Motion Synthesis By Example

A Tutorial in 3 and 3/2 parts

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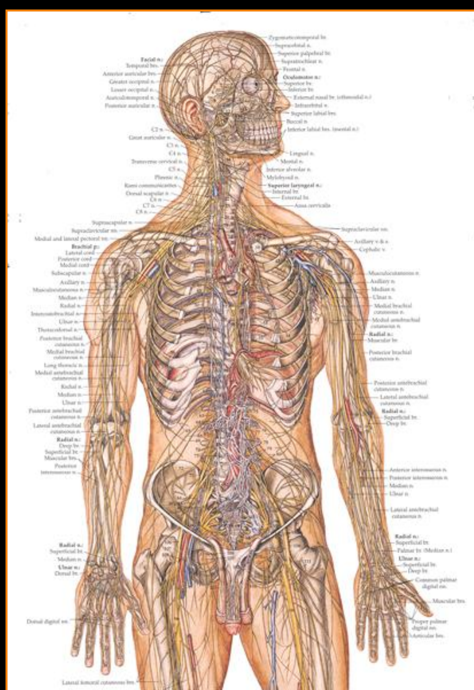
Foundations:

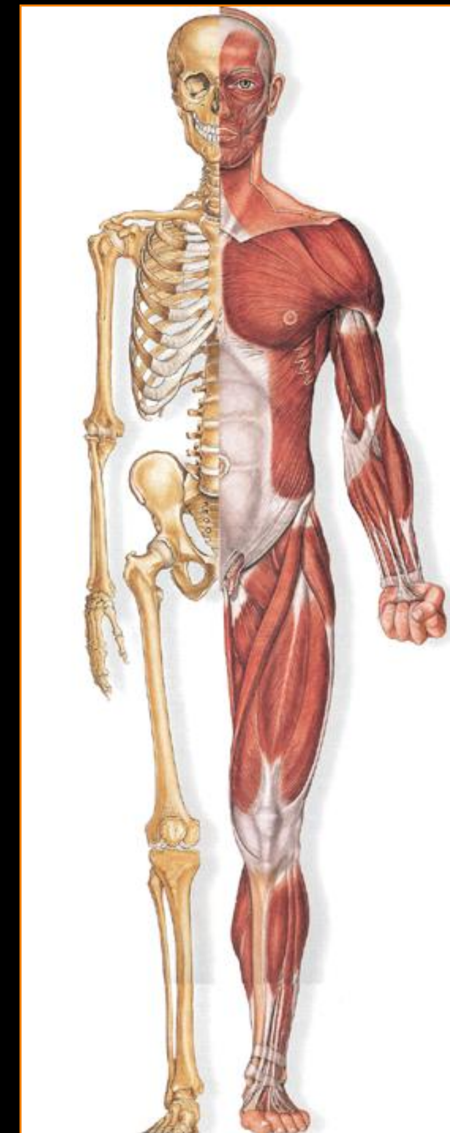
How to Represent a Pose?

Modeling Humans

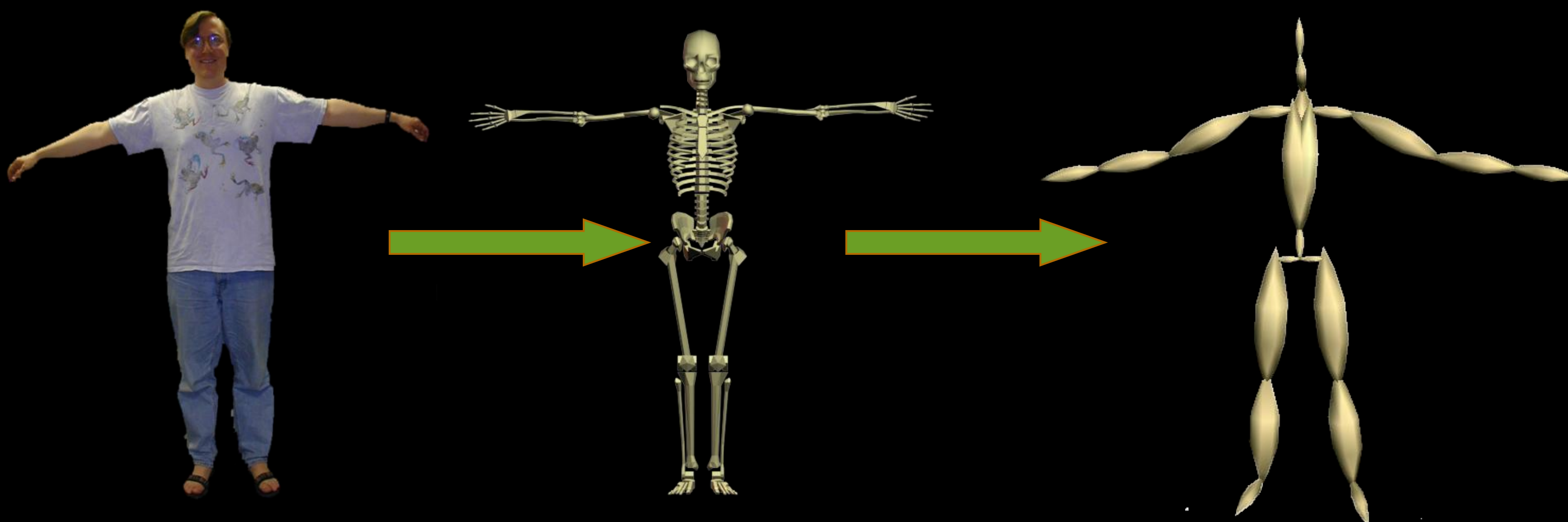
- Humans are complex!



