Animation and Interaction

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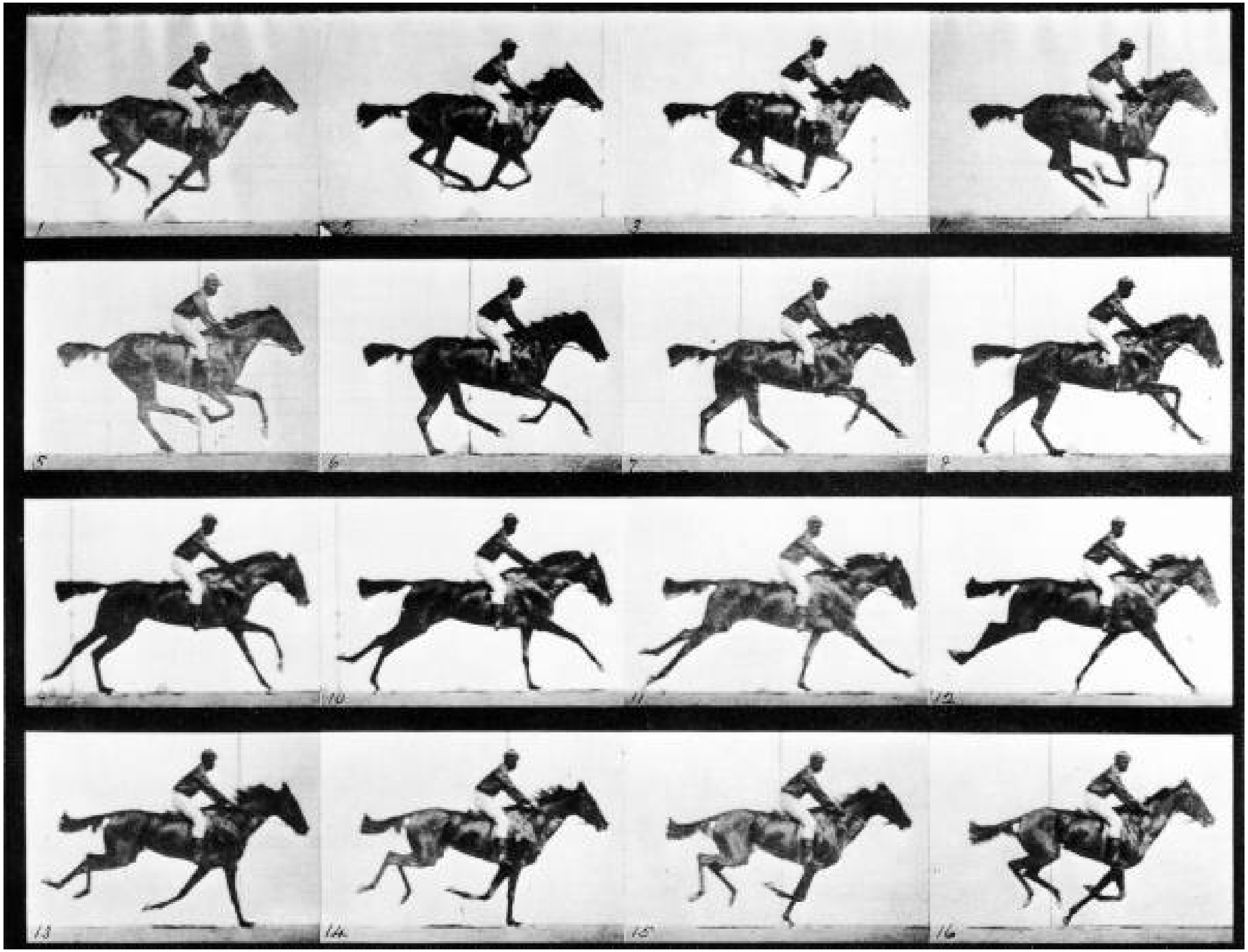
Siddhartha Chaudhuri

Video: Luxo Jr. (Pixar, 1986)

00:00:06
00:00:12
00:00:18
00:00:24
00:00:31
00:00:37
00:00:43
00:00:49
00:00:56
00:01:02
00:01:08
00:01:14
00:01:21
00:01:27
00:01:33
00:01:39

