Animations

Animations

- **Computer animation generally refers to any time sequence of visual changes in a scene.**
- Computer generated animation could display time variations in
  - object size, color, transparency or surface texture.
- Computer animations can be generated by changing
  - camera parameters, such as position, orientation and focal length.
- Computer animations are produced by changing
  - lighting effects or other parameters
  - procedures associated with illumination and rendering.

Design of Animation Sequences

- Animation sequence is designed with the following steps.
  - Storyboard Layout
  - Object Definitions
  - Key-Frame specifications
  - Generation of in-between frames.

1.Storyboard Layout

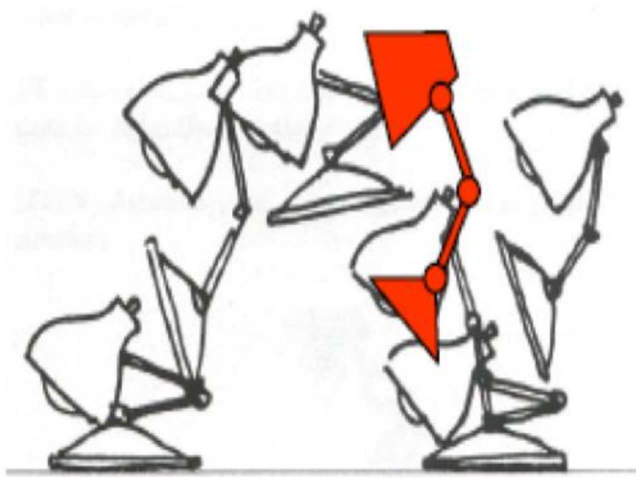
- Outline of the action.
- Defines the set of basic events that are to take place.
- Story board consists of rough sketches or basic ideas for motion.
- Storyboard is divided into scene segments.
- Animators and Mentors decide which segments each animator will work on.
- Segments are reviewed and revised.
- Dialog is created based on storyboard and segments.

2.Object Definition

- Object definition is given for each participant in the action.
- In simple manual systems, the objects can be simply the artist drawings
- In computer-generated animations, models are used
- Objects can be defined with basic shapes such as polygons or splines.
- The associated movements along with the shape are also specified.
- Examples of models:
  - a "flying logo" in a TV ad
  - a walking stick-man

3.Key Frame Specifications

- Define character poses at specific time steps called “keyframes”
- Some key frames are chosen at extreme or characteristic positions in the action.
- Others are spaced so that the time interval between key frames is not too large.
- More key frames are specified for intricate motions than for simple and slowly varying motions.



