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Lecture 8

2D Animation

Animation Basics: Sprite Sheets

- Animation is a sequence of **hand-drawn frames**
  - Smoothly displays action when change quickly
  - Also called flipbook animation
- Arrange animation in a **sprite sheet** (one texture)
  - Software chooses which frame to use at any time
  - So programmer is actually the one doing animation

Anatomy of SpriteNode Class

```
/**
 * Sets the active frame as the given index.
 *
 * @param frame the index to make the active frame
 */
void SpriteNode::setFrame(int frame) {
    this->frame = frame;
    int x = (frame % cols)*bounds.size.width;
    int y = (frame / cols)*bounds.size.height;
    bounds.origin.set(x,y);
    setPolygon(bounds);
}
```


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Anatomy of AnimationNode Class

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    setPolygon(bounds);
}
```

Actual code has some minor optimizations

Adjusting your Speed

- Do not want to go too fast
  - 1 animation frame = 16 ms
  - Walk cycle = 8/12 frames
  - Completed in 133-200 ms
- General solution: *cooldowns*
  - Add an int timer to your object
  - Go to next frame when it is 0
  - Reset it to > 0 at new frame
- Simple but tedious
  - Have to do for each object
  - Assumes animation is in a loop

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Matching Your Translation

- Movement is *two* things
  - **Animation** of the filmstrip
  - **Translation** of the image
  - These two must align
- **Example:** Walking
  - Foot is point of contact
  - “Stays in place” as move
  - This constrains translation
- Make movement regular
  - Measure distance per frame
  - Keep same across frames

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Point of contact

Distance forward

Combining Animations

Landing Animation

Idling Animation

- Characters do a lot of things
  - Run, jump, duck, slide
  - Fire weapons, cast spells
