the gamedesigninitiative at cornell university

Lecture 12

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

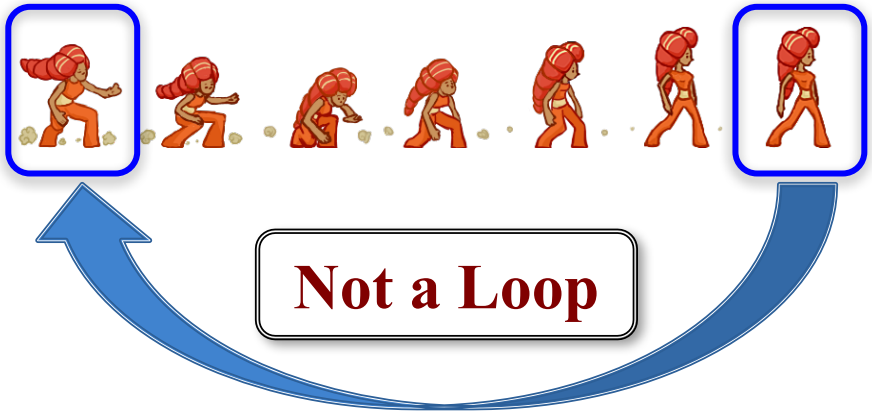
Landing Animation

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

Landing Animation



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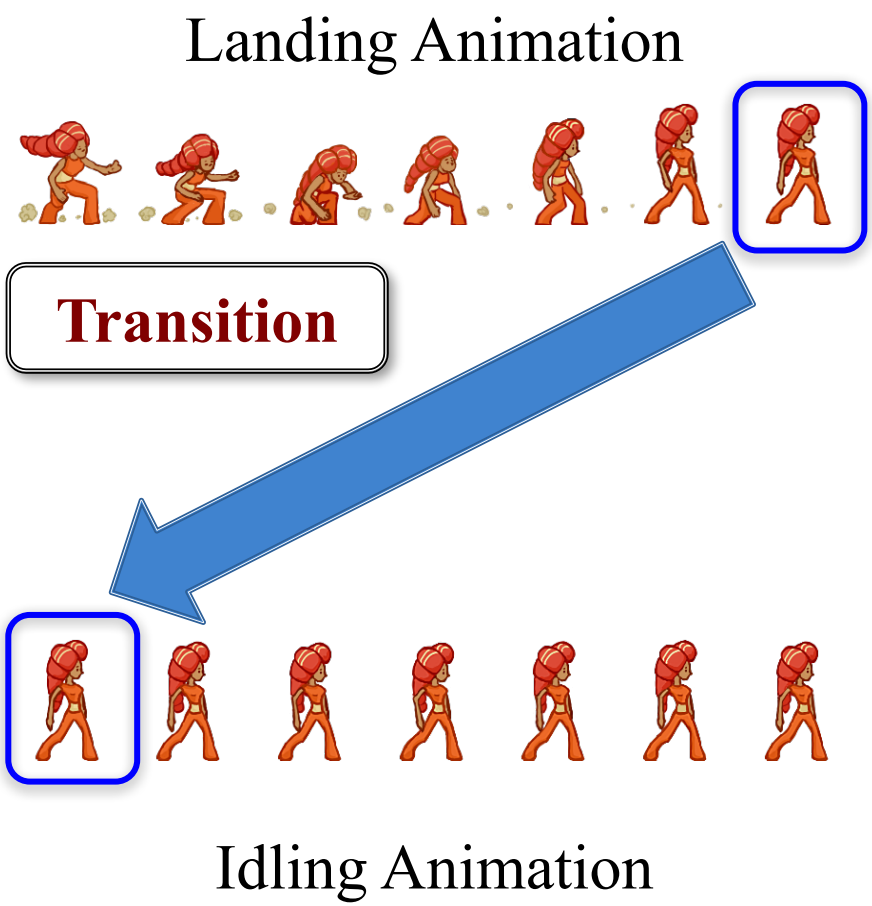

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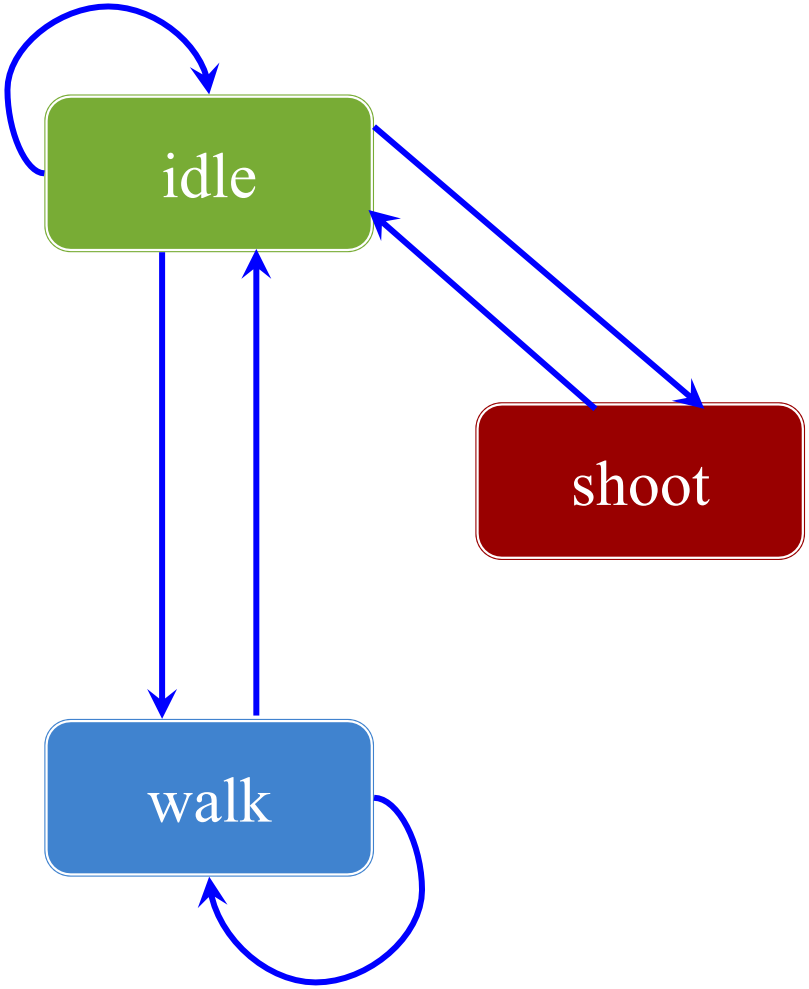
Animation and State Machines

- 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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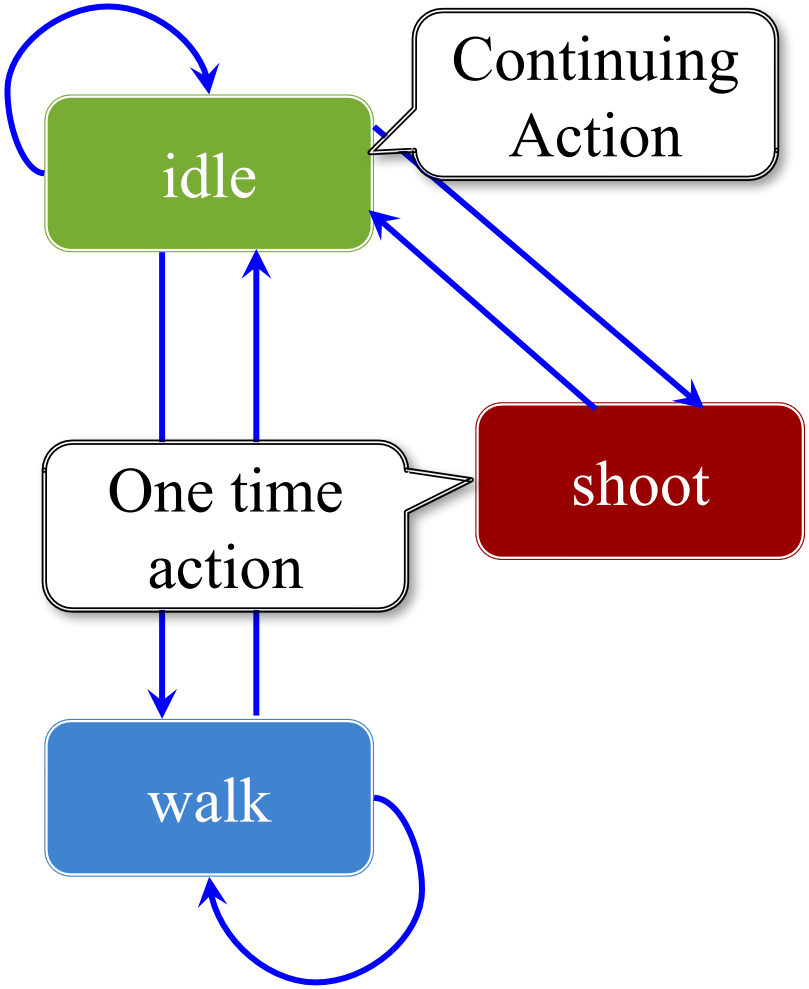
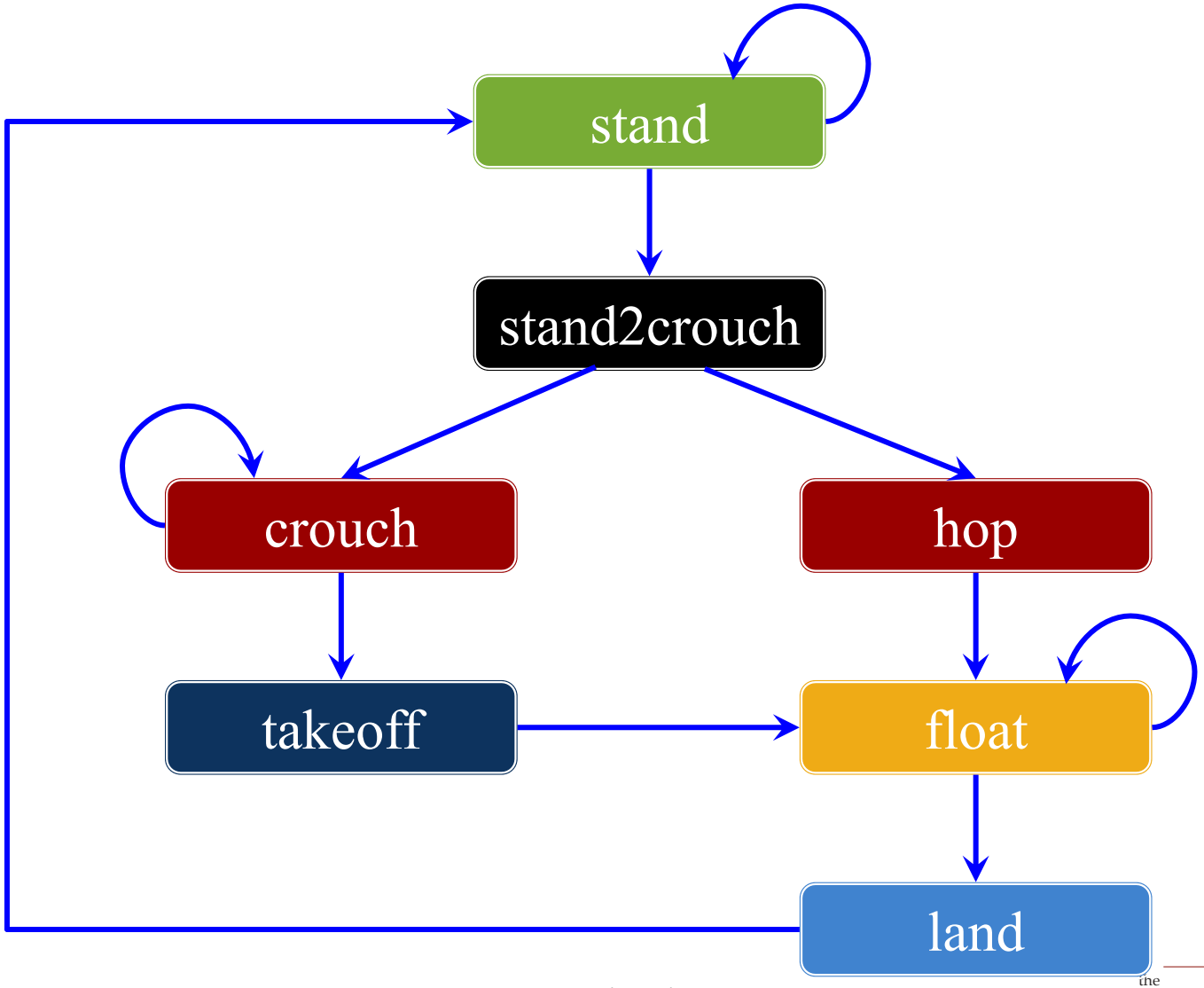


