the gamedesigninitiative at cornell university

Lecture 8

2D Animation

Animation Basics: The FilmStrip

- 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 AnimationNode Class

```
/**
 * Sets the active frame as the given index.
 *
 * @param frame the index to make the active frame
 */
void AnimationNode::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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```

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

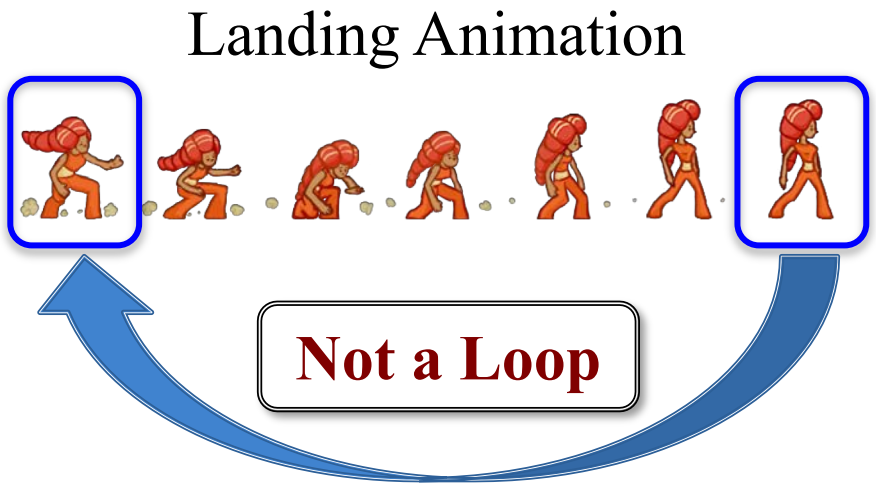
Combining Animations

Landing Animation

Idling Animation

- Characters to 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

Combining Animations



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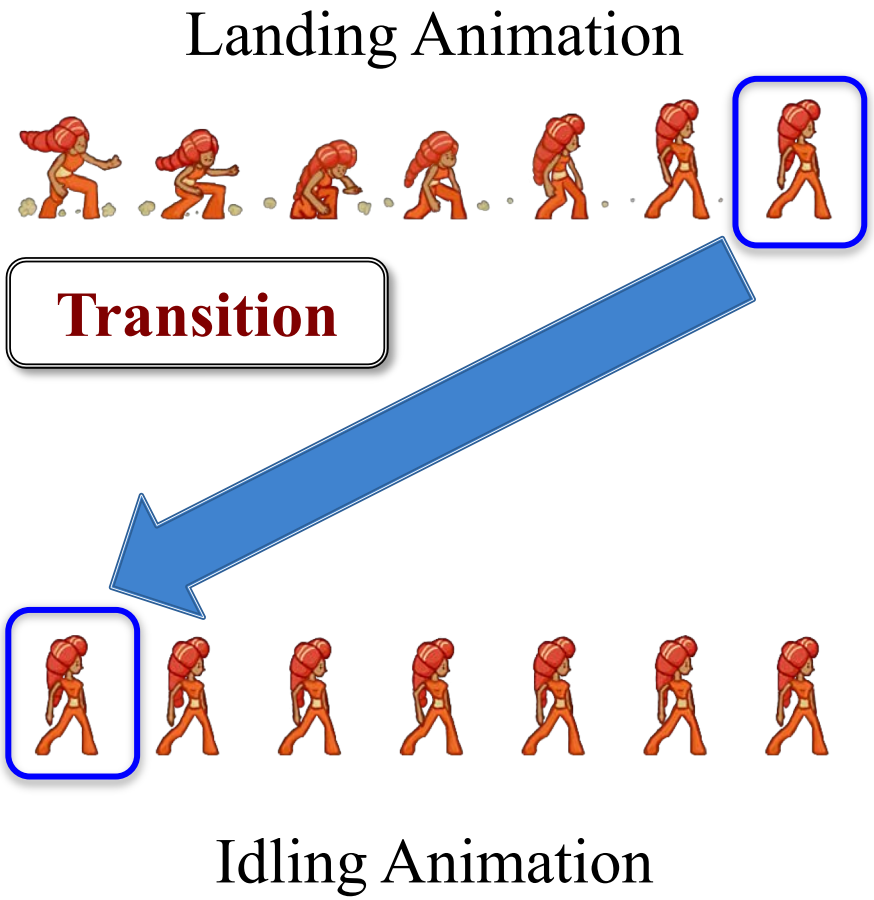

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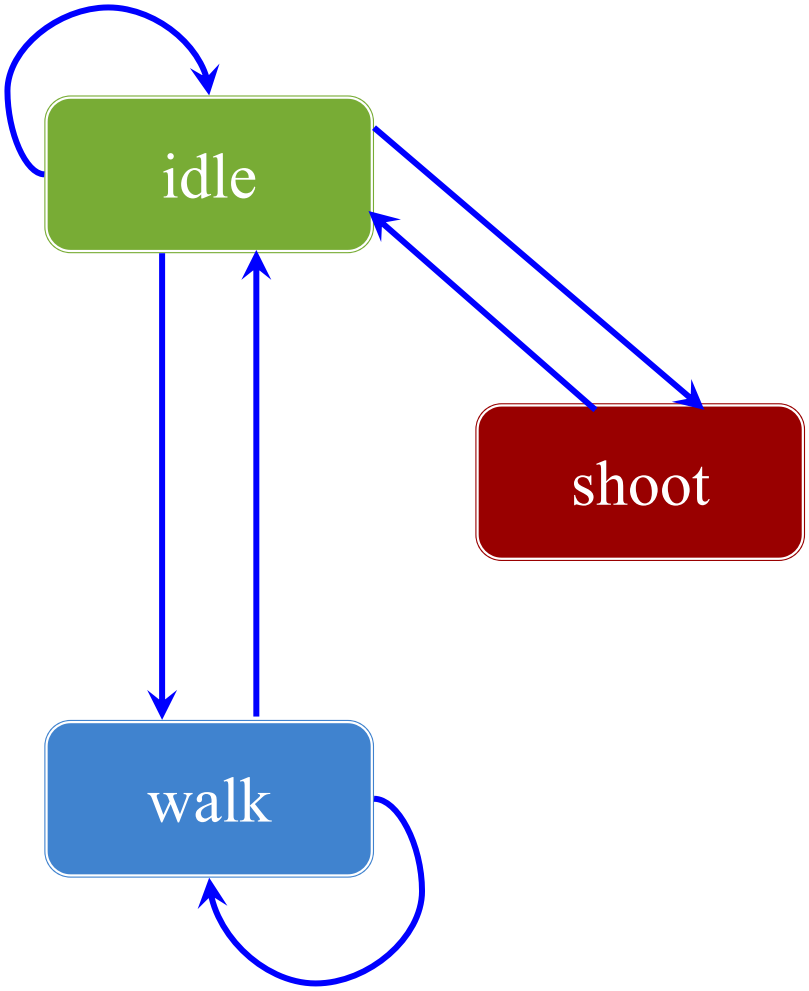