Human motion can be understood at a very fine level of detail!



Abstractions



206 bones, muscles, fat, organs, clothing, …

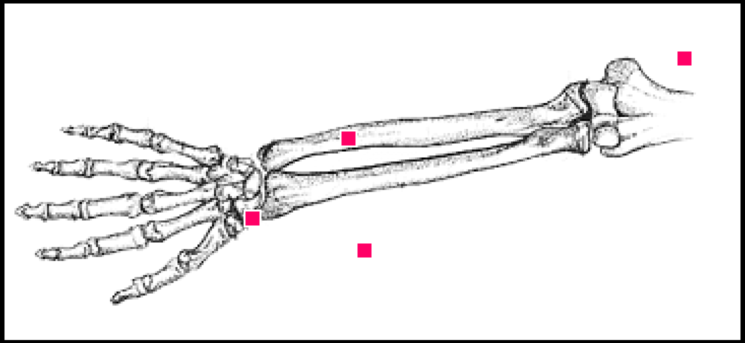
206 bones, complex joints

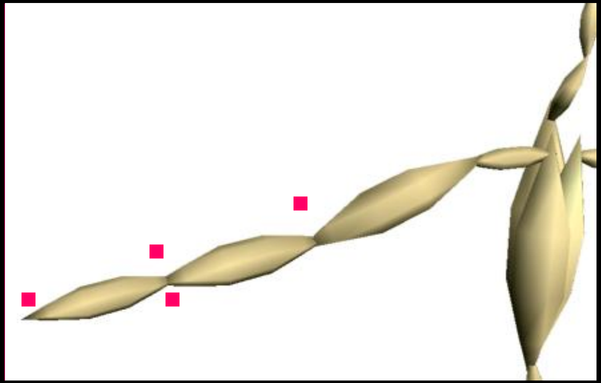
53 bones Kinematic joints

Complexities of Skeletal Representation

- Can't just measure

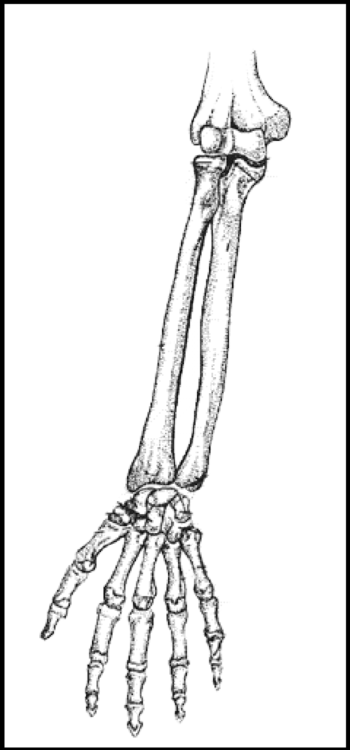
(even x-rays wouldn't help, no real "joints")