Complex Example: Jumping



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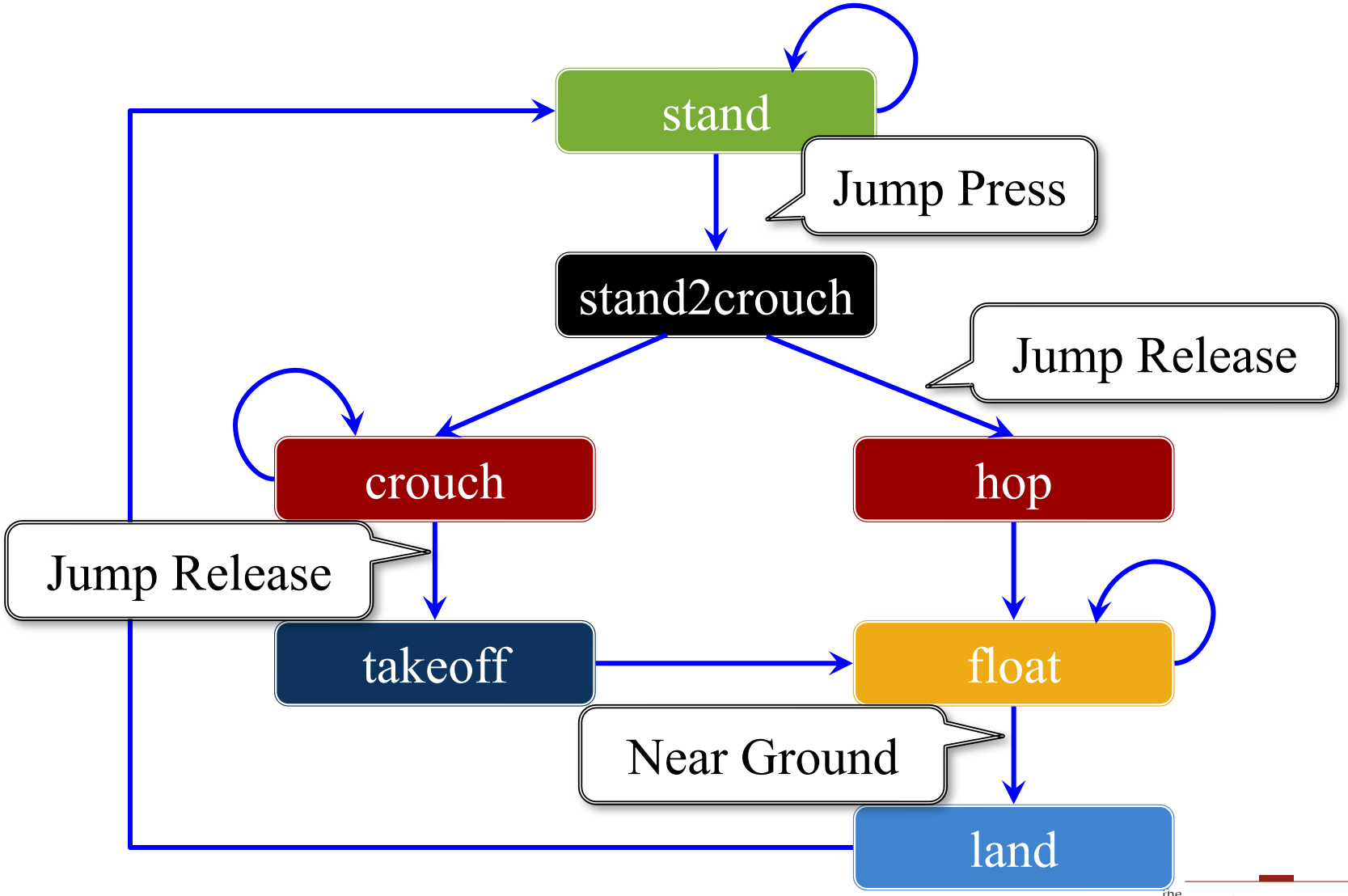

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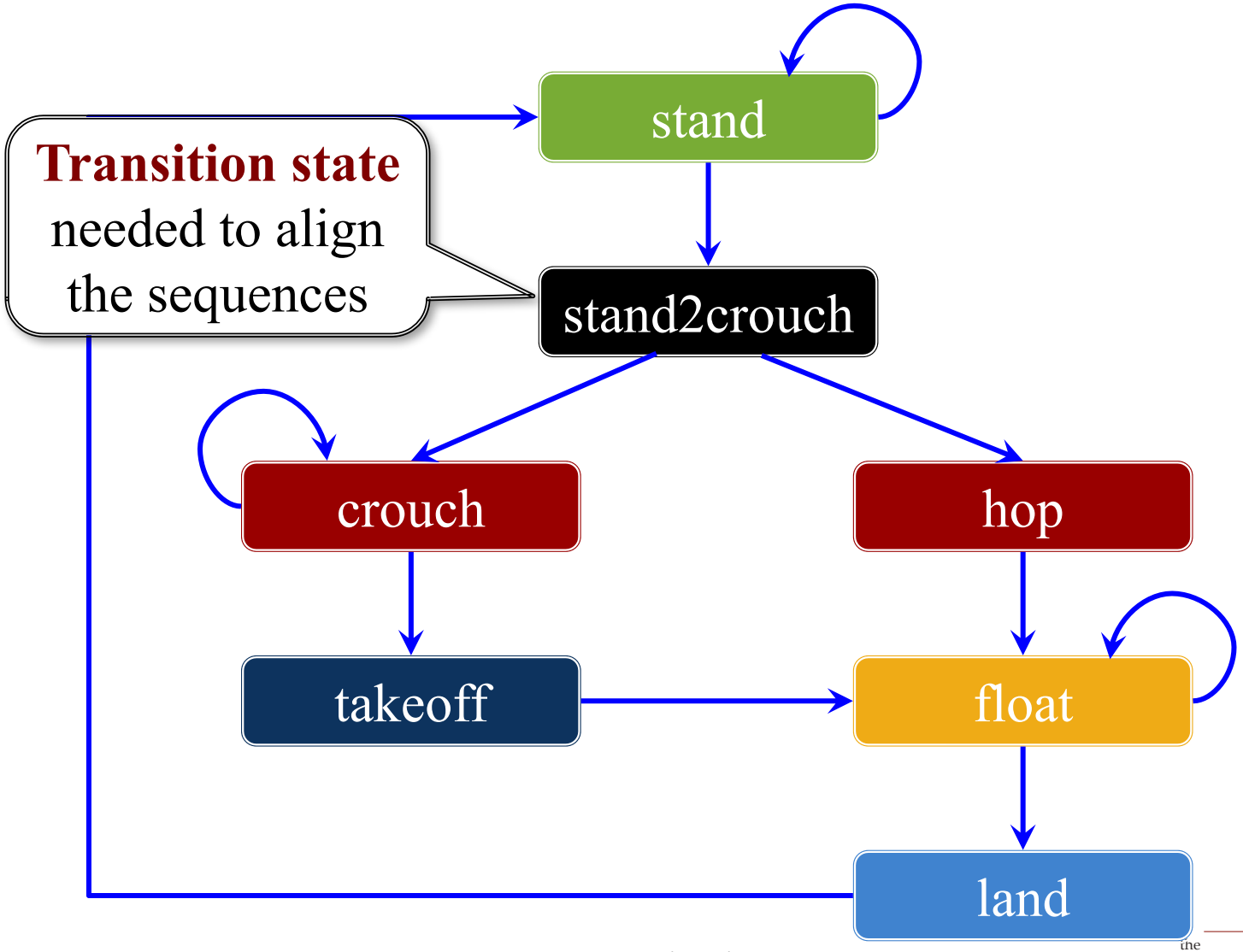
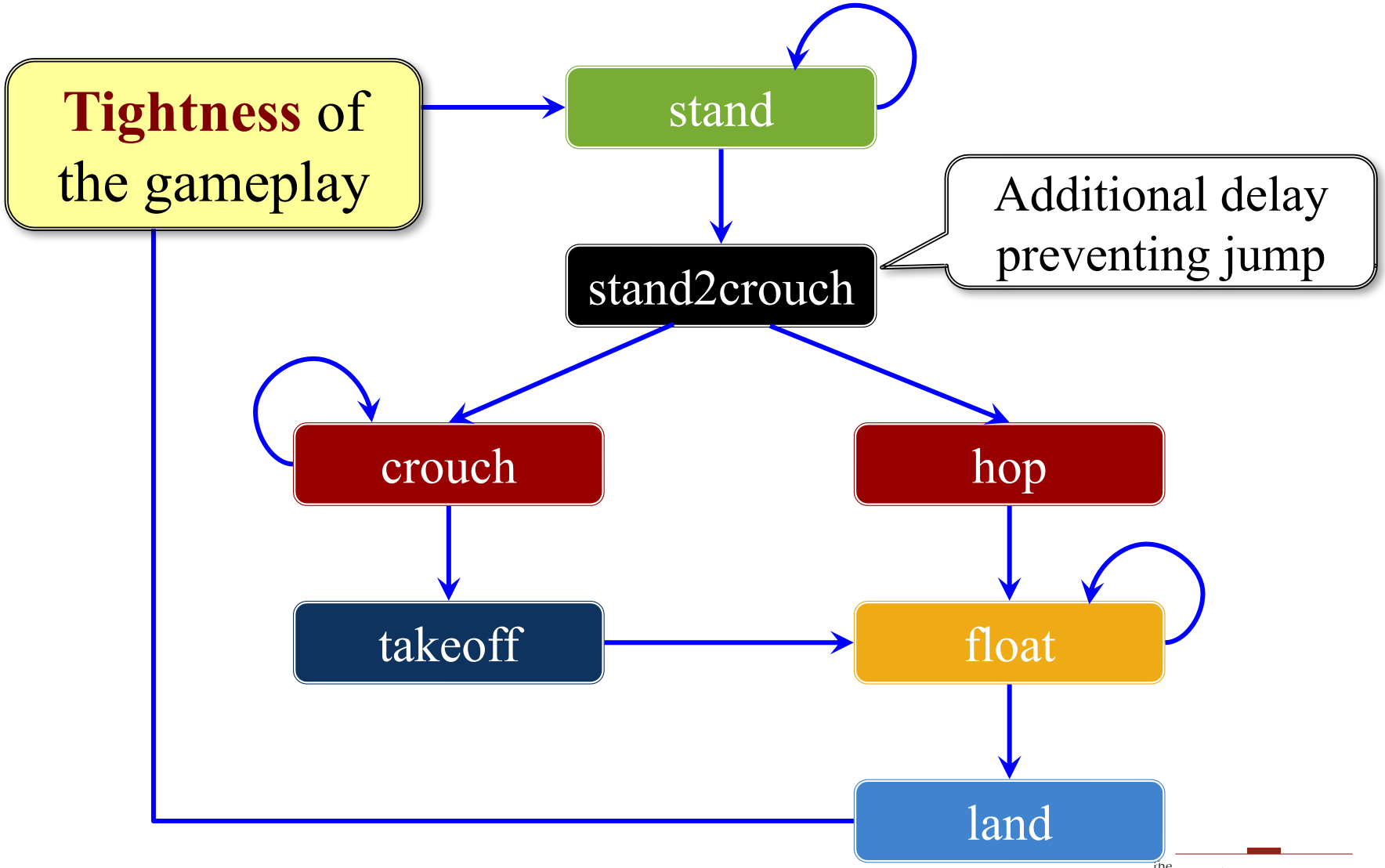
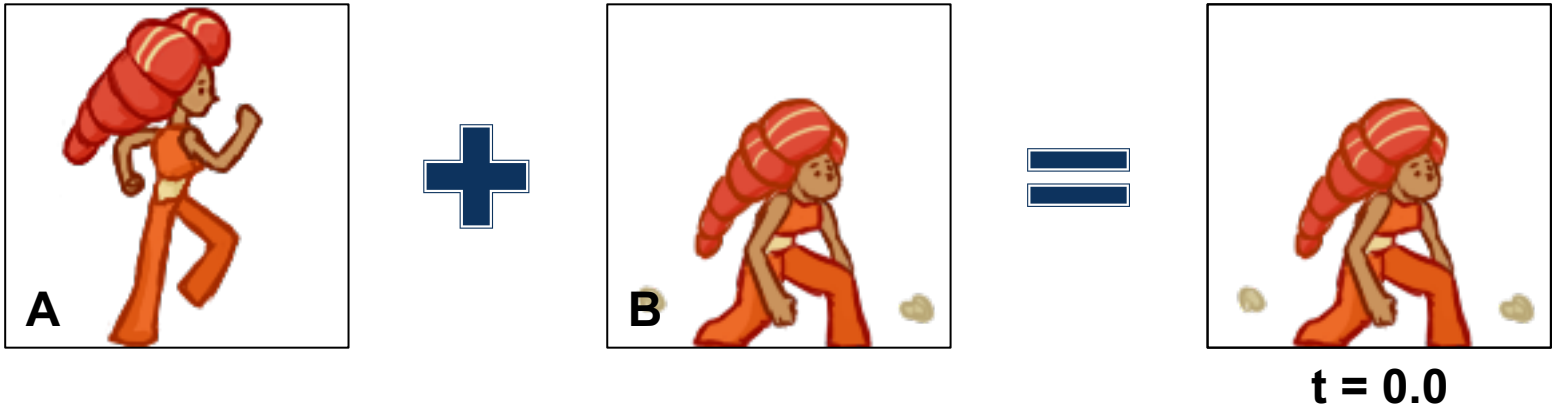