Animation and State Machines

- 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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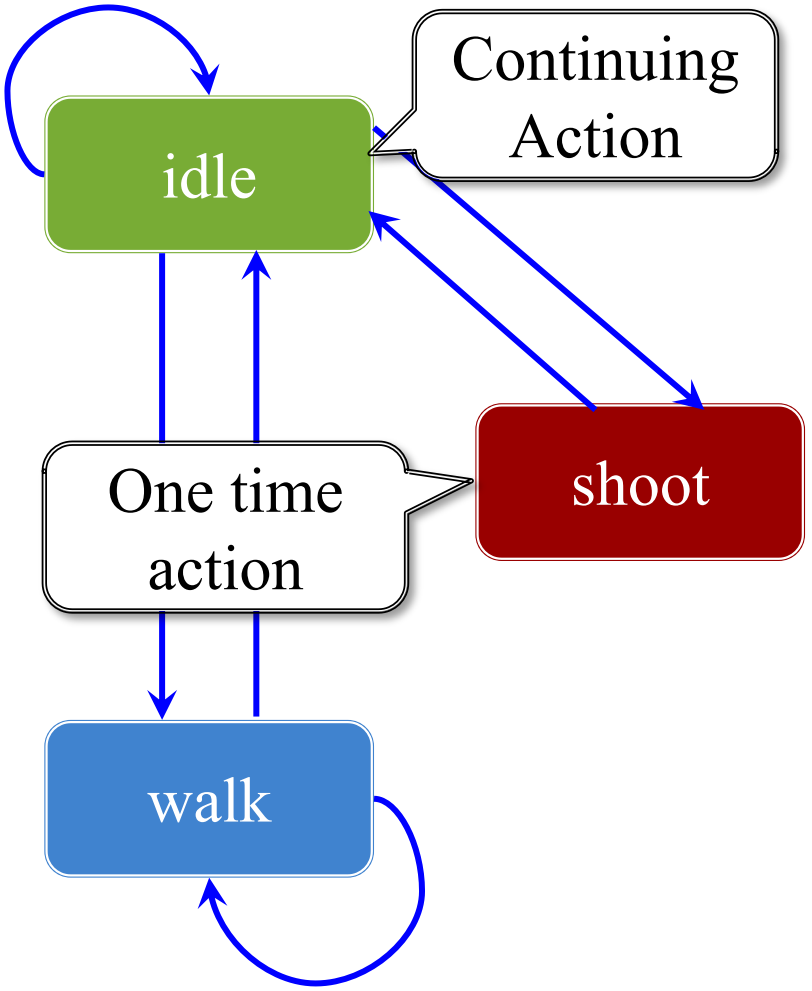
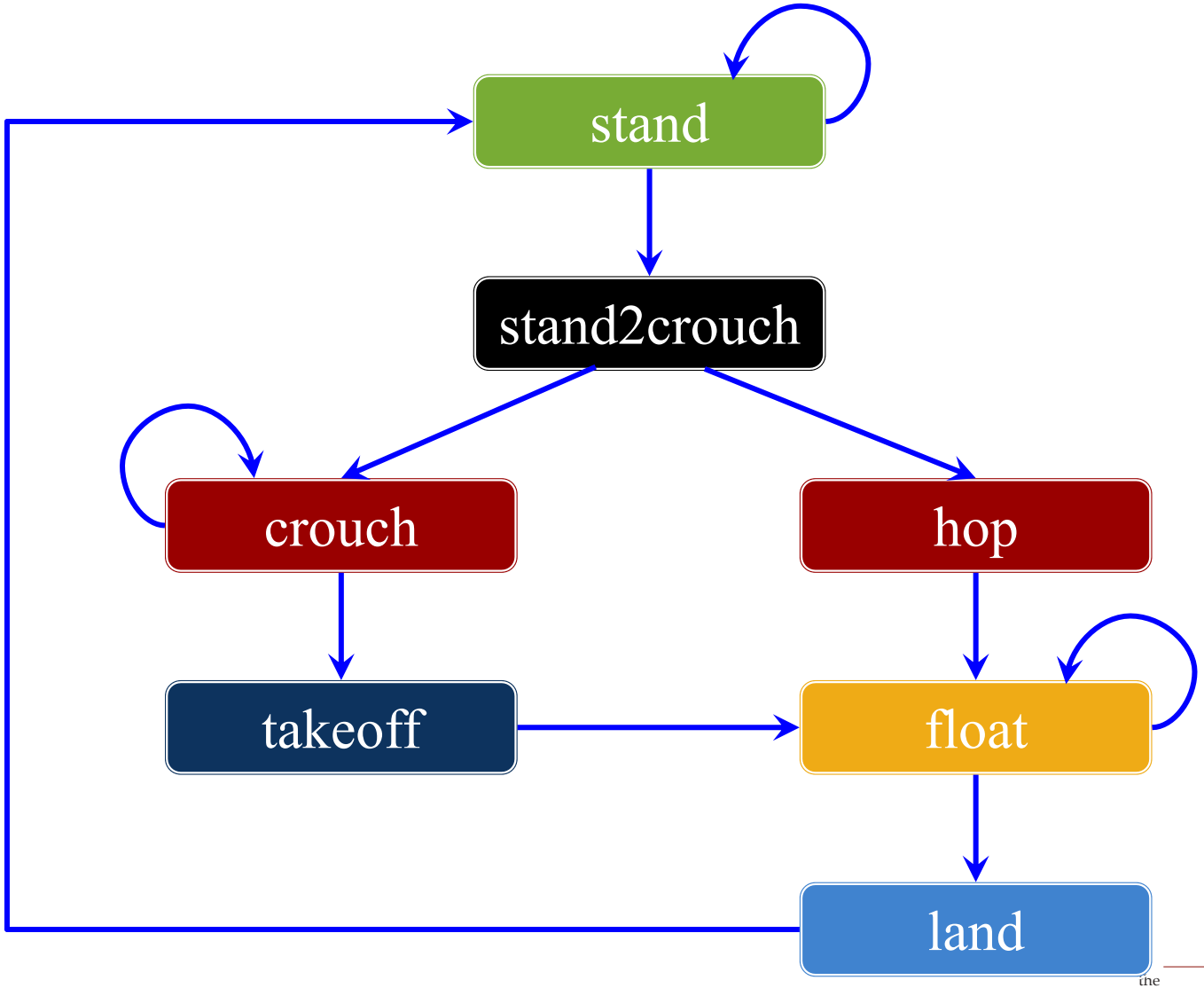


Complex Example: Jumping



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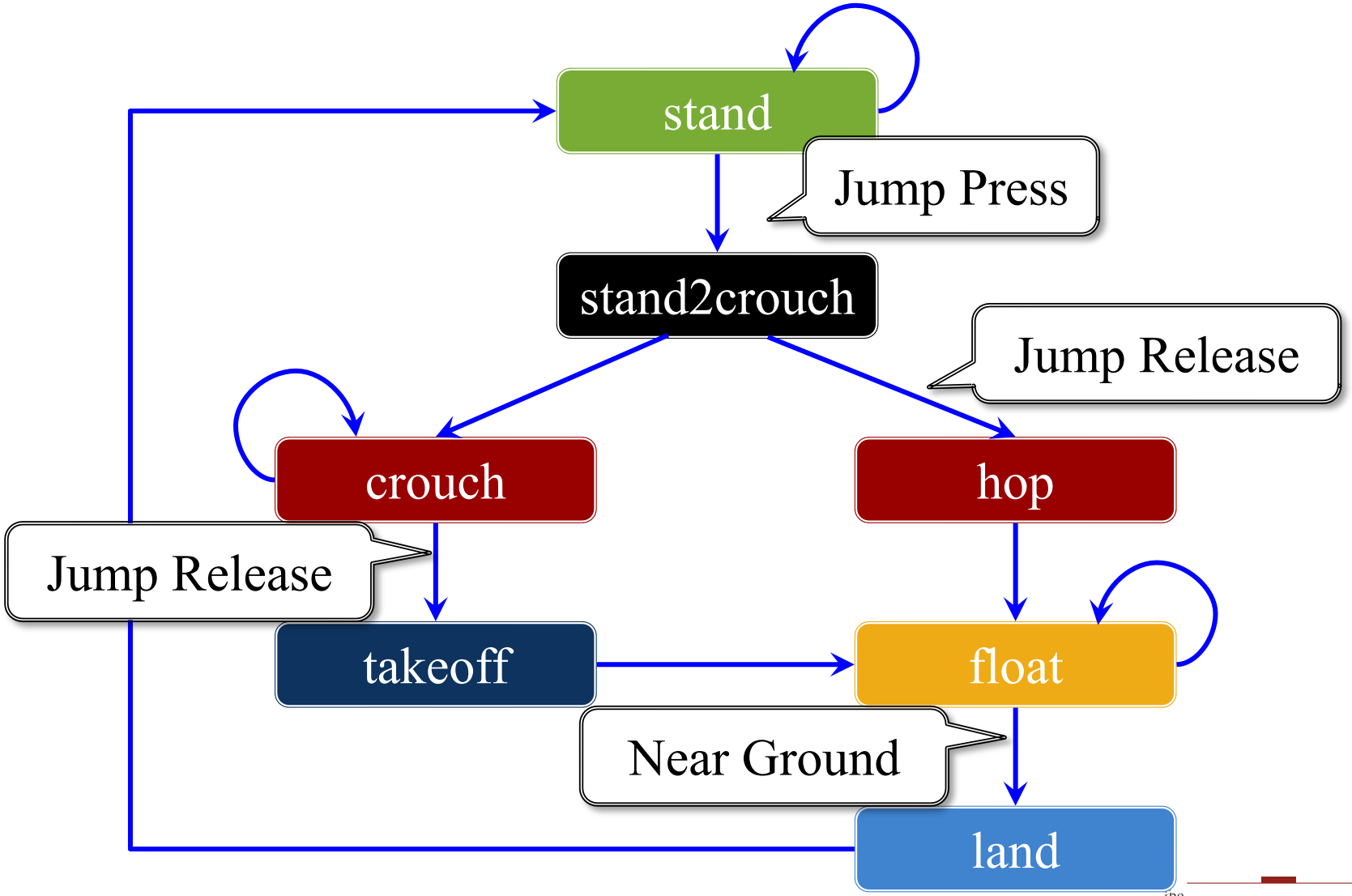

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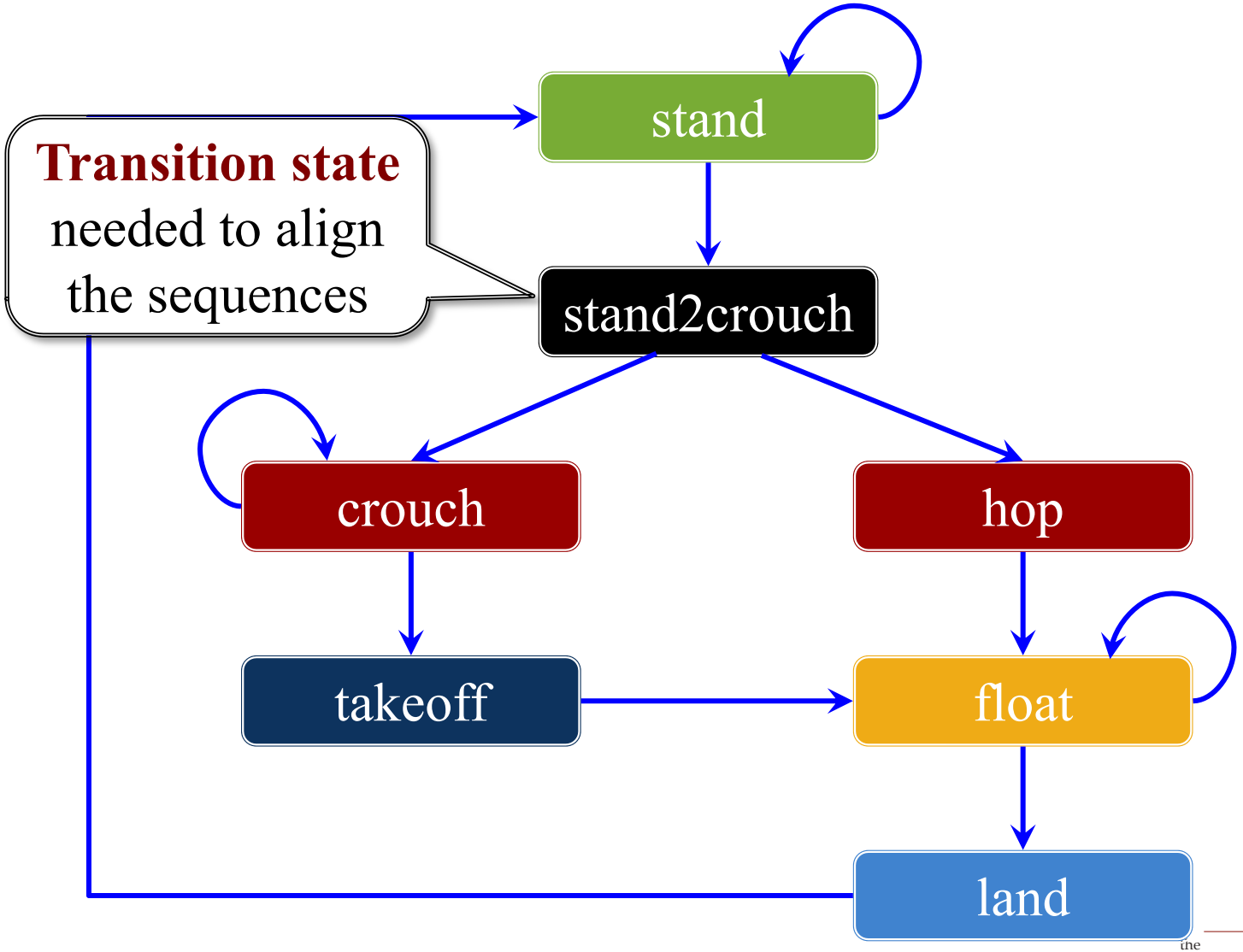
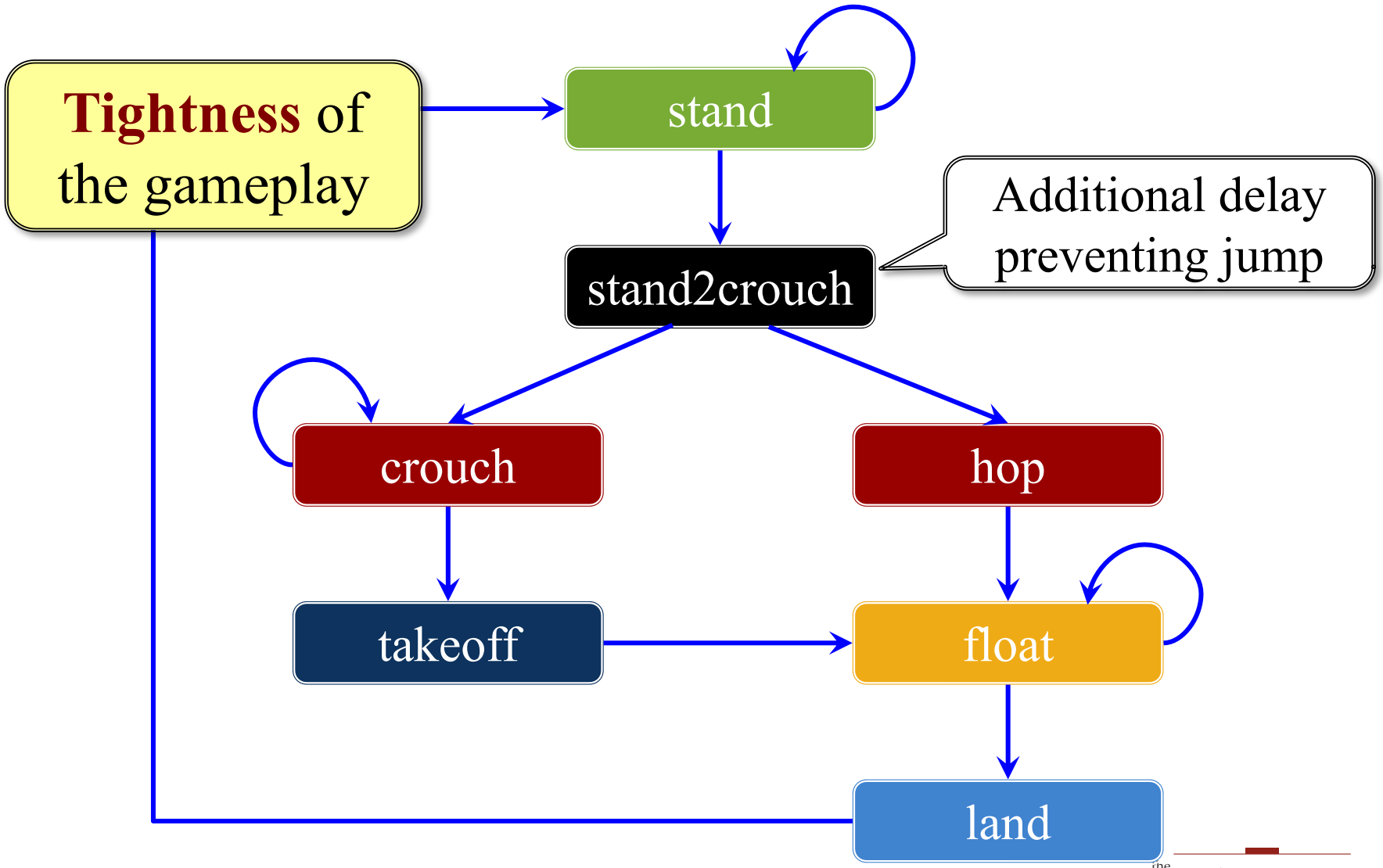
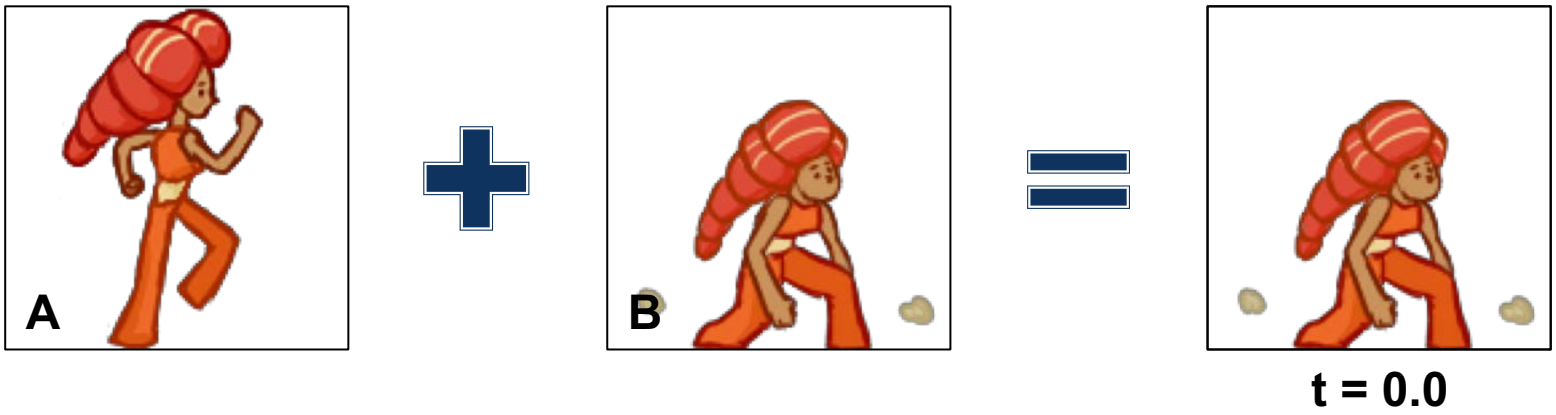


Aside: Sync Kills

The Responsiveness Issue



Fast Transitions: Crossfade Blending



- Linear interpolation on colors

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

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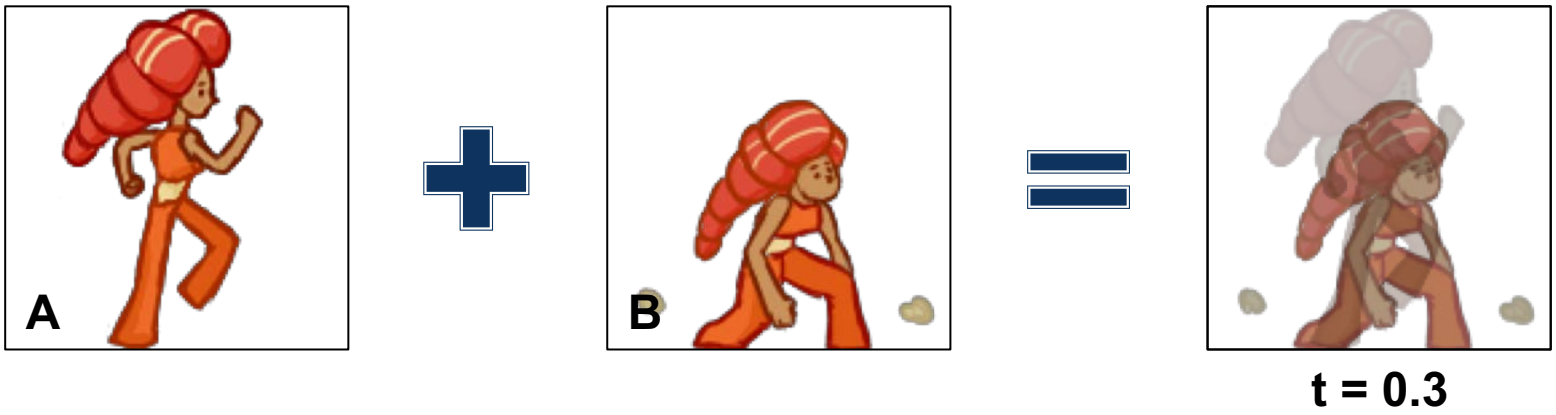

