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.