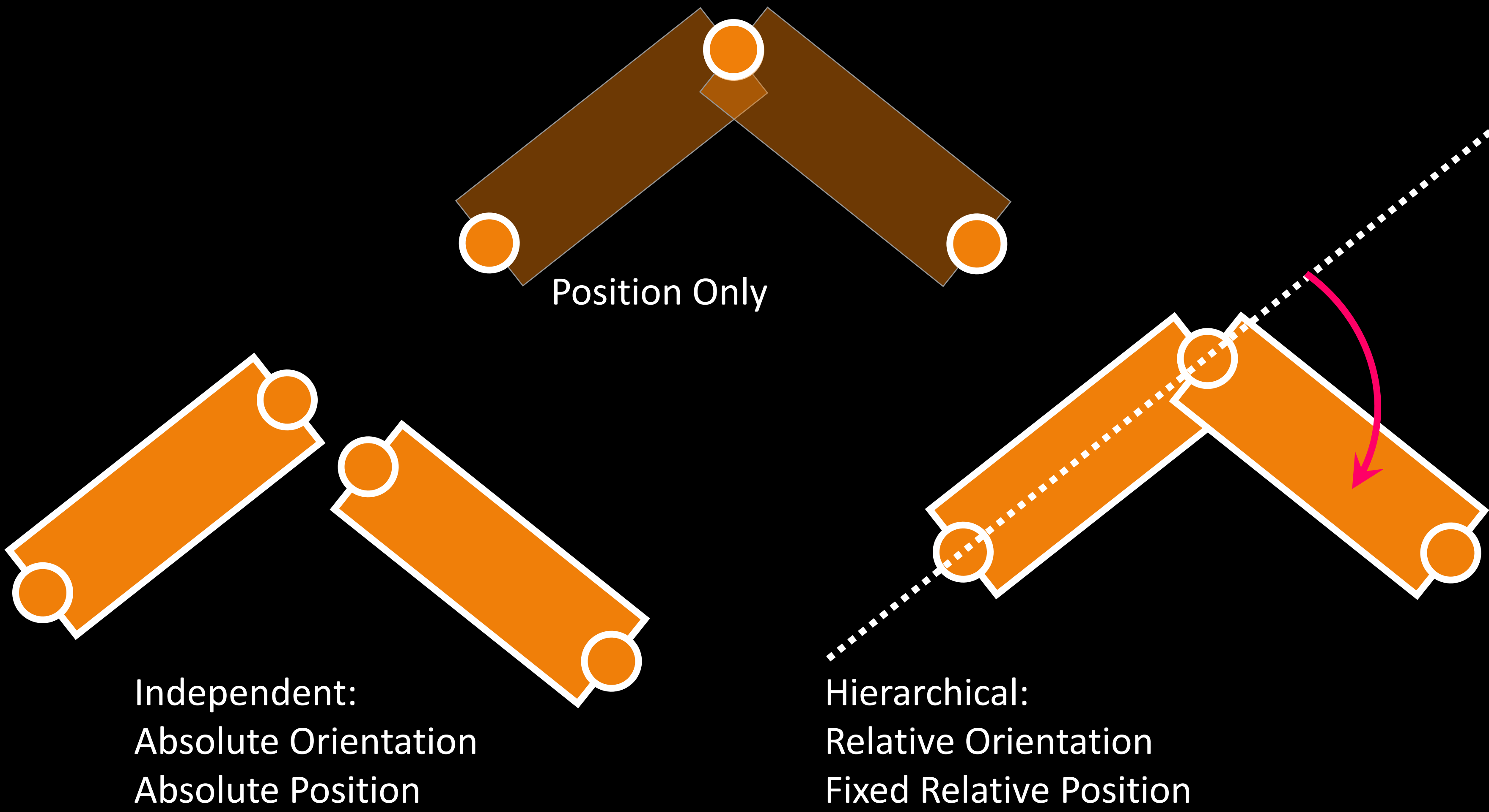


- Abstraction
- Don't know parameters
- Need to know skeleton and relation of skeleton to markers

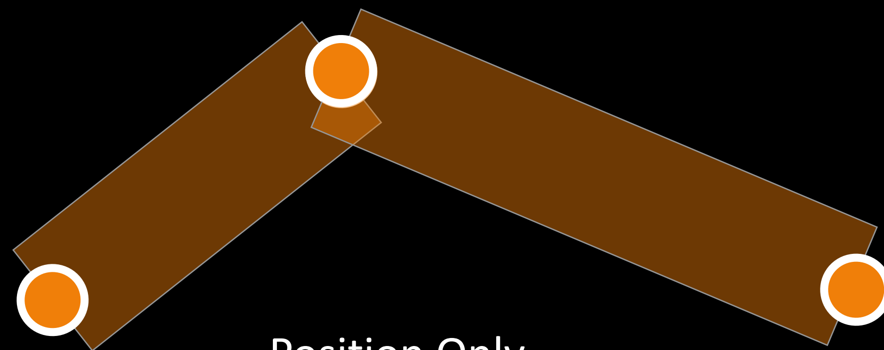
Abstractions vs. Reality (skeletons vs. humans)



