Tackling Physics

getting ragdolls to move

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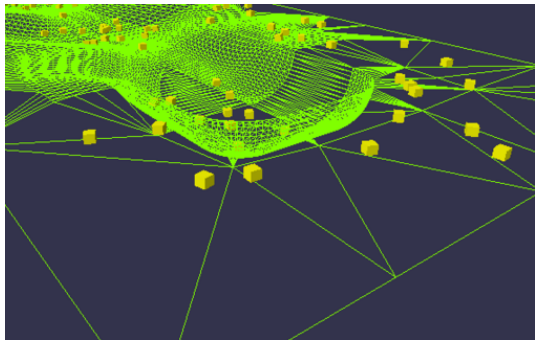
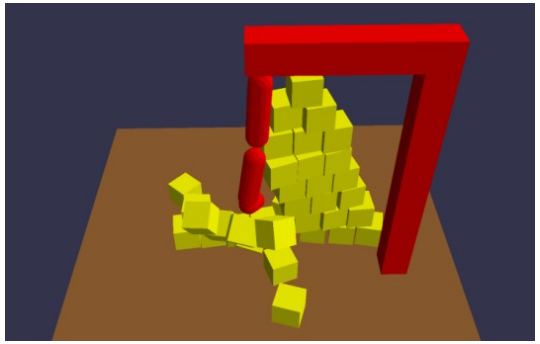
Current Game Physics

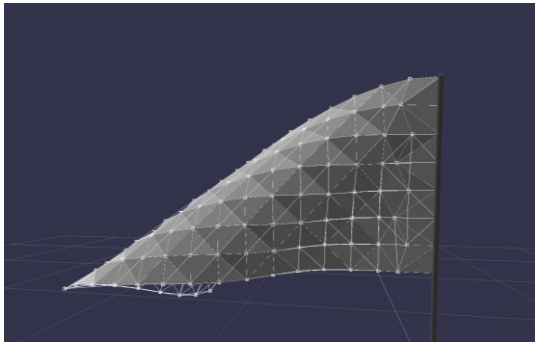


Avoiding Interpenetration

Object Motion



Simulate Stacking and Joints



Cloth and Clothing

Real World Physics

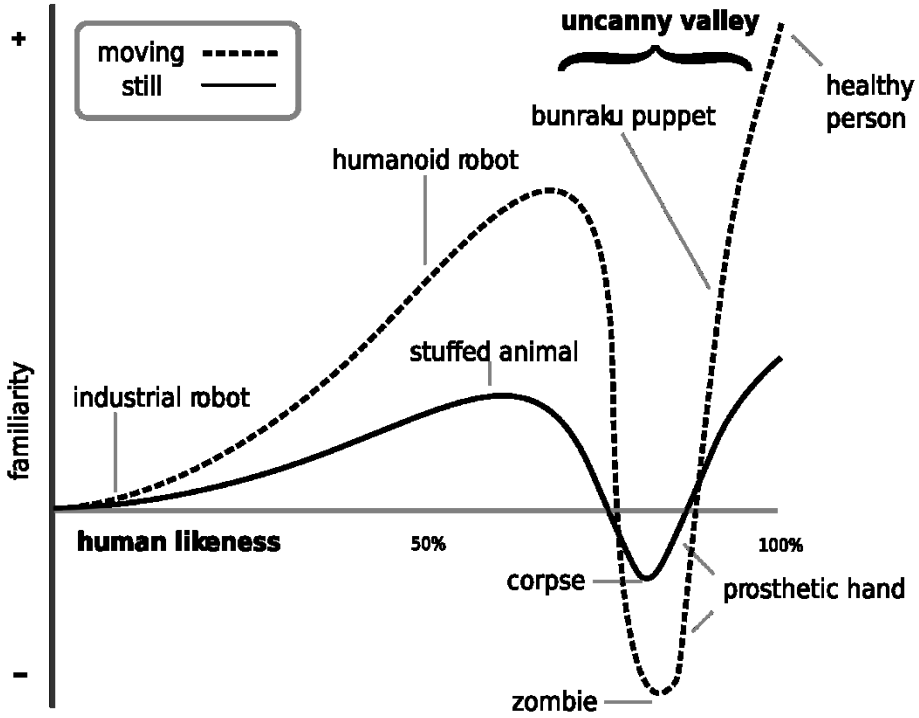
Interactive Fluids

Destruction

Deformation

Character Physics

Why Character Physics?

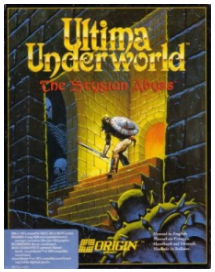


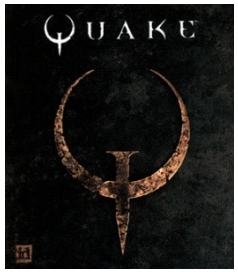
The Uncanny Valley (Masahiro Mori)

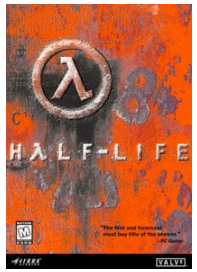
What is Character Physics?

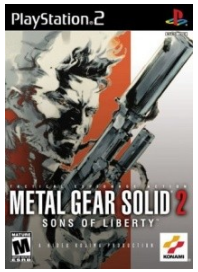
- Biomechanically accurate model?
- How to control?
- How to make a model look human?
- Has to run in real-time
- Has to be robust

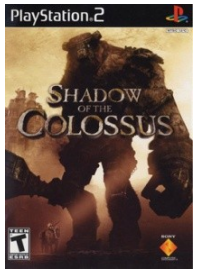
3D Animation in Games



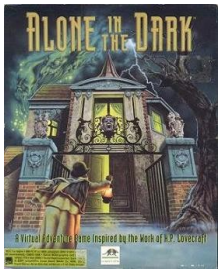


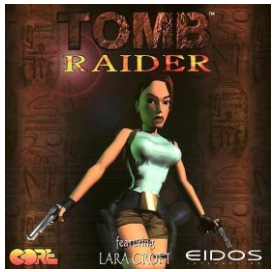


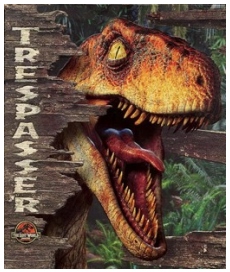


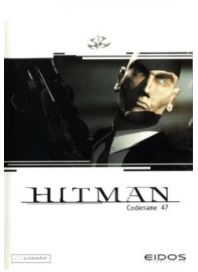


1992 1994 1996 1998 2000 2002 2004 2006 2008

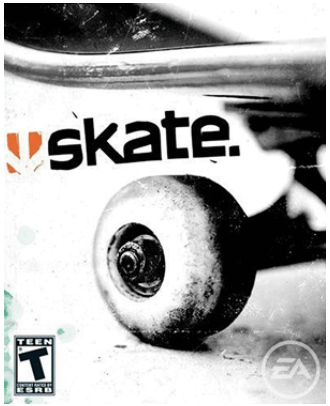




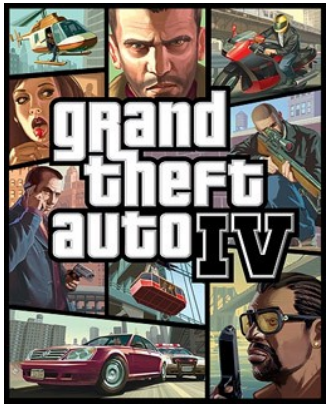




Powered Ragdolls in Games



2007



2008

2009

2010

2011

Video

- Fight Night Round 4
  - Producer Video about Physics

http://www.youtube.com/watch?v=oqlPNb05aQ0

Video Summary

- Prevent clipping
- Realistic/natural looking interactions
- Motion variety
- New game-play opportunities