4.In-Between Frames

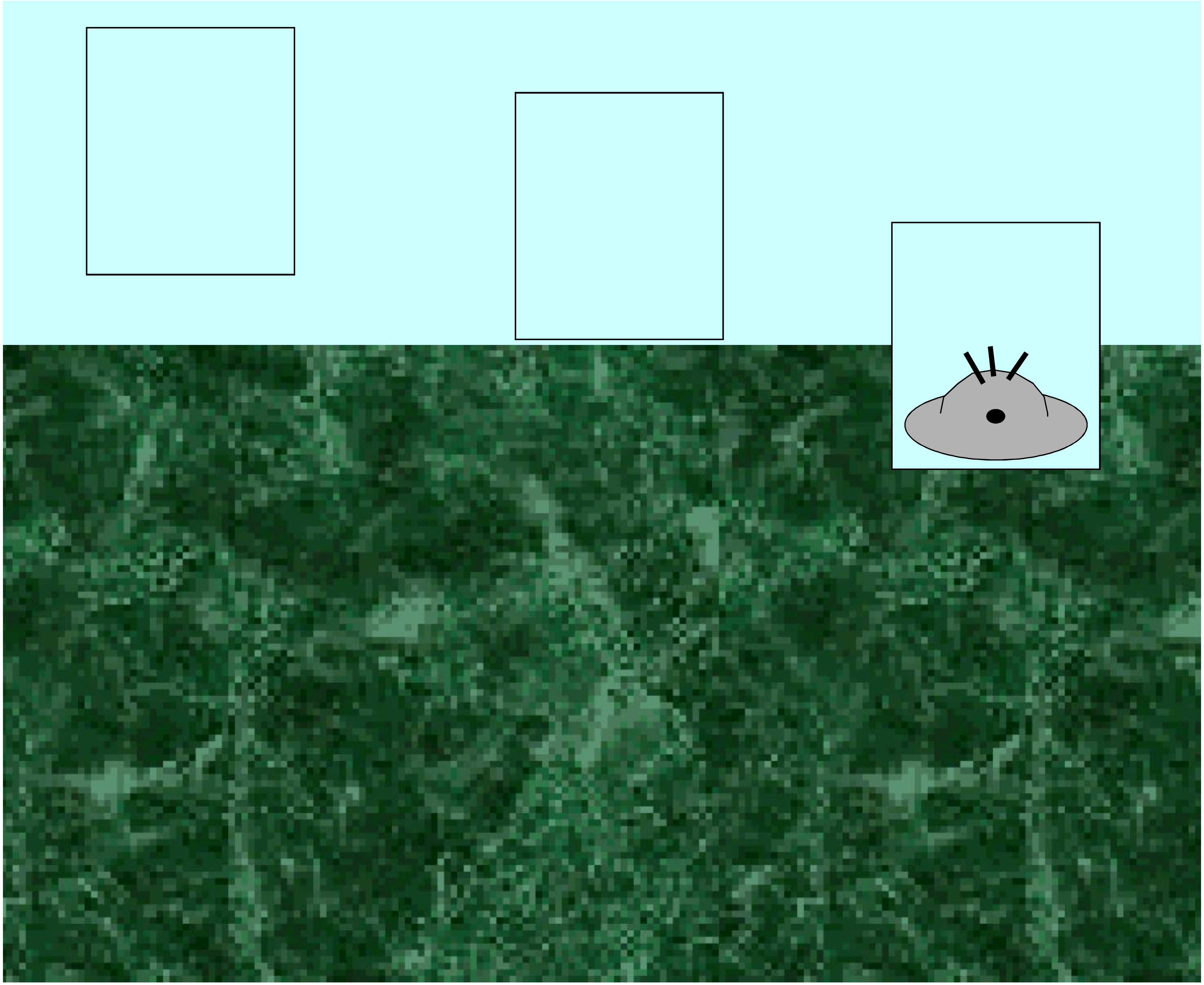
- They are intermediate frames between the key frames.
- Interpolate variables describing keyframes to determine poses for character “in-between”.
- Interpolation is either be linear interpolation, spline interpolation or cubic spline interpolation.
- The process of generating in-betweens is called in-betweening.
- The number of in-betweens needed is determined by the media to be used to display the animation.
  - Film requires 24 frames per second and graphics terminals are refreshed at a rate of 30 to 60 frames per second.
- Time intervals for motion are setup so that there are from 3 to 5 in-betweens for each pair of key frames.
- Depending upon the speed specified for the motion, some key frames can be duplicated.

Animation Systems

- **Raster animation systems : U**se a sequence of raster operations to produce real-time animation of 2-D or 3-D objects.
- **Key-frame systems:** Designed to generate the in-betweens from the user specified key frames using interpolation.
- **Parameterized systems :**
  - Allow object-motion characteristics to be specified as part of the object definitions.
  - These characteristics are controlled by adjustable parameters: degrees of freedom, motion limitations, and allowable shape changes.
- **Scripting systems:** object specifications and animation sequences to be defined with user-input script

Raster Animation Systems

- Real time animations are generated for limited applications using raster operations.
- Animation done using raster operations or colour-table transformations.
- Raster based animation frames are made up of individual pixels. These pixels each contain information about the colour and brightness of that particular spot on the image
- Color Table Transformations:
  - Predefine the objects at successive positions along the motion-path and set the successive block of pixel values to color-table entries.
  - Set the pixels at the first position of the object to “on” values and set the pixels at other positions to the background color.
  - Animation is accomplished by changing the color-table values so that the object is “on” at successive positions of the motion path as the preceding position is set to background intensity



Key-frame systems

- From the specified two or more key frames, the key-frame systems generate sets of in-betweens.
- Motion paths, can be
  - given with a kinematical description as a set of spline curves.
  - physically based by specifying the forces acting on the objects to be animated.
- Given the animation paths, we can interpolate the position of individual objects between any two times.
- With the application of complex object transformations, the shapes of objects may change over time. Eg: clothes, facial features etc.,

Key-frame systems

- If all surfaces are described with polygon meshes, the number of edges per polygon can change from one frame to the next.
- Consequently, the total number of line segments can be different in different frames.