Representations of 2 bodies



Ease of manipulation



Position Only

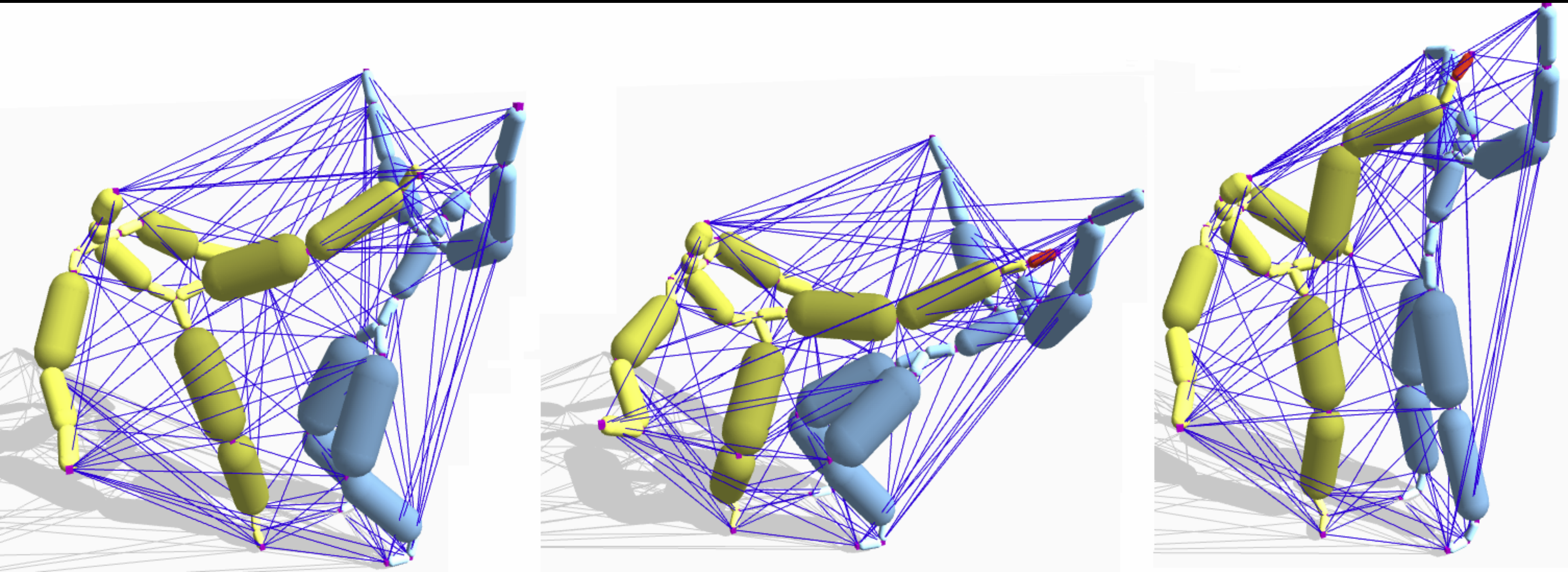
Independent:
Absolute Orientation
Absolute Position

Hierarchical:
Relative Orientation
Fixed Relative Position

An Aside…

Alternative Representations

Mesh of points



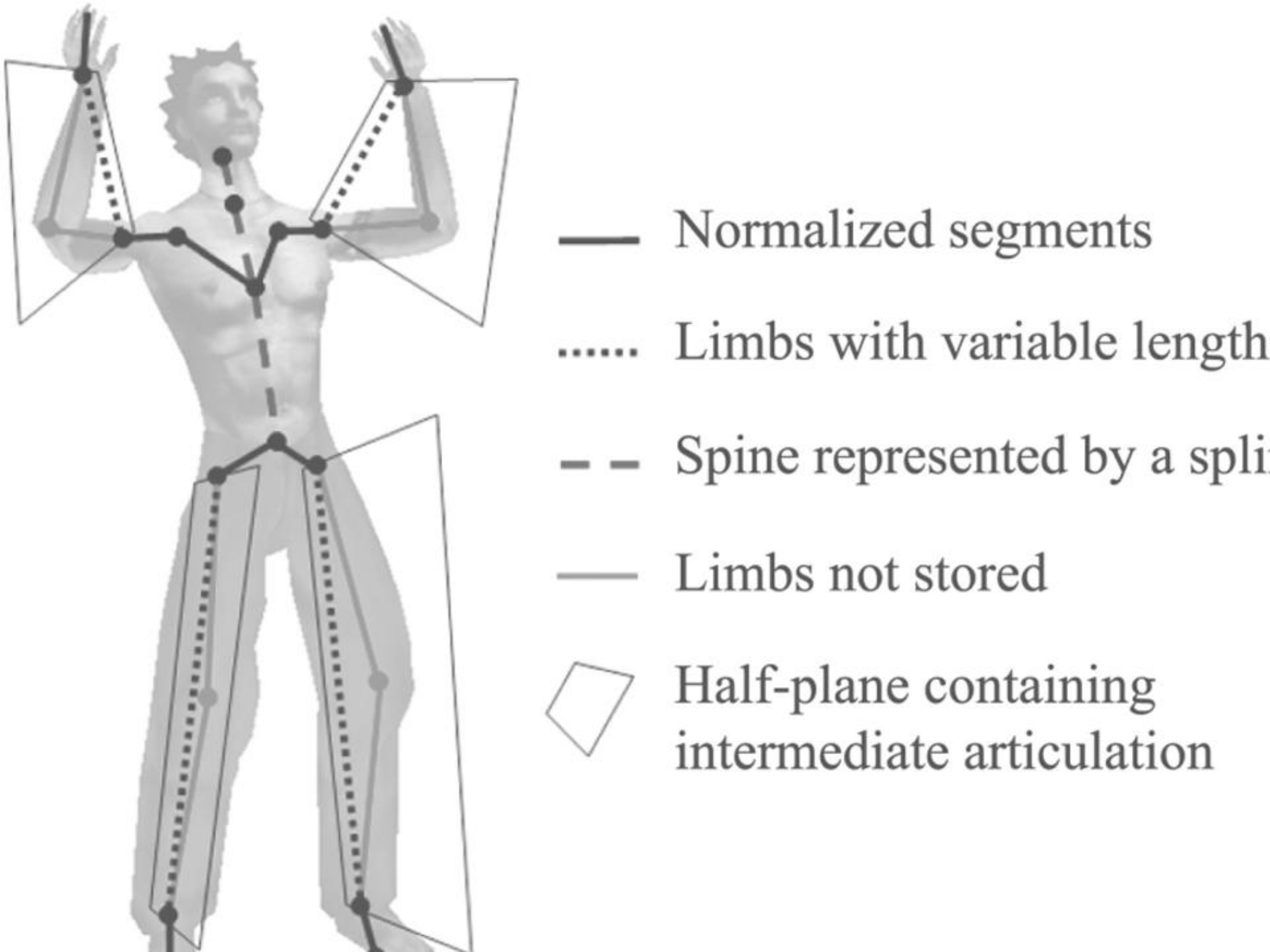
Preserve Distances using Mesh Editing techniques

