Basics of Motion Generation

let \( X_i \) = position, orient. of \( O_i \) at \( t_k = t_0 \), \( \forall \ i \)

END = false

while (not END) do

display \( O_i \), \( \forall \ i \)

\( t_k = t_k + \Delta t \)

generate \( X_i \) at \( t_k \), \( \forall \ i \)

END = function(motion generation)
Methods of Motion Generation

- Traditional Principles (Keyframing)
- Performance Capture (Motion Capture)
- Modeling/Simulation (Physics, Behaviors)
- Automatic Discovery (High-Level Control)
Applications → Choices

• Computer Animation
• Virtual Environments
• Rapid Prototyping
• Haptic Rendering
• Computer Game Dynamics
• Robotics and Automation
• Medical Simulation and Analysis
Keyframing (I)

1. Specify the key positions for the objects to be animated.

2. Interpolate to determines the position of in-between frames.
Keyframing (II)

Advantages
- Relatively easy to use
- Providing low-level control

Problems
- Tedious and slow
- Requiring the animator to understand the intimate details about the animated objects and the creativity to express their behavior in key-frames
Motion Interpolation

- Interpolate using mathematical functions:
  - Linear
  - Hermite
  - Bezier
  ... and many others

- Forward & inverse kinematics for articulation

- Specifying & representing deformation
**Motion Capture (I)**

1. Use special sensors (trackers) to record the motion of a performer

2. Recorded data is then used to generate motion for an animated character (figure)
Motion Capture (II)

Advantages
- Ease of generating realistic motions

Problems
- Not easy to accurately measure motions
- Difficult to "scale" or "adjust" the recorded motions to fit the size of the animated characters
- Limited capturing technology & devices
  - Sensor noise due to magnetic/metal trackers
  - Restricted motion due to wires & cables
  - Limited working volume
Physically-based Simulation (I)

- Use the laws of physics (or a good approximation) to generate motions
- Primary vs. secondary actions
- Active vs. passive systems
- Dynamic vs. static simulation
Physically-based Simulation (II)

**Advantages**
- Relatively easy to generate a family of similar motions
- Can be used for describing realistic, complex animation, e.g. deformation
- Can generate reproducible motions

**Problems**
- Challenging to build a simulator, as it requires in-depth understanding of physics & mathematics
- Less low-level control by the user
High-Level Control (I)

- Task level description using AI techniques:
  - Collision avoidance
  - Motion planning
  - Rule-based reasoning
  - Genetic algorithms
  ... etc.
High-Level Control (II)

Advantages
- Very easy to specify/generate motions
- Can reproduce realistic motions

Problems
- Need to specify all possible “rules”
- The intelligence of the system is limited by its input or training
- May not be reusable across different applications/domains
Reading

- *Principles of Traditional Animation Applied to 3D Computer Animation*, by John Lasseter, ACM SIGGRAPH 1987
Principles of Traditional Animation

- **Squash and Stretch** - defining the rigidity and mass of an object by distorting its shape during an action
- **Timing and Motion** - spacing actions to define the weight and size of objects and the personality of characters
- **Anticipation** - the preparation for an action
Principles of Traditional Animation

- **Staging** - presenting an idea so that it is unmistakably clear

- **Follow Through and Overlapping Action** - the termination of an action and establishing its relationship to the next action

- **Straight Ahead Action and Pose-to-Pose Action** - The two contrasting approaches to the creation of movement
Principles of Traditional Animation

- **Slow In and Out** - the spacing of the in-between frames to achieve subtlety of timing and movement
- **Arcs** - the visual path of action for natural movement
- **Exaggeration** - Accentuating the essence of an idea via the design and the action
Principles of Traditional Animation

- **Secondary Action** - the action of an object resulting from another action
- **Appeal** - creating a design or an action that the audience enjoys watching

*Personality* in character animation is the goal of all of the above.