

AI-Based Real-Time Body Posture Correction and Injury Risk Detection System

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Abstract - Physical fitness matters to stay healthy and feel better overall. But doing exercises wrong can cause muscle problems or joint issues that add up and maybe lead to bigger injuries later. A lot of people are trying workouts at home these days without anyone around to check form, so it feels like posture help could matter more now. Advances in AI and computer vision make it possible to watch movements automatically and send feedback as things happen. This project describes a system built around pose estimation from Media Pipe along with some machine learning to look at body positions in live video. Joint angles get calculated from the points it finds and then the setup tries to spot when a move looks off enough to raise injury risk. Exercise types also get sorted out during the process. The whole thing runs on Fast API with a React front end and stores data through SQLite. WebSocket helps keep the responses quick. It seems to manage real time checks without needing heavy resources though I am not totally sure how well it handles every single exercise variation that might come up. Tests indicate it can flag bad alignment and suggest fixes while keeping things simple enough to scale. Some people see this as mainly for fitness apps, but others might use it in recovery settings too and that part still feels a bit open.

Keywords: Human Pose Estimation, Media Pipe, Computer Vision, Injury Risk Detection, Exercise Classification, Machine Learning, Posture Correction, Fitness Analytics.

1. INTRODUCTION

It is well known that physical activity is one of the most powerful means of preserving cardiovascular health, and that it can trigger positive changes in the body. It is well known that physical activity is one of the best ways to maintain cardiovascular health and that it can cause positive changes in the body.

Increase muscle strength, flexibility and prevent lifestyle diseases. Increasing awareness of personal fitness has led to a significant rise in fitness memberships, fitness programs on the internet, and home fitness programs. While these developments have made exercising easier to access, they have also made it more likely that people will be exercising without the proper supervision of a qualified trainer or physiotherapist. Thus, the importance of correct exercise posture has become a major concern and is a

frequent source of diminished exercise effectiveness and injuries.

Posture is important for the effectiveness and safety of physical activities. Using incorrect form for activities like squats, lunges and step-ups may overwork joints, muscles and ligaments. The repeated movement errors over time can lead to chronic musculoskeletal conditions, decreased mobility, and chronic health issues. Traditional methods of posture evaluation are mainly dependent on the manual observation of fitness experts, coaches, and physiotherapists, who determine and give feedback on body movements. Though effective, these methods tend to be costly, qualitative, and unavailable for many people.

With recent developments in artificial intelligence and computer vision, there are opportunities to conduct posture analysis and monitor exercises with minimal effort. Pose estimation can pick out body points from normal cameras in real time so there is no need for costly motion setups or extra sensors. Media Pipe and Open Pose have demonstrated their ability to extract skeletal information from video streams and enable various applications, such as gesture analysis or fitness assessments. Many current tools still handle posture fixes or exercise types one at a time though. It seems like few pull all the pieces together such as monitoring movements and spotting injury risks at once. Some also depend on heavy models that do not run well on simpler hardware.

This paper puts forward a system meant to handle real time posture correction and risk detection together. It combines pose estimation with joint angle checks and exercise classification in one setup that stays lightweight using tools like Fast API and WebSocket links.

The idea is to make exercise safer overall and cut down on injuries while keeping the platform flexible.

I think the main goal is better safety through combined analysis but maybe not every detail about deployment is settled yet. Some parts feel like they could overlap more than expected.

2. LITERATURE REVIEW

Application of artificial intelligence and computer vision for fitness monitoring is attracting researchers' interest. Over the past decade, research has been done on the use of computer vision techniques like pose estimation and machine learning in order to study possible applications in posture correction, exercise classification, rehabilitation assistance and injury prevention. With the recent advances in human pose estimation algorithms, skeleton tracking can be done in an ordinary camera and presents new potential for smart exercise monitoring systems.

Posture correction studies have been conducted several times, mostly using landmark detection and angle analysis between each landmark. This type of application serves to process and track the position of each landmark and then compares that position with some standards using the pose estimation algorithms like Media pipe or Open Pose. These systems have been successful in postural irregularity detection and correction. Most of them only carry out a simple posture correction, however, analyzing and giving feedback about the posture of the user.

Many researchers have been working on systems aiming to classify different exercises using the same type of approach, and as such, include their variations in the analysis. Through different key point recognition and classification algorithms, diverse types of exercises are recognized to provide feedback. Even though these applications achieve relatively good accuracy in the exercise classification, none of them focus on the risk of injury.

For rehabilitation purposes, some methods using similar technology have been used to provide a way to visualize the progress of a patient under treatment. By analysing the movement of the user and comparing it to ideal standards, these works focus on the user's state and provide a way to see if the movement is adequate for a physiotherapist to recommend further actions. However, these systems were mainly developed for the purposes of rehabilitation, not fitness training.

Recently, some works have focused on using artificial intelligence to recognize unsafe movement patterns to prevent injuries on the user. By analysing key pose landmarks, biomechanical analysis is made to estimate the risk of injury during the movements. However, even though most of these applications are effective in detecting unsafe movement, they require additional equipment or complex algorithms to achieve their results.