  - Fidget while player AFK
- Want animations for all
  - Is loop appropriate for each?
  - How do we transition?
- **Idea**: shared boundaries
  - End of loop = start of another
  - Treat like advancing a frame

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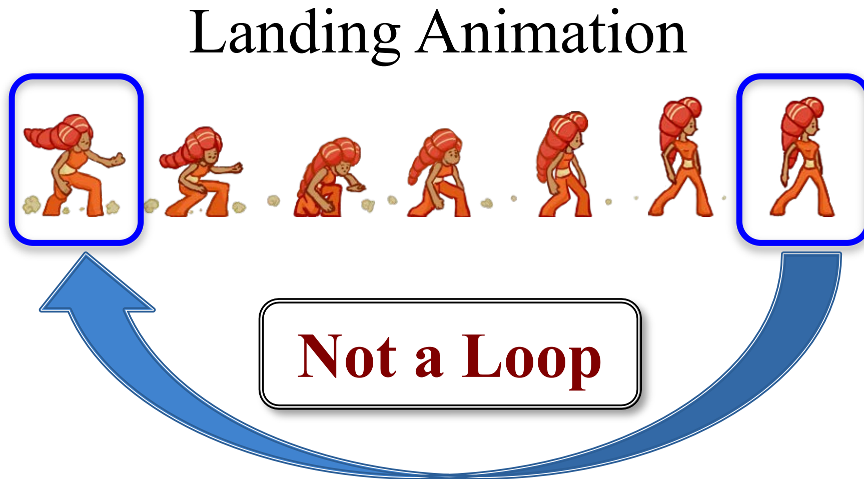
Combining Animations

Landing Animation



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  - F… …r
  - T… …

But do not draw ends twice!

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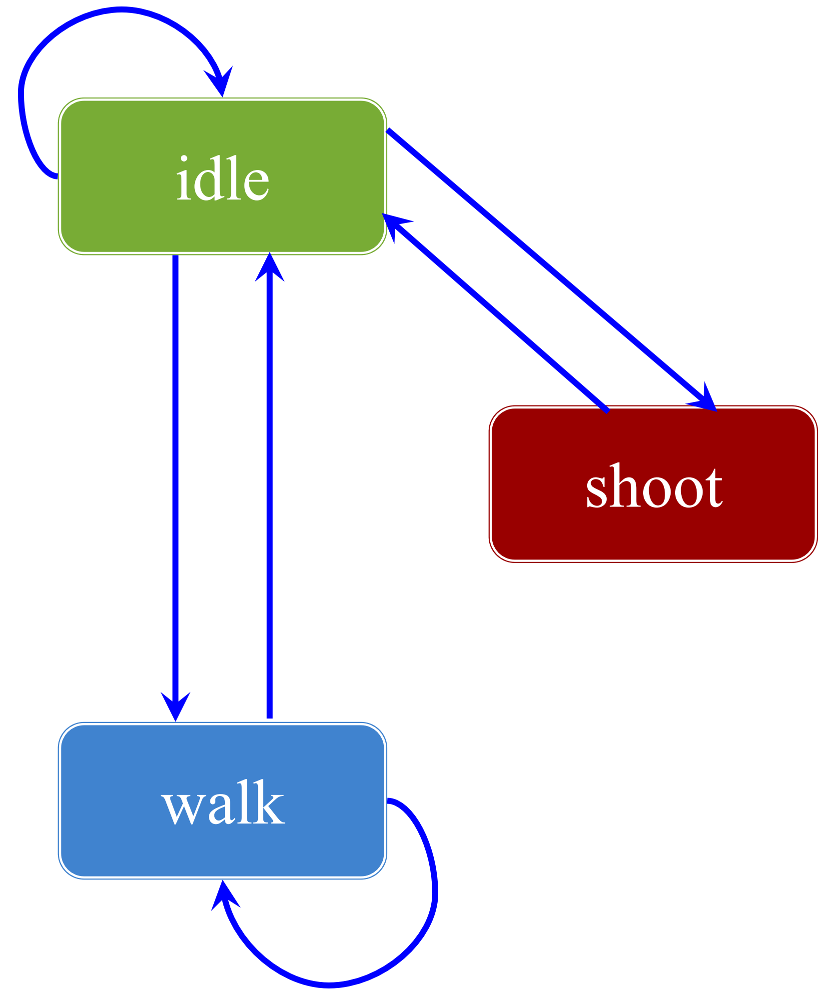
Animation and State Machines

- Idea: Each sequence a state
  - Do sequence while in state
  - Transition when at end
  - Only loop if loop in graph
- A graph edge means…
  - Boundaries match up
  - Transition is allowable
- Similar to data driven AI
  - Created by the designer
  - Implemented by programmer
  - Modern engines have tools



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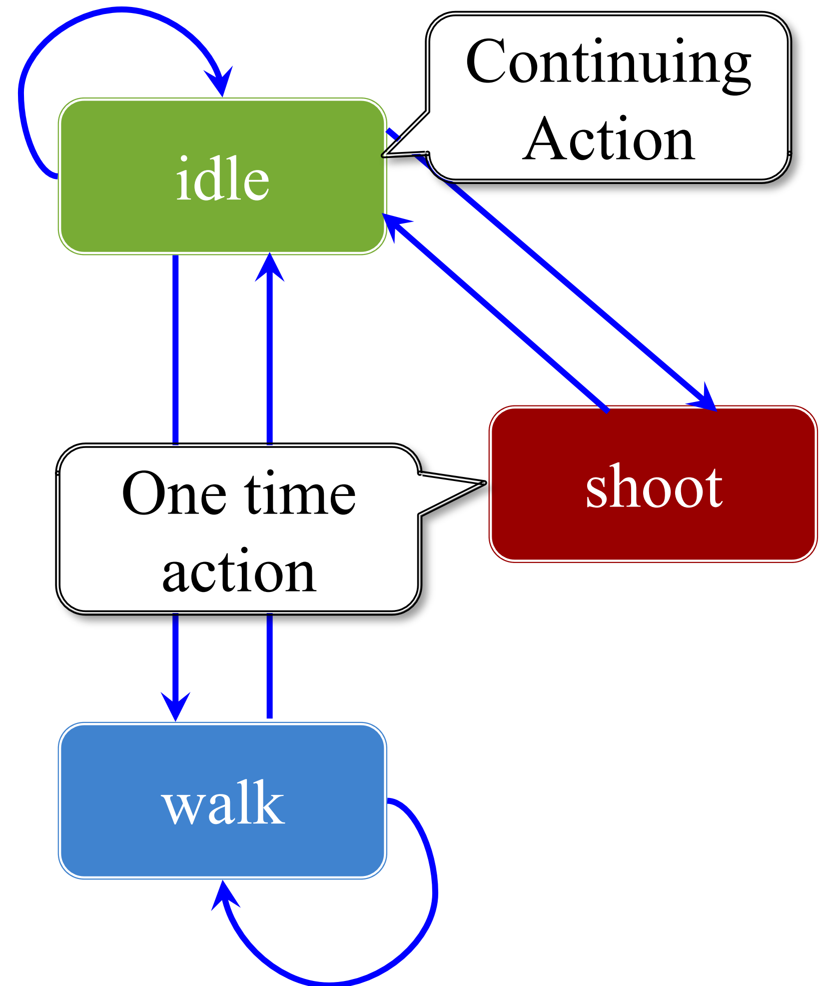
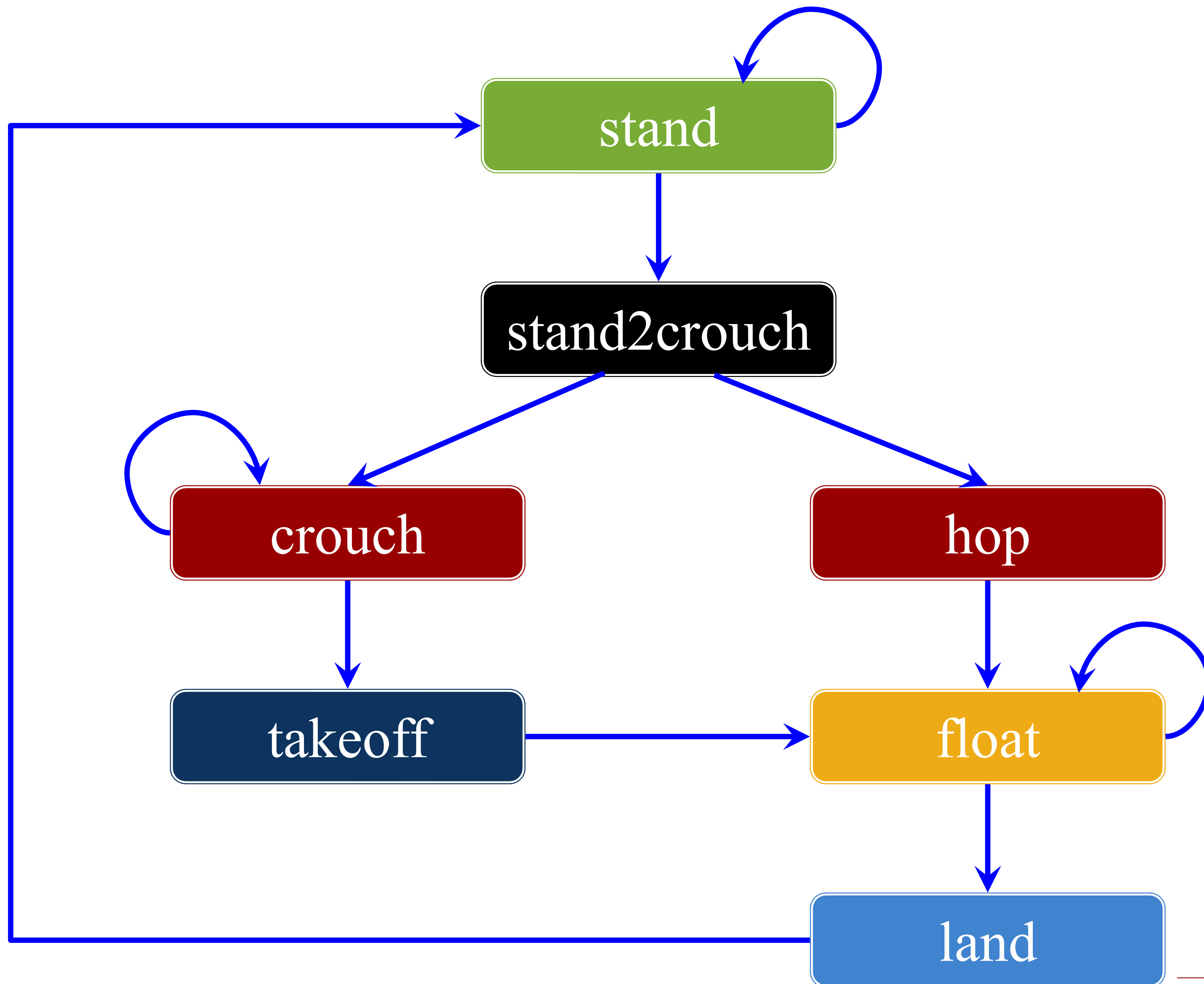


Complex Example: Jumping



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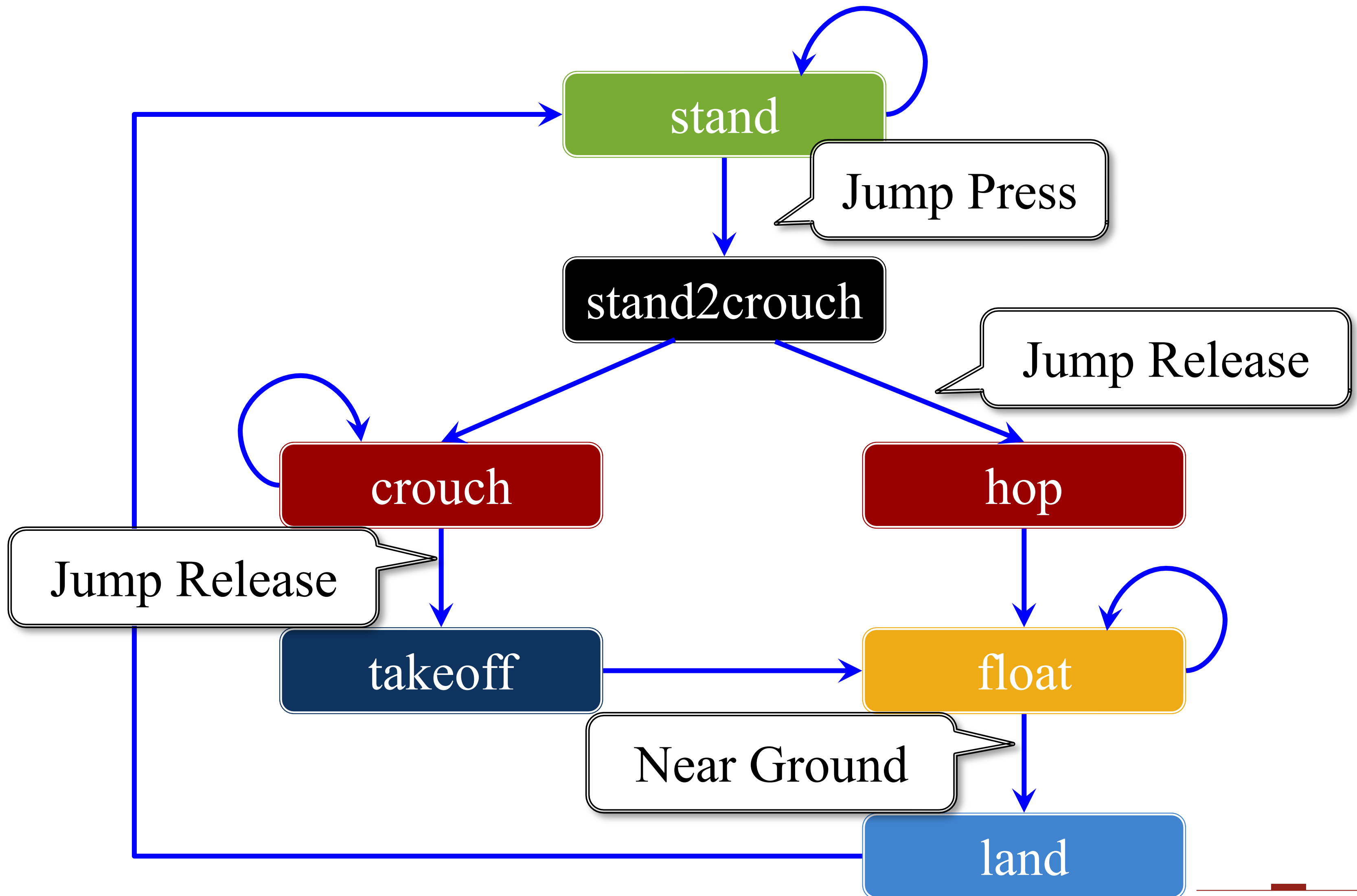

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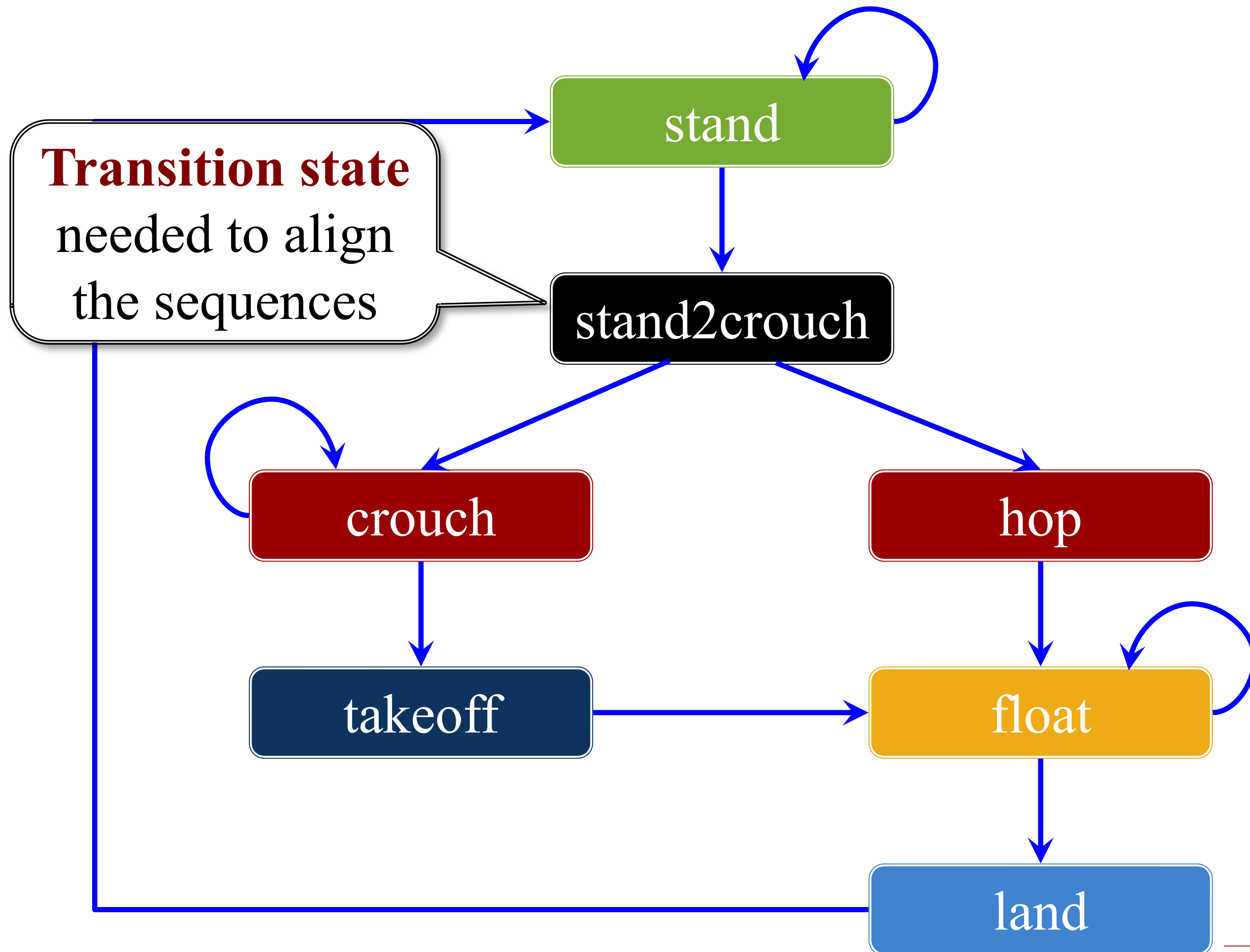
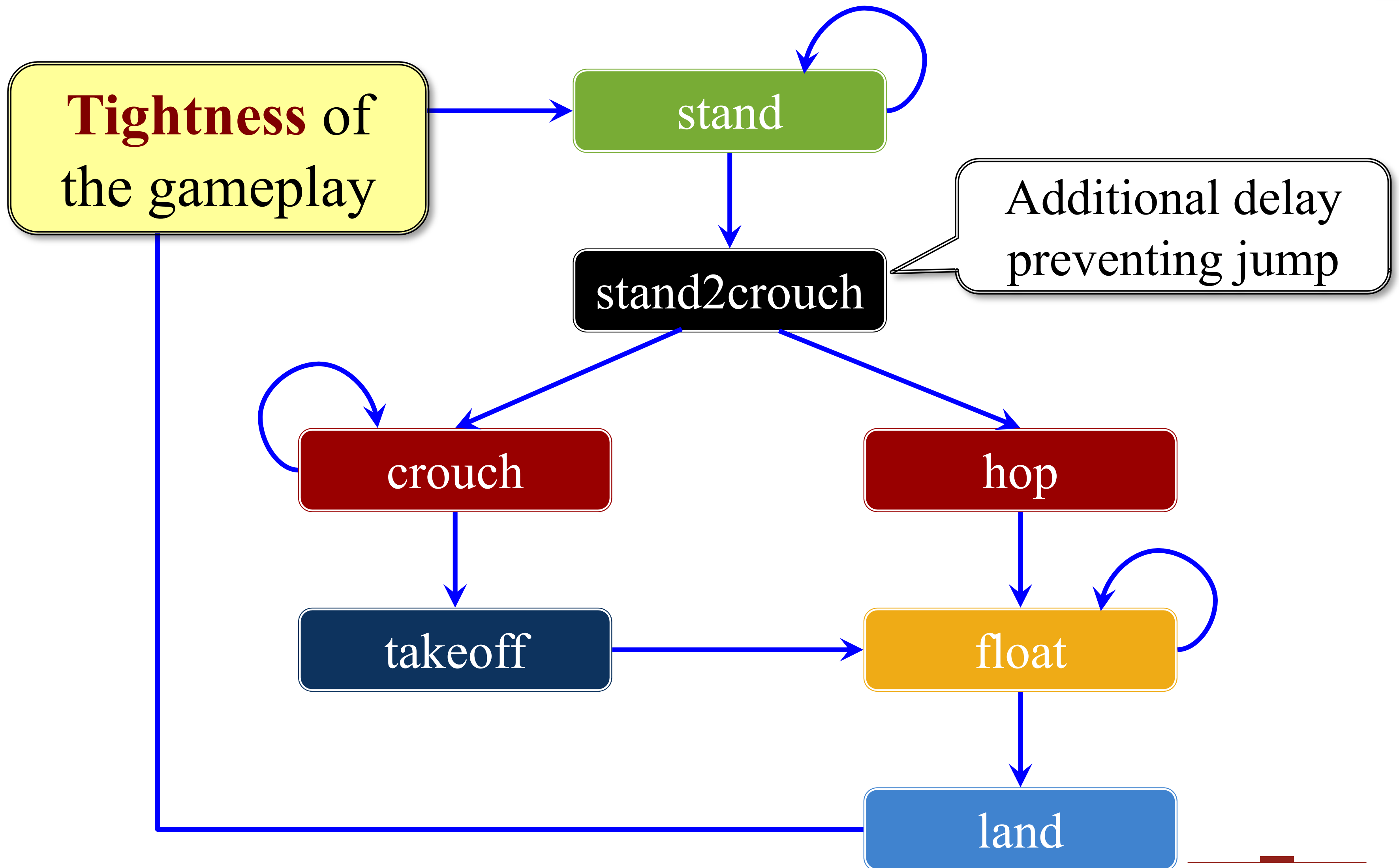
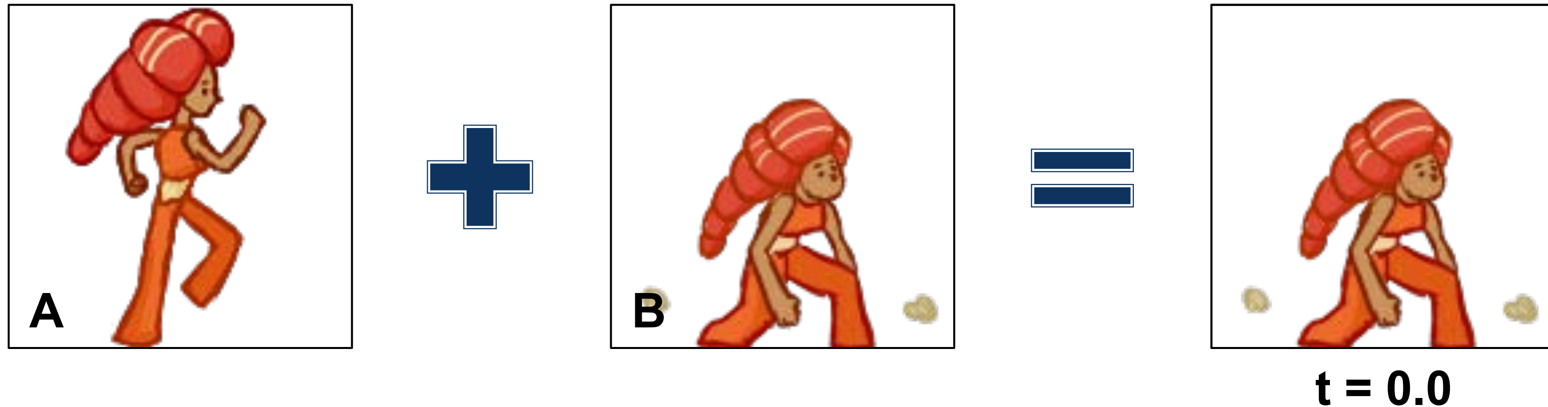


Aside: Sync Kills

The Responsiveness Issue



Fast Transitions: Crossfade Blending



- Linear interpolation on colors

$$r_c = tr_a + (1-t)r_b$$
$$g_c = tg_a + (1-t)g_b$$
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Note weights sum to 1.0

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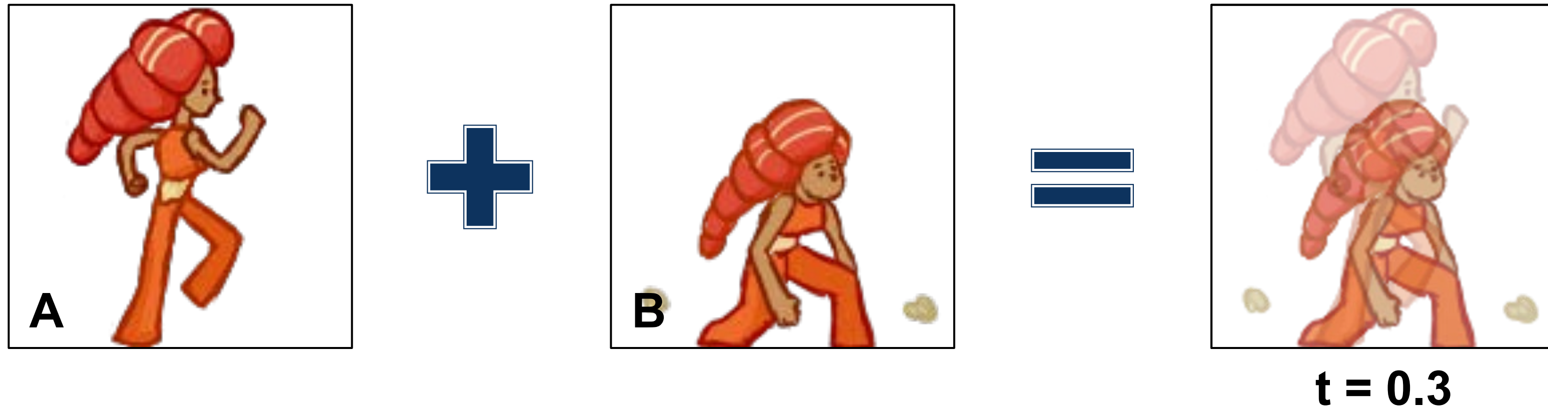

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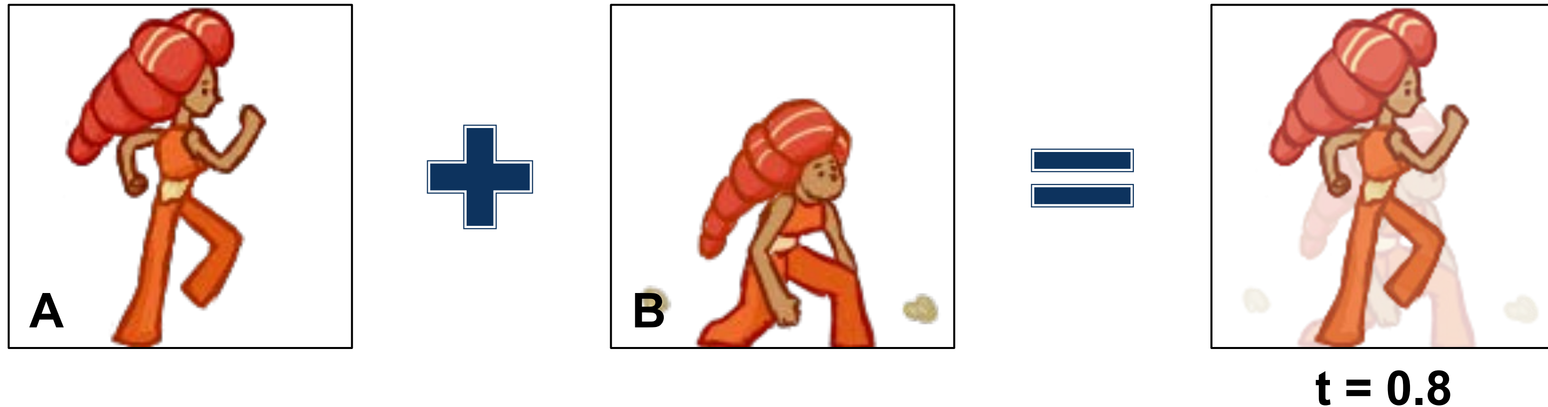

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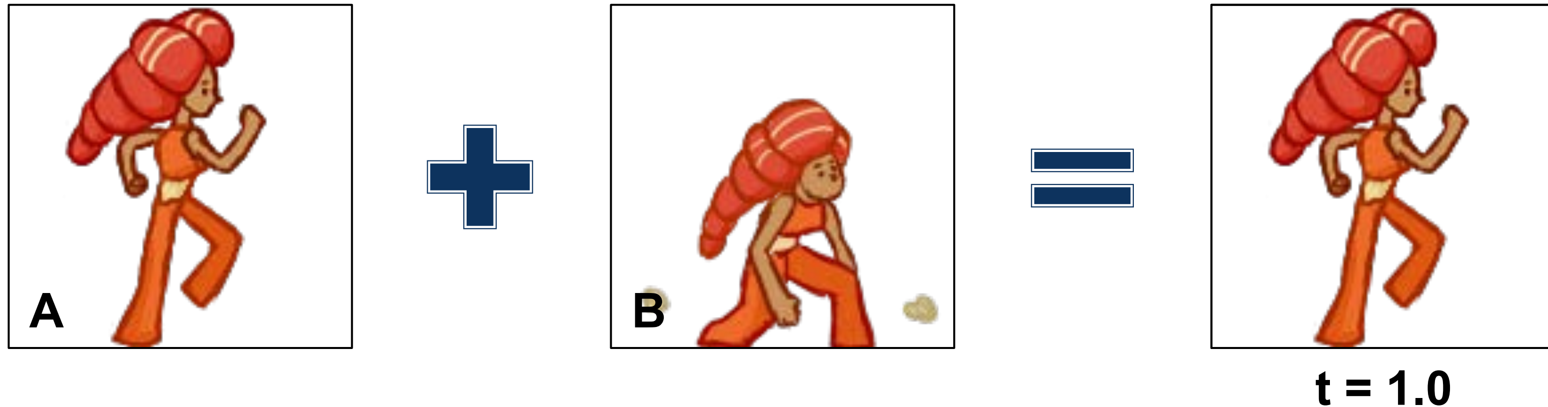

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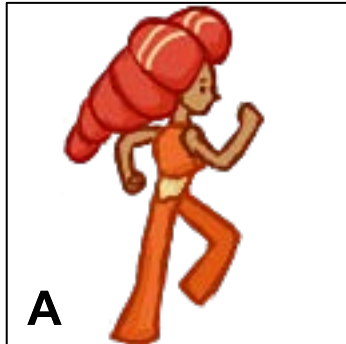