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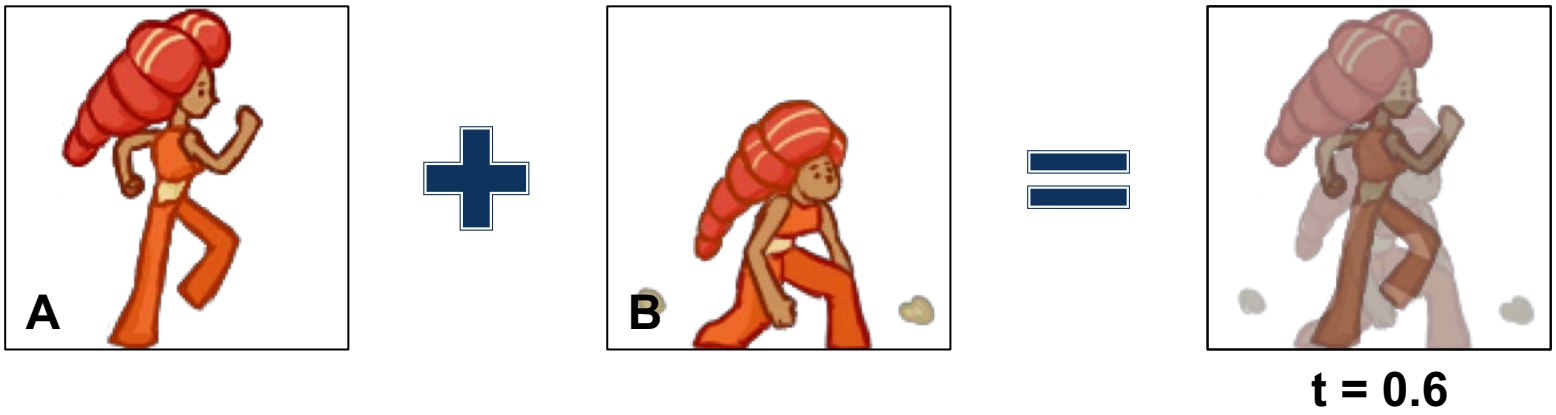

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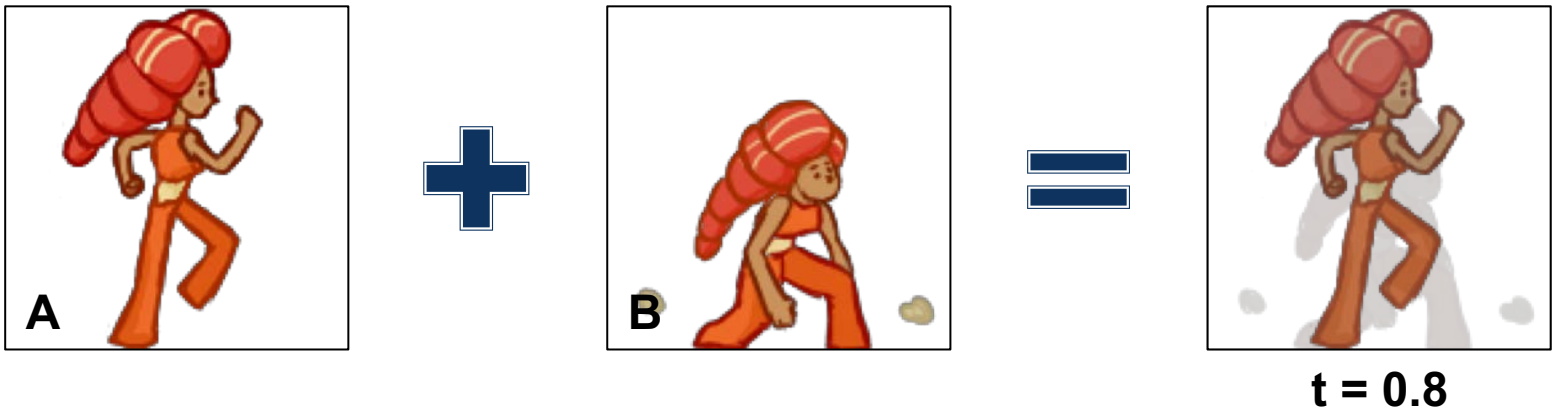

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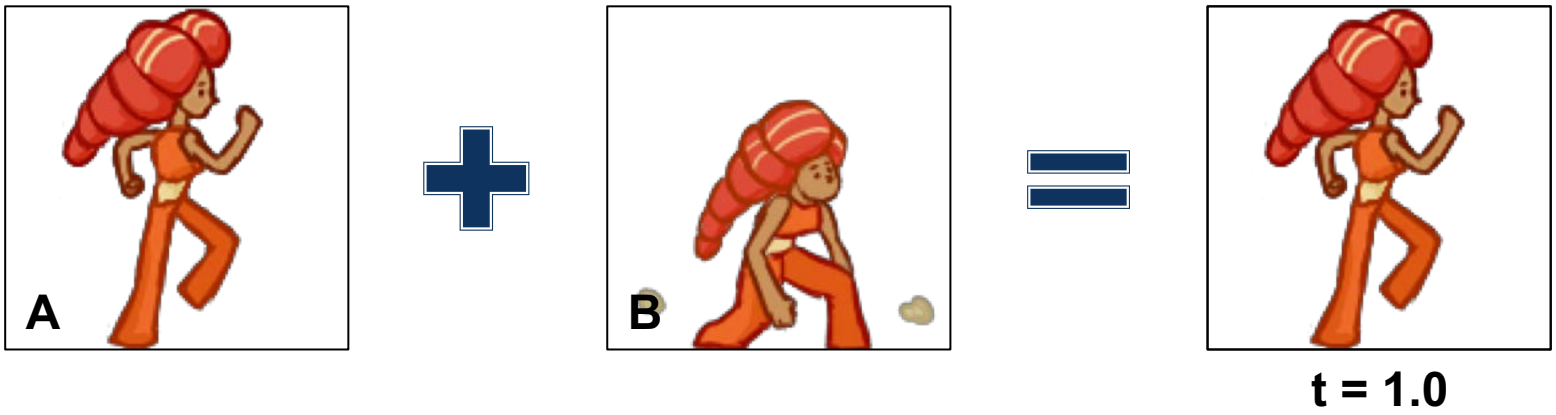

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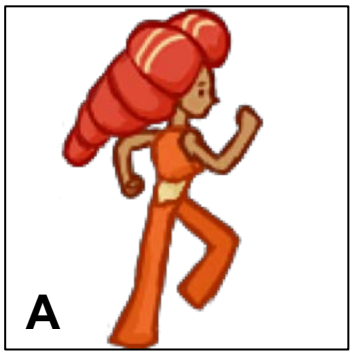
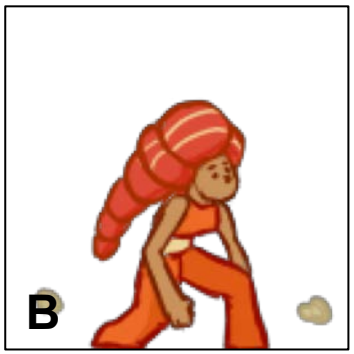
Combining With Animation



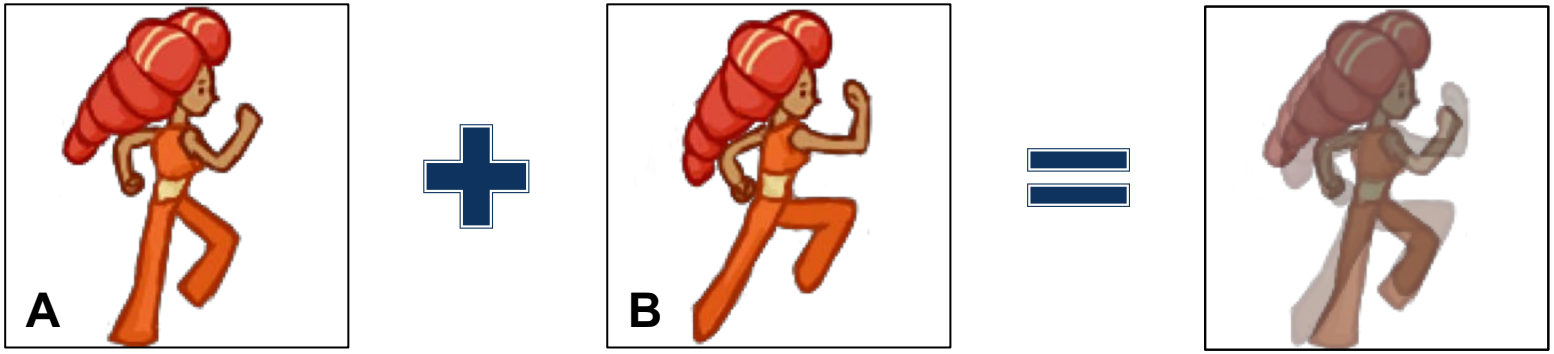
Cycle the filmstrip normally



Cycle the filmstrip normally

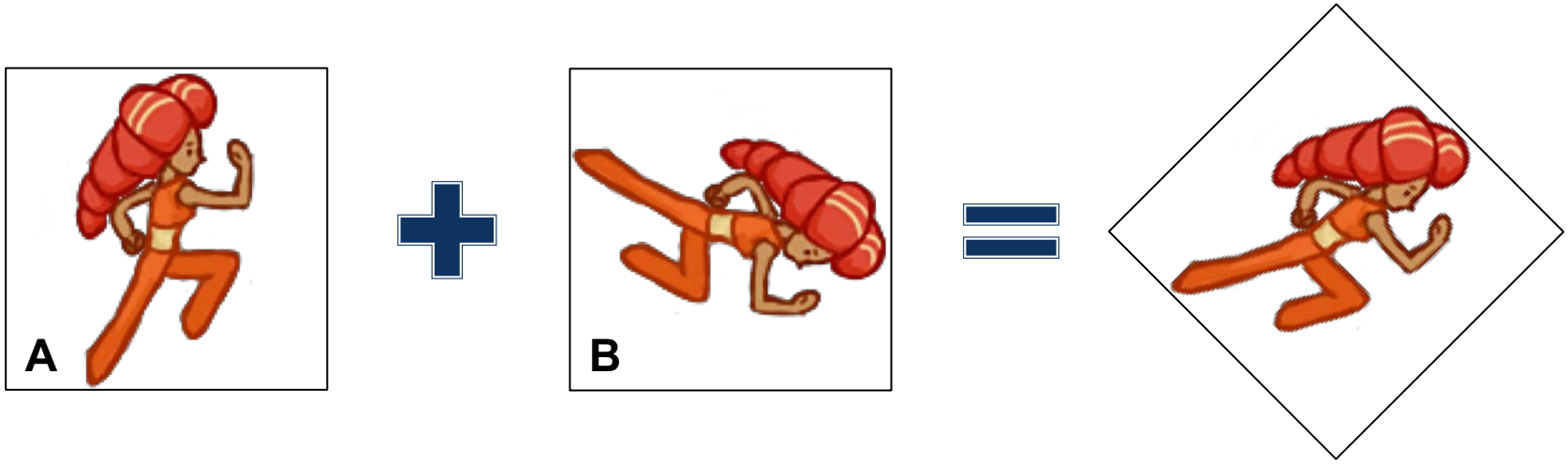
Combine with alpha blending

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

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

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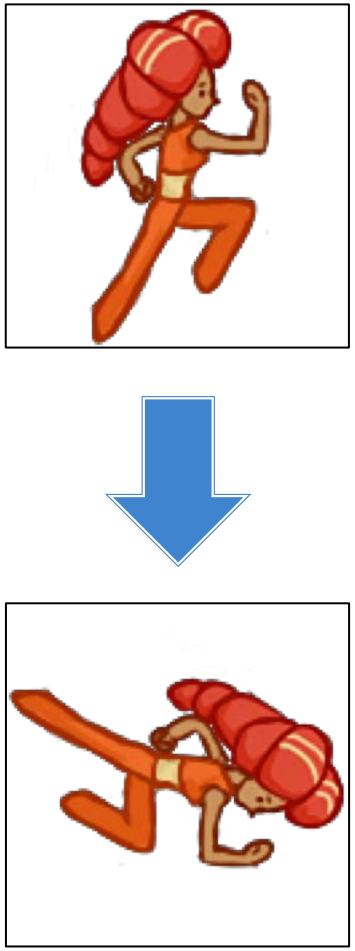
Executing Actions: Transforms