By reviewing the current state of research, it is possible to notice that each work focuses on one area without considering the others. Mainly, articles focus on posture correction, exercise classification, injury prevention, and rehabilitation progress. However, few applications

combine multiple features such as posture detection and feedback, making the training sessions more efficient. Moreover, most of the systems described in the articles are not lightweight algorithms that can run on any device but instead require additional hardware to perform calculations. As such, there is a need for a system combining all useful features of the existing systems while being lightweight enough to be useful and widely adopted. For this reason, the research will focus on developing a posture correction and injury detection system which will provide feedback in real-time while being complex enough to be used in daily fitness routines.

3. PROBLEM STATEMENT

The growing popularity of digital fitness platforms and home exercise programs transformed the way people work out. Although such tools provide a convenient and engaging environment for workouts, they cannot ensure the correct exercise posture and analyses potentially harmful movements. Therefore, the exercising persons are increasingly at risk of injury and ineffective workout due to the lack of professional oversight.

Maintaining a good posture during physical activity is critical for exercise efficiency and body health. Incorrect movement patterns during body-weight exercises, such as squats, lunges, and step-ups, can cause unnecessary stress to joint and muscles. The accumulated strain on the knees, hips, spine, and shoulders will lead to a variety of injuries and physiological disorders. Although personal trainers and specialist physiotherapists offer posture assistance, the cost and accessibility of professional services remain highly limited.

Current posture monitoring solutions typically address the exercise repetition counting or classification while providing limited injury assessment capabilities. In addition, most of them offer only rule-based posture correction without evaluating the detected deviations' effects on the human body. Another limitation is that most existing solutions rely on specialized hardware and advanced computer vision algorithms, which decreases their practical applicability. An intelligent system that can estimate the body posture, classify exercises, identify dangerous movements, and visualize feedback in real-time using a standard webcam is necessary to ensure effective and safe exercising.

The proposed research aims to design an AI-Based Real-Time Body Posture Correction and Injury Risk Detection System, which employs pose estimation, computer vision, and real-time feedback to ensure safe and effective exercising. The designed solution will address the current limitations of existing posture monitoring solutions while introducing new beneficial aspects.

4. PROPOSED SYSTEM

The AI-Based Real-Time Body Posture Correction and Injury Risk Detection System monitors human movements to ensure safe and effective exercising. The proposed solution employs recent advances in computer vision and machine learning to develop an automated posture assessment framework. The system will offer multiple benefits over the current solutions by introducing an end-to-end approach that binds posture monitoring, exercise classification, injury risk detection, and real-time feedback visualization.

First, the system will be able to capture real-time video streams with a regular RGB camera. The proposed framework will be easily implemented with a regular camera while the existing solutions have to rely on special hardware. Media Pipe pose estimation will be used for processing video frames, which separates body parts and limbs.

Then, the absolute angles of the body joints will be estimated using a combination of vector operations. The calculated angles will be indicative of the current body posture when performing the exercise. Joint angles will then be used as features for training an exercise classification model. The classifier will be able to detect the exercises performed, including performing a squat, lunge, step-up and arms raise. The proper classification of the exercise is a very important step, because this allows the system to evaluate the body position when it comes to the certain movement patterns, and then issues the appropriate recommendations.

The next stage is to analyse the postural correctness following the identified exercise. The system will rely on biomechanical principles to evaluate if the current joint angles follow the recommended ranges for the given exercise. If the body posture deviates from the optimal position, it compromises exercise effectiveness and causes additional stress to the working muscles and joints. The posture assessment will also serve as the basis for the injury risk detection, which uses similar biomechanical principles to identify unsafe movement patterns.

Specifically, the injury risk assessment will analyse the detected postural deviations and estimate the potential harm to the body. The system will maintain a set of safety rules to evaluate if the current exercise follows the established movement patterns. Depending on the assessment outcome, the injury risk will be categorized as Safe, Warning, or Critical. Ultimately, the system will provide real-time feedback regarding detected postural deviations, unsafe movements patterns, and injury risk level to support the user in achieving a proper exercise technique.

To ensure fast data exchange between the server and

clients, the proposed framework will use Fast API and Web Sockets communication layer. All exercise-related data, including posture assessment, injury risk level, exercise classification, repetitions count, and others will be stored in a SQLite database. The database will be maintained with SQL Alchemy ORM to enable efficient data manipulation and querying.

The proposed system will offer significant benefits over the existing solutions by eliminating the need for special devices and providing real-time feedback. Moreover, the system will include an injury risk assessment module, which will estimate the current state of the body posture and identify hazardous movement patterns. The ability to monitor the past and current workouts will provide valuable insights into the user's progress and support exercising persons in assessing their performance.

