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FitCoachAR: Automated Coaching Feedback System

Verification & Validation Plan

Mohamad Mirhoseininejad

FitCoachAR

General Information

- Summary:
  - pose estimation + state machine
    - count reps
    - Provide form feedback
- Objectives: Build confidence in correctness, accuracy of angle calculation.
- Out of Scope: Usability testing
- Relevant Docs: SRS

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SRS Verification Plan

- **Peer Review**: SRS is being reviewed via by Domain Expert (Yibing).
- **SRS Checklist**: Verified completeness of
  - Goal Statements,
  - Data Definitions,
  - Instance Models,
  - Input Constraints.

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Design Verification Plan

- The related documents have not been completed yet.
- Planned Approach:
  - Peer review of design documents by Domain Expert when ready.

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VnV Plan Verification

- Approach: VnV Plan itself is going to be reviewed by the Yibing.
- Checklist:
  - Completeness: VnV plan includes all necessary sections.
  - Formatting: The document has a clear, logical structure, and properly organized.
  - Appropriateness: Confirm that the methods and tools proposed in the VnV plan are appropriate for the project.
  - Coverage: Make sure the VnV plan covers all the requirements.

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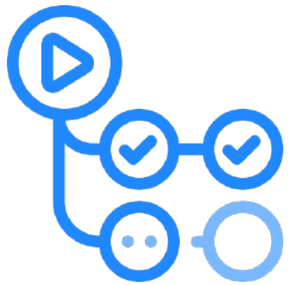
Implementation Verification Plan

- Static Analysis: Code review and inspection during development.
- Code Walkthrough: Final class presentation serves as a code walkthrough.
- Dynamic Testing: Points to the System and Unit test sections below.

We use both static and dynamic verification.

Automated Testing & Verification Tool

Tool	Purpose
Pytest	Unit and system test execution
GitHub Actions	CI — runs tests on every push
Robot Framework	Automated E2E testing



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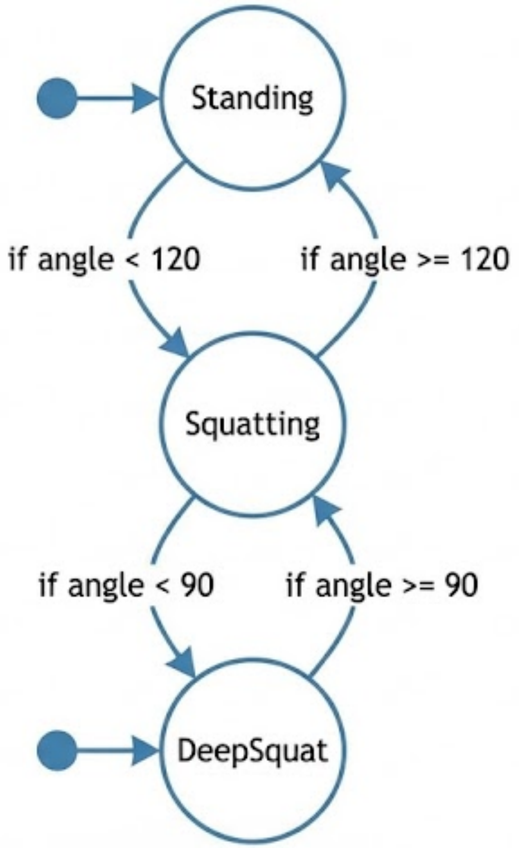
State Machine Logic

System Test Context — How the Rep Counter Works

- **Explanation**: Defining a valid rep as a cycle of states.
  - **Start**: Standing (Angle $\approx 180°$)
  - **Descend**: Angle decreasing.
  - **Bottom**: Angle $\leq 90°$ (Threshold).
  - **Ascend**: Angle increasing.
  - **Complete**: Return to Standing.