Morphing

- Morphing, a shortened form of metamorphosis is a transformation of an object from one form to another.
- Morphing methods can be applied to any motion or transition involving a change in shape and thus they yield evolving shapes.
- Uses linear interpolation for generating the in-betweens.
- Object shapes are described by polygons.
- Given two key-frames for an object transformation,
  - adjust the object specification in one of the frames such that the number of polygon edges (or the number of vertices) in two frames is the same.

Morphing

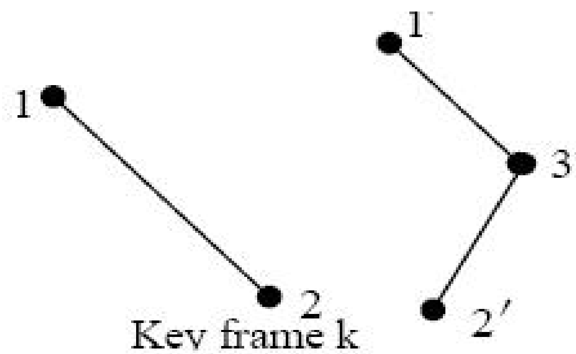


Fig. 1 Key frame k+1

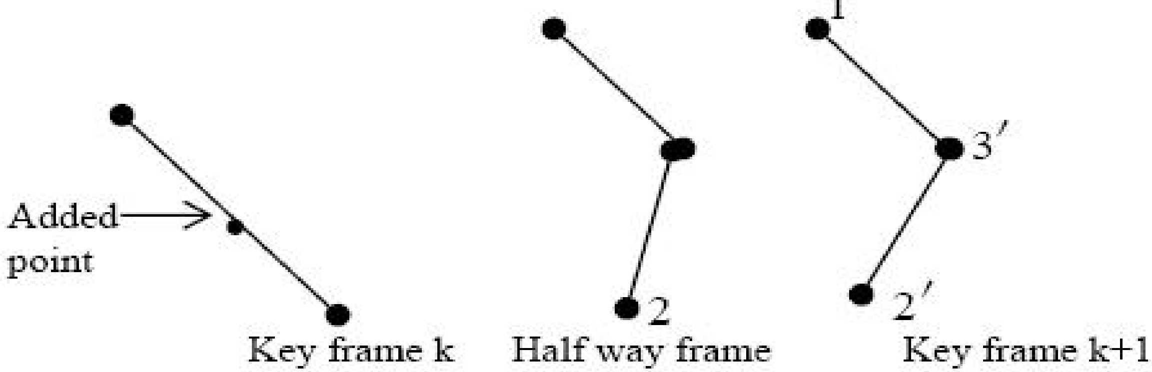


Fig. 2 Linear interpolation

Morphing

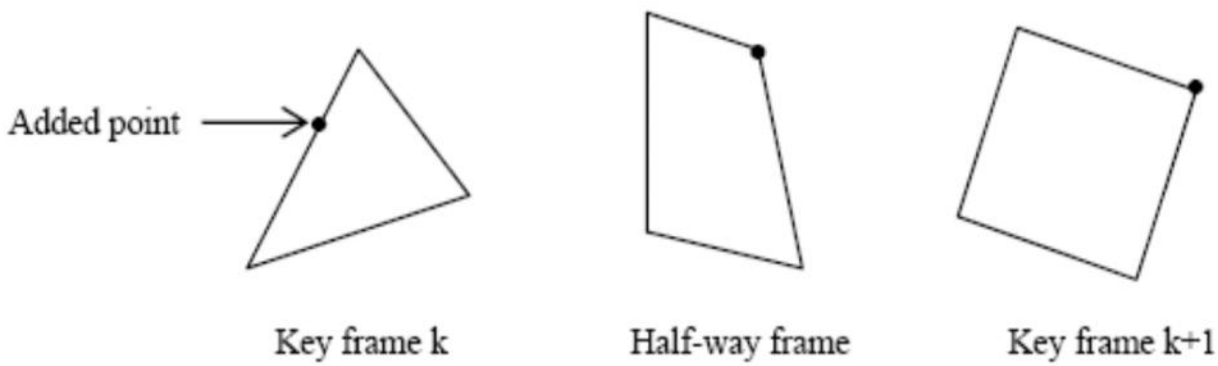


Fig.3
Linear interpolation for transforming a triangle into quadrilateral

Morphing

- We can equalize either edge count or vertex count

Equalizing Edge count:

- Let L_k and L_{k+1} denote the number of line segments in two consecutive frames. We define,

$$L_{\max} = \max(L_k, L_{k+1}) \qquad L_{\min} = \min(L_k, L_{k+1})$$

$$N_e = L_{\max} \bmod L_{\min} \qquad N_s = \operatorname{int}\left(\frac{L_{\max}}{L_{\min}}\right)$$

- Preprocessing is accomplished by

1) Dividing N_e edges of keyframe$_{min}$ into N_s+1 sections
2) Dividing the remaining lines of keyframe$_{min}$ into N_s sections

Eg: $L_k = 15$ and $L_{k+1} = 11$ we would divide 4 lines of keyframe$_{k+1}$ into 2 sections each. The remaining lines of keyframe$_{k+1}$ are left intact.

Morphing

- **Equalizing the vertex count:** let parameters V_k and V_{k+1} denote the vertices

$$V_{max} = \max(V_k, V_{k+1}) \qquad V_{min} = \min(V_k, V_{k+1})$$

$$N_{ls} = (V_{max} - 1) \bmod (V_{min} - 1) \qquad N_p = \operatorname{int}\left(\frac{V_{max} - 1}{V_{min} - 1}\right)$$

- Preprocessing using vertex count is performed by

  1. Adding N_p points to N_{ls} line sections of $keyframe_{min}$
  2. Adding N_p-1 points to the remaining edges of $keyframe_{min}$

- For the triangle to quadrilateral examples, $V_k = 3$ and $V_{k+1} = 4$.
- Both N_{ls} and N_p are 1 from Eqns.
- we would add one point to one edge of $keyframe_{k.}$
- No points would be added to the remaining lines of $keyframe_{k+1}$.

Simulating Accelerations

- we use time interpolation to specify the animation paths between key frames and produce realistic displays of different speed changes.
- Curve fitting techniques used to specify the animation paths between keyframes.
- Given the vertex positions at the key frames, we can fit the positions with linear or nonlinear paths.
- But to simulate accelerations, we need to adjust the time spacing for the in-betweens.
- First, we consider constant speed (zero acceleration) using equal time-interval spacing for the in-betweens

Simulating Accelerations

- Let there be n in-betweens for key frames at times t1 and t2
- We now divide the time interval between key frames into (n+1) sub intervals, yielding an in-between spacing of

