AVALANCHE STUDIOS

Physics Meets Animation
Character Stunts in Just Cause 2

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Talk Overview

Motion Control

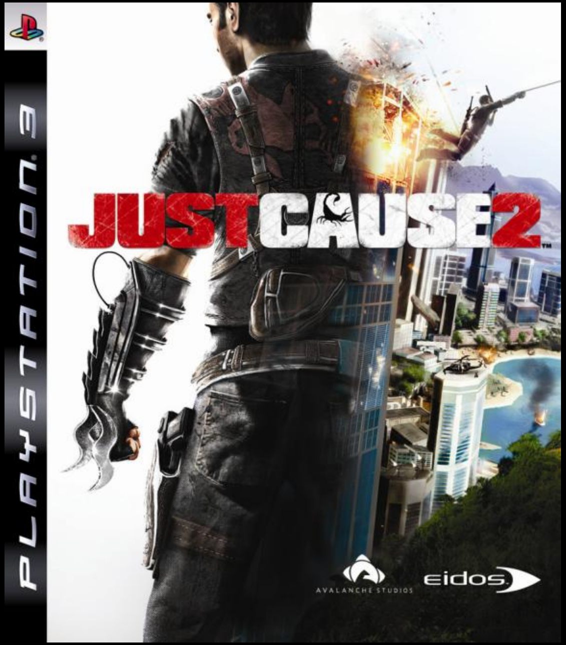
Animation + Physics +IK

Parametric Animation

Effectors / Manipulators

Just Cause 2 : Requirements

- Huge open world
- Fast-paced, over-the-top action
- Reactive environment
- High level of responsiveness
- Large number of game mechanics
- Large number of vehicles



Freedom!

Concept Video

videomatic_060918_01_xvid.av

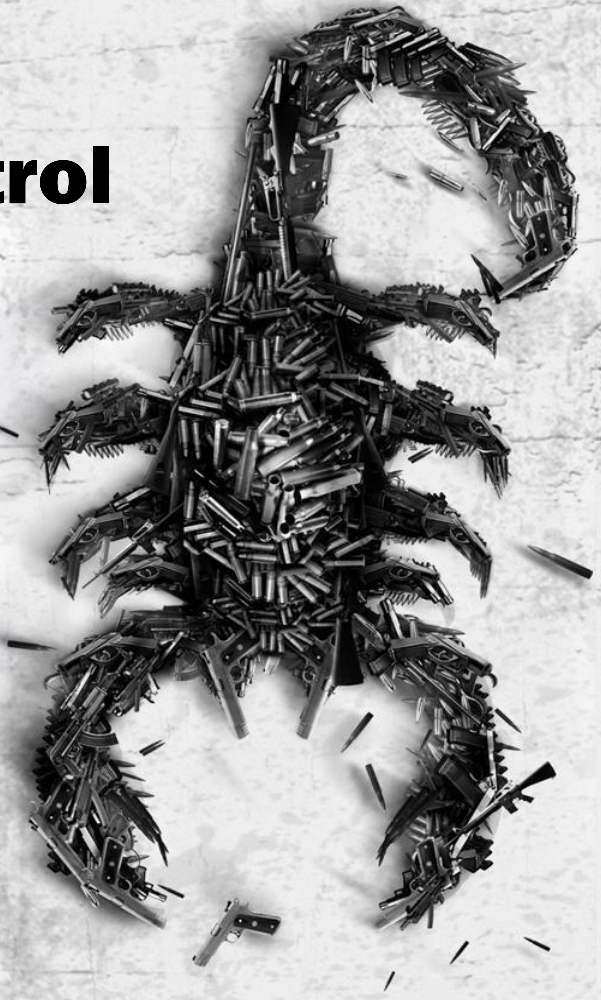
Approach

- Small animation budget
- Large feature set
- Small animation staff budget

$$\frac{\text{Small}}{\text{Large}} = \text{Tiny}$$

Procedural animation?

Motion Control



Motion Control

- Started with badly structured character control system
- Slow and cumbersome to create behaviors
- First : decoupled root motion from posture update
- Refactored functional elements into ‘Motion States’

