Ghost Motion

Data forensic, detection and reconstruction
of occluded human movement

Motion capture - Group 3

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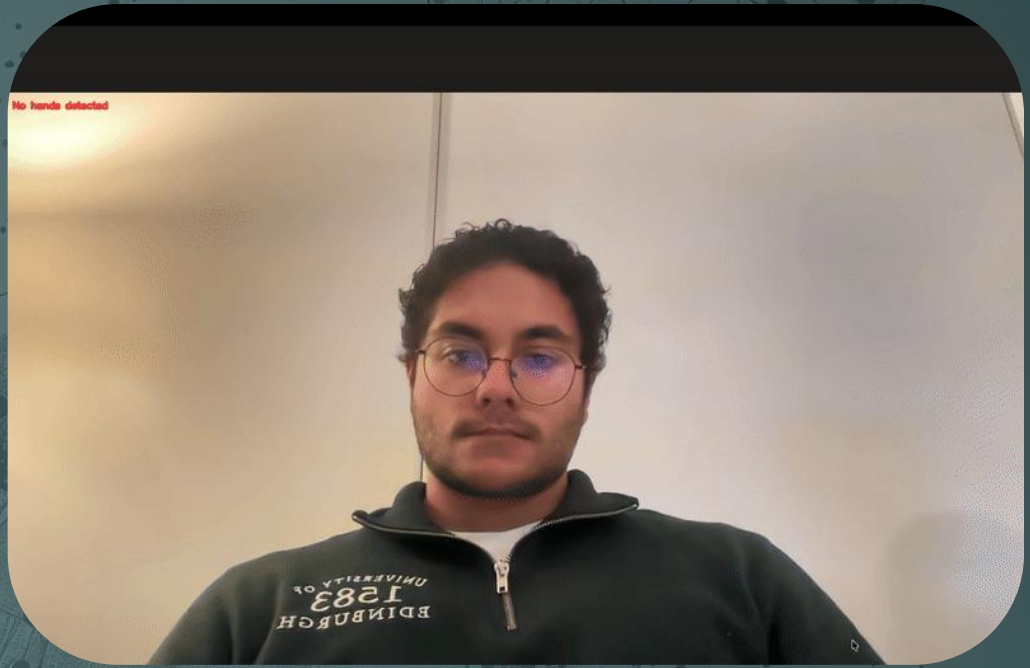


Key Points

Motion Capture (MoCap)

Captures 3D human movement for analysis, animation, and machine learning.

“Complete” Datasets

Show every joint clearly; occluded data has missing or obscured markers.

Our Focus

How to understand, visualize, and reconstruct motion when the data is incomplete.

The Problem: Occlusion and Missing Data

What is Occlusion?

- Occlusion = when sensors lose sight of body markers (e.g., arm behind torso, poor camera angle)
- Results in data gaps, unrealistic movement reconstructions, and loss of meaning
- For both humans and algorithms, missing motion disrupts interpretation

Possibilities of Occlusion

1. Body markers are obstructed
   - Temporary missing
2. Sensor error
   - Whole time missing
3. Camera error
   - Variable missing
4. Anomalies
   - stylistic complexity/expressive noise

Challenge

Understanding Incomplete Motion

1. Occlusion data hides the "story" of motion - we see fragments, not fluidity.

2. Humans can intuitively fill the gaps, but algorithms can't without reconstruction.

3. We aim to visualize incompleteness itself - turning missing data into something we can perceive and reason about.

4. **Visual:**
   - "Ghost trail" visual of missing joint data fading out
   - Heatmap of visibility per joint (where occlusion is most common)

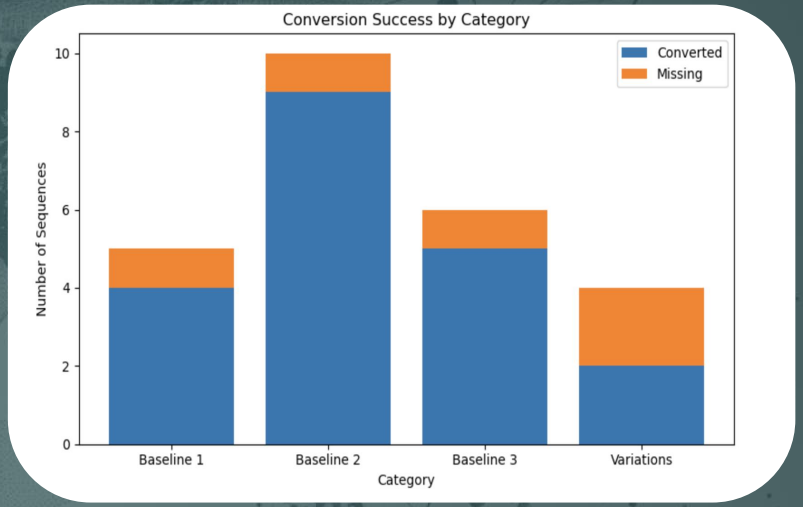
Objective

This project investigate how motion-capture data breaks when body markers become occluded or stylistic anomalies arise. It reveals, detects and reconstructs these breakdowns through a transparent, interpretable pipeline.