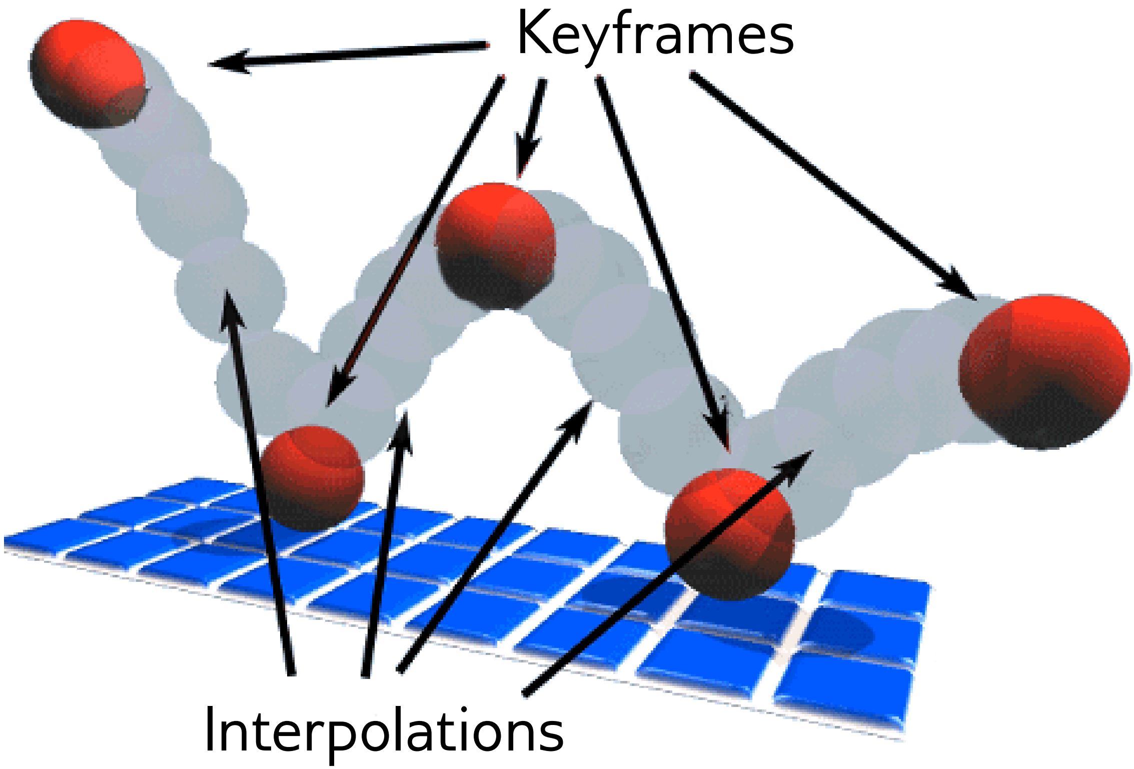
Motion from Sequence of Still Frames



Eadweard Muybridge, 1887

Basics of Animation: Keyframes

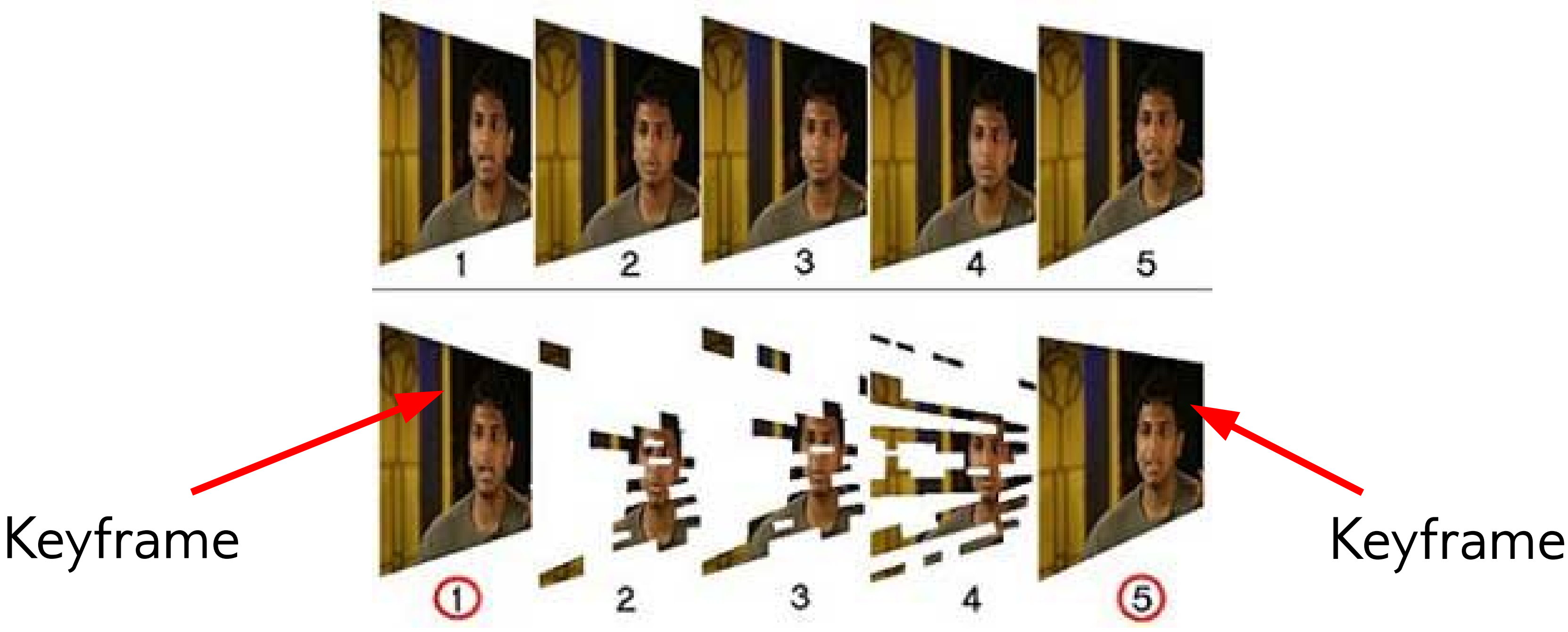
- *Keyframe:* significant pose of an animated object
- Artist/computer interpolates between successive keyframes to generate intermediate poses
- Splines can provide smooth transitions!



