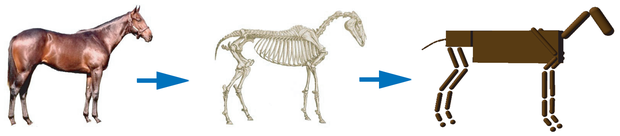

Physics-Based Horse Model

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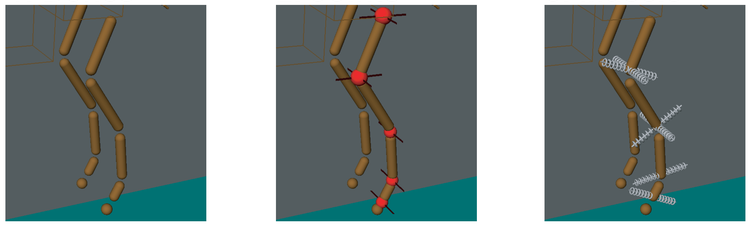
Co-funded by **IRCSET** and **IBM**

Construction

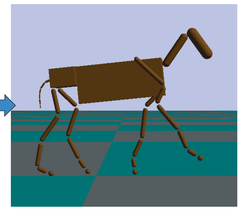
1. Bones **2. Joints** **3. Muscle**



1. Body segment attributes taken from measured data
2. Joint degrees of freedom and limits based on anatomy
3. Effect of muscle on the bones is emulated by springs

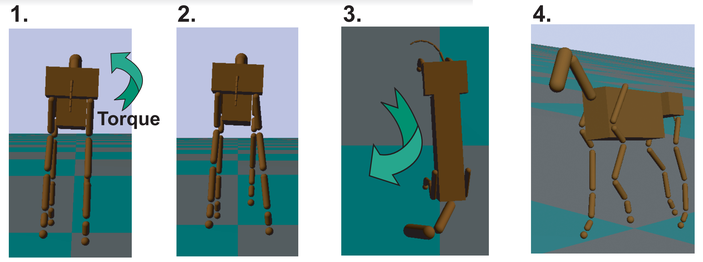
Movement

1. Data → 2. Spline → 3. Spring → 4. Tune



1. Joint angles from sample gait data
2. Smooth angles with cubic B-spline
3. Springs move joints to match spline angles
4. Tune spring constants and simulation parameters to achieve correct movement

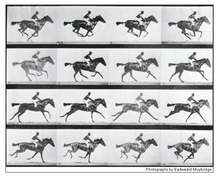
Balance and Direction



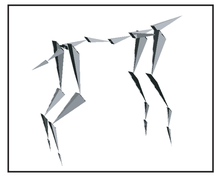
1. Apply torque to counter minor unbalance
2. Laterally move out limb to counter major unbalance
3. Neck and tail bend in towards the direction of the turn
4. Horse leans into faster turns, without bending

Collected Data

Muybridge photographs



Motion capture data



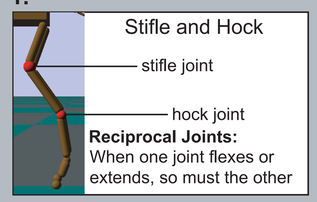
- Joint angle data gathered from multiple sources
  - published data, photographs, motion capture
- Data is not freely available
- Inconsistency due to multiple sources
- Manual editing of data usually necessary

OR

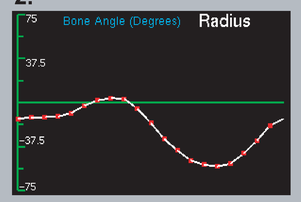
Generated Data

- Fabricate sample data for multiple gaits
- Overcome difficulties encountered with data acquisition and inconsistencies of that data

1.



2.

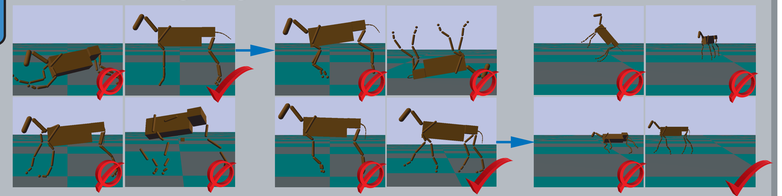


1. Generate data based on anatomical observations
2. Exploit the sinusoidal nature of joint movements

OR

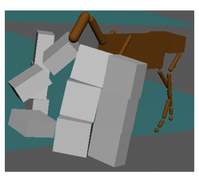
Evolved Data

- Evolve gait patterns using an optimization approach
- Automatic gait generation, no need for sample data

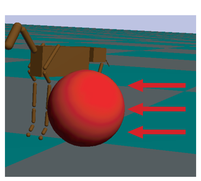


- Run multiple simulations with varying parameters and an optimization and rejection strategy
- Choose the simulation which moves the furthest, in the shortest time, using the least energy

Animation Application Additions

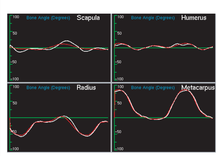


- **Uneven terrain:** The model should be able to easily traverse undulating terrain and step through rougher terrain
- **Obstacles:** For a larger obstacle, the model may attempt to automatically avoid it or take measures to traverse it, e.g. jump

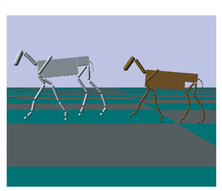


- **Real-time user control:** Potentially useful for the games industry or for storyboarding in the film industry, e.g. sketch-based interface
- **External force reaction:** The model should react to maintain balance and direction if subject to a significant external force, e.g. laterally extend limbs to maintain balance if struck from the side

Veterinary Application Additions



- **Visualize data:** Extract and visualize useful scientific information from the simulation
- **Simulate lameness:** Adapt the gait patterns to simulate lameness or handicap the model and observe the effect on its gait



- **Effects of breeding and conformation:** Visually compare the gaits from horses of different breeds and conformations
- **Running surface:** Simulate the effect of varying ground properties on the model's gait