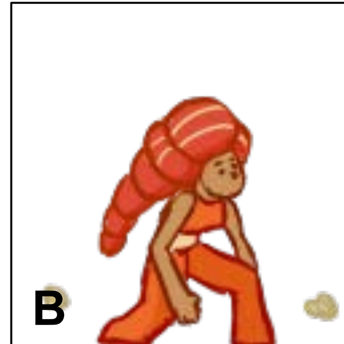
Combining With Animation



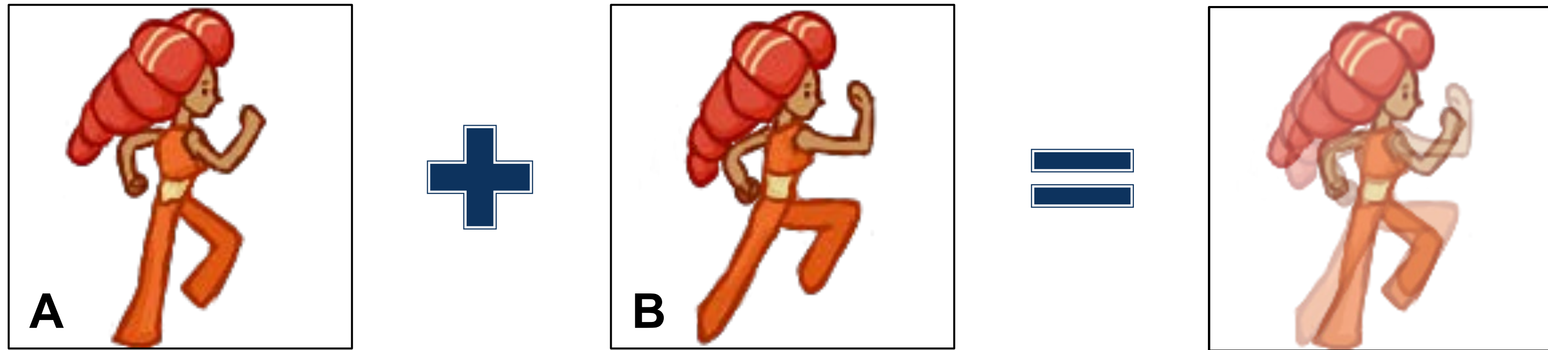


Cycle the filmstrip normally

Cycle the filmstrip normally

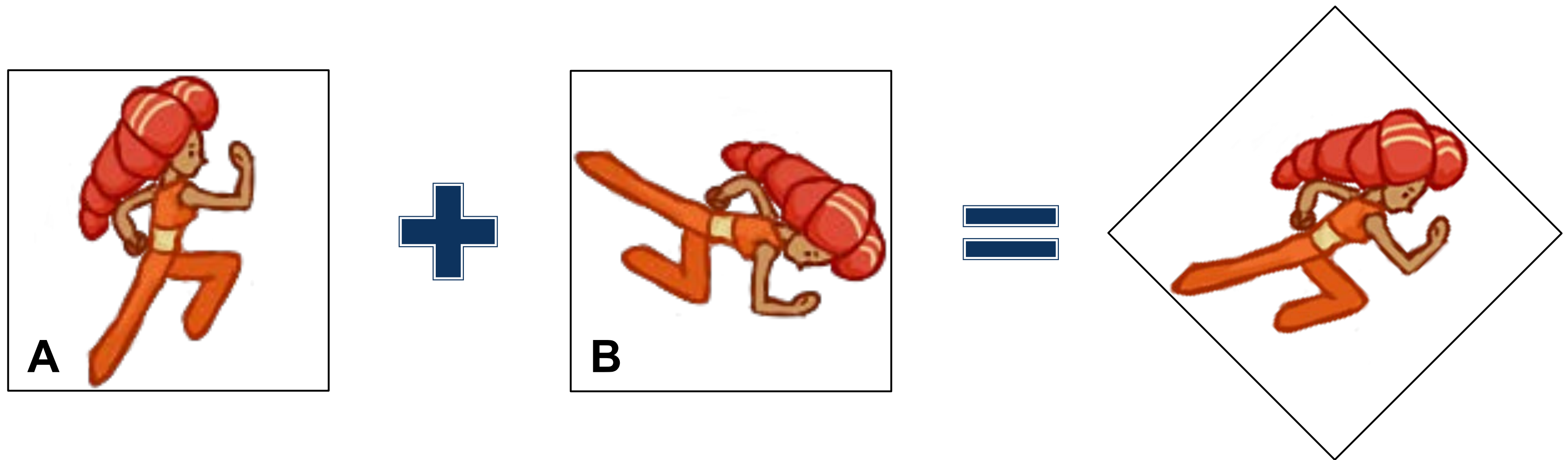
Combine with alpha blending

Related Concept: **Tweening**



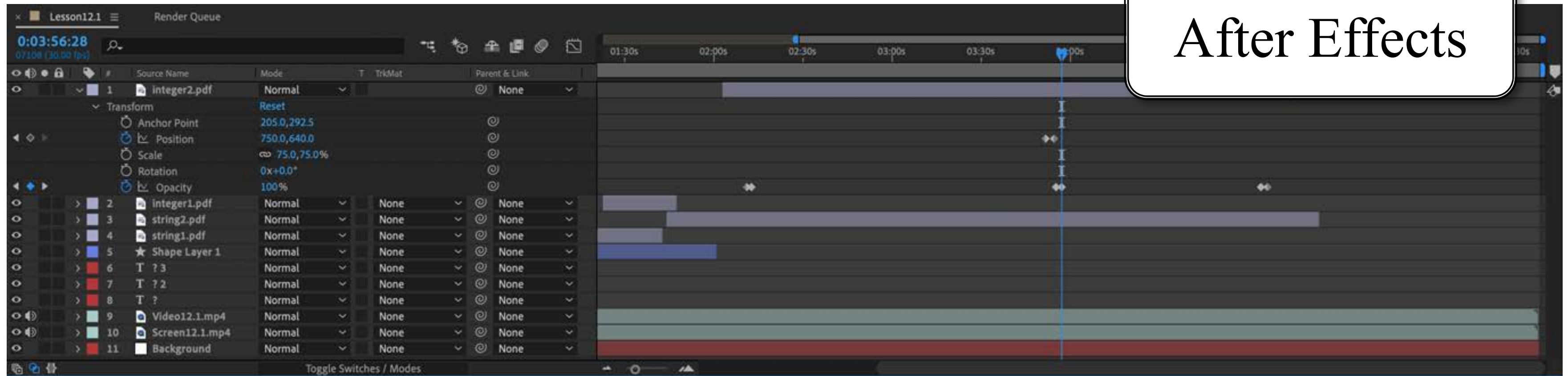
- Act of linear interpolating between animation frames
  - Because we cycle filmstrip slower than framerate
  - Implements a form of motion blur
- If animation **designed right**, makes it smoother

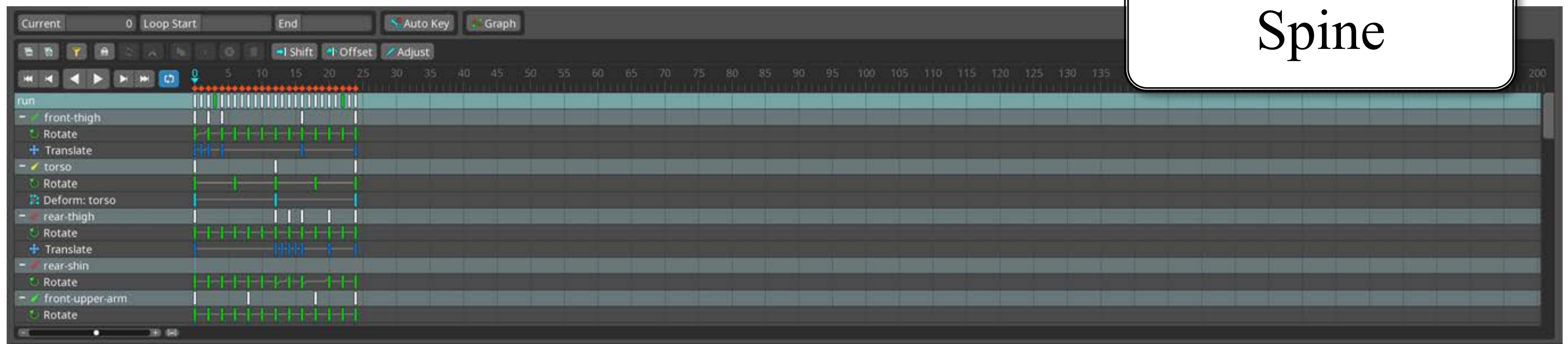
Tweening Works for Transforms Too



- Any transform is represented by a matrix
  - Can linearly interpolate matrix components
  - Gives a reasonable transform "in-between"
- **Aside**: This is a motivation for quaternions
  - Gives smoother interpolation for rotation

Tweening vs Keyframes





Tweening vs Keyframes

Tweening

- Specify the action
  - Give an action and a time
  - Frames are interpolations
- **Programmer** centric

Keyframes

- Specify the result
  - Give start and end points
  - Middle is interpolated
- **Designer** centric

Essentially the same concept.
Difference is the specification.

Supporting Tweened Animations

Actions

- Represents animation type
  - Moving, rotating, scaling
  - Filmstrip sequences
- But not active animation
  - Can be reused and replayed
  - Can be copied safely
- Think of as a "template"
  - Defines the tweening
  - But has no internal state

ActionManager

- Manages active animations
  - Maps actions to scene graph
  - Allocates animation state
- Has a separate update loop
  - Initialization step at start
  - Update step to increment
- Similar to **asset manager**
  - Animations have key id
  - Run `update()` to fit budget

Supporting Tweened Animations

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- Similar to **asset manager**
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Executing Actions: Transforms

