

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

Motion Capture, Motion Edition

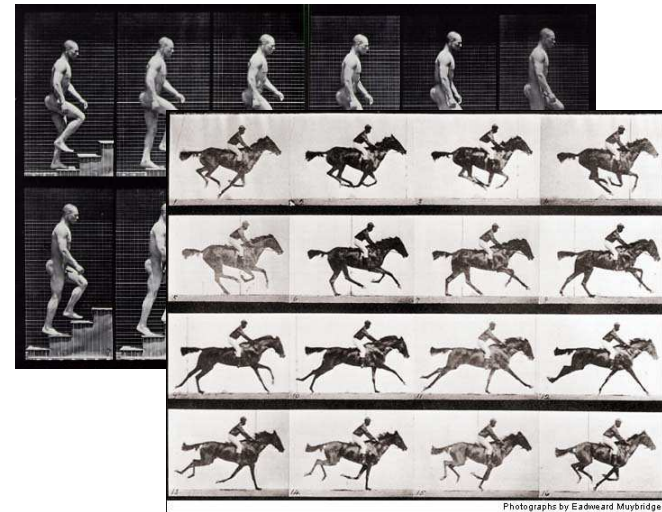
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Historical background

- 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

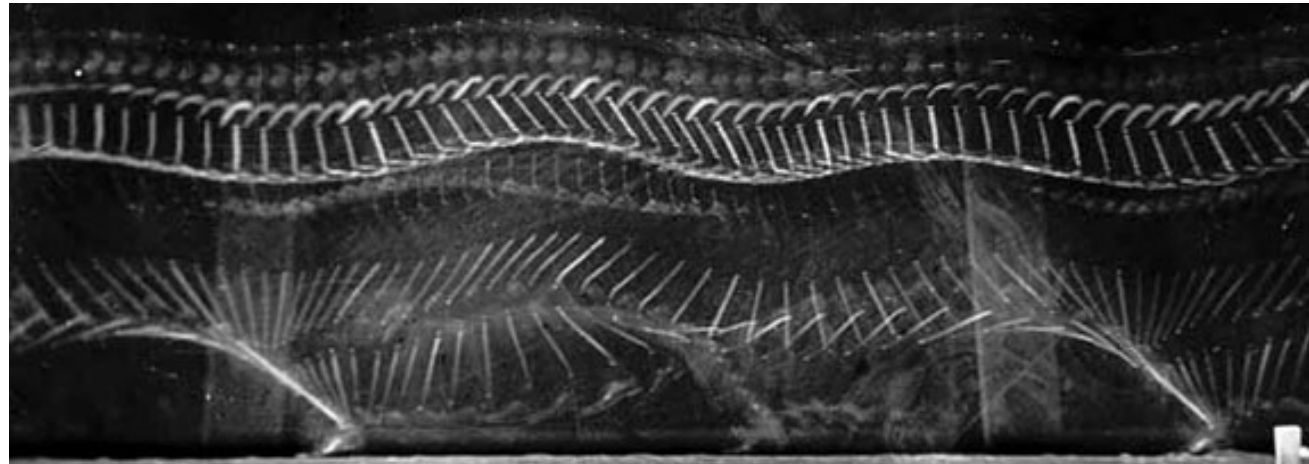


- E.-J. Marey, 1830-1904
 - Physiologist, Collège de France
 - “méthode graphique” (1859)
 - Chronophotography (1882)