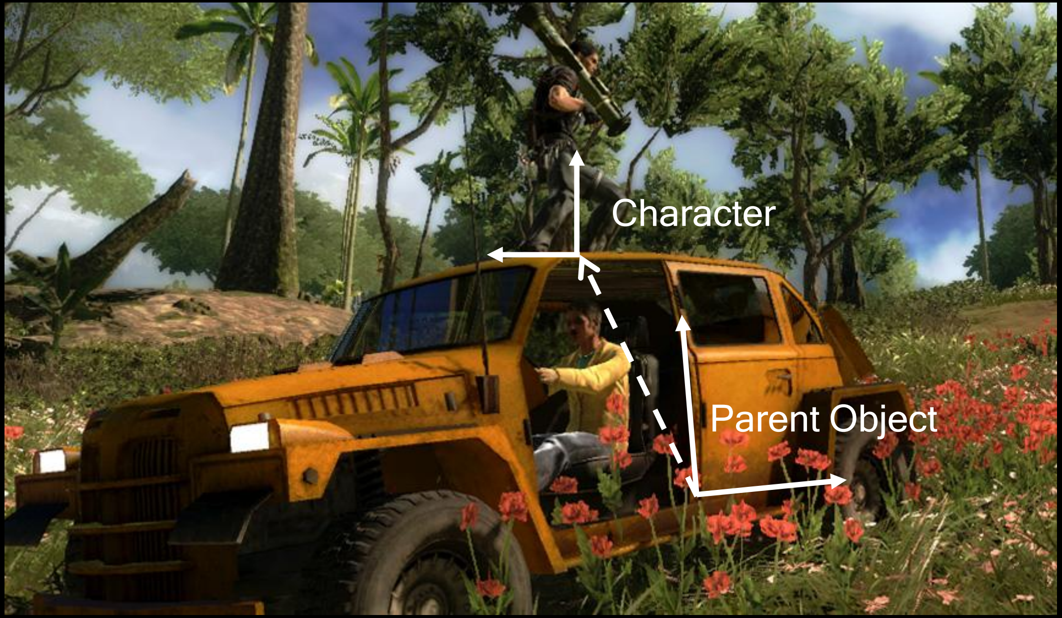
Fast-paced
Motion Transitions

Motion States - Root Node Update

- Desired motion:
  - Procedurally driven motion
  - Animation driven motion
  - Attached motion
- External influences:
  - Collision response
  - Gravity

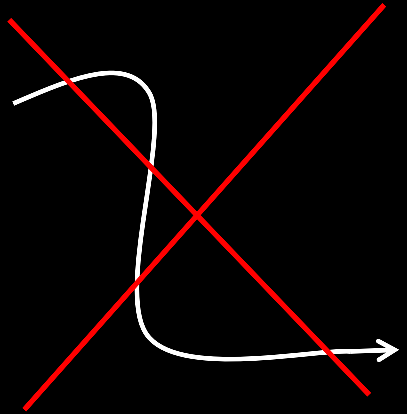
Attached Motion

- Attached characters live in parent's local space
- Character movement changes relation between parent and child
- Animated root node translation and rotation affects offset



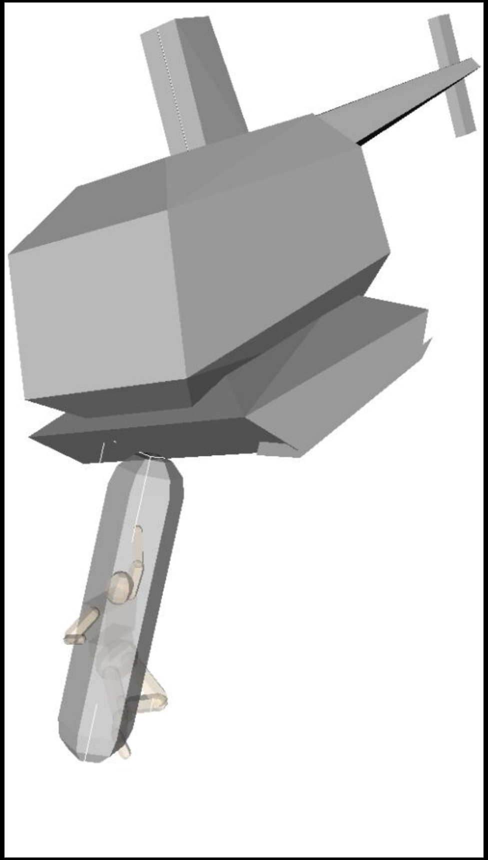
Scaling for fixup / alignment

- Scale motion to realign for specific targets
- Introduces two constraints on the assets
    - Low curvature within the translation
    - No translation during contact with parent
- Animator has control over timing and acceleration



Rigid Body Proxy

- Physical effects applied in a controllable way
- Applying impulses to a ragdoll : less controllable
- Single rigid body represents entire character
- Can be constrained to other objects

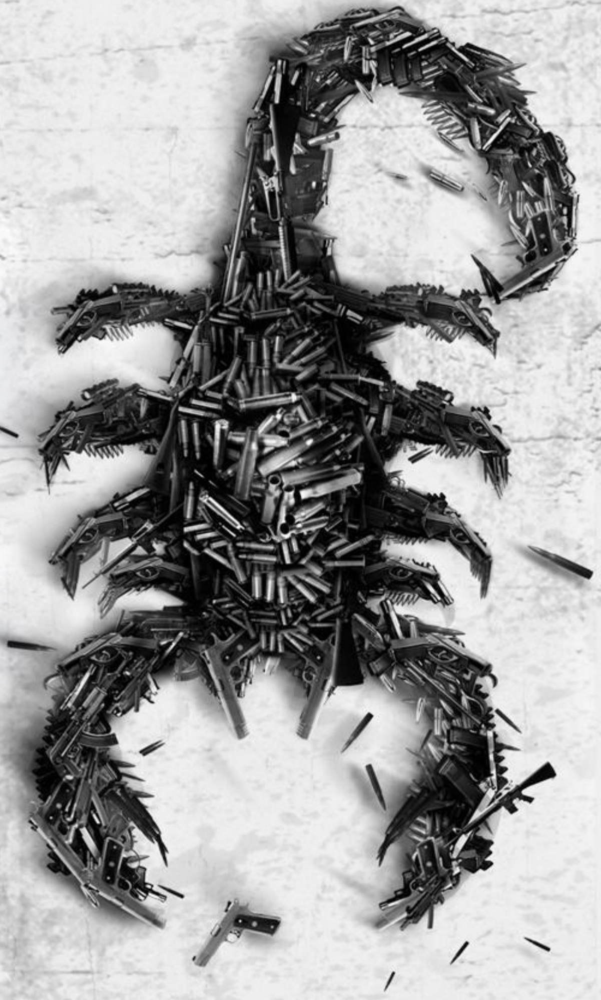


Recoil

Custom Transition States

- Some transitions needed special care
- Transition states bridge between motion states with different velocities
- Applies custom velocities and impulses
- Crucial to fluid gameplay
- These are context dependent