```
auto mgr = ActionManager::alloc();
auto action = RotateBy::alloc(90.0f,2.0f);
mgr->activate(key,action,sprite);

while (mgr->isActive(key)) {
    mgr->update(TIMESTEP);
}
// No clean-up.  Done automatically
```

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ActionManager

Action

Map Action to key and start

Increments animation state

Tweens rotation

Executing Actions: **Sprite Sheets**

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```

How long to spend

Maps to framerate

Tweens rotation

Executing Actions: Sprite Sheets

```
auto mgr = ActionManager::alloc();

std::vector<int> frames;
frames.push_back(f1);
 ...
frames.push_back(f8);

auto action = Animate::alloc(frames,2.0f);

mgr->activate(key,action,sprite);
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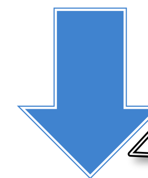
Sequence indices

Frames displayed uniformly



Does not tween

Executing Actions: **Sprite Sheets**

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auto action

mgr->activa
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}

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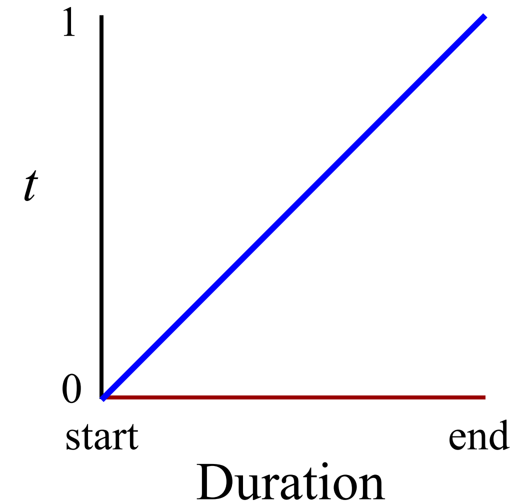
Alternatively, could specify time per frame

Easing Function

- Basic approach to tweening
  - Specify duration to animate
  - Set $t = 0$ at beginning
  - Normalize $t = 1$ at end
  - Interpolate value with t
- How does t change?
  - Usually done *linearly*
  - Could be some other way
- **Easing**: how to change t
  - Used for bouncing effects
  - Best used for *transforms*



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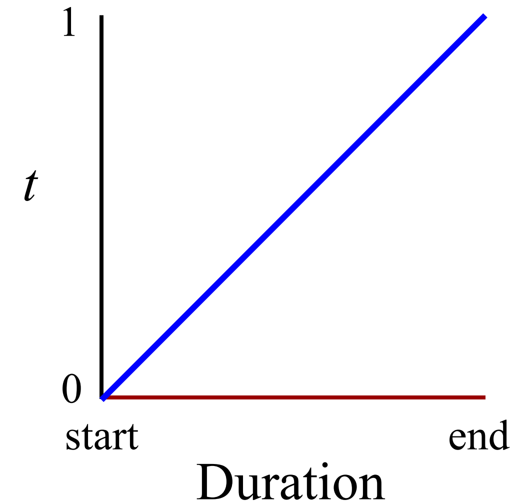
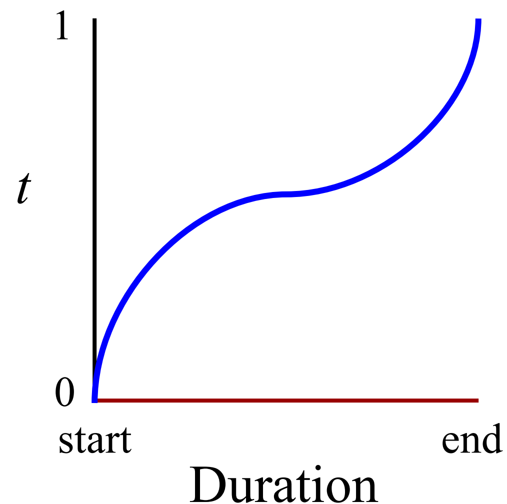
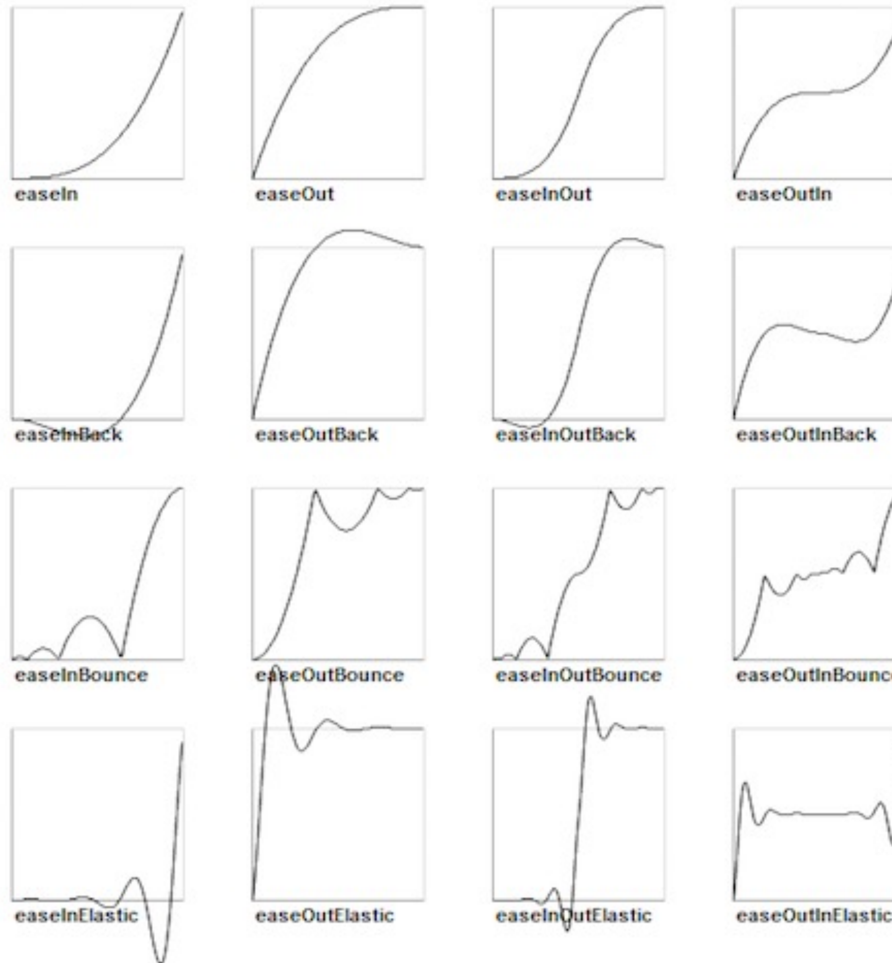