Methodology

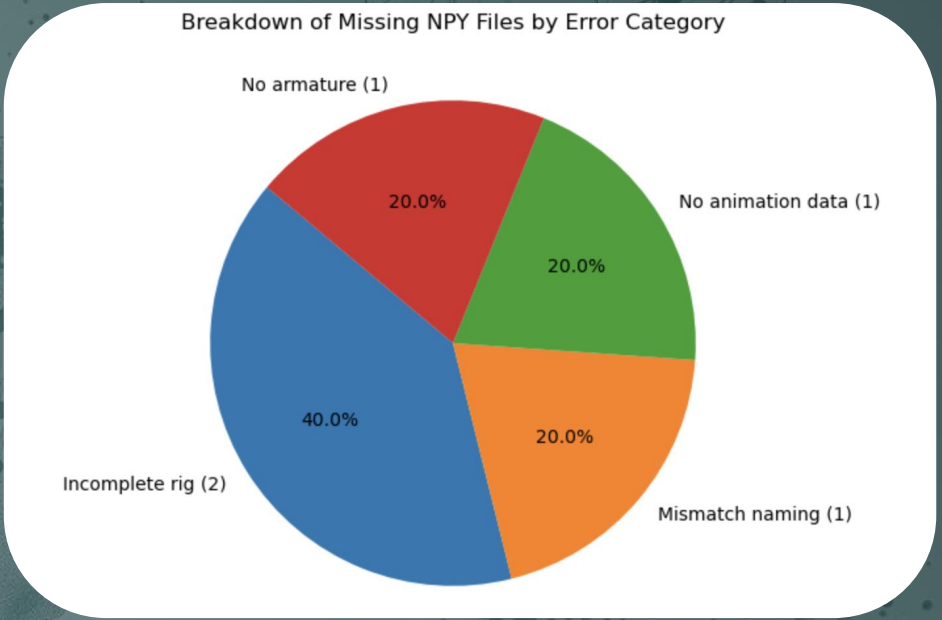
Data Processing

- 27 Numpy sequences converted from raw. fbx data, validating rigs, joint counts and NaN patterns.
- Convert rotation formats (6D → matrices / quaternions)
- Apply forward kinematics to compute joint positions
- Normalise coordinates (root-centering, axis alignment)
- Filter noise + remove unstable frames
- Extract structured arrays for telemetry + 3D plotting
- Tools: NumPy, SciPy, PyTorch3D, FK mapping functions



Forensic Data Audit

- Review raw FBX motion files
- Inspect missing markers & corrupted frames
- Five files and figure joints were dropped
- Identify rotation formats (6D / quaternions)
- Validate skeleton hierarchy
- Tools: FBX SDK, Python (numpy, scipy)

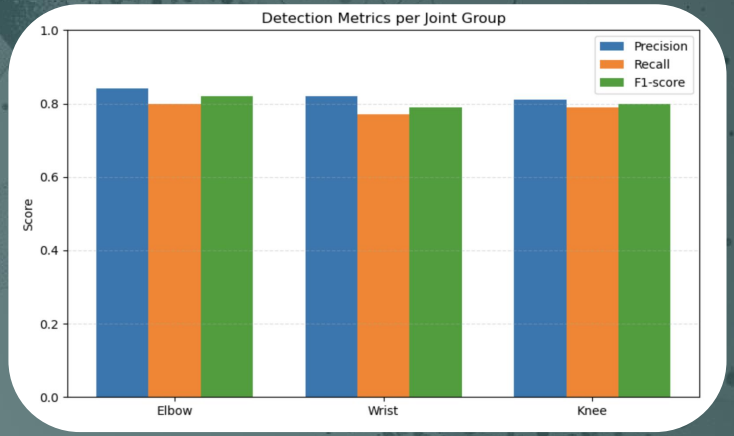


Occlusion Detection

- Compute visibility ratio per joint
- Threshold low-visibility frames
- Detect occlusion windows & patterns
- Generate timelines + phase labels