```
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

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How long to spend

Maps to framerate

Tweens rotation

Executing Actions: FilmStrips

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

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

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

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Sequence indices

Frames displayed uniformly

Does not tween

Executing Actions: FilmStrips

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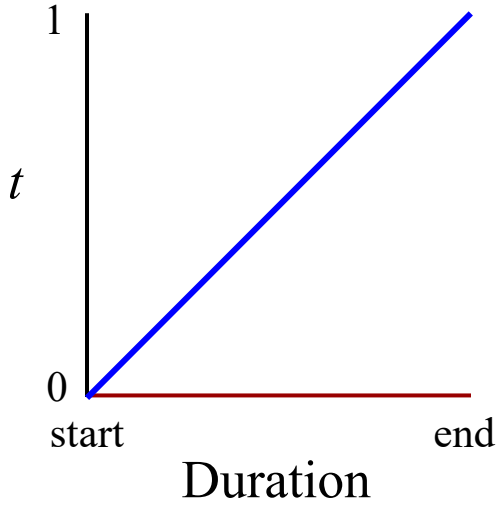
Alternatively, could specify time per frame

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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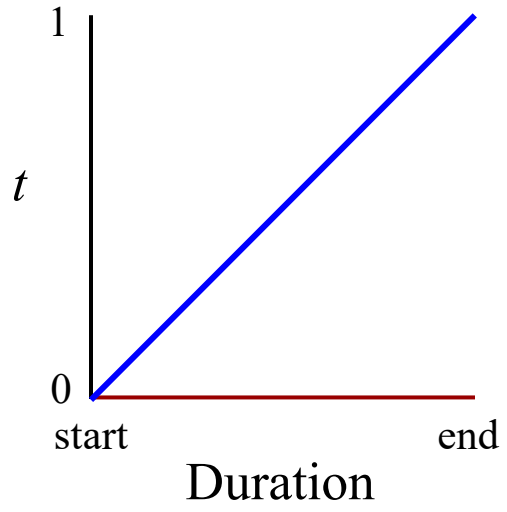
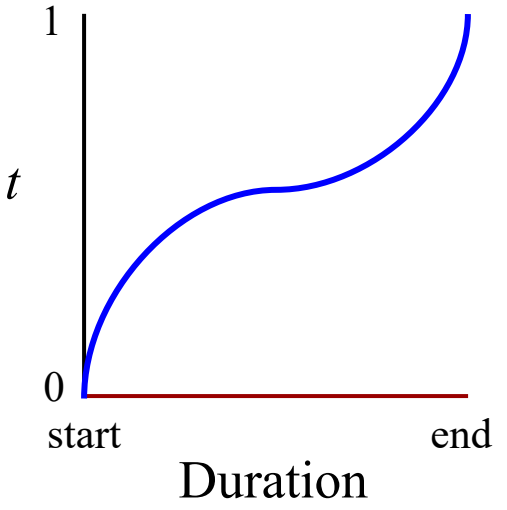
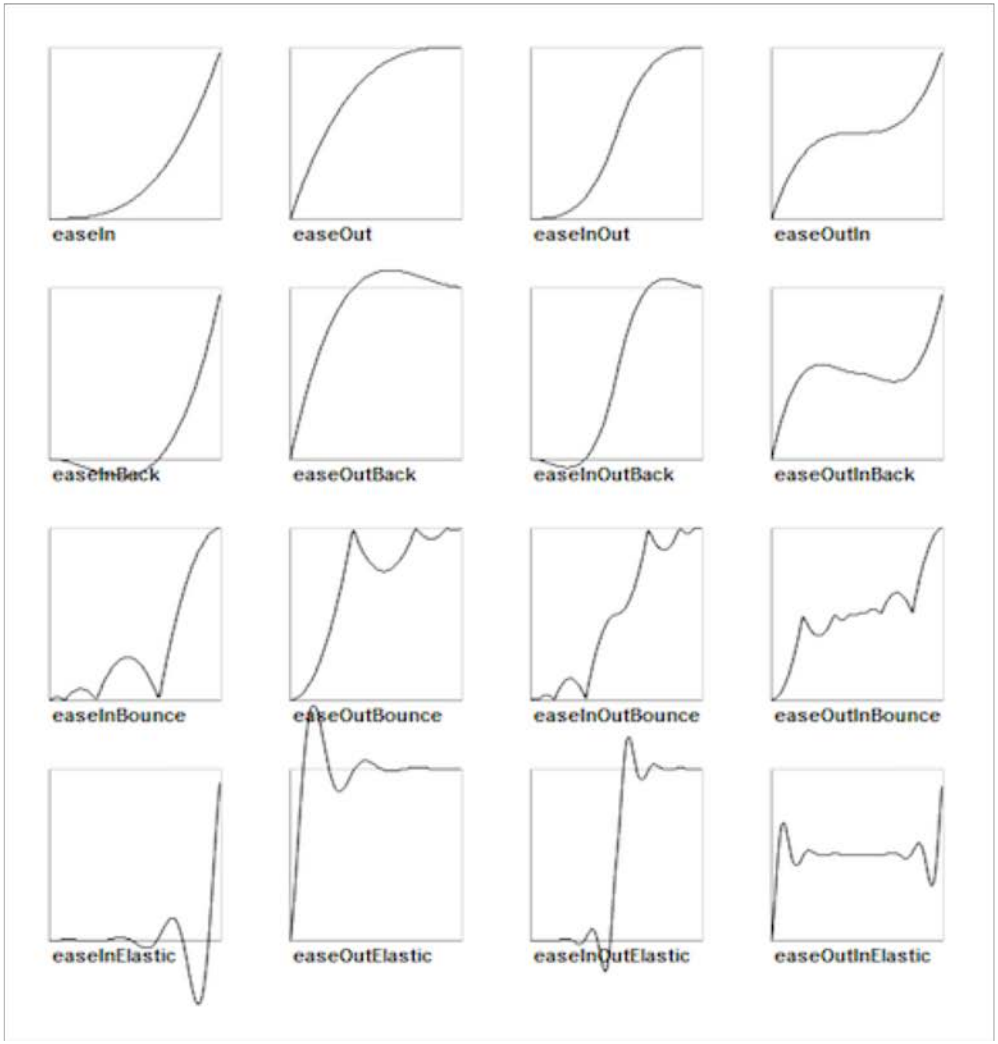




Classic Easing Functions



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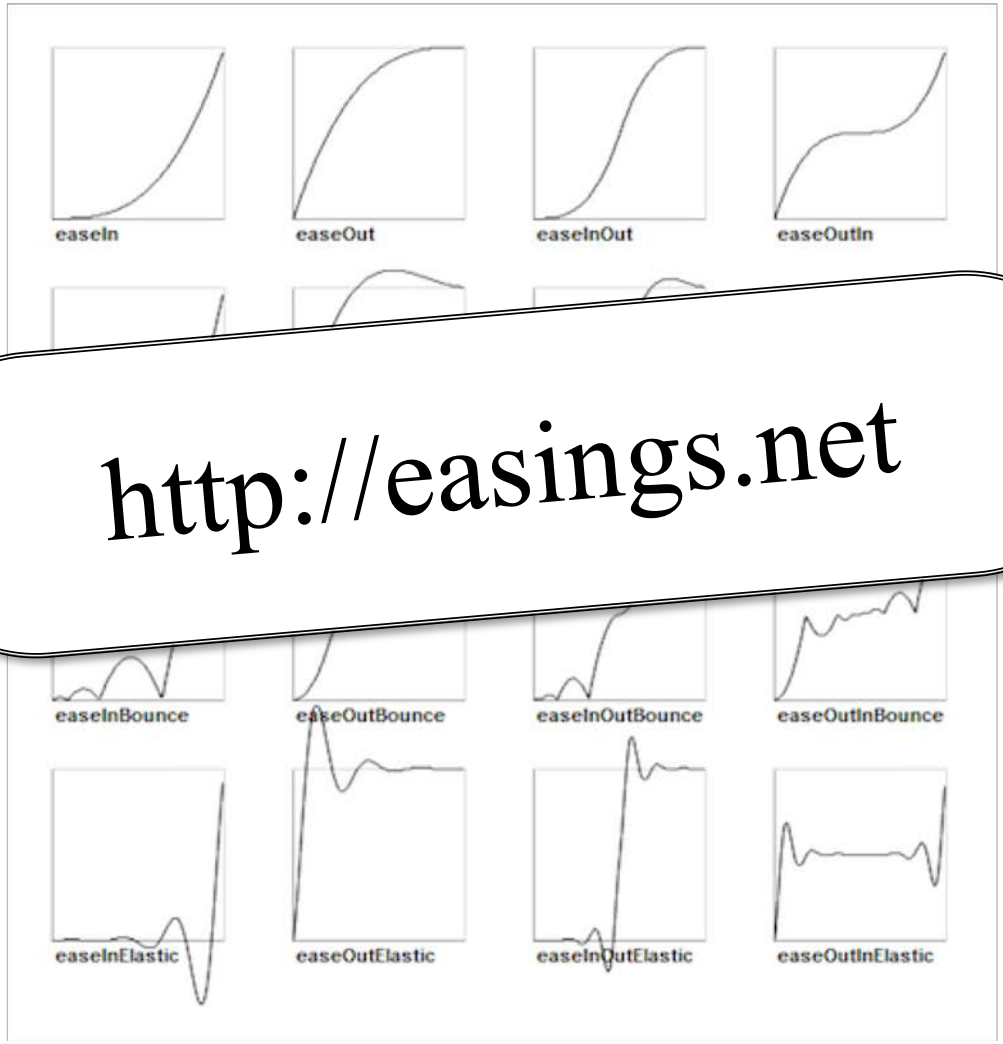

http://easings.net

Problem With Decoupled Animation

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

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mgr->activate(key,action,sprite);
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What if we change our mind before 2 seconds?