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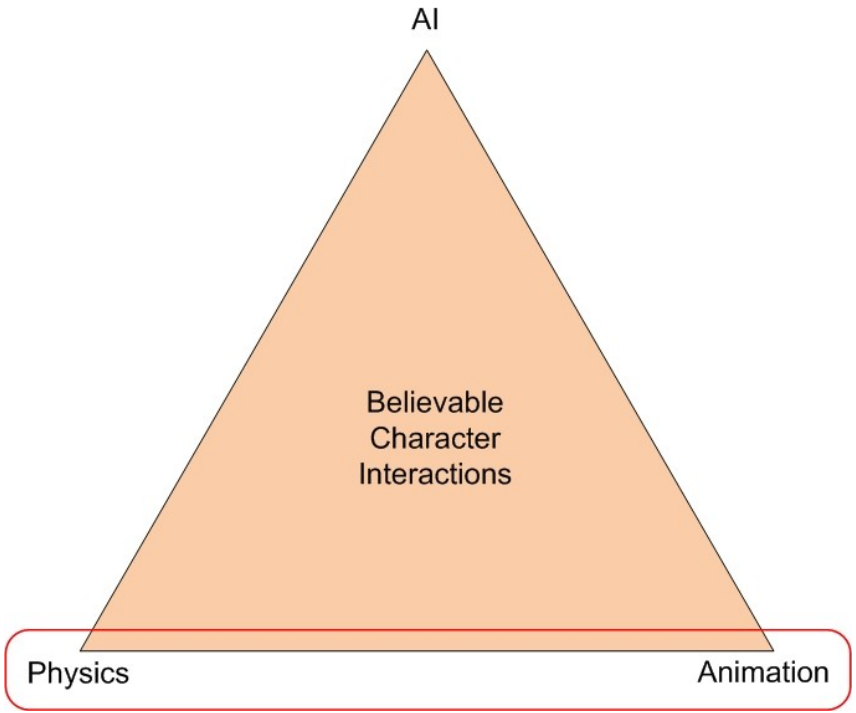
Game-play Considerations

- Instant control response
- Maintain animation style
- Allow physically unrealistic game-play
- Game-play needs to be fun!

Animation System

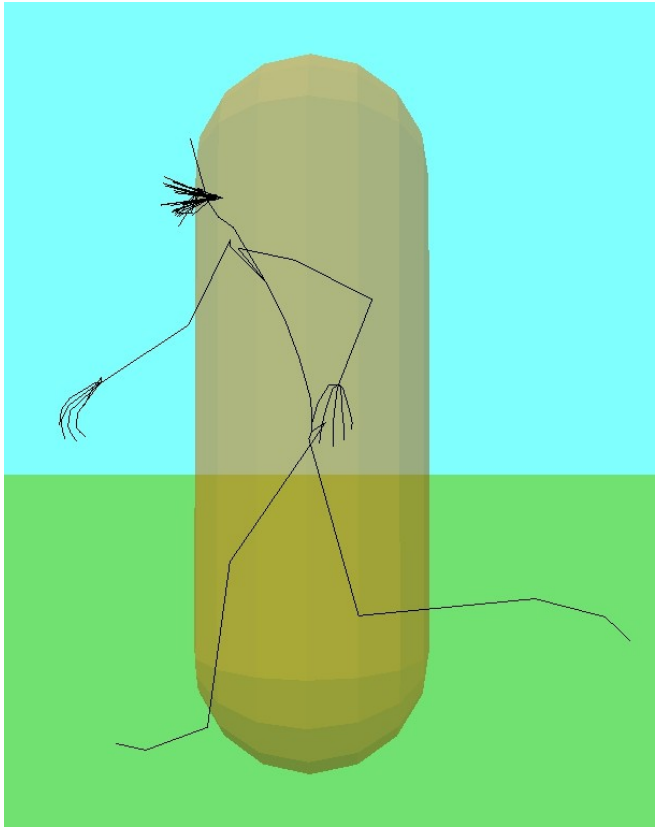
- Mo-cap/hand-keyed data
- Pose-based
- Blending & Transitions
- Good for capturing style
- Repetitive Interactions

What is Character Physics?



Crude Character Control

- Capsule around character
- Avoids interpenetration
- No local deformation
- Occupies too much space