5. SYSTEM ARCHITECTURE

The system architecture of the proposed AI-Based Real-Time Body Posture Correction and Injury Risk Detection

System is organized to maintain real-time processing, offer end-to-end learning, and ensure modular design. The architecture is composed of the following modules: Video Input Module, Pose Estimation Module, Joint Angle Calculation Module, Analysis Engine, Backend Module, Database Module, Communication Layer, and Dashboard Visualization Module. These modules are structured according to the functional requirements of the system and support the key operations of data acquisition, pose estimation, injury detection, and feedback visualization.

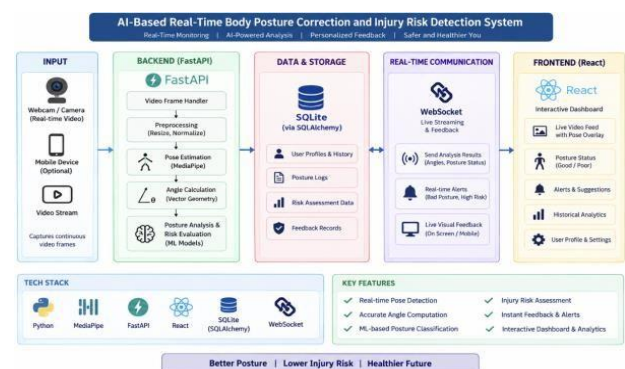


Figure 1: Overall System Architecture

The Video Input Module is the module to capture the live video stream. The Pose Estimation Module further processes the video data and the body joints and limbs are isolated using Media Pipe algorithm. The Joint Angle Calculation Module then uses the joint positions to calculate the relative angles, indicative of body posture. Analysis Engine determines current exercise, analyzes the body posture, calculates the number of repetitions and the risk of injury based on the calculated joint angles. The

Backend Module is written in Fast API, which is responsible for managing the data and communicating with the Database Module and Communication Layer. Use SQL Alchemy ORM to store exercises in the database, with SQLite being used.

To ensure data is exchanged in real-time, Communication Layer uses Web Sockets technology to create a robust connection between the server and clients. Lastly, the Dashboard Visualization Module is the user interface, where the processed data is shown to the end-users. Such architecture facilitates data processing and storage in an efficient manner and gives the users immediate feedback on the processed information.

The system architecture is modular and allows adding new features or upgrading the existing modules without affecting the other components. For instance, additional exercises can be recognized by implementing new

computer vision models or updating the existing classifiers. Similarly, the Backend Module can include new features, such as user authentication, data encryption, and advanced analytics tools. Lastly, the Dashboard Module can be enhanced by incorporating new visualization options or improving the current ones.

The posture correction area is rich with research as many exercise-related injuries are caused by improper movement patterns. Most of the existing works address the problem of posture correction using landmark detection and joint-angle estimation. Such methods typically rely on pose estimation frameworks, such as Media Pipe or Open Pose, to identify body posture and compare it to the reference frame. Several studies utilize these principles to visualize harmful movements and offer correction feedback. Although many current systems provide accurate posture monitoring and basic feedback, they do not address the injury risk assessment.

Research on exercise classification using machine learning is also an actively developing area. Most of the works focus on designing solutions that can distinguish various physical activities based on the detected skeletons. By employing pose estimation and extracting relevant posture features, the researchers trained classification models that can recognize different types of exercises. Although the accuracy of such methods is relatively high, most of the papers address only exercise classification and ignore other crucial aspects of workout monitoring.

Computer vision methods have been applied to physiotherapy and rehabilitation to visualize the movement patterns of patients. Like fitness-related applications, such systems use pose estimation to track body posture and assess rehabilitation progress. Most of the reviewed works demonstrate that video-based monitoring is beneficial for rehabilitation settings. The

current literature indicates that posture analysis is a valuable tool for physiotherapy, but most of the applications are designed for a specific set of movements and cannot be utilized in a broad context.

Some study has also been conducted to assess the potential use of artificial intelligence for injury prevention in sport and exercise. The majority of the works are based on biomechanical principles and machine learning to recognize the actions linked to an increased risk of injury. While there are many advantages to injury prevention

systems for athletes and for those who exercise, some require special hardware, or a more complicated algorithm. Some papers report good results, but the solutions that are proposed are hard to find in practice as they are difficult to put into action.

A thorough review of the literature indicates that the present techniques have a number of drawbacks. First, most of the works focus just on some aspects of posture monitoring, such as posture correction or preventing injuries. Secondly, most of the applications are limited in scope and don't contain all the benefits of exercise. Lastly, a lot of the works don't encompass crucial components of effective exercising, including real-time suggestions or sophisticated analytics.

The identified research gap allows the ability to create a novel approach in one application, that incorporates posture correction, injury prevention, exercise classification and analytics.

6. METHODOLOGY

6.1 Overview of the Methodology

The proposed AI-Based Real-Time Body Posture Correction and Injury Risk Detection System introduces an intelligent system for monitoring physical exercises, combining Computer Vision (CV), machine learning (ML), biomechanical analysis (BA) and real-time communication technologies (RTCT). The primary goal of the methodology is to track human body movements, analyze the quality of posture, determine types of exercises, analyze the risk of injury and give instant correction. The whole operation is carried out with a generic RGB camera and without the need for any special motion capture equipment or sensors to be worn.

