Motion Capture,
Motion Edition

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Motion Capture, Motion Edition

- Overview
  - Historical background
  - Motion capture systems
  - Motion capture workflow
  - Re-use of motion data
  - Combining motion data and physical modeling

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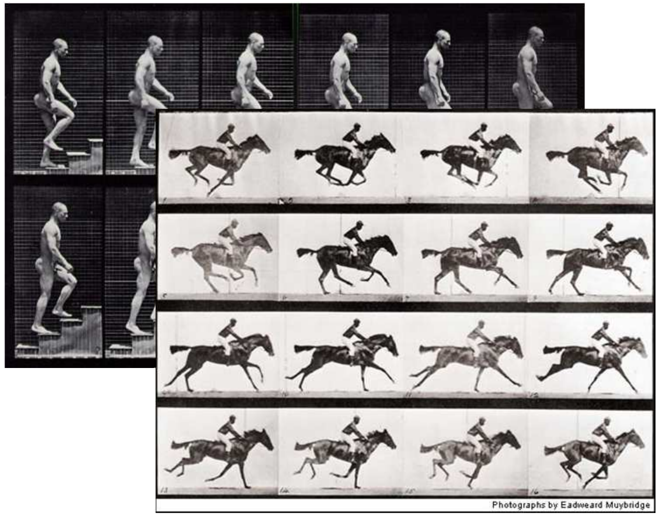
Historical background

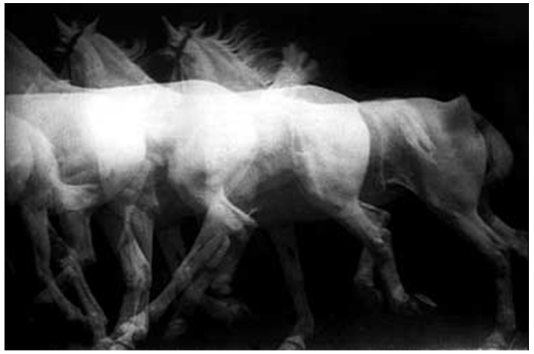
- Photography
  - Studying motion
- Rotoscoping
  - Key-framing appearance
- Puppetry
  - Disappearing animator

Historical background

- Photography of motion
  - E. Muybridge, 1830-1904
    - Photograph
    - Study for horse racing
    - zoopraxiscope

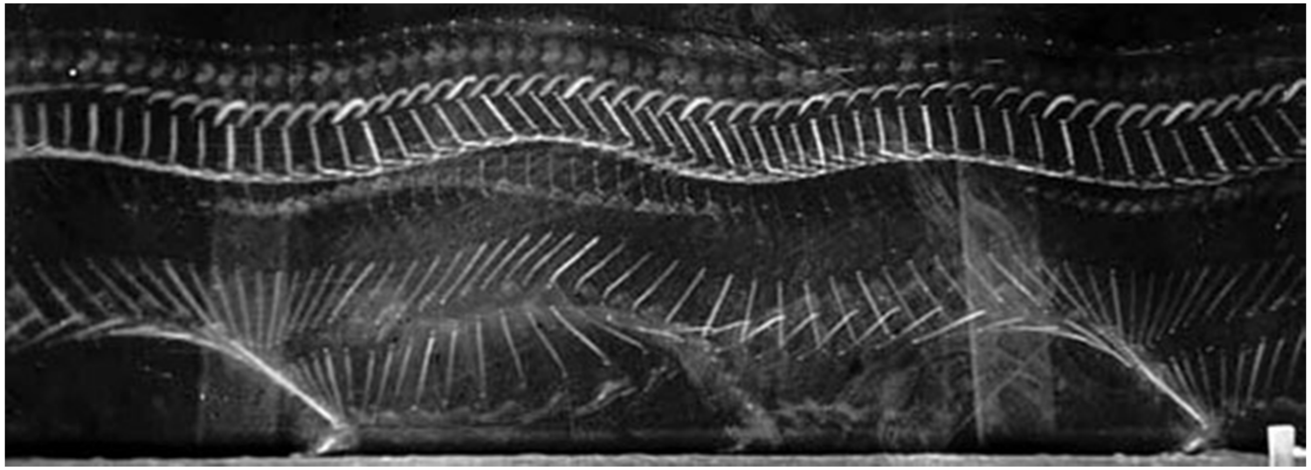


  - E.-J. Marey, 1830-1904
    - Physiologist, Collège de France
    - “méthode graphique” (1859)
    - Chronophotography (1882)



