Automatic Human Model Parametrization From 3D Marker Data

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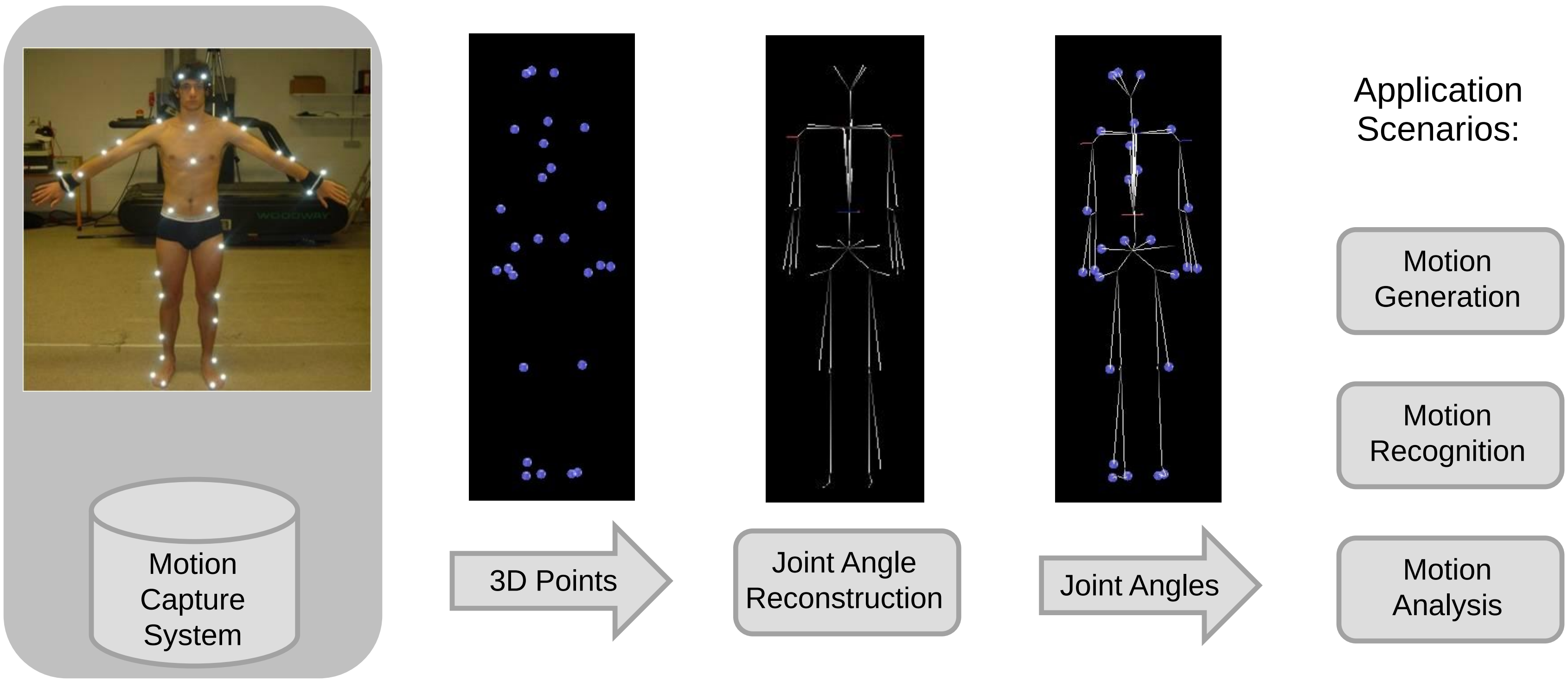
Agenda

- Application Scenario
  - Motion Tracking, Fitting Problem
- Model Specification
  - Rigid Model, Adaptive Model
- Motion Reconstruction
  - Iterative Interior-Reflective Newton Algorithm
- Results
  - Qualitative Improvement, Quantitative Improvement