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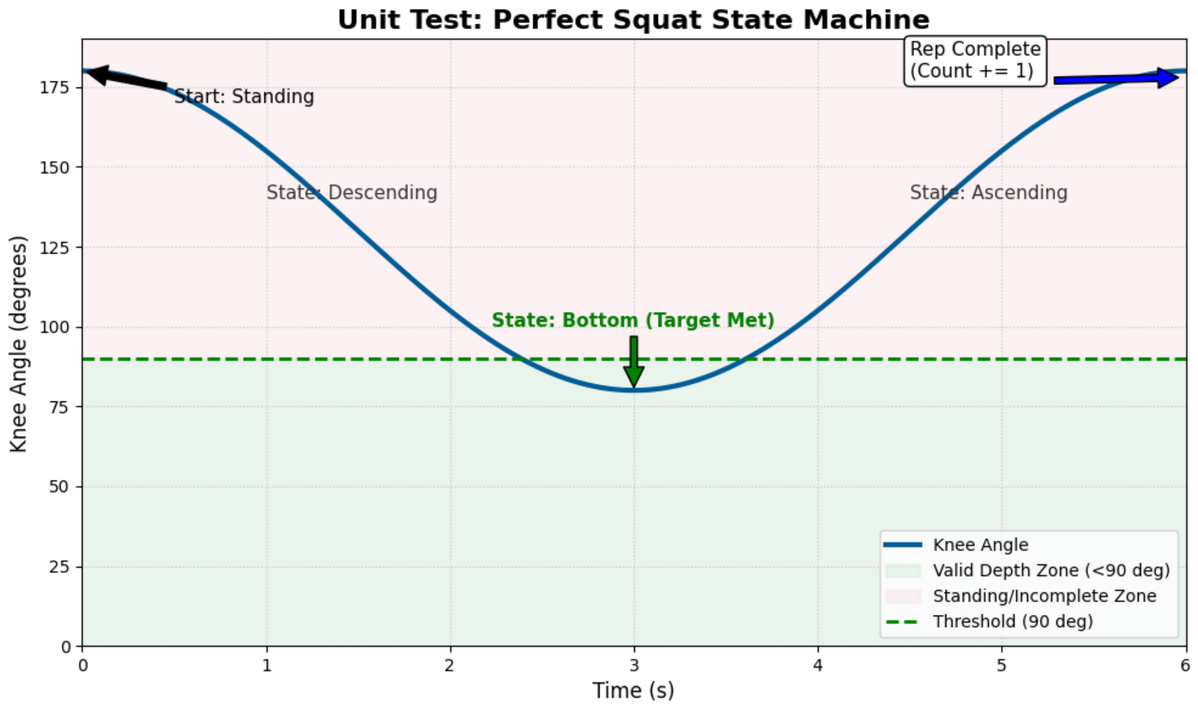
System Tests — Functional Requirements

Test Case 1: Perfect Squat (Rep Counting)

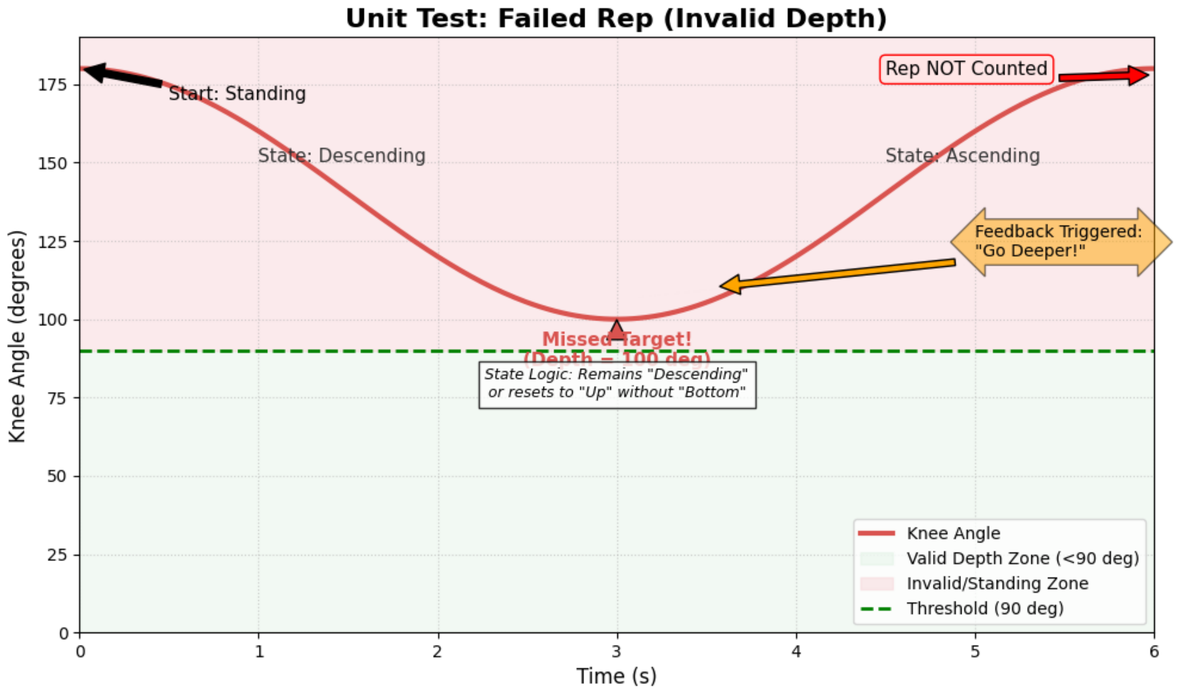
- **Type**: Functional, Dynamic, Automatic
- **Input**: Synthetic cosine wave of knee angles (180° → 90° → 180°)
- **Expected Output**: RepCount increments by 1;
- **states**: Top → Down → Bottom → Up → Top