Problems With Decoupled Animation

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Compatible: Combine
Incompatible: Replace

Problems With Decoupled Animation

Transform Tweening

Physical Animation

Complete Disaster

Recall: 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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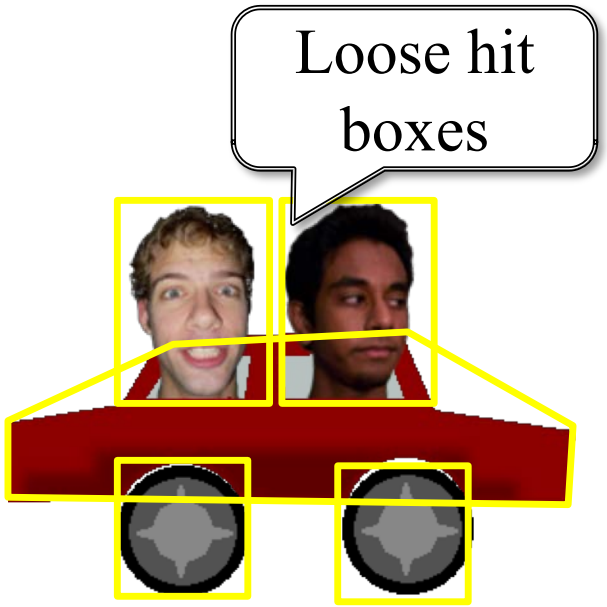
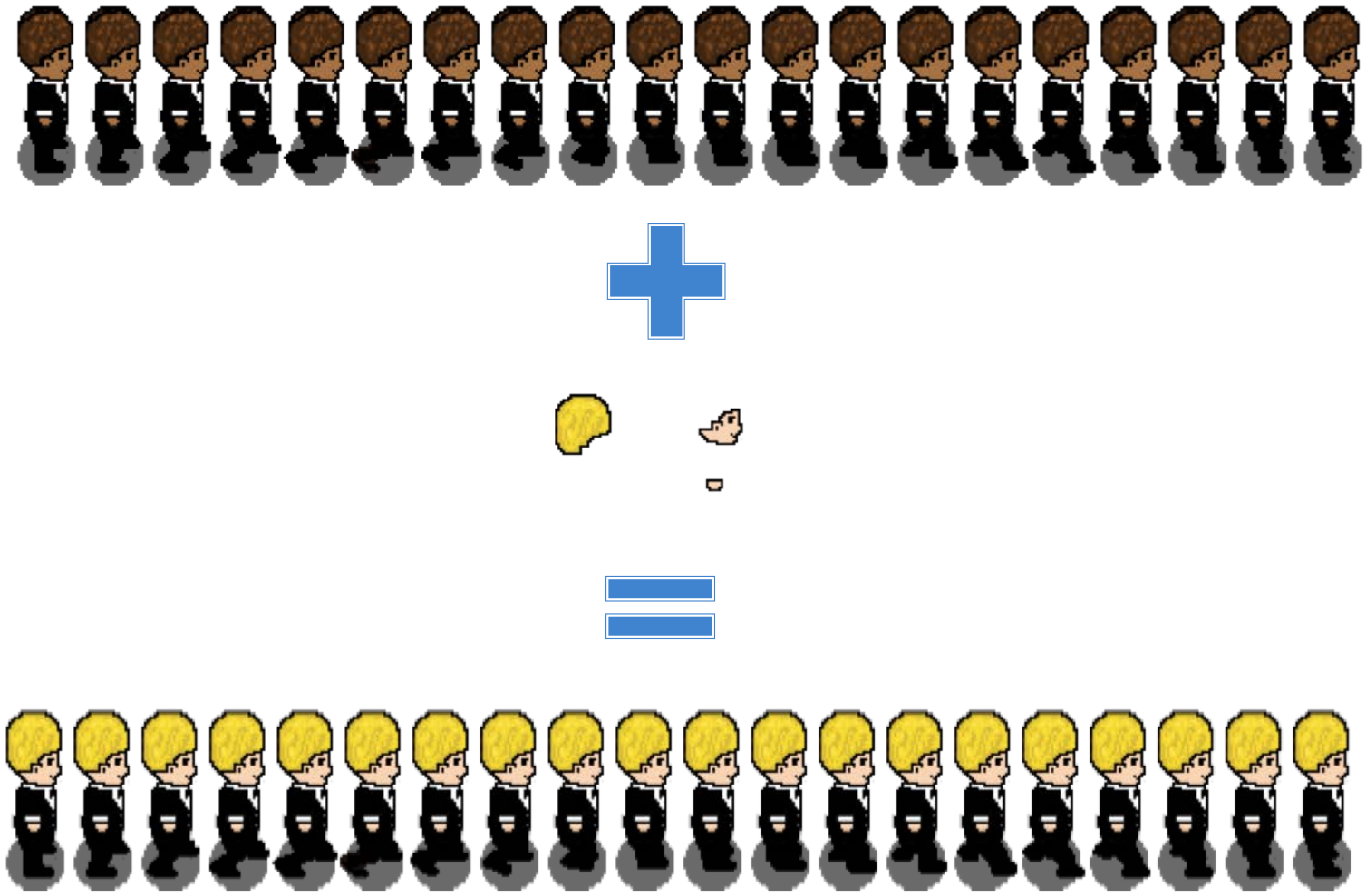


- Inside hit box can safely
  - Transform with duration
  - Tween animations
  - Manage multiple actions

Aside: Skinning



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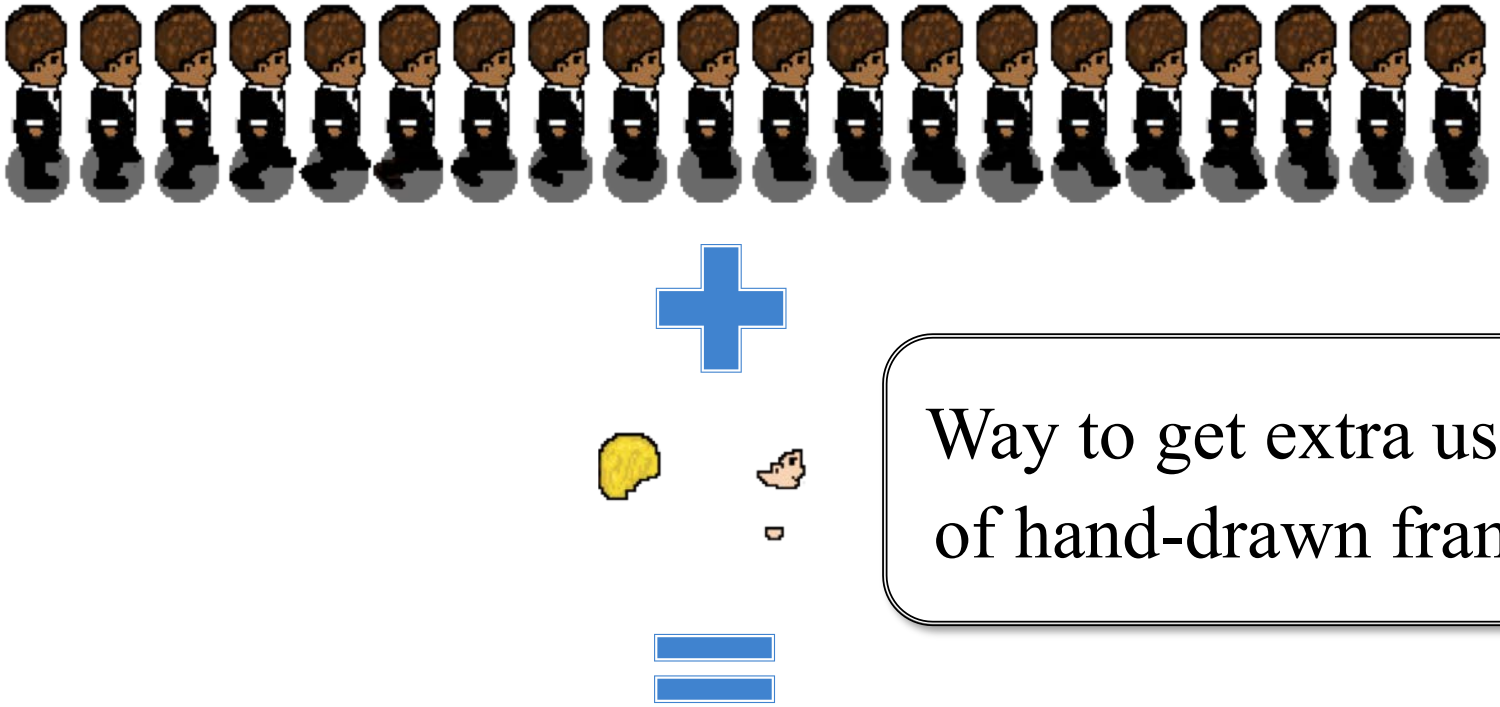
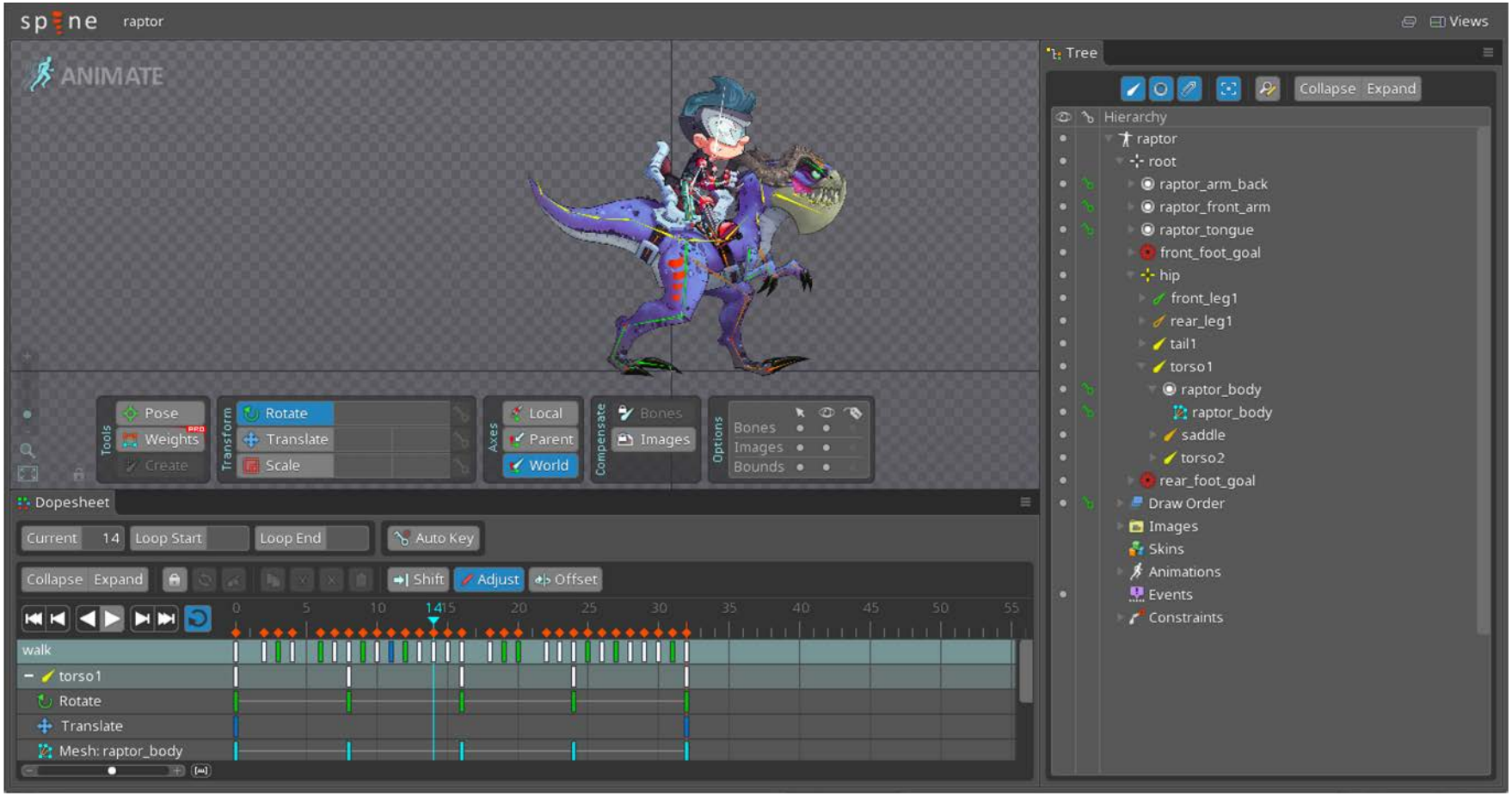