Application Scenario

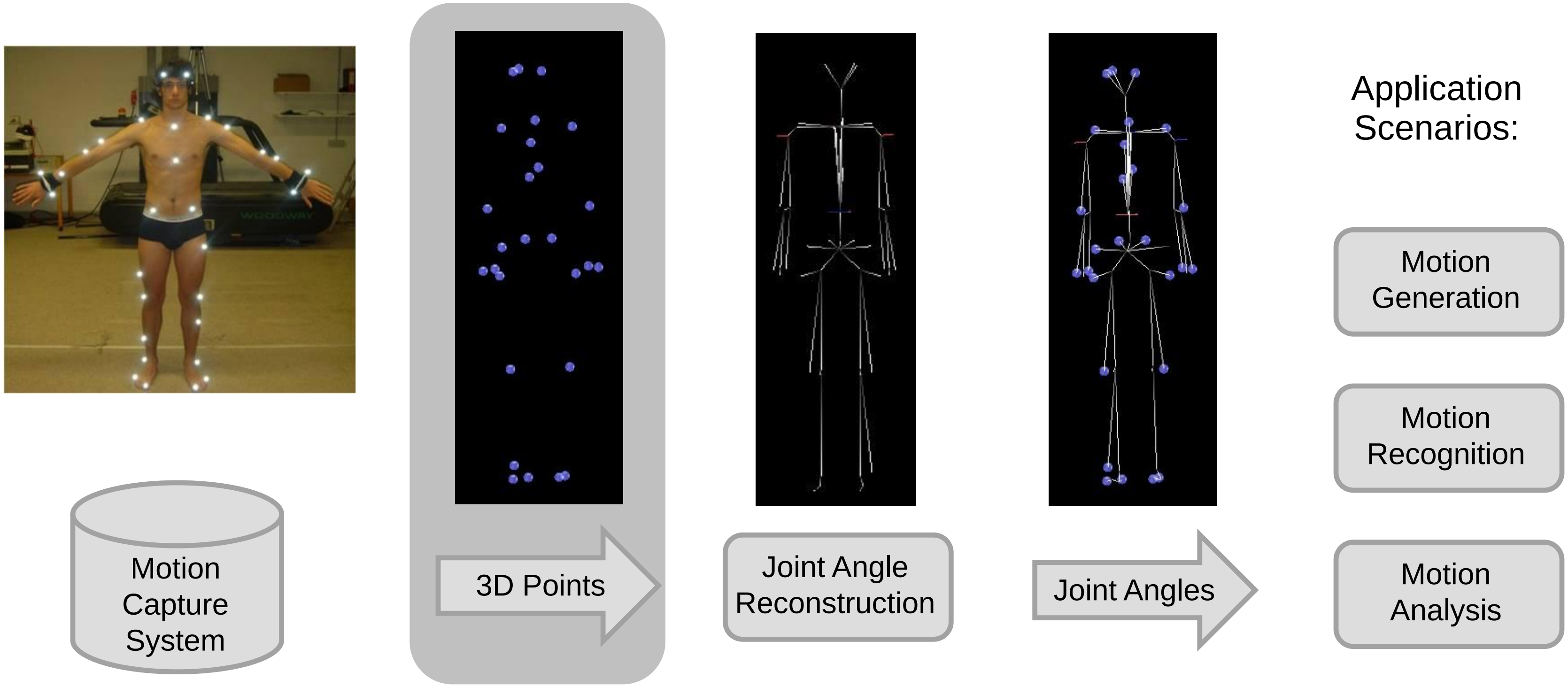
Human Motion Tracking



Capture 3D marker with a Vicon motion capture system

Application Scenario

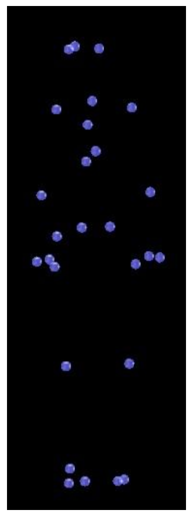
Human Motion Tracking

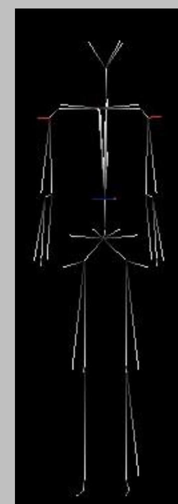


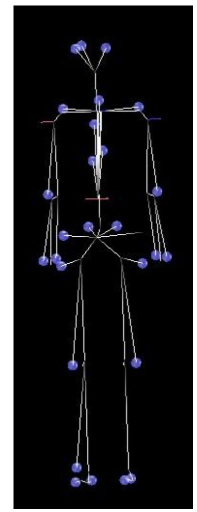
Result: 3D marker points

Application Scenario

Human Motion Tracking







Application Scenarios:

Motion Capture System → 3D Points → Joint Angle Reconstruction → Joint Angles →

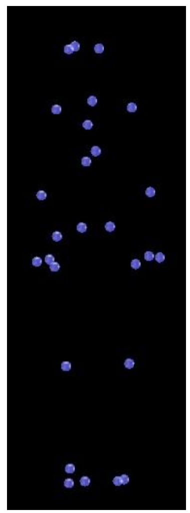
- Motion Generation
- Motion Recognition
- Motion Analysis

Apply a kinematic human model to reconstruct joint angles

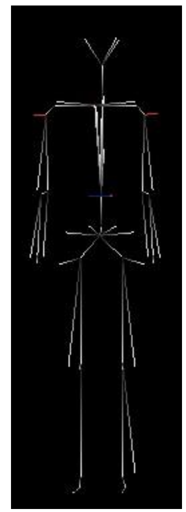
Application Scenario

Human Motion Tracking

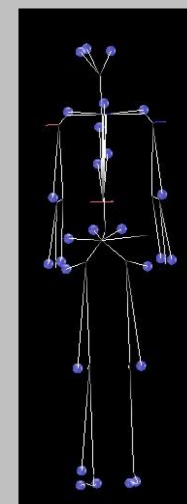
Motion Capture System



3D Points



Joint Angle Reconstruction



Joint Angles

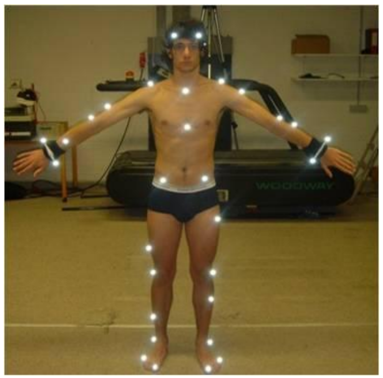
Application Scenarios:

- Motion Generation
- Motion Recognition
- Motion Analysis

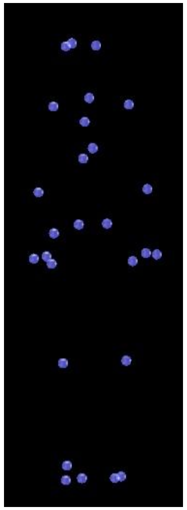
Result: Joint angles of the actual pose

Application Scenario

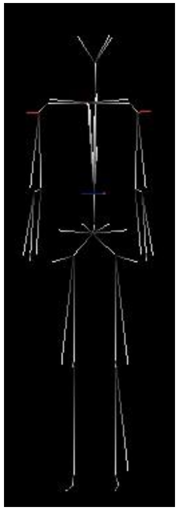
Human Motion Tracking



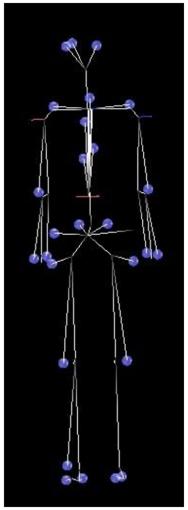
Motion Capture System



3D Points →



Joint Angle Reconstruction



Joint Angles →

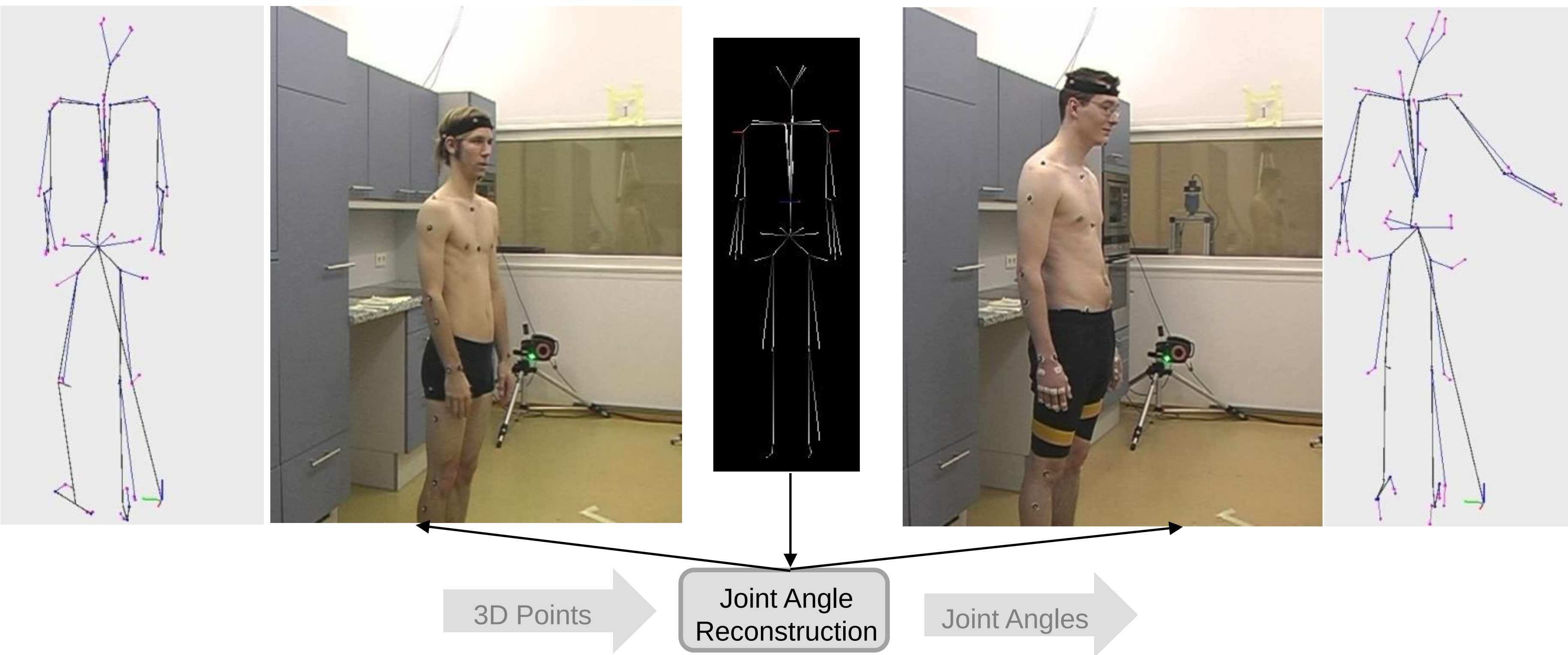
Application Scenarios:

- Motion Generation
- Motion Recognition
- Motion Analysis

Basis for different application scenarios

Fitting Problem

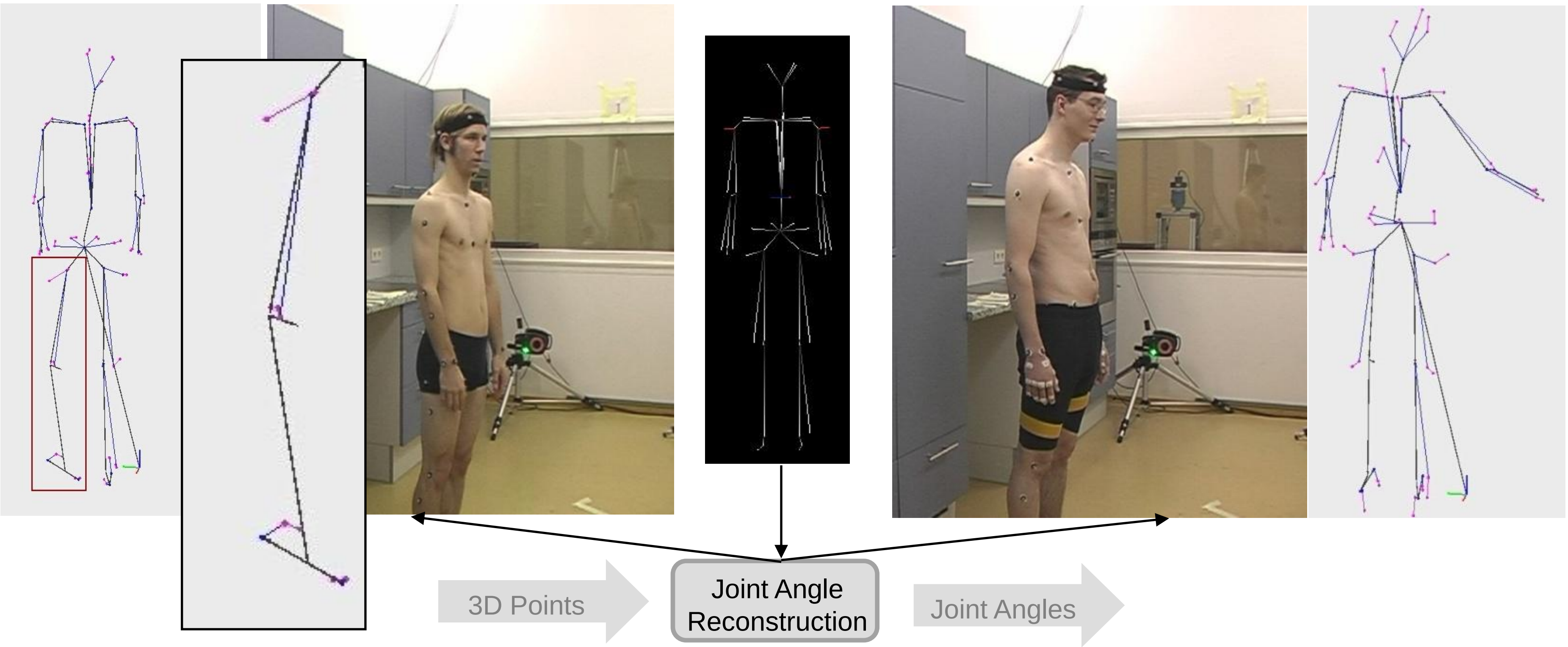
Problem in Joint Angle Reconstruction



Anatomy of test persons does not fit a static model

Fitting Problem

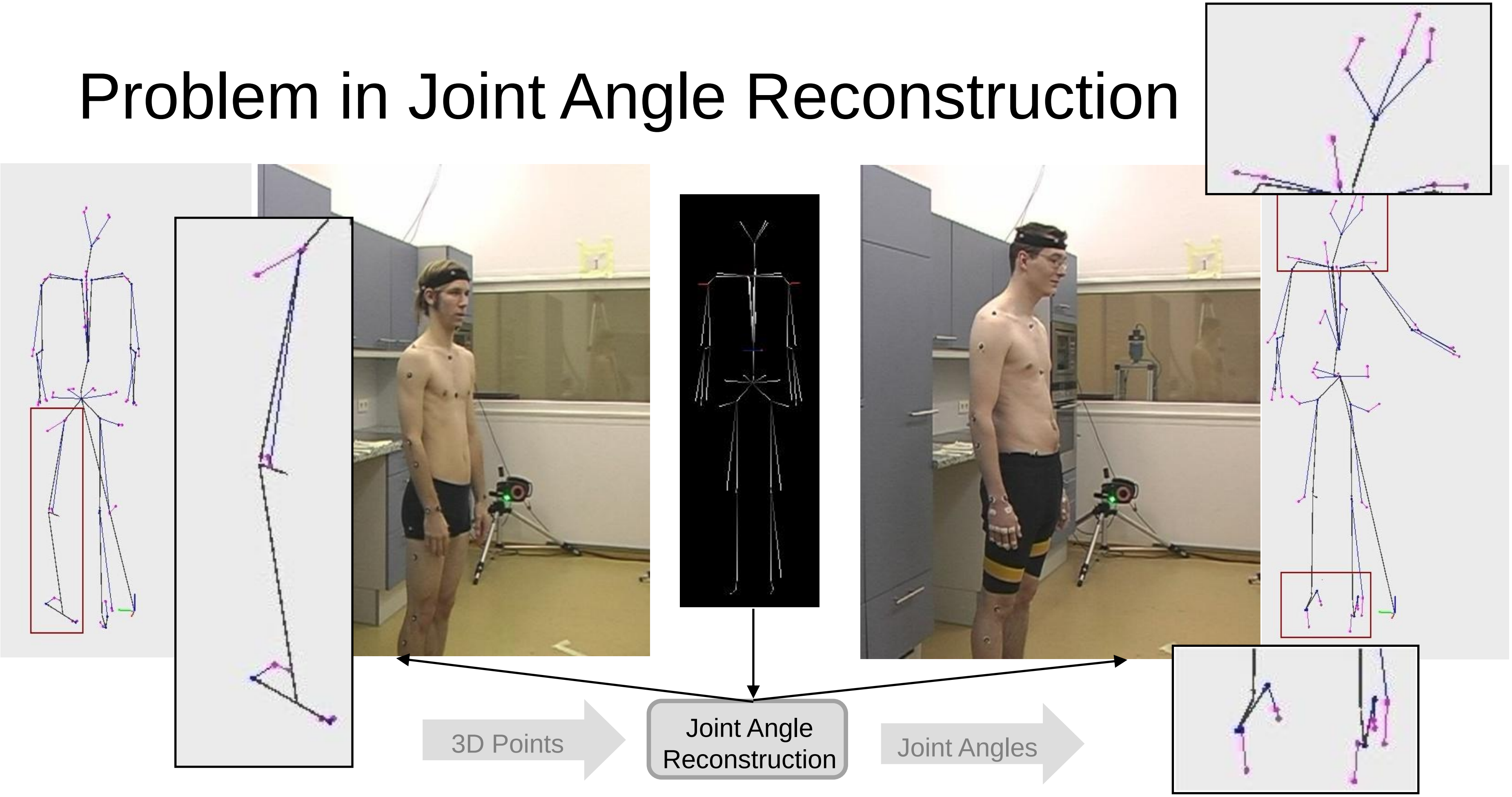
Problem in Joint Angle Reconstruction



Test person to small: model tends to bend

Fitting Problem

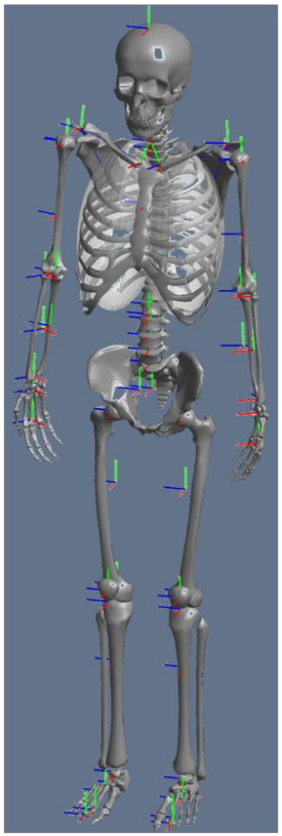
Problem in Joint Angle Reconstruction