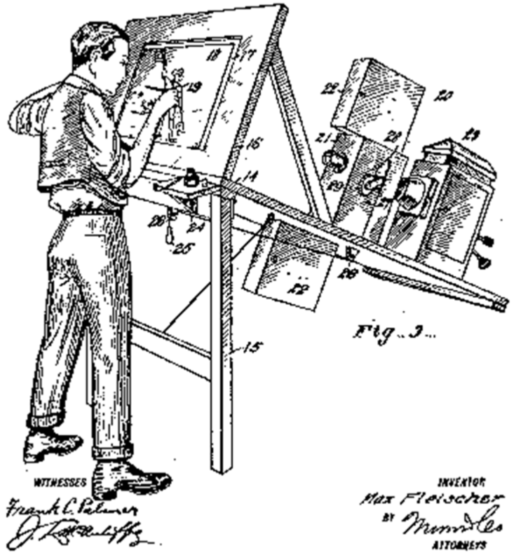
Historical Background

- E.-J. Marey
  - "méthode graphique", 1859



Historical background

- Rotoscoping
  – Key-framing appearance



[Fleischer, 1915]

[Disney, 1937]

Historical background

- Puppetry
  - J. Henson, the Muppet Show, 80s
    - Remote control from capture of the puppeteer's gesture

  - Tippet Studio, Jurassic Park, 1992
    - Inverse robotics,
    - electrical engine creates motion signal

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Motion capture systems

- Mechanical
  - Exo-skeleton
- Electromagnetic
  - 6 DOF of a solid
- Optical
  - 3D positions of markers
- Embedded device
  - Gyroscope, accelerometer

Motion capture systems

- Mechanical, exoskeleton
  - ☺ : very reliable, low cost
  - ☹ : constrained motion

© Animazoo

Motion capture systems

- Electromagnetic,
  - ☺ : 6 DOF => few markers
  - ☹ : sensitive to interference, limited space

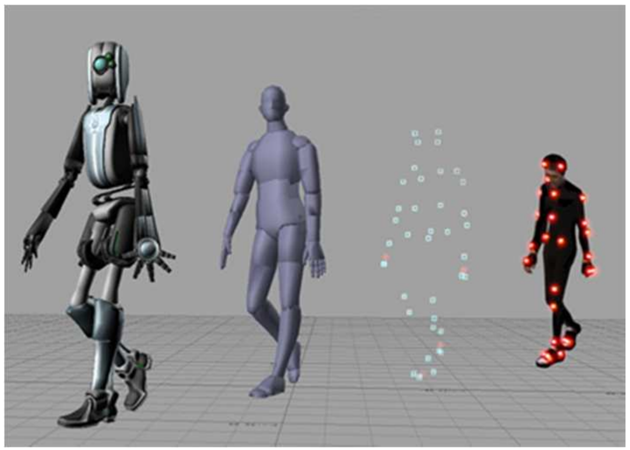
Motion capture system

- Optical, active markers

  Ex: each marker encoded by LED pulse

  ☺ : no ambiguities between markers

  ☹ : several markers for rigid body, limited number of markers



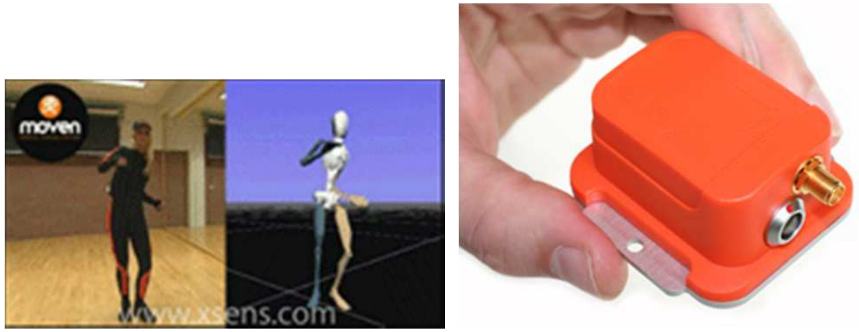
[PhaseSpace]