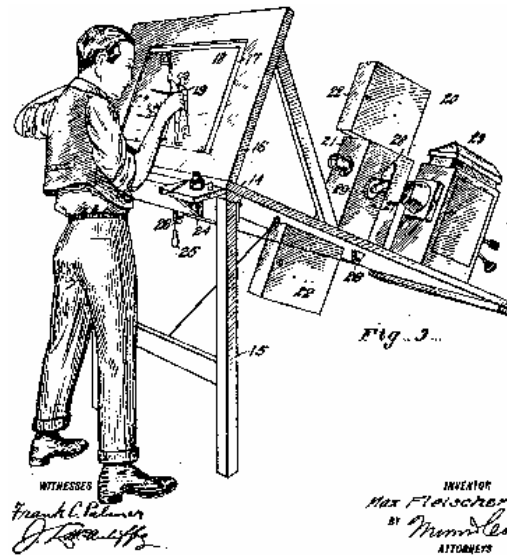
Historical Background

- E.-J. Marey
 - “méthode graphique”, 1859



Historical background

- Rotoscoping
 - Key-framing appearance



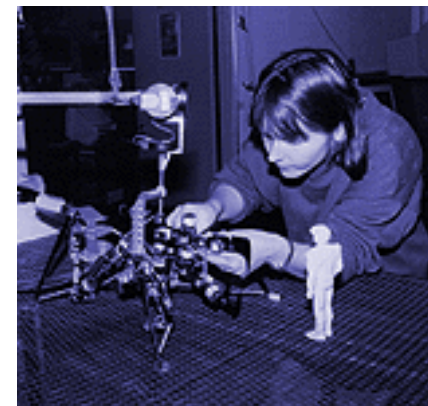
[Fleischer, 1915]



[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



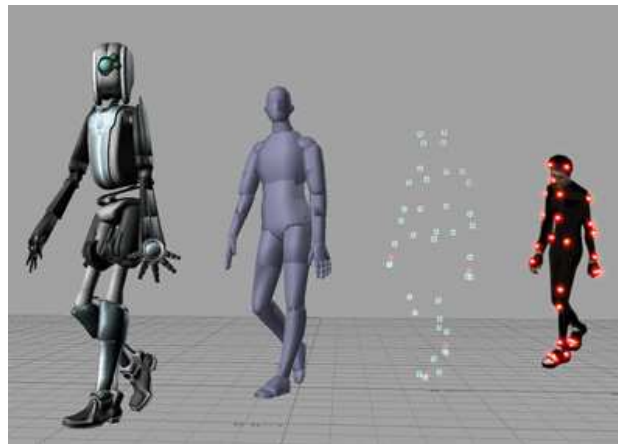
Motion capture system

- 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



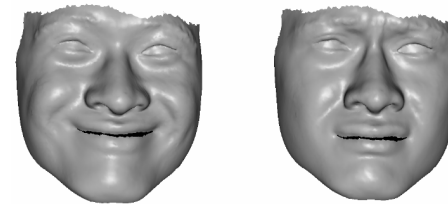
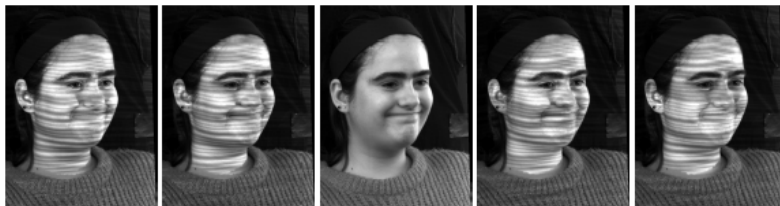
[Moven / xsens]



[Nintendo]

