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

I. Pshenichniy, A. Morozov, V. Sholukha
Universite Libre De Bruxelles, Belgium –
St. Petersburg State Polytechnic University, Russia

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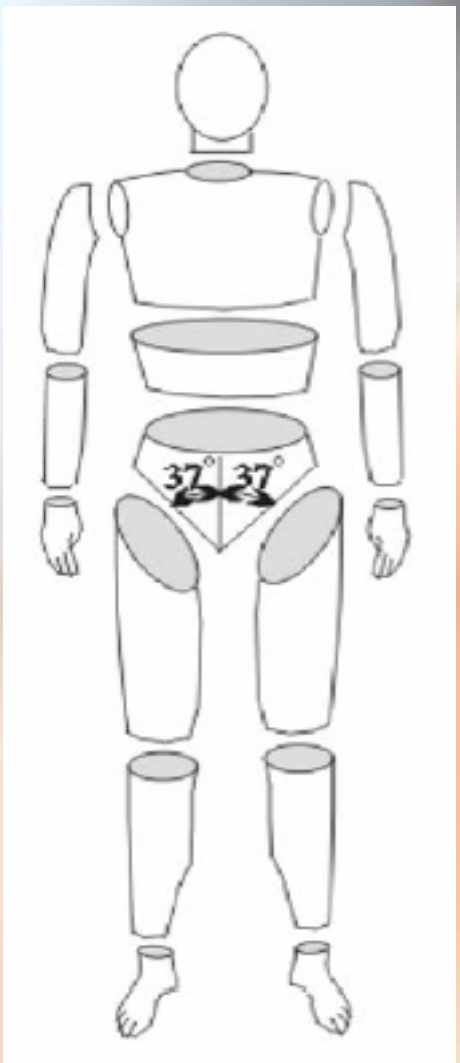
Biomechanical conformity

