Computer Graphics

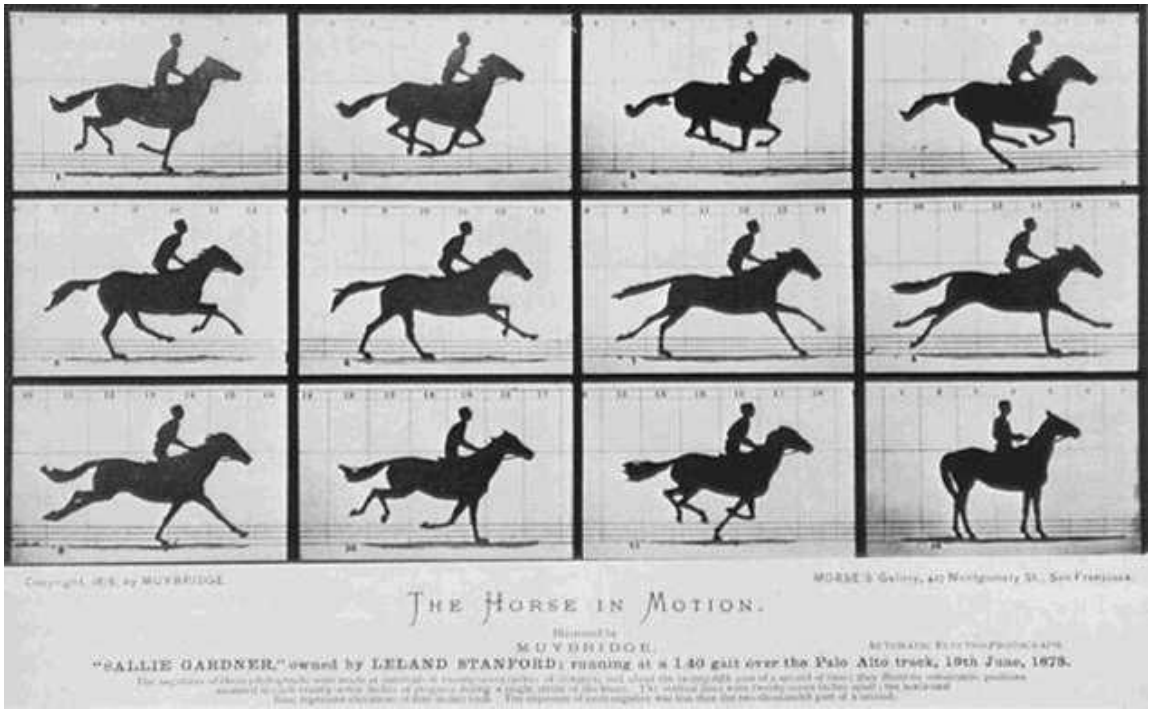
Lecture 15

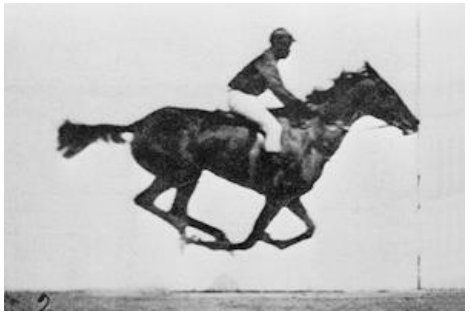
Animation

Even simple polygonal shapes can convey a number of human qualities when animated: identity, character, gender, mood, intention, emotion, and so on.

Frame Animation

- A movie is a sequence of frames of still images. For video, the frame rate is typically 24 frames per second. For film, this is 30 frames per second.