Aside: Sync Kills

The Responsiveness Issue



Fast Transitions: Crossfade Blending



- Linear interpolation on colors

$$\left.\begin{aligned} r_c &= tr_a + (1-t)r_b \\ g_c &= tg_a + (1-t)g_b \\ b_c &= tb_a + (1-t)b_b \end{aligned}\right\} \text{Note weights sum to 1.0}$$

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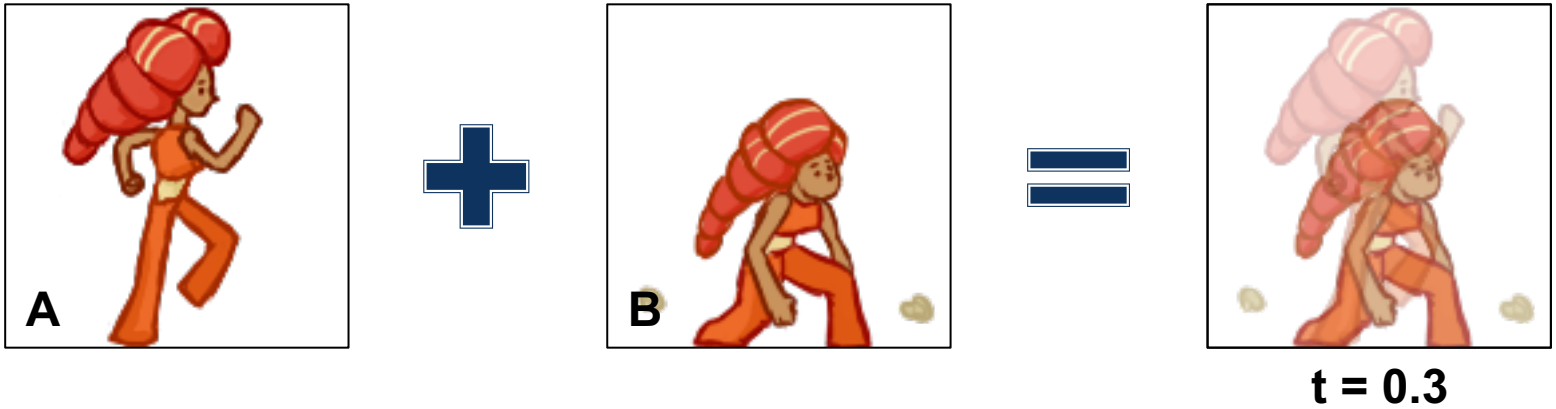

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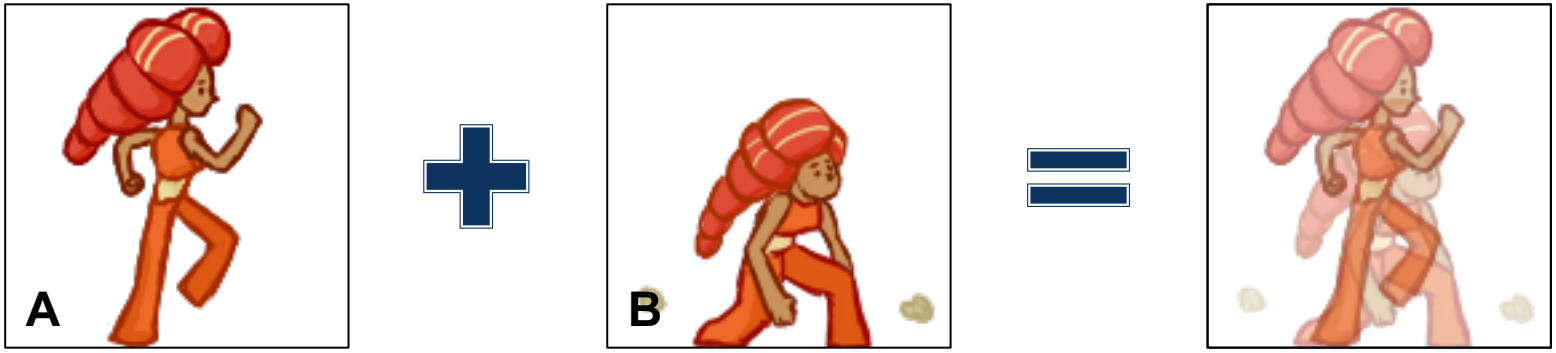

t = 0.6

- Linear interpolation on colors

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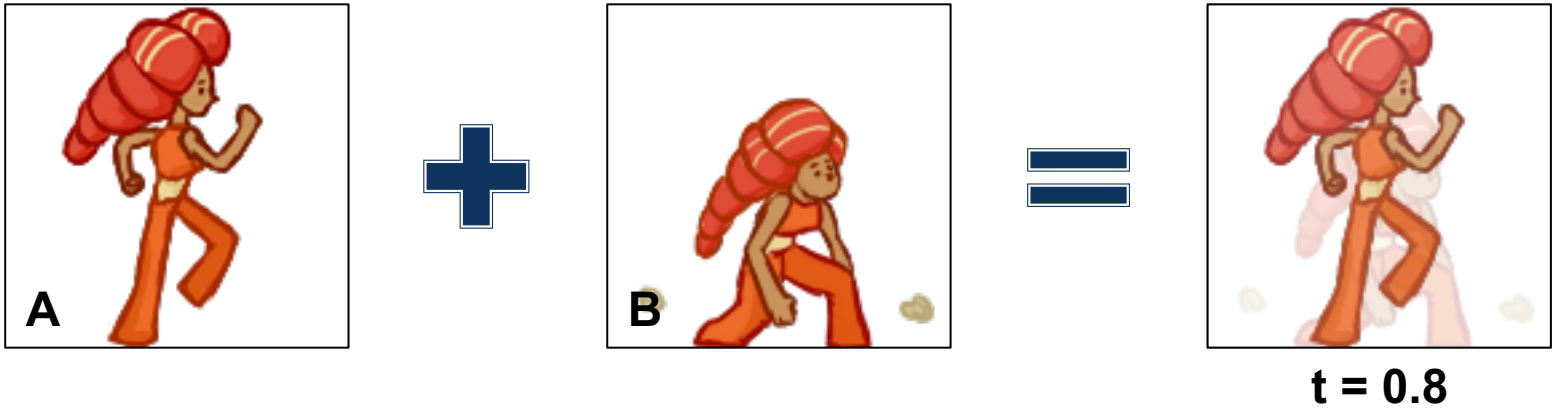

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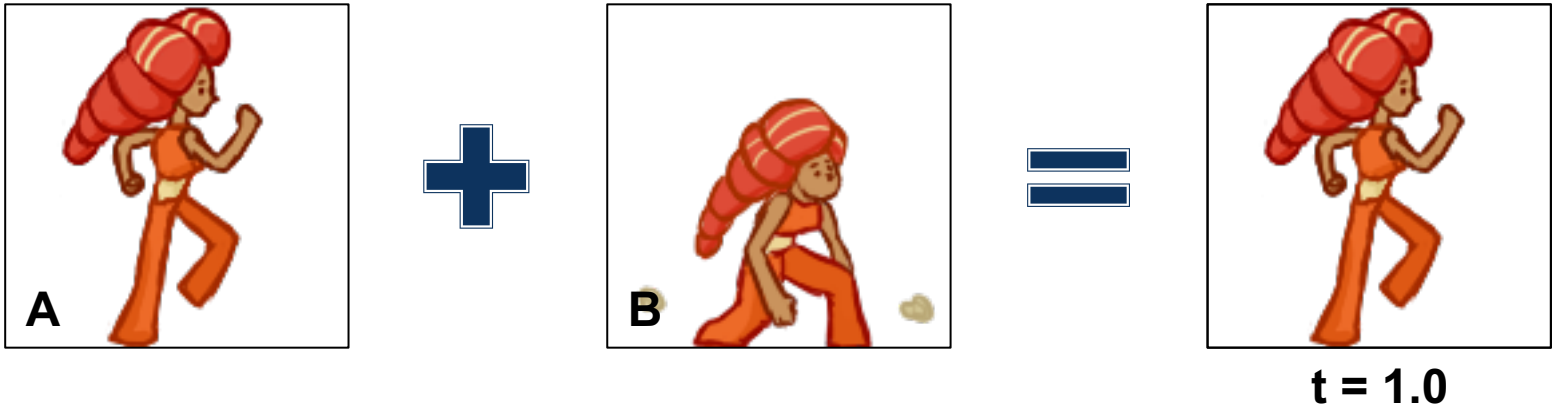

