



Physio AI Companion

Your AI Guide to Physical Rehab



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Speed to Recovery - Three Use Cases

Where Automation Could Help



Health Assessments

Unsupervised Exercise

At Home



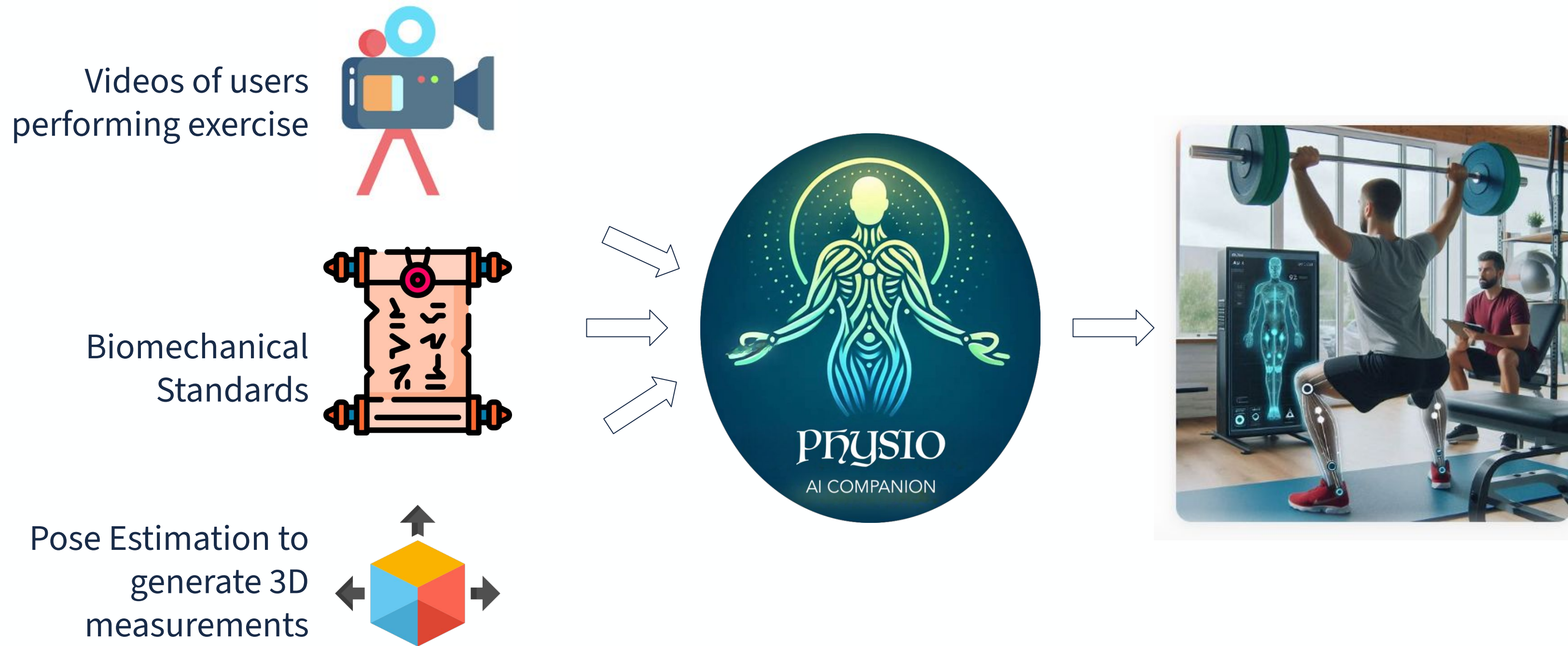
At the Gym



Holistic View into Client Base



Physio AI Companion



Images generated by Copilot

'images: Flaticon.com'. This diagram has been designed using images from Flaticon.com

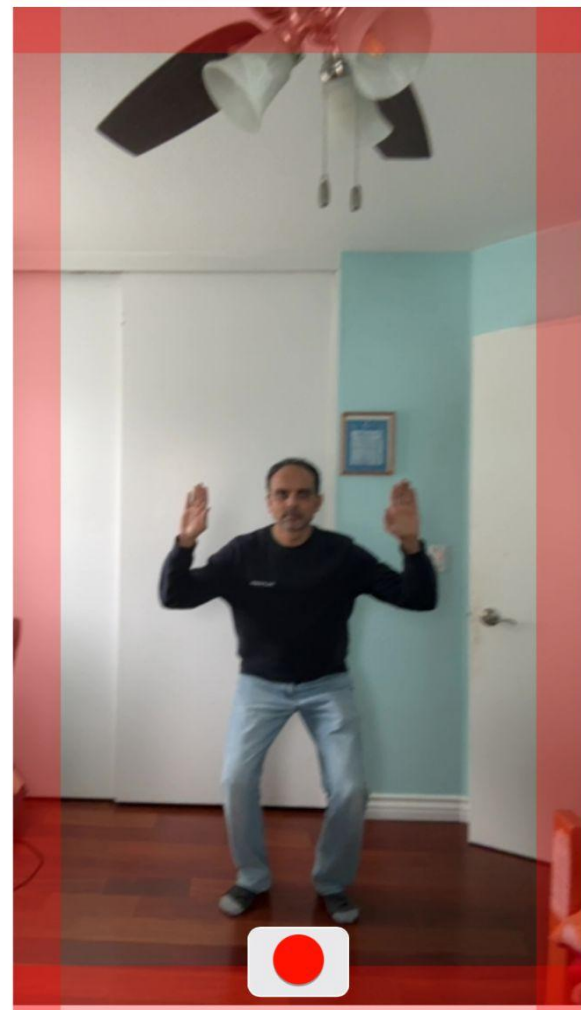
Data Collection

Capture Video

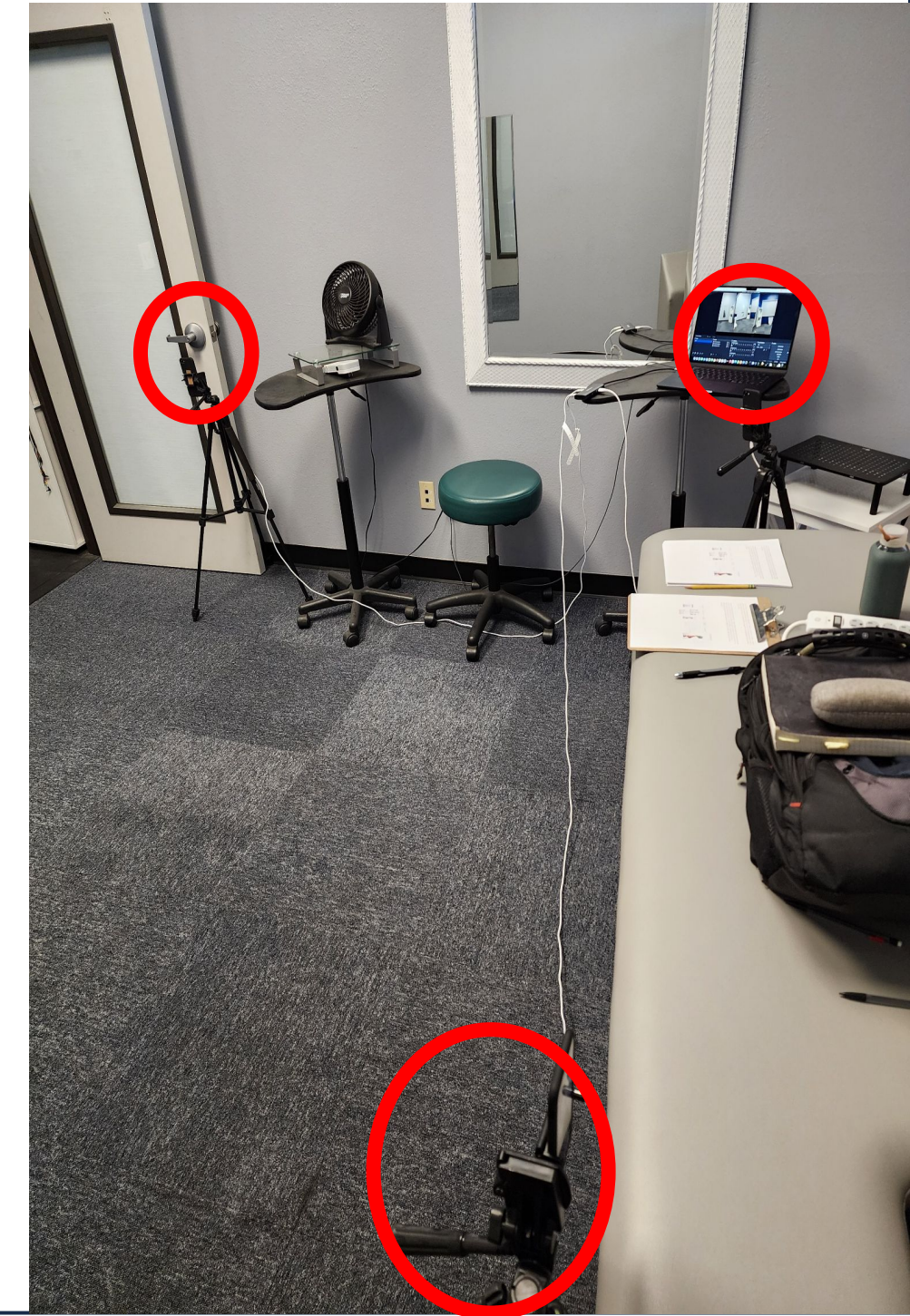
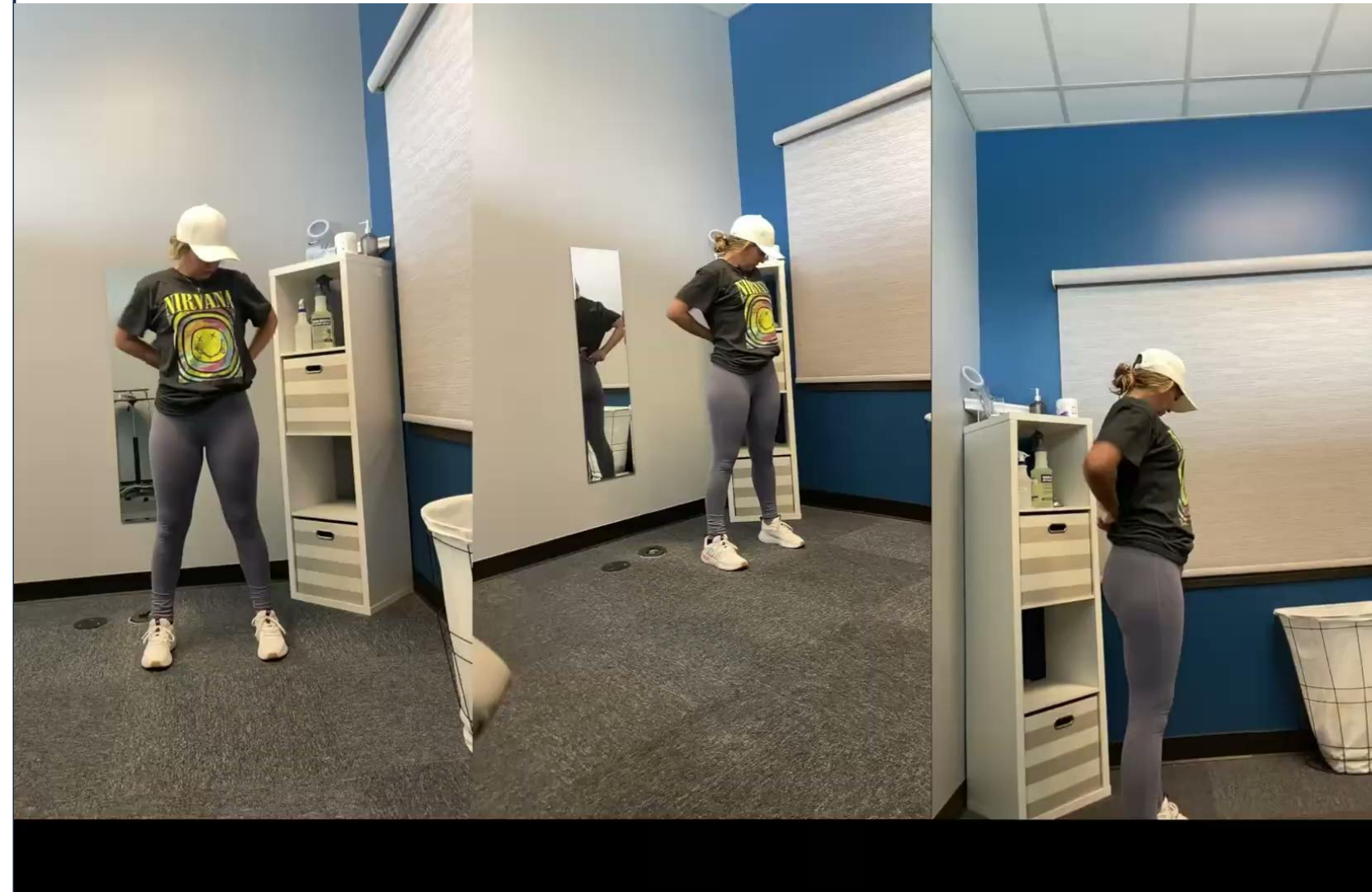
Recommend using a phone to capture video in portrait mode. Once the Red button is pressed to start recording, a 10 second timer starts to allow user to position entire body within the red frame. Actual recording starts after the 10 second timer expiry. Recording automatically stops after 15 seconds. Stay in the position until recording ends.