Animation / Physics / IK

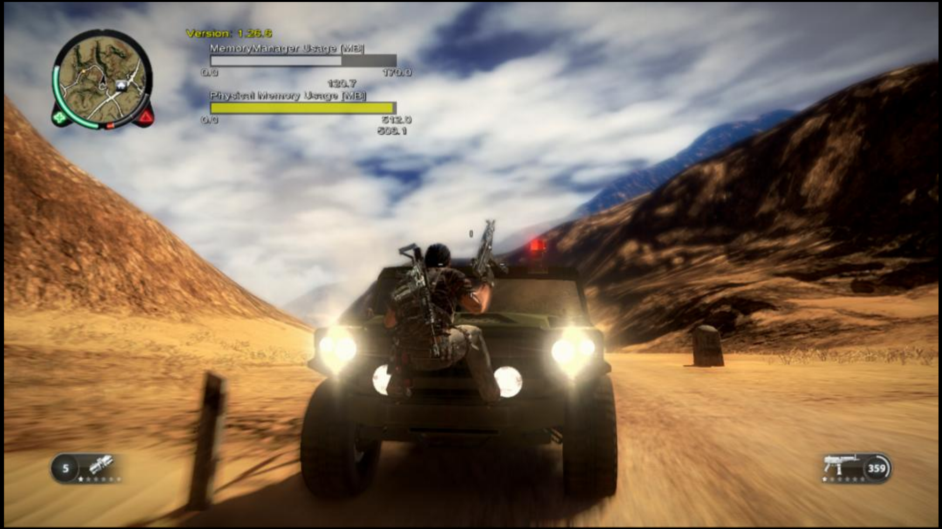


Pre-visualization

Ragdoll / Animation / IK Blending

Systems influencing pose:

- Ragdoll
- Cling animations
- Hand and foot IK
- Aim Constraints



Control Flow

Sample Animation Pose

Foot / Hand IK attachment

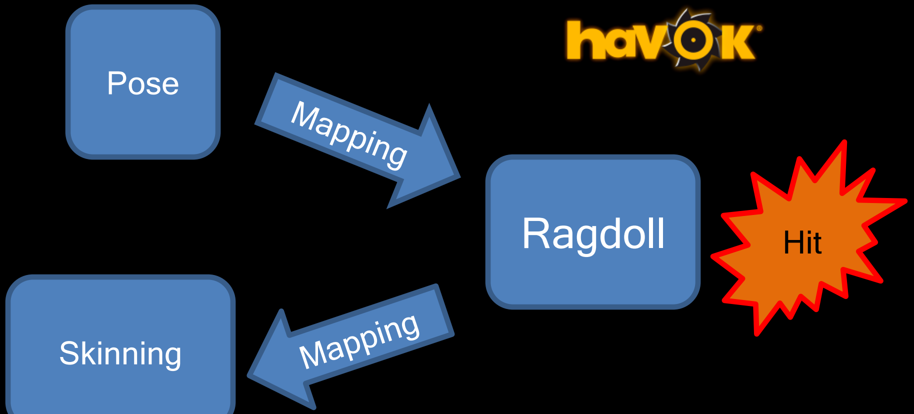
Update ragdoll

Physics Update

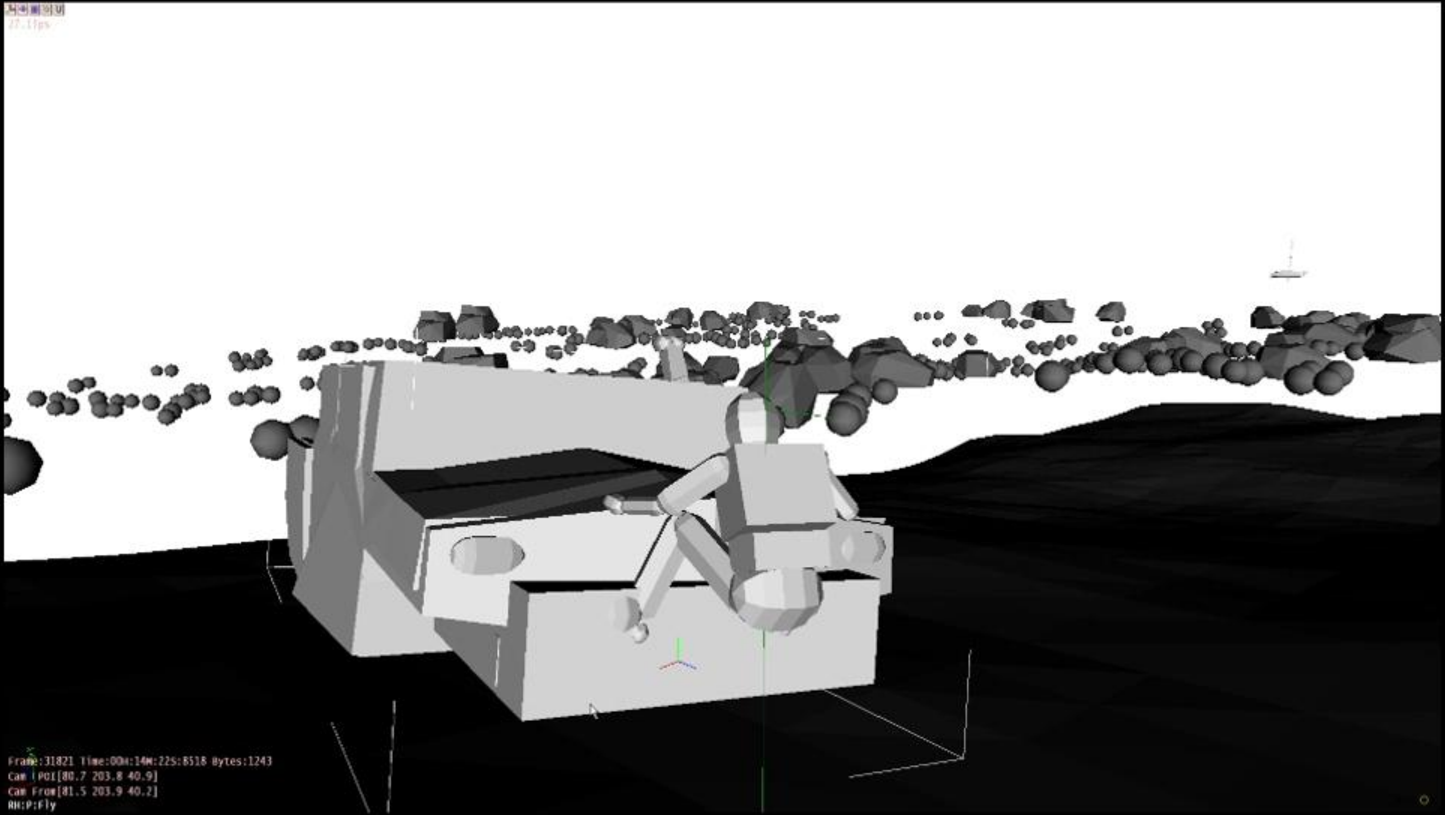
Aim constraints

Skinning

Pose Driving



- Drive ragdoll towards animation pose (using impulses / joint motors)
- Not a keyframed ragdoll - can still respond to collisions



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Cam POI[80.7 203.8 40.9]
Cam From[81.5 203.9 40.2]
RH:P:Fly
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Transition from Ragdoll to Animated

1. Below a certain velocity, transition to Pose Matching state
2. Compare orientation with a number of Get-Up start frames
3. Drive ragdoll towards the closest start frame
4. When close to target pose, start the animation and blend to it

Spinning Ragdolls

Needed Over-the-top, extreme reactions to explosions

1. Applied impulses to torso and hips

   -> Very ragdolly ☺

   -> Occasional instability (stretching)

2. Evenly spread impulses on all bones

   -> Lots of translation, not much spin

   -> Synchronized swimmers (in-sync flailing animation)

   -> Reminiscent of sprites!

Spinning Ragdolls

3. Vector field

   -> Get an axis perpendicular to explosion

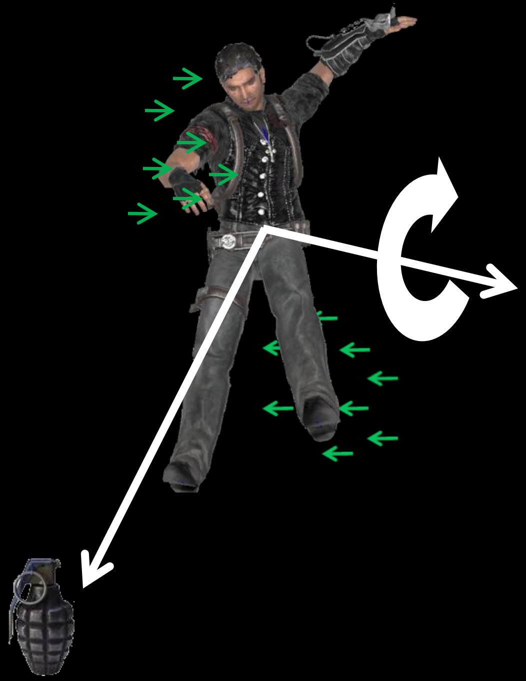
   -> Evenly spread impulses to achieve rotation