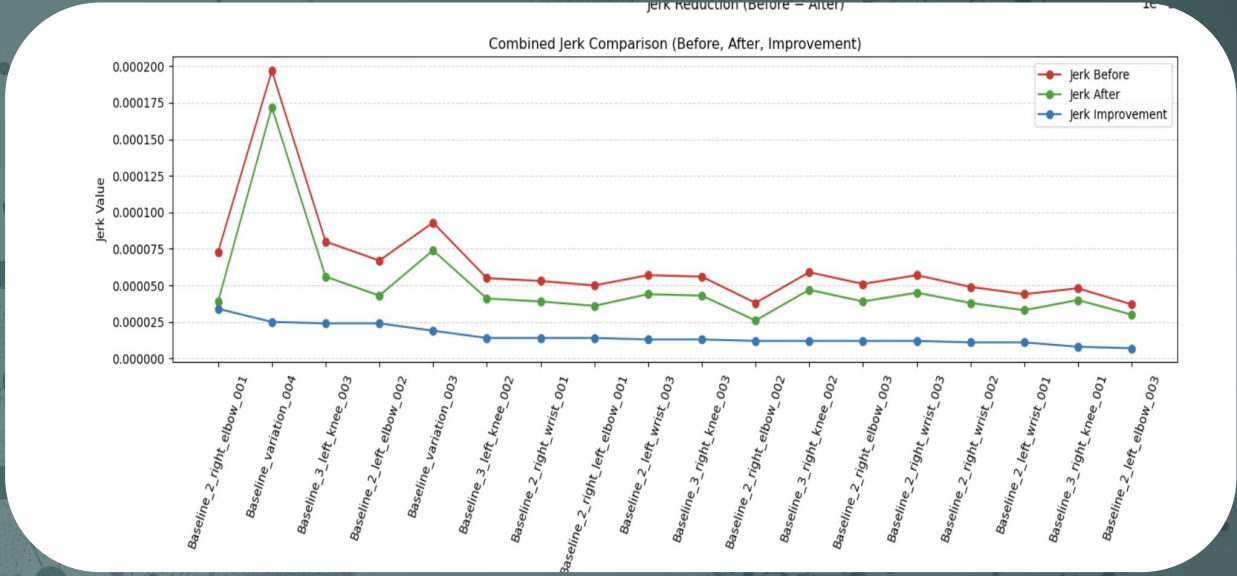
Algorithm Model:

- Unsupervised statistical anomaly detection (Interpretable ML type), using seq2seq temporal logic
- Tools: NumPy, Telemetry plots (Matplotlib)



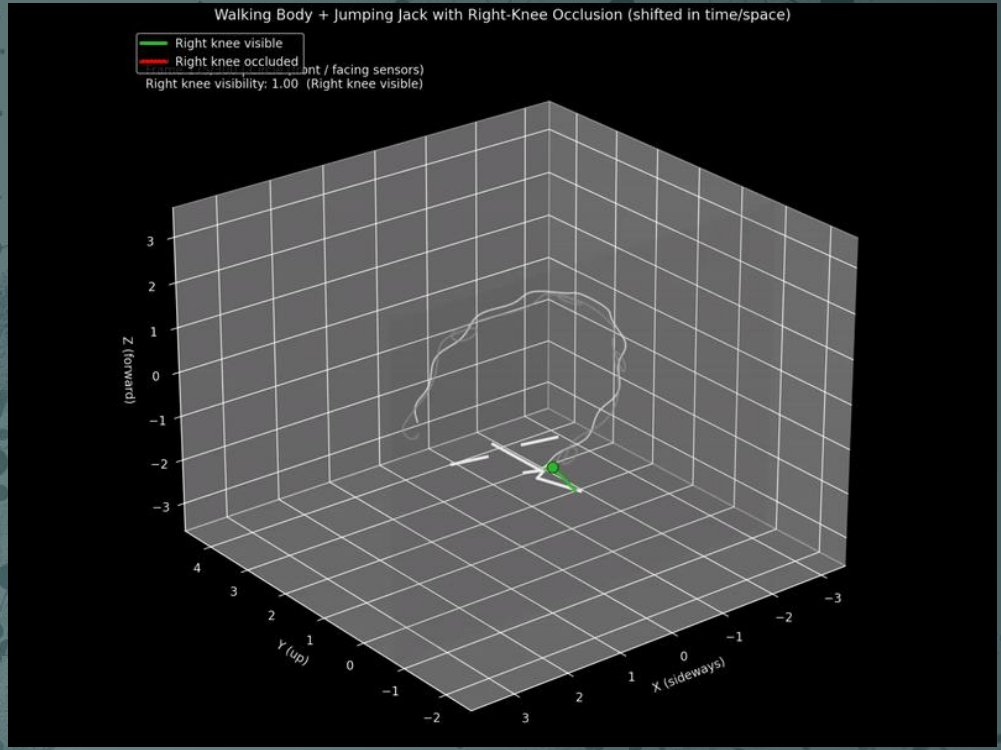
Occlusion Correction

- Interpolate missing joint positions
- Smooth noise using velocity/acceleration/ jerk minimisation
- Apply quaternion SLERP (Spherical Linear Interpolation) for rotation gaps
- Stabilise end-effectors + correct drift
- Tools: SciPy interpolation, quaternion SLERP, jerk-based smoothing filters