Name of the person

John



Multi Camera Setup for Facilities



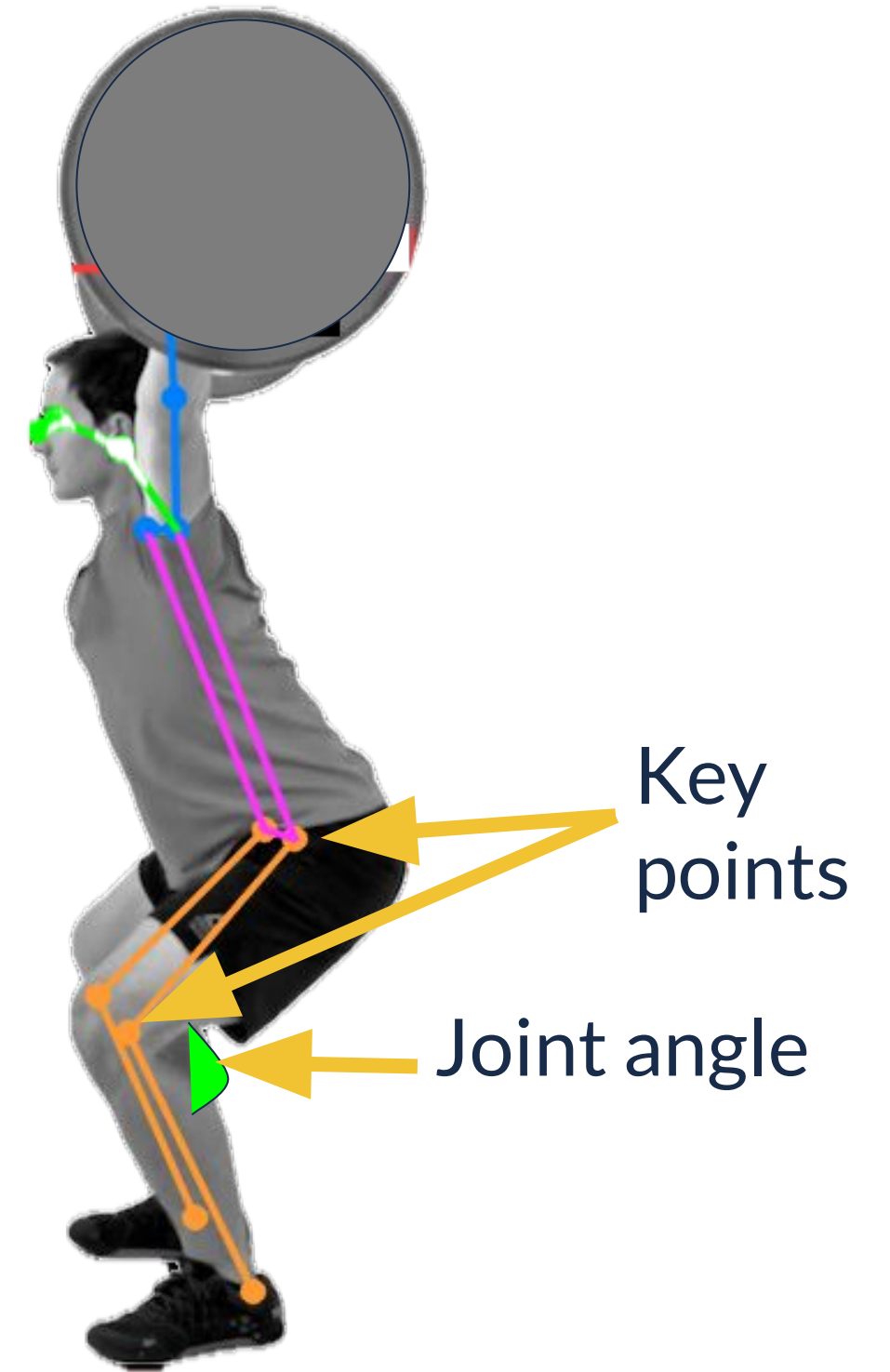


Data Capture Demonstration

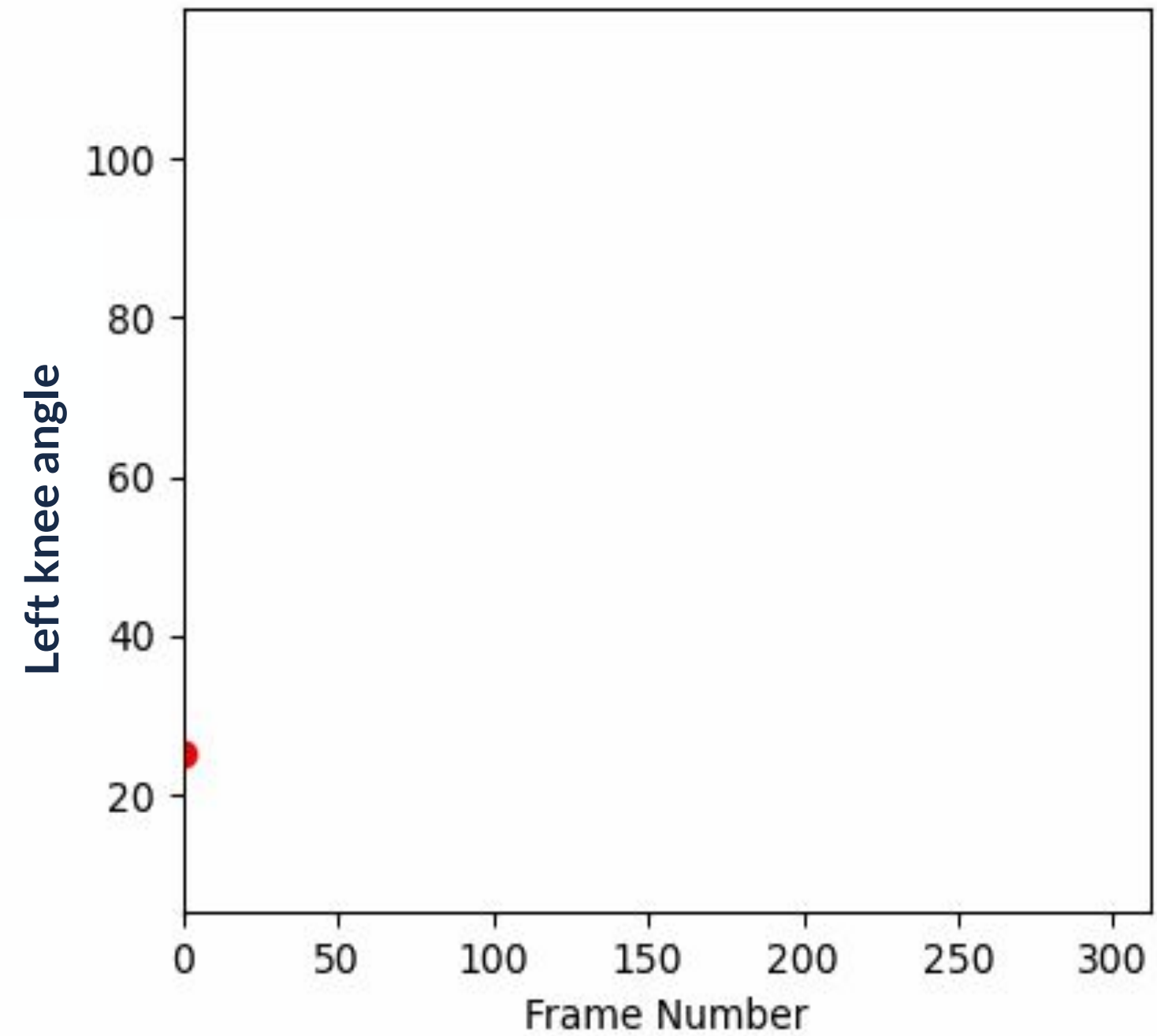
Hypothesis



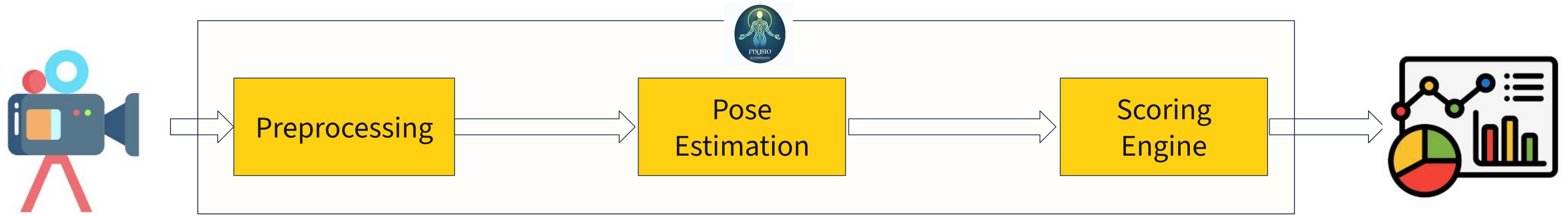
Measurement of Human Biomechanics using Computer Vision to determine Incorrectness of posture



Biomechanics example



Model to Achieve Hypothesis



Preprocessing

Prepare videos for consumption by the model

Pose Estimation

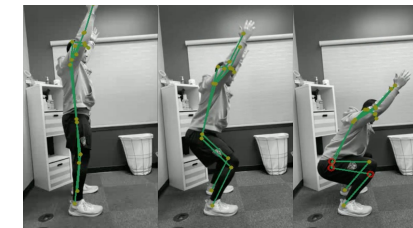
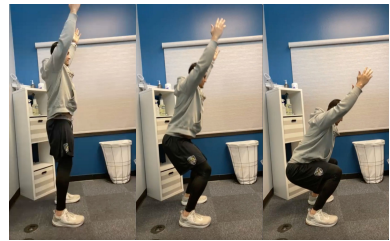
Extract **Biomechanics** information (key points & joint angles) from each frame