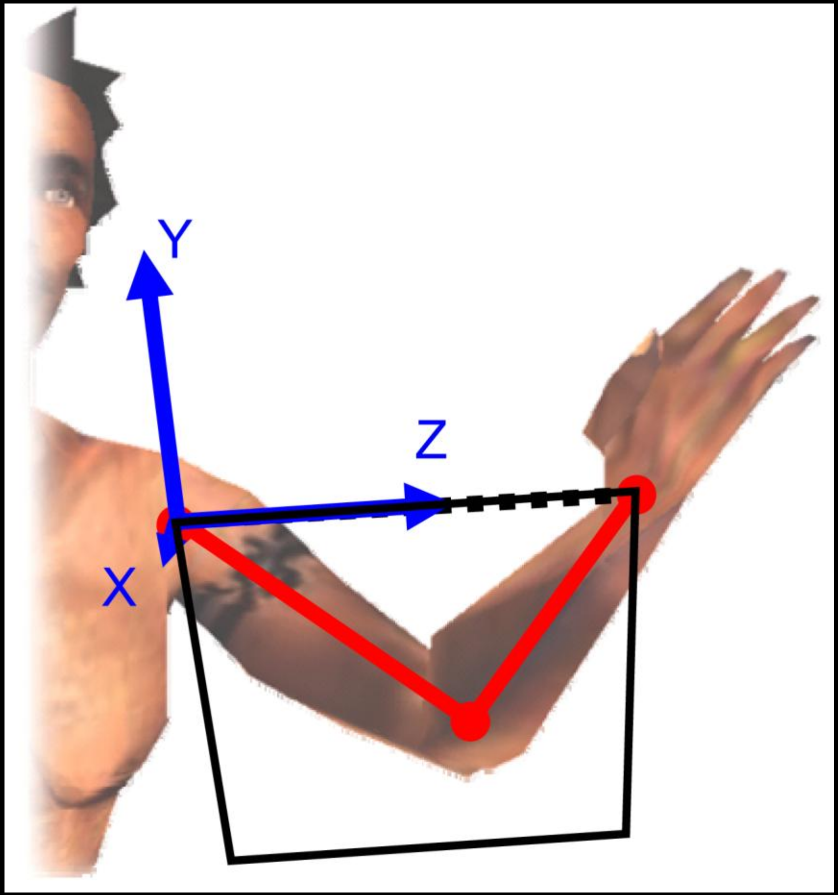
Ho, Komura, Tai. Spatial Relationship Preserving Character Motion Adaptation. SIGGRAPH 2010.

MKM: A non-hierarchical approach

- Richard Kulpa, Franck Multon and others
- Several papers

- Multon, Kulpa, Bideau. MKM: A Global Framework for Animating Humans in Virtual Reality Applications. Presence. 17 (1) 2008.