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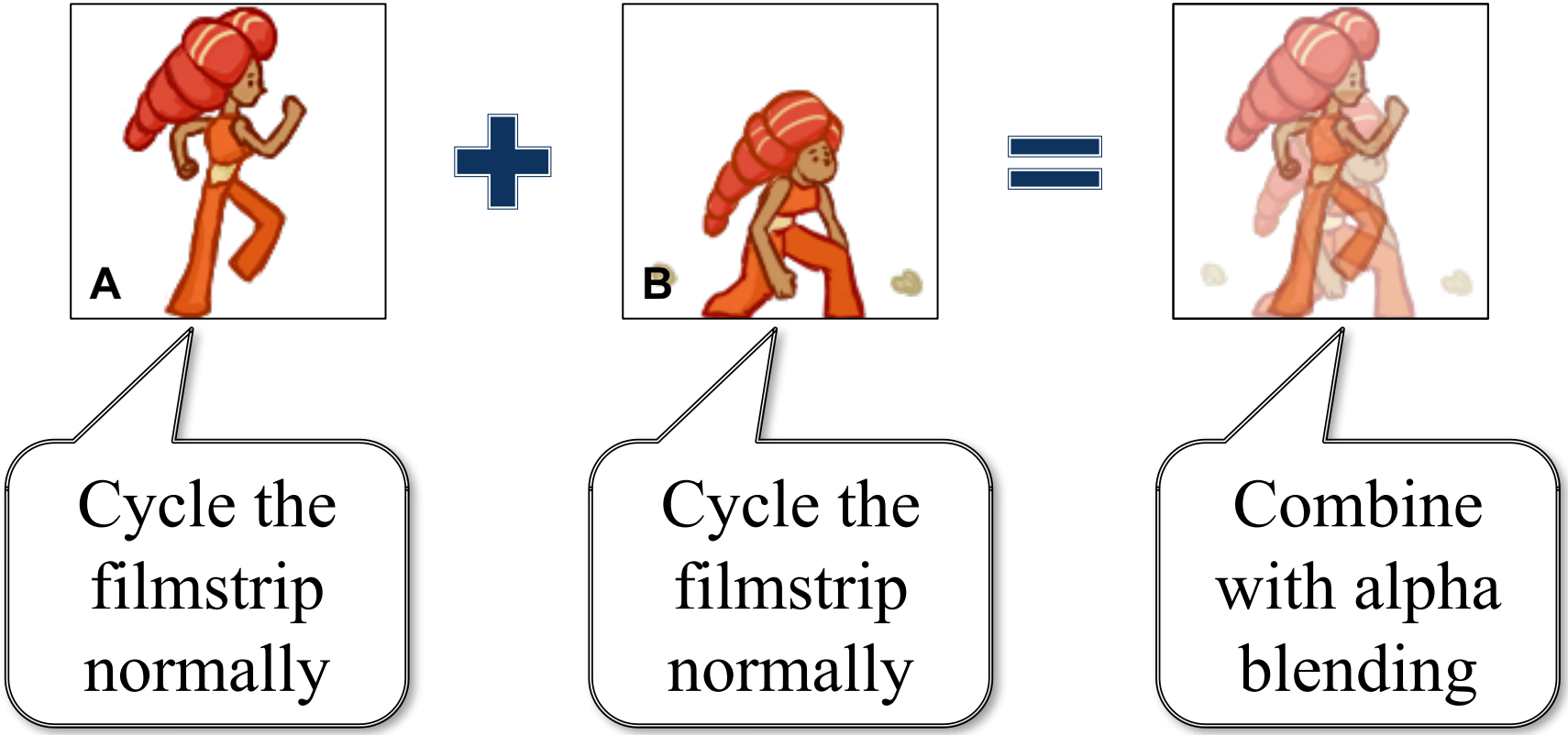
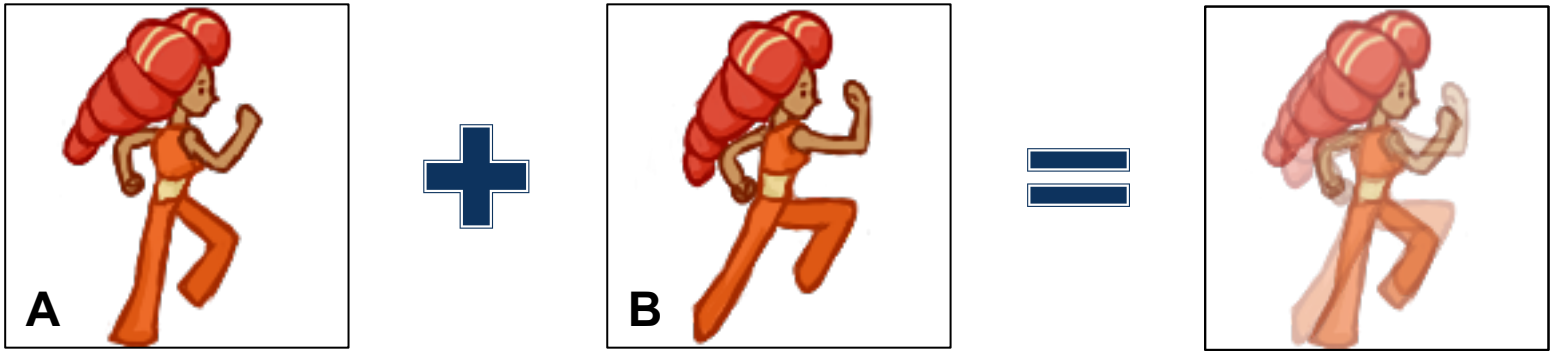
Combining With Animation

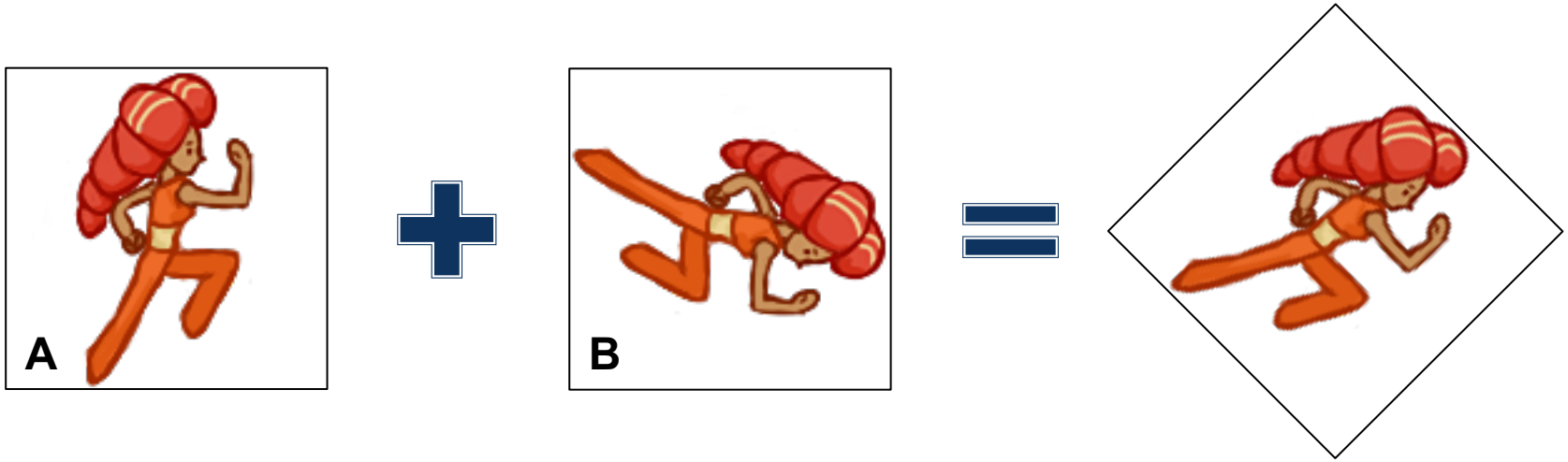


Related Concept: **Tweening**



- 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
```

Executing Actions: **Transforms**

ActionManager

Action

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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

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auto action

mgr->activa
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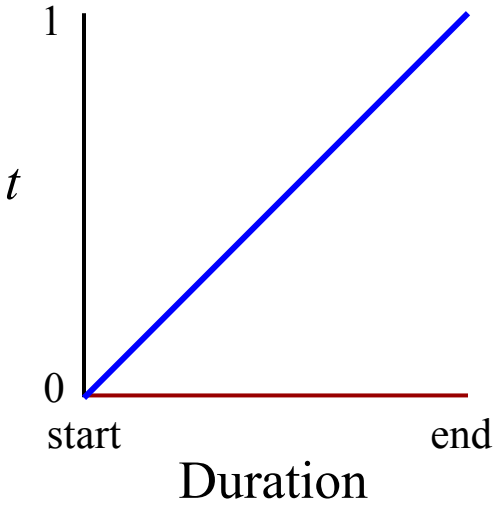
Alternatively, could specify time per frame

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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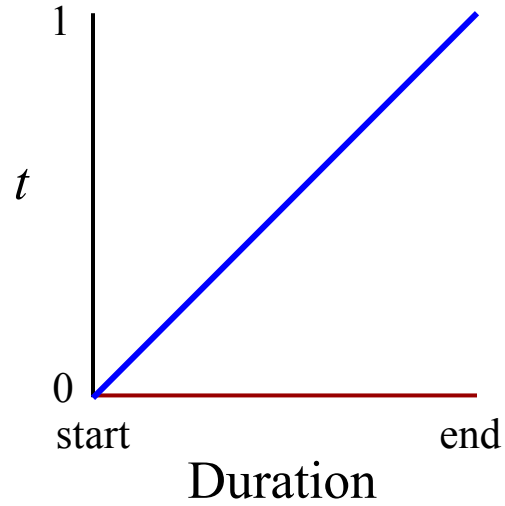
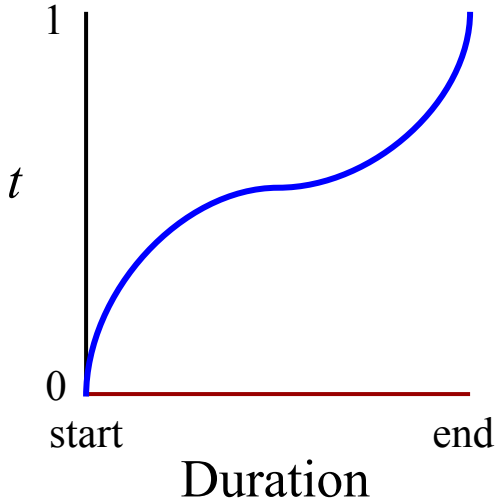
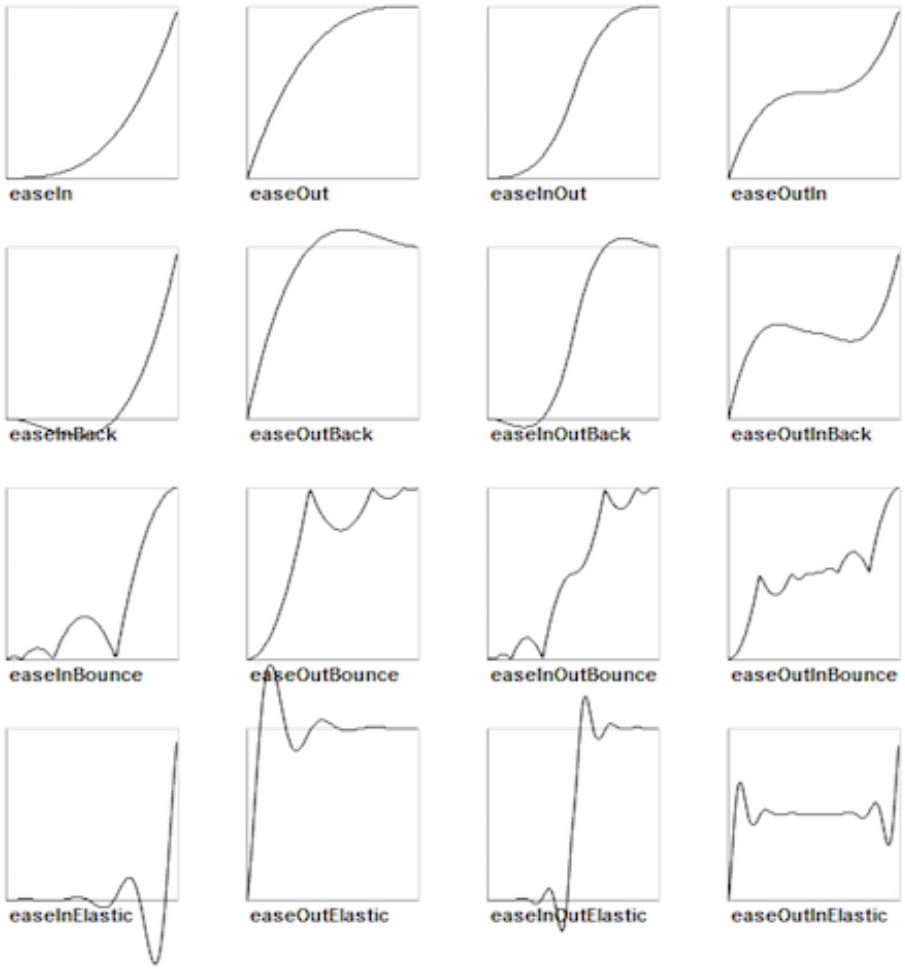




Classic Easing Functions



Classic Easing Functions

Problem With Decoupled Animation

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

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mgr->activate(key,action,sprite);
```

What if we change our mind before 2 seconds?