Scoring Engine

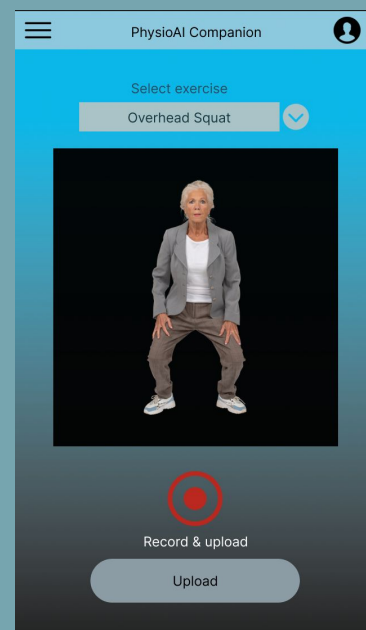
Process model output, identify repetitions, compute **incorrectness score**



Product Architecture



Live capture



Raw videos

Input

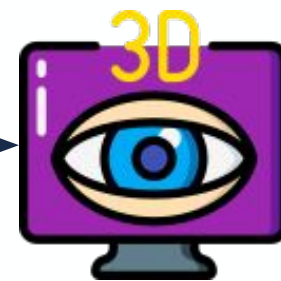
Video Pre-processing



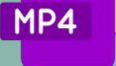
Preprocessed videos



Pose Estimation Computer Vision



3D Body model, Skeleton



Key points, Joint angles



Scoring Engine Algorithms



- Smoothing Spline
- Rep Identifier
- Incorrectness Scoring

Repetitions, Scores



Physio AI Companion Core

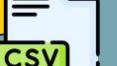
Client Portal



Practitioner Portal



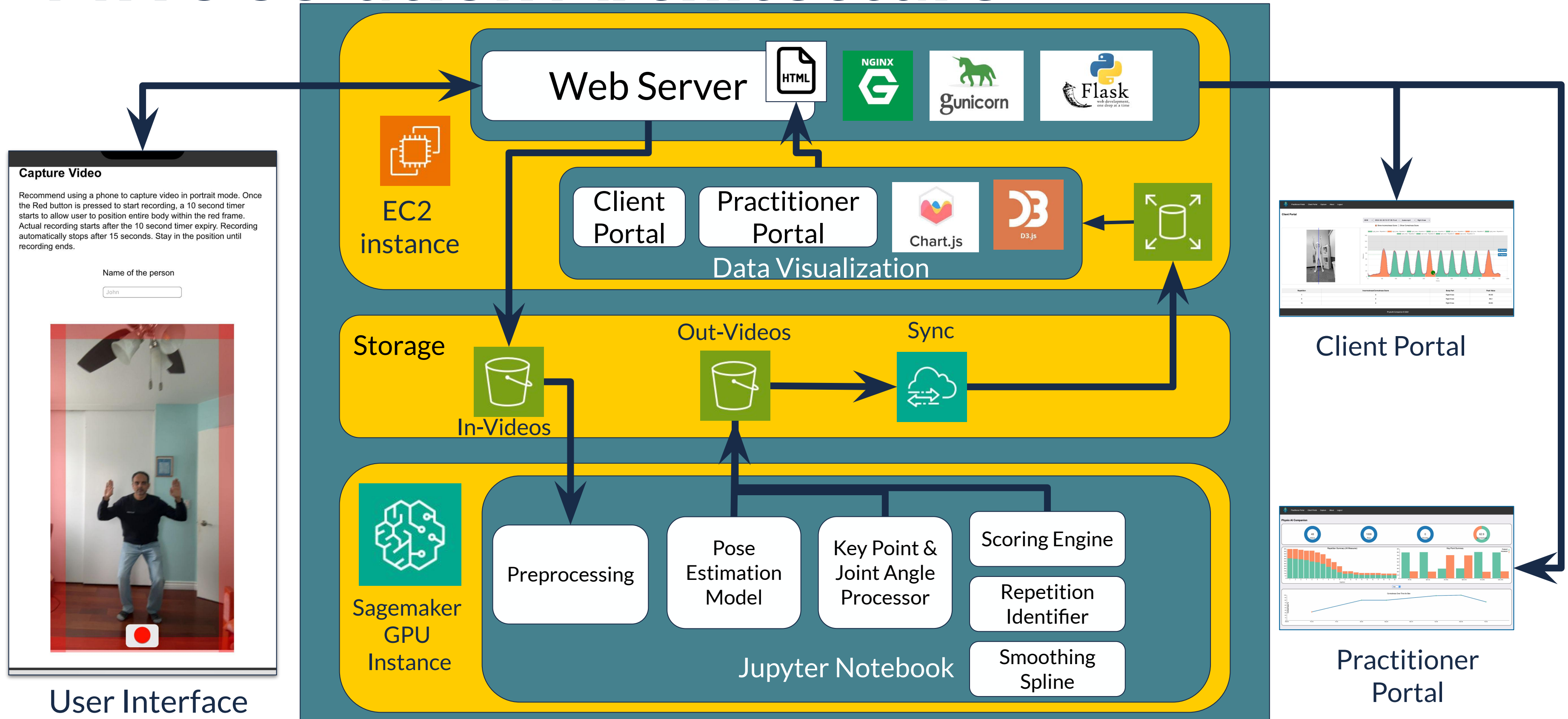
Data filtering, Rollup



Output



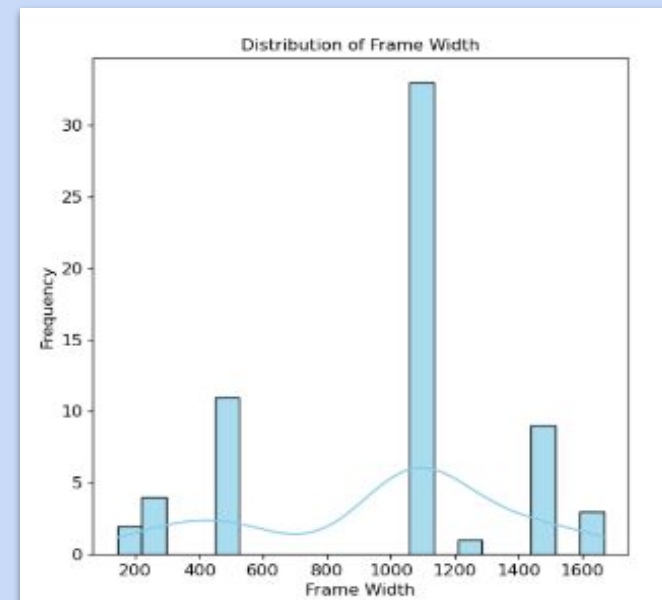
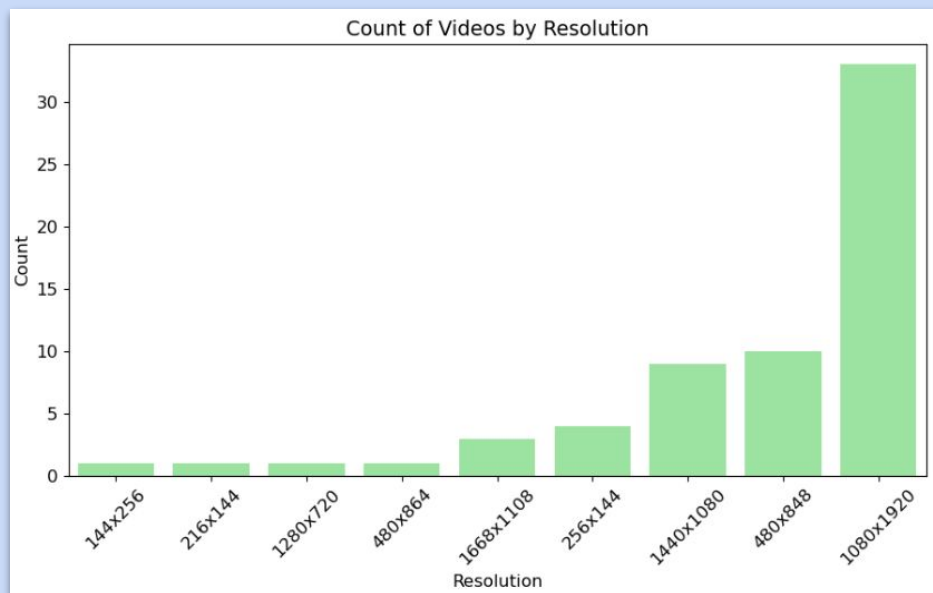
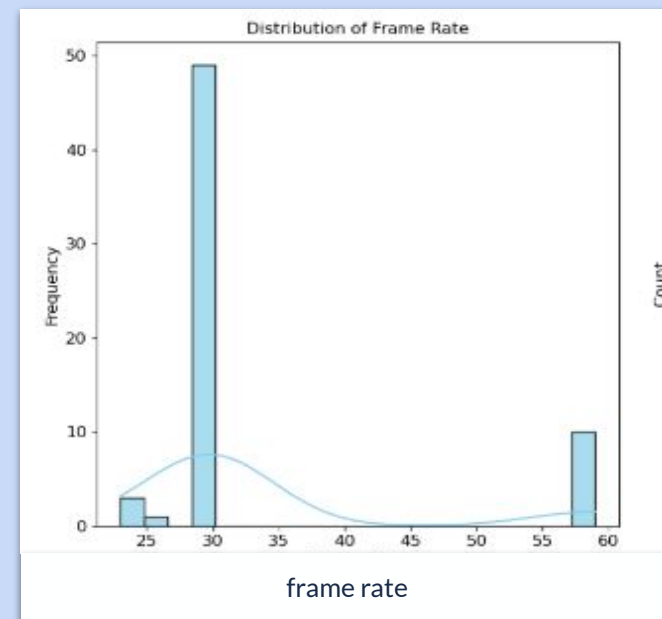
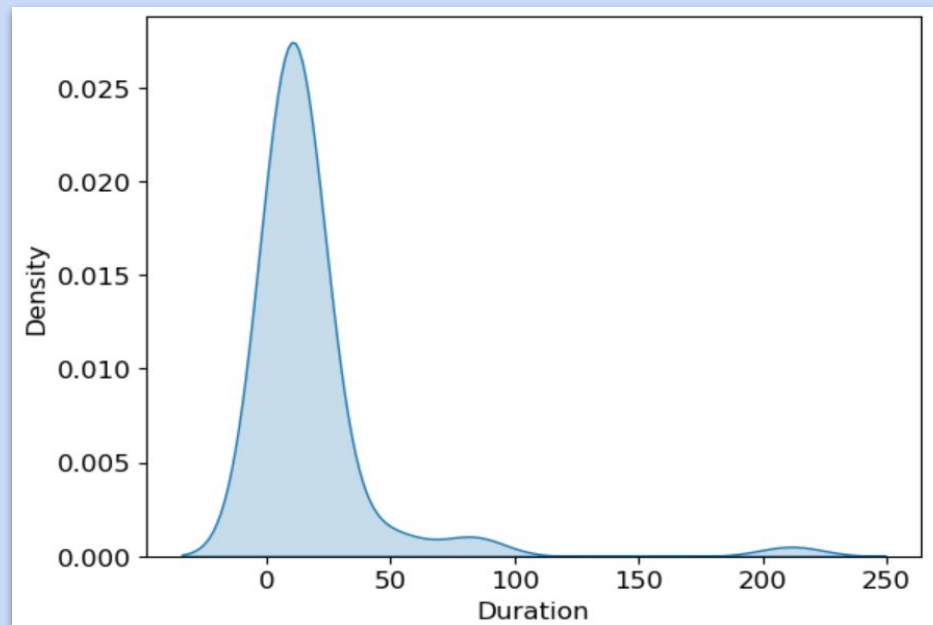
AWS Solution Architecture



