CSE 888.14 Advanced Computer Animation Short Presentation

Topic: Locomotion

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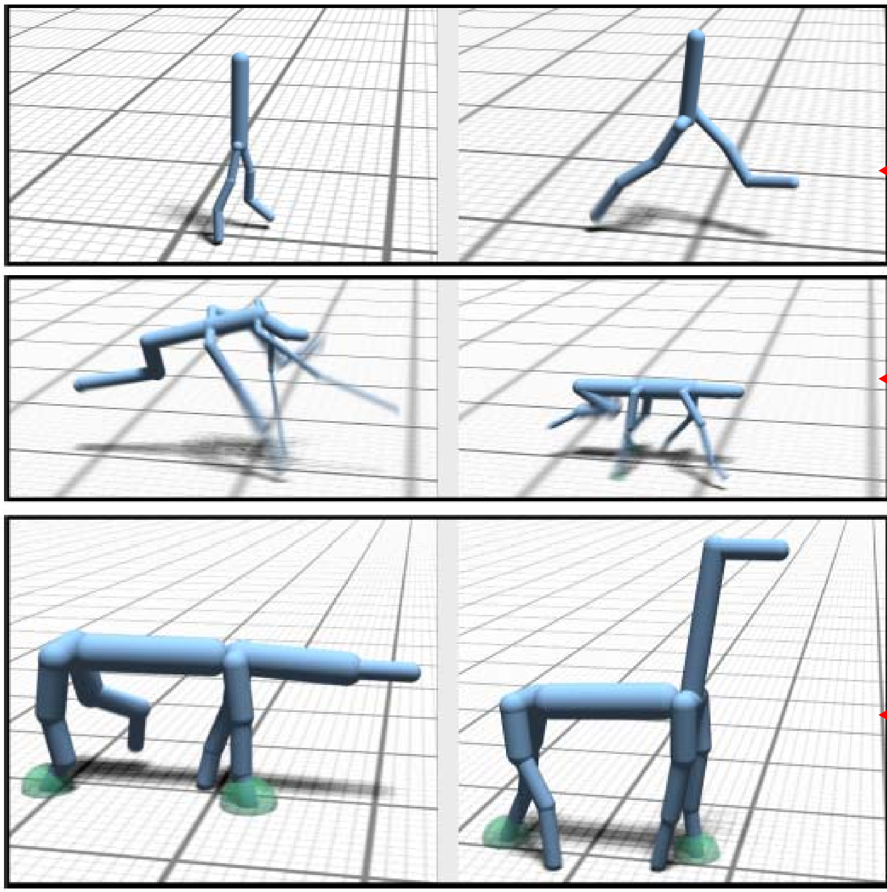
Locomotion

- **How a character moves from place to place.**
- **Optimal gait and form for animal locomotion.**
  K. Wampler, and Z. Popović,
  University of Washington, *Siggraph 2009.*
- **Interactive simulation of stylized human locomotion.**
  M. Silva, Y. Abe, and J. Popovic,
  MIT, *Siggraph 2008.*
- **Optimizing walking controllers.**
  J. M. Wang, D.J. Fleet, and A. Hertzmann,
  University of Toronto, *Siggraph Asia 2009.*
- **SIMBICON: Simple biped locomotion control.**
  K. Yin, K. Loken, and M. Panne.
  University of British Columbia*, Siggraph 2007.*

Optimal gait and form for animal locomotion (*Siggraph 2009*)

- Motivation:
  - Generate gaits and morphologies for legged animal locomotion.
  - without requiring a starting motion or foot contact timings.
- Fully automatic
- Realistic animals
- Morphology (shape & motion)
- Changing constraints (to optimize over different gait styles)
  - Given basic shape of a legged animal, synthesize a visually plausible gait without relying on any pre-authored or recorded motions.
  - Given the shape of an animal and constraints on its motion (speed), animal's motion pattern and timing in which an animal's feet should contact the ground.

Optimal gait and form for animal locomotion (*Siggraph 2009*)



Longer step length

different contact time

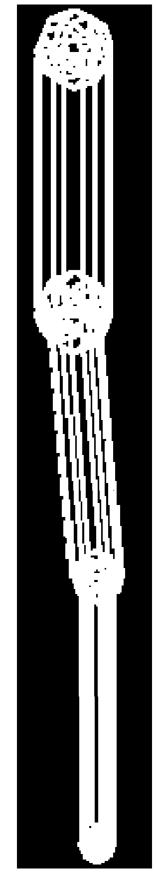
min height of head

Figure 4: *Some examples showing varying morphologies. From top to bottom: same contact times but different speeds, same speed but different contact times, and a user constraint setting the minimum height of the head.*

Optimal gait and form for animal locomotion (*Siggraph 2009*)