Problems With Decoupled Animation

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mgr->activate(key,action,sprite);
```

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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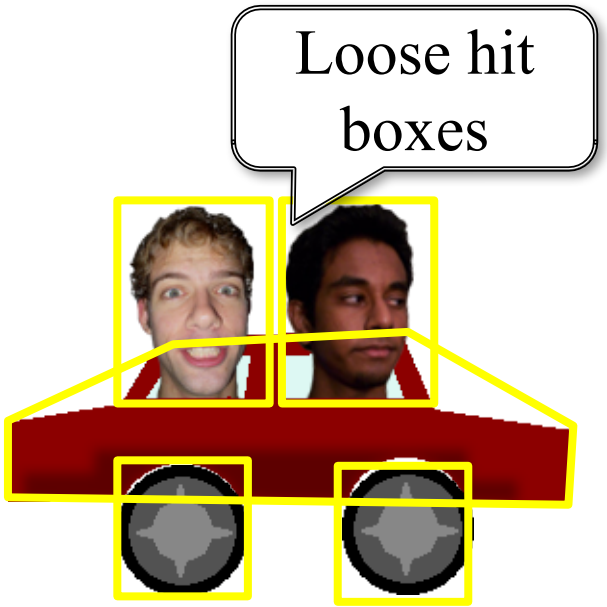
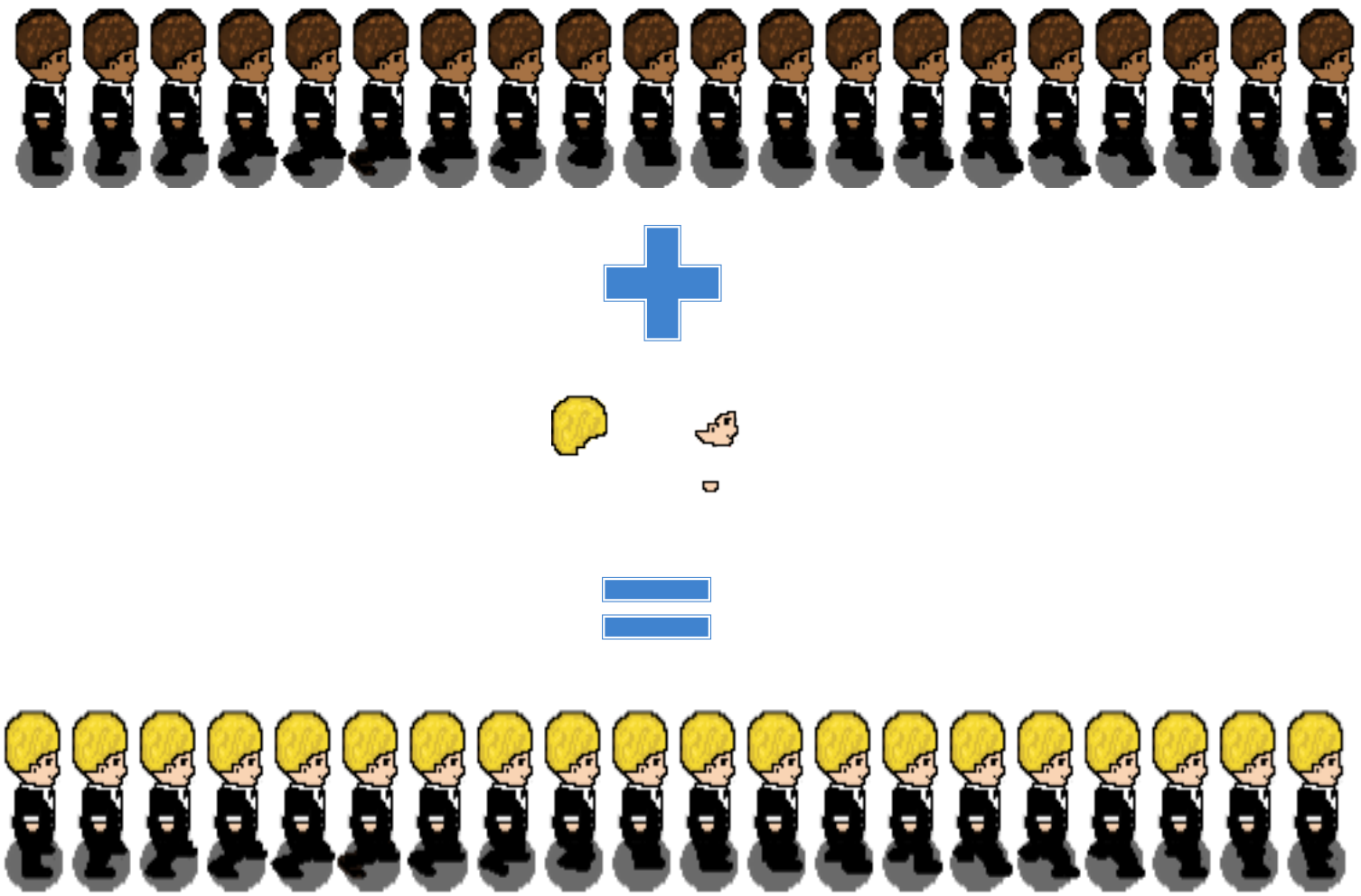


- Inside hit box can safely
  - Transform with duration
  - Tween animations
  - Manage multiple actions