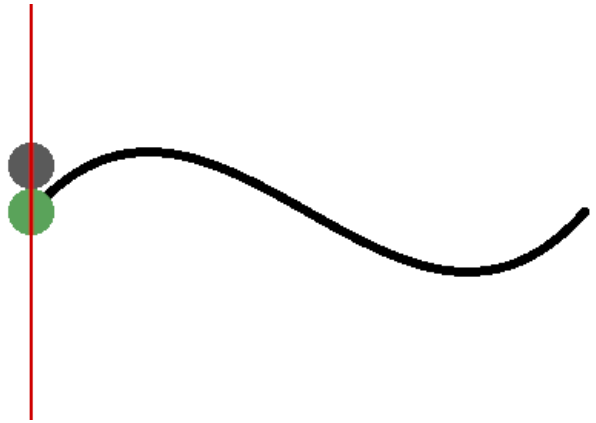


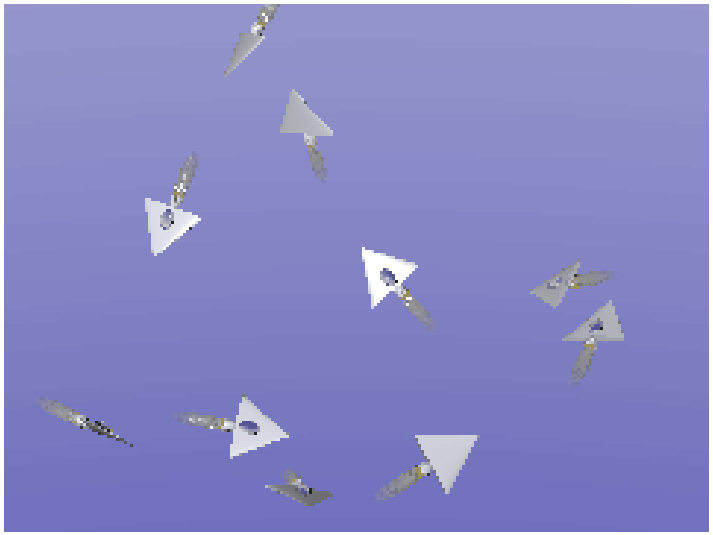
- In general, animation may be achieved by specifying a model with n parameters that identify degrees of freedom that an animator may be interested in such as
  - polygon vertices,
  - spline control,
  - joint angles,
  - camera parameters,
  - color