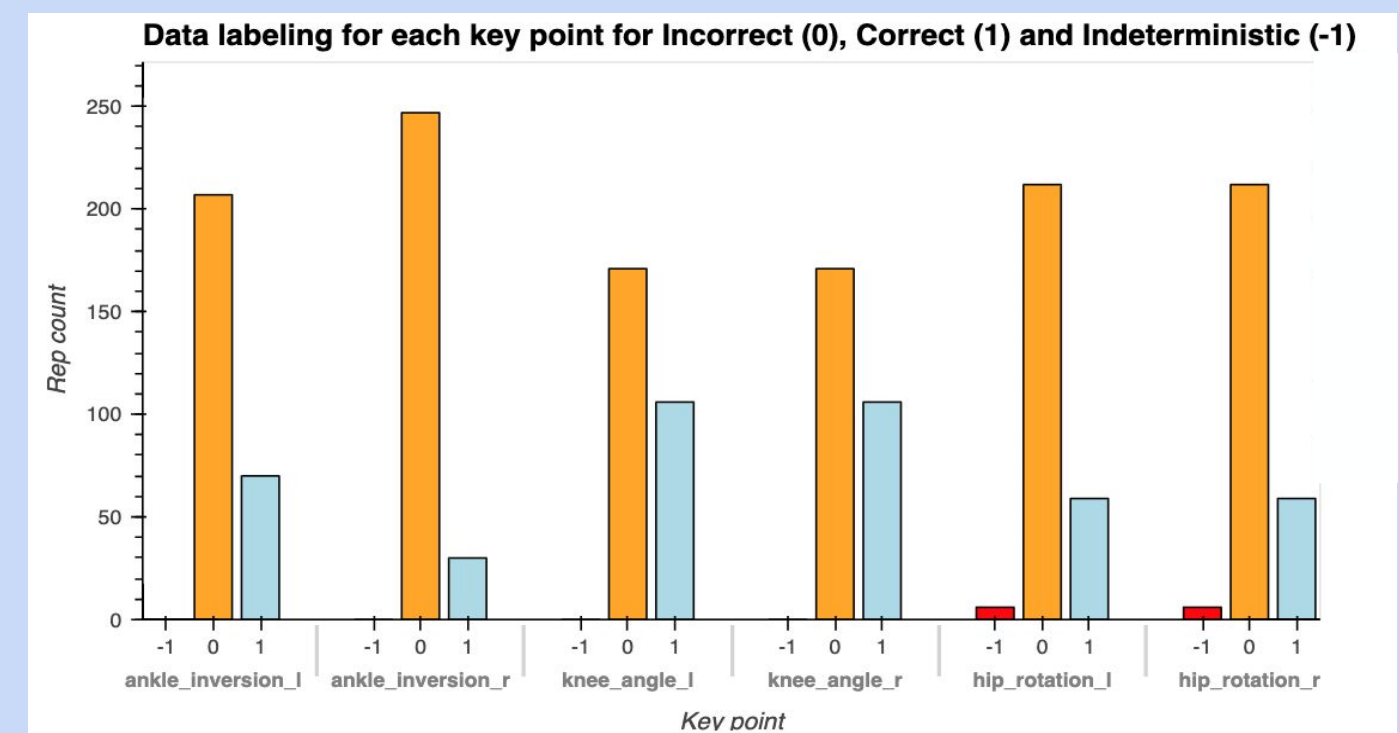
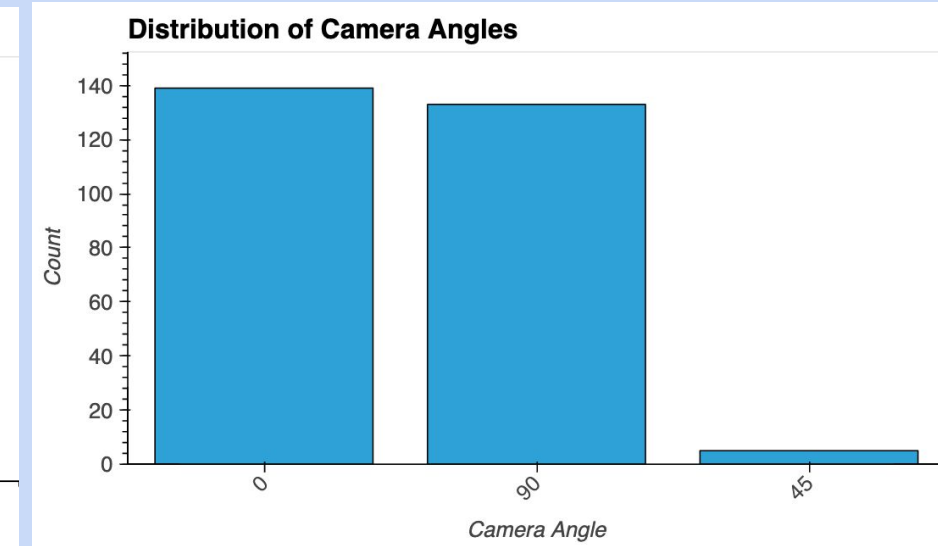
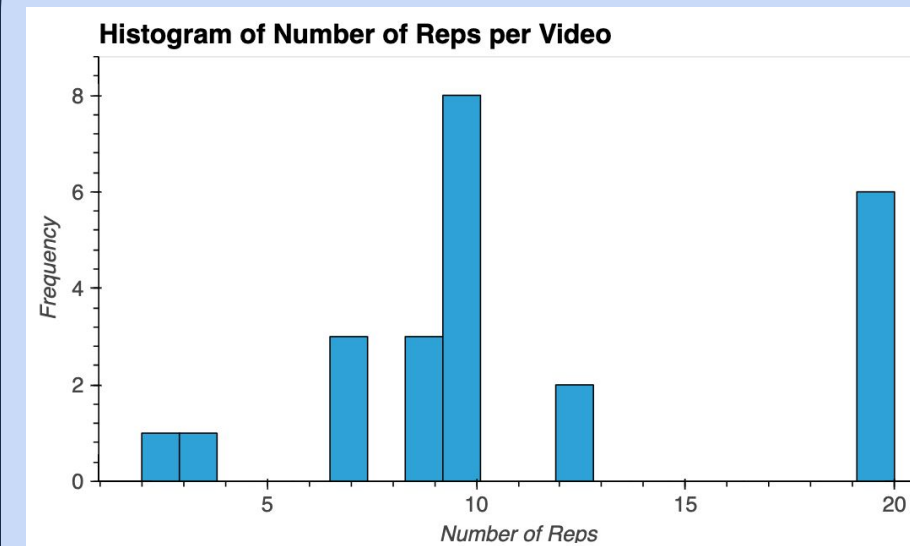


Preliminary Data Analysis

EDA

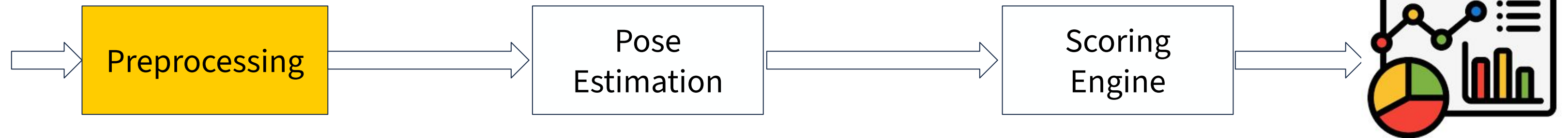


Data Labeling



Preprocessing

Goal: Reduce storage, compute requirements and improve model execution time

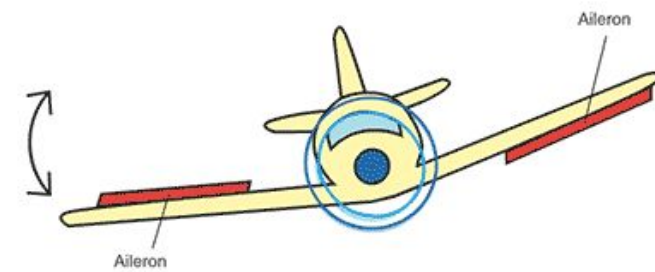


- Remove audio and color
- Reduce Resolution (480px min)

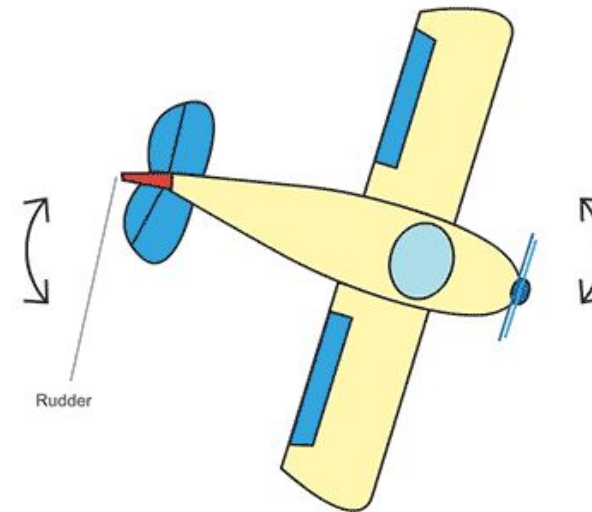
Storage reduction	80%	All videos
Execution time improvement	92%	A subset of 6 videos
Model accuracy improvement	39%	A subset of 6 videos Domain advisor's labels are "Ground truth"

What are Poses?

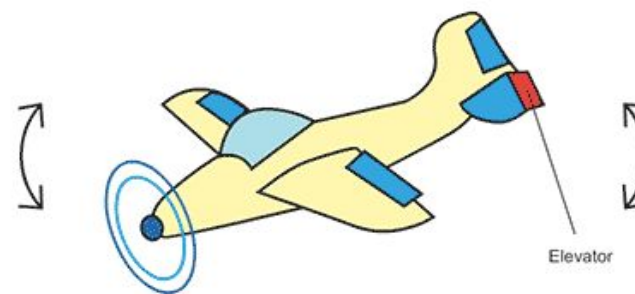
Orientation of an object with respect to a reference in real world