Aside: Skinning



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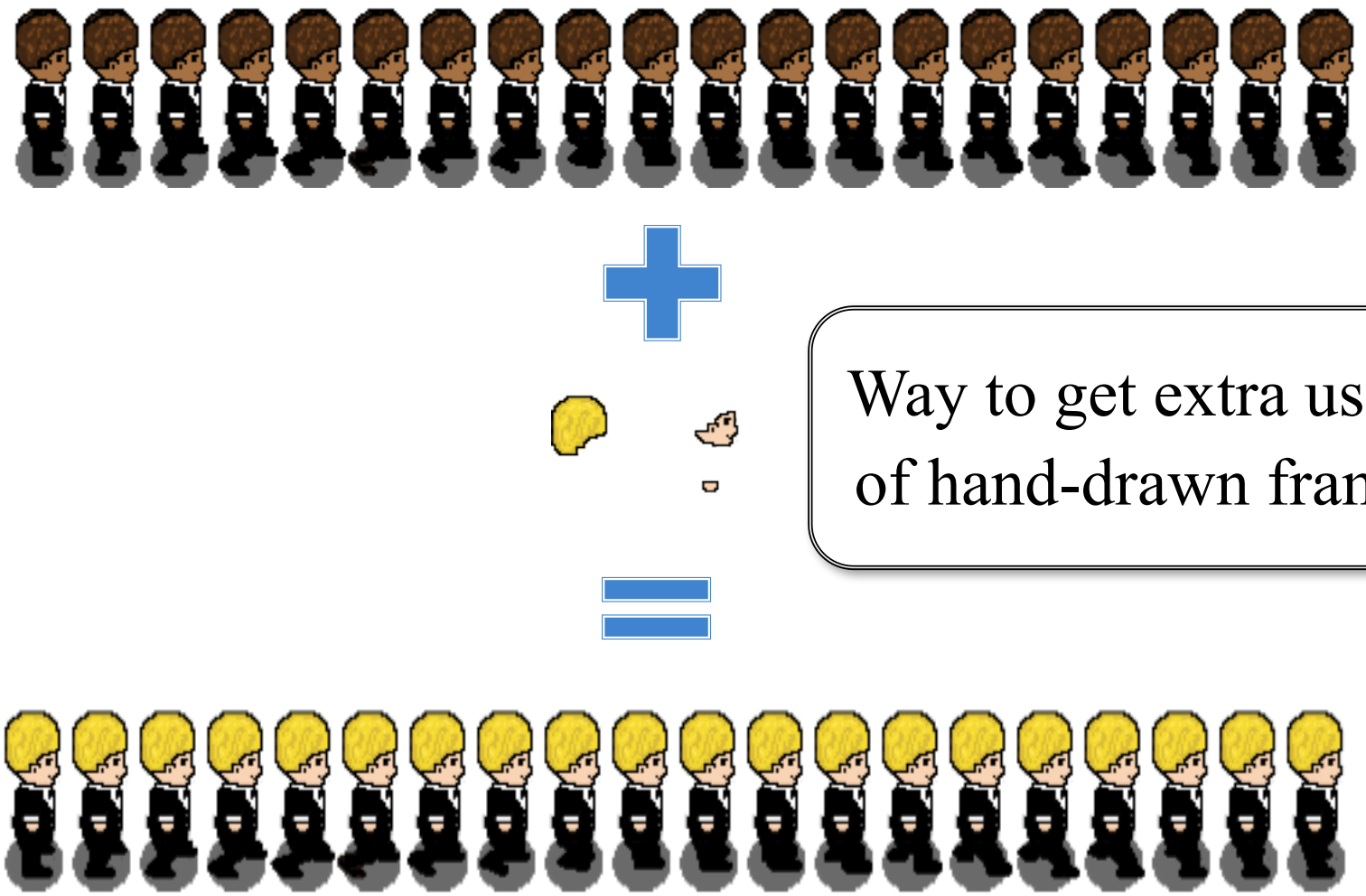
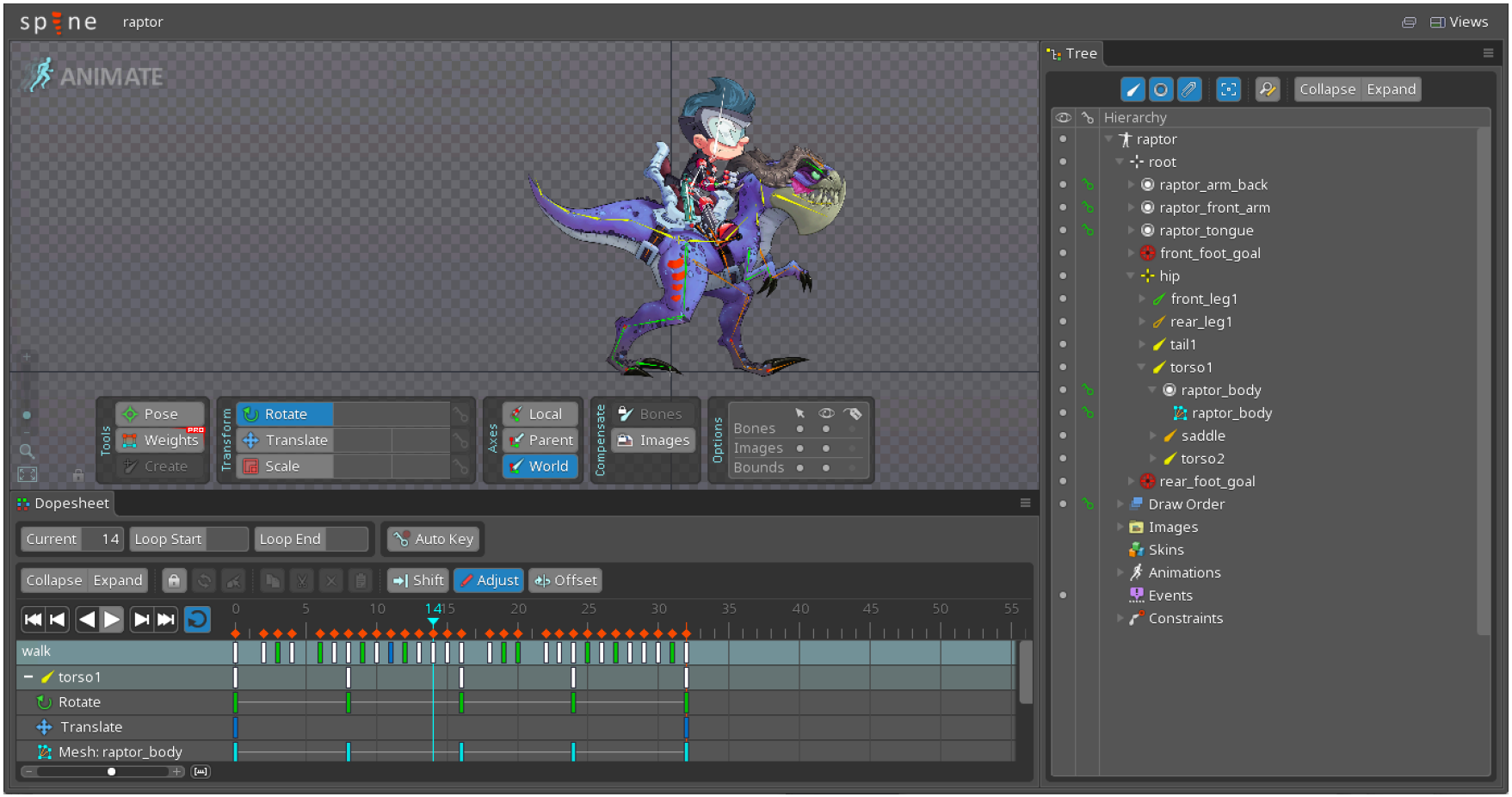
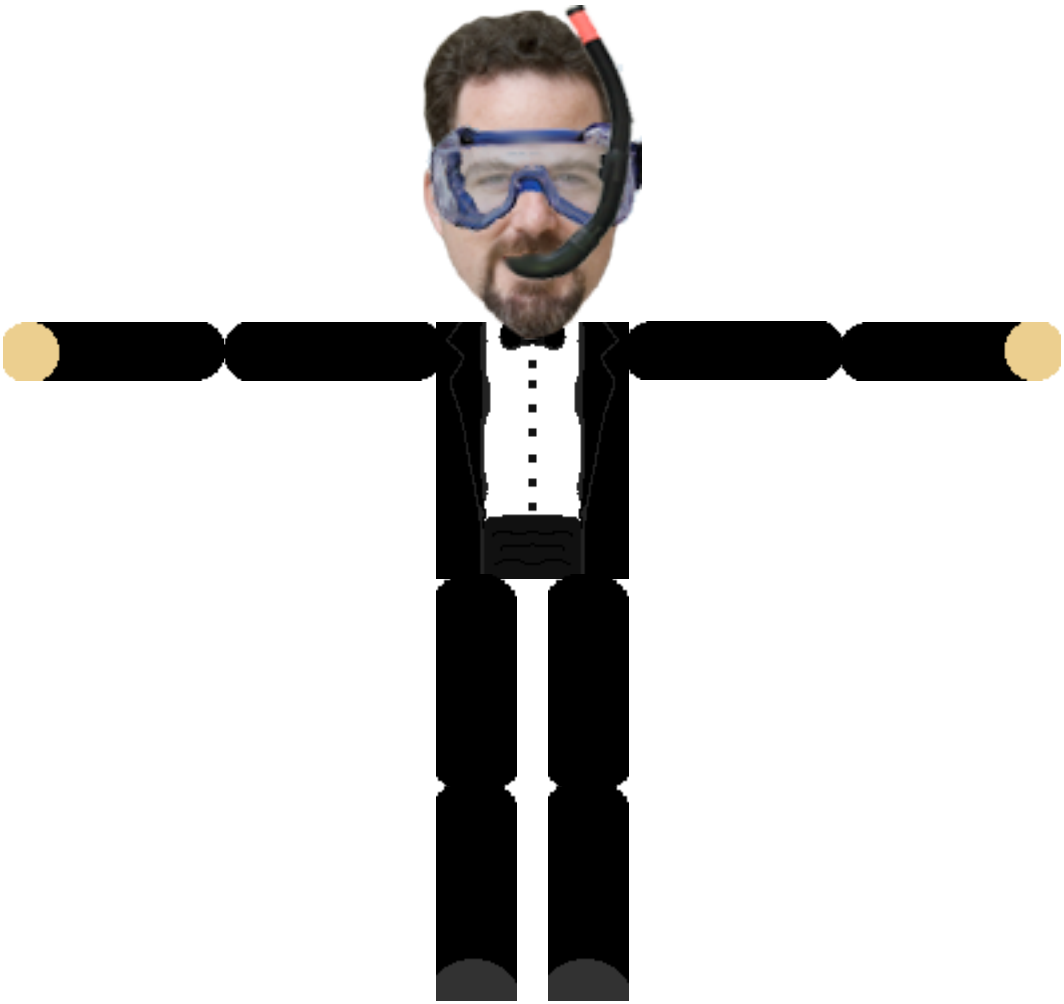


Way to get extra usage of hand-drawn frames

Spine Demo


spine
raptor
Views
ANIMATE
Tools
Pose
Weights
Create
Transform
Rotate
Translate
Scale
Axes
Local
Parent
World
Compensate
Bones
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
