



Real time human body dynamics modeling for biomechanical analysis of unsupported motion

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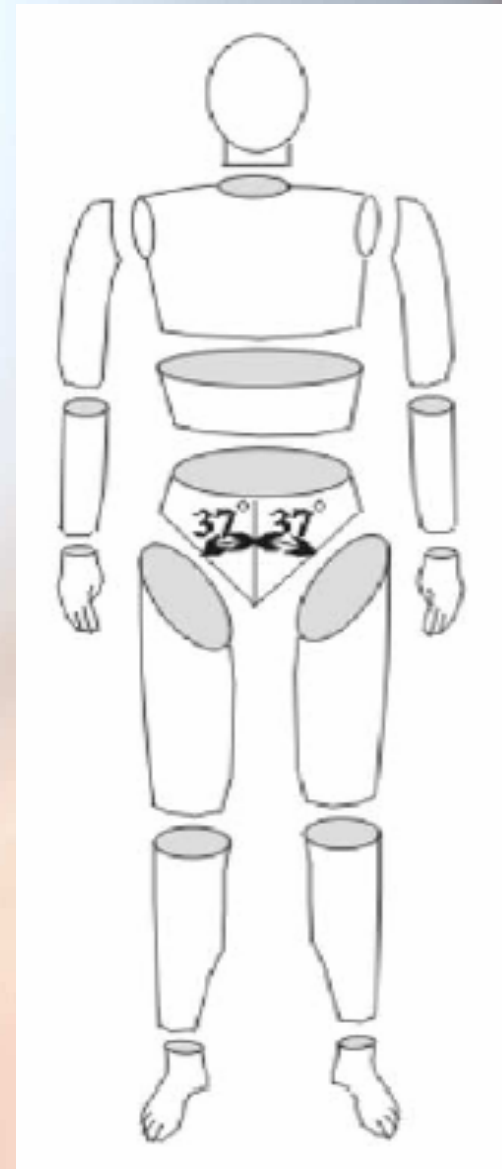
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Biomechanical conformity

- **Shan, Bohn:**
 - 16 bones
 - 45 DOFs
- **Regression analysis based on:**
 - Gender
 - Nationality
- **Possibility to generate arbitrary model**



G. B. Shan, C. Bohn. Antropometrical data and coefficients of regression related of gender and race. Applied Ergonomics, 34 (2003), 327-337. A.F.

Unsupported motion

- Movement in weightlessness



- Movement of sportsmen during gymnastics



Mixed dynamics

- **Forward dynamics:**
 - set forces
 - get general coordinates
- **Inversed dynamics:**
 - set general coordinates
 - get forces
- **Mixed dynamics (Our goal):**
 - forward dynamics
 - constraints equations

Approaches

- **Reduced (generalized) coordinates:**
 - Less problem dimension (+)
 - Satisfy constraints implicitly (+)
 - Difficult to find parameterization (---)
- **Lagrangian multipliers:**
 - Maximal coordinates (-)
 - Constraint forces (-)
 - Applied in arbitrary case (+++)
- **Both:**
 - Linear time in articulated case

Baraff, Faure approach

$$\dot{q} = Dv \quad (1)$$

$$M \dot{v} = F^{ext} + J^T \lambda \quad (2)$$

$$g(t; q; v) = 0 \quad (3)$$

$$A = JM^{-1}J^T$$

$$A\lambda = b \quad (4)$$

$$b = -(JM^{-1}F^{ext} + a_v)$$

$$a_v = \frac{\partial^2 g}{\partial t^2} + \dot{J}v$$

$$(4) \iff \begin{pmatrix} M & -J^T \\ -J & 0 \end{pmatrix} \begin{pmatrix} \delta \dot{v} \\ \lambda \end{pmatrix} = \begin{pmatrix} 0 \\ -b \end{pmatrix} \quad (5)$$