The workflow begins by acquiring the video and then continues with pose-estimation, landmark extraction, computation of the joint angles, generation of features, classification of exercises, assessment of the posture, evaluation of injuries and generation of feedback. The results are retrieved and placed in a lightweight database and at the same time are presented graphically on an interactive dashboard. The methodology to be followed in the proposed system is highlighted as figure 2.

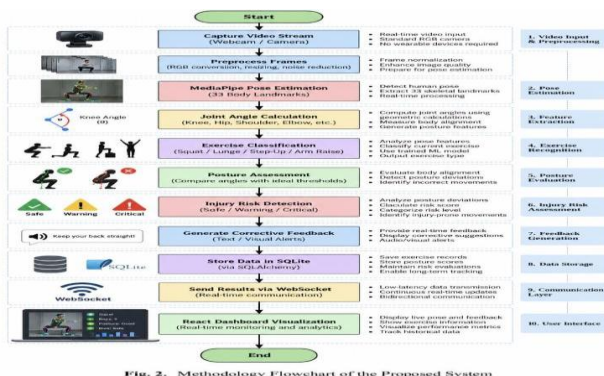


Fig. 2. Methodology Flowchart of the Proposed System

Figure 2: Methodology Flowchart

6.2 Video Acquisition and Preprocessing

The first step of the proposed system is to record the live video stream through the webcam or mobile video camera. The captured frames can be used as a database to analyze the posture and to monitor the exercise. Processing takes place one frame at a time, allowing the body movements to be followed during the whole exercise session.

The video frames are then taken and some basic pre-processing is done on it prior to pose estimation. The frames are then converted to RGB, if needed, and downsized to render the processing faster. Preprocessing guarantees that the landmarks will be detected under different environmental conditions and are compatible with Media Pipe.

To be able to capture frames continuously is necessary, since the posture and movement patterns are constantly changing when the exercise is performed. Therefore, the system needs to be able to process the frames continuously in real-time for tracking.

6.3 Human Pose Estimation using Media Pipe

The system acquires video and then uses Media Pipe Pose Estimation to detect and track body landmarks of the human body. MediaPipe is a streamlined computer vision system that can identify 33 skeletal landmarks representing key body landmarks and anatomical features. Shoulders, elbows, wrists, hips, knees, ankles, feet, eyes, ears and nose are all landmarks.

The pose estimation module extracts the three-dimensional coordinates of the landmarks represented by x, y and z values from each video frame. These coordinates give a detailed insight into the dynamics of the body posture and movement. Media Pipe is suited for pose estimation because it can find the poses efficiently in real-time. Therefore, the pose estimation is suitable for fitness monitoring applications where the user has an ongoing interaction.

The extracted landmarks are used as a basis for posture analysis and recognition of exercises. The accuracy of skeletal information is crucial for higher level calculations like calculating angles and determining injury risk, so landmark detection is critical.

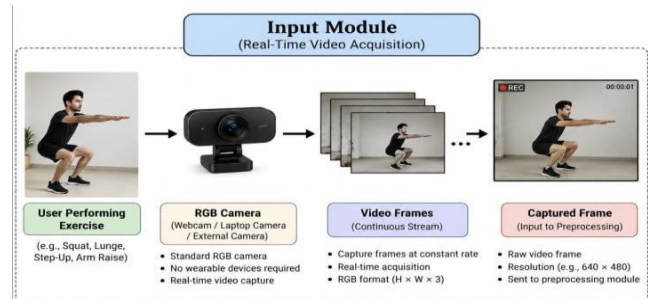


Fig. 3. Input Module for Real-Time Video Acquisition

Figure 3: Pose Estimation Process

6.4 Joint Angle Computation

Following identification of skeletal landmarks, the proposed system determines joint angles, which represent the body orientation and provide crucial information about the user's posture during exercise.

In particular, the system evaluates angles of several critical joints, including knees, hips, shoulders, elbows, and the spine, as these joints largely determine the correctness of an exercise.

The angle between three body points (A, B, and C) was calculated using vector math, with B representing the joint of interest (Fig. 1).

The angle between vectors BA and BC was finally computed using the cosine formula.

The mathematical formulation is expressed as:

$$\theta = \cos^{-1} \left(\frac{(A - B) \cdot (C - B)}{|A - B| |C - B|} \right)$$

where:

- θ represents the joint angle.
- A, B, and C denote landmark coordinates.
- BA and BC represent vectors originating from the joint.

For instance, knee-angle calculation involves the hip, knee, and ankle landmarks while the calculation of a shoulder-angle involves the shoulder, elbow, and wrist landmarks. The resulting values can then be used to determine posture quality and movement analysis.