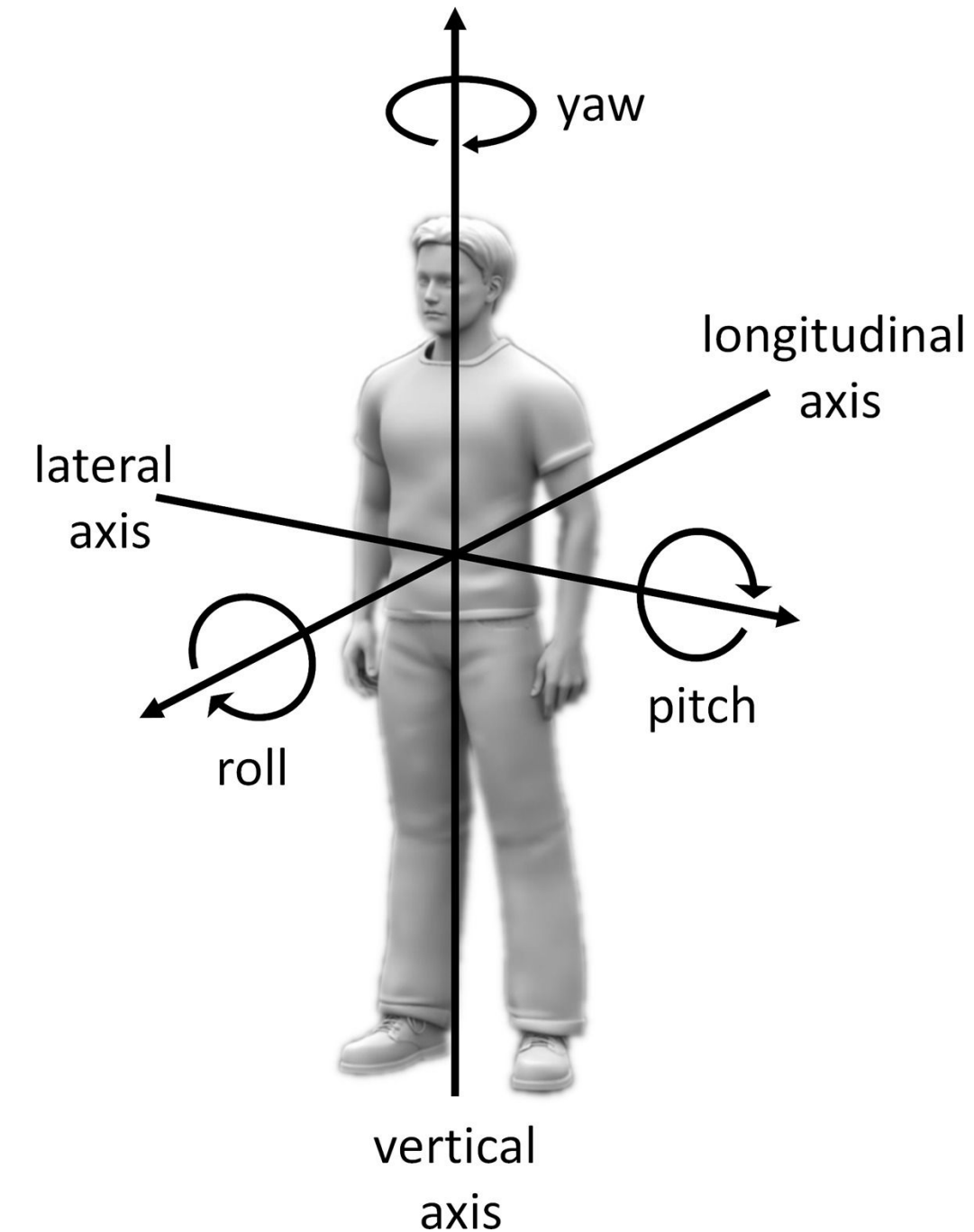
Use the ailerons to control
Roll



Use the rudder to control
Yaw

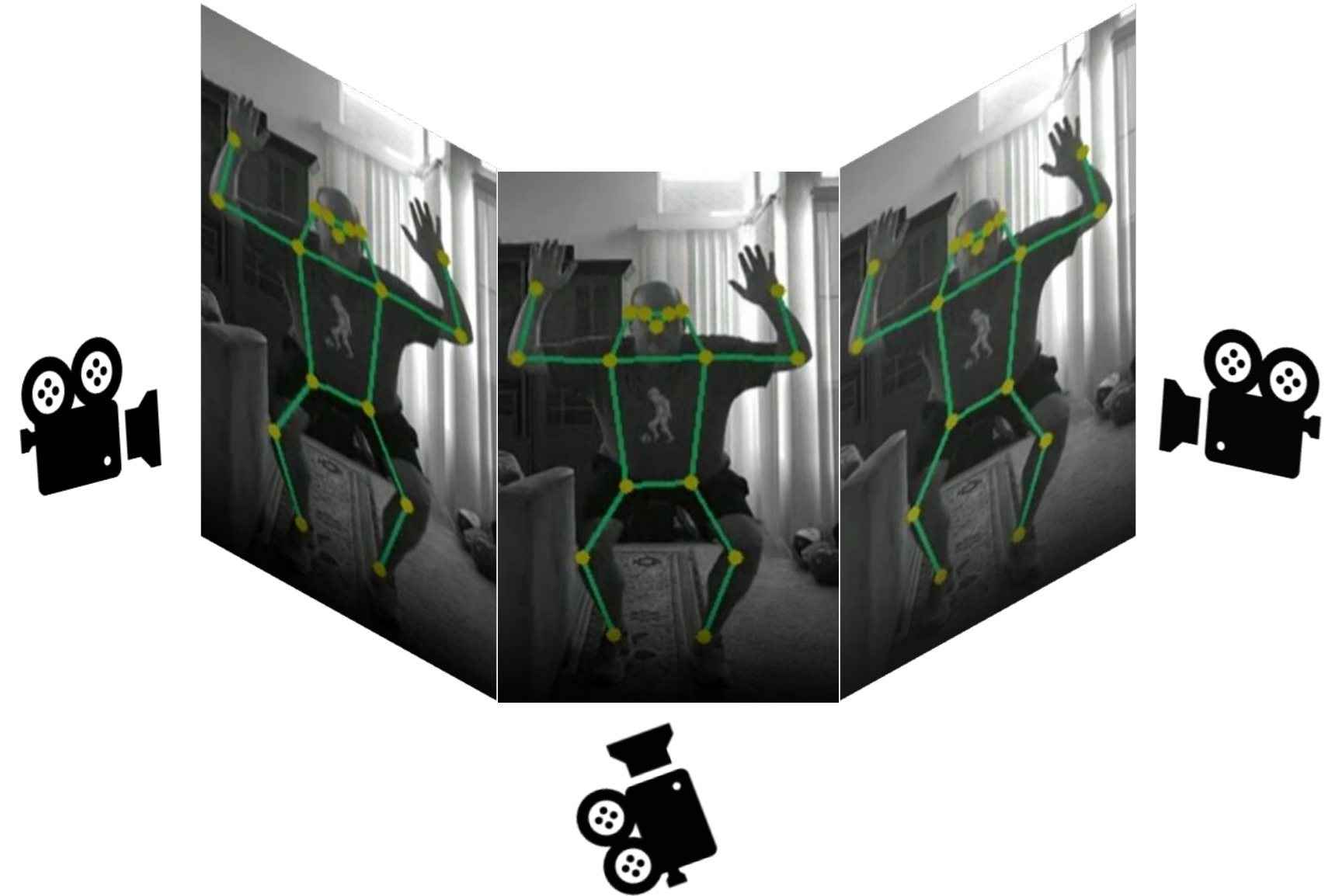


Use the elevator to control
Pitch

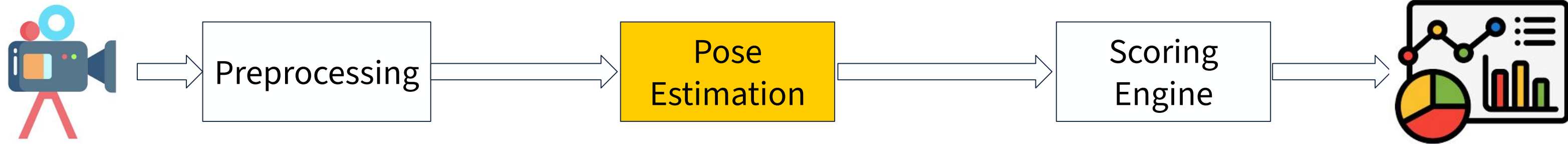


Pose Estimation in Real World

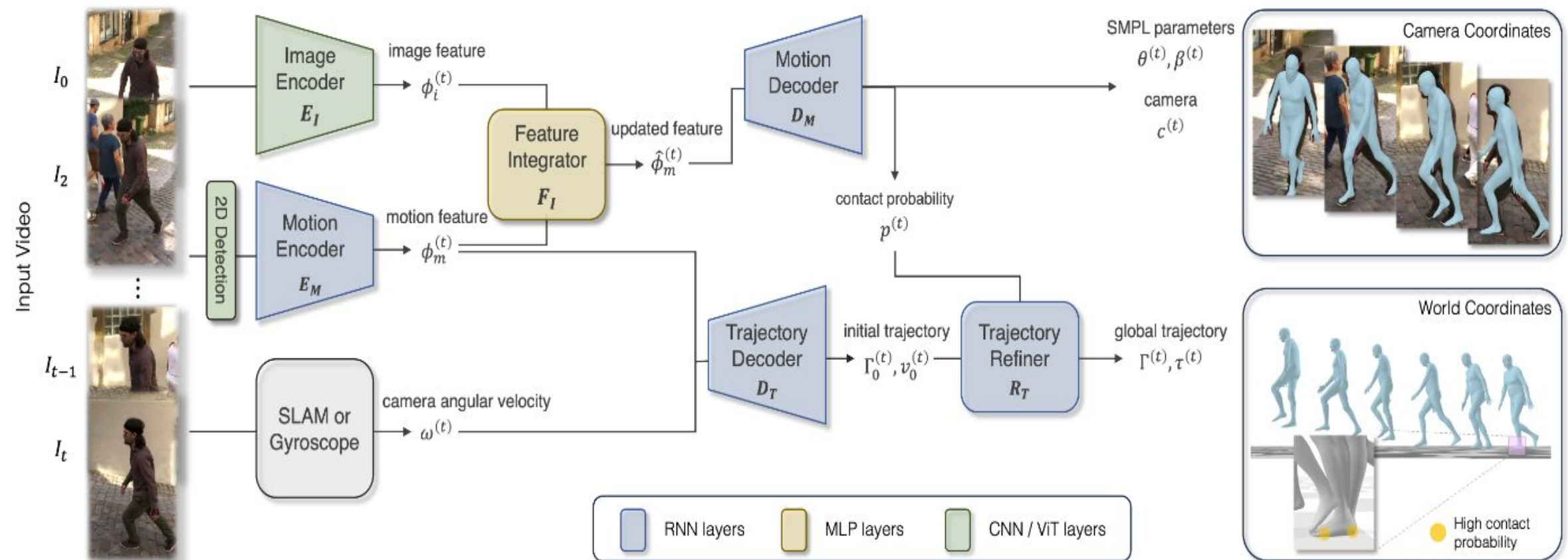
- Images or videos contain limited information of the scene
- To understand and analyze poses in the real world (3D space), we harnessed the power of Deep learning
- We employ a state-of-the-art model, World-grounded Humans with Accurate 3D Motion ([WHAM](#)), to perform 3D pose estimation and derive accurate measurement of joint angles and rotations



3D Pose Estimation - WHAM



- Takes 2D key points from a video and converts them into 3D human motion including how a person moves and contacts the ground
- Refines this data to produce a 3D representation of the person's movement