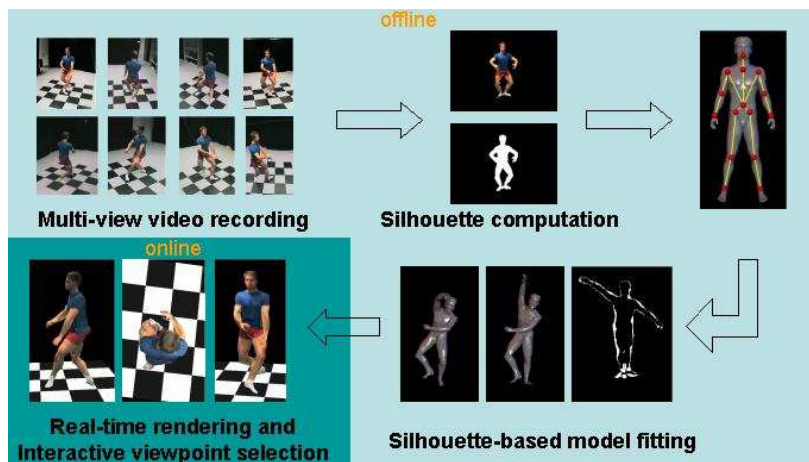
Motion capture beyond markers

- 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

• 1 DOF: knee



2 DOF: wrist



3 DOF: arm



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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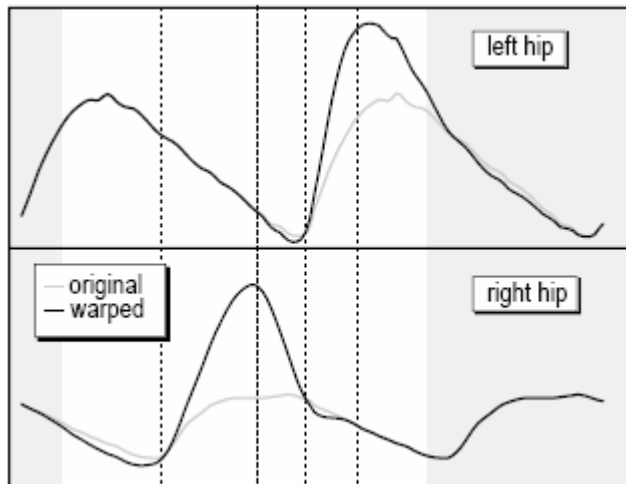
Re-use of motion data

- 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



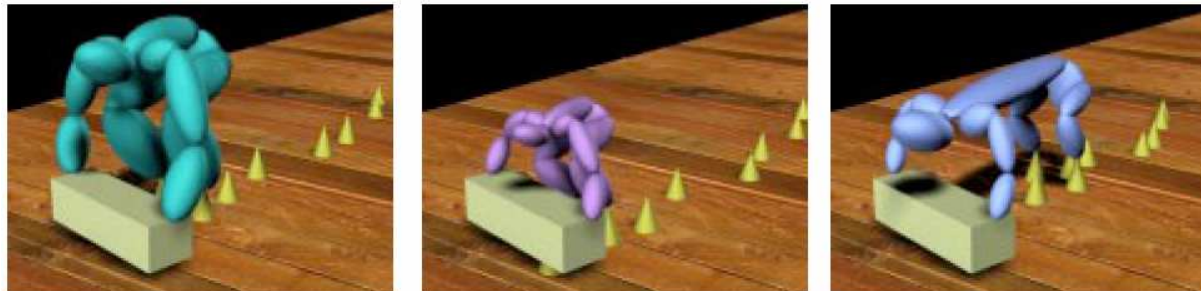
Warp: $C(t) \Rightarrow C'(t')$
Time warp : $t = g(t')$
Curve warp: $C'(t) = a(t)C(t) + b(t)$

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



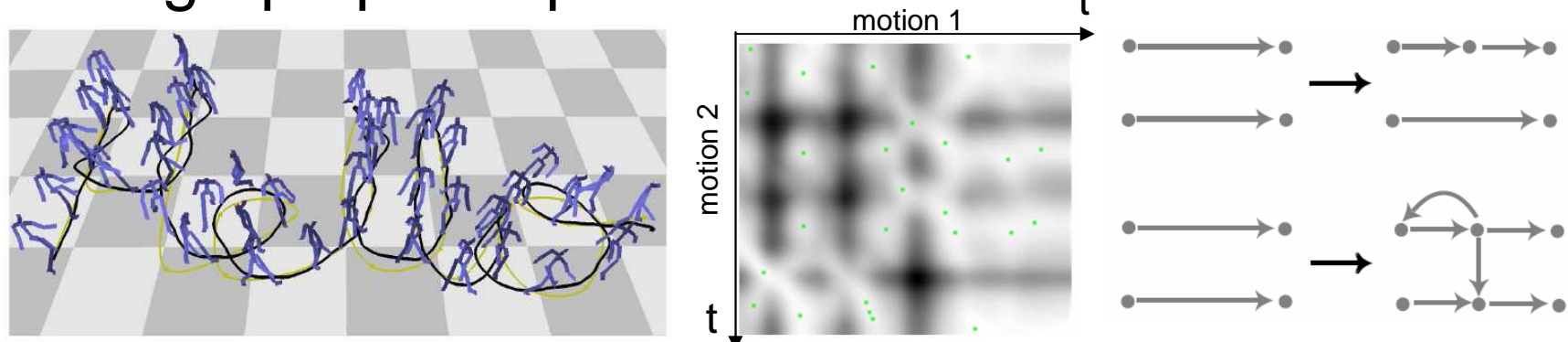
[Gleicher, 98]

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



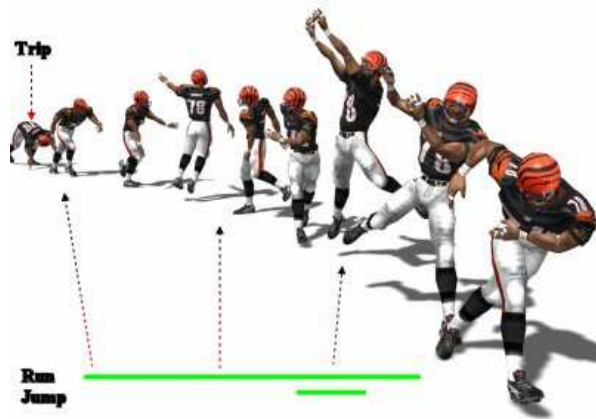
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[Kovar et al., 02]