$$\Delta t = \frac{t_2 - t_1}{n+1}$$

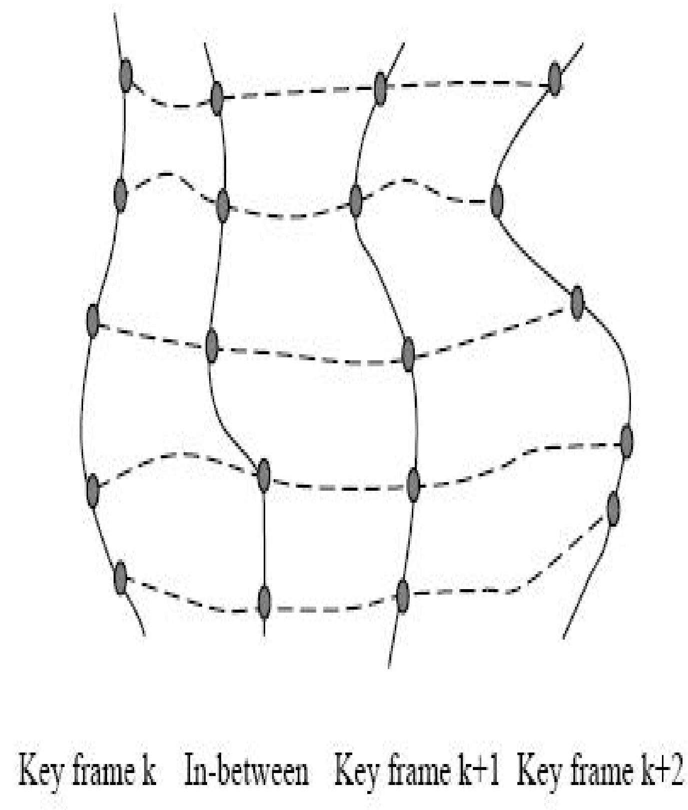


Fig. 4: Fitting key frame vertex positions with non linear splines

Simulating Accelerations

- We can calculate the time for any in-between by the interpolation as

$$tBj = t1 + j\ \Delta t, \qquad\qquad j = 1, \ldots\ldots\ldots\ldots, n \quad \ldots(6)$$

- Then, determine the values for coordinate positions, color, and other physical parameters.

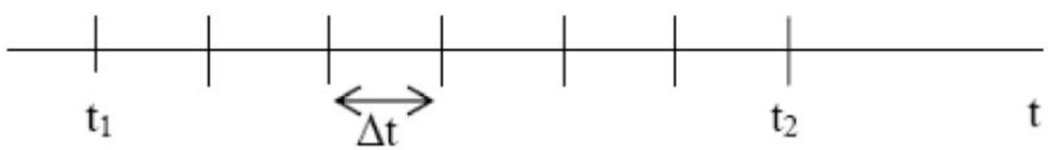


Fig. 5 :
In-between positions for motion at constant speed

Simulating Accelerations

- To produce realistic displays of speed changes particularly at the beginning and at the end of a motion sequence, Non zero accelerations are used
- Model the start-up and slow-down portions of an animation path with spline or trigonometric functions.
- To model an increasing speed (positive acceleration), the time spacing between frames has to be increased so that greater changes in position occur as the object moves faster.
- We can obtain an increasing interval size with the function

$$1-\cos\theta \qquad 0 < \theta < \pi/2$$

- The time for the jth in-between can be calculated from the above function as

$$t_{bj} = t_1 + \Delta t \left[1 - \cos\frac{j\pi}{2(n+1)}\right], \qquad j = 1,2,\ldots,n$$

Simulating Accelerations

- We can model decreasing speed (deceleration) with sinθ, using the angle in the range $0 < \theta < \pi/2$.
- The time spacing of an in-between in this case is defined as

$$t_{bj} = t_1 + \Delta t \sin \frac{j\pi}{2(n+1)} \qquad j = 1, 2, \ldots, n$$

- Can model a combination of increasing-deceasing speed by first increasing the in-between time spacing, then decreasing this spacing.
- A function to accomplish these time changes is

$$\frac{1}{2}(1 - \cos\theta) \qquad 0 < \theta < \pi/2$$

•The time for the j-th in-between is now calculated as:

$$t_{bj} = t_1 + \Delta t \left\{ \frac{1 - \cos[j\pi/(n+1)]}{2} \right\} \qquad j = 1, 2, \ldots, n$$

Motion Specifications

- Several ways in which the motions of objects can be specified in an animation system.
- Define motion directly or in a more abstract or general approach.