Pose Estimation Model Output

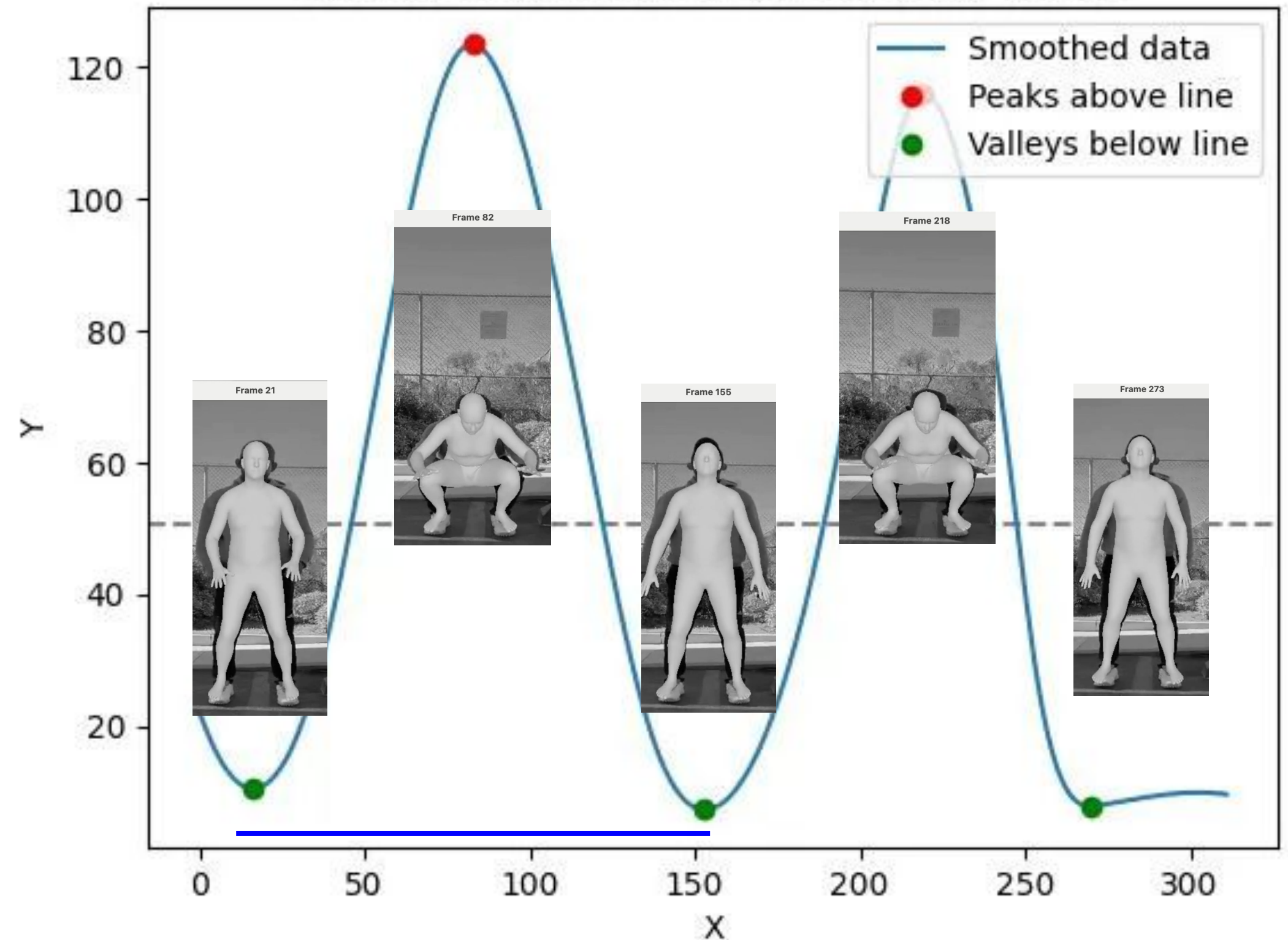
- After processing, WHAM
 - Produces pixel-aligned 3D human motion
 - Provides detailed tensors that encapsulate pose, shape, and joint information
- We utilize the joint coordinates to visualize the Incorrectness in a video



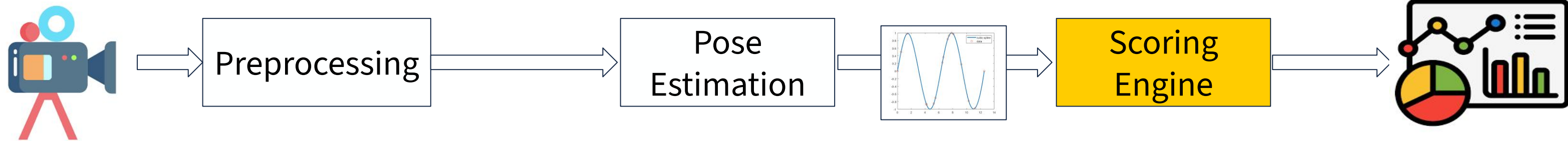
Repetition Identification

- Repetition identification is important for score computation
- Frame-by-frame data from a Keypoint processed to identify repetitions
- All frames included within valley-peak-valley identify as a repetition

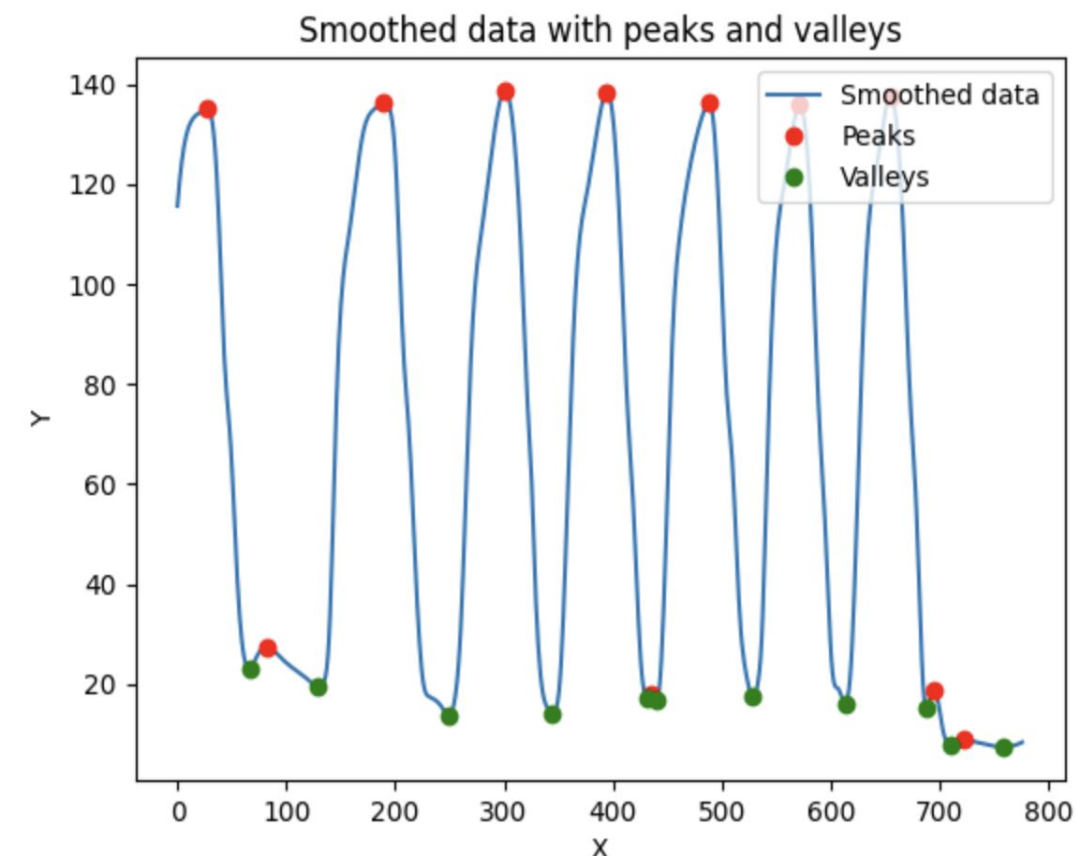
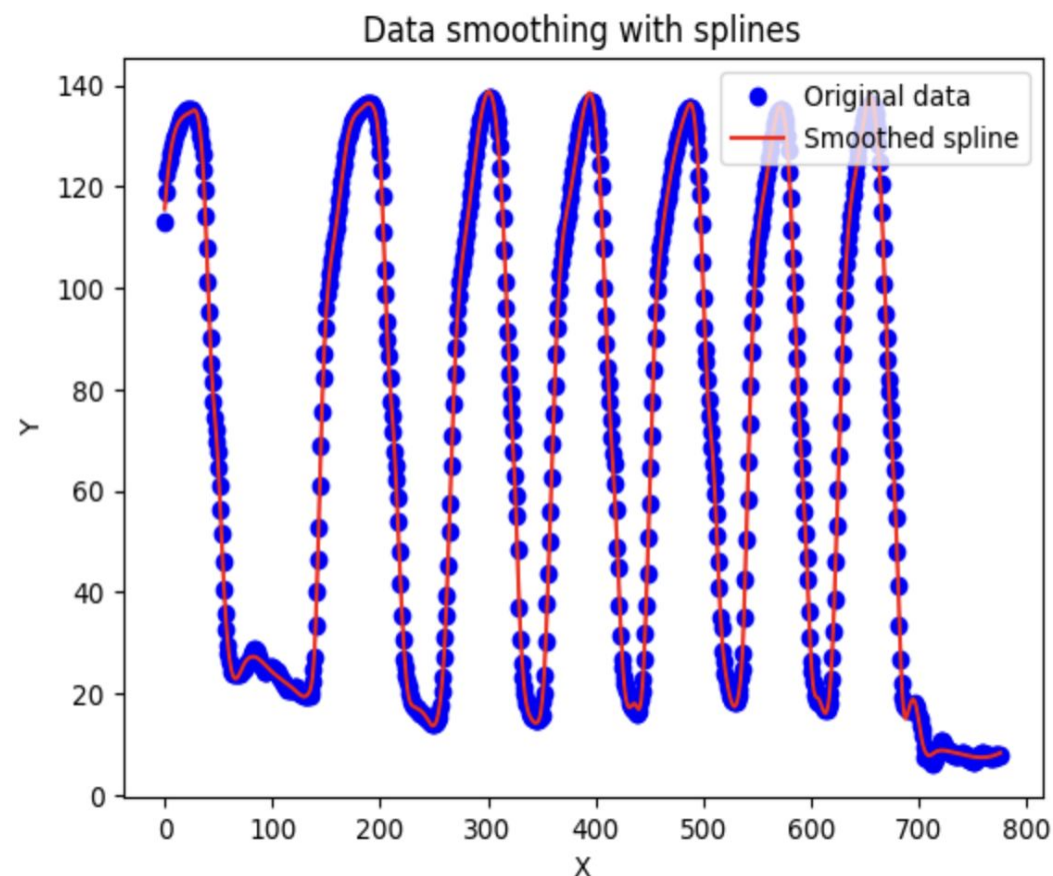
Smoothed data with line, peaks, and valleys