(www.erimez.com)

Video Compression with Keyframes

- Store a complete new image (keyframe) only when the scene substantially changes
- For intermediate frames, store only the difference from the previous frame
- Difference images are mostly zero, so compress better



Keyframe

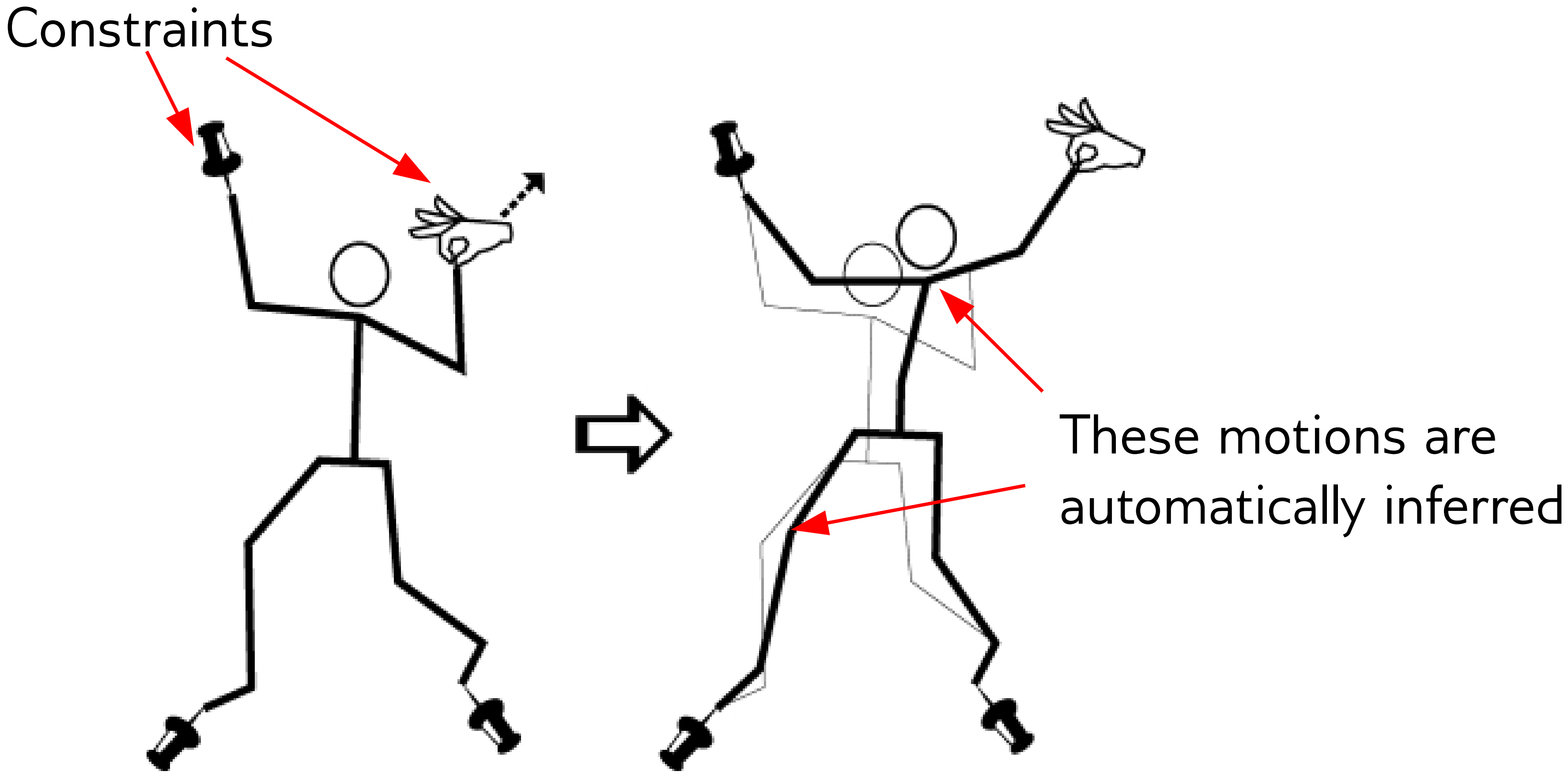
Keyframe

(EasyDivX Team)

Kinematics

- Study of motion of objects without considering what causes that motion (i.e. forces)
- *Forward kinematics:*
  - Describe transformation of object as function of time
  - Advance in small steps to generate frames
- *Inverse kinematics:*
  - Describe motion of some parts of the object
  - Automatically infer motion of remaining parts, respecting object constraints
    - Such constraints might look like: keep some points fixed, and move the parts as little as possible