   -> Still have synchronized swimmers

4. Randomness

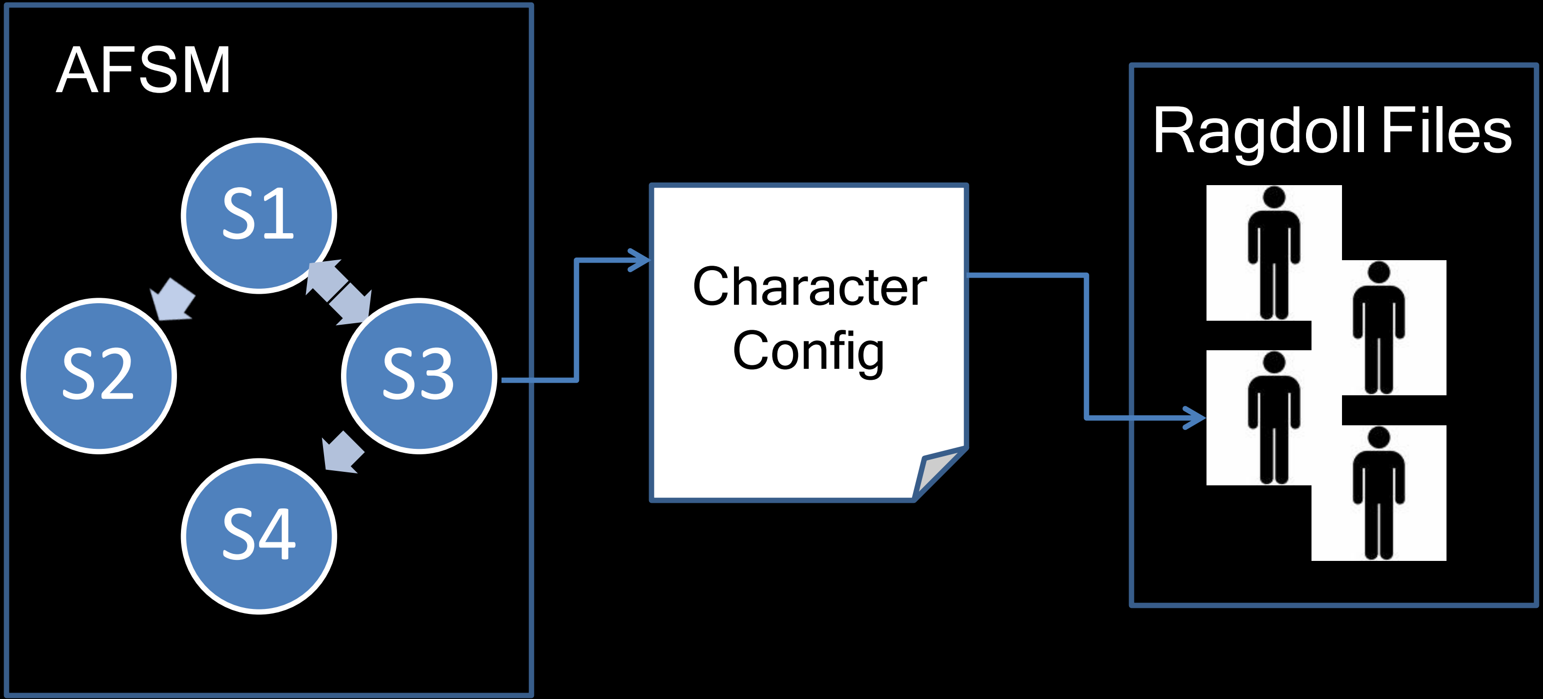
   -> Vary the axis within a 45 degree cone