- 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

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

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

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

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

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

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

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

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

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

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

Approaches performance comparison

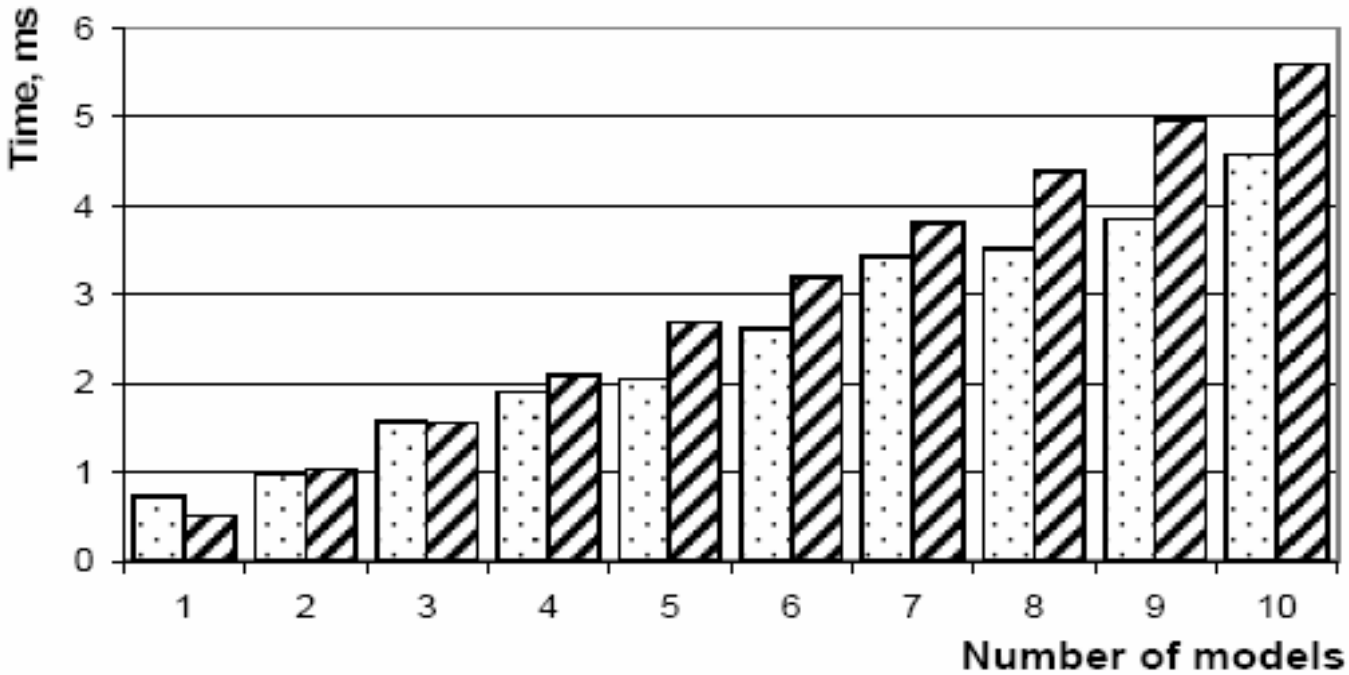
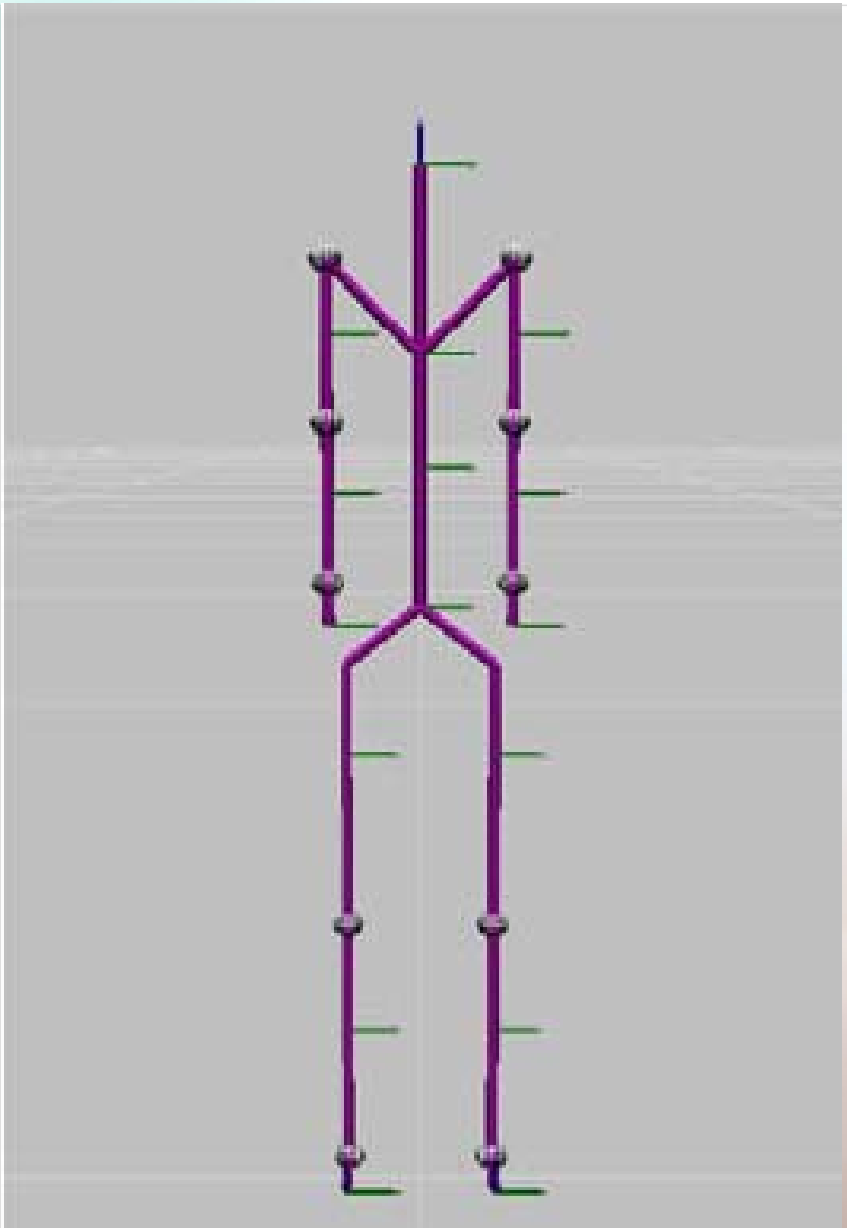


Fig. 1

- 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!