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

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Abstract. Exercises that include physical activity are quite important in our day-to-day lives, and this is especially true for patients who are in the midst of the healing process and require their bodies to recover more quickly. As a direct result of this particular circumstance, the relevance of physical activity in our lives has grown. The enhancement of human capabilities and the extension of human lifespans are both made possible by them as the essential premise. The utilization of Artificial Intelligence and Image Processing has the potential to improve and supplement the process of working out, hence removing the necessity for the supervision of fitness professionals. During your training session, a motion tracker that is powered by software can not only monitor and record all of the exercises that you have completed, but it can also provide feedback on how your body is aligned. It is anticipated that the favorable efficiency of the activity would be improved by the utilization of computational data and analysis. Because of the nature of this application, the MediaPipe architecture could be utilized. In this machine learning model, points are plotted at various joints of the human body posture. The movement is then captured, stored, and evaluated once it has been recorded. This in-depth investigation of body tracking might be applied in the construction of an application that could monitor the medical exercise routine of a user who has registered for the program. It is possible that the programming might be improved such that it enables registered users to be connected with verified physicians who have access to the diagnostic reports and exercise history of the patients who correspond to them through databases.
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Keywords: MediaPipe, BlazePose, BlazeFace, Bicep curls.

I. INTRODUCTION

Weight training is a form of exercise that is widely recognized as being of great significance and importance for the promotion of good health. It is possible to treat certain muscle illnesses by employing workouts that are specifically targeted. On the other hand, partaking in free exercise can be scary for novices and physically hard if it is not completed properly or if it is done without help. There is a lack of effort in leveraging technology to help the learning of new material by new students, despite the fact that there are activities that are both exciting and occasionally harmful. When it comes to exercise instruction, traditional methods frequently rely on subjective visual cues, which are prone to errors and uncertainties. By evaluating the motions of your body with astonishing accuracy based on data, artificial intelligence, on the other hand, provides a method that is both objective and accurate. With the use of cutting-edge machine learning strategies and forward-thinking ideas, this research investigates a wide variety of artificial intelligence (AI) and technologies that are utilized in the context of the human body to recognize and monitor motion. We intend to develop a user-friendly interface technology that will be of assistance in the rehabilitation of those who are in need of physical activity or who are capable of recovering on their own without the assistance of a professional. The features of this system include the calculation of repetitions, the monitoring of grades, the notification of time, and the exhibition of creative exercises that are carried out under the supervision of a medical professional.

In addition, the purpose of this study is to identify areas in which there is a deficiency in research and to provide a point of departure for further inquiries. Last but not least, offering advice on how to improve your posture in order to achieve the best possible results from your workouts, as well as keeping a record of your prior workouts in order to acquire historical information on your daily, weekly, and monthly practice of physical activity

II. LITERATURE REVIEW

The author of the research [1] presents an AI-driven intelligent system that employs image and video processing to oversee and recommend adjustments for exercise posture, aiming to enhance performance. The system utilises Python libraries such as MediaPipe, TensorFlow, and OpenCV for the purpose of acquiring, processing, and analyzing images and videos. The technology utilizes advanced algorithms to recognize and analyses major body components and joints, enabling it to accurately assess exercise posture and detect any deviations from correct form. The user is given visual feedback and remedial suggestions to enhance their workout technique. This research study utilizes Python, Jupyter notebook, OpenCV for computer vision, and machine learning methods, as well as MediaPipe for posture estimation. This technology employs computer vision and machine learning algorithms to analyses and enhance workout technique. The system utilizes the MediaPipe library to do real-time posture estimation, accurately identifying crucial body markers such as joints and extremities. By comparing collected postures to pre-existing data, the system finds departures from ideal form and delivers visual feedback and correction suggestions. Users are enabled to optimize their exercise efficiency, mitigate the likelihood of injury, and perhaps experience enhanced mental well-being by engaging in frequent physical activity. In contrast to previous methods, this system is characterized by its low weight, reduced training time, and ability to effectively process smaller datasets. Furthermore, it integrates object identification and makes use of the quicker and more adaptable MediaPipe library for posture estimation. This research presents a streamlined and immediate workout posture analysis system that utilizes MediaPipe for position assessment and use machine learning for providing feedback. In contrast to previous systems, it operates efficiently on low-end devices, manages smaller datasets, and identifies people prior to analysing their form. The device offers visual feedback and remedial recommendations to enhance the efficacy of exercise and perhaps enhance mental well-being through consistent physical activity.