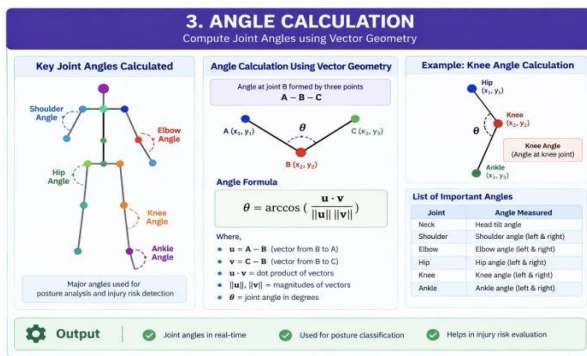


Figure 4: Joint Angle Calculation Process

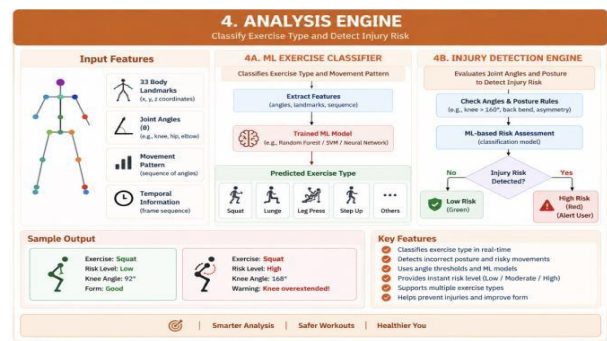


Figure 5: Exercise Classification

6.4 Feature Extraction and Posture Representation

After calculating joint angles, posture feature vectors are produced as a combination of body posture features. It is essential to extract posture features from the calculated body joint features since the extracted features are used in the subsequent processing stages.

Mathematically, the posture feature vector can be represented as:

$$F = \{A_1, A_2, A_3, \dots, A_n\}$$

where $A_1, A_2, \dots, A_n$ represent individual posture-related attributes extracted from skeletal landmarks.

The generated posture feature vector set can be used in the exercise classification stage and injury-risk detection stage.

6.5 Exercise Classification Methodology

The exercise classification module helps recognize the type of activity performed by the user. The posture recognition methodology differs depending on the type of exercise.

For example, different movement patterns are observed while performing squats, lunges, step-ups, and arm raise; therefore, a unique posture assessment model should be created for each type of exercise.

The exercise classification model takes the posture feature vector set as input and determines the type of exercise performed by the user. In the training process, squat, lunge, step-up, and arm raise examples are used. After determining the posture features for each activity, a classifier module can predict the type of exercise based on posture cues and send the results to the posture assessment module.

The generalized formulation is expressed as:

$$RiskScore = w_1D_1 + w_2D_2 + w_3D_3 + \dots + w_nD_n$$

where:

- D_i represents posture deviation parameters.
- w_i denotes weighting coefficients assigned to each parameter.

6.6 Posture Assessment Methodology

The detected posture features are assessed by the posture assessment module to determine if the exercise is performed correctly.

A reference posture feature set is used to analyze the detected posture features and assess the exercise quality.

For example, some specific posture cues should be maintained in knee dominant movements like squats and lunges, and significant deviations from these posture cues indicate errors in exercise performance.

Therefore, the posture assessment module should continuously monitor body posture and provide feedback on detected posture deviations.

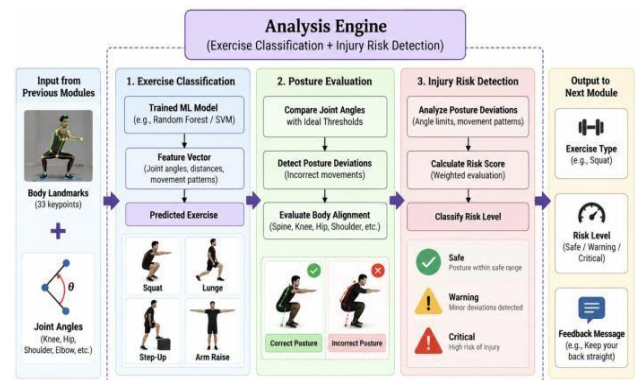


Figure 6: Analysis Engine for Exercise Classification and Injury Risk Detection

Figure 6: Injury Risk Detection Process

6.7 Injury Risk Detection Methodology

The injury-risk detection module is the main contribution of the proposed research since it can detect the risk of injuries caused by incorrect postures. Most conventional posture detection systems only detect posture errors but do not consider injury levels.

The injury detection algorithm consists of several criteria, such as excessive knee flexion, spine inclination, shoulder rotation, and others. These criteria are used to assess the risk of knee, lower back, and shoulder injuries during strength training exercises.

An overall risk score is assigned based on the detected features to estimate the injury's severity level.

The injury-risk detection model takes the posture assessment result as input and applies to a set of weighted criteria to detect potential injuries.

Based on the calculated risk score, movements are classified into three categories:

1. Safe
2. Warning
3. Critical

The generated risk level provides users with a clear understanding of posture quality and potential injury concerns.

