attached to it, confirming that the proposed system does not require any special equipment.

The graphical interface helps users choose exercises, observe their movements, and get instant feedback regarding their actions. Moreover, the interface also provides users access to the diet recommendation part, helping them examine their nutritional intake and estimate the number of calories needed depending on their body mass index. It is evident that the proposed system provides an interactive approach to home training sessions.

The user interface of the system is shown in Fig. 2, where users can select different exercises and initiate the exercise detection process.

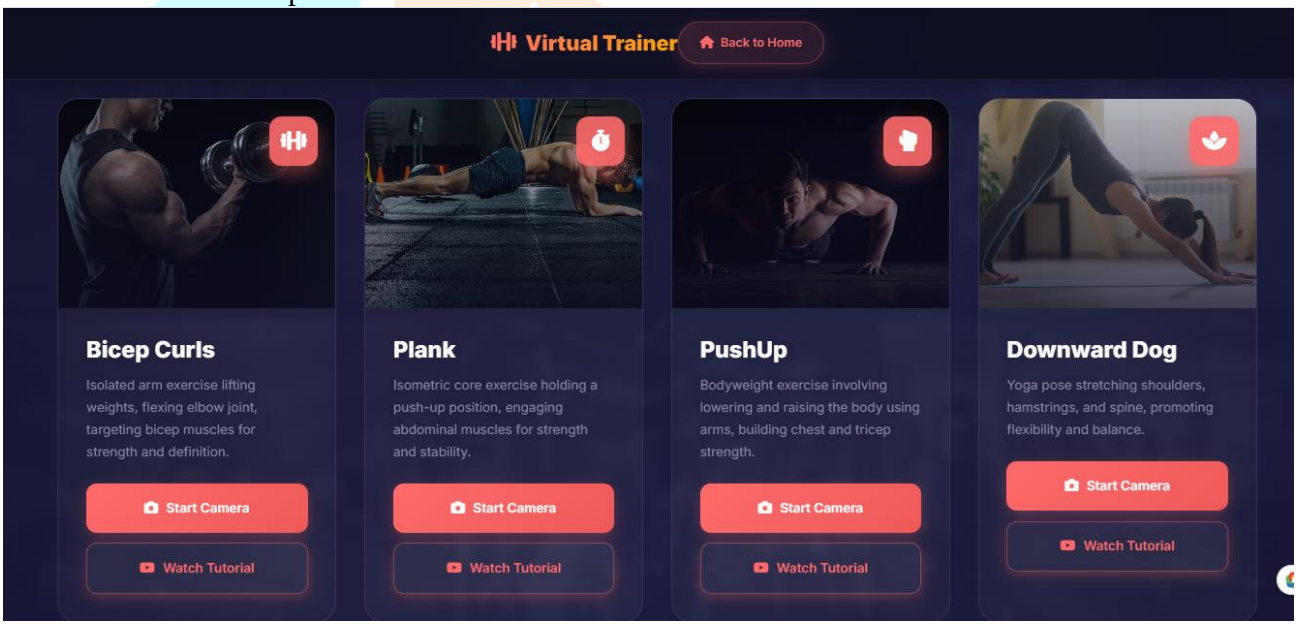

Fig. 2. User interface of the Virtual Fitness Trainer showing exercise selection options.

Pose detection plays a vital role in analyzing body movements. The application uses the MediaPipe Pose Estimation approach to detect specific skeletal landmarks within the webcam stream and map them on the human body. The landmarks are used to calculate the angles of the joints and the posture of the body while exercising. An example of pose detection and landmark tracking while exercising is shown in Fig. 3.