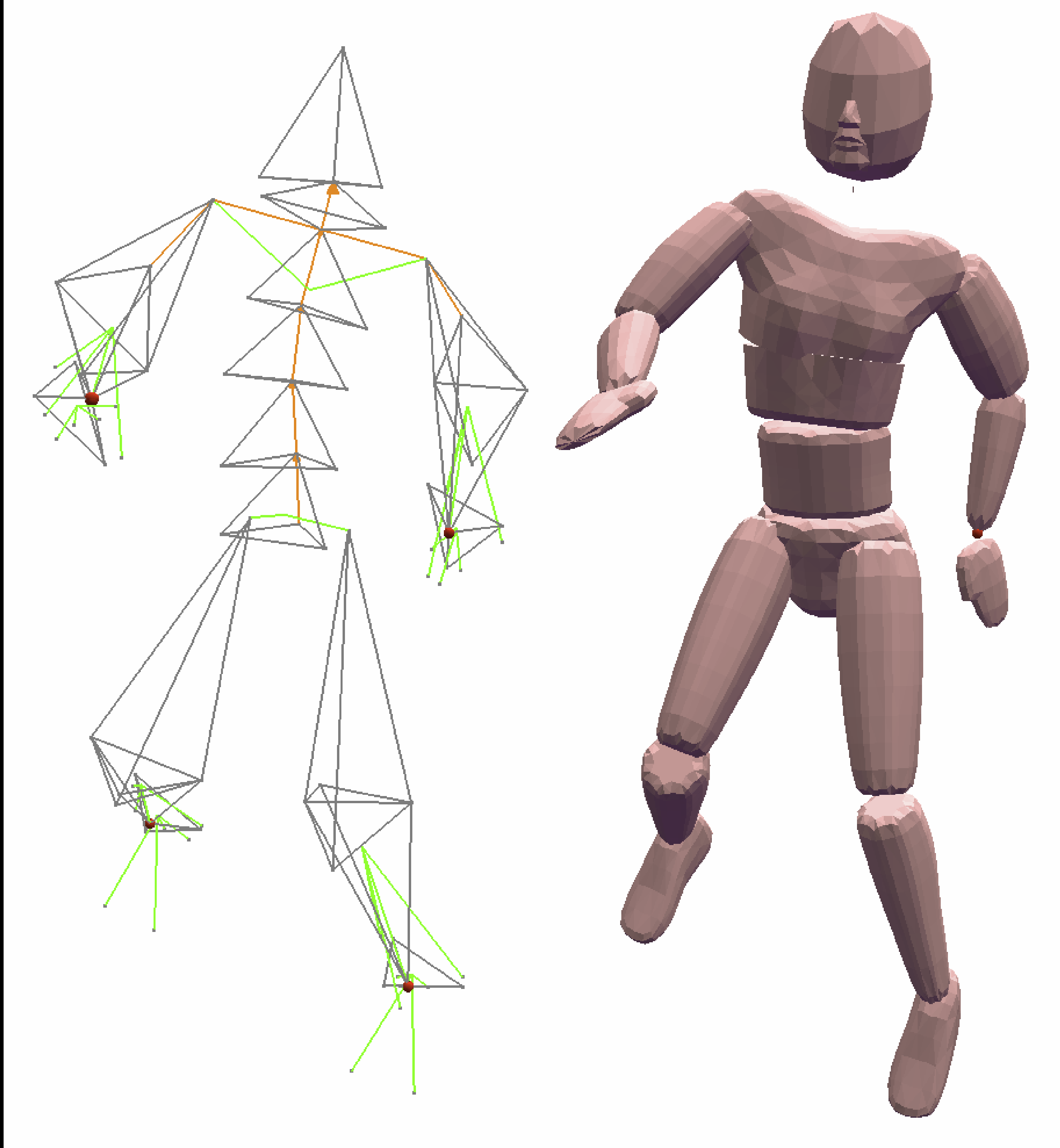

Normalized segments
Limbs with variable length
Spine represented by a spli
Limbs not stored
Half-plane containing
intermediate articulation