In their research article [2], the author presents BlazeFit, a workout analysis system driven by artificial intelligence. BlazeFit utilizes MediaPipe to analyses body posture and provides immediate feedback in real-time. BlazeFit's primary objective is to connect patients and healthcare professionals through the use of medical exercises and remote recuperation. This is achieved by analysing the correct execution of exercises, keeping track of the number of repetitions, suggesting appropriate workouts, and potentially enabling doctor consultations depending on the patient's exercise history. BlazeFit enables users to enhance workout precision and efficacy by reducing the requirement for continuous expert oversight, hence promoting improved recovery and general well-being. The project use artificial intelligence to analyses the execution of physical exercises and deliver immediate feedback from a remote location. Media Pipe, a framework developed by Google, is utilized to track body and hand motions, quantify repetitions, and evaluate form. Subsequently, this data is exhibited on dashboards accessible to both patients and clinicians. The patients' exercise routines are monitored and the outcomes are sent to a dashboard accessible by the doctor. The doctor may then personalize daily exercise and food regimens according to the patients' progress. The technology utilizes two essential models: a palm detector and a hand landmark model, which collaborate seamlessly to enable hand tracking. The accuracy tests revealed an overall workout accuracy rate of 92%, with bicep curls achieving 84% accuracy and push-ups achieving 92% accuracy. The accuracy of the system is influenced by lighting conditions and camera resolution. However, there is potential for additional improvement through breakthroughs in training datasets and algorithms.

In the study [3], the author proposes a project aimed at helping individuals do tasks with correct posture. The project utilises pose estimation to ascertain the user's workout posture, subsequently providing suggestions for enhancement and feedback.The system consists of two main components: a pose estimator and a posture corrector. The pose estimator identifies the user's posture using an OpenPose pre-trained model. Upon assessing the user's posture, the posture corrector provides feedback to the user. This study demonstrates the utilisation of computer vision for the purpose of analysing exercise posture and delivering immediate feedback. It functions via Identifying crucial anatomical landmarks The programme OpenPose utilises computer vision algorithms to detect and locate 18 specific anatomical landmarks on the human body, such as knees, elbows, and shoulders, by analysing video recordings. Examining body alignment for particular physical activities: The system computes angles and motions between these crucial places, depending on the specific exercise being performed. For instance, during a bicep curl, it verifies if your upper arm remains parallel to your torso. The system offers personalized comments on your form by utilizing analysis. It can indicate excessive movement in your back during a shoulder press or insufficient depth in your bicep curl. The main objective of this work is to assist individuals in enhancing their exercise technique and reducing the risk of injuries through the utilization of real-time posture analysis.

According to the reference [4], This study introduces a system that utilizes lidar and inertial sensors to track and estimate the real-time 3D location of humans. The technique use lidar data to first detect the human body and accurately determine its height and bone features. Subsequently, it utilizes data obtained from lidar and inertial sensors to precisely monitor the body's location and alignment. Ultimately, it replicates human motion on a three-dimensional representation. The technology employs an Octree-based methodology to discern the human body from the lidar data. This method is highly effective and adept at managing occlusions. Upon detecting the human body, the system utilizes a one-time algorithm to determine its height and skeletal data. Empirical evaluation of the system has demonstrated its accuracy and robustness. It has diverse uses, including human- computer interaction, virtual reality, and fitness training.