Motion capture systems

- Optical, passive markers
  - – reflective marker, directional lighting
  - ☺ : no limits in markers
  - ☹ : loss of markers

Motion capture systems

- Embedded device (gyroscope, accelerometer)
  - ☺ : as small as 5 mm^3 , wireless
  - ☹ : signals difficult to calibrate

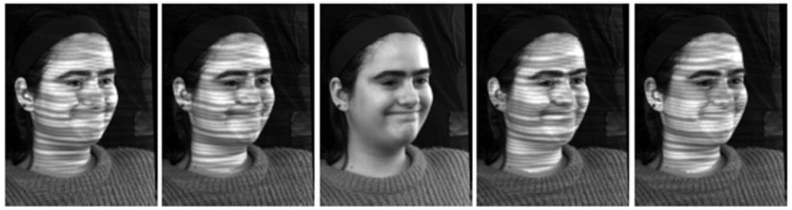


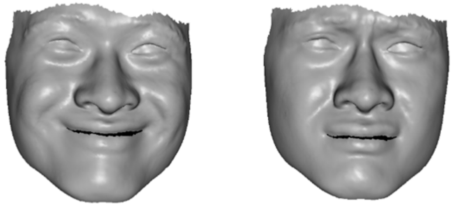
[Moven / xsens]

[Nintendo]

Motion capture beyond markers

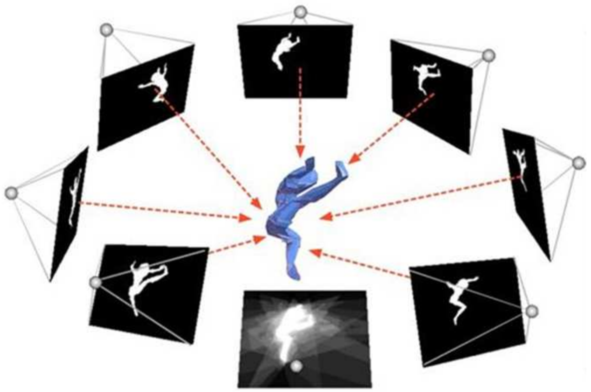
- Structured-light scanner

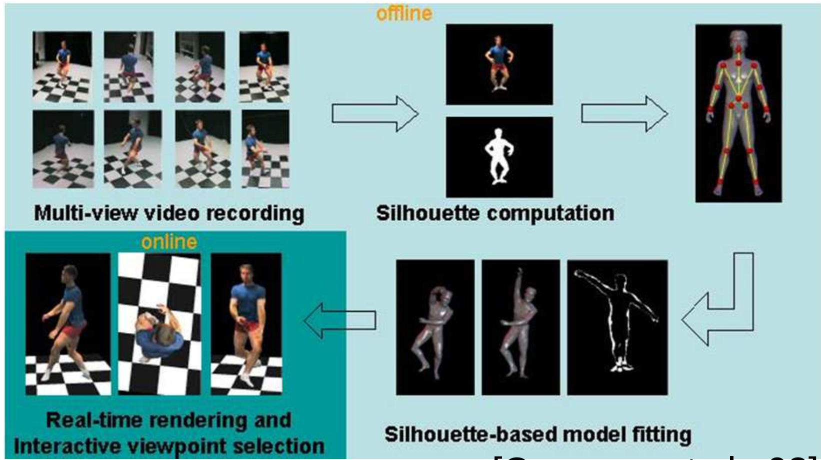




[Zhang et al., 04]

- Silhouette and convex hull





[Carranza et al., 03]

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Motion capture workflow

- Data sampled ~100Hz
- Goal :
  - 3D rotations for 3D skeleton body pose
  - 3D positions for facial animation
- Post-processing
  - filtering, marker loss, etc

Motion capture workflow

- Rotational measure
  - direct mapping
  - morphological adaptation can be complex
    - see motion retargetting
- From 3D positions to 3D rotations:
  - 3 points enough for 6 degrees of freedom of rigid body (bone)
  - physiological constraints
    - => less DOF => less markers

Motion capture workflow

- Rotational measure
  - direct mapping => motion curve
  - morphological adaptation can be complex
- 