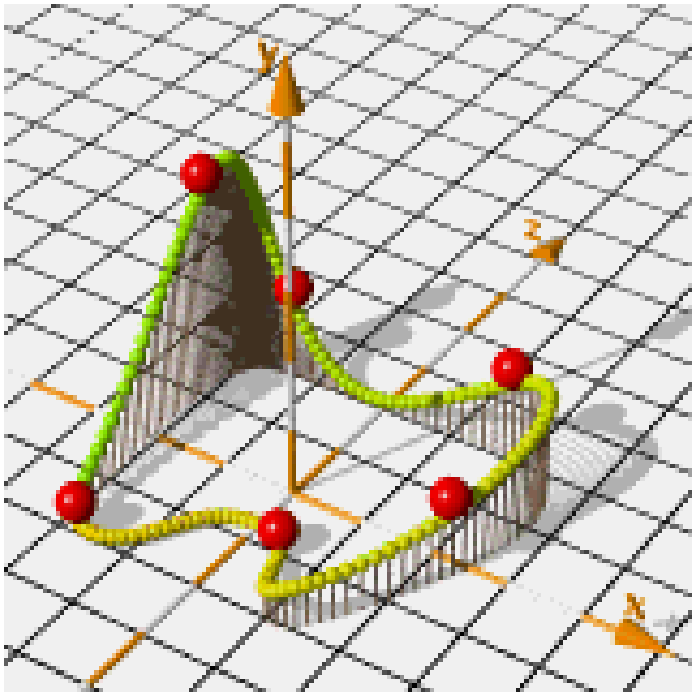
polygon vertices

- Example
  - https://www.youtube.com/watch?v=3cj9fzY48bY

Spline control

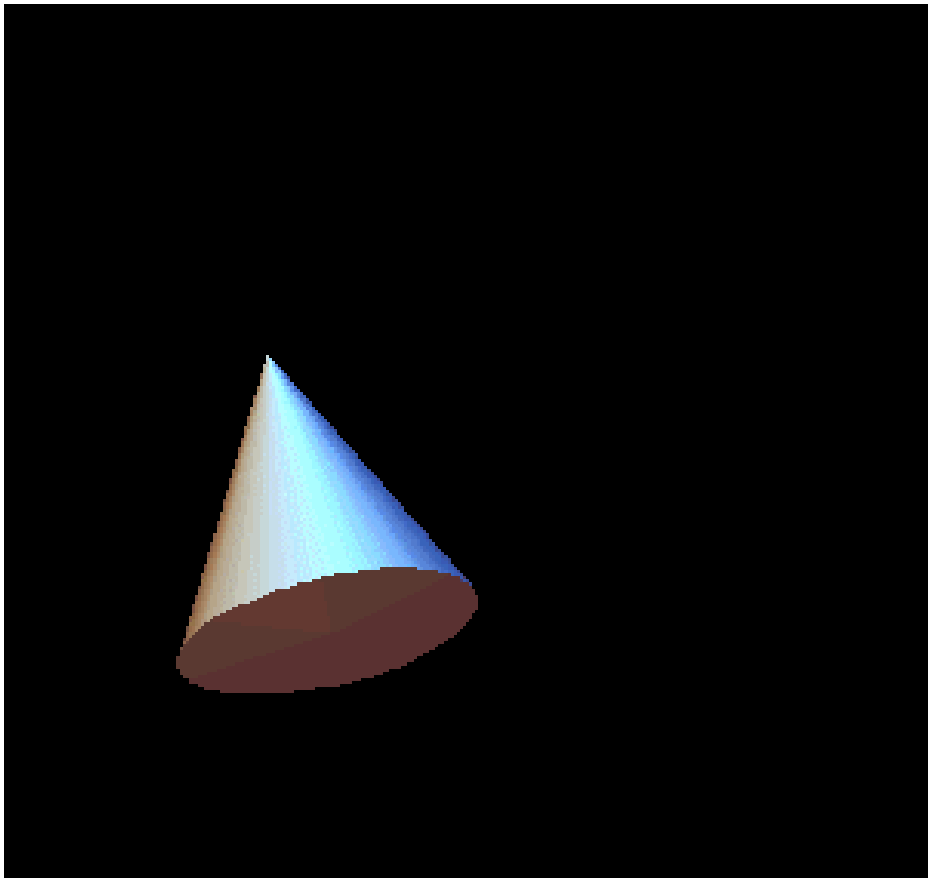






joint angles

camera parameters



Modeling and Animation

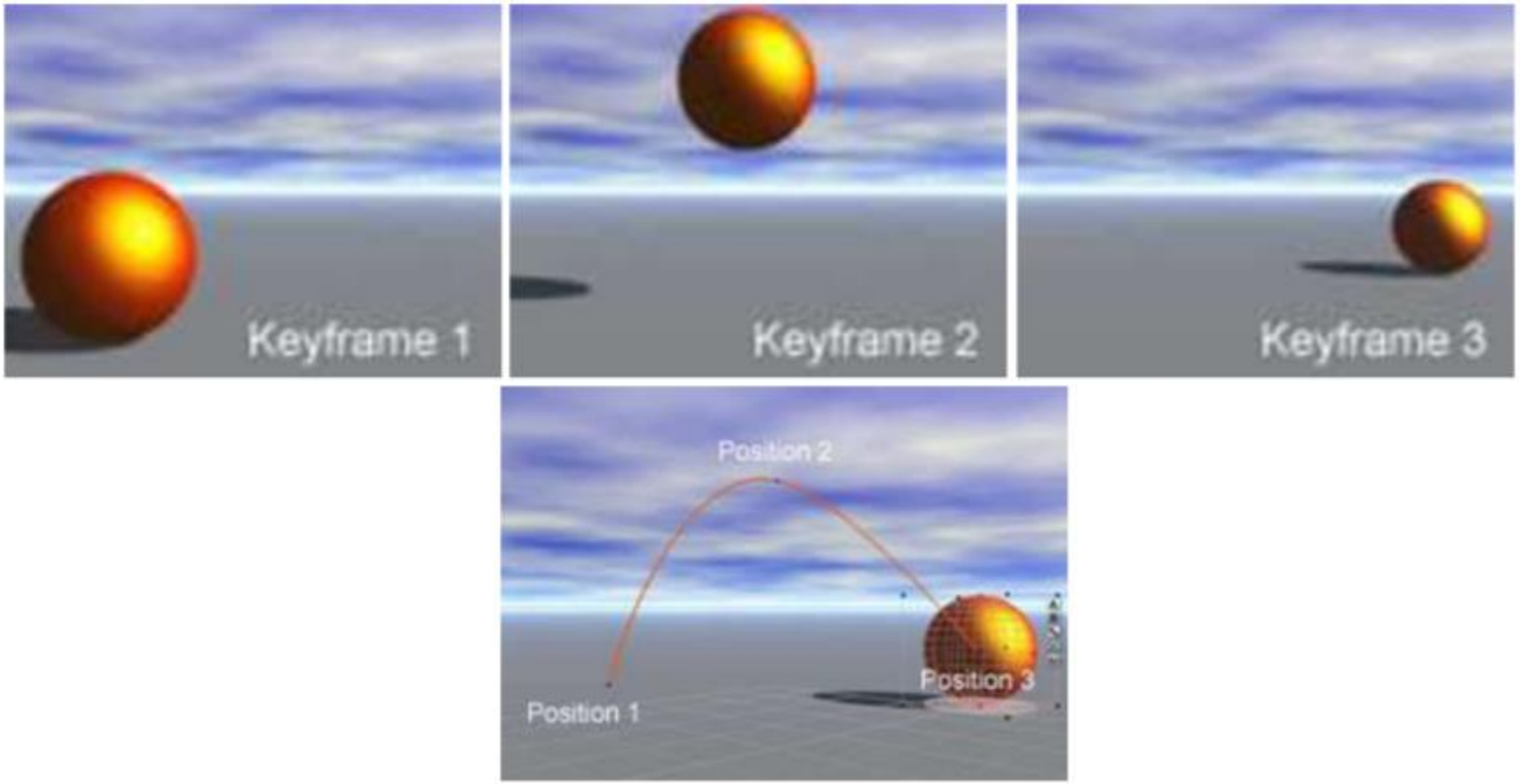
- Modeling describes control values and their actions.
- Animation describes how to vary the control values