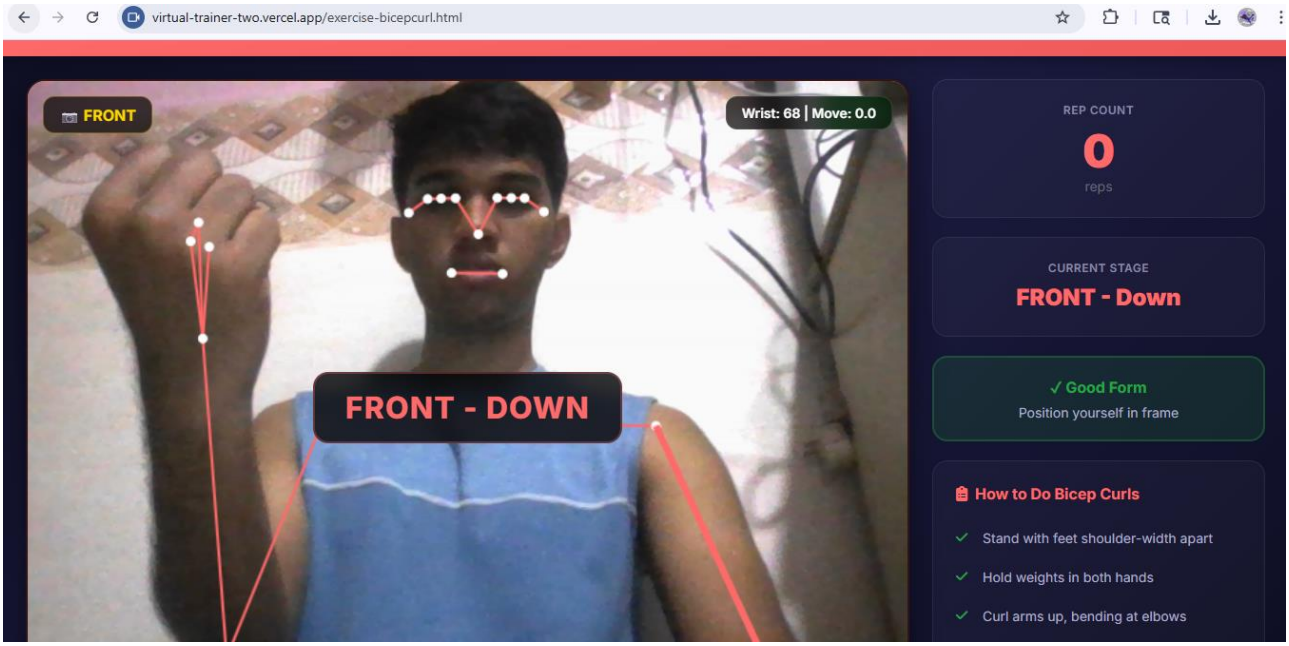

Fig. 3. Human pose detection and landmark identification during exercise monitoring.

The system tracks the progression of the exercise in terms of counting reps from joint threshold values. In this case, when a user goes from one position to another, for example, when performing biceps exercises or push-ups, changes in positions are monitored, and the rep-counter gets incremented. The feedback is provided in real time on the interface to ensure proper posture and exercise form.

In addition to exercise monitoring, the system includes a diet recommendation module that analyzes users' dietary intake and body metrics. Users can enter the food items they consumed, and the system calculates estimated calories and protein intake. The system also integrates a diet recommendation module to assist users in managing their nutritional intake. The meal analysis interface allows users to input food items and obtain estimated calorie and protein values, as illustrated in Fig. 4. In addition, the system includes a BMI and calorie calculator that provides personalized dietary suggestions based on body metrics and fitness goals. The implementation of this module is shown in Fig. 5.

Fig. 4. AI-based meal analysis interface showing calorie and protein estimation from user-input food items.