Note: Also drive towards flail animation

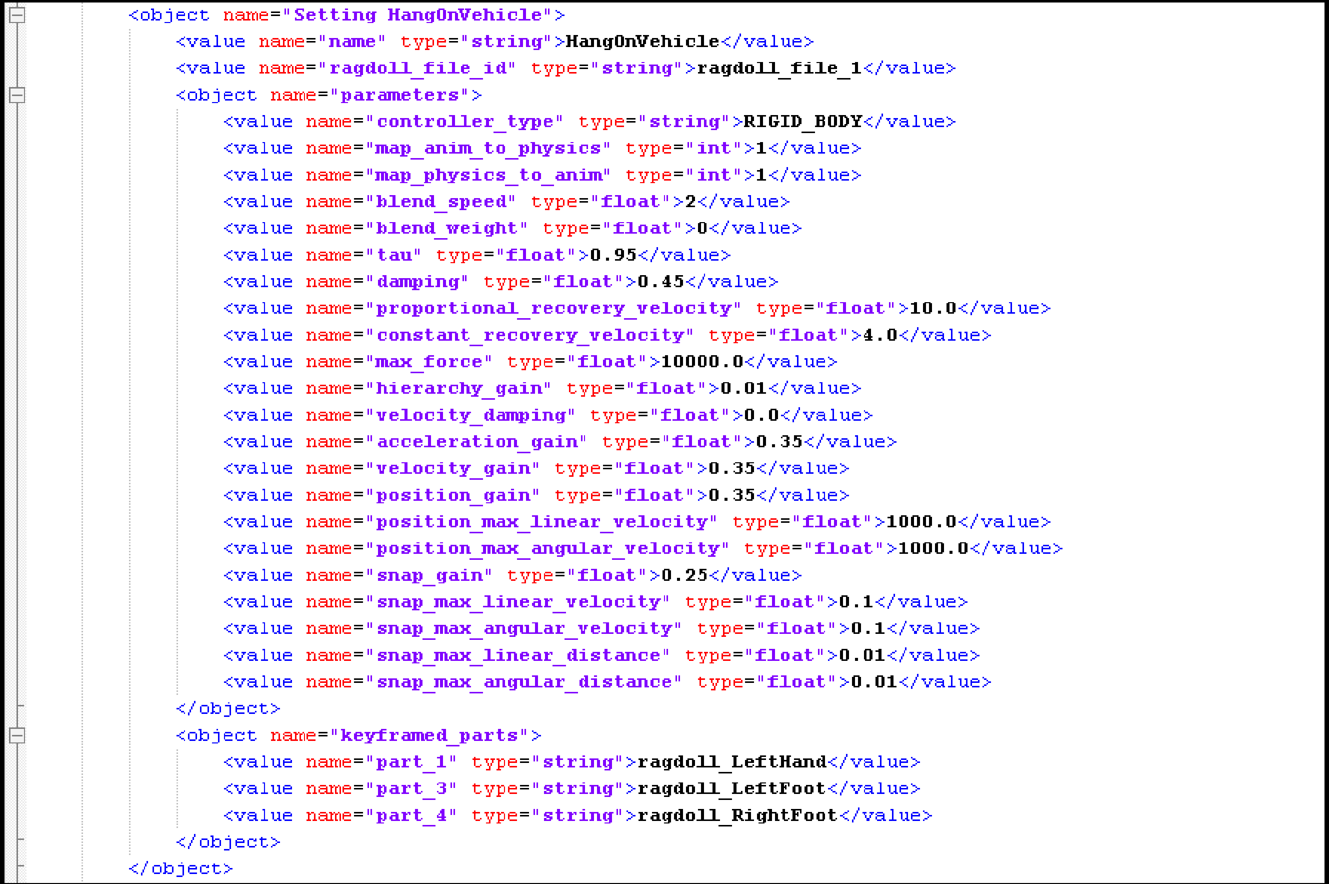


22%

Authoring Ragdoll / Character setup



Authoring Ragdoll / Character setup



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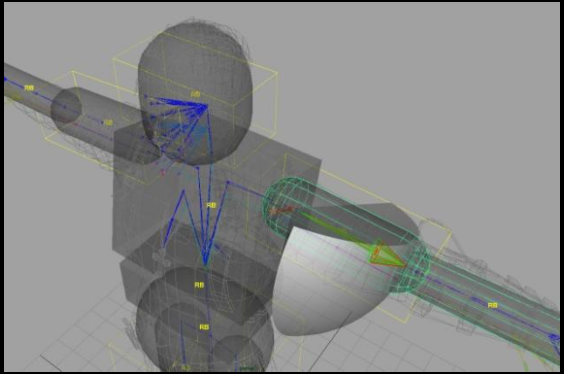
Authoring Ragdoll / Character setup

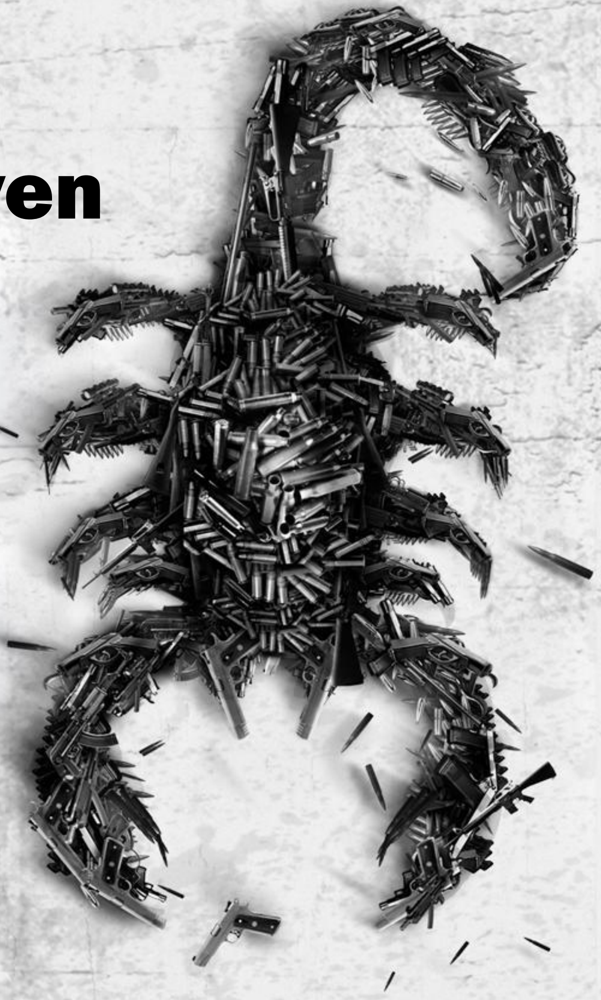
Anecdote:

- Rico freefall colliding state had artifacts
- Technical Animator diagnosed problem:
    - conflicting animation and constraints
- Tweaked ragdoll constraint limits
- Created a new Character Configuration
- Changed ‘Falling’ state to point to this character configuration