Way to get extra usage of hand-drawn frames

Spine Demo


spine
raptor
Views
ANIMATE
Tree
Collapse
Expand
Hierarchy
raptor
root
raptor_arm_back
raptor_front_arm
raptor_tongue
front_foot_goal
hip
front_leg1
rear_leg1
tail1
torso1
raptor_body
raptor_body
saddle
torso2
rear_foot_goal
Draw Order
Images
Skins
Animations
Events
Constraints
Tools
Pose
Weights
Create
Transform
Rotate
Translate
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World
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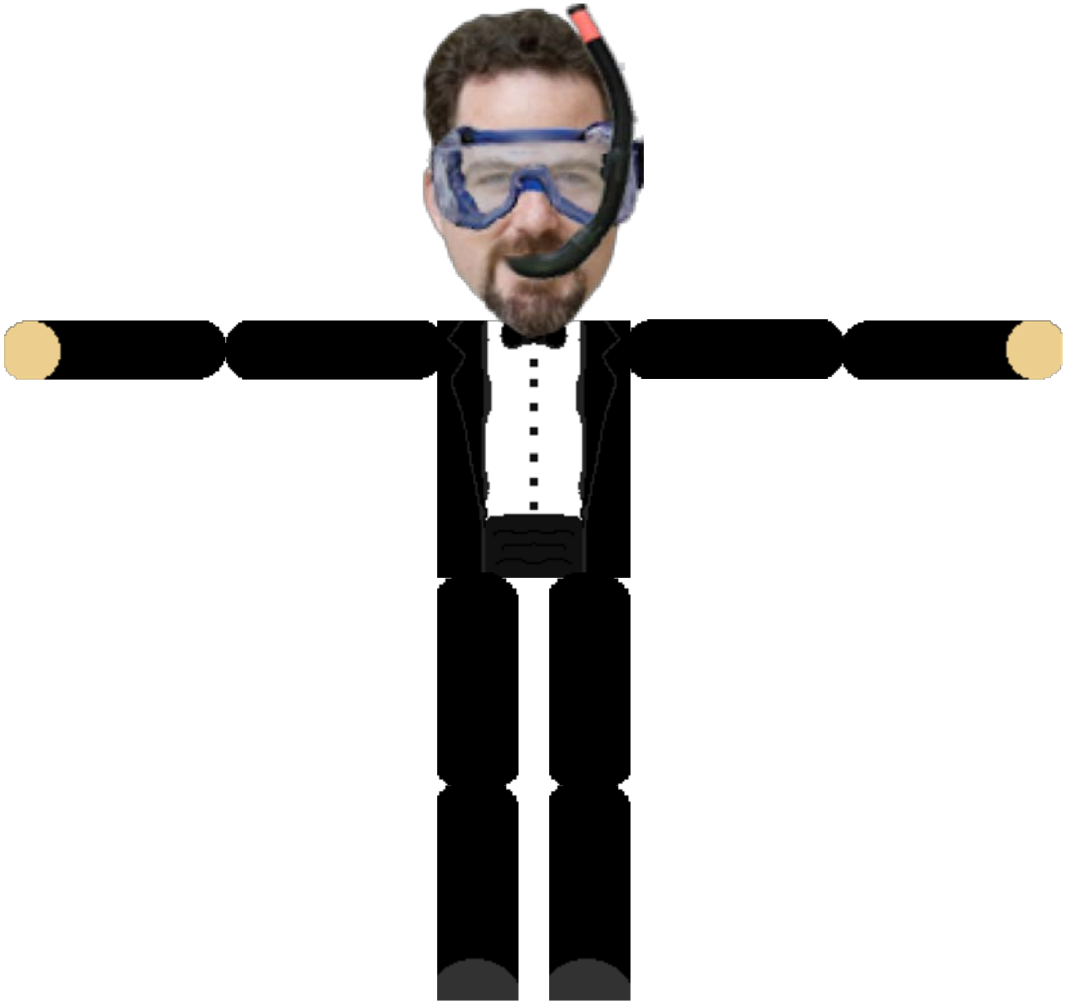
Images
Options
Bones
Images
Bounds
Dopesheet
Current
14
Loop Start
Loop End
Auto Key
Collapse
Expand
Shift
Adjust
Offset
walk
torso1
Rotate
Translate
Mesh: raptor_body

Basic Idea: **Bones**



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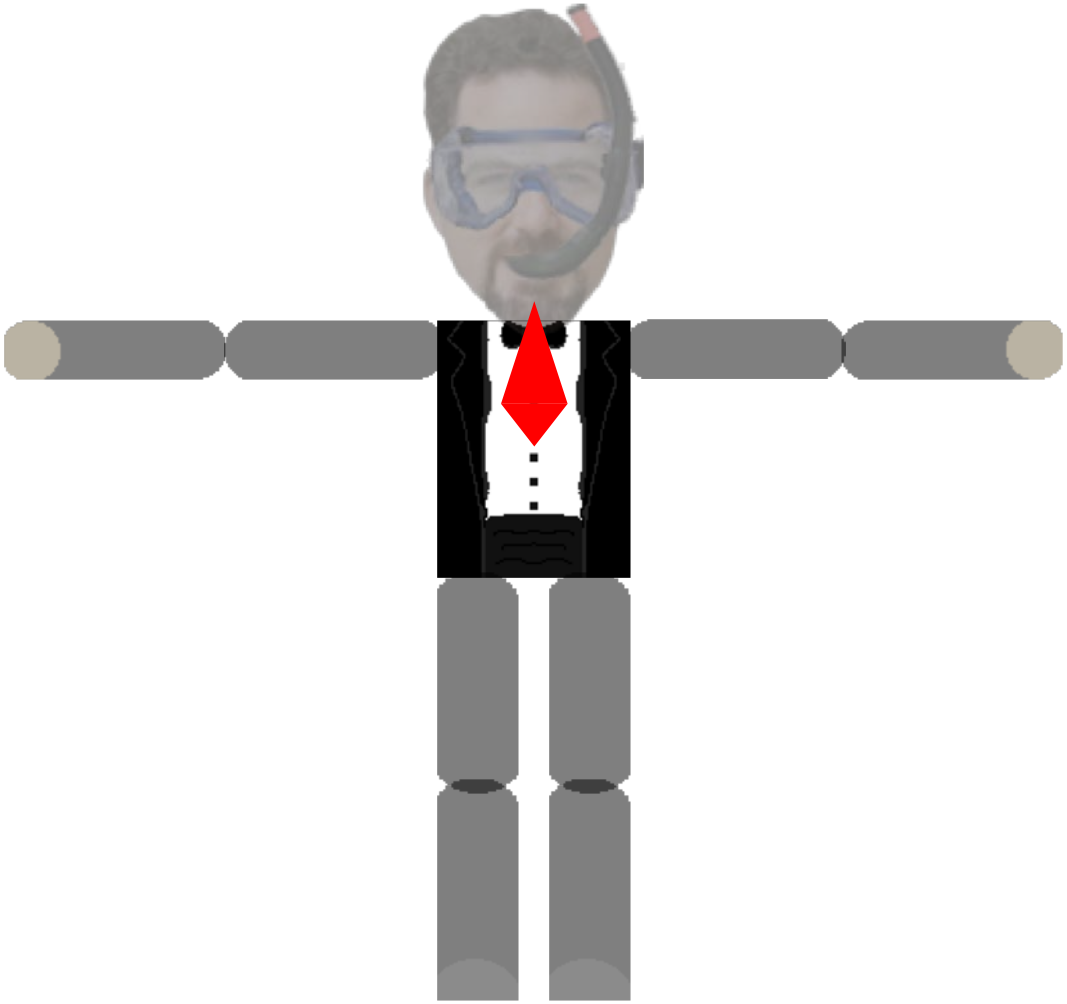

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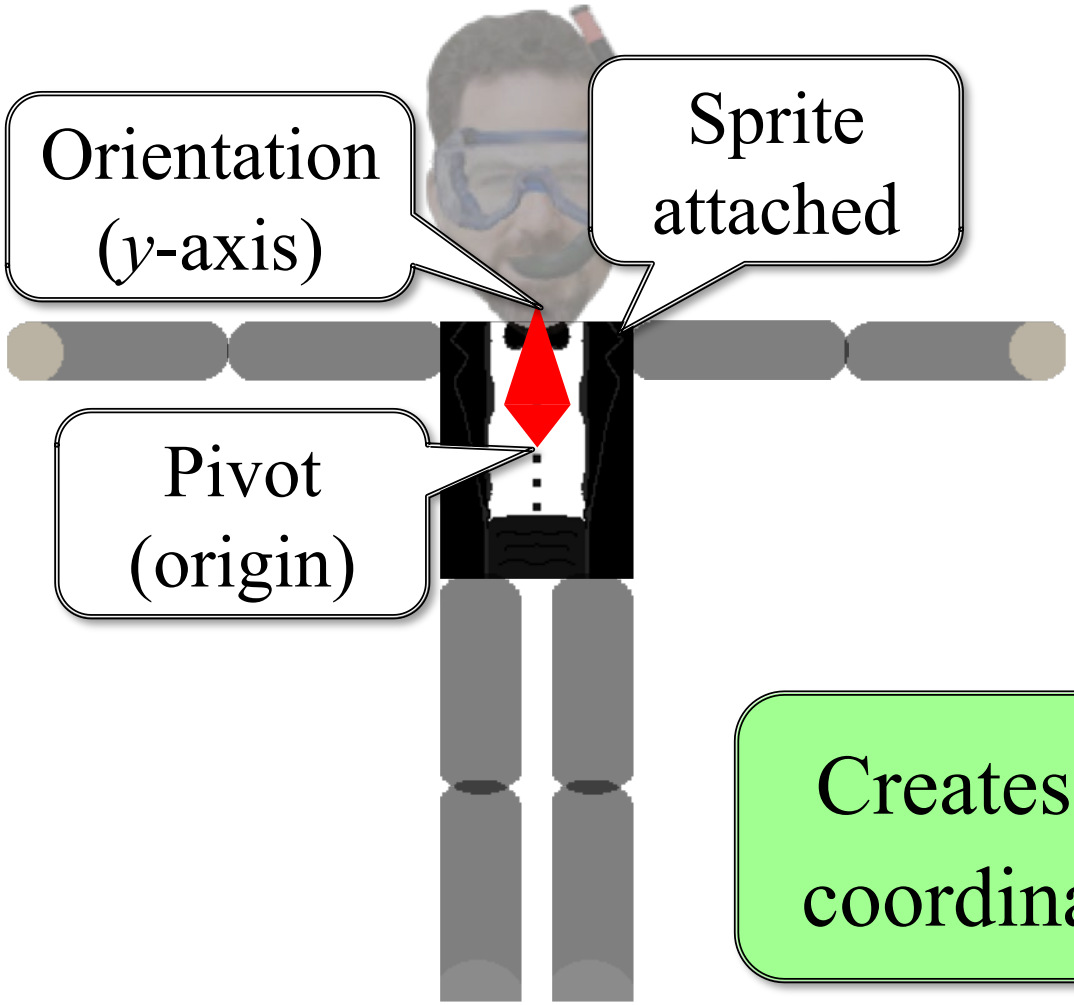
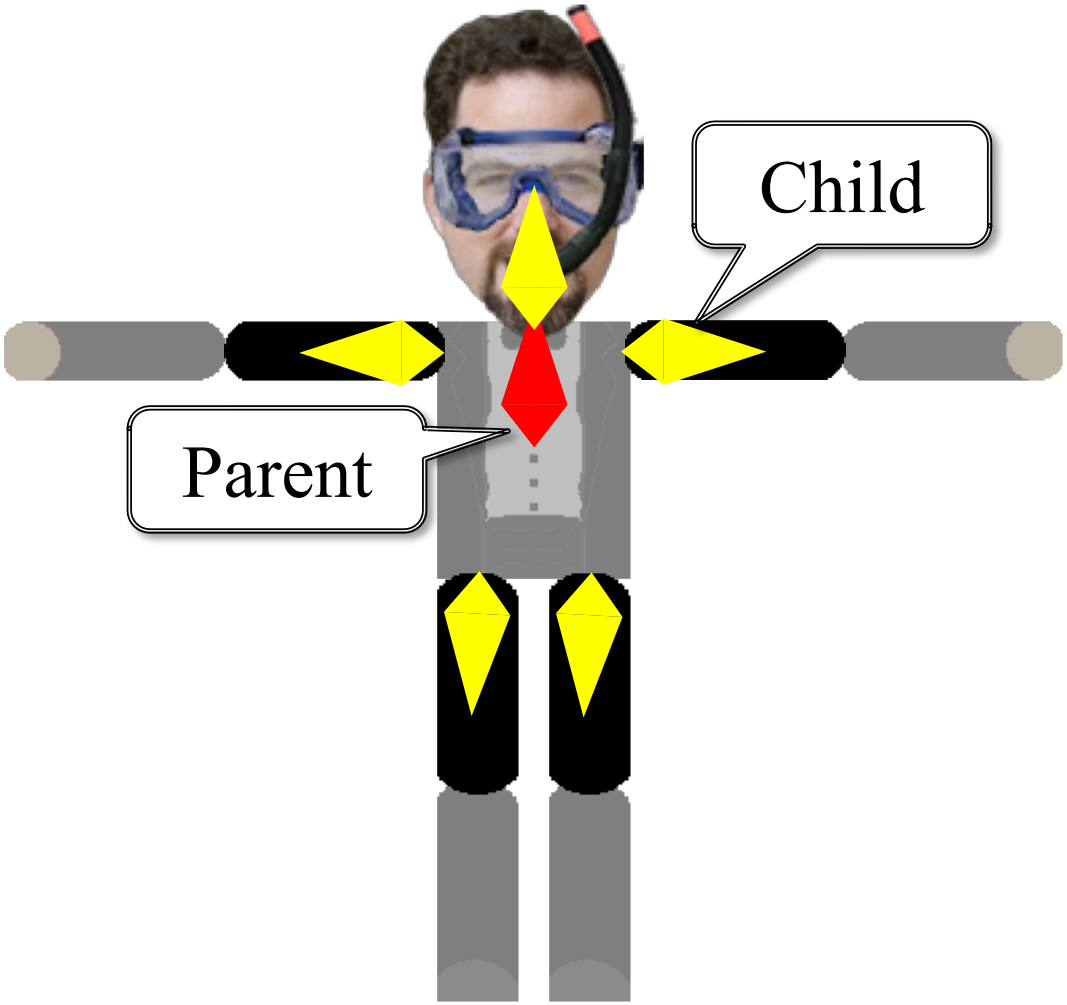