6.8 Real-Time Feedback Generation

The feedback generation module is primarily accountable for providing information concerning corrections of detected postures and warnings of possible injuries. After completing the posture evaluation and injury detection procedures, the system utilizes specific messages related to the identified issues.

For instance, the system may offer advice on adjusting a squat exercise if large forward movements of the knees were detected or notify the user of a poor posture due to an excessive spine inclination.

The feedback messages are then relayed to the user via WebSocket communication to ensure a minimal delay between detecting an issue and providing a correction suggestion.

6.9 Database Management and Data Storage

The proposed system makes use of an SQLite database to store relevant information regarding the application's performance. The database, which is managed by the SQLAlchemy framework, allows the framework to retain information on all performed exercises, including the type

of activities, repetitions, posture scores, injury risk classifications, and received feedback.

The stored information helps the user track their progress in terms of repetitions and achieve results.

Moreover, the use of an SQLite database is appropriate in this case due to its lightweight nature, which is beneficial for the standalone application.

6.10 Dashboard Visualization and User Interaction

The proposed system suggests the implementation of a dashboard to provide the user with a more profound insight into the detected issues and received recommendations. It relies on the React framework to visualize the data obtained from the system during the exercise.

The dashboard is updated in real-time with information on detected posture classifications, injury risk, repetitions, and overall performance, which assists the user in identifying their progress during the repetitions.

It conveys the necessary information in a compact form and serves as the central element of the system, enabling the user to communicate with the application.

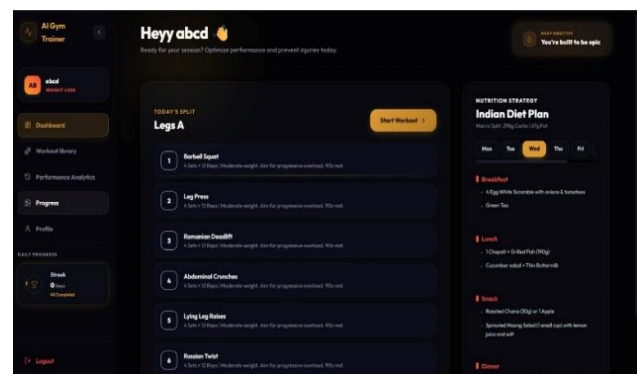


Figure 7: below presents the general design of the dashboard.

6.11 Summary of the Methodology

The conclusion section aims to summarize the key aspects of the research in one section without going into detail. In this regard, the current study proposed an approach to a video-based system for monitoring exercises. It involves using Media Pipe framework, machine learning, biomechanical calculations, and feedback module for detection of postures, calculation of joint angles, identification of exercises, detection of injury risks, and real-time data visualization. On top of that, the suggested approach integrates Fast API framework, SQLite database, SQL Alchemy framework, WebSocket, React framework, and dashboard to ensure an optimal user experience. It can

be stated that such a system would be beneficial for a variety of applications ranging from fitness industry to health care.

7. RESULTS AND DISCUSSION

7.1 Experimental Evaluation

A set of experiments were conducted to evaluate the effectiveness of the proposed Real-Time Body Posture Correction and Injury Risk Detection System, with the exercise scenarios described above that included squats, lunges, step-ups and arm-raise exercises. In particular, an assessment of the framework's ability to identify body landmarks, identify an exercise, analyse the correctness of posture, detect injuries prone movements and give real time corrections was conducted. The experiments were done using a standard RGB camera to replicate real-world fitness scenarios.

The proposed framework could successfully process the videos for live feeding and track the body movements with Media Pipe Pose Estimation. The use of obtained body landmarks was noted to be an effective way to obtain joint angles. During the experiments, the system was able to ensure stable results and track movements without needing an external sensor.

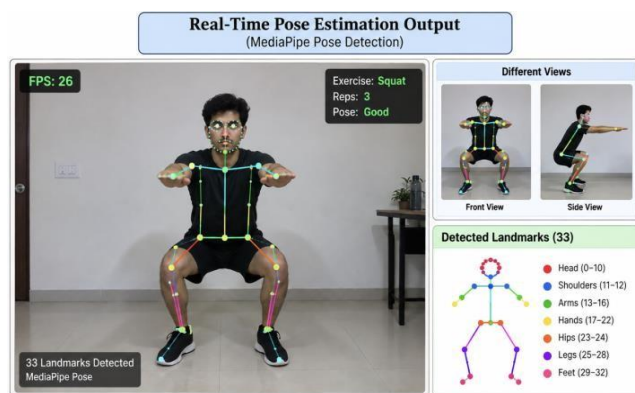


Fig. 8. Real-Time Pose Estimation Output Generated Using MediaPipe Pose Detection

Figure 8: Pose Estimation Output

The output of the pose estimation shows the ability of the Media Pipe framework to accurately estimate body landmarks in real time. The skeletal structure identified may be utilized for posture evaluation as well as exercise categorization. Landmark tracking proved to be enough to provide reliable joint angle measurement even during motion.