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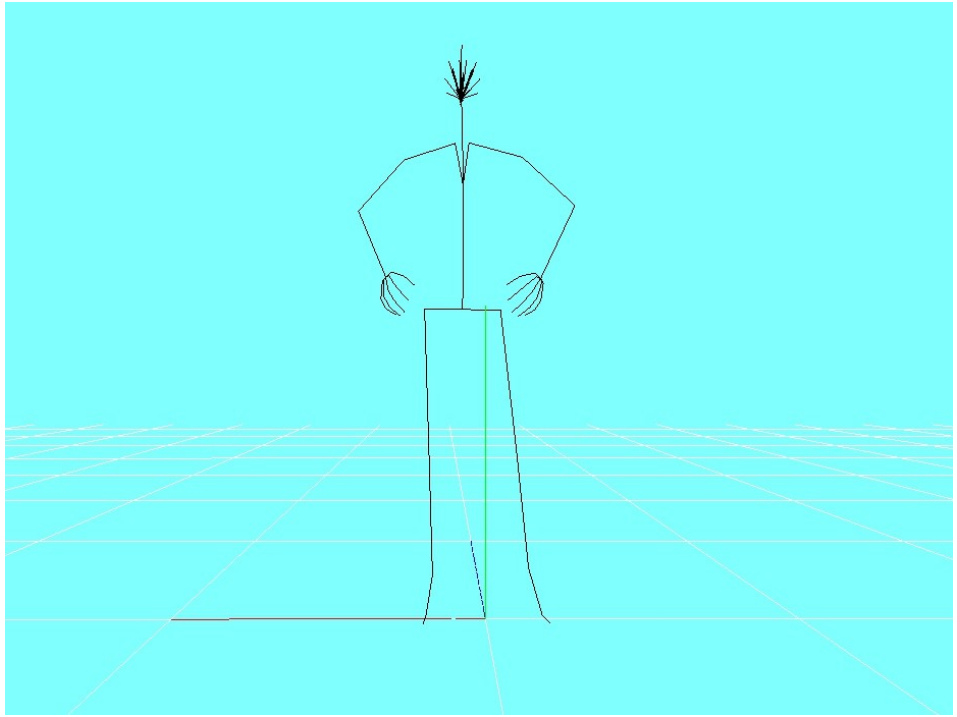
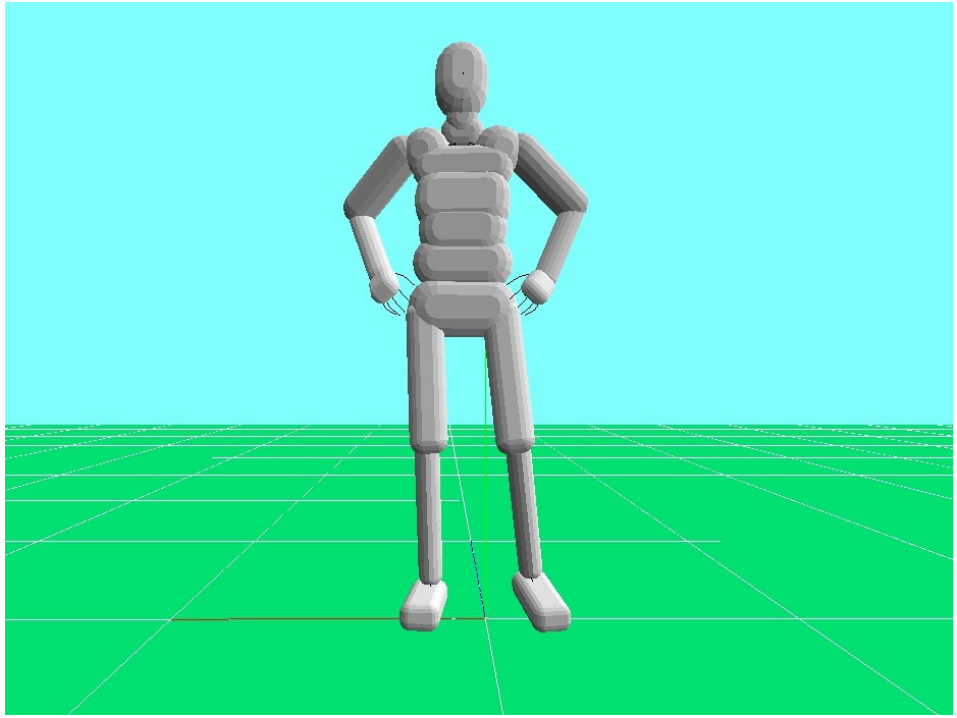
Don’t Run before you can Fall

- Physics ragdoll
- Can look pretty bad
- Get joint limits right
  - Use elliptical joint limits
- Looks very lifeless