Creates implicit coordinate space

Bones are Heirarchical



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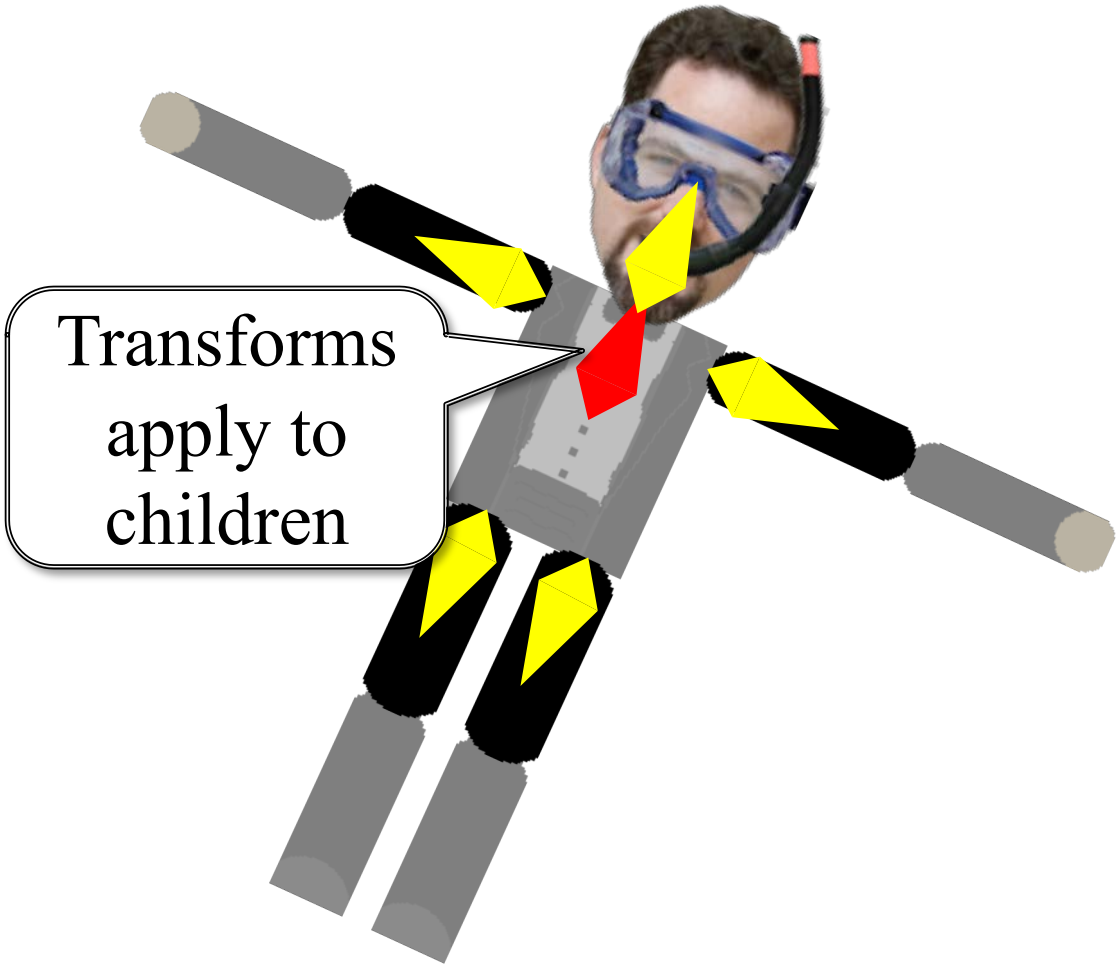

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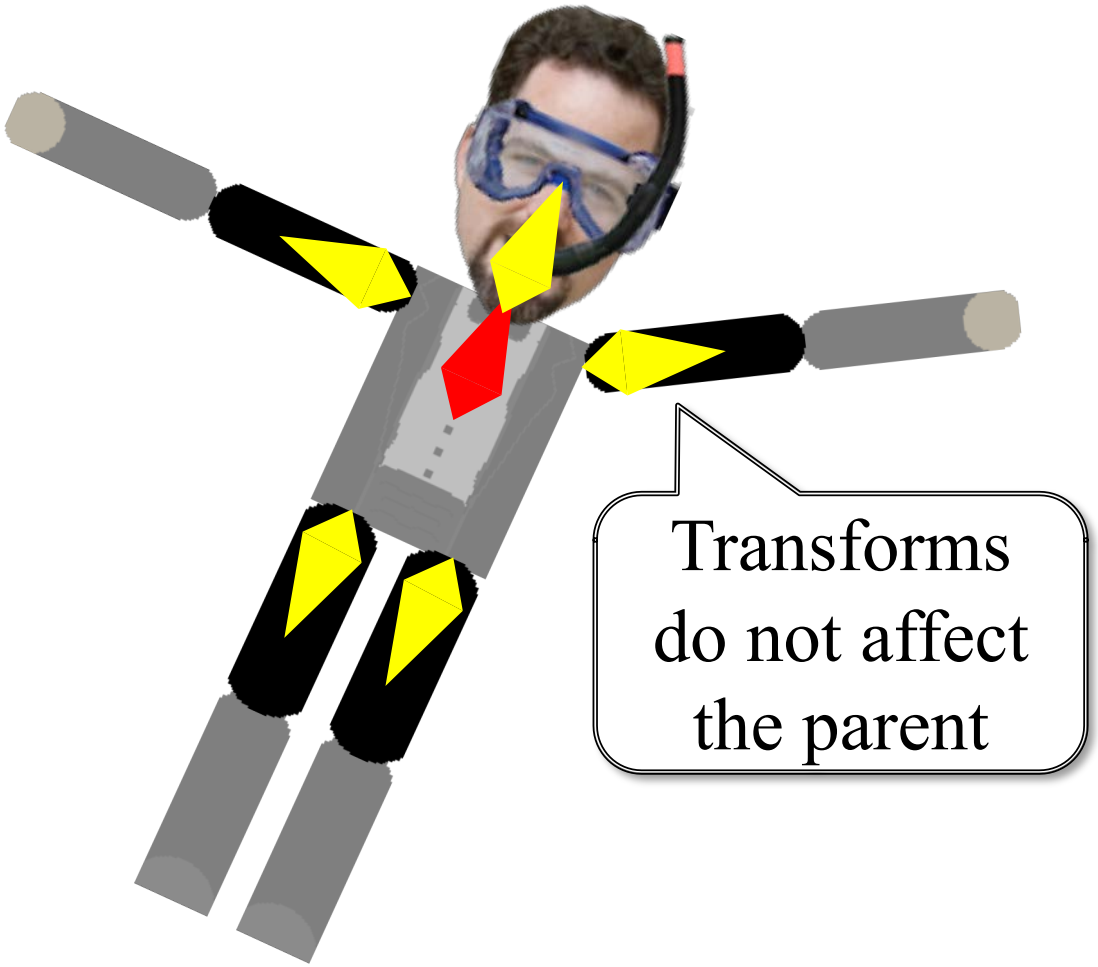
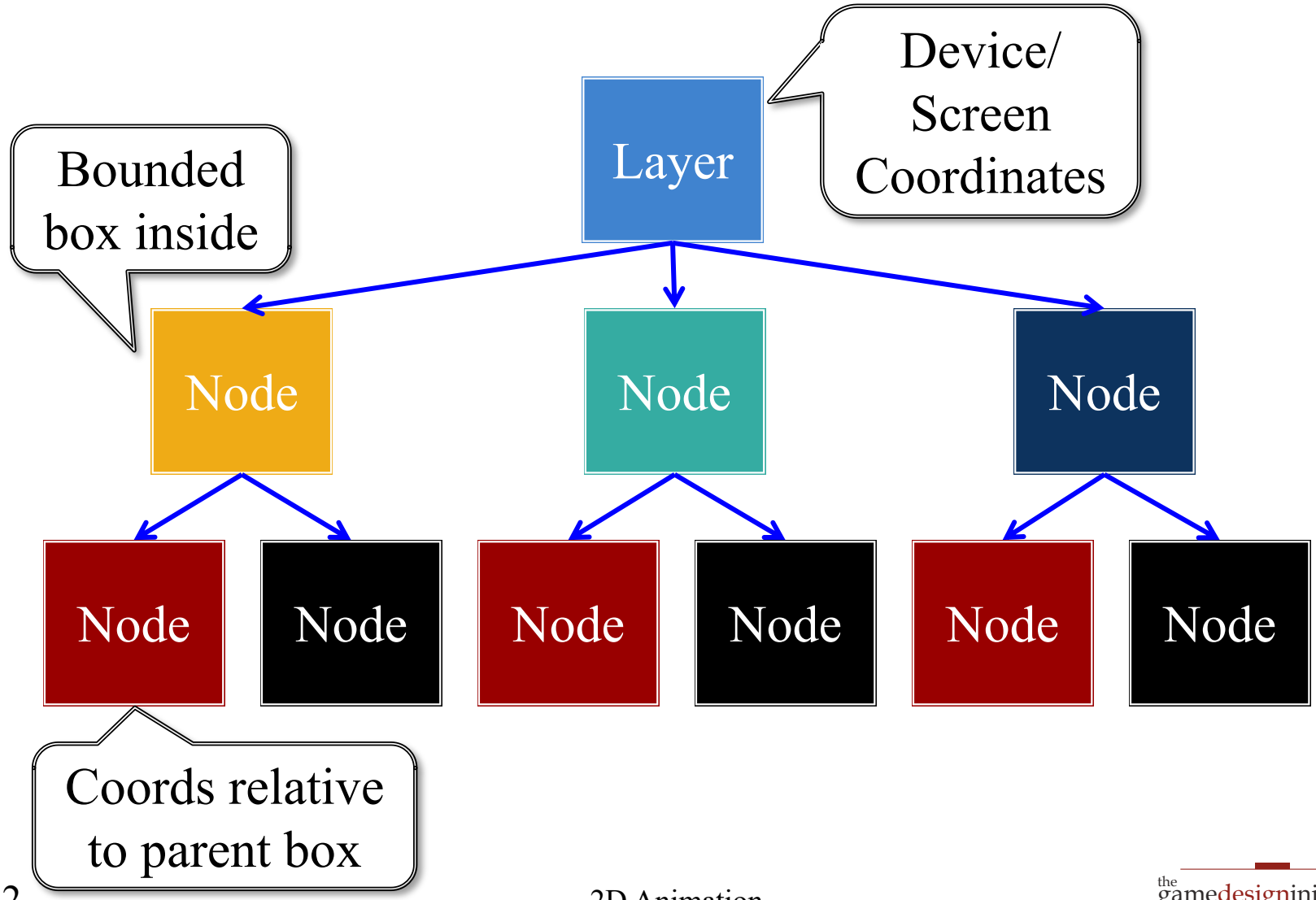
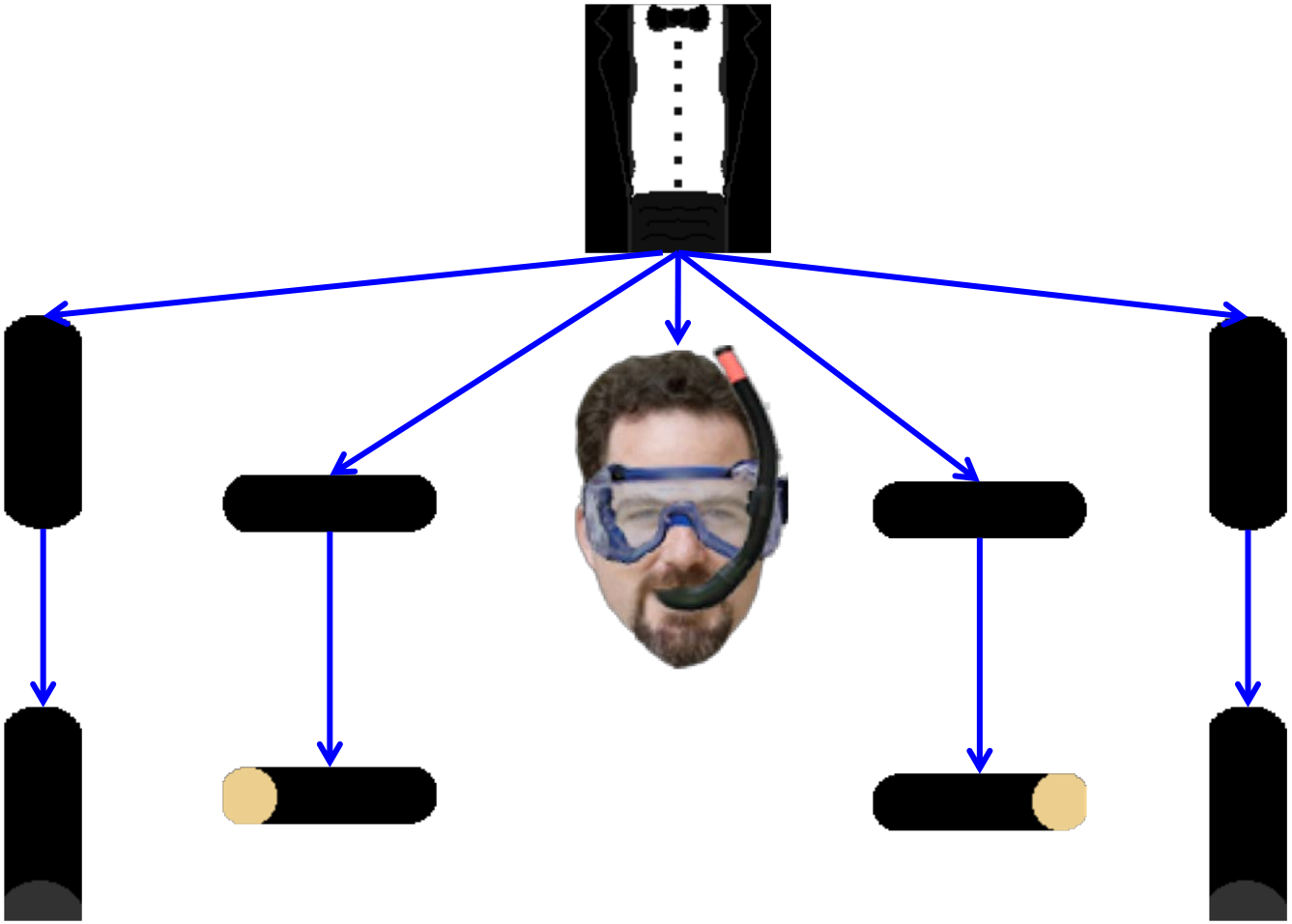