System Tests — Functional Requirements

Test Case 2: Failed Rep (Half-Rep)

- **Type**: Functional, Dynamic, Automatic
- **Input**: Angle dips to 100° only (never reaches 90° threshold)
- **Expected Output**: RepCount does NOT increment;
- **feedback**: "Go Deeper"

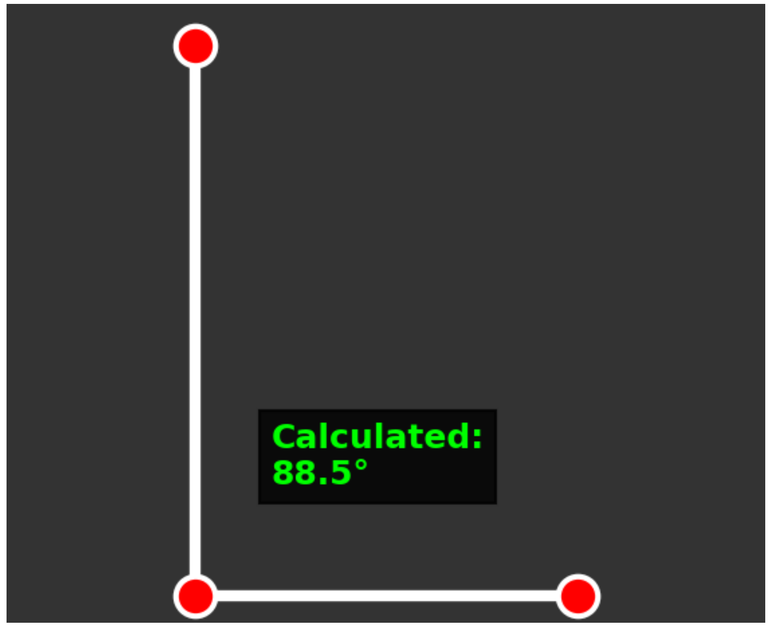


System Tests — Nonfunctional Requirements

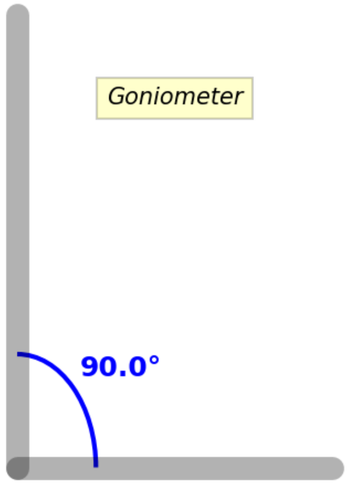
Test Case 3: Failed Rep (Half-Rep)

- **Type**: Functional, Dynamic, Manual
- **Input**: Static image with known joint angles
- **Expected Output**: MediaPipe calculated angle matches ground truth within ±5°

FitCoachAR Output



Ground Truth (Physical)



Accuracy Validation

Ground Truth	Measured	Error
0.0°	1.2°	+1.2°
45.0°	44.1°	-0.9°
90.0°	88.5°	-1.5°
180.0°	179.8°	-0.2°

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Software Validation Plan

- Validation Approach: Compare system output against labeled datasets.
- Method: Use exercise datasets with annotations (correct form vs. incorrect form). Run FitCoachAR on the dataset and compare expected agains actual.
- Oracle: The labeled dataset serves as the oracle — it provides the "known truth" for validation.

Traceability & Summary

Test Case	Requirement
Perfect Squat	IM_RepCount, GS_Analysis
Failed Rep	IM_RepCount, NFR_Feedback
Geometric Verification	NFR_Accuracy

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Thanks