Animation Skeleton

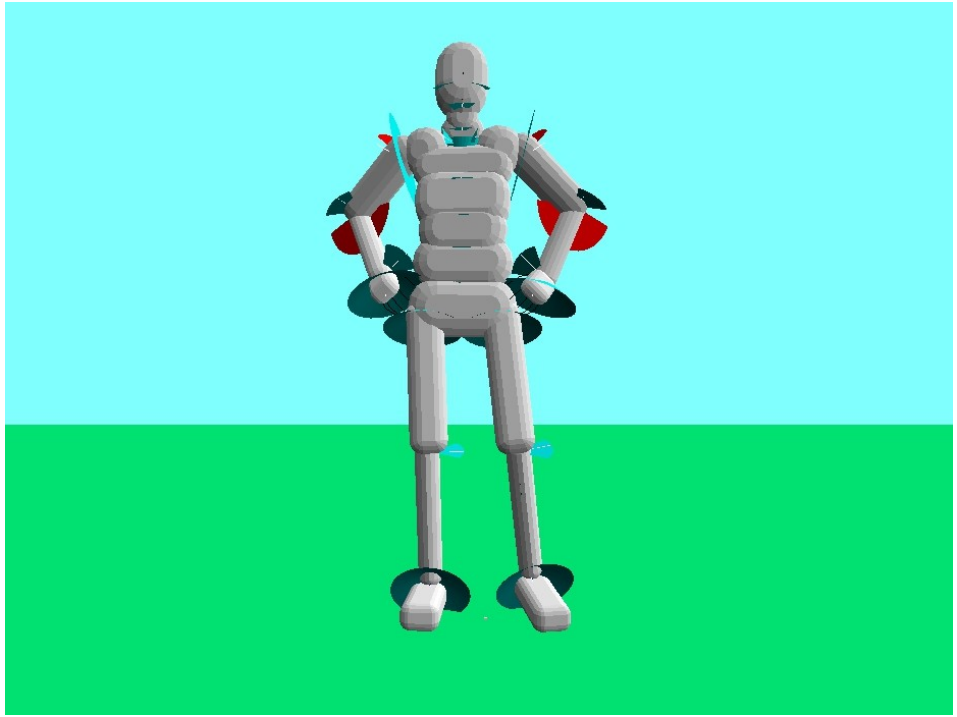


Ragdoll

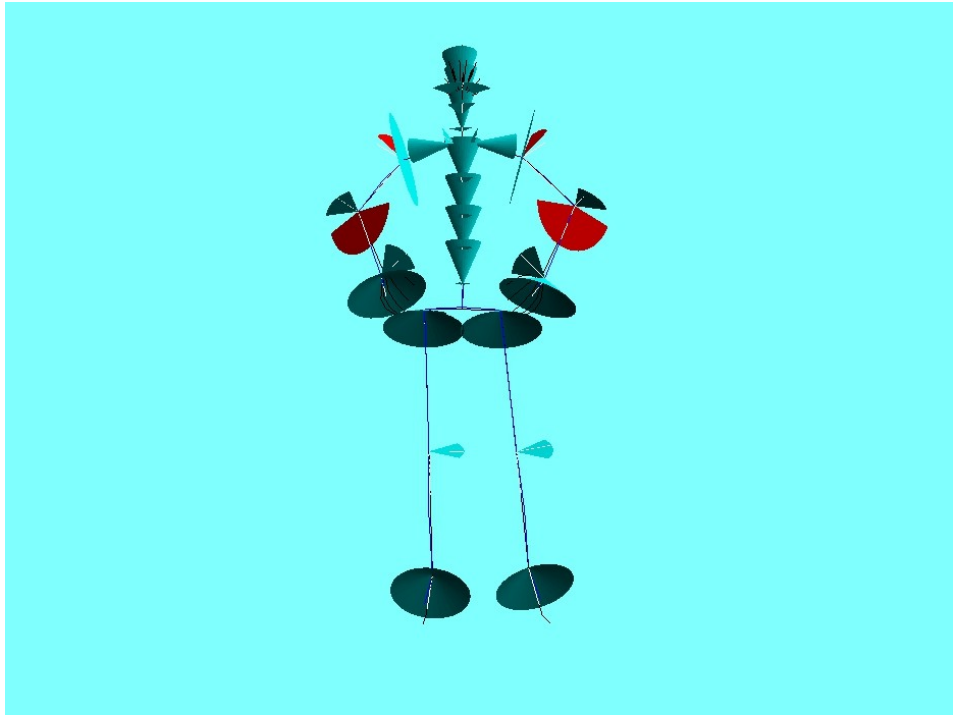


No Joint Limits

Joint Limits



Joint Limits



More Realistic Joint Limits

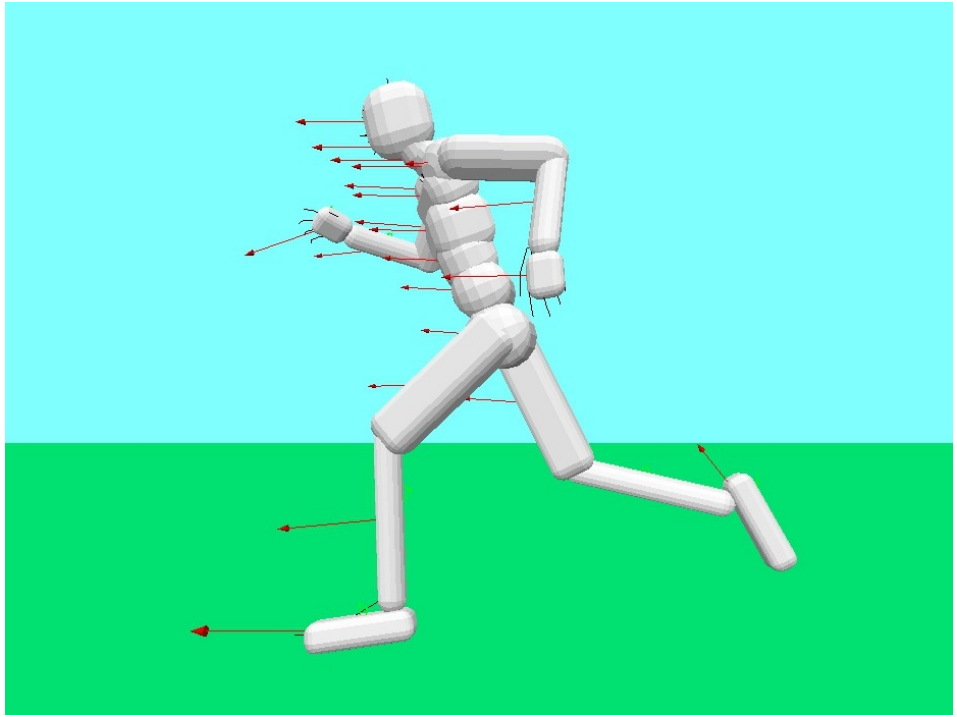
Moving the Ragdoll

- Want the ragdoll to follow animation
- Affect the physics world
- Deform to the physics world