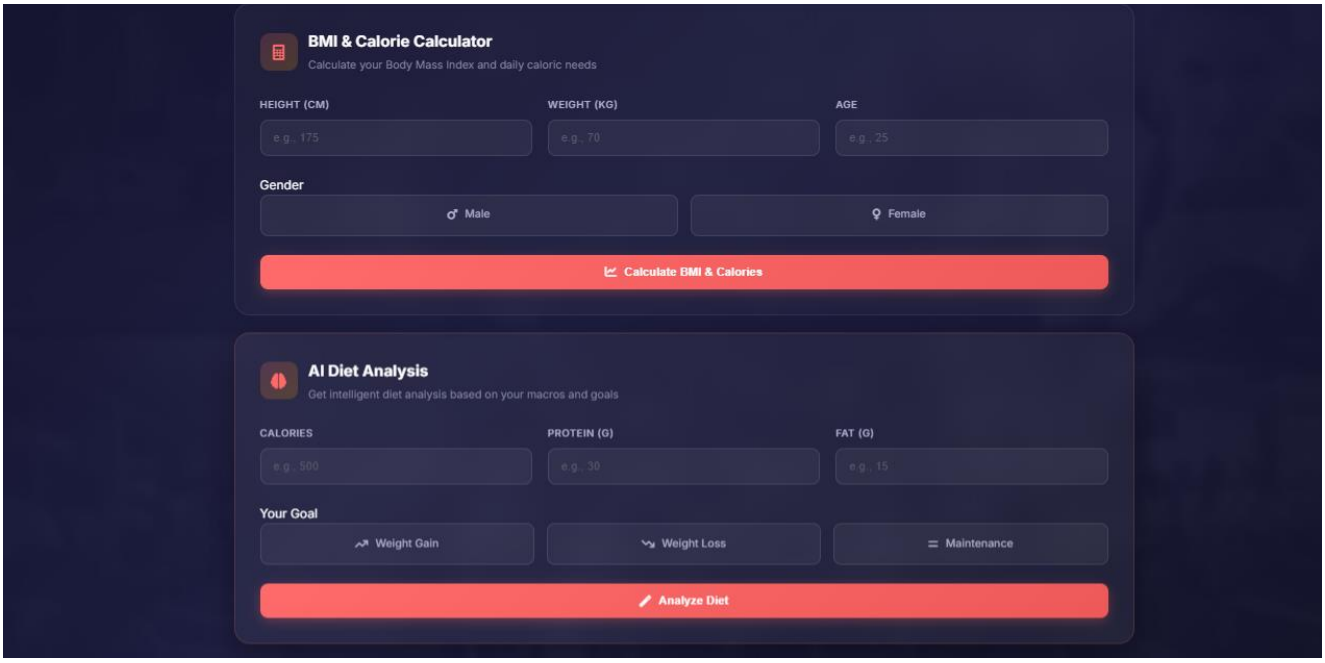

Fig. 5. BMI and diet recommendation module providing personalized nutritional guidance based on user metrics.

Experimental testing shows that the system is capable of doing pose detection and exercise detection at a speed of about 25-30 frames per second. Thus, smooth real-time results can be guaranteed with the current approach. The pose detection model accurately finds major body parts in regular lighting conditions and performs exercise detection of commonly practiced exercises such as push-ups, biceps curls, plank, and yoga poses.

To conclude, the current results indicate that the suggested Virtual Fitness Trainer is a useful and relatively cheap way to monitor exercise progress and provide personal recommendations without the use of additional gadgets and equipment.

VI. CONCLUSION

The purpose of this study is the development of a Virtual Fitness Trainer, which combines monitoring of physical exercises using computer vision techniques and the functionality of recommending a proper diet. In order to recognize various exercises, the application uses the technique of pose estimation, which allows identifying human landmarks as well as assessing their positions and analyzing exercise execution. The proposed software tool can detect various exercises, including push-ups, biceps curls, plank and yoga exercises by automatically counting repetitions and evaluating users' postures.

Besides monitoring exercises performed by the user, the architecture of this tool incorporates the feature of recommending a diet according to the consumption of particular nutrients and calculating necessary calorie requirements according to body mass index.

The experimental implementation of this software proved its efficiency in terms of its usage on traditional computers without the need for any special hardware and/or wearable sensors.

VII. FUTURE WORK

It is evident that the current approach has shown the viability of real-time monitoring of the exercises and providing diet recommendations via computer vision and the web. Still, there are some improvements that can potentially help make the project better. The next step would be developing more diverse types of exercises and improving the accuracy of the poses detection, especially when it comes to more complicated movements.

In addition to the above, the system may evolve towards mobile application development. The introduction of data from wearable devices would also provide the user with advanced capabilities when it comes to monitoring the performance of exercises. Moreover, the diet recommendation part of the system can be improved by using machine learning techniques to provide the user with personalized suggestions.

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