7.2 Exercise Classification Results

To classify exercise, the pose estimation results and joint angles were used to train a classifier. The classifier could successfully discriminate between supported exercises

and it has stable performance across exercise runs. The results showed that it was possible to describe a movement, and that this could be done by only capturing the posture characteristics.

Table 1: Exercise Classification Performance

Exercise Type	Accuracy (%)
Squat	95
Step-Up	92
Lunge	93
Arm Raise	96
Average Accuracy	94

It was observed that the classification model was able to reliably identify commonly performed fitness exercises. The main reason behind the high accuracy of movement recognition was the quality of landmark extraction and the efficiency of angle-based feature engineering. The classification module plays an important role as posture evaluation criteria depend on what exercise is being performed.

7.3 Posture Assessment and Injury-Risk Analysis

The posture assessment module was continuously monitoring body alignment by comparing detected joint angles to a set of biomechanical thresholds. During the experimentation, the system was able to detect posture deviations such as improper knee flexion, forward spinal bending, and incorrect shoulder positioning. These aberrations were then fed into the injury-risk detection module to determine the injury risk grade.

The injury-risk detection mechanism categorized movements into Safe, Warning, and Critical levels. Safe classification meant that the posture of the user was adequate, whereas Warning and Critical classifications indicated increasingly severe deviations from proper body alignment and injury risk. The results from the injury-risk detection module were utilized to notify the user of potentially harmful movement patterns.

Table 2: Injury-Risk Detection Performance

Risk Category	Detection Rate
Safe	97
Warning	92
Critical	90

The results demonstrate that the proposed framework can distinguish between safe and unsafe movement patterns. The ability to provide risk-based detection significantly improves the capabilities of conventional

posture correction systems that only report if a given posture is correct or not.



Figure 9: Injury Risk Detection Output

The injury-risk detection interface highlights posture deviations and displays relevant warning messages. These alerts serve to warn the user from potentially harmful movements that can cause an injury.

7.4 Real-Time System Performance

One of the main aims of this research was to prove whether or not posture analysis and the ability to predict injuries can be done in real time. Based on the experimental results, it is shown that the system can be run with low-latency processing, and can be continuously monitored during the exercise session.

Table 3: Real-Time Performance Metrics

Parameter	Observed Value
Average Processing Time	40 ms
Average Frame Rate	25 FPS
Feedback Response Time	< 1 Second
Dashboard Update Delay	Negligible

The outcomes indicate that the system can be used to identify improper posture and can alert the user to possible harmful movement patterns. The use of the Fast API framework and WebSocket communication minimized latency and instantaneously reported feedback.

7.5 Discussion

The results of the experimentation show that the intelligent system comprising of Media Pipe Pose Estimation, calculation of the joint angles, machine learning, and the detection of injuries holds great promise for assisting the user during the exercise session. Multiple tasks can be accomplished with the system, combining posture tracking, exercise classification, injury-risk

detection, and dashboard visualization in one system. This approach decreases the needs for extra systems and offers a convenient fitness experience offering comprehensive feedback.

The proposed framework's most significant feature is its capabilities for assessing injury risk rather than just posture deviation. The posture deviation severity is analyzed and the movement pattern is categorized into Safe, Warning or Critical grade, which helps the user to understand the severity of the posture deviation and increase the performance of exercise. The ability to predict the risk of injury can help minimise the incidence of exercise-related injuries and help to create a healthier fitness experience for the long term.

The Media Pipe tracking framework is used for extracting the body landmarks, which does not need any expensive motion-capture system or any external wearable sensors. Likewise, SQLite and SQL Alchemy offer sufficient data management, and React and WebSocket communication provide for a seamless real-time visualization and interaction with the system. All of these factors played a part in developing a viable and usable system that assisted the user while they exercised.

Although the outcome is positive, several things should be thought about to improve the future outcome. Environmental lighting, camera position and body occlusion can affect the quality of pose estimation. In addition, the current implementation only has a limited number of exercises and uses a limited set of biomechanical thresholds for detection of injury risk. Future enhancements should consider using personalized injury-risk prediction models and advanced deep learning models.

Finally, the outcomes of the experiments indicate that the proposed AI-Based Real-Time Body Posture Correction and Injury Risk Detection System can be applied by a smart personal trainer to enhance the fitness experience of the user.

8. CONCLUSION AND FUTURE WORK

8.1 Conclusion

This research presented an AI-Based Real-Time Body Posture Correction and Injury Risk Detection System to enhance the fitness experience of the user by tracking the body posture and predicting the potential risk of injury in real-time. The proposed system involves the use of Media Pipe Pose Estimation, exercise classification using machine learning, joint-angle biomechanical analysis, risk assessment for injuries, and visualization of the dashboard in real time. The system uses a standard RGB camera, eliminating the need for additional expensive motion capture systems and sensors to track the posture.

Experiments results show the feasibility of using the proposed system for body landmark detection, joint angle calculation, classification of performed exercise, correctness assessment of posture and real-time detection of injury-prone movement.