- Rico’s death sequence reworked in one morning, no coders involved



Physics Driven Animation



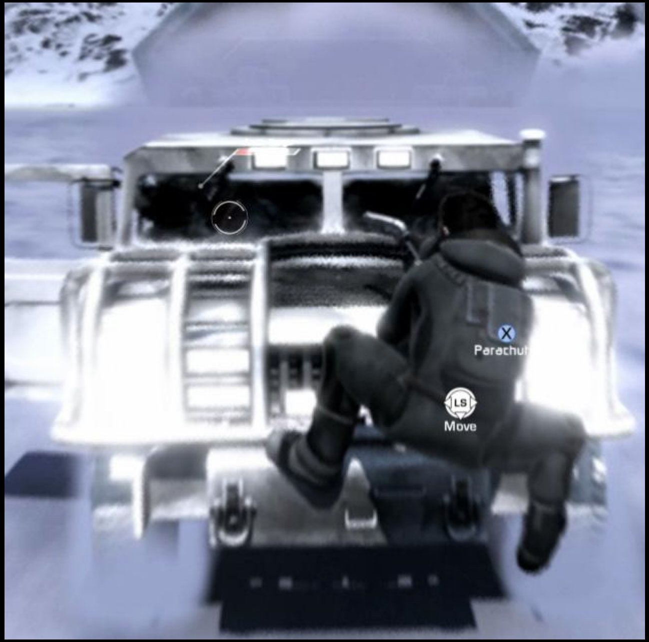
Ragdolls and parent motion

Ragdoll pros

- Feeling of presence
- Collision handling

Ragdoll cons

- Feeling of intention and awareness
- Poor momentum transfer



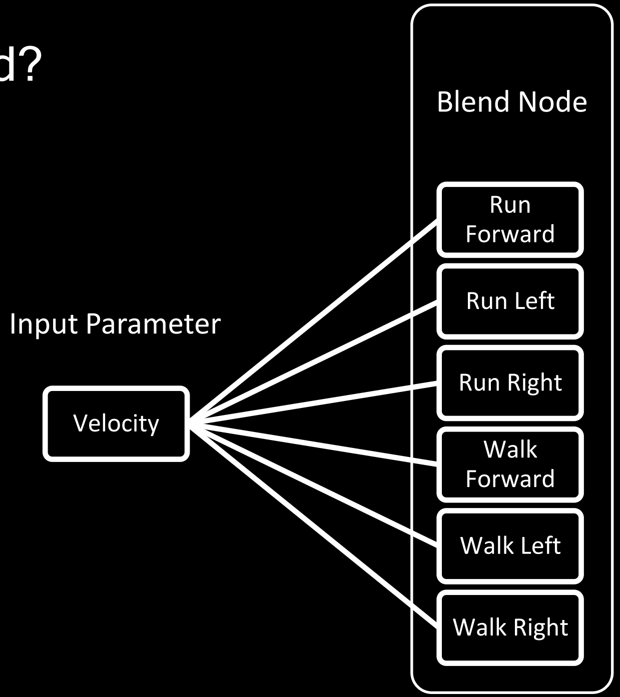
Traditional Link Between Animation and Physics

- Physics Event -> Animation Transition
- Results in:
    - Series of discrete animation states and transitions
    - Recognizable state machine style
    - Repetitive timing and movement patterns
- Artifacts typically combated with:
    - Shorter animations, more transitions, more complex trees?

But ... neither physics nor character behavior is discrete!!!

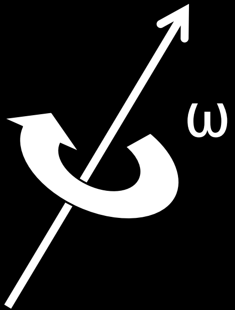
Parametric Animations

- Commonly used for navigation on ground?
- Smooth dynamic motion



Physics Driven Animation

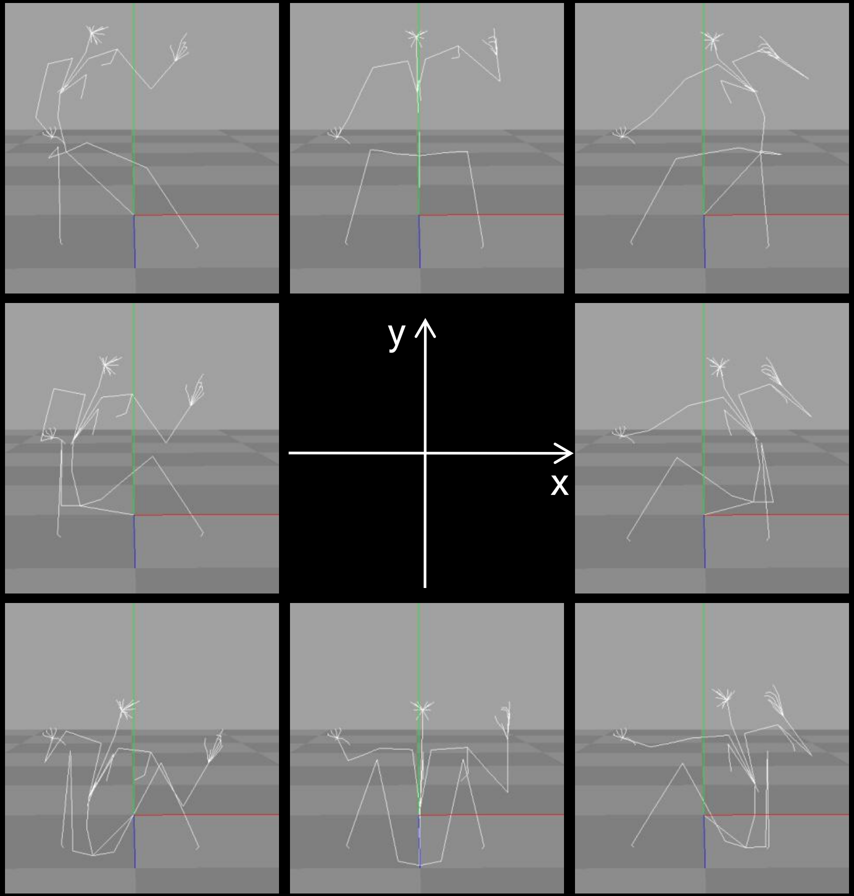
- Parameterize blend nodes with parent’s motion
- Feed in continuous values to act as inputs to single states
- Result? Non-repetitive, smooth motion



Ragdoll Only

How does it work?

- All poses are baked into two animations
  - Upper row from left to right
  - Lower row from left to right
- Middle row is the result of blending
- Project parent’s angular velocity onto..
  - X-axis to determine blend weight
  - Y-axis to determine sample time