Test person to tall: model tends to stretch

Model Specification

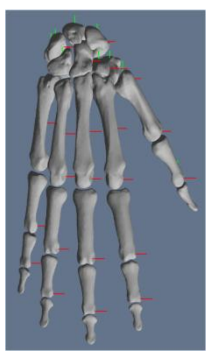
SFB 588 Human Model



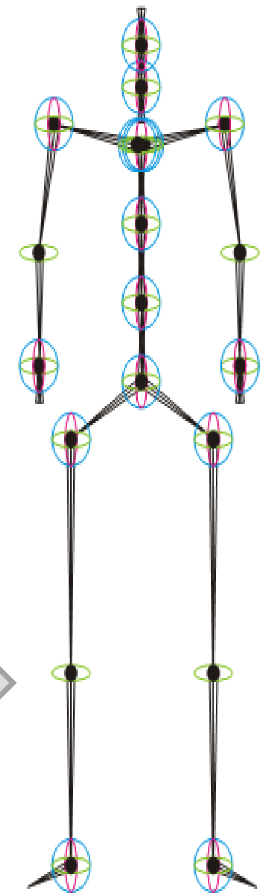
- full definition of the human body:

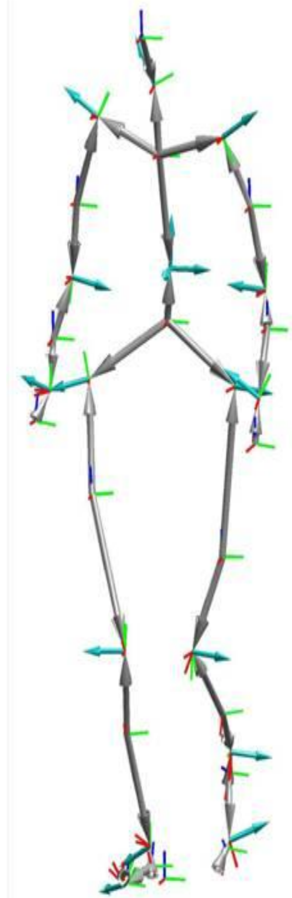
→maximum of 108 degrees of freedom

- following real human joint kinematic
- basis for reduced models, marker sets and joint angle reconstruction



Example with reduced degrees of freedom (DOFs)





Model Specification

Adaptive Approach:

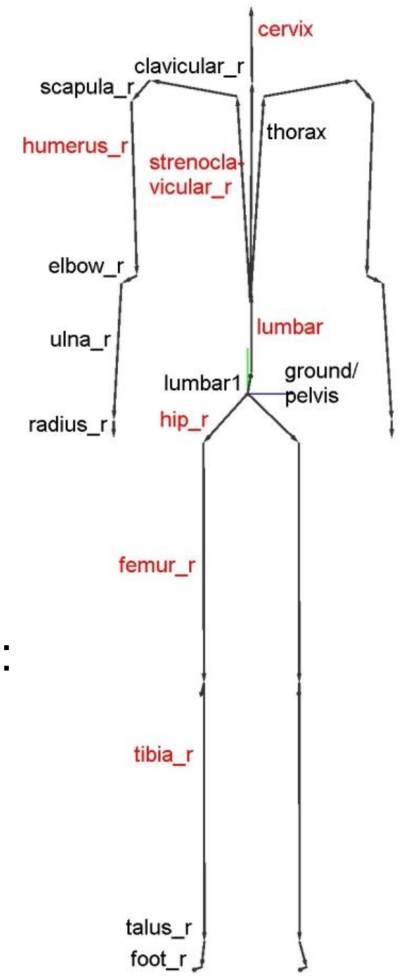
-reduced model with

- 35 body segments
- 34 body joints
- 44 degrees of freedom
- 29 defined marker points

-extended by 14 additional degrees of freedom,

representing individual segment lengths of the test person:

Torso	Upper extremity	Lower extremity
lumbar	humerus (l, r)	hip (l, r)
crevix	ulna (l, r)	femur (l, r)
sternoclavicular(l, r)		tibia (l, r)



Motion Reconstruction

Main Idea

Optimize the degrees of freedom of the model so, that the distance of the actual marker set x_0 and the result of the forward kinematics of the reconstructed pose x becomes minimal:

(1.1)

$$\min \sum_{x \in X} (d(x, x_0) \times weight(x_0))^2$$

$$d(x, x_0) = \sqrt{(x_a - x_{0a})^2 + (x_b - x_{0b})^2 + (x_c - x_{0c})^2}$$

With X : the set of the result of the forward kinematics

$weight(x_0)$: the weight of the markers

Minimizing a large scale smooth non linear function with bounds:

(1.2)

$$\min_{x \in \Re^n} f(x), l \le x \le u$$

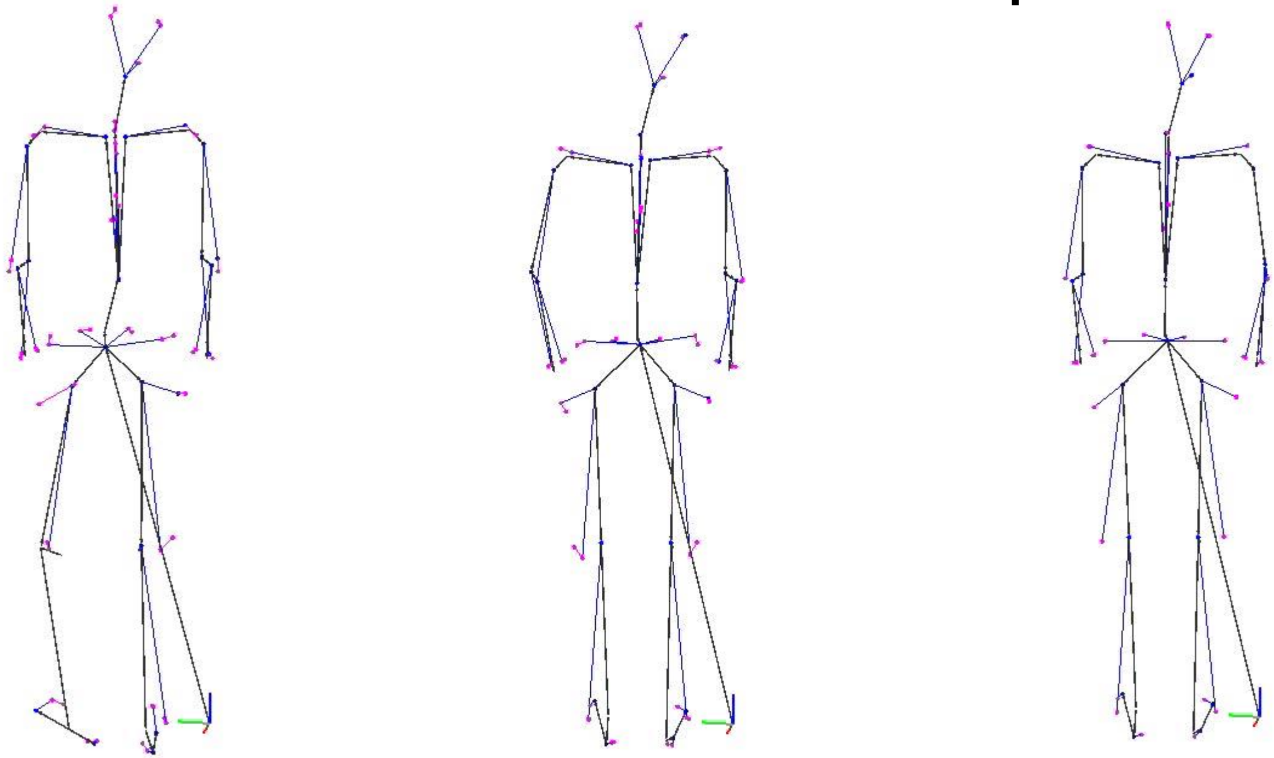
Motion Reconstruction

Iterative interior-reflective Newton Method

- → Minimizing a smooth non linear function with upper and lower boundaries
- → No activity set needed
- → Globally & quadratically convergent
- → Uses reflective transformation to maintain feasibility
- → Very slow growth in the required number of iterations