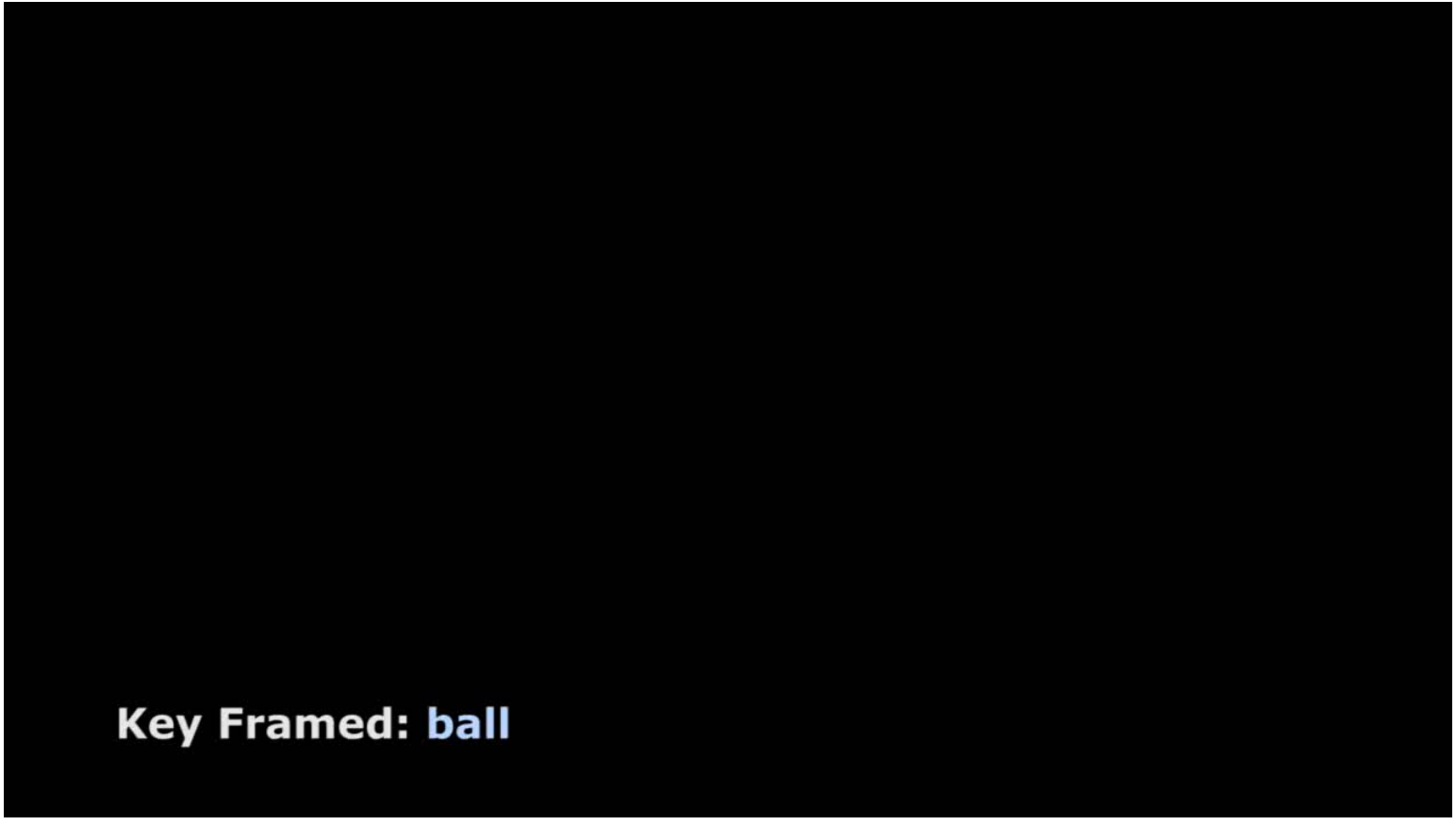
Key-Framing Physics

- Set velocities
- “Infinite mass”
- Guaranteed to match animation

Key-Framing Physics



Key-Framing Physics



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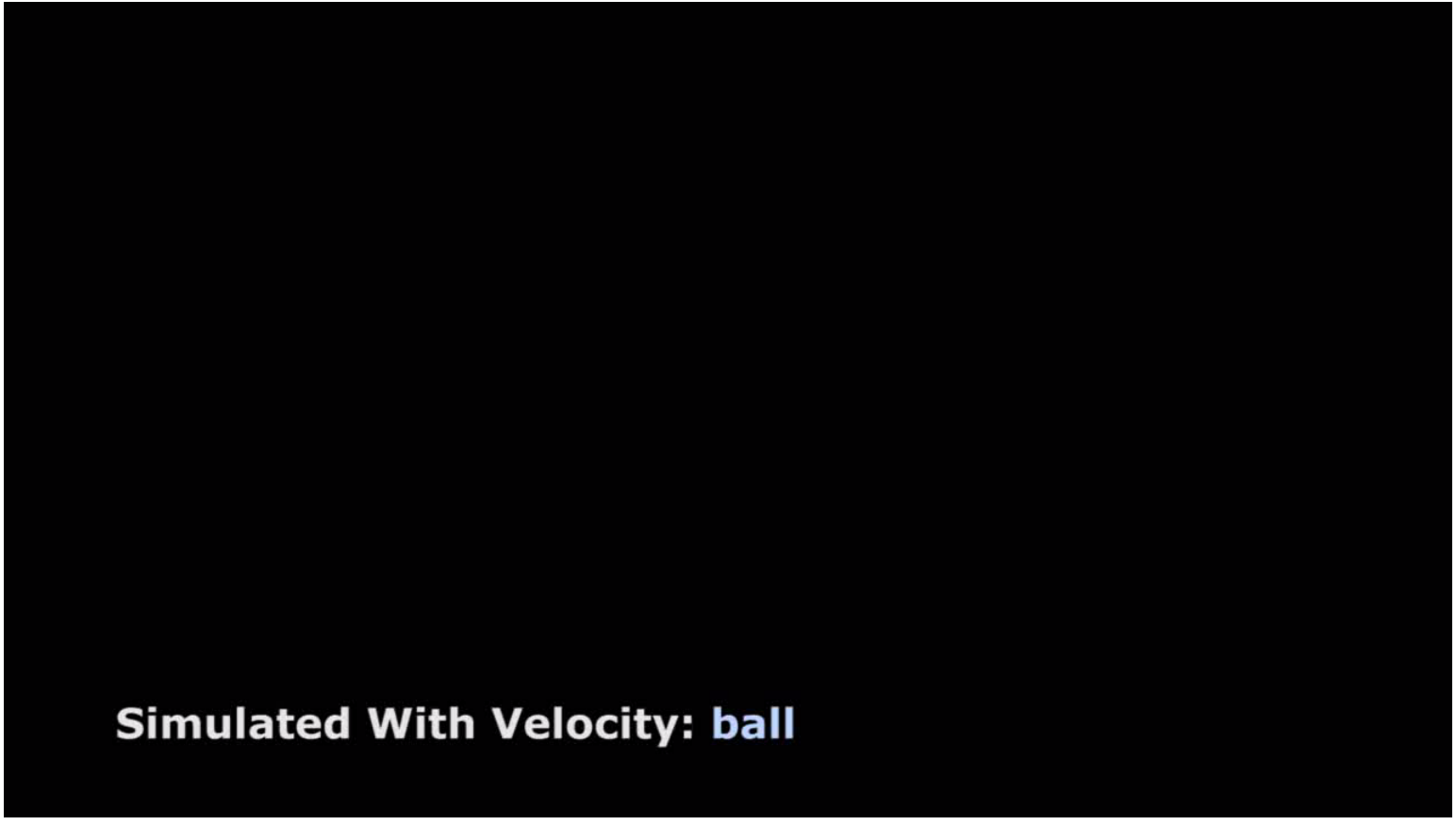
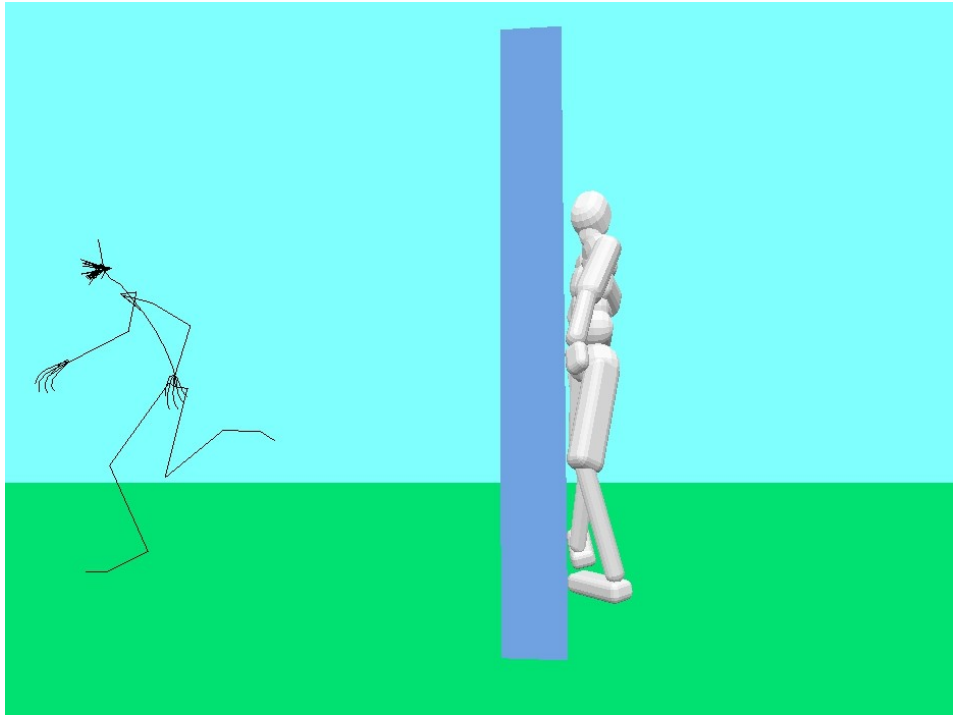
Turn Down the Mass

- Set velocities on a dynamic ragdoll
- Attempt to match pose at end of frame
- Will follow animation
- Can get unrealistic motion when deflected

Turn Down the Mass



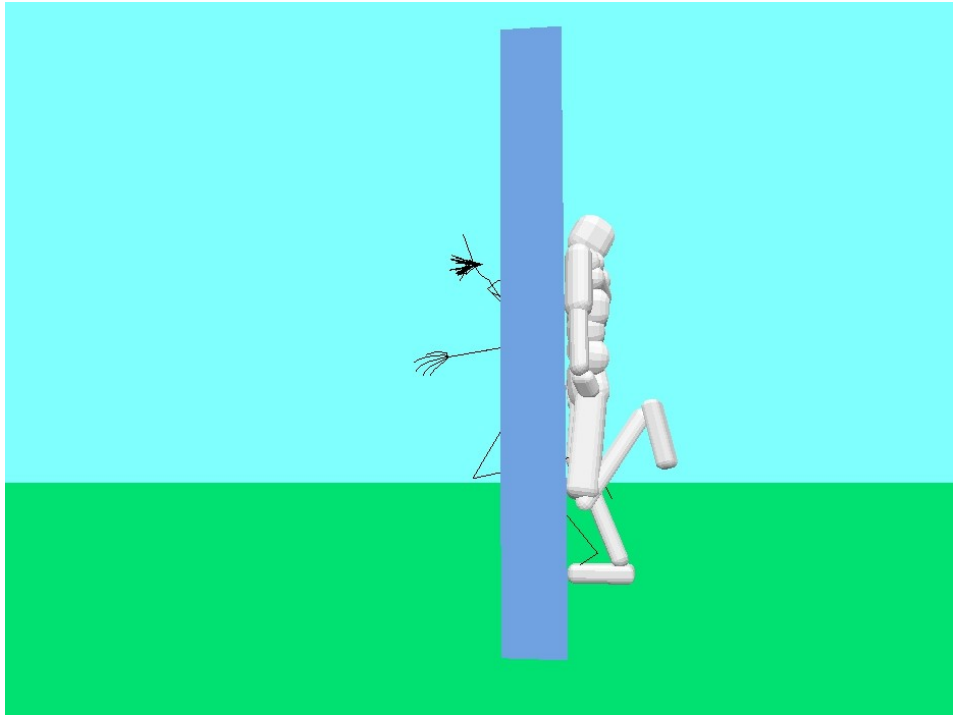
The Root of the Problem



The Root of the Problem

- Allow physics to modify root position
- Will follow animation
- Motion still not great when deflected