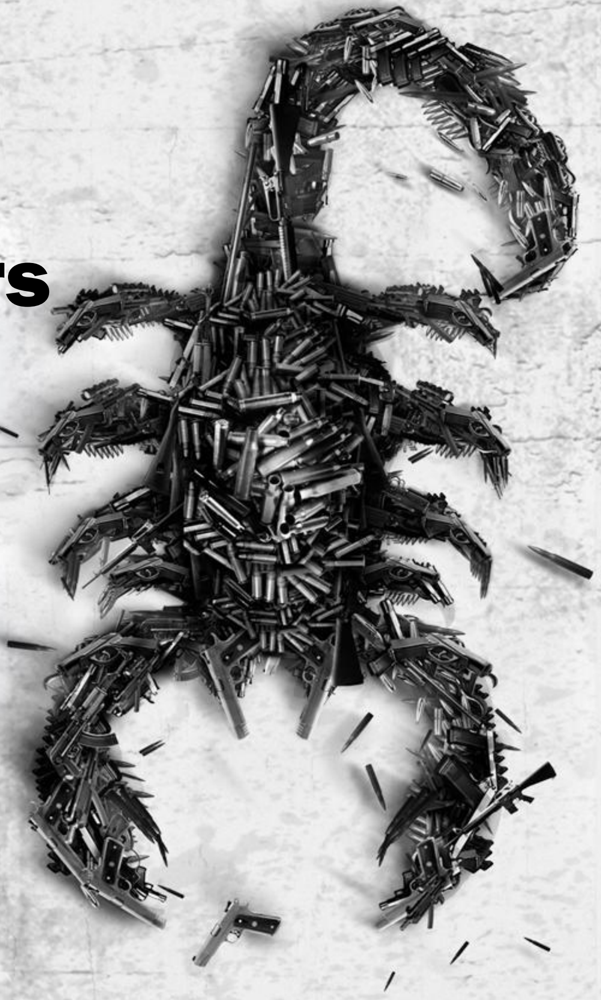


...One Step Further

- Multiple parameterizations create variation
- Parachuting has the following inputs:
    - Acceleration, velocity and gamepad input
- Riding motorcycle has the following inputs:
    - Suspension length rate of change
    - Speed
    - Orientation
    - Gamepad input

Physics Driven Animation

Effectors / Manipulators



Animation Driven Impulses

- Wanted data driven physical effectors

- Animations contain annotations, e.g:

  DOWNWARD-IMPULSE-LIGHT

  DOWNWARD-IMPULSE-HEAVY

- Impulses applied to parent or target body

- E.g. foot down event, enter vehicle, some cling positions

Motorbike Tilt

- Let the player feel in control of the driver
- Forward-back controls player lean … C.O.M. shift
- Re-align constraint limits on front and back
- Makes it easier to tip backwards
- Also allows for leaning forwards / backwards in air

The Almighty Grapple

- Physical constraint

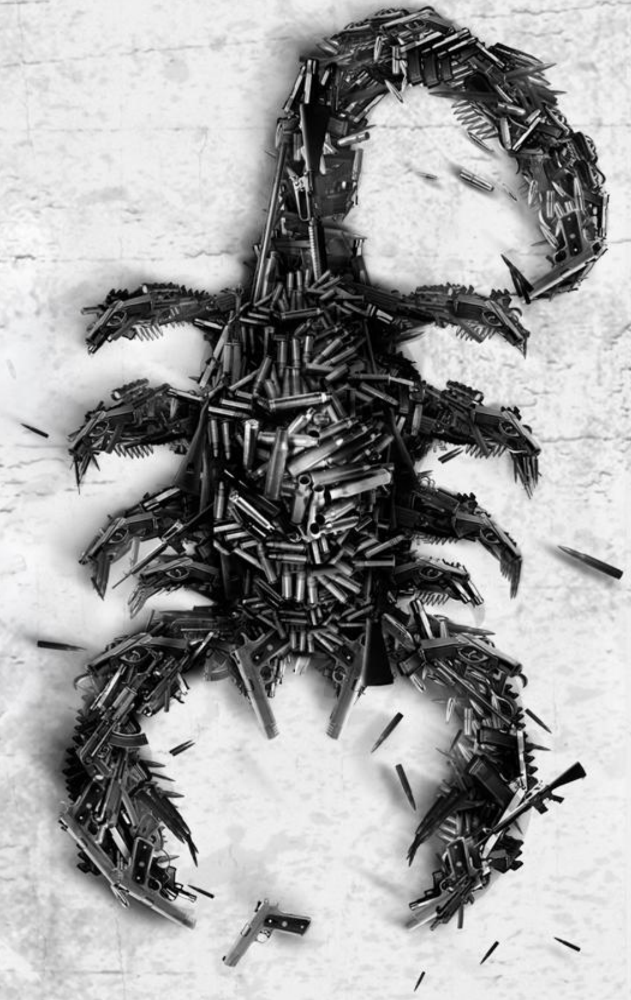
- Can ‘tie’ nearly any two physics objects together

- Custom impulses applied: e.g. yanking, wall tether, dual tether two enemies, etc.

- Shorten the constraint to draw things together

Animation Driven Impulses

Findings



Problems we faced / Tips

Ragdoll Stability:

- Requires constant maintenance
- Animation poses must not violate constraint limits
  - Use different ragdolls to suit the context
- QA unfamiliar with problem domain
- Monitor edge cases : have a fallback

Problems we faced / Tips

Ragdoll Driving:

- Varied quality at different speeds
- Tried varying driving params with speed, ran out of time

Motion:

- Transitions between Motion States took a lot of work

Problems we faced / Tips

Blending:

- Noisy physics signal – filter
- Blending away from a parametric blend node can be difficult

Dependencies:

- Difficult to tweak without side effects

Important decisions we made

- We separated motion state from pose generation

- Many states had different control flow for IK / Animation / Physics.
    - We were able to vary this control flow for each state.
    - Not quite a dynamic ‘shader pipeline’, but flexible

- Exposed elements of the character configuration to content creators

Advantages of using Physics

- Cheap variation - few added animations
- Rich context data to drive animation blending
- Collision response enriches feeling of interaction and presence
- Fun emergent gameplay, e.g. grapple

Disadvantages of using Physics

- Requires constant maintenance and tuning

- Hard to preview final visual outcome

- Requires expertise across the organization, e.g. game designers, animators, QA

Thanks!

Just Cause 2 Team

Avalanche Studios

Eidos

Square Enix

Havok

Q & A