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

Basic Idea: **Bones**



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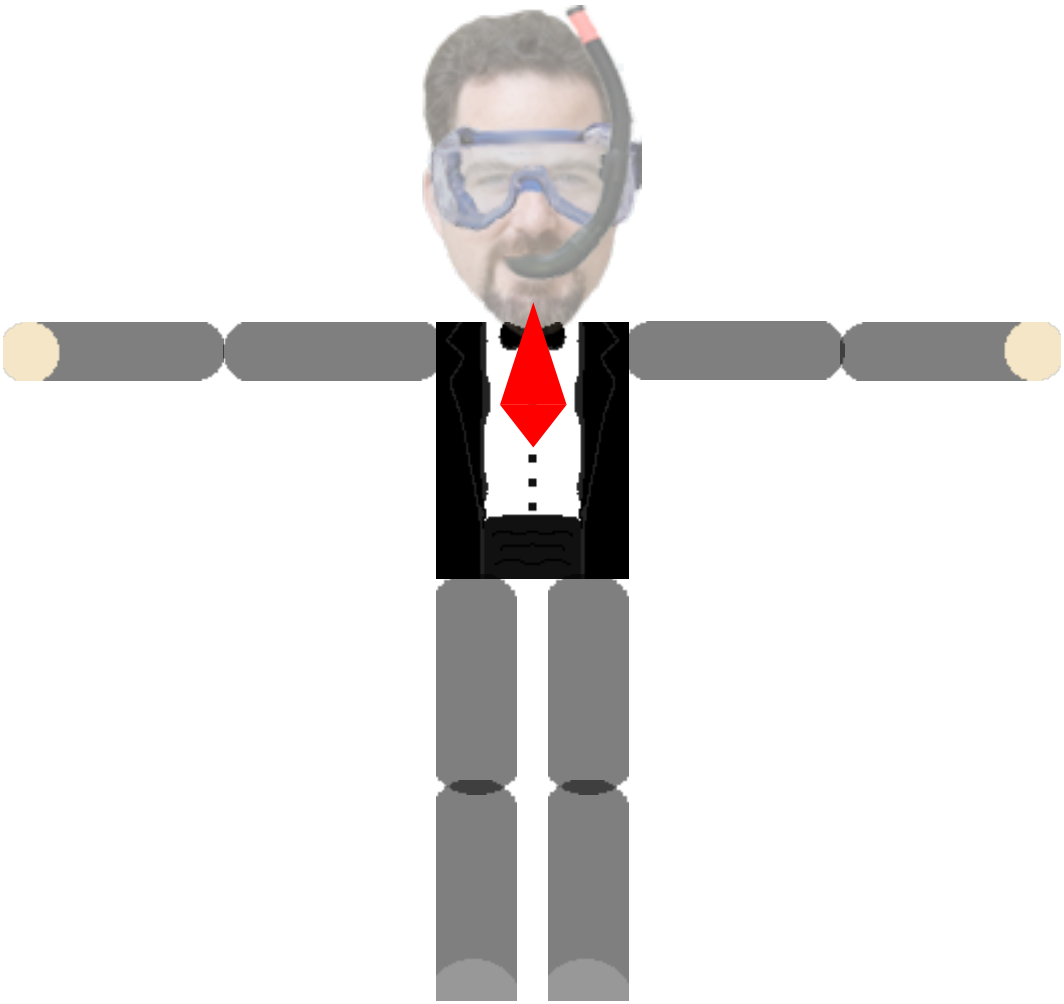

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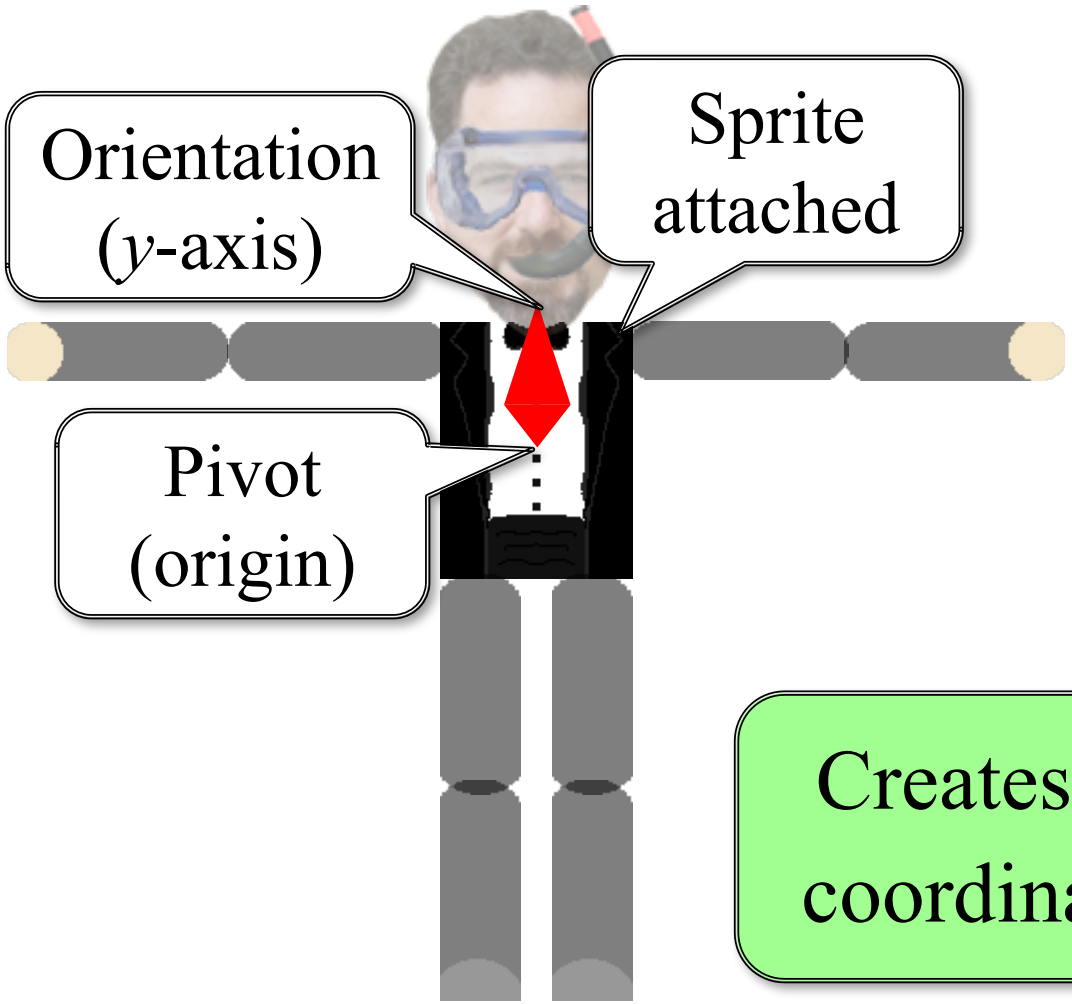
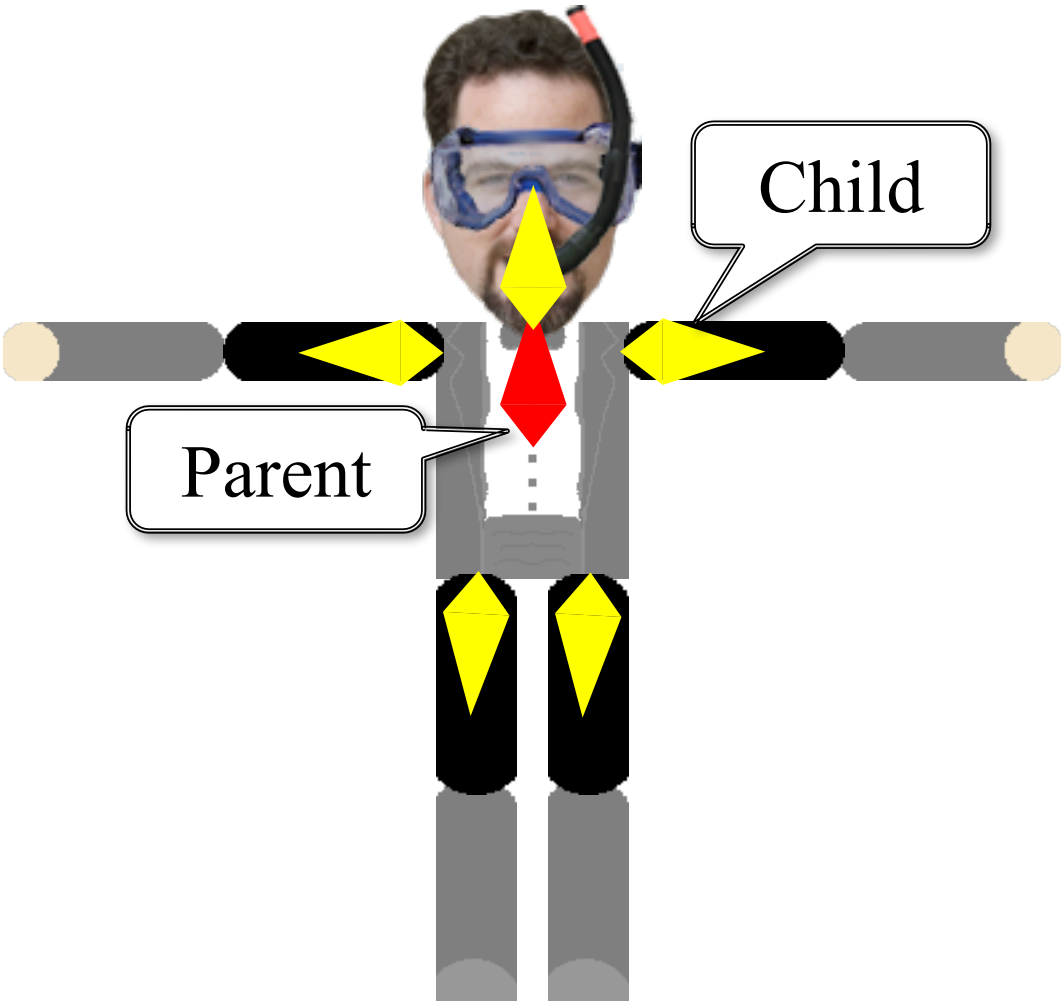


Creates implicit coordinate space

Bones are Heirarchical



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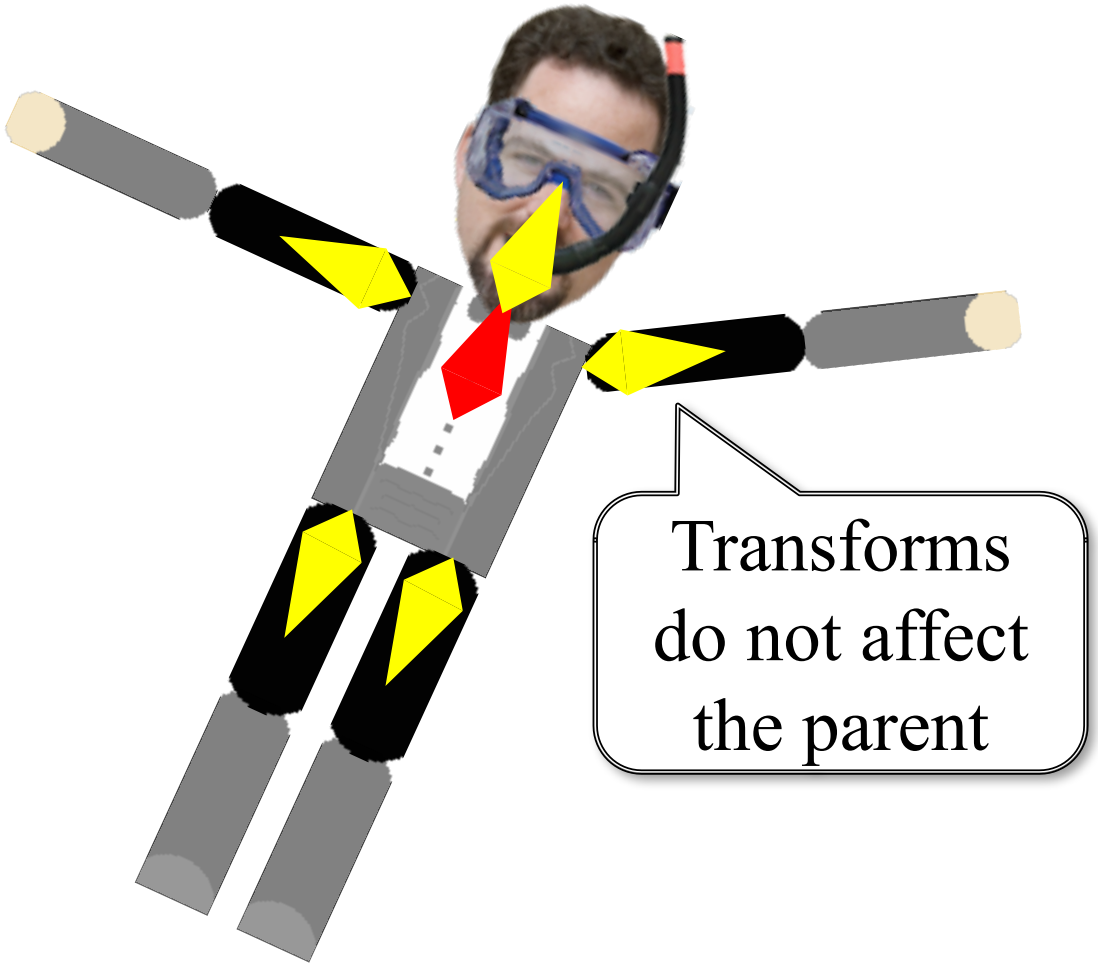