Motion capture workflow

- Open problems in R&D

  (Optical passive markers)

  - identifying markers
  - occlusion/crossing markers
  - losing/recovering markers
  - appropriate filtering

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Re-use of motion data

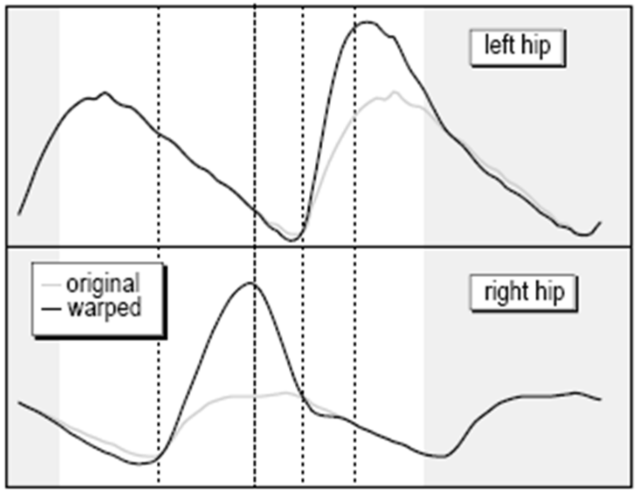
- motion clip limited to the capture session

- target character might be in an unexpected position (video games)

=> need for modifying data without destroying naturalness of motion

Re-use of motion

- Motion warping
  - modifying animation curves



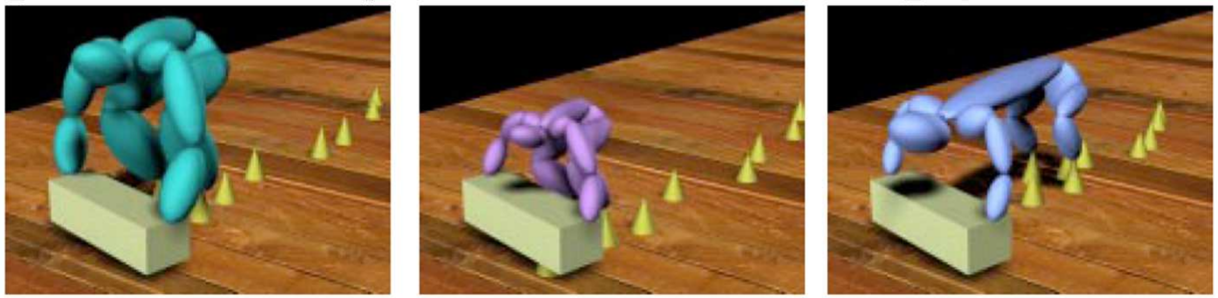
Warp: $C(t) \Rightarrow C'(t')$
Time warp : $t = g(t')$
Curve warp: $C'(t) = a(t)C(t) + b(t)$

1. Choose key-frame
2. Edit pose $C'(t_i)$ at key-frame
3. Solve for $a(t_i)$ or $b(t_i)$
4. Interpolate $a(t)$ and $b(t)$

[Popovic and Witkin, 95]

Re-use of motion

- Motion retargetting
  - Smoothly enforce hard constrains (not just IK)
    - Footplants, distances, etc
  - Optimize minimal displacement curve given constrains
  - Original mocap data as starting point



[Gleicher, 98]