Inverse Kinematics



Constraints

These motions are automatically inferred

“UTPoser”, Yamane and Nakamura, 2003

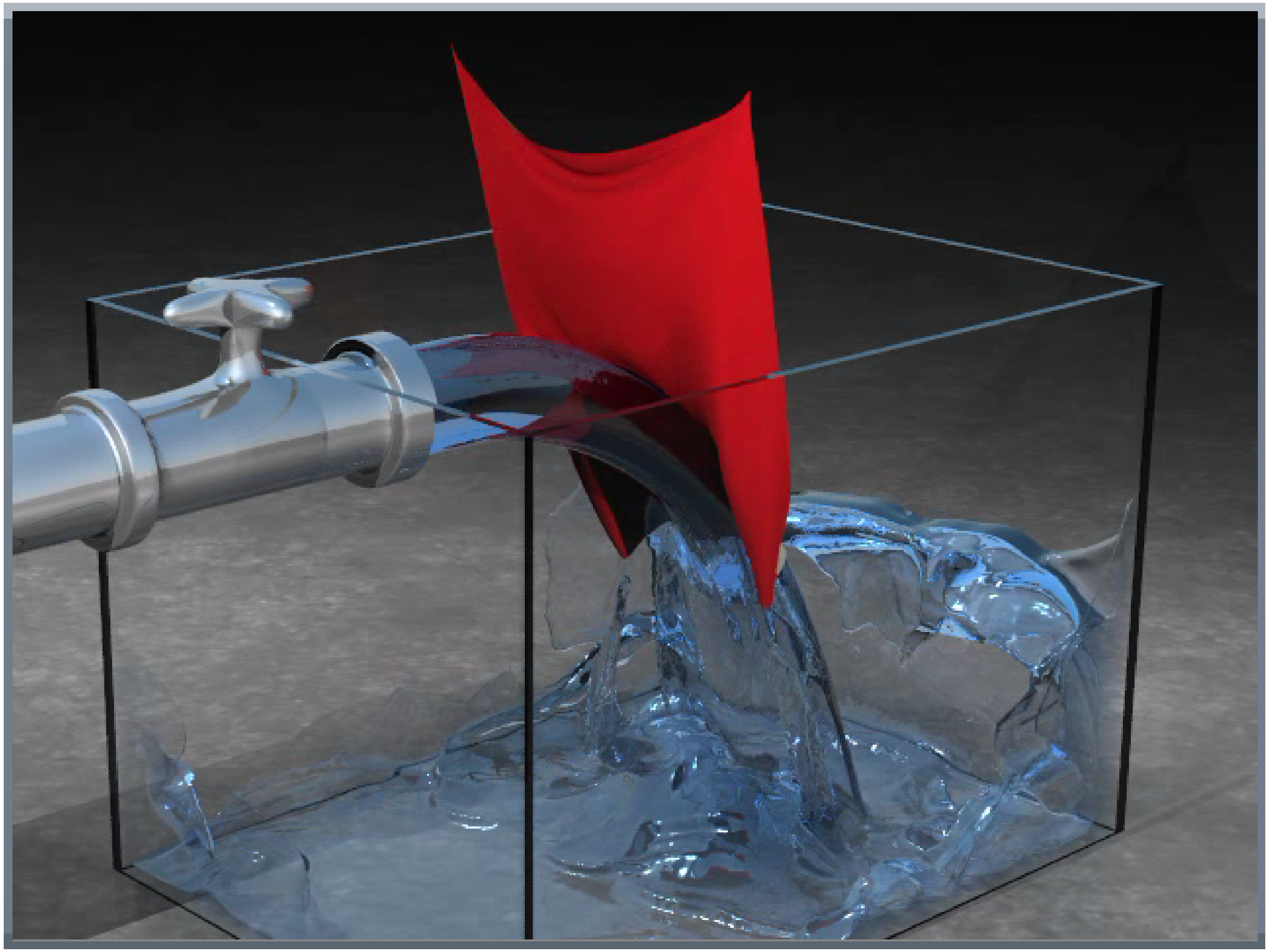
Video: Combining Path Planning with IK

Synthesizing Animations of Human Manipulation (Yamane, Kuffner and Hodgins, 2004)

Physically-Based Animation

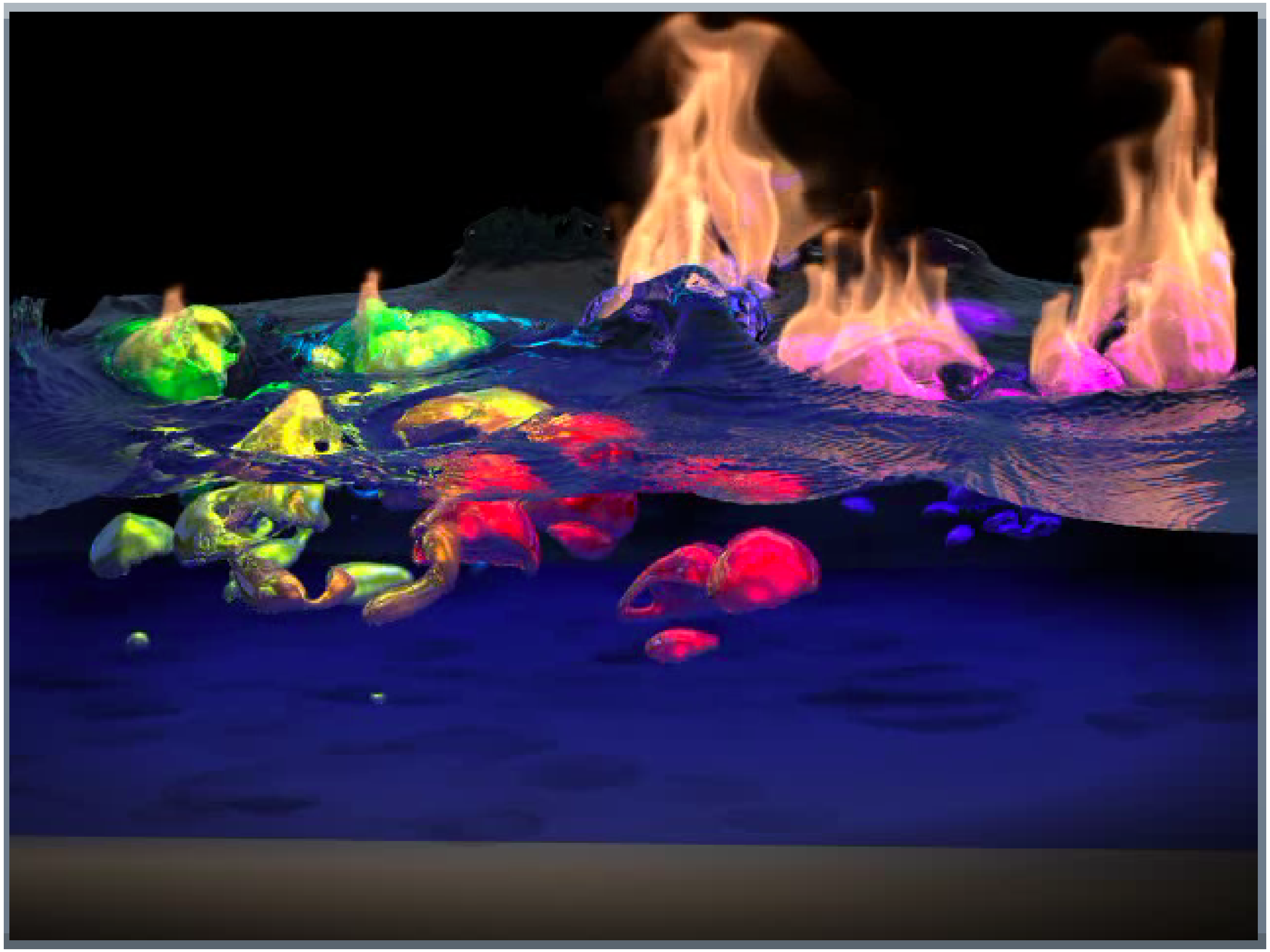
- *Dynamics:* Study of motion as a product of the stimuli/forces that cause it
- Simulate the evolution of a system as forces are applied to it
- Typically:
    - Model the system as a collection of differential equations
    - Set boundary conditions (constraints)
    - Numerically solve the equations for trajectories