- hybrid optimization method
  - related work: spacetime optimization, continuous optimization, authored parametric methods
- tree of connected limbs (cylinder with a length, radius, and mass.)
- limbs are connected by joints

m the default mass of the animal
q a single joint degree of freedom
f,t force and torque, respectively
$p(i,j)$ position of bone endpoint (node) or joint j at frame i
$v(i,j)$ the linear velocity of node j at frame i
$R(i,j)$ The 3×3 rotation matrix of node j at frame i



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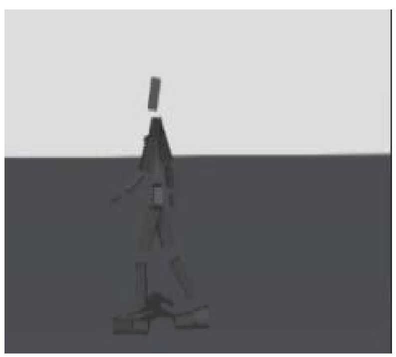
Optimal gait and form for animal locomotion (*Siggraph 2009*)

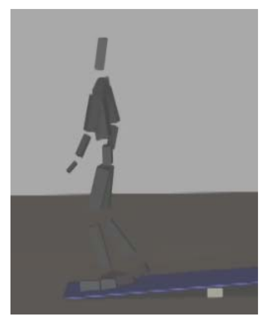
- Contributions
  - Solve for form and motion of realistic animals
  - Large-scale highly-nonlinear global optimization

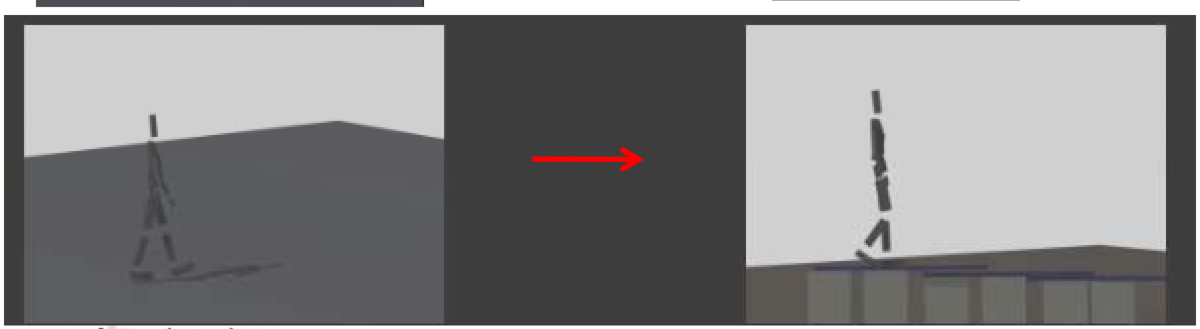
- Future work
  - more accurate biomechanical models
  - be able to do this for a large variety of animals
  - to integrate the results form this directly into game

Interactive simulation of stylized human locomotion (*Siggraph 2008*)

- Describes controllers for interactive simulation of stylized human locomotion
  - given a reference motion that describes the desired style
  - reproduce that style in simulation and in new environments

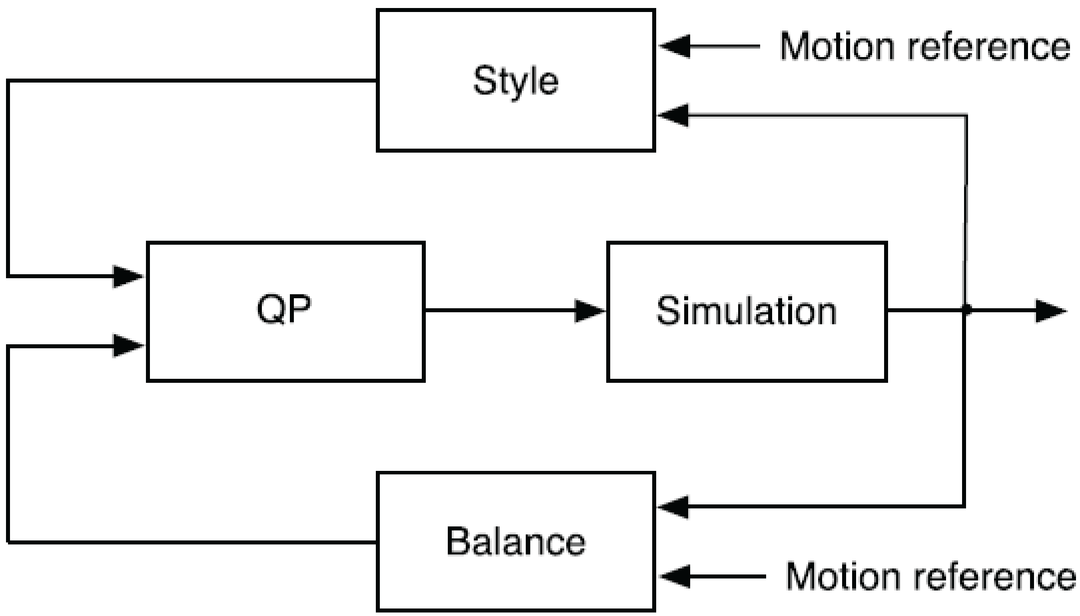






Interactive simulation of stylized human locomotion (*Siggraph 2008*)