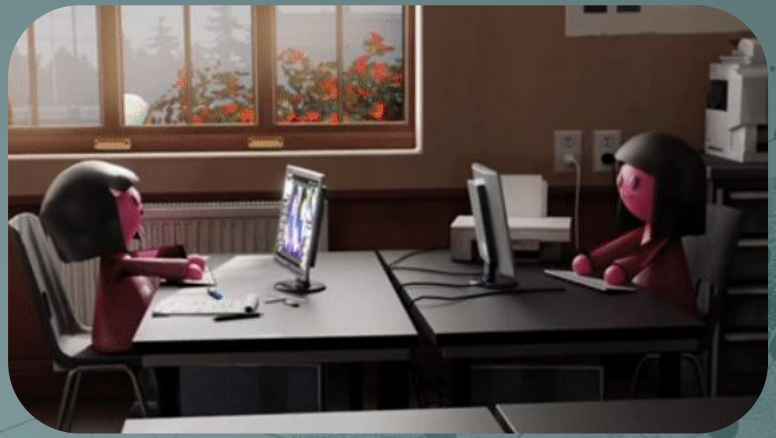


Ghost Motion Visualization

- 3D animated skeleton playback
- Colour-coded occlusion segments
- Trajectory traces (speed-coloured)
- Telemetry overlays + timelines
- Tools: Matplotlib 3D, FuncAnimation, LineCollection
- Ghost Motion converts invisible telemetry breakdowns into visible, explorable storytelling material, strengthening visibility and forensic transparency.



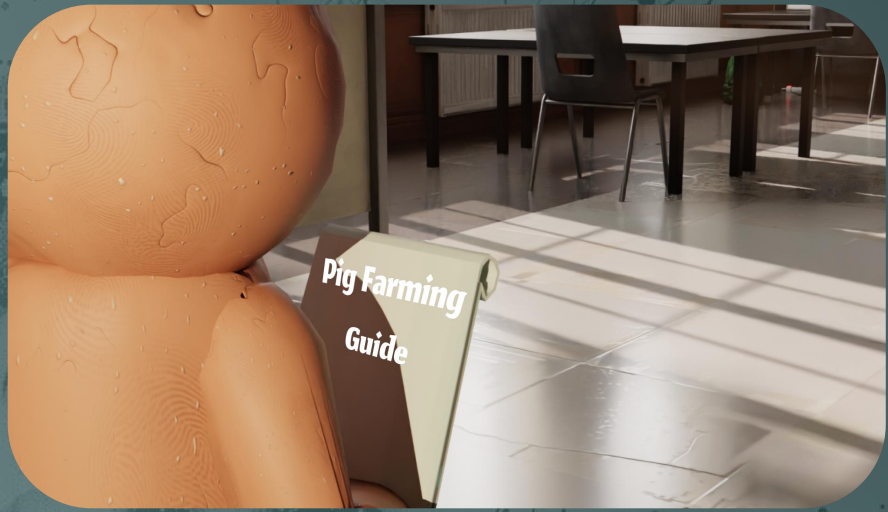
Data Forensic Creative Artifact



- **Baseline 3:** Knee occlusions
- **Character Settings:** Employees who sit at their desks for extended periods but produce very little

- **5 total missing data**
- **Character Settings:** Employees who were fired by the company for having no output(melted)

Data Forensic Creative Artifact



- **Variations:** Highly dynamic, noisy
- **Character Settings:** Employees who regularly steal electricity and water from the company

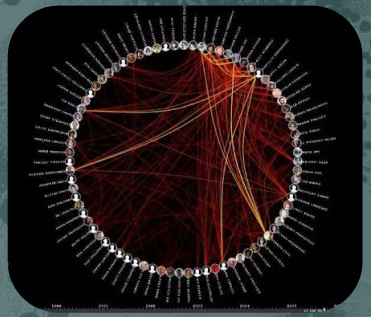
- **Baseline 2:** Knee occlusions
- **Character Settings:** Employees who pretend to be busy all day by holding files

Results & Expected Insights

Reconstructed Sequences

Restores motion flow, making patterns interpretable

Visualization



Exposes where and how occlusion occurs, not just that it happens

Dual Understanding

Intuitive human insight + algorithmic inference readiness

Reflection / Takeaway

- Occlusion highlights the limits of data capture but also inspires creative reconstruction
- Through telemetry, visualization, and modeling, we learn how to see absence as information
- Potential future direction: build adaptive systems that handle occlusion dynamically and visualize uncertainty in real time
- The project highlights the fragility of motion capture and the interpretive labour behind reconstruction.