Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Project-1

Automated Squat Analysis: A Comprehensive Posture Monitoring Using AI-Powered Gym Tracking

REVIEW-1

Department:- SCORE (BITE497J)
Domain:- Machine Learning

Project Guide and Project Members:-

Project Guide:-

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PROBLEM STATEMENT

Many struggle with correct squat technique due to the limitations of traditional methods, which rely on manual observation or expensive equipment. These methods can be both time-consuming and inaccessible.

This project aims to solve these issues by creating a cost-effective, real-time system that uses computer vision to provide instant feedback on squat posture.

INTRODUCTION

- Incorrect squat techniques can lead to injuries and reduce exercise effectiveness. So, proper squat form is crucial. Past studies have used machine learning models and sensors to analyze squat form.

- Our approach, utilizes MediaPipe and OpenCV for real-time computer vision, providing immediate feedback on squat posture by capturing video through a webcam.

- If any joint angle deviates from the optimal range, the system offers instant feedback, guiding users on which joint to correct. This study presents a cost-effective, accessible tool for fitness enthusiasts and trainers.

MOTIVATION

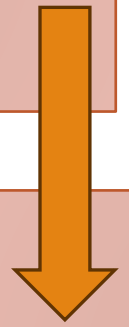
Challenges faced by individuals in maintaining correct squat technique using traditional methods.

OBJECTIVE

To develop a cost-effective, real-time system to analyze and provide immediate feedback on squat posture.

WORK PROGRESS

Literature Survey has been done



Machine Learning Model has been developed

WORK TO BE DONE

The model will test various postures to ensure consistent performance and accuracy.

Feedback will be compared with pre defined metrics to validate the model effectiveness and make necessary improvements.

LITERATURE REVIEW

- Studies show that correct squat form enhances lower body strength and core muscle activation, crucial for injury prevention and training optimization.

- Traditional squat analysis often relies on costly, specialized equipment like force plates and 3D motion capture, which are not accessible to everyone.

- Recent developments in MediaPipe and OpenCV have made real-time, markerless posture estimation feasible with just a camera, offering immediate feedback.

- This project aims to provide a practical and affordable real-time squat form analysis solution, making effective squat monitoring accessible for regular training routines.

GAP IDENTIFICATION

Current squat analysis methods require specialized equipment and are often complex. There’s a need for a user-friendly, real-time tool for accurate analysis that doesn’t rely on expensive gear. This project addresses this by creating a practical, accessible solution with MediaPipe and OpenCV.

TECHNOLOGY USED

1. Technology Stack

• Languages: Python

• Libraries: MediaPipe, OpenCV, NumPy

• Hardware: Standard webcam, 8GB RAM, multi-core processor

2. System Architecture

• Input: Real-time video feed via webcam.

• Processing: Pose detection using MediaPipe.
Joint angle calculation (hip, knee, ankle).
Form evaluation against optimal ranges.
Immediate visual feedback.

• Output: Real-time feedback overlay on video.

OBJECTIVE FRAMING

1) Pose Estimation:

•Develop a real-time model to detect body landmarks (shoulder, hip, knee, ankle, toe) using MediaPipe.

•Ensure accuracy despite variations in lighting, camera angle, and positioning.

2) Angle Calculation:

•Compute joint angles (hip, knee, ankle) to assess squat form.

•Provide dynamic angle measurements during the exercise.

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3) Feedback Mechanism:

- Offer real-time feedback on squat form with visual alerts (e.g., "HIP: WRONG") and optional audio cues.
- Highlight common errors and provide corrective suggestions.

4) **User Accessibility:**

- Create a user-friendly interface compatible with standard webcams and computers.
- Ensure ease of use with minimal setup and no need for specialized hardware.
- Adapt to various body types and squat styles.

PROJECT PLAN

Phase 1: Completed

- Conducted a literature review on pose estimation and squat analysis.
- Defined system requirements and created a detailed project plan.

Phase 2: Completed

- Developed the pose estimation module using MediaPipe for landmark detection.
- Integrated OpenCV for real-time video capture and processing, ensuring accurate pose tracking.

Phase 3: Completed

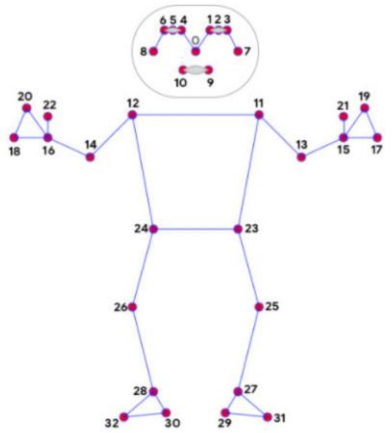
- Created algorithms for computing joint angles (ankle, knee, hip) and designed a feedback mechanism.
- Implemented real-time feedback with visual alerts to indicate correct or incorrect squat form.