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Motion re-use

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



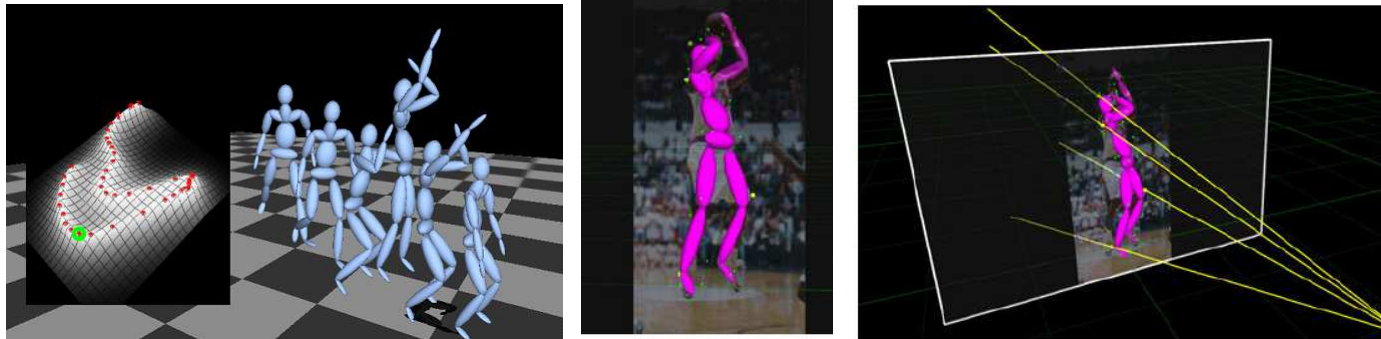
[Arikan et al., 03]



[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



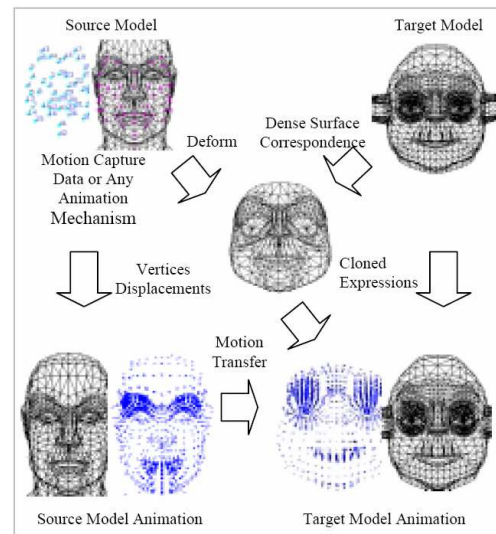
most probable pose w.r.t. constrains, [Grochow et al., 2004]

Motion re-use

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

Motion re-use

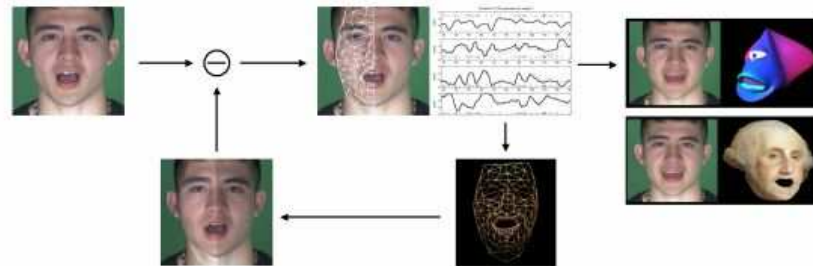
- Facial animation
 - Transfer of local motion of markers
 - ☺ direct animation of the target 3D model
 - ☹ complex morphological adaptation