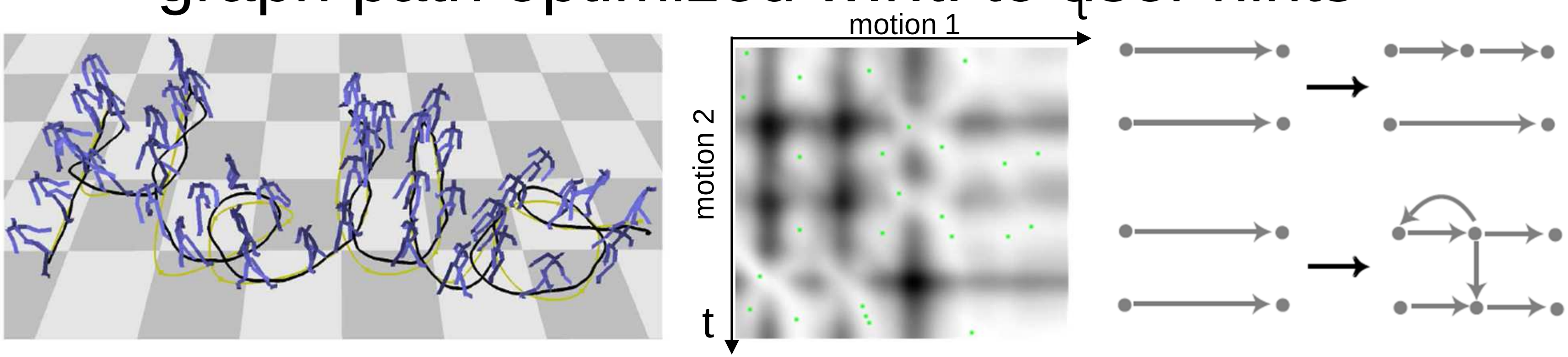
Re-use of motion

- Starting in 2002, methods based on massive database of mocap data

- Great initiative from CMU
  - http://mocap.cs.cmu.edu
  - 2605 motion clips, 23 categories, several subjects
  - free for research
  - amc (rotations) and c3d (markers) formats

Motion re-use

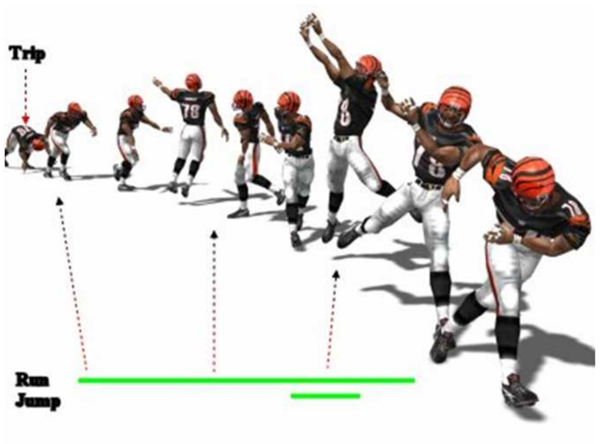
- Motion graph
  - transition/blend between segments of motion
  - metric between two frames
    - on joints global positions
    - time window for smoothness
  - graph path optimized w.r.t. to user hints



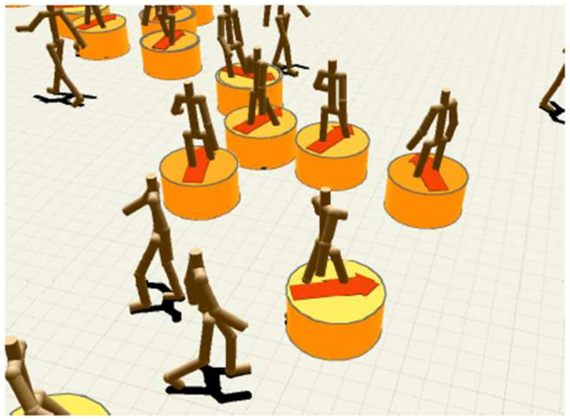
[Kovar et al., 02]

Motion re-use

- Motion graph as dynamic programming
  – cost function to satisfy user constrains
  – choose best clips sequence



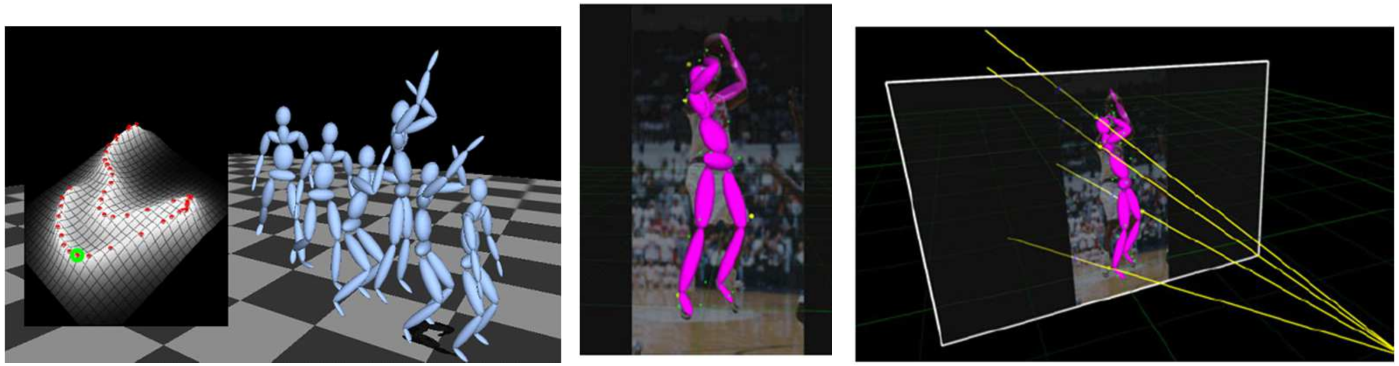
[Arikan et al., 03]