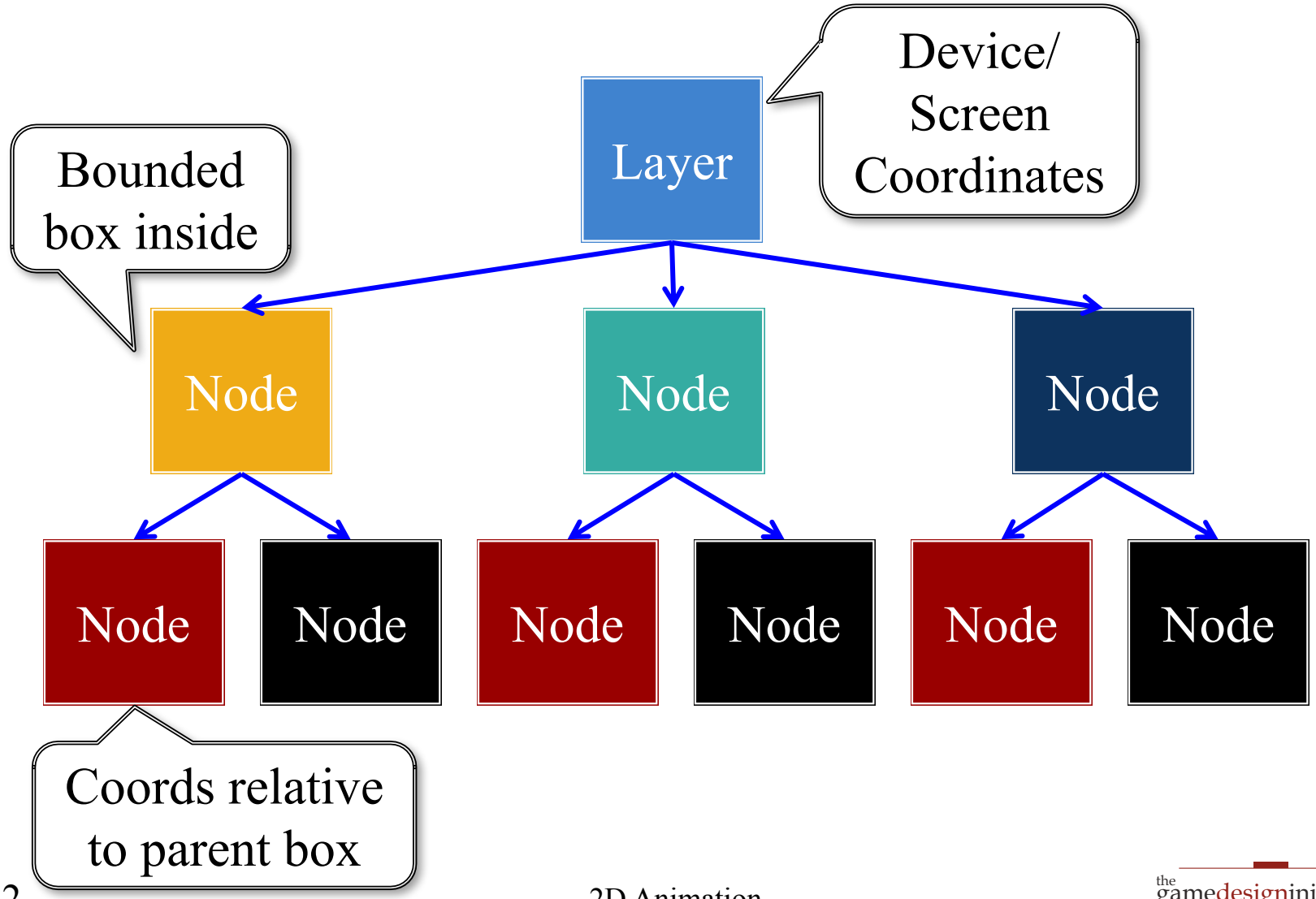
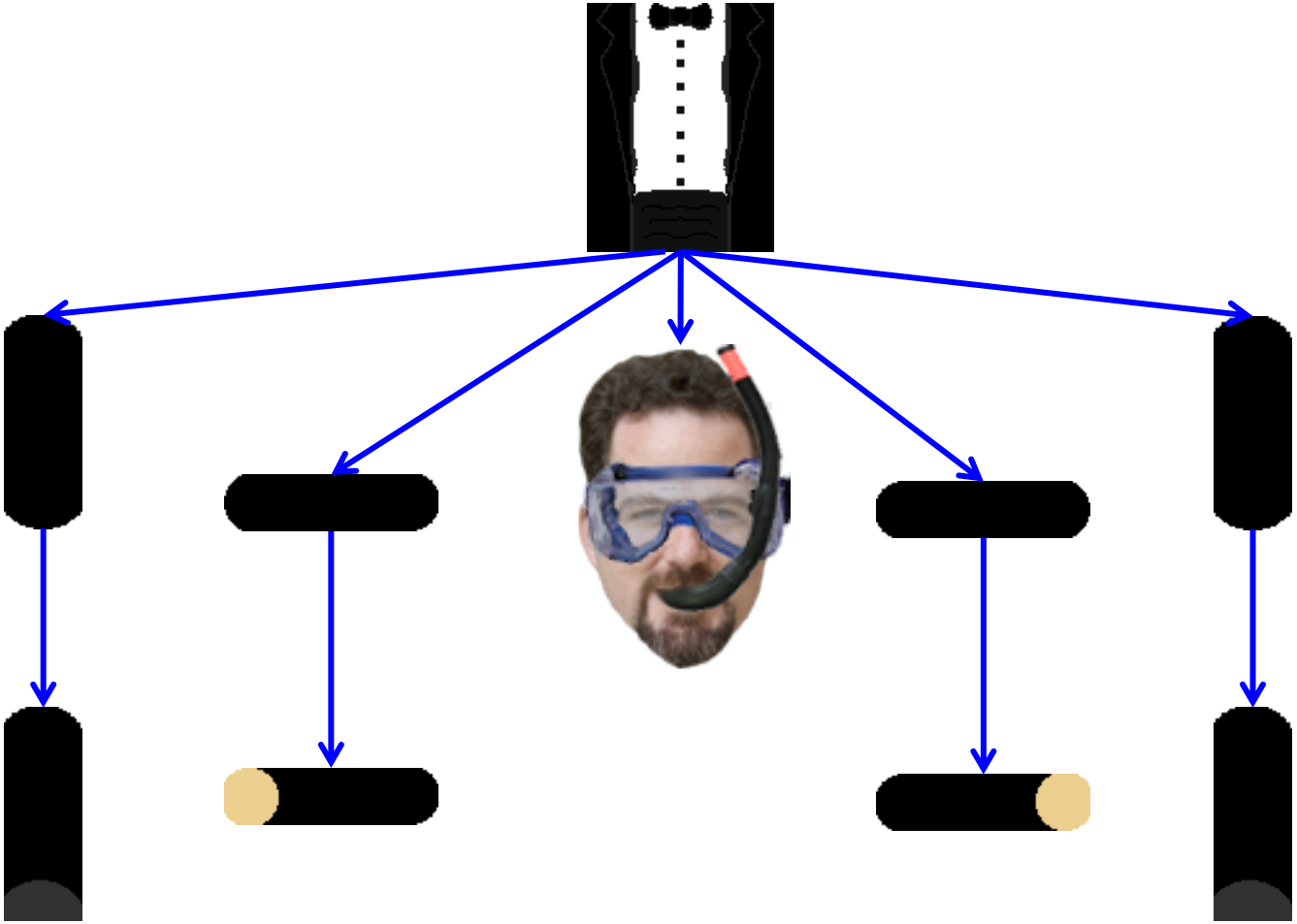


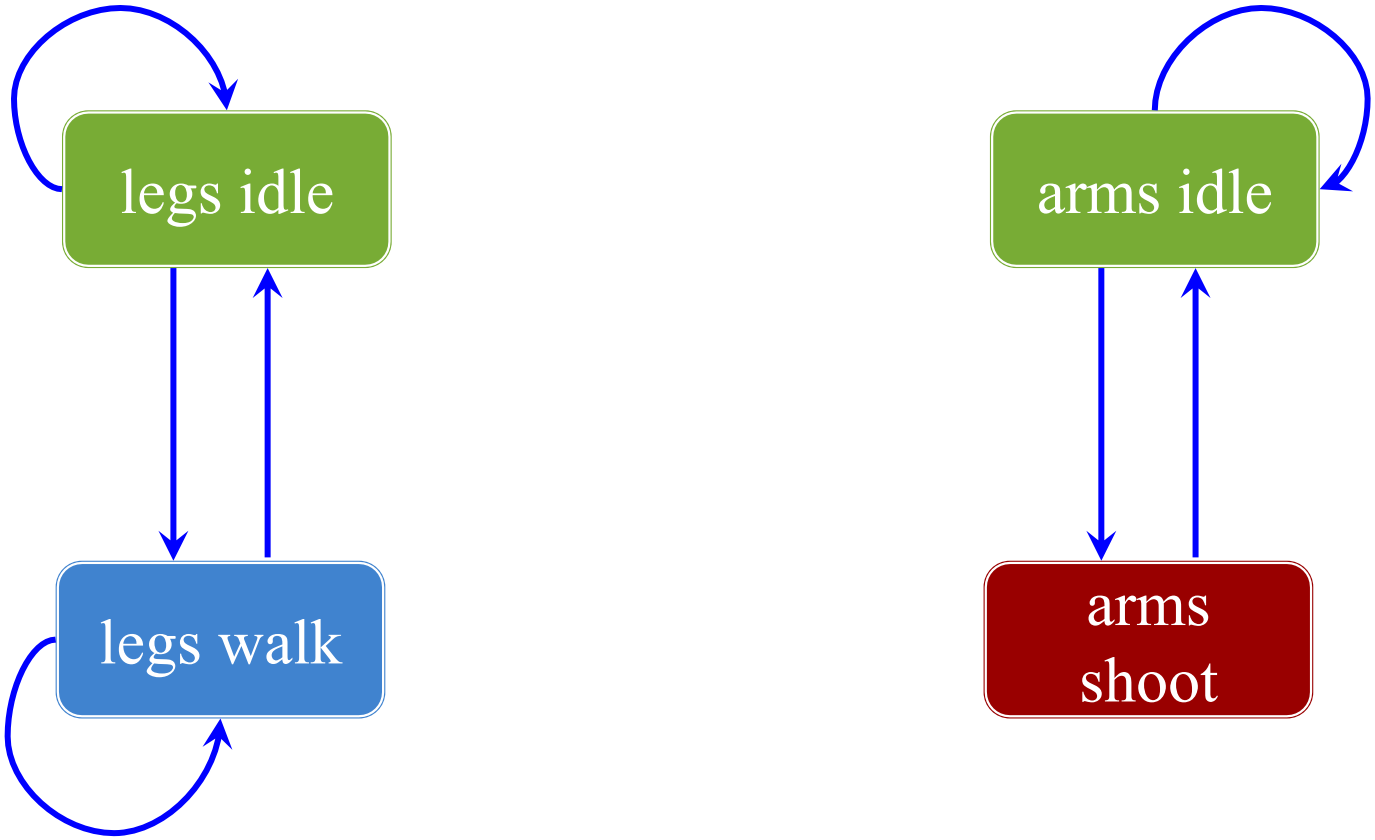
Recall: Scene Graph Hierarchy



Bones are a Scene Graph Visualization



Manage With Multiple State Machines



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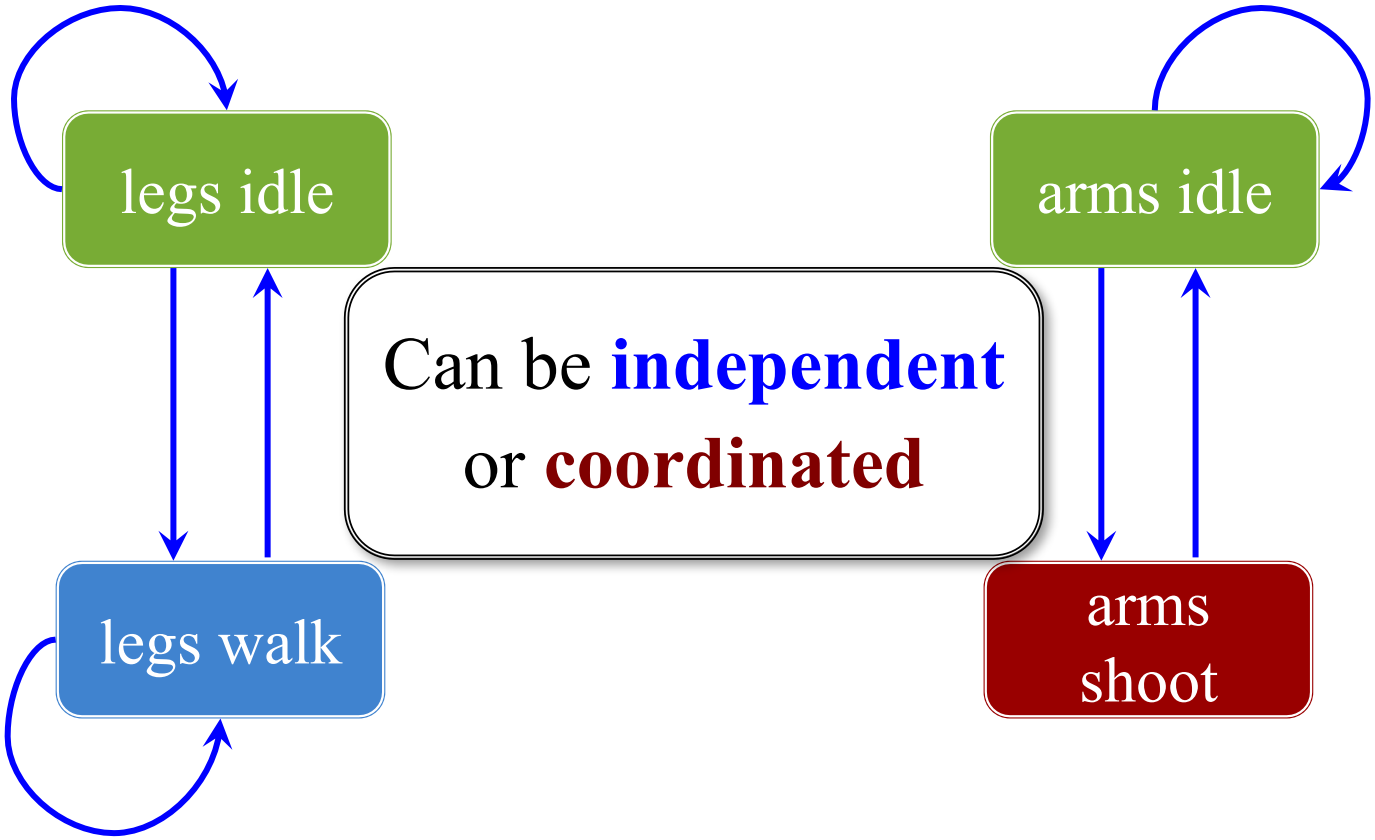

Summary

- 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