The Root of the Problem



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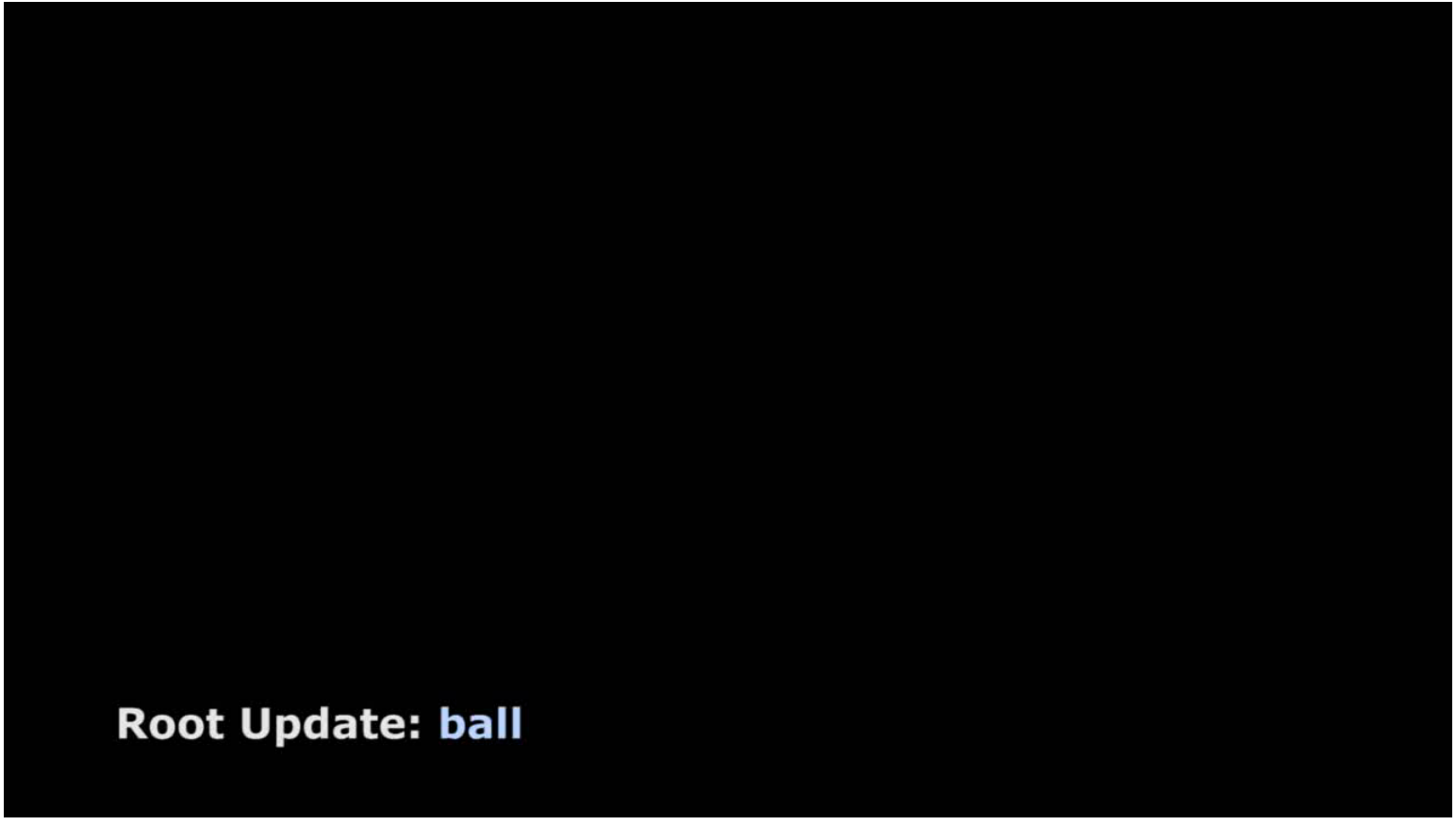
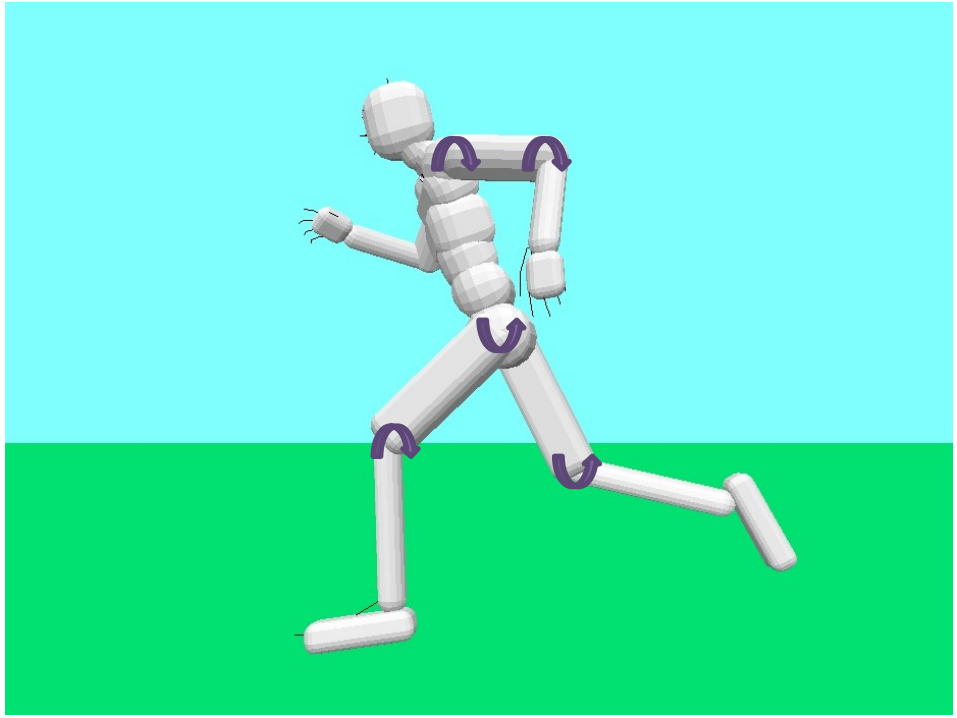