[Treuille et al., 07]

Motion re-use

- Statistical methods
  - reduction of character parametric space (set of joint orientations) to high-level parameters
  - inference in parametric space given user constrains using optimization



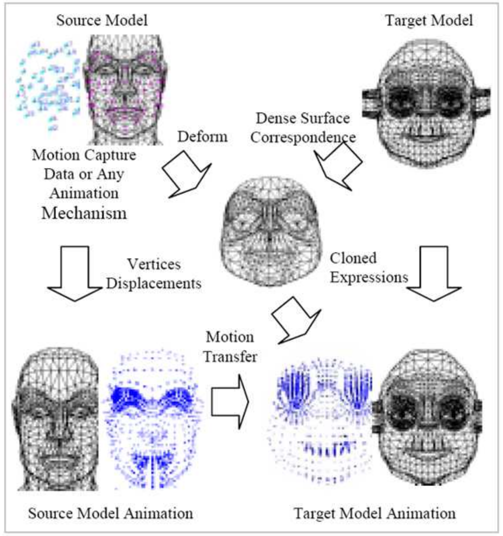
most probable pose w.r.t. constrains, [Grochow et al., 2004]

Motion re-use

- Facial animation
  - Transfer of local motion of individual markers
  - Transfer of global motion

Motion re-use

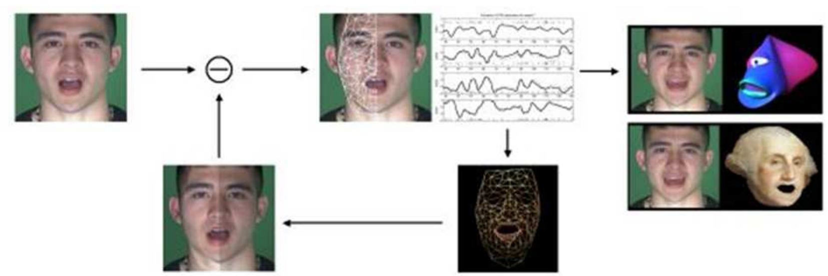
- Facial animation
  - Transfer of local motion of markers
    - ☺ direct animation of the target 3D model
    - ☹ complex morphological adaptation



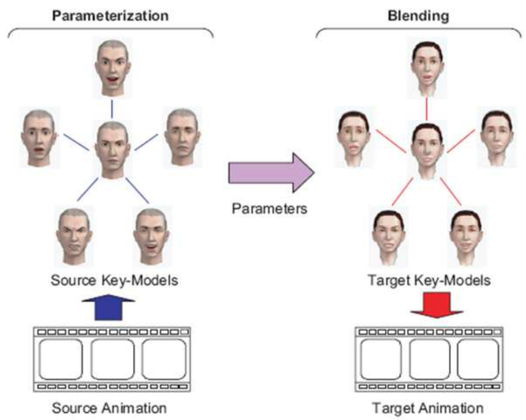
[Noh and Neuman, 01]

Motion re-use

- Facial animation
  - Transfer of global motion
    - ☺ mapping independent of morphology
    - ☹ user must specify several target shapes



[Reveret et Essa, 01]



[Pyun et al., 03]

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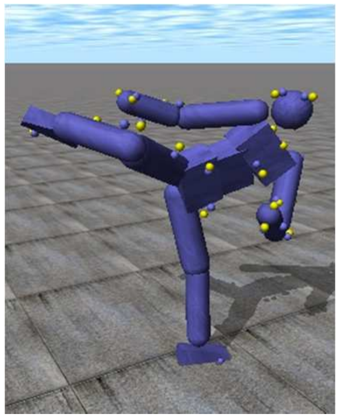
Motion capture and physics