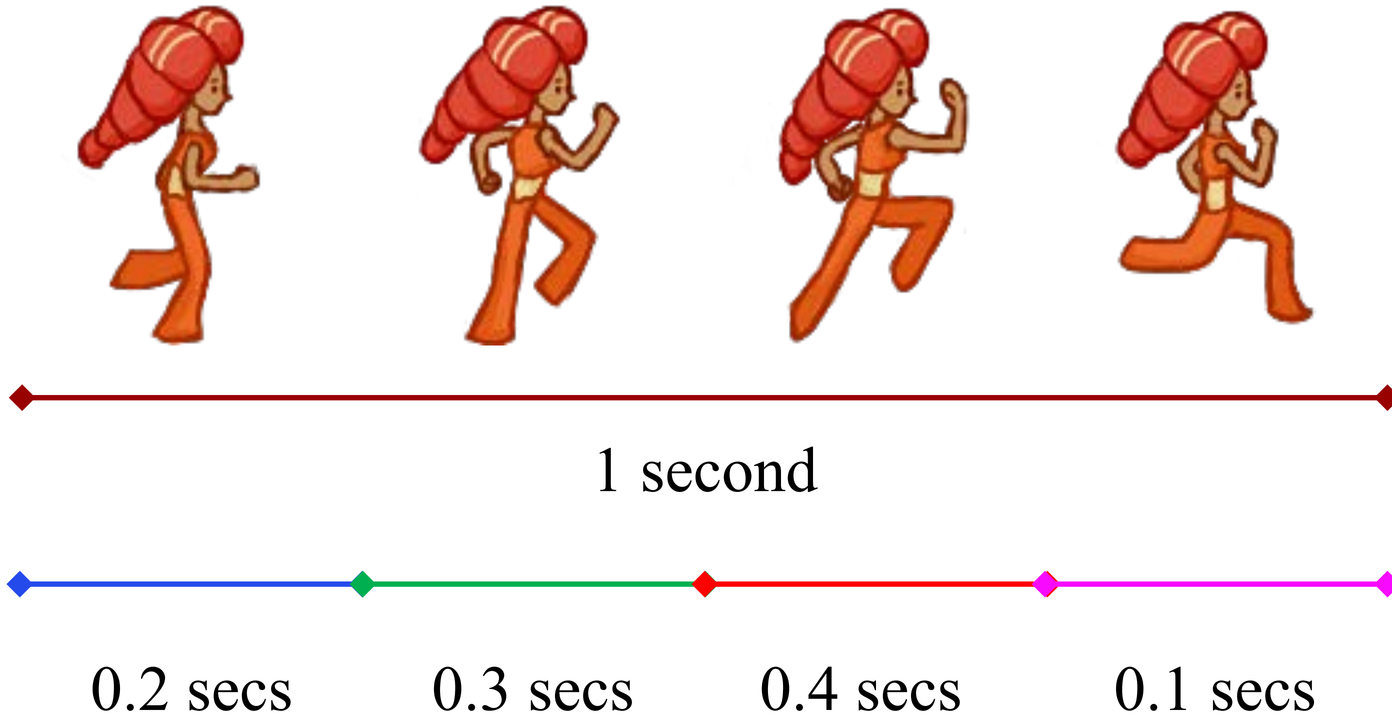


Classic Easing Functions



Classic Easing Functions

Application to Sprite Animation



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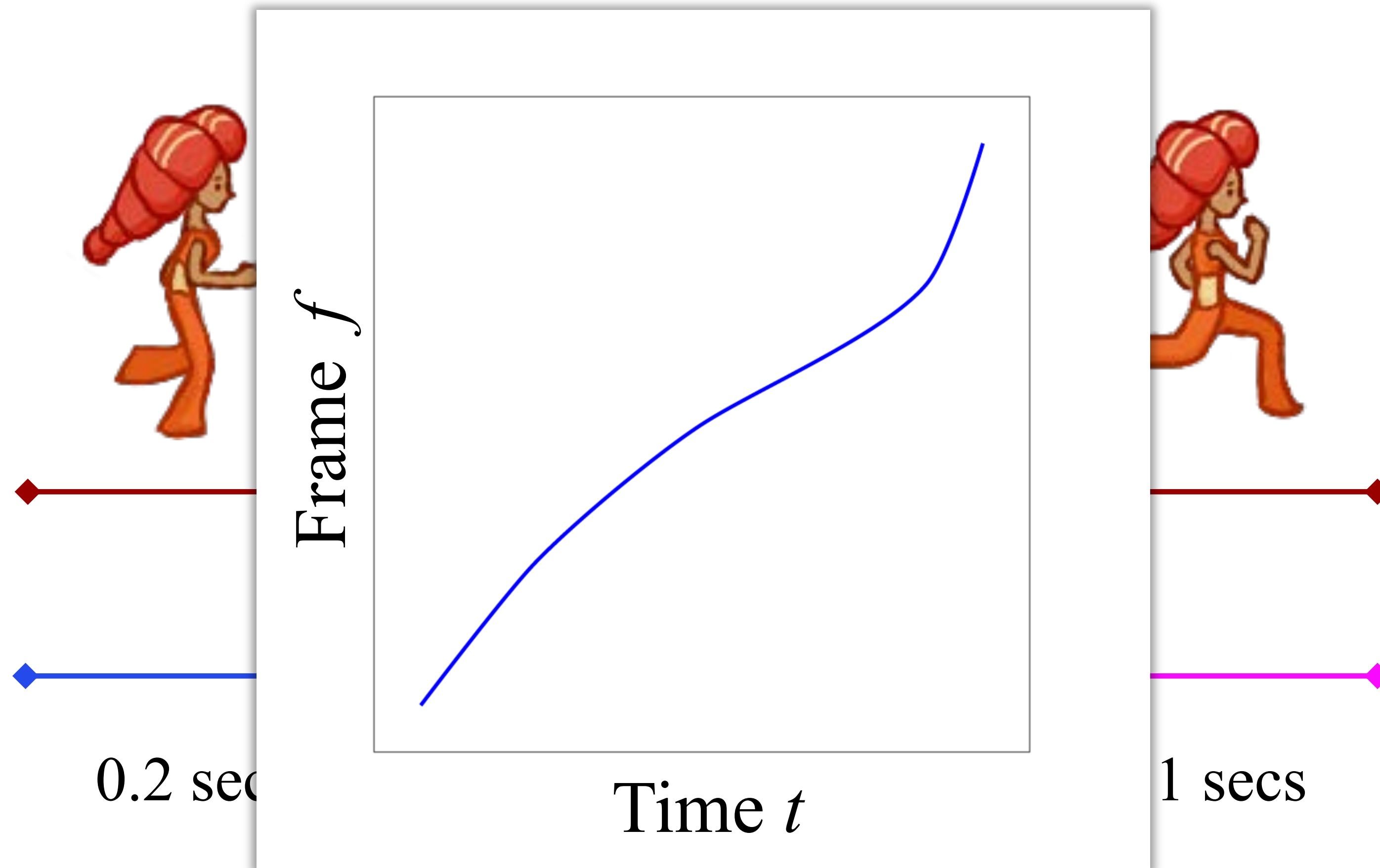

Problems With Decoupled Animation

```
auto mgr = ActionManager::alloc();
auto action = RotateBy::alloc(90.0f,2.0f);
mgr->activate(key,action,sprite);
```

What if we change our mind before 2 seconds?

Problems With Decoupled Animation

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Compatible: Combine

Incompatible: Replace

Modular Animation

- Break asset into parts
  - Natural for joints/bodies
  - Animate each separately
- Cuts down on filmstrips
  - Most steps are transforms
  - Very natural for tweening
  - Also better for physics
- Several tools to help you
  - **Example**: *Spriter, Spine*
  - Great for visualizing design

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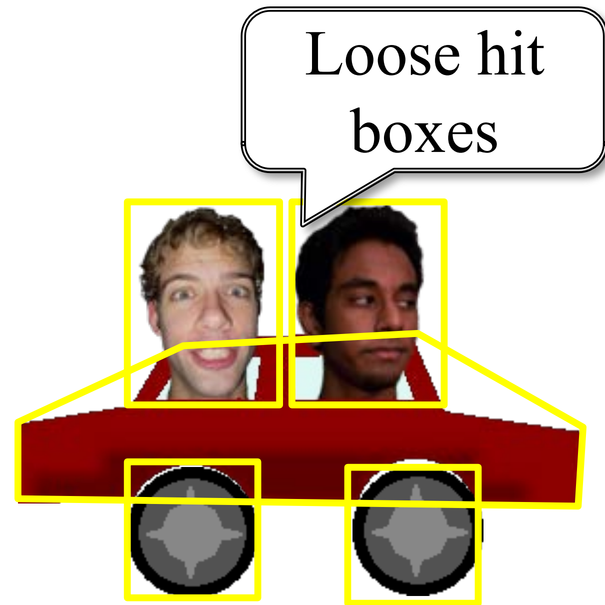
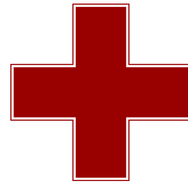


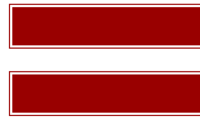
- Inside hit box can safely
  - Transform with duration
  - Tween animations
  - Manage multiple actions