Video: Solid-Fluid Coupling



Coupling Water and Smoke to Thin Deformable and Rigid Shells
(Guendelman, Selle, Losasso and Fedkiw, 2005)

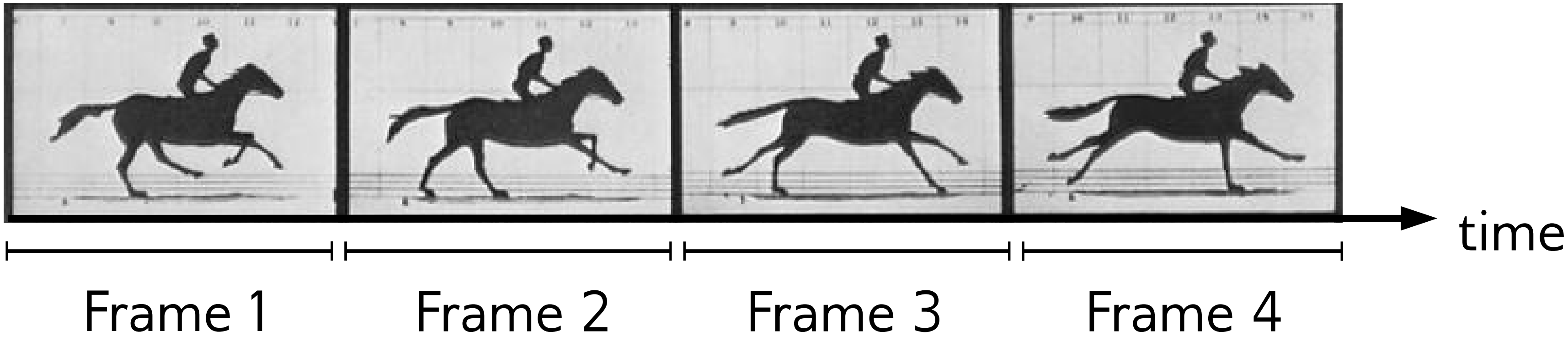
Video: Multiple Interacting Fluids



Mutiple Interacting Liquids (Losasso, Shinar, Selle and Fedkiw, 2006)