- In addition to traditional kinematic solutions …….
- Style Feedback, Balance Feedback, Quadratic Programming



Interactive simulation of stylized human locomotion (*Siggraph 2008*)

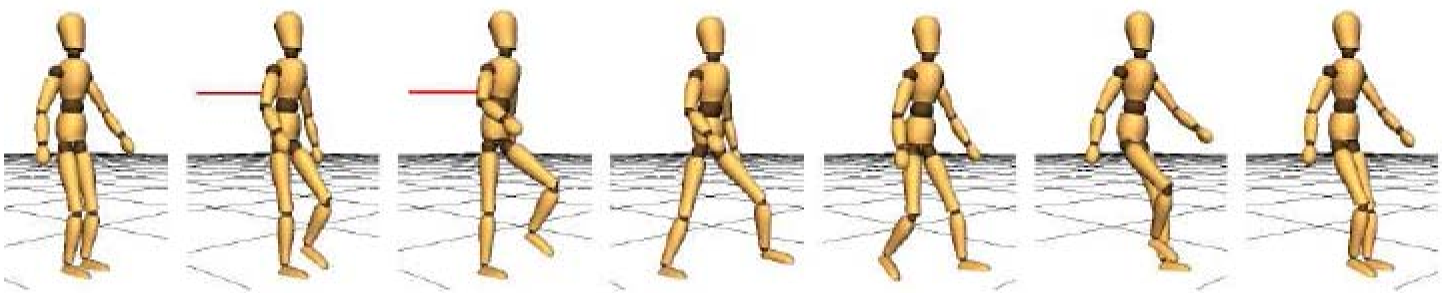
- New controller produces high-quality motions for a large variety of reference motion styles
- Able to combine it with existing controllers to improve their stability
- Not designed to handle higher level motion planning tasks (unable to walk up large steps)
- Two major advantages
  - can adapt motion-capture data to physically consistent dynamic environments
  - can produce large amount of different simple actions

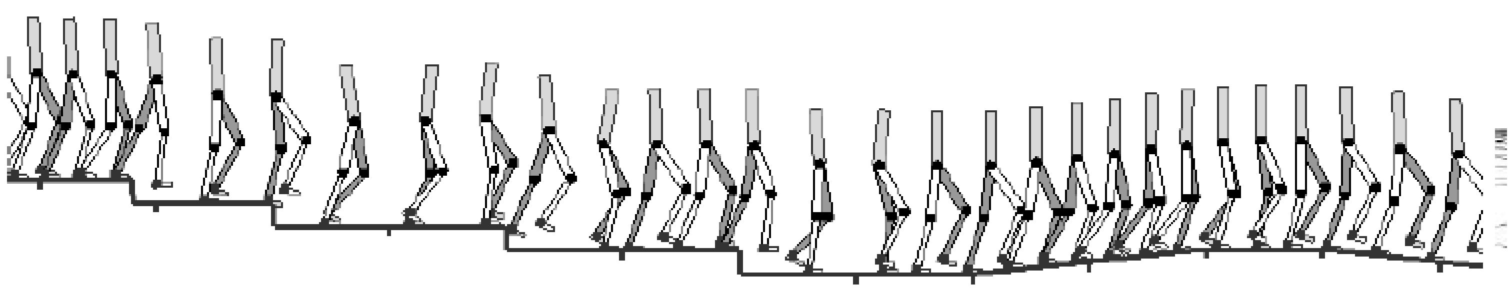
SIMBICON: Simple biped locomotion control (*Siggraph 2007*)

- Control of biped locomotion is difficult because bipeds are unstable, high-dimensional dynamical systems.
- A simple control strategy
  - few parameters
  - generate a large variety of gaits and styles
  - in real-time
- Walking in all directions (forwards, backwards, sideways, turning), running, skipping, and hopping.
- Controllers
  - authored using a small number of parameters,
  - or can be informed by motion capture data.