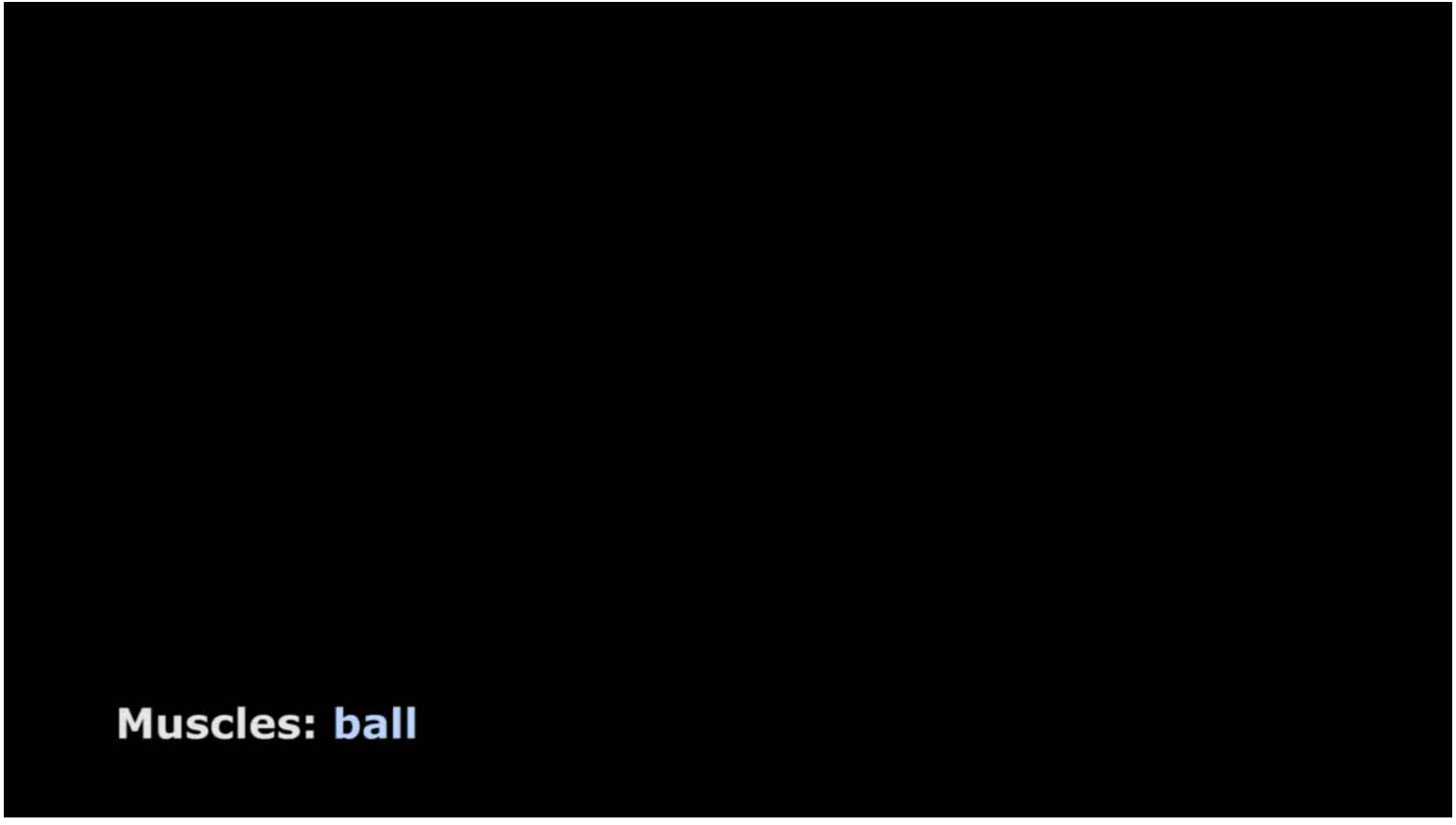
Adding Muscle

- Add strength to the ragdoll
  - Use motorized constraints at joints
- Following animation more challenging
- Deflected Motion looks much better