Smooth Animation: Motion Blur

- A frame is not an instant but an ***interval*** in time

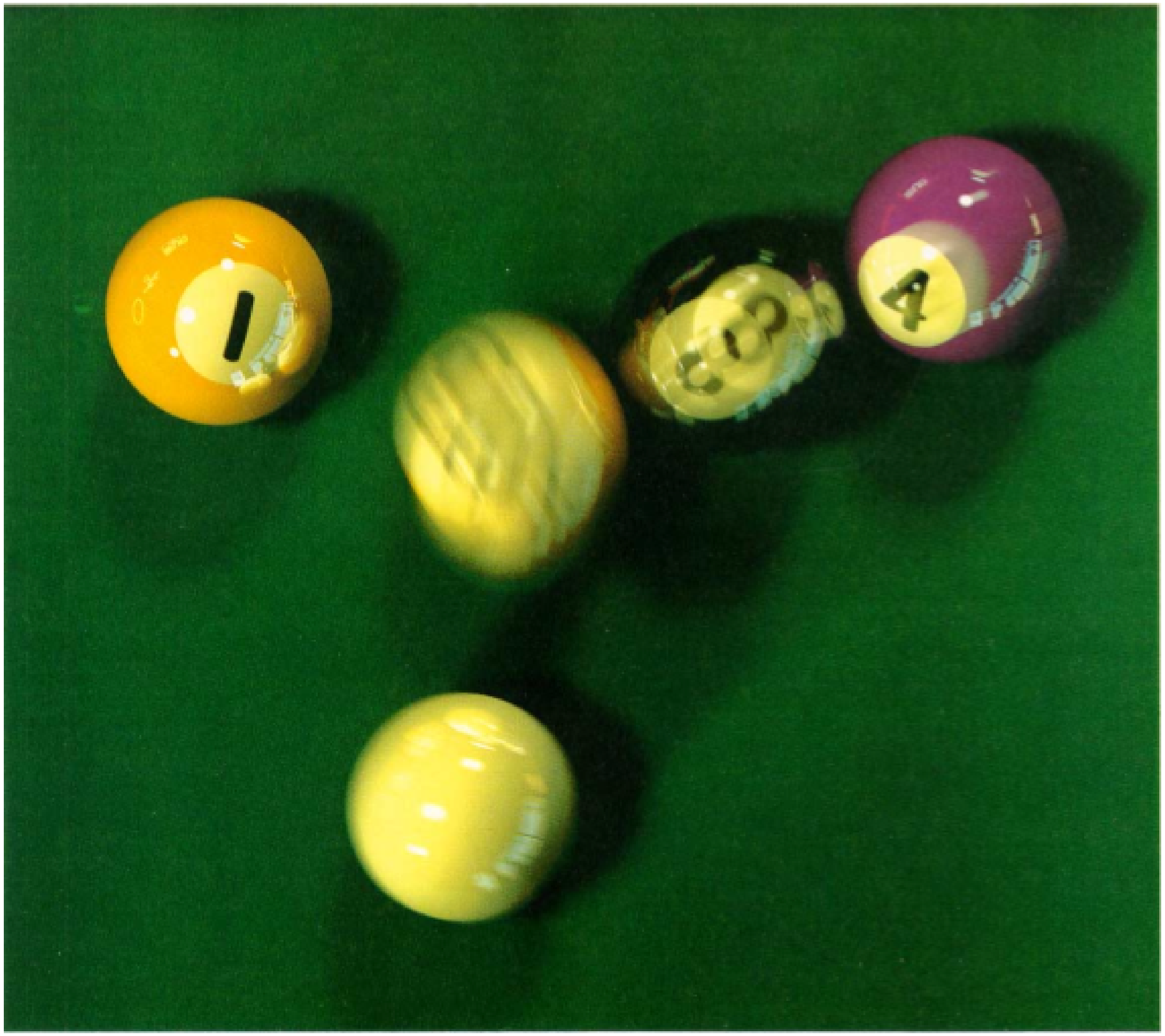


- For smooth transitions from the frame to the next, the frame should ***integrate*** all positions of the object during the interval

- This is naturally captured by longer exposures on film, and can be simulated on a computer

(Eadweard Muybridge)