Problems With Decoupled Animation

Transform Tweening



Physical Animation



Complete Disaster

Aside: Skinning

Way to get extra usage of hand-drawn frames

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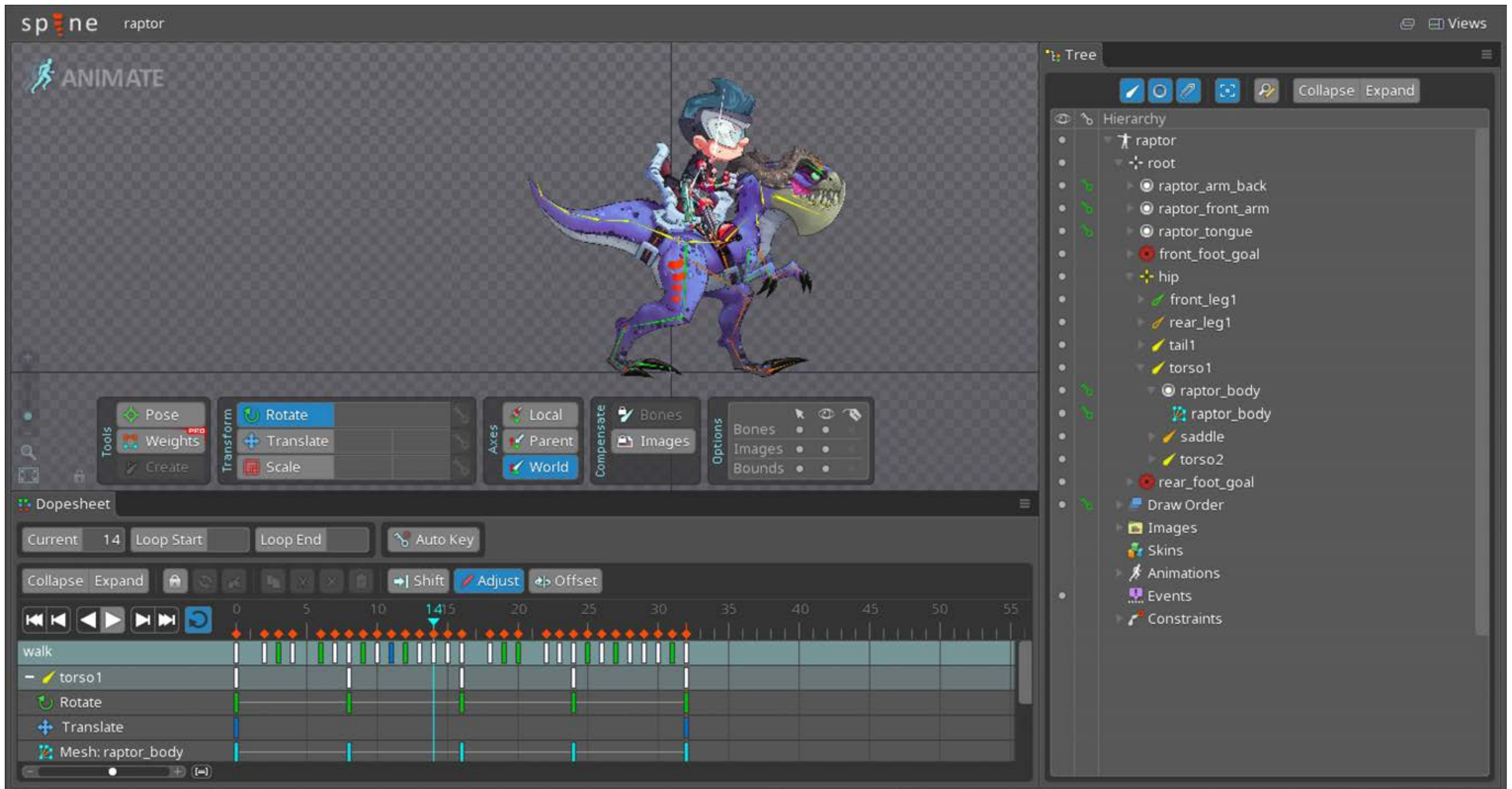
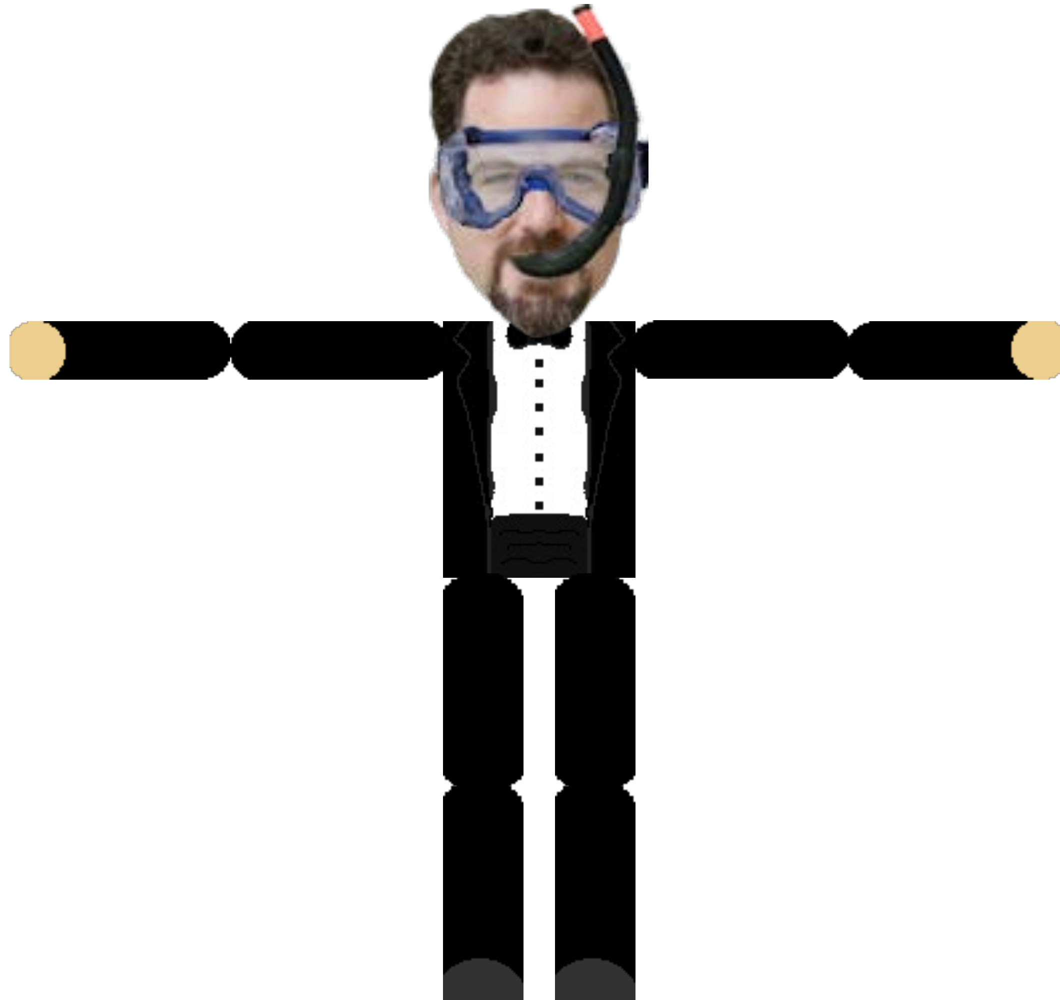
Aside: Skinning

Way to get extra usage of hand-drawn frames

Spine Demo



Basic Idea: **Bones**



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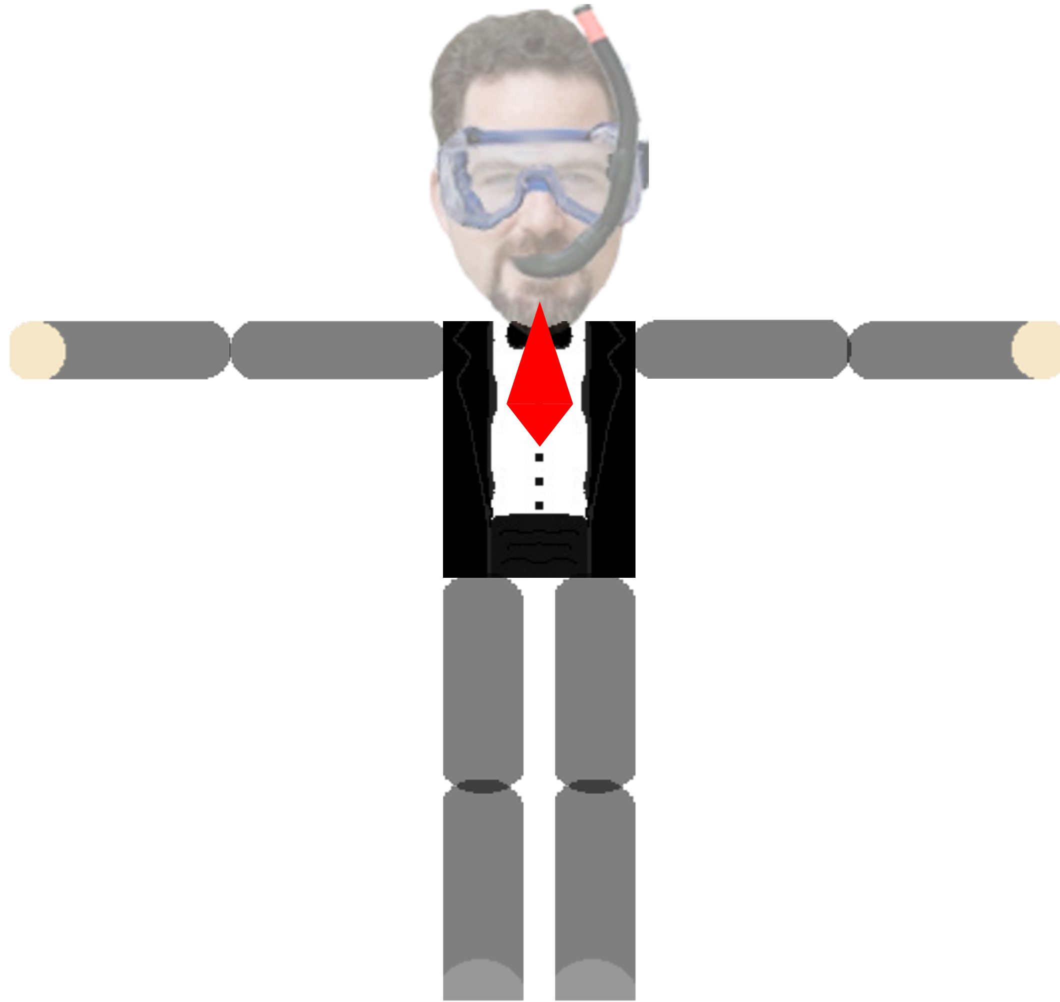