Y
Z
X

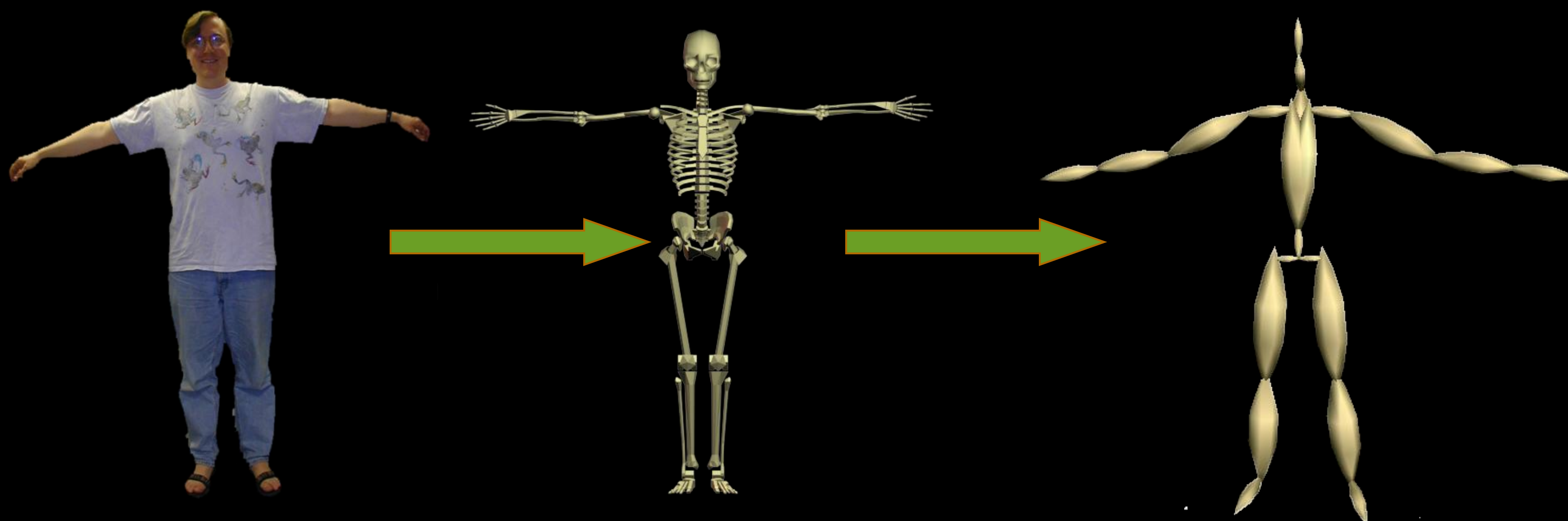
Points + Distances

- Others (particularly in the game industry)
- Cormac O'Brien, John Dingliana, Steven Collins. Spacetime Vertex Constraints for Dynamically-based Adaptation of Motion-Captured Animation. SCA 2011.



- James, Twigg, Cove, Wang. **Mesh Ensemble Motion Graphs: Data-driven Mesh Animation with Constraints. SIGGRAPH Asia 2008.**

Back to Skeletons



206 bones,
muscles, fat,
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…

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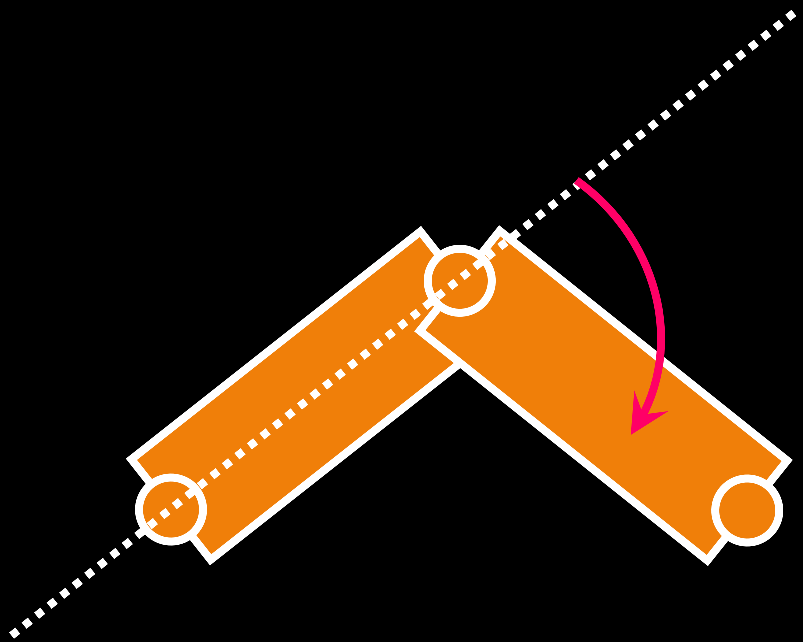
complex joints

53 bones
Kinematic joints

Skelletal Representation

- One position
- One global orientation

- One relative orientation per joint



Why hierarchical skeletons?

They are the standard

- Enforce constraints
  - Stretching
  - Connection
- Methods for orientations
  - Compact
- Tie to fast drawing (skins)
- Easy forward kinematics

There are challenges

- Can’t go beyond constraints
  - Biomechanic adaptations
  - Cartooning / Fudging
- Orientations are hard!
  - Some things tricky
- Not general controls
- Hard inverse kinematics