Smooth Animation: Motion Blur

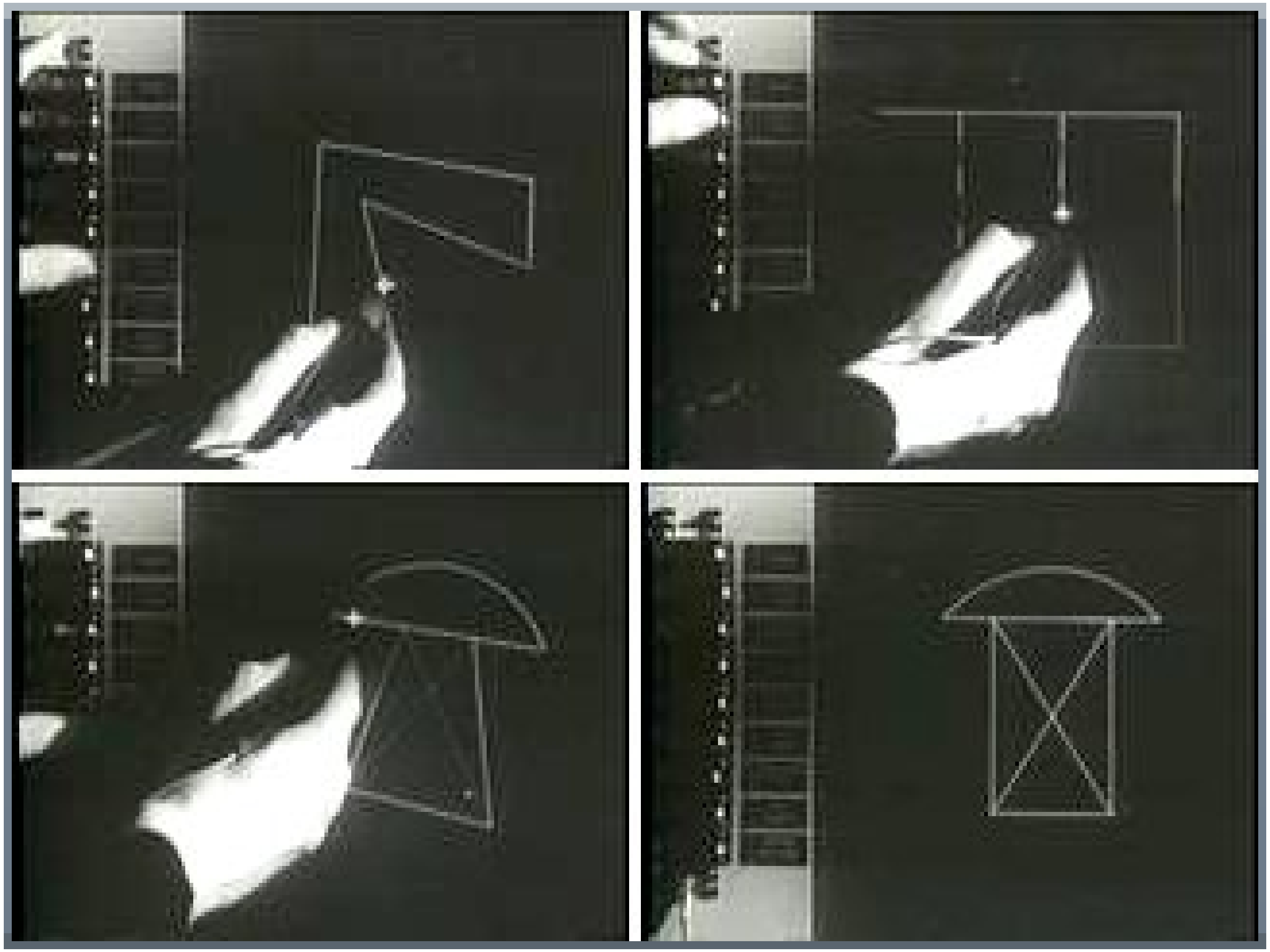


"1984", using distribution ray tracing (Cook, Porter and Carpenter, SIGGRAPH 1984)

Smooth Animation: Double-Buffering

- **Problem:** Screen flicker and tearing, when
  - display is cleared between frames, or
  - display refresh is not synced to redraw rate
- **Solution:** Maintain two framebuffers, one for the display and one for drawing
  - Display device reads display buffer, renderer draws on drawing buffer
  - Once the frame is drawn and the next display refresh is due, the buffers are quickly swapped
    - Just the pointers are swapped, no memory is copied
- **Demo:** Single- vs double-buffering

Video: Ivan Sutherland's Sketchpad, 1962



(Presented by Alan Kay, 1987)

Interaction

- Detecting input:
  - *Polling:* I periodically query the system
  - *Interrupts:* OS notifies me asynchronously
- *Picking:* Finding the nearest object (e.g. window, button, jetpack...) at the pointer location
  - Picking = raycasting!
  - Can do in object space, or via the framebuffer
- Input events trigger responses/actions
  - e.g. a widget's *onClick*() callback is called when the widget is clicked