$\delta \dot{v}$ - acceleration correction

$$\dot{v} = M^{-1}F^{ext} + \delta \dot{v}$$

Approaches performance comparison

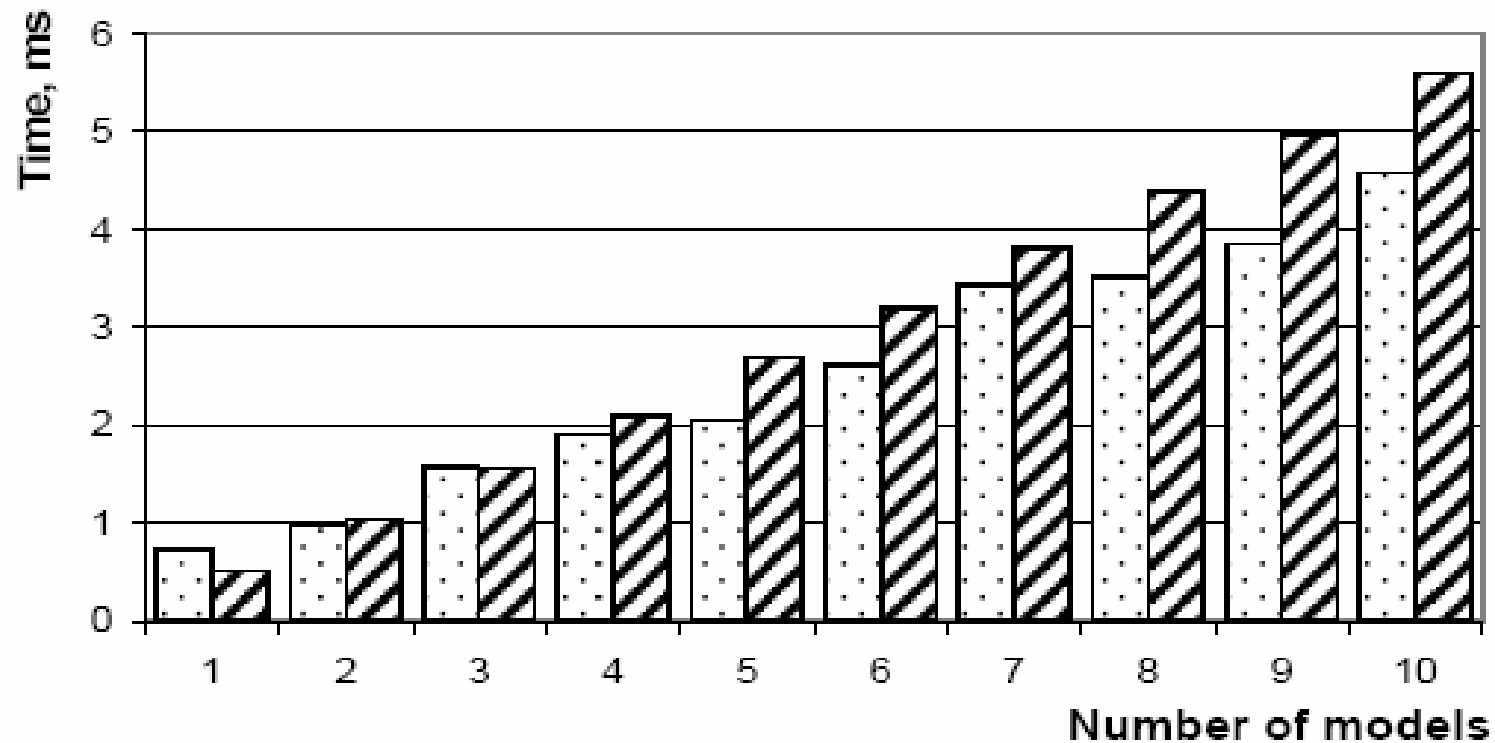
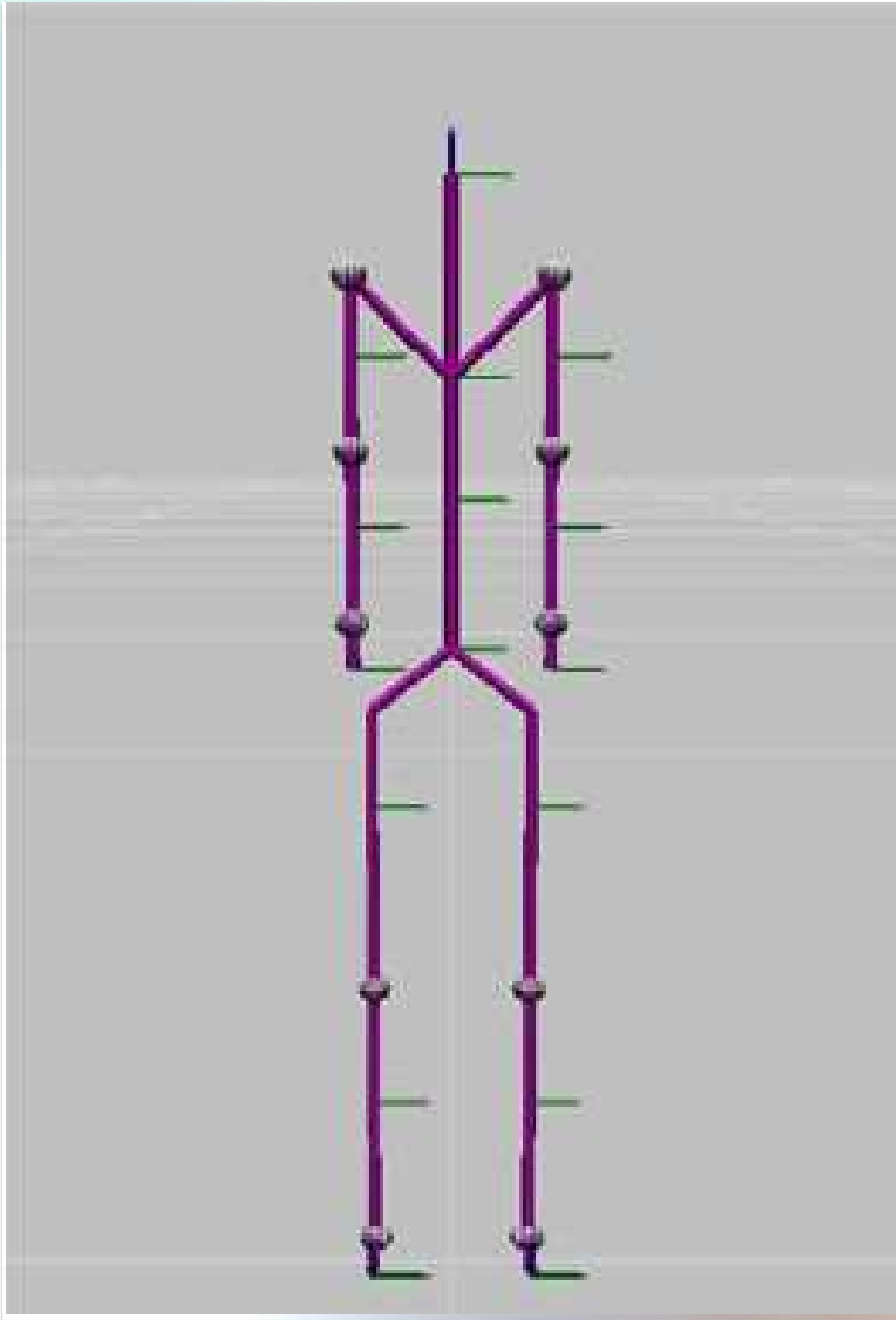


Fig. 1

 - ABA,  - Baraff-Faure

Demo



Future work

- **Joint constraints development**
- **Possibility to add extended set of constraints (e.g. user defined)**
- **Possibility to introduce data from motion capture (e.g. markers trajectories)**
- **Morphologically correct joints simulation (e.g. controllable collision and dislocation)**

References

- G. B. Shan, C. Bohn. Antropometrical data and coefficients of regression related of gender and race. *Applied Ergonomics*, 34 (2003), 327-337. A.F.
- D. Baraff. Linear-time dynamics using Lagrange multipliers. In *Computer Graphics (Proc. SIGGRAPH '96)*, Computer Graphics Proceeding, Annual Conference Series, pages 137-146. ACM SIGGRAPH, Addison Wesley, August 1996. ISBN 0-201-94800-1.
- F. Faure. Fast refinable equation solution for articulated solid dynamics. *IEEE Transactions on visualisation and Computer Graphics*, Volume 5, Number 3, page 268-276. July 1999.
- R. Featherstone. The calculation of robot dynamics using articulated-body inertias. *International J. of Robotics*, 1983, 2(1), 13-29.

Thank you!