Unlike many posture correction products available today, the proposed framework incorporates the detection of injuries to provide the user with information about injury as well as simple posture tracking. Furthermore, the use of the Fast API framework, WebSocket communication, SQLAlchemy database management and SQLite database makes it easy and reliable to use the system.

The findings indicate that the proposed framework could be used to help the user maintain correct exercise posture and minimize the chances of exercising-related injuries. The system is modular, enabling its future expansion and improvement.

8.2 Future Work

Although the findings of this research were encouraging, it would be beneficial to further investigate the use of deep learning for exercise classification and injury-risk detection in future studies. To enhance the accuracy of the system, advanced deep learning architectures like Long Short-Term Memory (LSTM), Graph Neural Networks (GNN), and Transformer-based models can be used. Moreover, the personalized injury-risk prediction can be performed to consider the user's age, body mass, fitness and injury history.

A future version of the framework can also support a greater variety of exercises to provide enhanced support across a variety of fitness activities. The system can be adapted to include multi-person pose estimation to operate in the gyms, training centers, and physiotherapy clinics. Analyzing cloud data and building mobile applications are also options to increase system accessibility.

Another research direction would be to study how to merge the camera pose estimation and the wearable sensor data for achieving the advantages of both. The utilization of artificial intelligence-driven virtual coaching and personalized workout recommendations can also be explored for future improvements.

To sum up, the outcomes of this research point to the possibility of leveraging AI and computer vision technology to enhance the user's fitness journey.

9. REFERENCES

[1] H. Bhattacharya, R. Kalia, S. S. Yadav et al., "AI Gym Trainer and Fitness Tracker using GPT-LLM and Prompting Techniques," in International Conference on Advanced Computing and Networking, pp. 249–

254, 2024, doi: 10.1109/ICAC2N63387.2024.10895114.

[2] M. Balpande, M. Khandelwal, J. Sharma, S. Dhanray and A. Nair, "AI Based Gym Trainer and Diet Recommendation System," in 2023 IEEE 4th Annual Flagship India Council International Subsections Conference (INDISCON), Mysore, India, pp. 1–7, 2023, 10.1109/INDISCON58499.2023.10270066. doi:

[3] K. M., V. N., M. Kandala, S. Palaniswamy and V. G. S., "AI Based Posture Correction, Real-Time Exercise Tracking and Feedback using Pose Estimation Technique," 2024.

[4] D. Rai, A. Anjali, A. Kumar and A. Baghel, "Pose Detection using OpenCV and Media Pipe," 2024.

[5] A. Hussain, M. A. Zahid, U. Ahmed and S. Nazeer, "Time Series Data to Refined Insights: A Feature Engineering Driven Approach to Gym Exercise Recognition," 2024.

[6] G. Gowrish, Y. S. Vineeth and M. Thenmozhi, "AI Powered Gym Tracker using AI Pose Estimation," 2024.

[7] S. Swathi, A. Rajan, B. R. and G. A. R., "AI Tool As A Fitness Trainer Using Human Pose Estimation," 2025.

[8] M. M. Helmy, M. K. Gendy, Y. A. Kawashti and M. S. Yousef, "PoseRight: An AI Empowered Automatic Posture Estimation and Correction Model," 2024.

[9] A. K., K. P. Kumar and H. K. R., "An AI-Driven Multi-Modal Framework for Exercise Form Detection and Correction in Strength Training," 2025.

[10] A. Jayasankar, K. M. Uday, I. Shokeen and S. Lalitha, "Smart Gym Assistant: Posture Monitoring and Rep Counting," 2025.

[11] R. Mhatre, V. Naik, D. Kharat, S. Narvekar and M. Kulkarni, "AI-Based Virtual Fitness Trainer with Real-Time Pose Estimation and Intelligent Diet Recommendation System," International Journal of Creative Research Thoughts, vol. 14, no. 4, pp. g496–g503, Apr. 2026.

[12] B. Yuvaraju, K. S. C. Sekhar, N. V. V. Satish and P. L. S. Charan, "UVFIT: Personalized Fitness and Nutrition Recommendation System Using Machine Learning," International Journal for Research in Applied Science and Engineering Technology, 2026.

[13] S. Bhandari, S. G. Bansal, S. Santhosh and I. P. Lakhekar, "AI-Powered Fitness and Diet Recommendation System: A Personalized Approach to

Health and Wellness," International Research Journal on Advanced Engineering and Management, vol. 3, no. 3, pp. 534–539, 2025.

[14] H. Tyagi, H. Pal, A. Kaushik and D. Sharma, "AI-Powered Personalized Fitness and Diet Recommendation System Using Machine Learning and Deep Learning Techniques," International Journal of Novel Research and Development, vol. 11, no. 5, 2026.

[15] "Flexi-Fit: AI-Based Fitness Tracker," in 2025 3rd International Conference on Disruptive Technologies (ICDT), IEEE, 2025.