This work introduces a real-time system that use a smart integration of lidar and inertial sensors to monitor and capture 3D human movement. Envision a laser-based system that identifies your body structure, calculates the locations of your bones, and monitors your movements while considering the constraints of the sensors. This research effectively does that. Initially, the device use lidar technology to meticulously examine the surroundings, precisely detecting and recognizing your physical form akin to a digital artist sculpting a model. Subsequently, it calculates your height and determines the precise placements of your main joints, resulting in the creation of a skeleton model. Subsequently, the system employs both lidar and inertial sensors to monitor your motions in real-time, even in the presence of sensor instability. Ultimately, it brings vitality to this bare- bones information by creating movement in a three-dimensional representation of a person, accurately imitating all of your movements. The system's accuracy and resilience have been demonstrated in testing, establishing it as a potential tool for many applications. Envision engaging with virtual environments by using your innate gestures, examining exercise regimens with accurate three- dimensional information, or remotely overseeing geriatric assistance through posture evaluation. The integration of lidar and inertial sensors enables a future where technology effortlessly merges with our physical environment, facilitated by sensor-powered magic.

In the publication referenced as [5], the author discusses the development of a system that utilises recurrent neural networks (RNNs) to assess the fitness posture of individuals based on video data. Users engage in workouts such as dumbbell lateral rises and bicep curls while their movements are being recorded. The method first identifies 25 body joints in each frame using OpenPose. Next, the video is divided into several workouts according to the movement of the wrist joint. There are a total of 17 keyframes for each workout, and each keyframe consists of 25 joint coordinates. An RNN model is used to analyses the series of keyframes and generate a 3-dimensional binary vector that indicates the correctness of the workout for three specified criteria, such as forearm angle and upper arm stability. This enables users to precisely identify places in which their form requires enhancement.
In essence, this study use Recurrent Neural Networks (RNNs) to examine the progression of body joint locations in workout films and detect improper posture using criteria guided by domain knowledge.

In paper [6], the author explains the application of convolutional neural networks (CNNs) in a real-time system that detects and evaluates the posture of teleworking workers. It aims to prevent health problems associated with bad posture that may result from the increase in telecommuting caused by the pandemic. The technology use Convolutional Neural Networks (CNNs) to examine video data and approximate the precise locations of the worker's neck, shoulders, and arms. Using these calculations, it evaluates the body position in relation to ergonomic standards and offers immediate feedback and suggestions for enhancement. The article assesses the precision and efficiency of the system on several embedded platforms, with a specific emphasis on its ability to respond in real-time and consume minimal power. In essence, this study employs Convolutional Neural Networks (CNNs) in a system that is incorporated into a monitor. The purpose is to monitor and enhance the posture of teleworkers in real-time, specifically targeting the heightened vulnerability to accidents associated with poor posture due to the growing prevalence of remote work.

Reference [7] This article proposes the use of a virtual trainer that provides immediate feedback on posture and confidence levels to help users enhance their workout performance. The trainer utilizes a Kinect sensor to get 3D skeletal data, which is then subjected to analysis using a Random Forest classifier. The outcome of this analysis is the determination of a genuine posture and a confidence score that indicates the accuracy of the workout. The system's average accuracy was 96% after assessing 10 people. This study primarily employs the technique of 3D skeleton extraction. The Kinect sensor is utilized to extract a 3D skeleton of the user's body, including 20 3D points. A subset of 12 joints and 8 angular characteristics are taken from the 3D skeleton data for feature extraction. The Random Forest classifier is employed to categories the gathered data into one of the nine core jobs. The user's screen displays a confidence score indicating the exercise's correctness, as well as real- time feedback on the recognized workout posture. The evaluation's findings indicate that the recommended technique achieves a high level of success, with an average accuracy rate of 96%. It provides real-time feedback on confidence and posture scores. In the future, the system has the potential to be enhanced by integrating animated avatars that may instruct users in language acquisition and provide feedback for progressively challenging tasks.