Adding Muscle



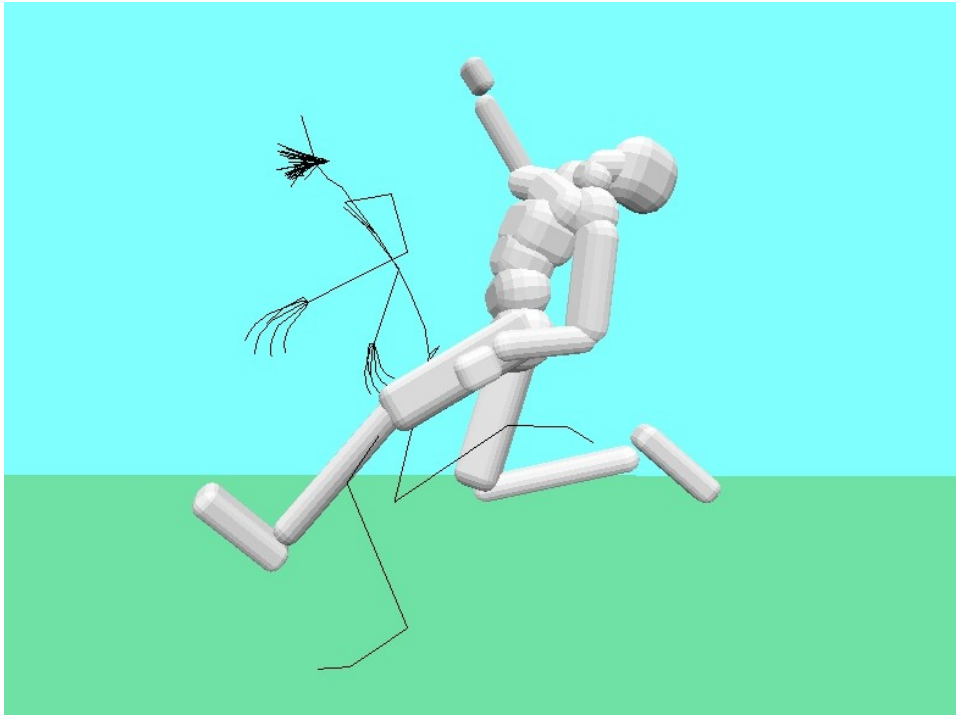
Adding Muscle



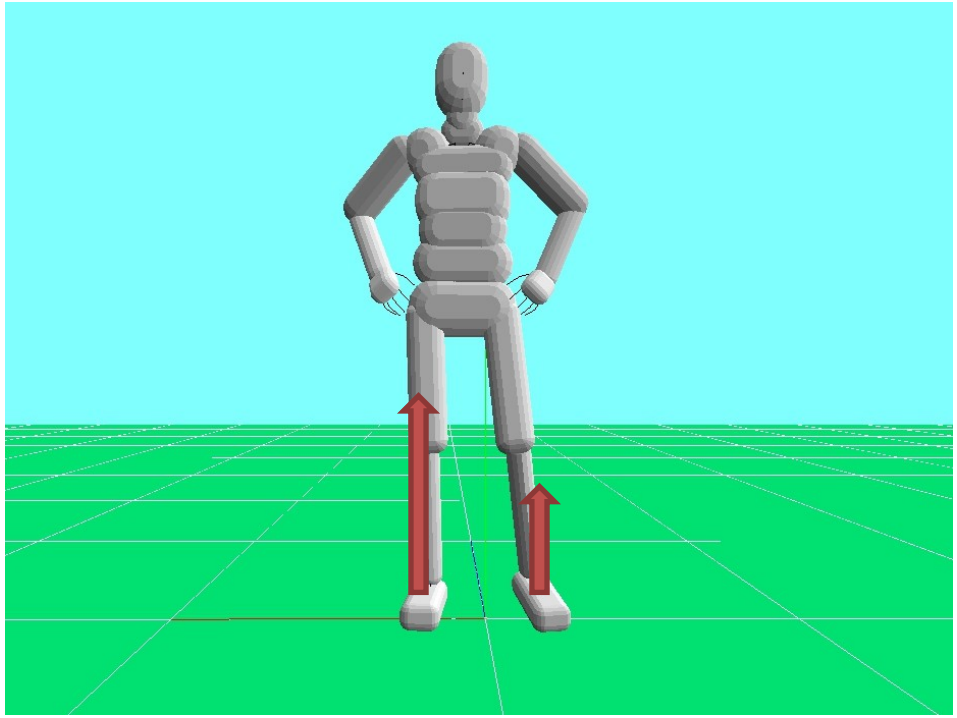
Two Big Problems

- Convergence & Stability
- Standing Upright

Convergence & Stability

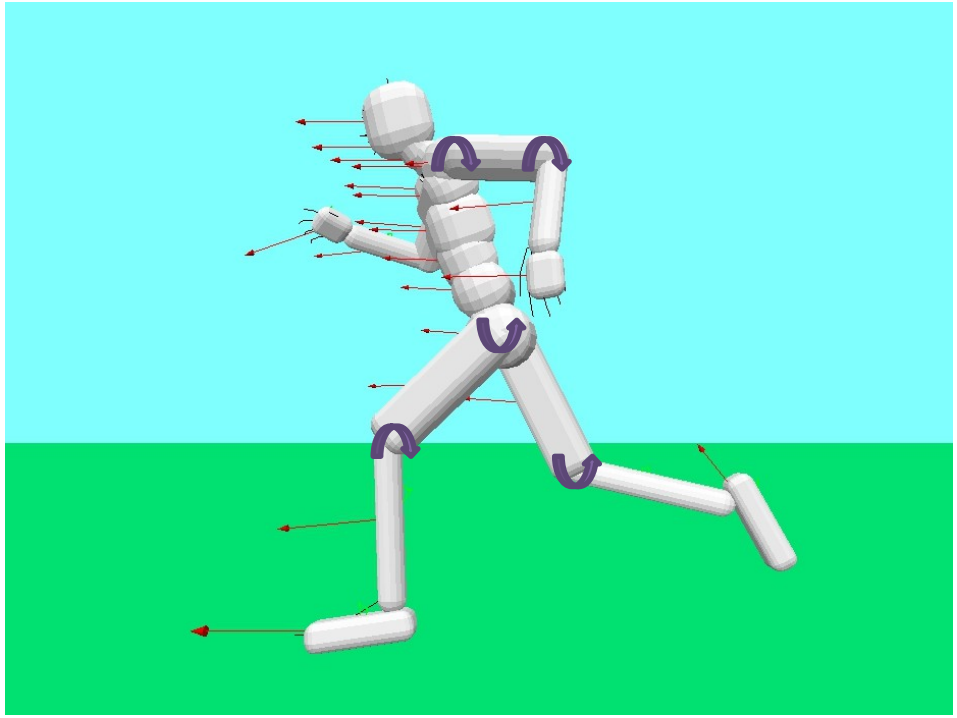


Standing Upright



Standing Upright

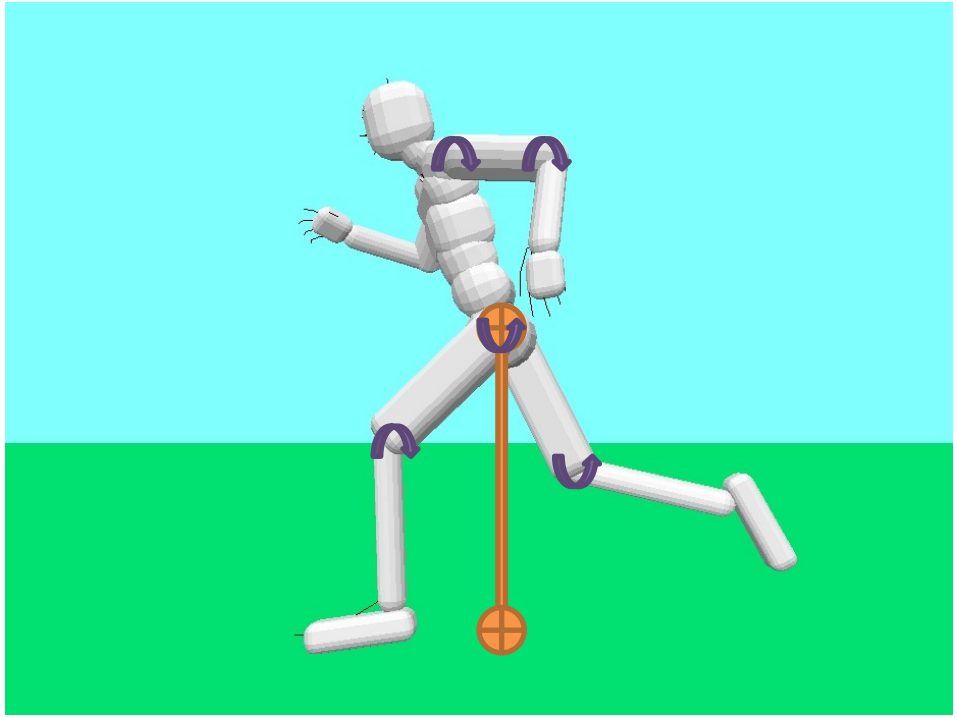
Solution 1



Further Reading

- Moving Beyond Ragdolls (GDC 2005)
  - http://www.mmandel.com/gdc/
- Use external forces to minimize error (and transition back to animation)

Solution 2



Further Reading

- Dynamo (SIGGRAPH 2006)
  - http://graphics.cs.williams.edu/papers/DynamoVGS06/
- Calculate desired torques from world space orientations
- “Week Root Spring” – for dealing with balance

Things to Run Into

- Need good stable ragdoll as a base
- Limb stretching
- Animations may violate joint-limits
- Breaking existing game-play
- Needs a lot of tuning

Another Video

- FIFA 12
  - Producer Video about FIFA Impact Engine

http://www.youtube.com/watch?v=gwBnToGDL6A

Video Summary

- Prevent clipping
- Realistic/natural looking interactions
- Motion variety
- New game-play opportunities

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Final Thoughts

- A very powerful technique
- Takes a big investment to get it right
- Will only work with collaboration from all
  - Animation/AI/Physics systems
  - Producers, animators, SEs, ...

Questions?

Contact: sfrye@ea.com