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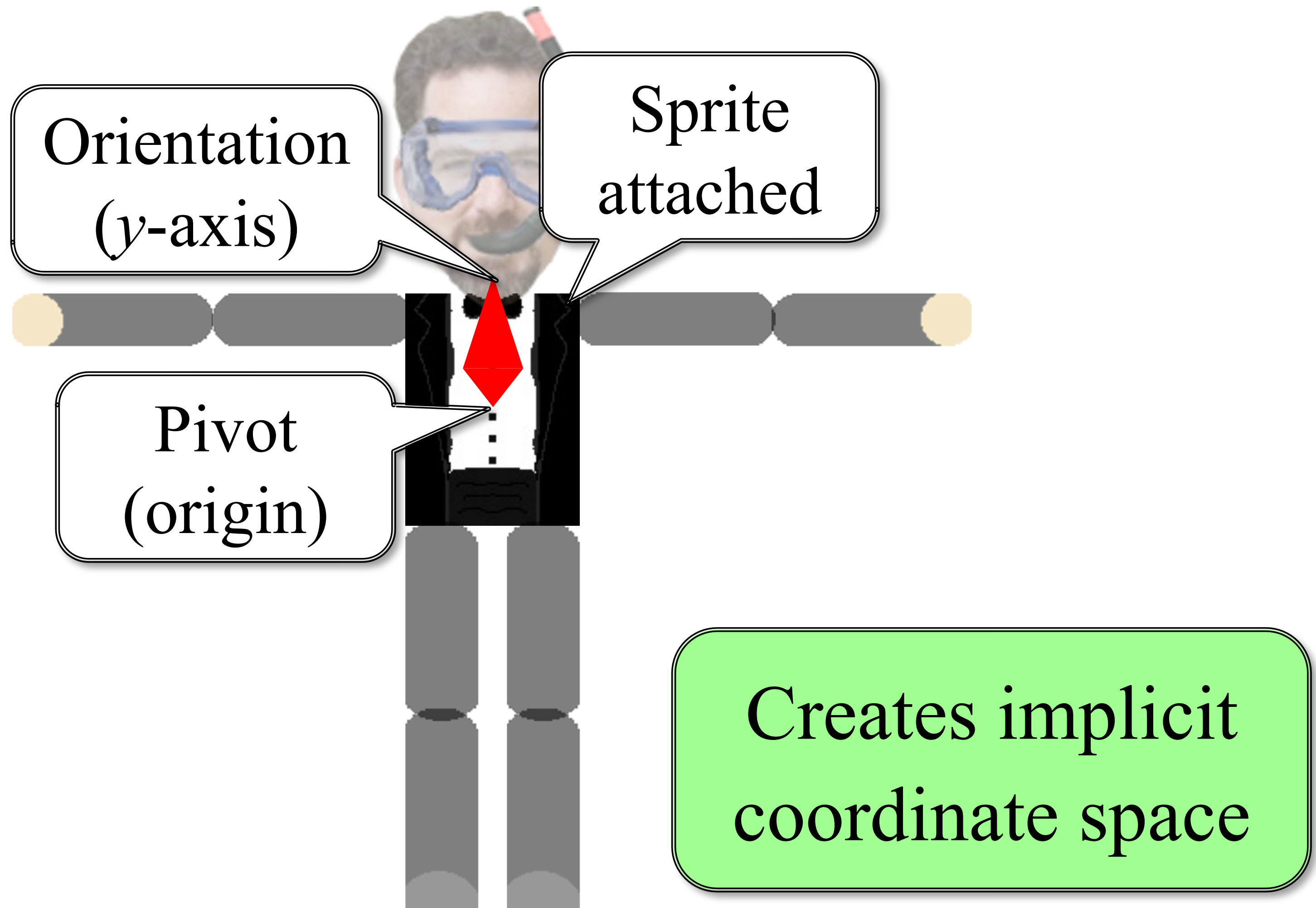
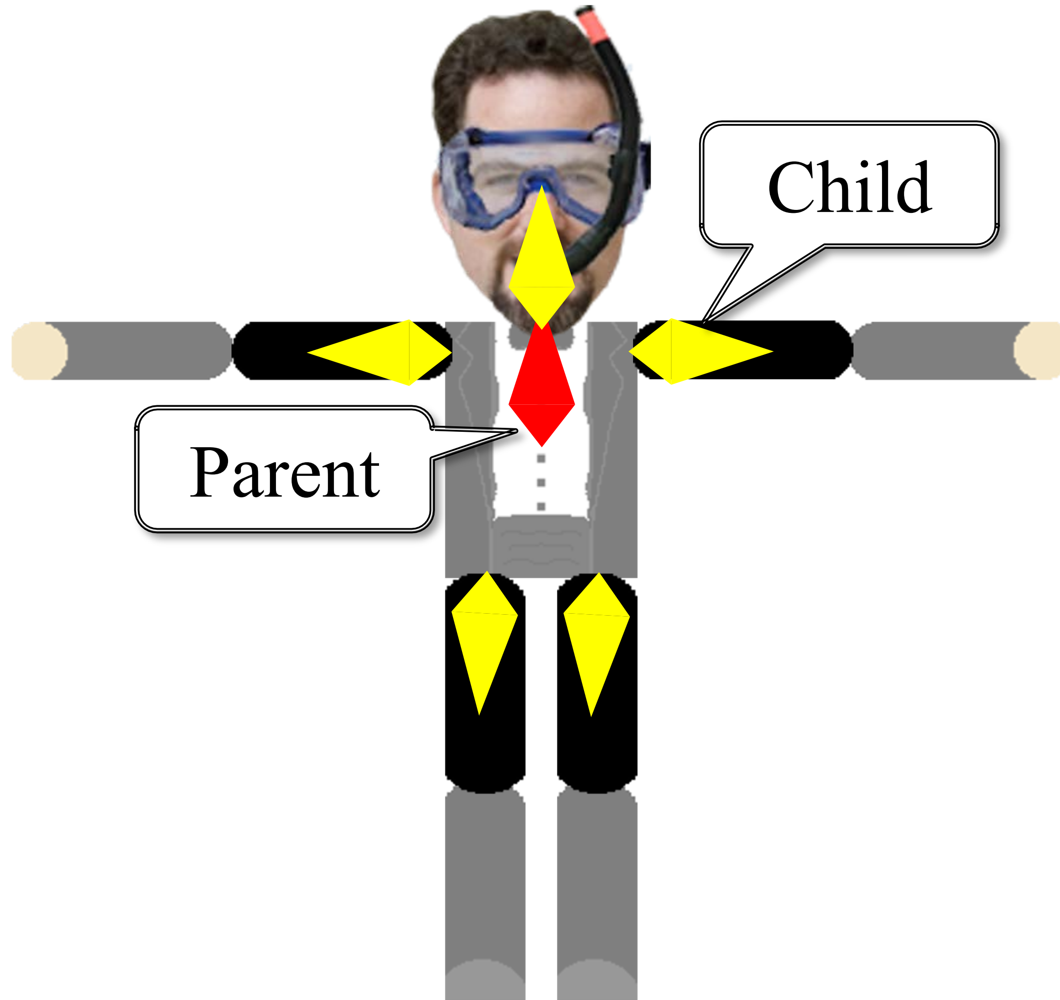


Bones are Heirarchical



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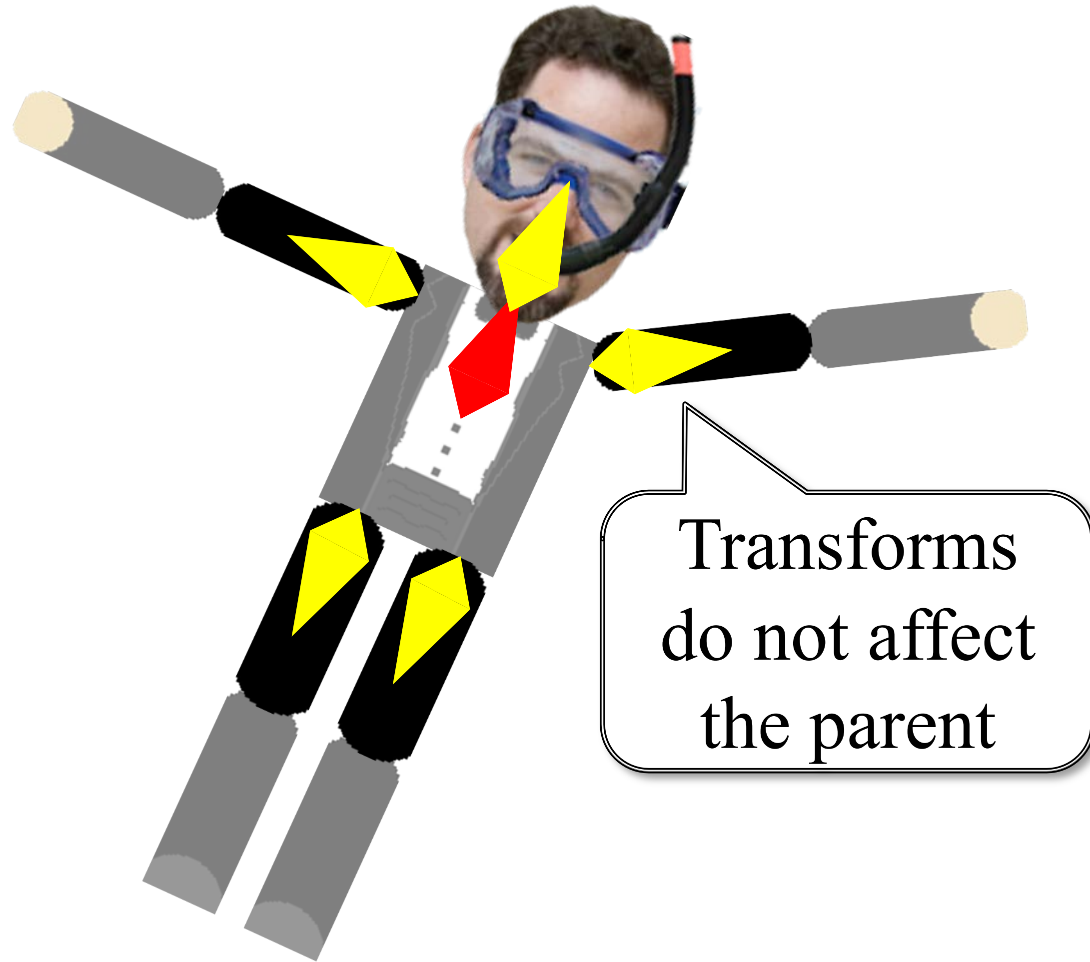
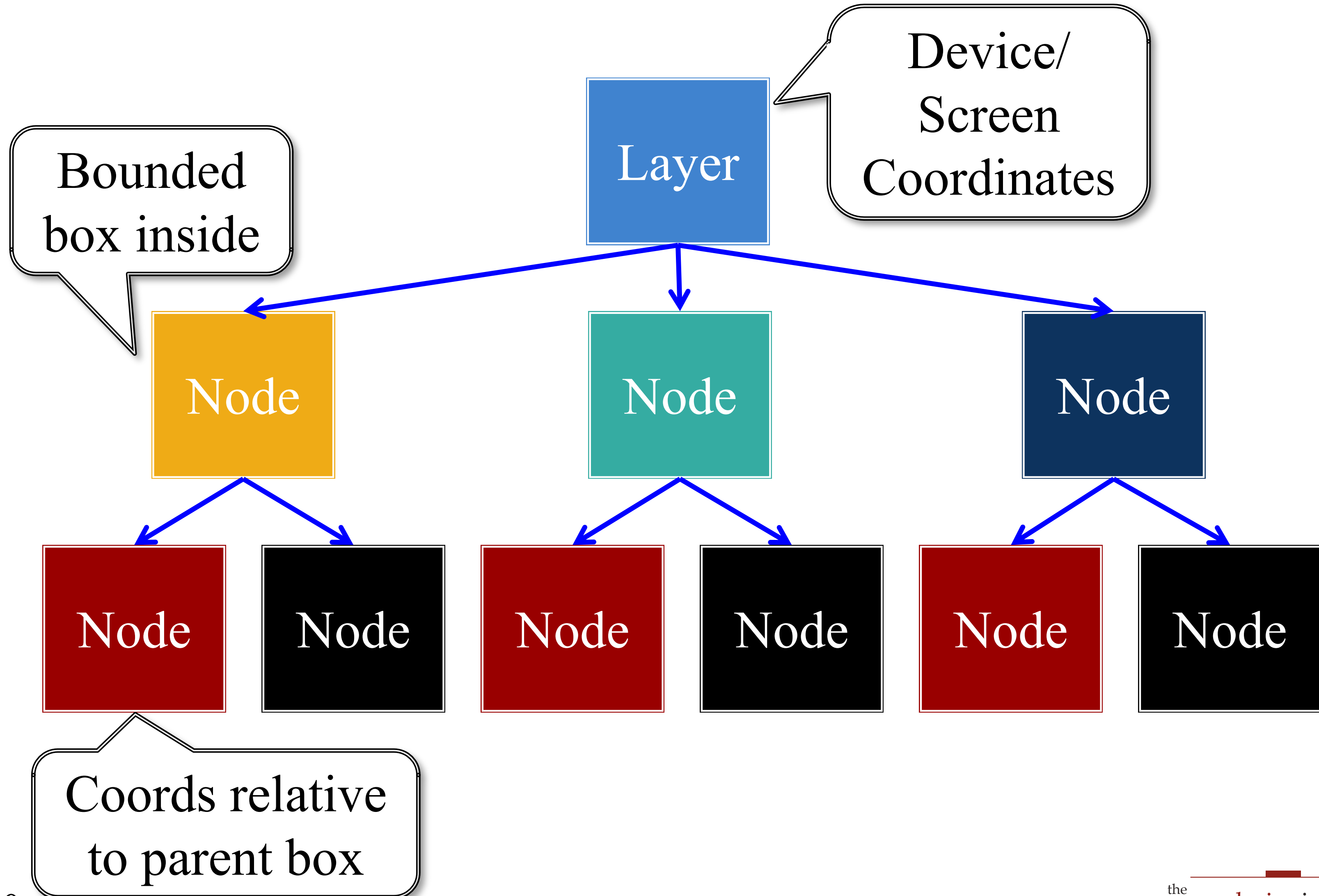
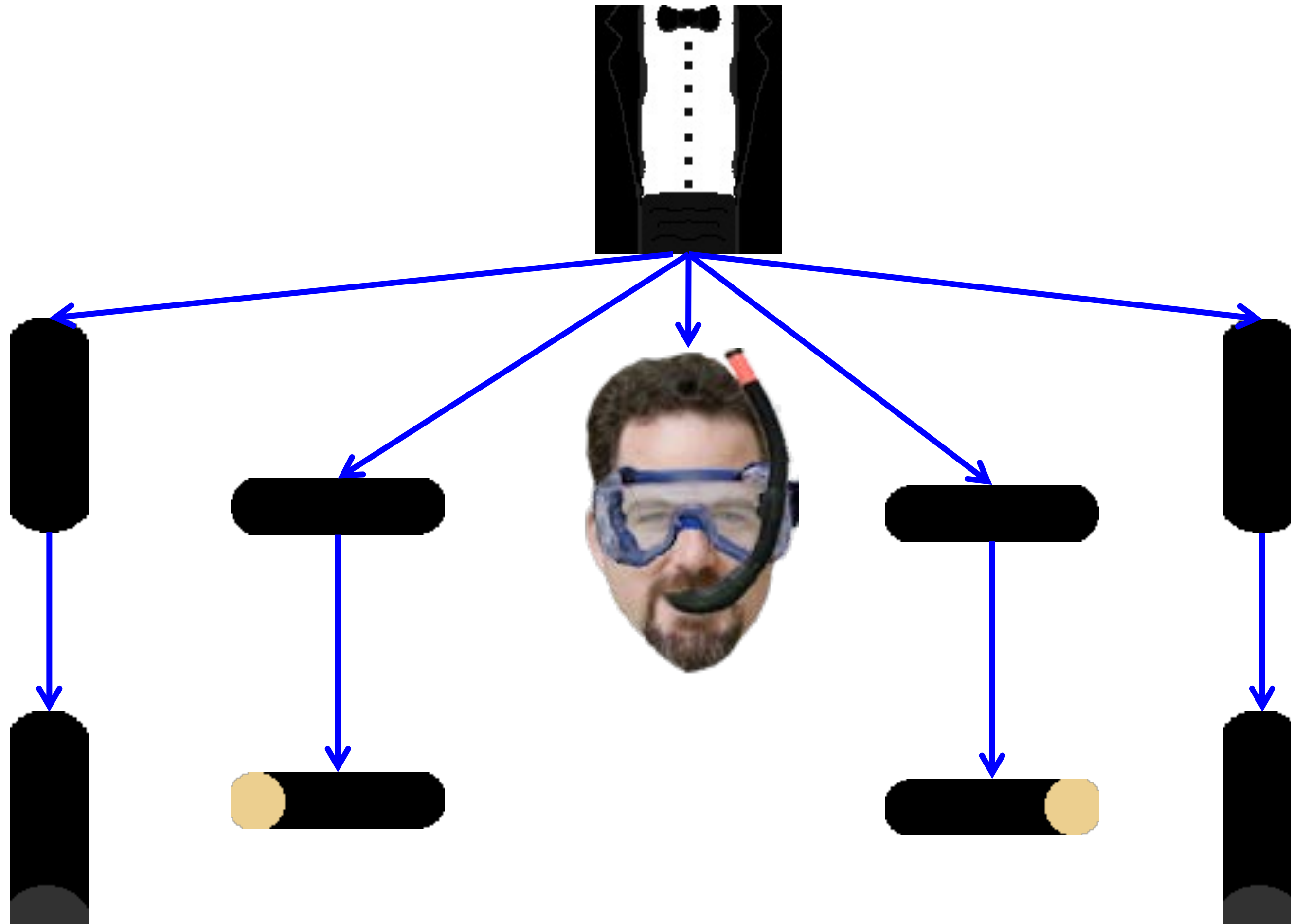