SIMBICON: Simple biped locomotion control (*Siggraph 2007*)

- Traditional:
  - keyframe, motion capture
  - fail to scale to the very large possible
- finite state machine, feedback error learning





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SIMBICON: Simple biped locomotion control (*Siggraph 2007*)

- Contributions
  - integrate and build on previous insights to develop a simple new strategy for the control of balance during locomotion (for a wide variety of 2D and 3D biped gaits)
  - controller-based imitation of motion captured gaits which exhibit robust balancing behavior
  - feedback error learning

Optimizing walking controllers (*Siggraph Asia 2009*)

- Describes a method for optimizing the parameters of a physics-based controller for full-body, 3D walking.
- Observed how to choose critical parameters for tuning to achieve better walking control and reasonable walking style
- Resulting gaits exhibit key properties of natural walking, for example, energy efficiency.
- The system does not require any motion capture data .

Optimizing walking controllers (*Siggraph Asia 2009*)

- Optimizing a controller involves
  - searching for control parameters
  - a start state that together produce good character simulations.
- Objective Function
  - features of human walking
  - constraints: User gait, Required gait, Head and body,
  - Efficiency and power terms
- A modified version of the SIMBICON controller is optimized.

Optimizing walking controllers (*Siggraph Asia 2009*)

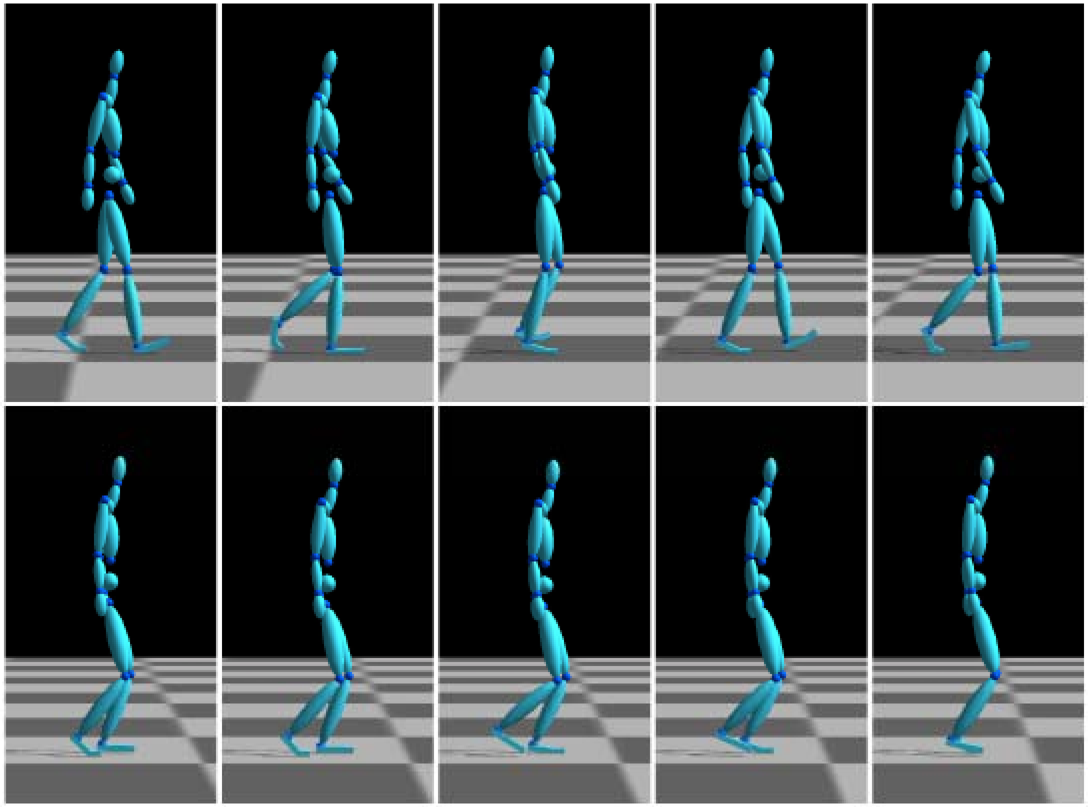

Figure 3: ***Top:*** *Optimization of "short" (Figure 8(bottom)) walking in 1.0 m/s.* ***Bottom:*** *Optimization without E_{ratio}. The lack of the power ratio term leads to a semi-crouching style.*

Optimizing walking controllers (*Siggraph Asia 2009*)

- Number of limitations
  - requires an expensive optimization procedure, and depends on a reasonable initialization
  - generated motion still differs from human motion in noticeable ways
    - (takes shorter steps than mocap data; lack of hind leg stretching in controllers).
  - anticipate that it may be possible to learn the parameters from mocap data.

Going to dig deeper into

- **Optimal gait and form for animal locomotion.**
  K. Wampler, and Z. Popović,
  University of Washington, *Siggraph 2009.*
- **Optimizing walking controllers.**
  J. M. Wang, D.J. Fleet, and A. Hertzmann,
  University of Toronto, *Siggraph Asia 2009.*

- *Controller, parameters, Optimization.*

Thank you !