Reference [8] is mentioned in the study. This study presents a technique designed to facilitate the rehabilitation of inappropriate postures, such as forward neck and bad posture, inside the comfort of one's own home. The system employs a Microsoft Kinect sensor to monitor the user's 3D skeletal information and derive joint angles. The data is subsequently inputted into a MATLAB-based pattern recognition neural network (PRNN) to ascertain the correctness of the posture. The user is provided with immediate visual feedback on their posture and a confidence score through the utilization of LabVIEW software.
The PRNN demonstrated a perfect accuracy rate of 100% when evaluated on a test dataset consisting of samples of different postures. Additional testing is scheduled to be conducted using a larger dataset in order to validate the system's efficacy in real-life situations. This technology provides a viable alternative for cost-effective and easily accessible in- home rehabilitation of postural issues..

III. Proposed Methodology

The hand tracking approach utilises a machine learning pipeline consisting of two collaborative models.
1. A palm detector that identifies the position of palms by utilising a hand bounding box that is properly aligned and operates on the whole input image.
2.A hand landmark model is used in conjunction with the palm detector's segmented hand bounding box to get accurate and detailed results. 2.5D landmarks refer to specific points in a three-dimensional space that are used for reference or measurement.

The Firebase framework was employed as the database system to store and effectively retrieve information on the experiment. The Django framework will oversee the user interface of the application...
The overall structure of the proposed system is depicted in Figure 1, illustrating the main sequence of steps involved, which encompass acquiring the real- time video stream from the patient's camera and presenting it on the dashboard. Moreover, the activity tracker monitors and records the workout activities, storing the findings in a database. These results are then transmitted to the doctor's dashboard, where directions for the next exercise regimen and dietary recommendations may be inputted. chart and send it back to the patient’s dashboard via the database.

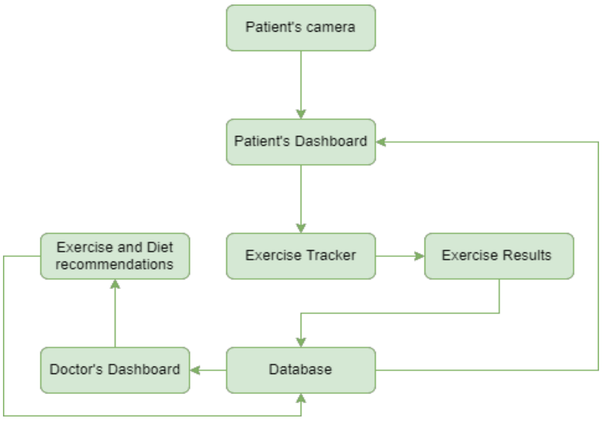

Fig. 1. The generalized flow of the system

The MediaPipe framework consists of two types of detection models: the BlazePose detector and the BlazeFace detector. BlazePose consists of two distinct machine learning models: a Detector and an Estimator. The Detector eliminates the area occupied by humans from the input image, while the Estimator provides crucial points from a 256×256 resolution image of the identified individual. Like BlazeFace, which is also present in MediaPipe, this single shot detector is well- suited for real-time applications on mobile devices. Hand gesture detection poses a formidable challenge. The model is required to accurately identify hands that are partially or completely hidden, including hands that are obstructed by other objects or by themselves. Additionally, the model should be able to handle hands of various sizes and a broad variety of scales, up to a maximum of 20 times the original size. The facial region has a pronounced contrast pattern in the vicinity of the eyes and mouth, but the hands lack such a pattern, rendering them less discernible just based on their visual attributes. The system utilises three distinct validation datasets, including many industries, to assess the efficacy of the models in comparison to other publically available solutions that demonstrate high performance. These datasets include Yoga, Dance, and HIIT. Each photo has a solitary individual positioned 2-4 meters distant from the camera. The model assesses the compatibility of 33 specific key points from the COCO topology with prior solutions. Figure 2 illustrates the capability of the BlazeFace detector to accurately identify human body position and execute segmentation masking with exceptional precision.