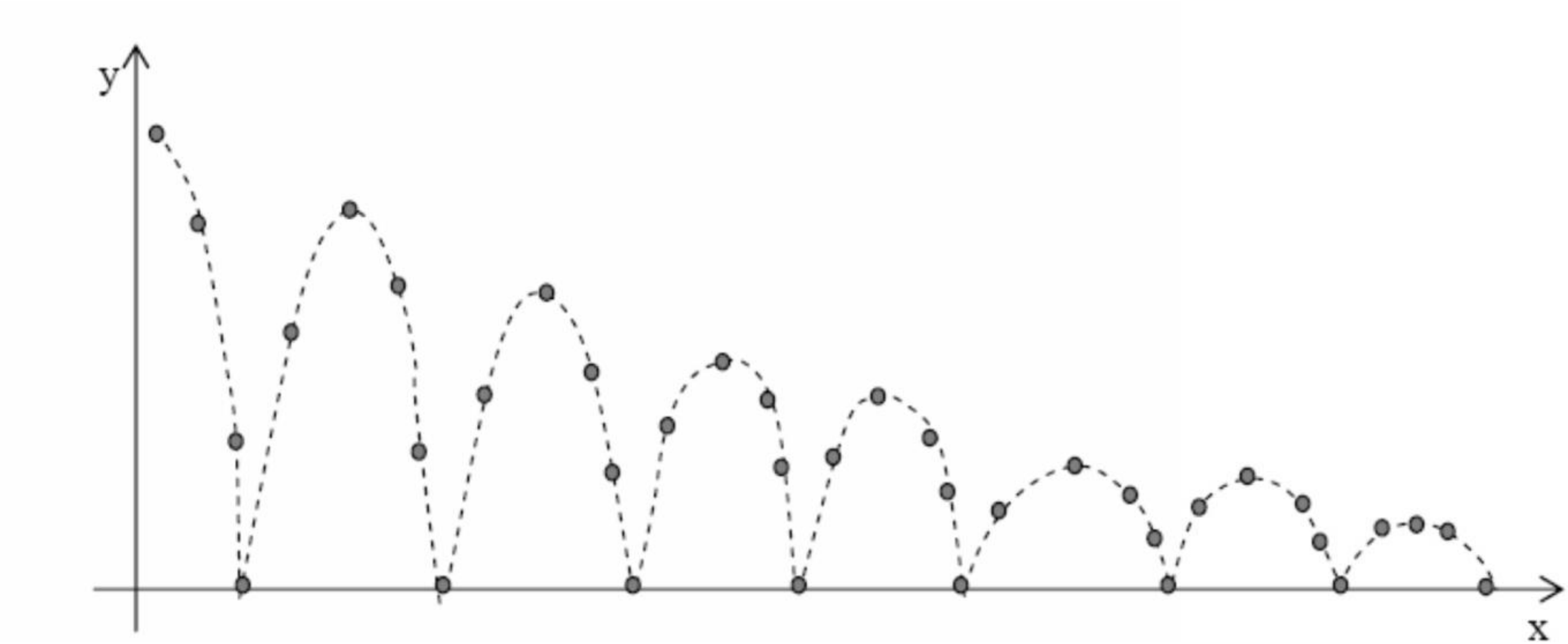
1) Direct motion specification
2) Goal Directed systems
3) Kinematics and Dynamics.

Direct motion specification

- The most straightforward method of defining a motion sequence is the direct specification of motion parameters.
- The specification consists of rotation angles and translation vectors.
- Then geometric transformation matrices are applied to transform coordinate positions.
- Alternatively, use an approximation equation to specify certain kinds of motions.
- Approximate the path of bouncing ball with a damped, rectified sine curve

$$y(x) = A|\sin(wx+\theta_0)|e^{-kx}$$

A- initial amplitude, w –angular frequence, θ_0 – phase angle, k- damping constant



– $y(x) = A|\sin(wx+\theta 0)|e\text{-}kx$

Constraint based and Goal directed system

- Specify the motions that are to take place in general terms that abstractly describe the actions.
- Called as goal directed ‘coz they determine the specific motion parameters given the goals of animation.
- Ex: specify - want an object to “walk” to run” to a particular destination.
- Input directives are then interpreted in terms of component motions that will accomplish the specified task.
- Human motions, can be defined as a hierarchical structure of sub motions for the torso, limbs etc.,

Kinematics and Dynamics

- We can also construct animation sequences using either kinematics, which refers to positions, velocities and acceleration of points without reference to forces that cause motion.
- For constant velocity we infer the motions by giving initial position and velocity vector for each object.
- Eg: If velocity is specified as (3,0,-4) km/sec then
  - Direction – straight line path
  - Speed (magnitude) is 5 km/sec
- If acceleration is also specified, speed-ups slowdowns and curved motion paths can be generated.
- **Inverse Kinematics:** we specify the initial and final positions of objects at specified times and the motion parameters are computed by the system.

Kinematics and Dynamics

- **Dynamics:** Requires specification of forces that produce the velocities and accelerations.
- **Physically based modeling:** Descriptions of object behavior under the influence of forces.
- **Eg of forces:** Gravitational, electro magnetic, friction and other mechanical forces.
- Object motions are obtained from force equations.
- Eg: Newton's second law , F= ma.
- **Inverse Dynamics:** Obtain forces given the initial and final positions of objects and type of motion.