Animation Techniques

- User driven animation
  - Keyframing
  - Motion capture
- Procedural animation
  - Physical simulation
  - Particle systems
  - Crowd behaviors
- Data-driven animation

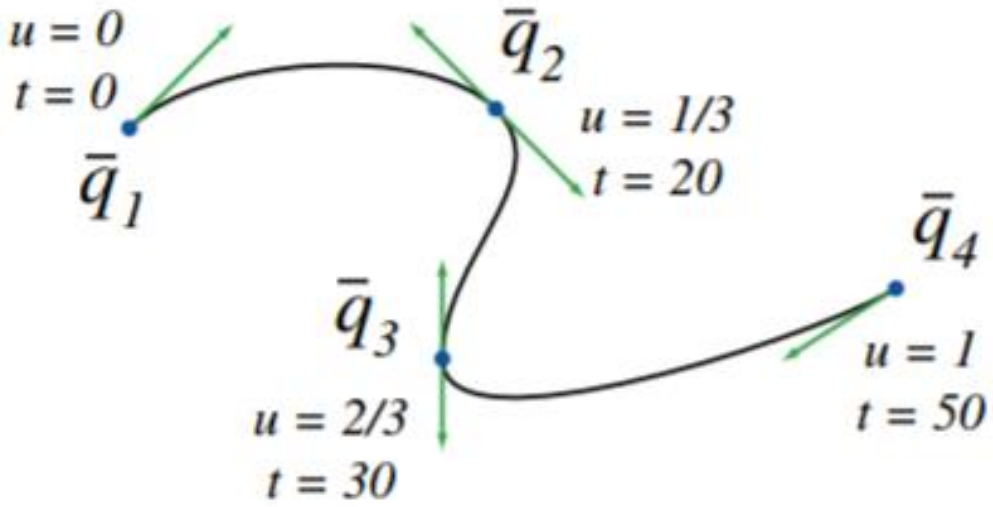
User driven animation

- Keyframing is an animation technique where motion curves are interpolated through states at times, ($\tilde{q}_1$, ..., $\tilde{q}_T$), called keyframes, specified by a user



- splines are well suited for keyframe animation because they pass through their control points.