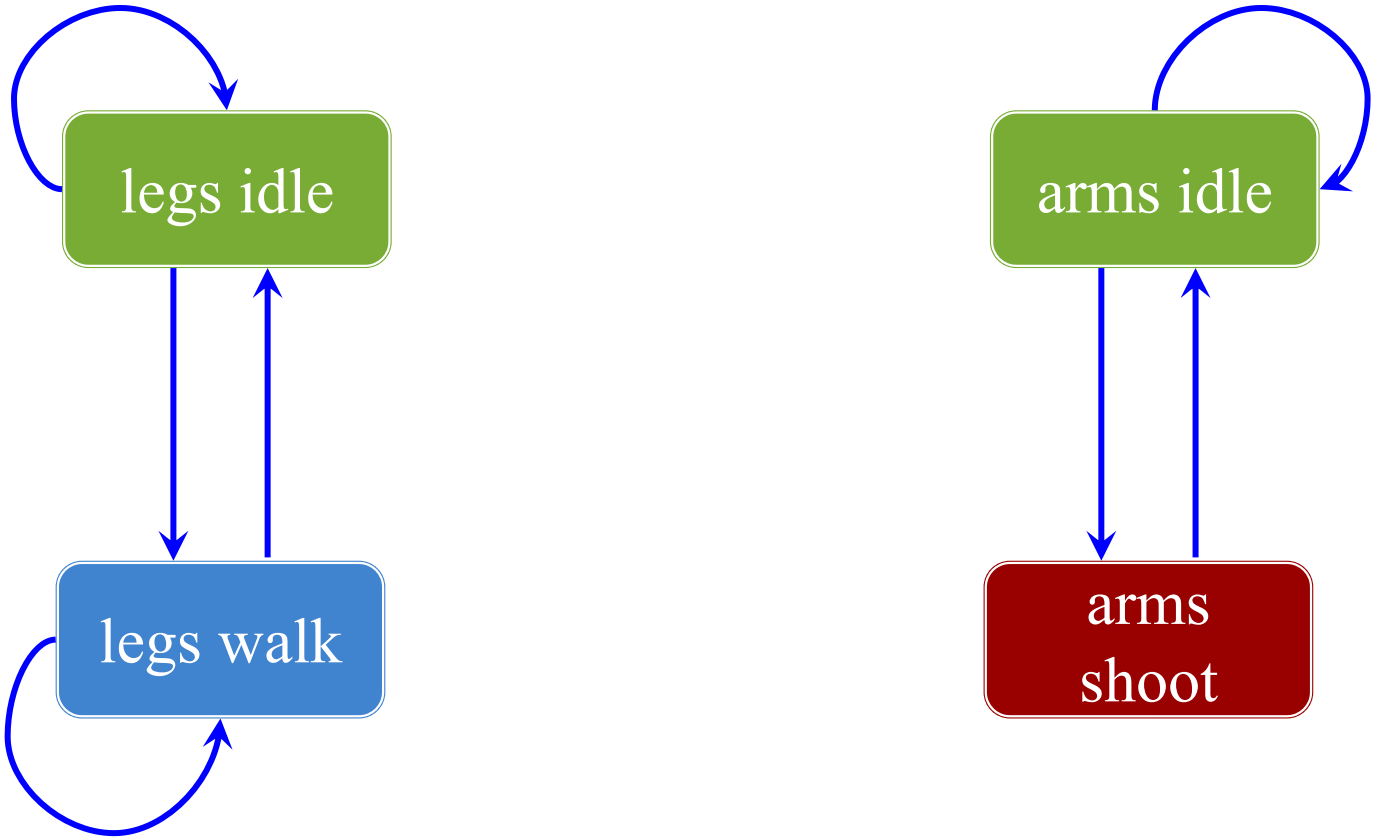
Recall: Scene Graph Hierarchy



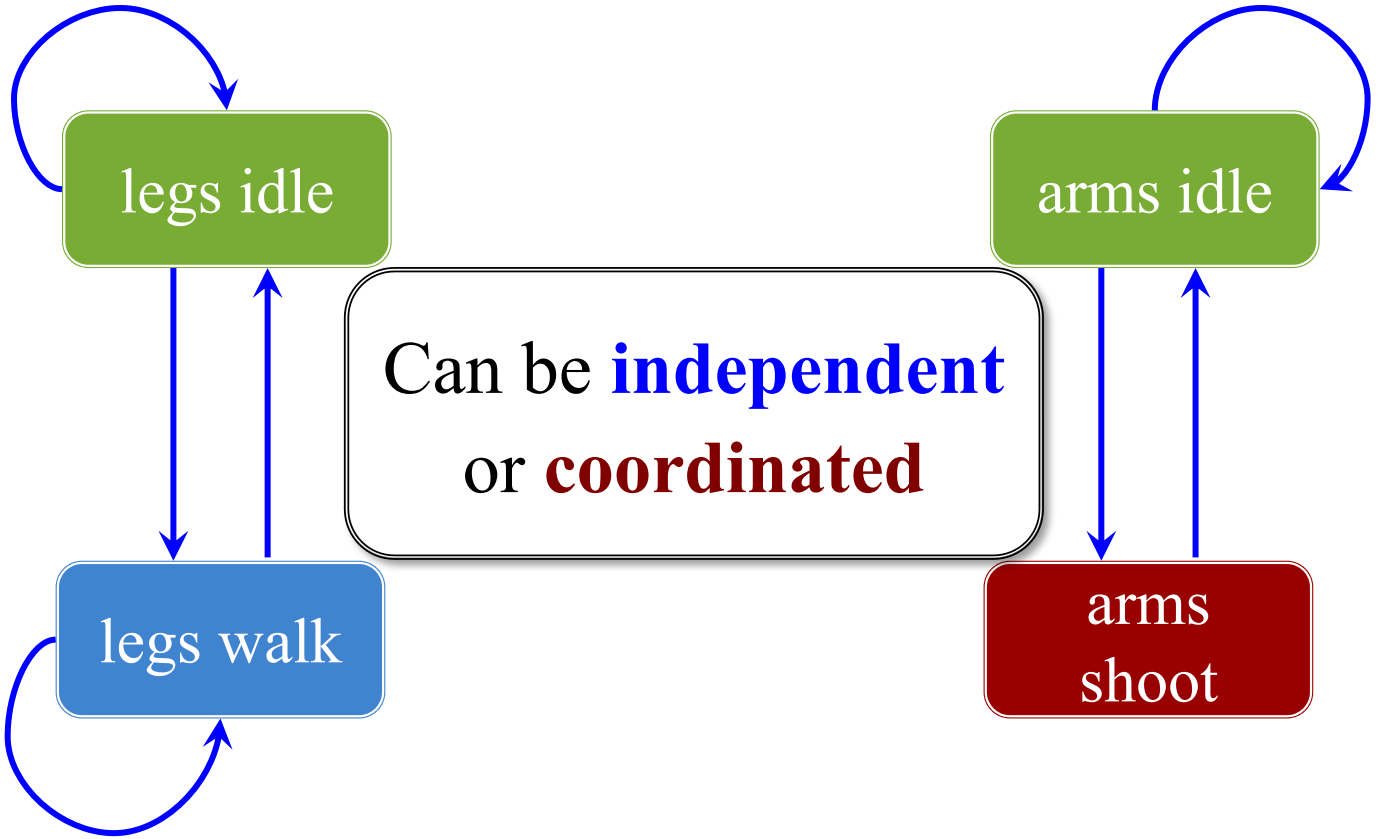
Bones are a Scene Graph Visualization



Manage With Multiple State Machines



Manage With Multiple State Machines



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