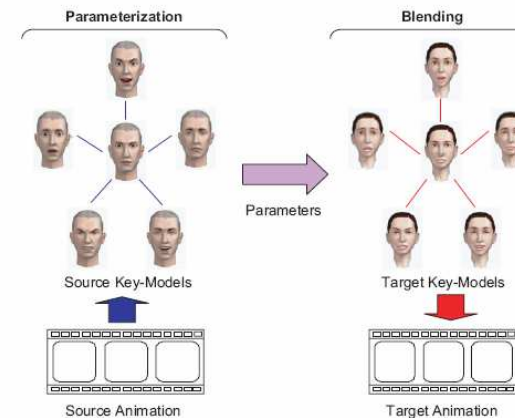
[Noh and Neuman, 01]

Motion re-use

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



[Reveret et Essa, 01]



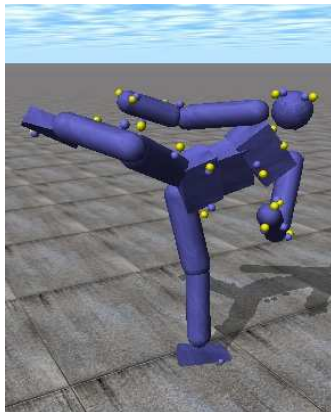
[Pyun et al., 03]

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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]



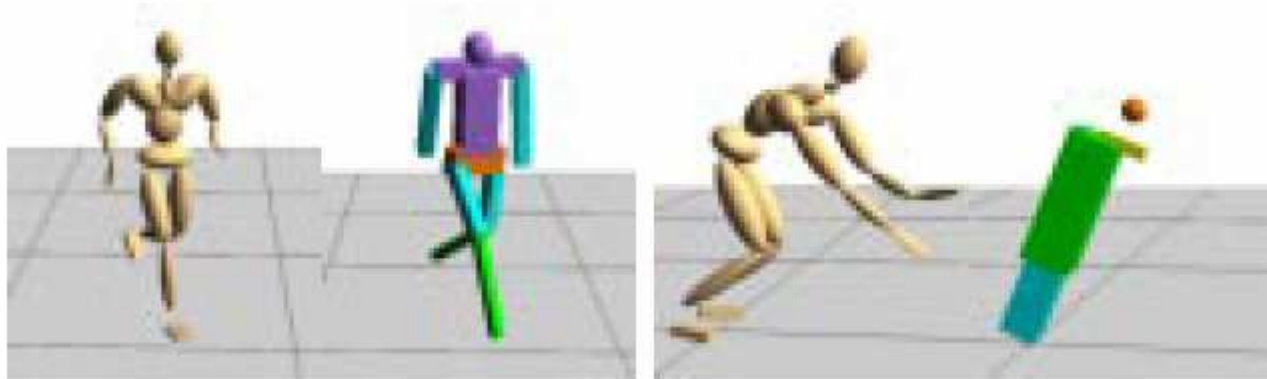
[Kry and Reveret, 07]

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
$$m d^2x/dt^2 - f - mg = 0$$
 - Find f_i so that boundaries constrains are satisfied and use as less fuel as possible
$$f_i = \arg \min \sum f_i^2$$
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

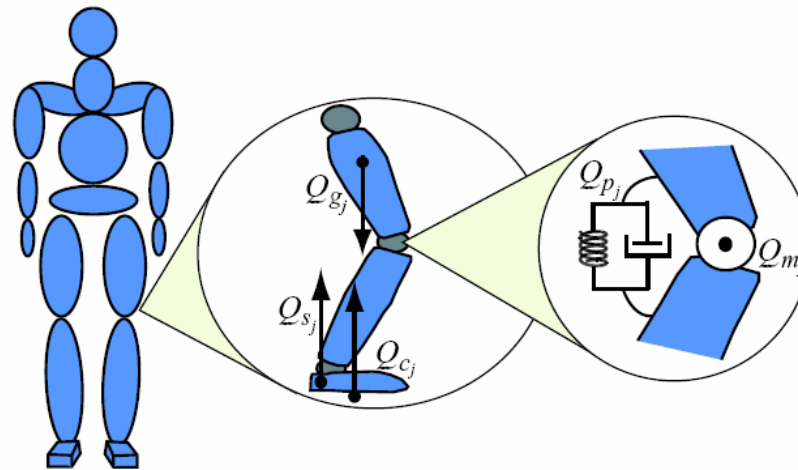
- Spacetime constrains using mocap
 - Key-frame taken as pose constrains
 - Estimate torques on a simplified phys model
 - Edit motion by changing physical parameter



[Popovic and Witkin, 99]

Motion capture and physics

- Spacetime constrains using mocap
 - Estimate all physical parameters



[Liu et al., 04]

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- References

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