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Fig. 2. Example of MediaPipe Pose real-world segmentation mask. [1]

The algorithmic flow of the MediaPipe architecture for hand movement detection is depicted in Fig.3. It involves pipelining picture snapshots from the camera into the BlazeFace module, which utilises extensive datasets to identify body points. Subsequently, the image is mapped, cropped, and projected onto the screen.

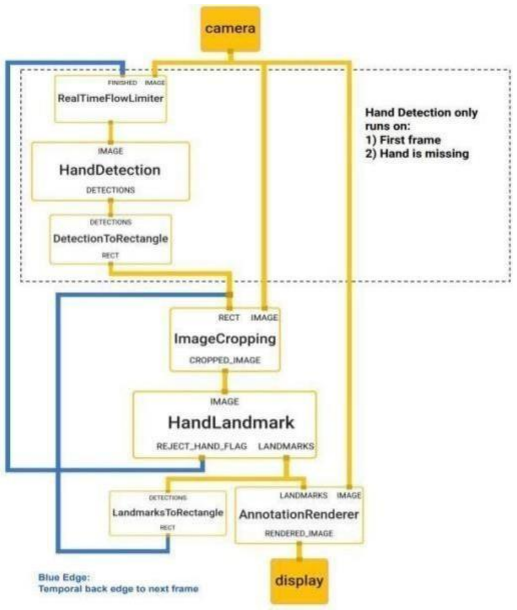

Fig. 3. MediaPipe pipeline flow. [1

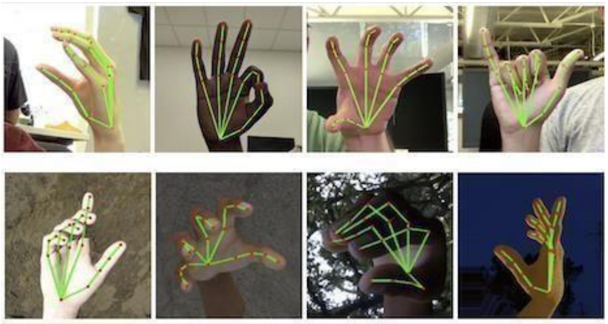

Fig. 5. Hand gesture tracking outputs [7]

Fig.4 and **Fig.5** shows how the MediaPipe model plots the joints and lines on the human body posture and palmfor movement detection using the angle between two joints.[6]

IV. CONCLUSION

AI-driven body posture identification and motion tracking for exercise has emerged as a revolutionary technology with the potential to alter the fitness industry. The capacity to offer immediate feedback on technique and precision, customize training routines, and mitigate the risk of injuries renders it a potent instrument for individuals at all levels of fitness experience. Despite existing challenges related to cost, accessibility, and data privacy, continuous research and development efforts hold the potential to improve and make this technology more accessible to all. This progress will enable a future where AI coaches provide personalized, interactive, and secure exercise experiences, assisting individuals in achieving their fitness objectives.

The research participants demonstrated enhanced push-up strength and technique, reaching a level of proficiency where they felt confident in successfully doing the activity..

V. Future Work

The system exhibits several areas that may be enhanced. Additional investigation is necessary to explore the precise sorts of physical activity employed by individuals with particular disorders. Consultation with a physician or physiotherapist is necessary to validate the appropriateness of the workout. The precision of certain workouts, such as push-ups, was compromised mostly owing to the subpar camera quality employed by the programmer. Enhancing the precision may be achieved by developing an android application that leverages the superior capabilities of its high-resolution camera for detecting purposes. Since the current system is only designed for food programmers and health tracking, there is much room for including additional functionalities like blood testing and immunization reports. To enhance the system's versatility, it might incorporate vernacular languages, particularly in nations like India where each state has its own distinct language. The programmer may also be customized to cater specifically to women's needs, allowing for tracking of menstrual cycles and providing tailored workout recommendations for women. The user interface should be enhanced to be more accessible for the intended audience, which includes older folks and others residing in rural regions who may have limited familiarity with technology..

I. REFERENCES

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