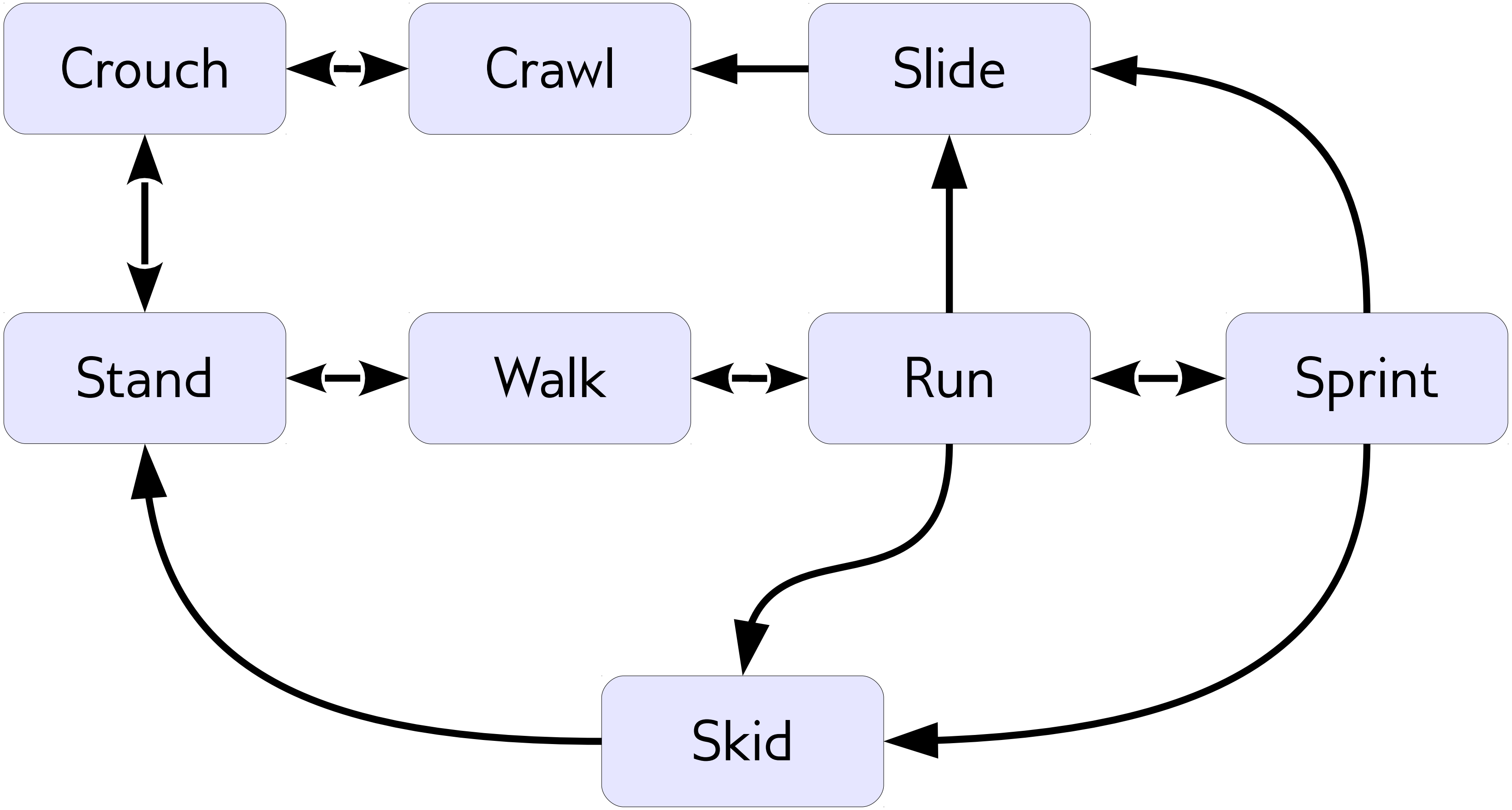
Events

- Operating system responds to interrupt
- Creates timestamped event record and places in an *event queue*
  - Queues are first-in first-out (FIFO)
  - May store state of other devices at time of event
    - e.g. polled devices like the mouse
- Callback manager
  - Reorder events based on priority
    - e.g. keyboard has priority over PostRedisplay
  - Event coalescing
  - Combine mouse motions for current position

Simple Game Control

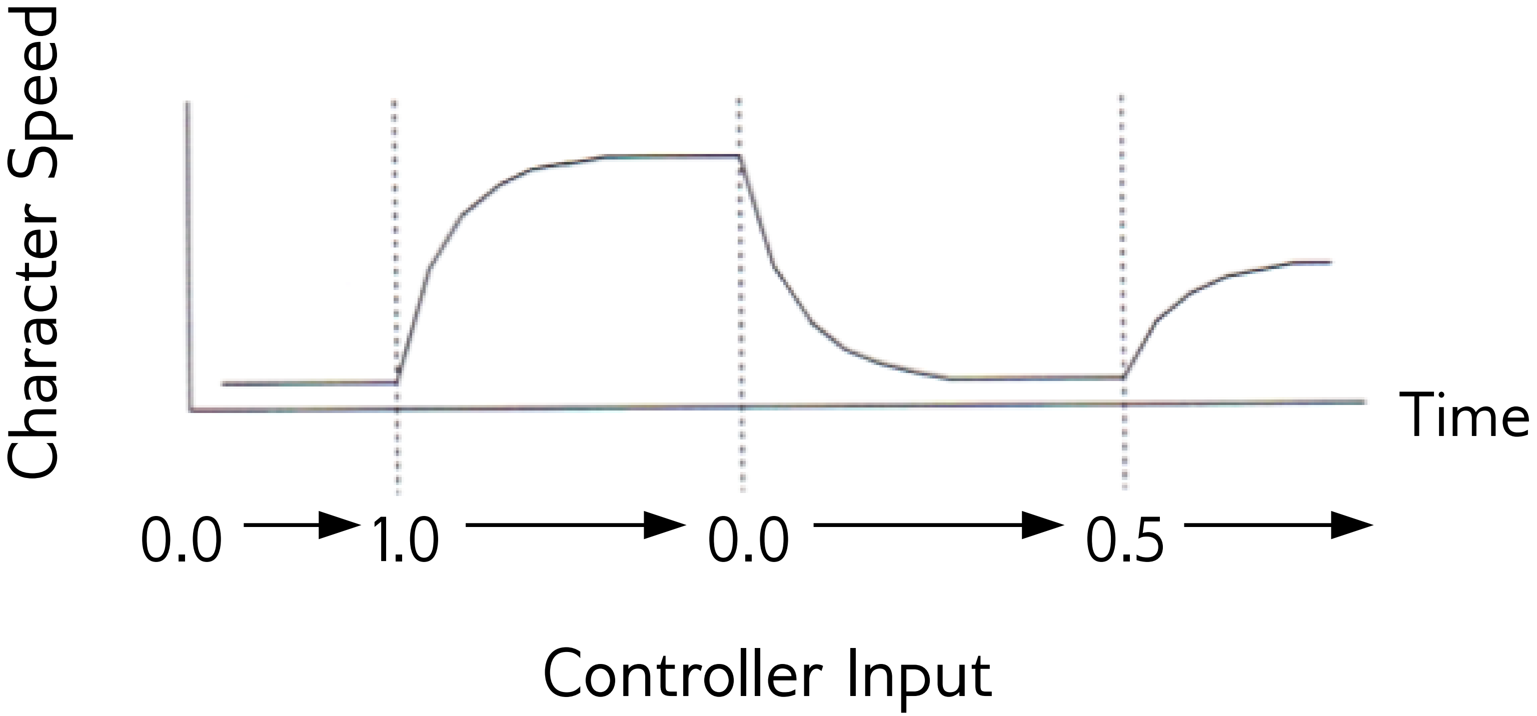
```
forever:
    readInputDevices()
    updateAI()
    processMovement()
    handleCollisions()
    draw()
```

Animation Graphs



Filtering/Smoothing Input

- We don't really want characters to respond instantaneously, so we take a little time to converge to the desired state



(“*Classic Super Mario 64 Third-Person Control and Animation*”, Steve Rabin)

Interaction: Things to Remember

- Flow from input to events to method invocation
  - Inputs cause interrupts which generate events
  - Events are routed to objects
  - Pointer events require “hit testing”
- Interaction “building blocks” for GUIs, games
  - State machines
  - Filtering/smoothing
  - Clicking, dragging
  - Character movement