- Mapping optical markers to physics
  - physical model of character (angular spring)
  - 3D markers attached to virtual springs
  - physical model acts as a “realistic” filter



[Zordan and Van der Horst, 03]

[Kry and Reveret, 07]

Motion capture and physics

- Space-time constrains [Witkin and Kass, 88]
  - physical simulation lacks of control
  - re-write physics laws as an optimization
    - Given a particule with propulsion f

      $md^2x/dt^2 – f – mg =0$

    - Find f_i so that boundaries constrains are satisfied and use as less fuel as possible

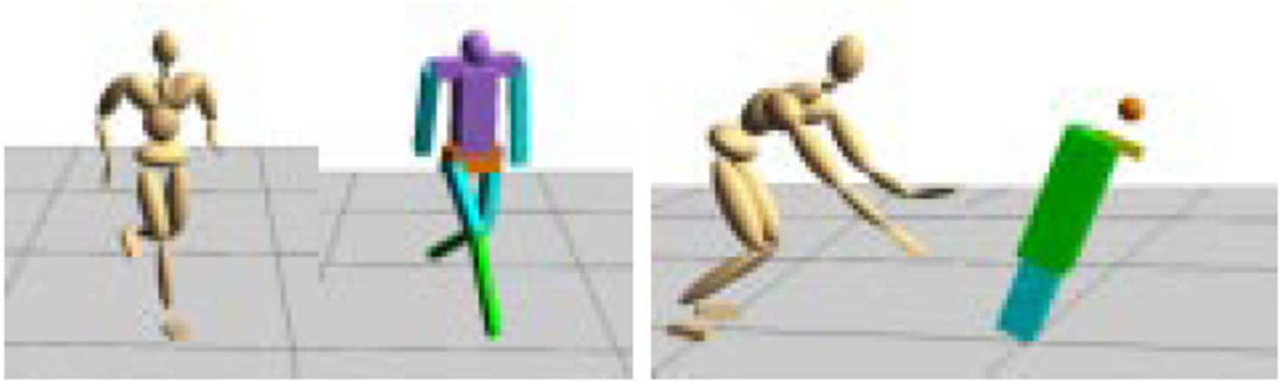
      $f_i = \arg\min \Sigma f_i^2$

      with: $m(x_{i+1} – 2x_i + x_{i-1})/h^2 – f_i –mg = 0$

      and $x_1 = a$, and $x_n =b$

Motion capture and physics

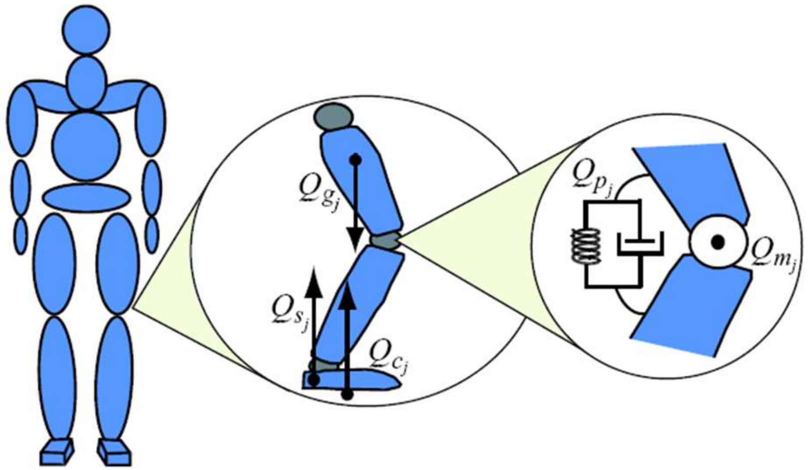
- Spacetime constrains using mocap
  – Key-frame taken as pose constrains
  – Estimate torques on a simplified phys model
  – Edit motion by changing physical parameter



[Popovic and Witkin, 99]

Motion capture and physics

- Spacetime constrains using mocap
  - Estimate all physical parameters



[Liu et al., 04]

Motion capture, Motion edition

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