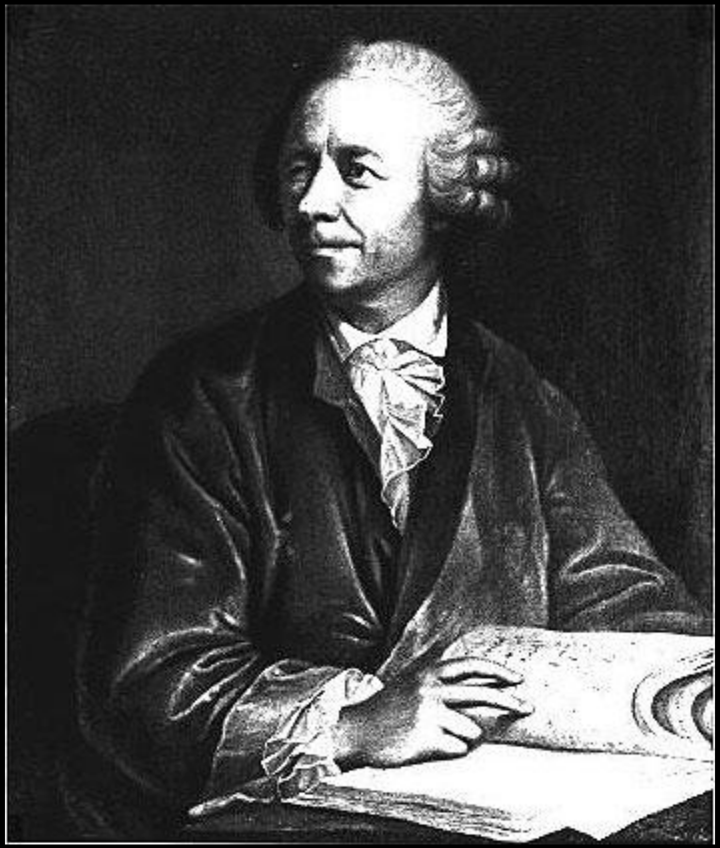
Rigid Bodies

- Does not deform

- Idealization

Rigid Kinematics

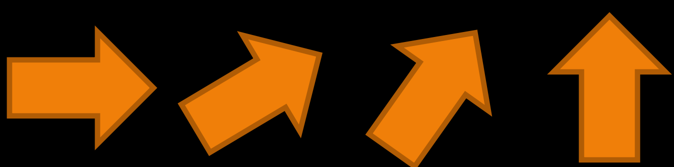
- Translation
- Rotation



Rotations and Orientations

Orientations

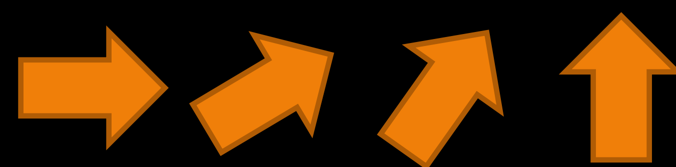
- Configuration



0 30 60 90

Rotations

- Transformation



30 30 30

Should we care?

No

- Rotation from zero

- It's a mathematical detail
- People are usually sloppy

Yes – they are different

Rotations (not orientations)

- Wrap around
- Scalar multiply
- Addition
- Linear combinations

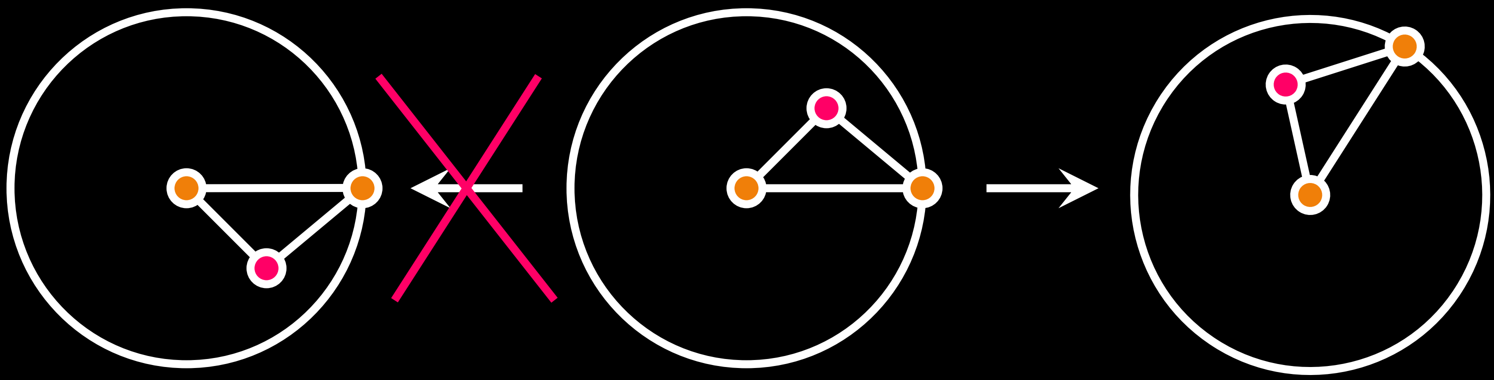
Use different parameterizations for each! (Jehee Lee)

Representing *Rotations* and *Orientations* in Geometric Computing, CG&A. March 2008

What is a Rotation Anyway?

and how do we parameterize them?

- Transformation $R^n \rightarrow R^n$
- $F(x) \rightarrow x'$
- Rigid $|a-b| = |F(a)-F(b)|$
- Has a zero $F(0) = 0$
- Preserves Handedness



Mathematics of Rotations

- Special Orthogonal Groups
- Rotation Vectors
- Rotation Matrices
- Logarithmic Maps / Exponential Maps
- Matrix Exponentials
- Quaternions
- Logarithmic Coordinates
- ….

Attempt Dynamic Presentation