Recall: Scene Graph Hierarchy

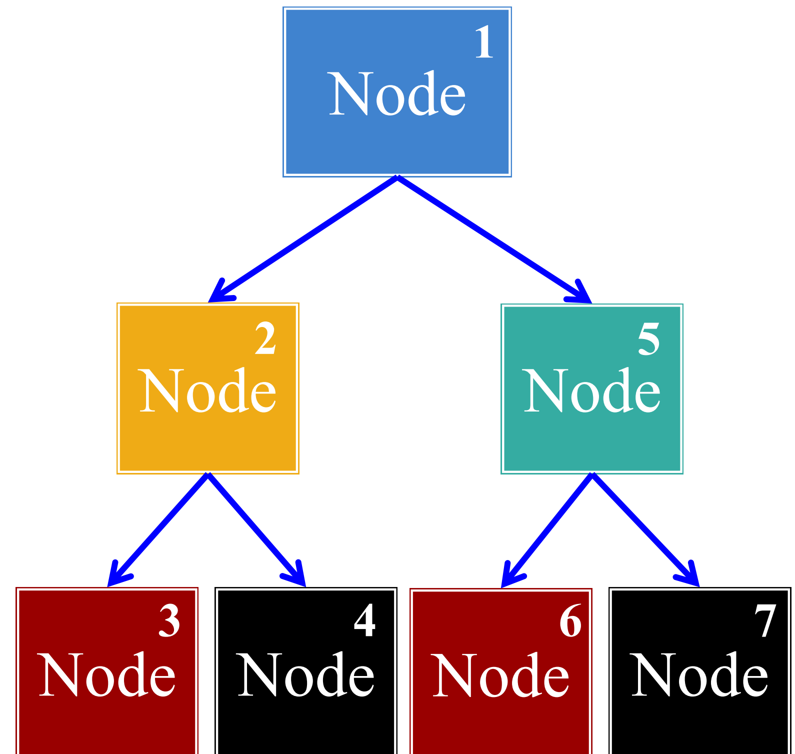


Bones are a Scene Graph Visualization



Problem: Scene Graphs are Preorder

- **Parents are drawn first**
  - Children are drawn in front
  - Ideal for UI elements
  - Bad for modular animation
- New class: `OrderedNode`
  - Puts descendents into a list
  - Sorts based on priority value
  - Draws nodes in that order
- Acts as a render barrier
  - What if nested `OrderedNode`?
  - Each `OrderedNode` is a unit
  - Priorities do not mix



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  - Children are drawn in front
  - Ideal for UI elements
  - Bad for modular animation
- **New class:** `OrderedNode`
  - Puts descendents into a list
  - Sorts based on priority value
  - Draws nodes in that order
- Acts as a render barrier
  - What if nested `OrderedNode`?
  - Each `OrderedNode` is a unit
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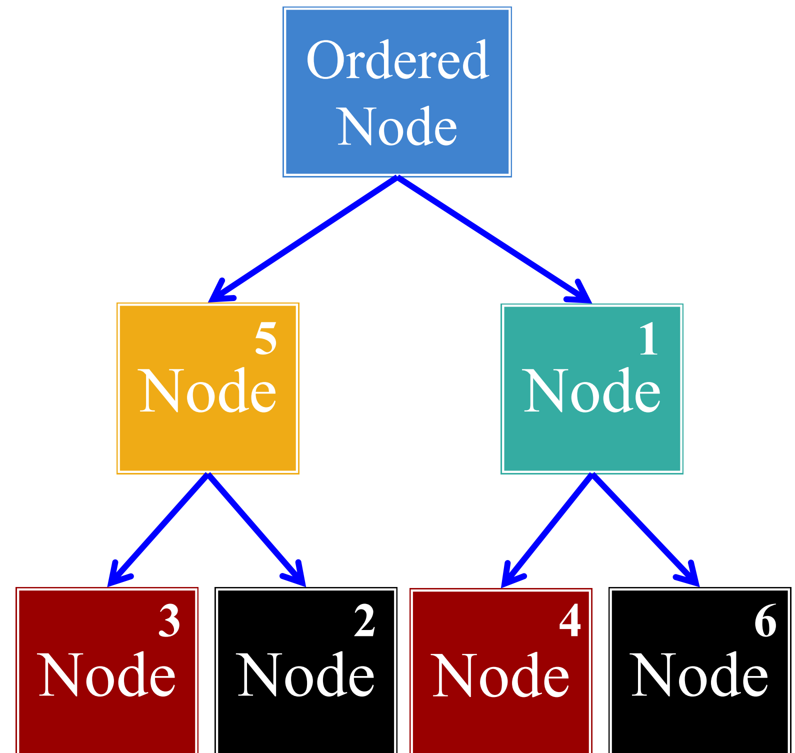

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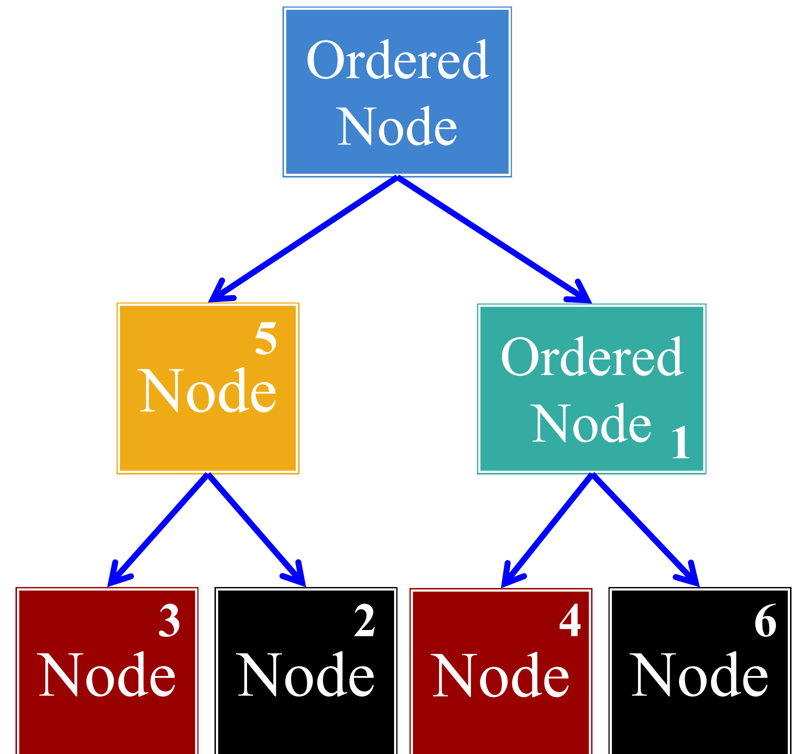

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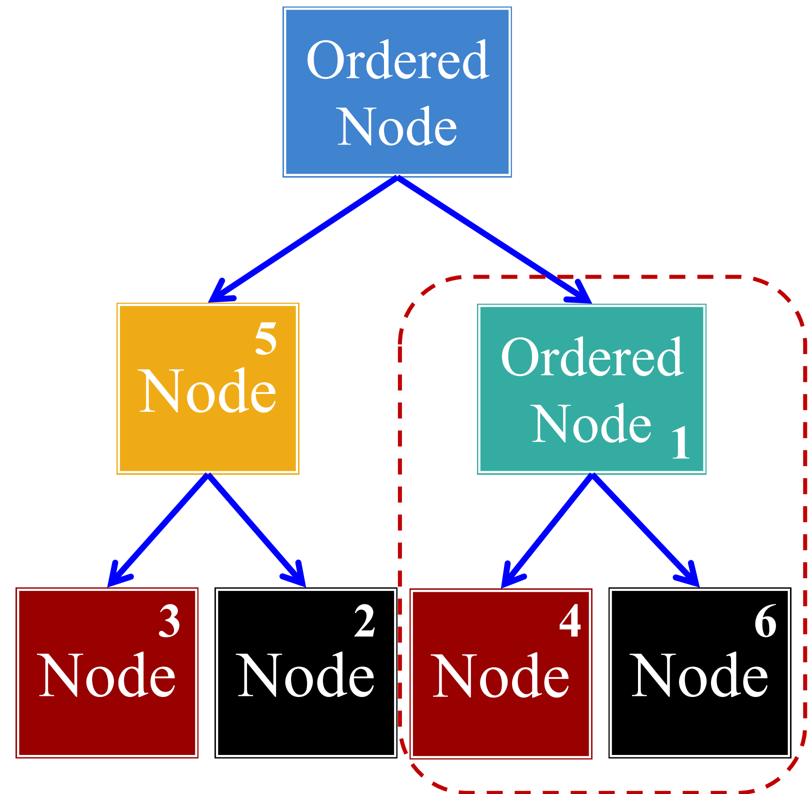

Summary

- Standard 2D animation is **flipbook** style
  - Create a sequence of frames in sprite sheet
  - Switch between sequences with state machines
- **Tweening** supports interpolated transitions
  - Helpful for motion blur, state transitions
  - Transforms can be combined with easing functions
- Professional 2D animation uses **modular sprites**
  - Scene graphs are a simplified form of model rigging
  - State machine coordination can be very advanced