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

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
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
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

Key Framed: ball
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

Simulated With Velocity: ball
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
The Root of the Problem

Root Update: ball
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

Muscles: ball
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
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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/Al/Physics systems
  – Producers, animators, SEs, ...
Questions?

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