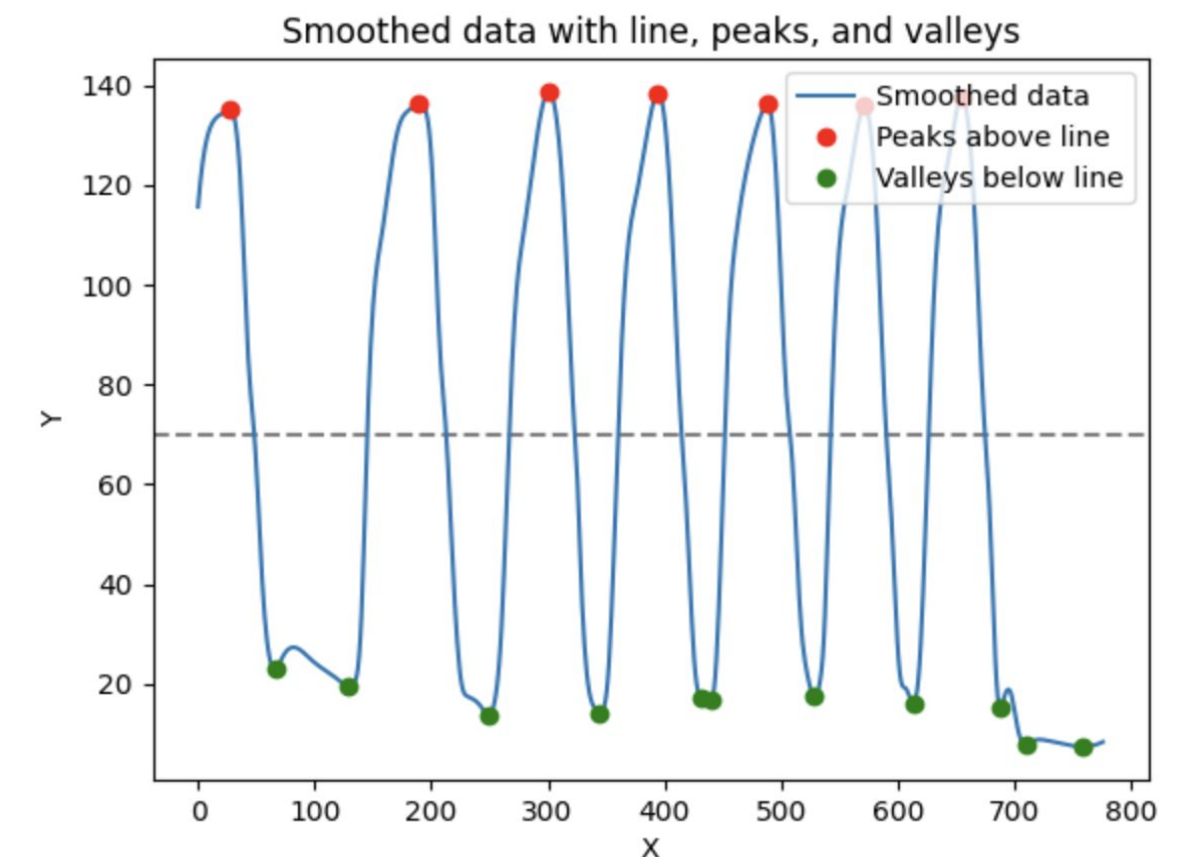
Repetition Identification Steps



- Used pose estimation model output of the left and right knee angle measurements
- Signal smoothing computational approach to find peaks
- Filtered out peaks below the threshold (y mean)



Number of peaks: 11
Number of valleys: 11



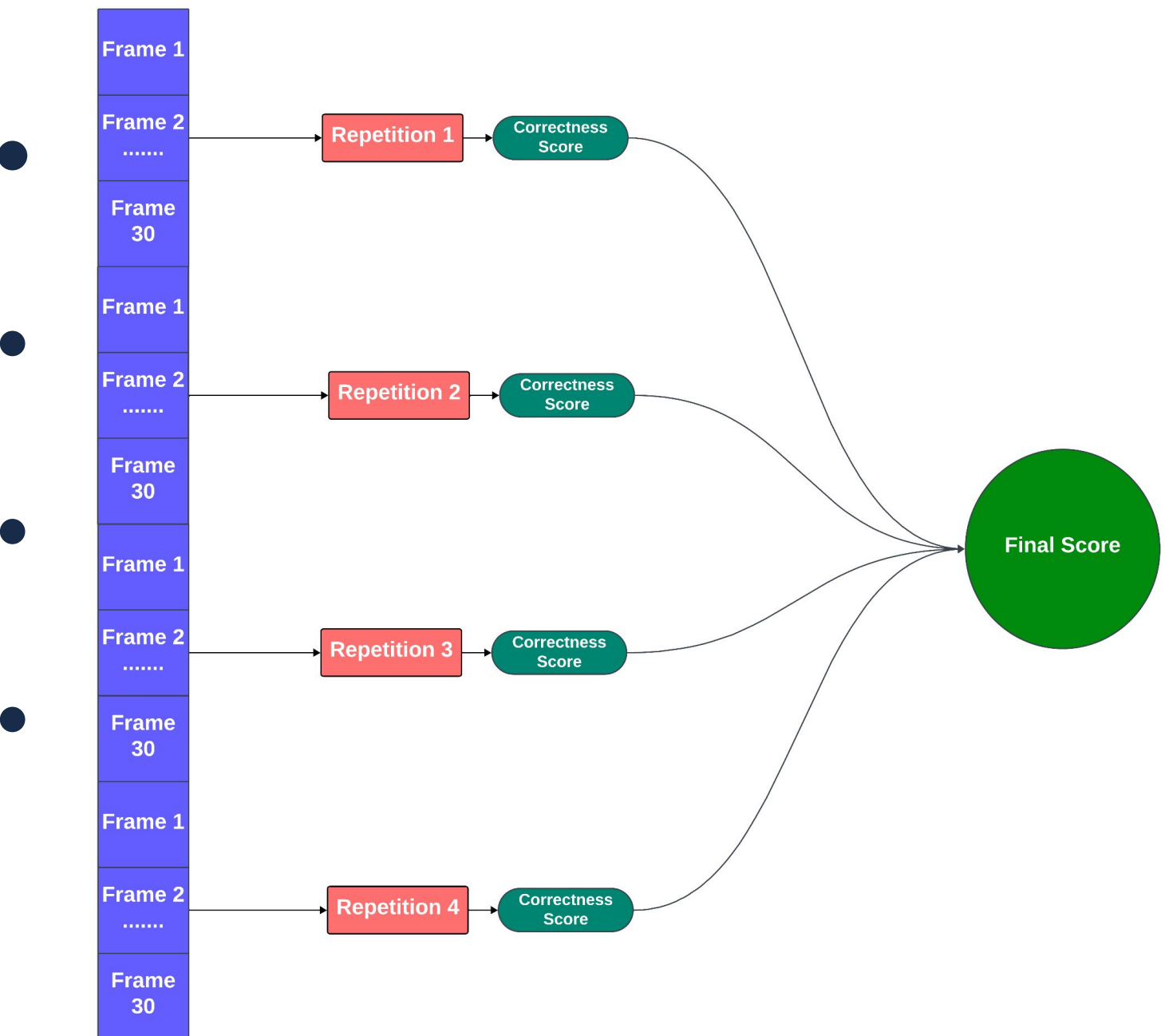
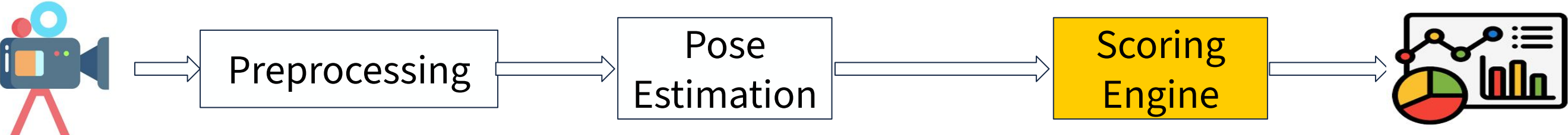
Number of peaks: 7
Number of valleys: 11

Incorrectness Score Measurement

- Final score is based on the type of exercise monitored
- For overhead squats, the important things to look for -
 - Knee bend
 - Ankle inversion/eversion
 - Hip rotation
- These measures need to be in a given specific range to classify them as safe



Score Calculations



Joint	Measure	Correctness Condition
Right Knee	`Norm`	$75 \leq \text{`Norm`} \leq 90$
Left Knee	`Norm`	$75 \leq \text{`Norm`} \leq 90$
Right Hip	`Y`	$-75 \leq \text{`Y`} \leq 45$
Left Hip	`Y`	$-75 \leq \text{`Y`} \leq 45$
Right Ankle	`P`	$-15 \leq \text{`P`} \leq 35$
Left Ankle	`P`	$-35 \leq \text{`P`} \leq 15$