Results

Qualitative Evaluation: Visual inspection

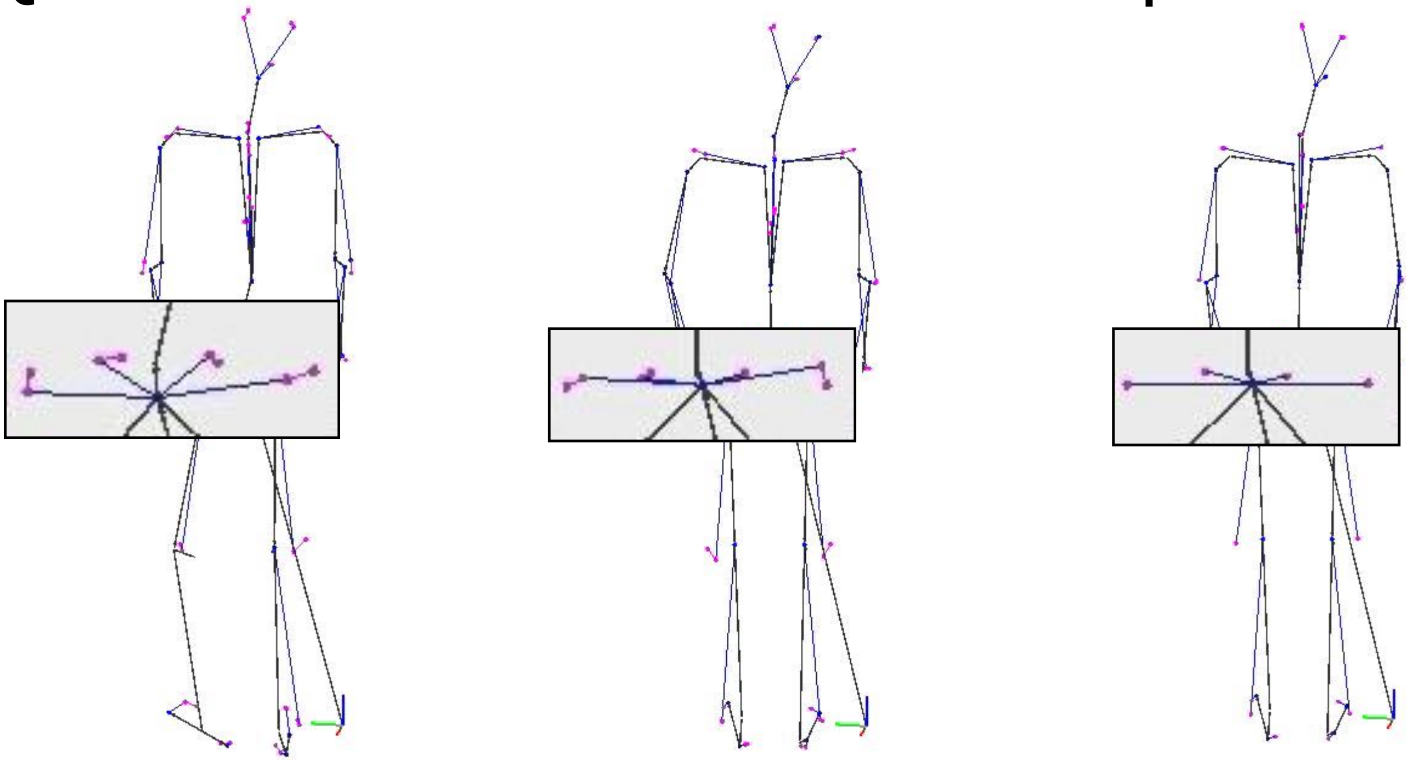


Rigid model — Adapted rigid model — Adaptive model

Check corect body pose: legs and upper body straight

Results

Qualitative Evaluation: Visual inspection



Rigid model Adapted rigid model Adaptive model

Check fitting of the 3D markers

Results

Precision Evaluation:

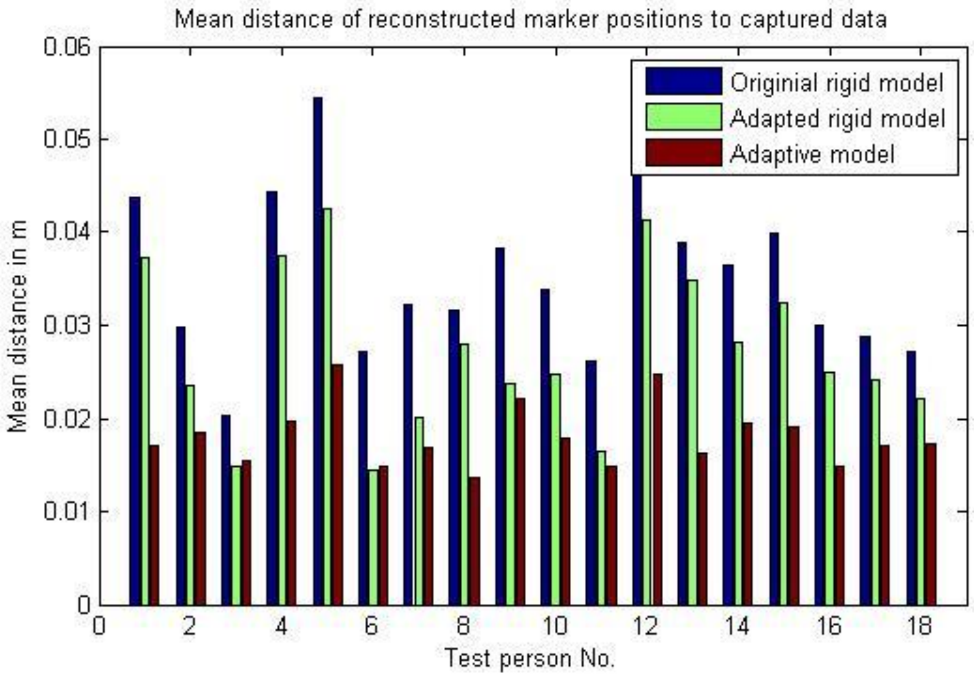
•Evaluation with 18 test persons, over 20 records per person, 200 frames per record ≈ 80000 samples

•Mean distance between reconstructed marker points and real marker positions:

-Rigid model: 3.53 cm/marker

-Adapted rigid model: 2.73 cm/marker

-Adaptive model: 1.81 cm/marker



Improvement of 1.7 cm/marker → almost 50%

Results

Runtime Evaluation:

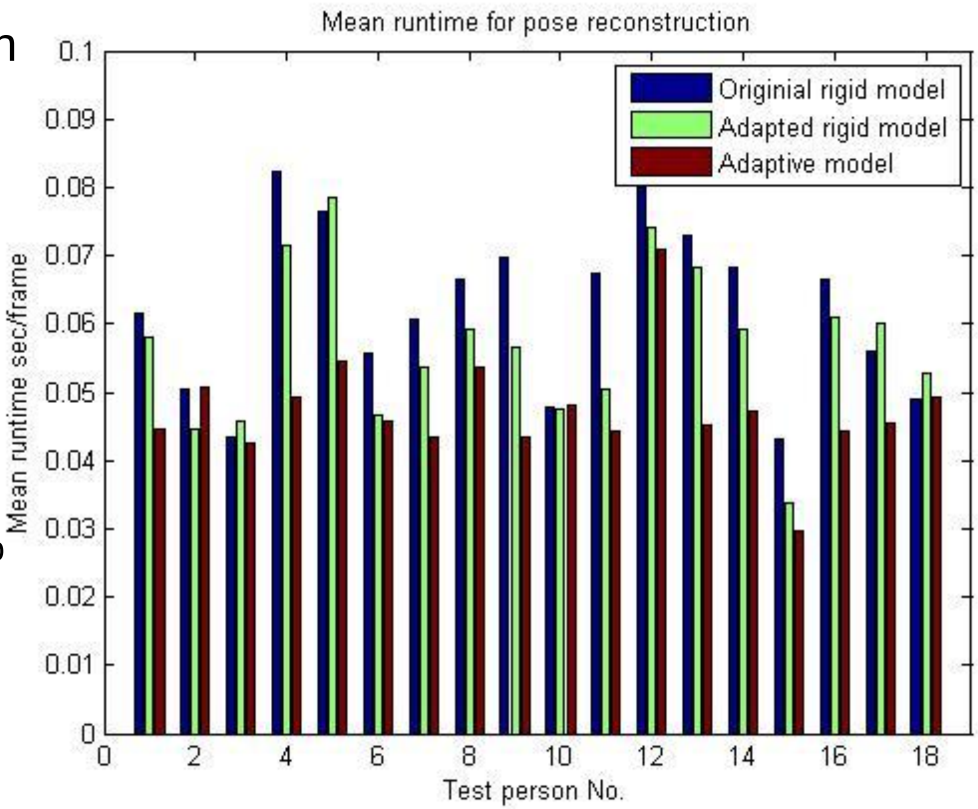
•Mean runtime for the reconstruction of one body pose

-Rigid model: 0.0622 sec/frame

-Adapted rigid model: 0.0568 sec/frame

-Adaptive model: 0.0473 sec/frame

Improvement of 0.015 s/f → almost 25%



Conclusion

Results:

- Transfer of a static body model to an adaptive one by preserving its overall specification
- Improvement in precision and runtime
- Interior-reflective Newton optimization to solve fitting problems with high accuracy in an efficient way

Further Work:

- Simulate stretching effects of the body
- Estimation of initial joint angles and related marker positions
- Extend application on different models

Thank you!