– Animator has complete control over all motion parameters

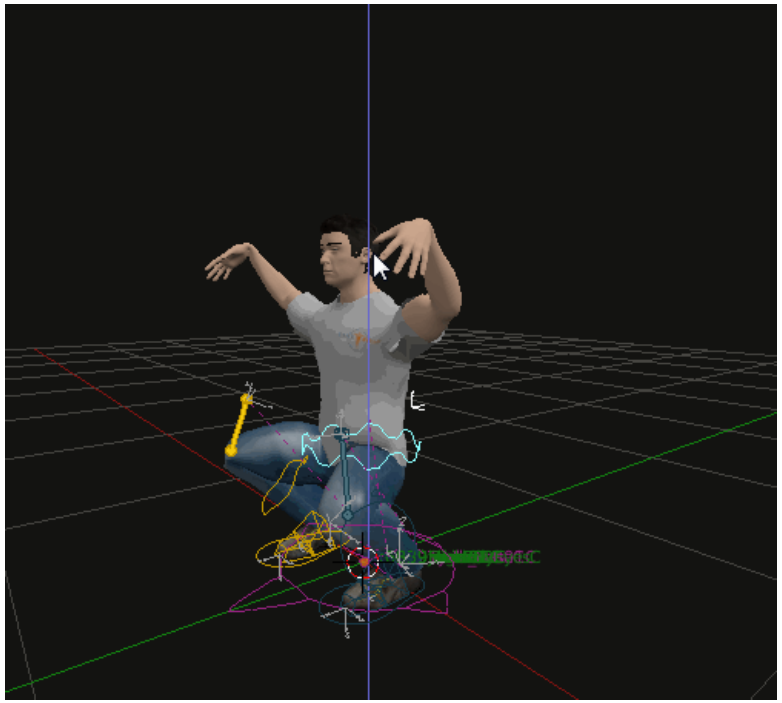


User driven animation

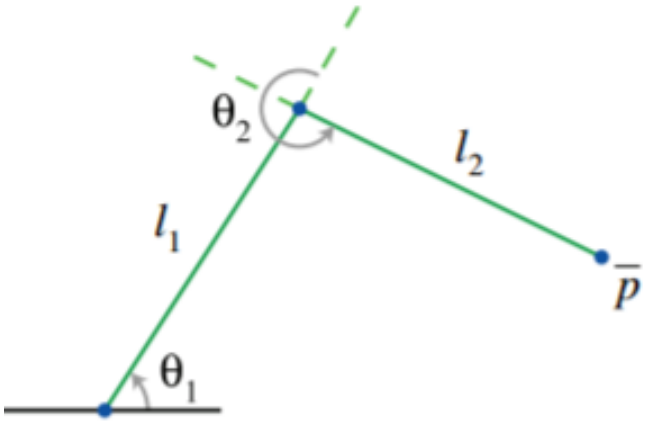
- Kinematics describe the properties of shape and motion independent of physical forces that cause motion

Kinematic techniques are used often in keyframing, with an animator either setting joint parameters explicitly with forward kinematics or specifying a few key joint orientations and having the rest computed automatically with inverse kinematics.

Forward kinematics



With forward kinematics, a point $\bar{p}$ is positioned by $\bar{p} = f(\Theta)$ where Θ is a state vector$(\theta_1, \theta_2, \ldots\theta_n)$ specifying the position, orientation, and rotation of all joints



For the above example, $\bar{p} = (l1 \cos(\theta1) + l2 \cos(\theta1 + \theta2), l1 \sin(\theta1) + l2 \sin(\theta1 + \theta2))$.

Inverse Kinematics

- With inverse kinematics, a user specifies the position of the end effector, $\bar{p}$, and the algorithm has to evaluate the required Θ give $\bar{p}$. That is, $\Theta = f^{-1}(\bar{p})$.
- Usually, numerical methods are used to solve this problem, as it is often nonlinear and either underdetermined or overdetermined

Motion Capture

- In motion capture, an actor has a number of small, round markers attached to his or her body that reflect light in frequency ranges that motion capture cameras are specifically designed to pick up
- With enough cameras, it is possible to reconstruct the position of the markers accurately in 3D.

Procedural animation

Physically-Based Animation

- It is possible to simulate the physics of the natural world to generate realistic motions, interactions, and deformations.
- Dynamics rely on the time evolution of a physical system in response to forces.

http://larc.unt.edu/ian/research/fire4/

- Particle Systems
  - A particle system fakes passive dynamics to quickly render complex systems such as fire, flowing water, and sparks
  - A particle is a point in space with some associated parameters such as velocity, time to live, color, or whatever else might be appropriate for the given application.
  - During a simulation loop, particles are created by emitters that determine their initial properties, and existing particles are removed if their time to live has been exceeded

  - http://david.li/flow/

Crowd Based

- More complicated rules of behavior can be designed to control large crowds of detailed characters that would be nearly impossible to manually animate by hand.
- However, it is difficult to program characters to handle all but simple tasks automatically.
- Such techniques are usually limited to animating background characters in large crowds and characters in games.

Data-Driven Animation

- Data-driven animation uses information captured from the real world, such as video or captured motion data, to generate animation
- The technique of video textures finds points in a video sequence that are similar enough that a transition may be made without appearing unnatural to a viewer, allowing for arbitrarily long and varied animation from video.
- A similar approach may be taken to allow for arbitrary paths of motion for a 3D character by automatically finding frames in motion capture data or keyframed sequences that are similar to other frames

Game sample Animation Demo

https://jbouny.github.io/fft-ocean/