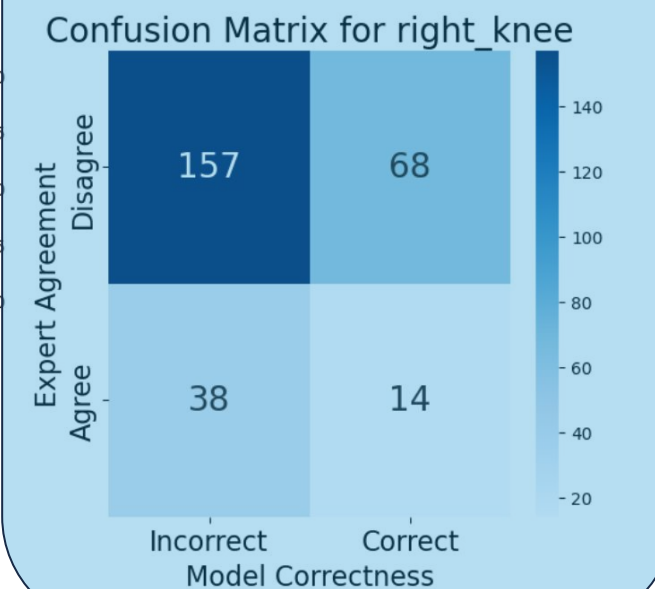
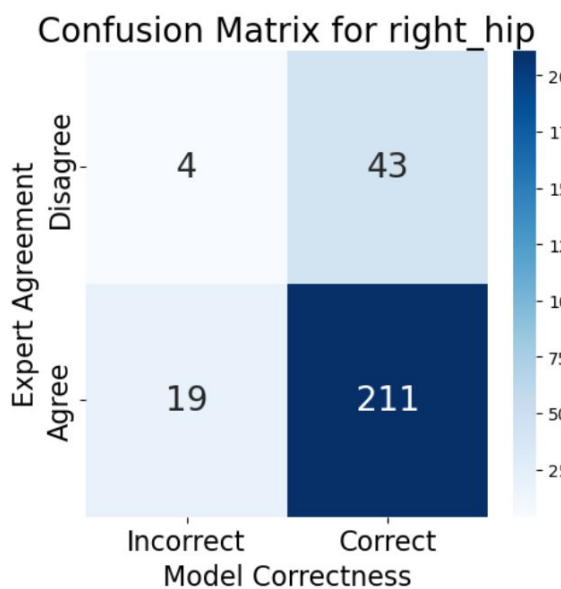
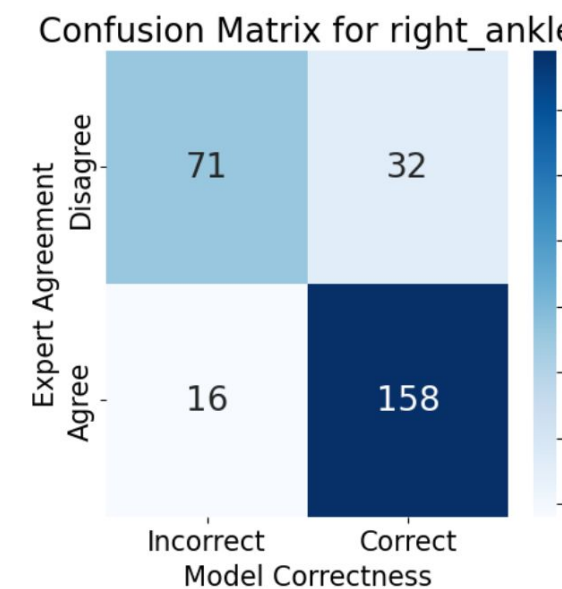
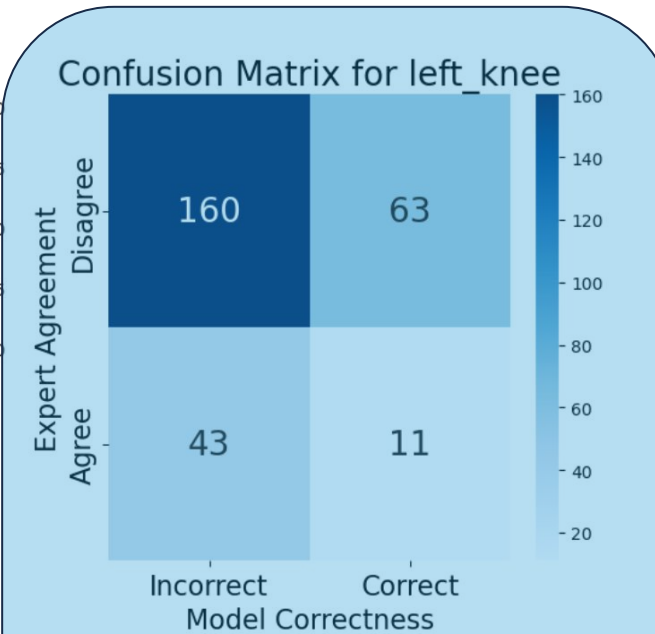
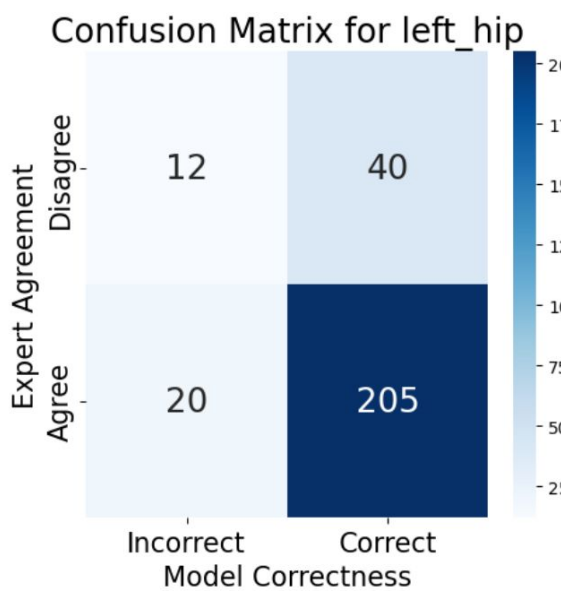
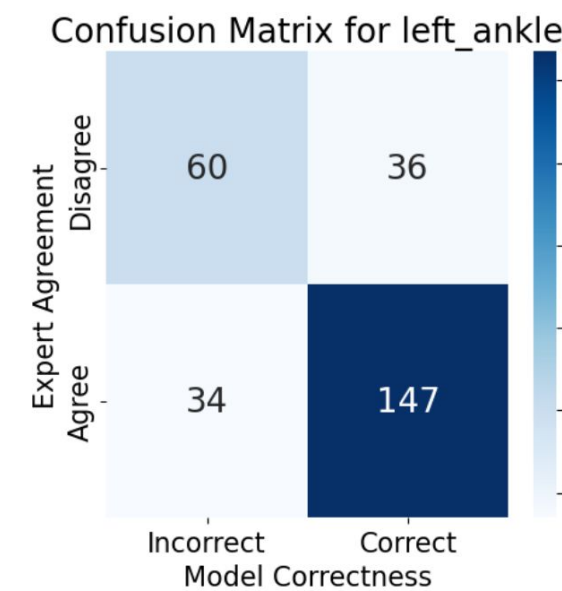
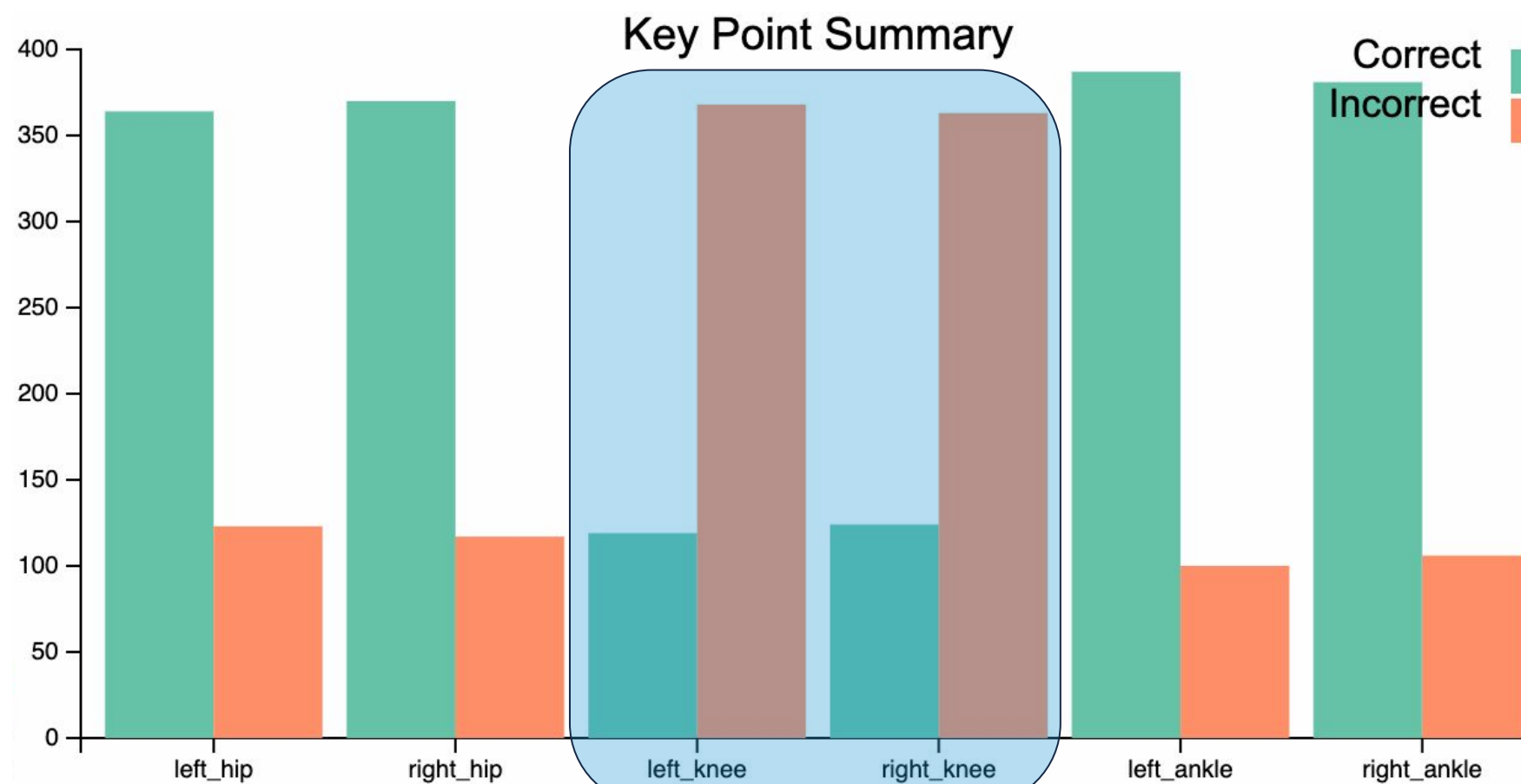
Physio AI Companion: Product Demo





Some **INTERESTING** Findings...

- WHAM model performs better estimation when the user is wearing shoes!
- The model will track down even your mirror image
- We cannot say how “correctly” you performed your exercise, only how “incorrectly” you did it
- Disagreement between model output and advisors when it comes to KNEE (left and right)

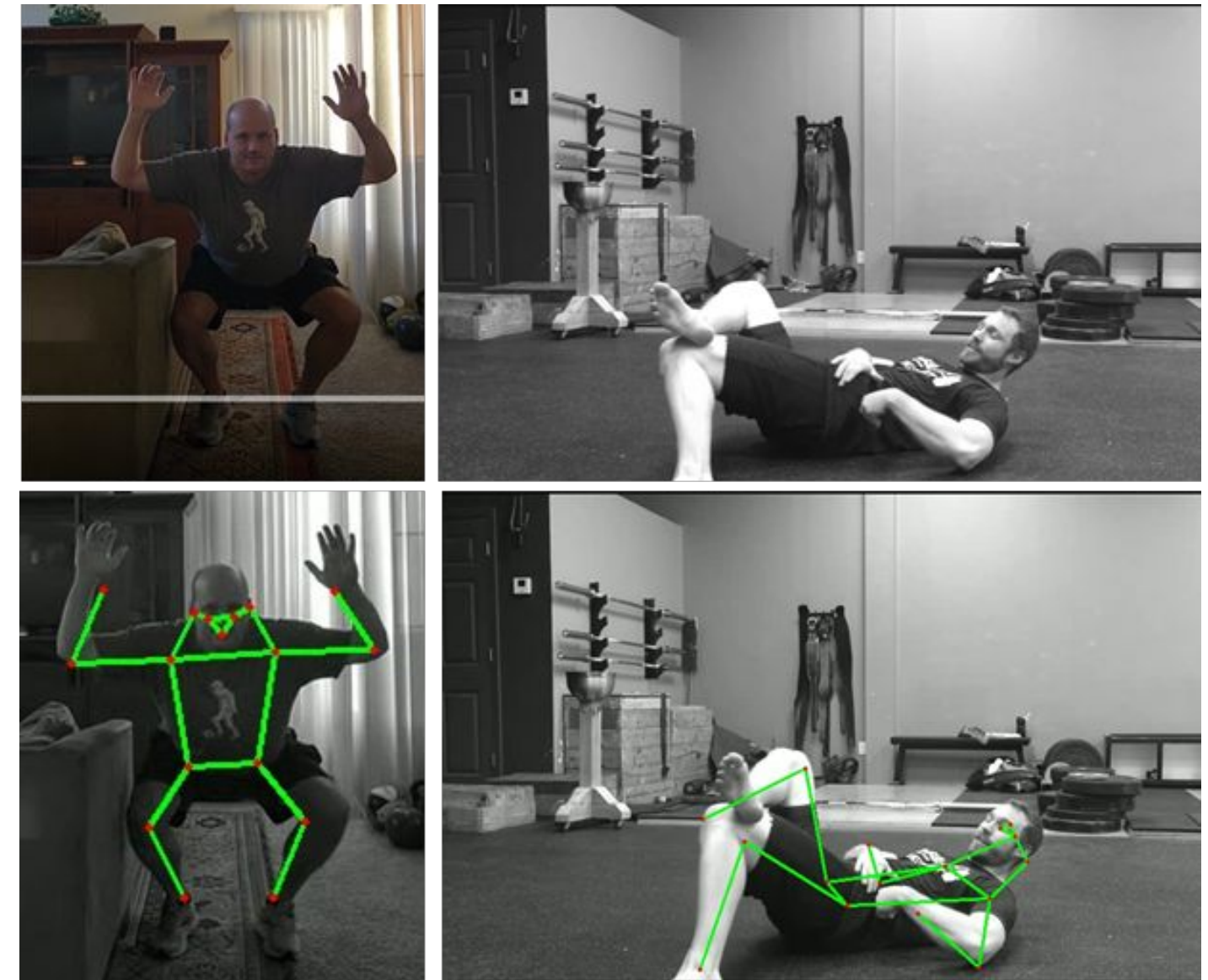




Scalability To Other Applications

Physio AI Companion can easily be extended and deployed to various other applications

1. Sports performance enhancements through posture monitoring & correction - e.g., golf, gymnastics
2. Generalize the solution to other type of exercises
3. General monitoring & assessment
4. Injury prediction & injury prevention
5. Assist in localized rehab targeting injured body part





Summary

Physio AI Companion will support your physiotherapy journey with the following capabilities

- Leverage the power of AI
- Automatically identify the part of your body incorrectly performing an exercise
- Easy to use tool that conveniently captures and shows your exercise mechanics

Domain advisors stated the website to be a useful tool as is

“This is pretty cool!”
- Malerie, DPT,PT



“It’s looking awesome!!”
-Brian, MS Kinesiology