Phase 4:

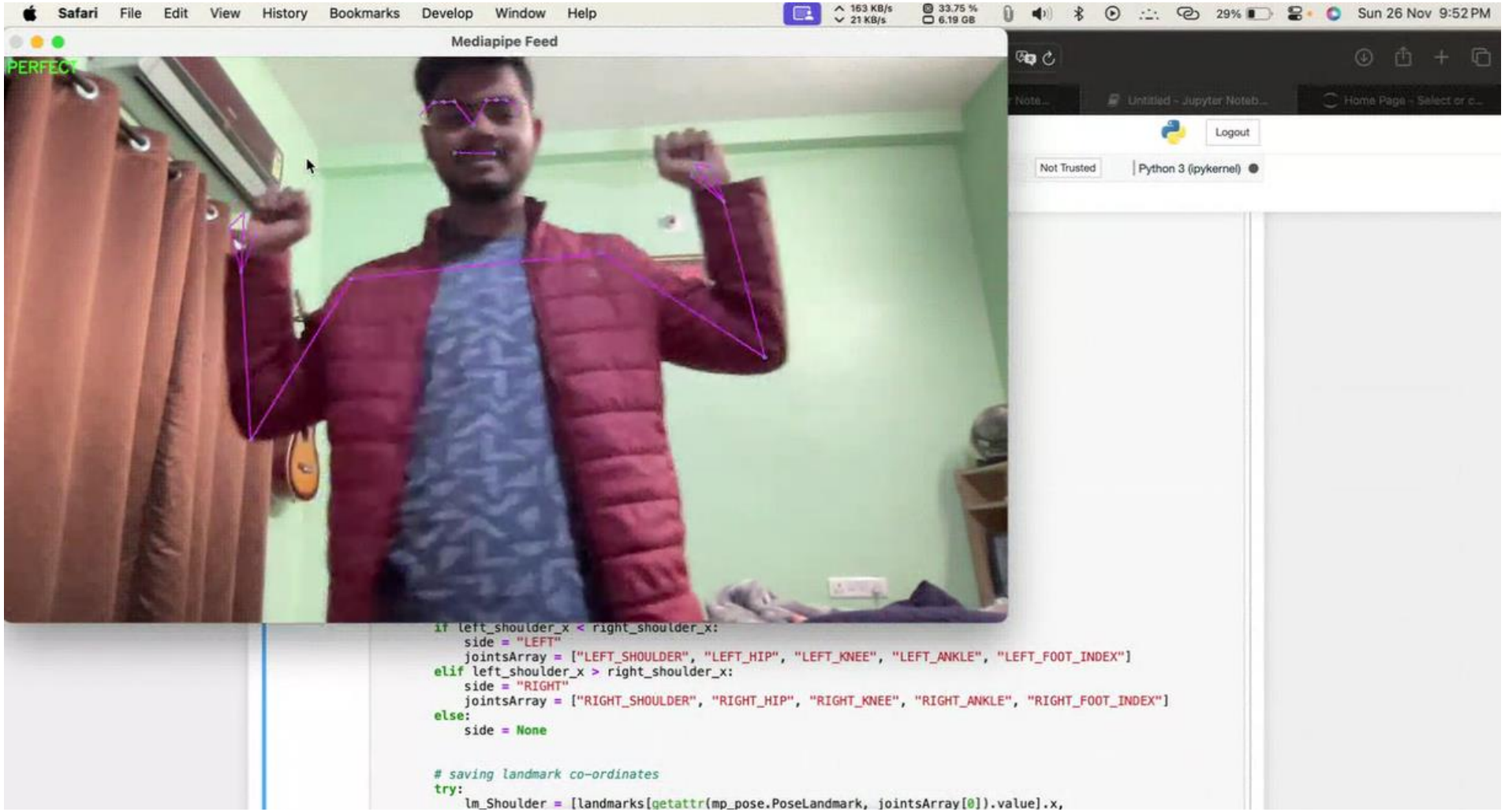
•Test and validate the system with various postures to ensure consistent performance.
•Compare feedback accuracy with pre-defined metrics and make necessary adjustments.

Phase 5:

•Develop an interface for the model.
•Finalize the model with necessary writings and calculations.
•Conduct a demonstration, and provide user manuals and support materials.



PROJECT DEMONSTRATION



METHODOLOGY

- Conducted a **literature review** to understand existing pose estimation methods and squat analysis techniques.
- Developed a pose estimation module using **MediaPipe** for real-time body landmark detection.
- Integrated **OpenCV** for capturing and processing live video feeds.
- Calculated **joint angles** at key points (hip, knee, ankle) using custom algorithms.
- Implemented a **feedback mechanism** to provide real-time alerts on squat form.
- Tested the system with **various postures** to ensure consistent performance.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