3D Animation summary

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Artificial Intelligence & Information Analysis Lab

3D Animation

- Introduction to 3D Animation
- History of 3D Animation
- Types of animation
- Applications
- Production Pipeline
- Essential parts of computer animation
- Principals of Animation
  - Movement
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Introduction to 3D Animation

- ***Animation*** is the rapid display of a sequence of images in order to create an illusion of movement.

- Animation comes from the word anime, which in Japanese means soul.

- 3D Animation is tightly connected with 3D compute graphics.

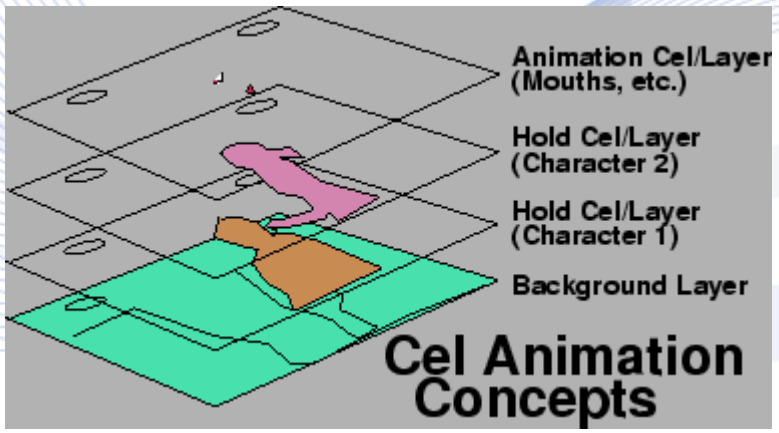
History of 3D Animation

- ***2000's***:
  - In 2000 we have powerful GPU's and NVIDIA becomes a standard graphics game card for computers.
  - Film productions have full digital features. Advertisements start using 3D Animation.
  - Some of the animated films produced this year are Lord of the Rings, Shrek 2 and Finding Nemo.

Types of animation

- ***Hand Drawn Animation*** (***Cel animation***): It is the traditional animation, where each frame is drawn by hand.

- Scene drawn in different layers and stacked one on top of the other.
- Static objects, like the background are drawn once.
- Cels can be reused for animation cycles, like running.



Reference:[CEL]

Types of animation

- ***Stop-motion animation***: Move models (real world objects) and record each frame to create a story, e.g., Coralline, Shaun the ship.

- ***Animatronics***: Uses mechanical models controlled by computer and filmed in real time by employing forward and inverse kinematics.

Reference:[STOP]

Types of animation

- ***Performance animation***: An actor performs wearing a suit and motion capture is used to obtain computer animation.

- ***Computer Animation***: Traditional animation was replaced by 2D and later 3D animation, while still using static backgrounds and keyframing.

Reference:[ANIM]

Applications

- 3D Animation is largely used for entertainment purposes. The industry of ***entertainment*** includes:
  - ***Games***: Massively popular and profitable industry. Interactive games with multiple players, animated creatures and virtual worlds.

Reference:[GAM]

Applications

- ***Films***: Include fully animated films, like The Toy Story, and Visual effect films, like Jurassic Park.
- ***Advertisements***: Short films, use of special effects, e.g., Coca Cola bear.

Reference:[FILM]

Reference:[ADV]

Applications

- ***Data visualization***: It is used for scientific purposes, to visualize the weather or differential systems.

- ***Simulators***: Applications for design purposes, like in architecture or for training in flight control, surgeries etc.

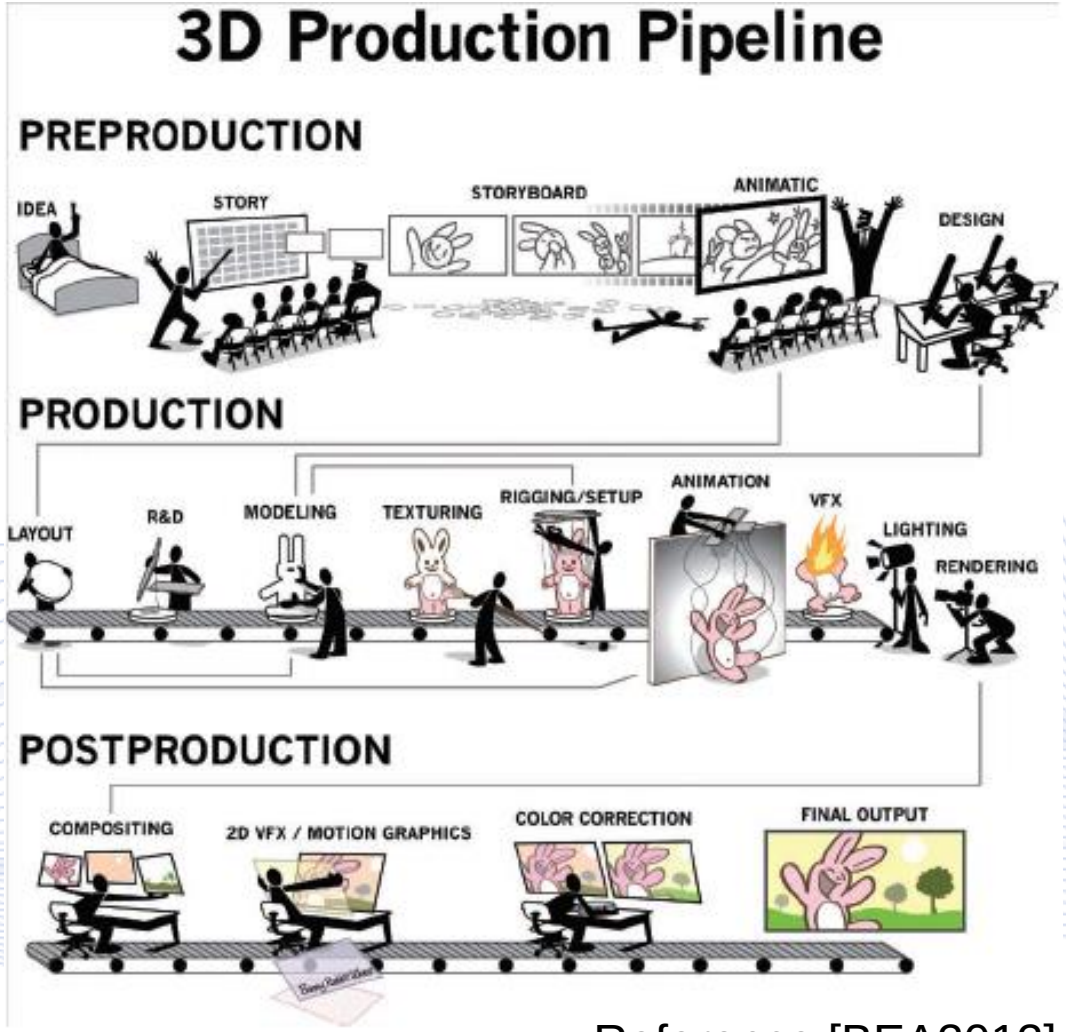
Reference:[SIM]

Applications

- ***Virtual Environments***: Includes immersive environments (virtual and augmented reality), as well as non-immersive environments.

Reference:[VR]

Production Pipeline



Reference:[BEA2012]

Production Pipeline

- ***Postproduction*** is the final stage of 3D Animation.

- It includes:
  - Compositing of all layers to create the final output image.
  - 2D visual effects and motion graphics are added to composition.
  - Color correction to have a consistent color imagery output.
  - Transfer the output to the according medium, e.g., film, video etc.

Essential parts of Animation

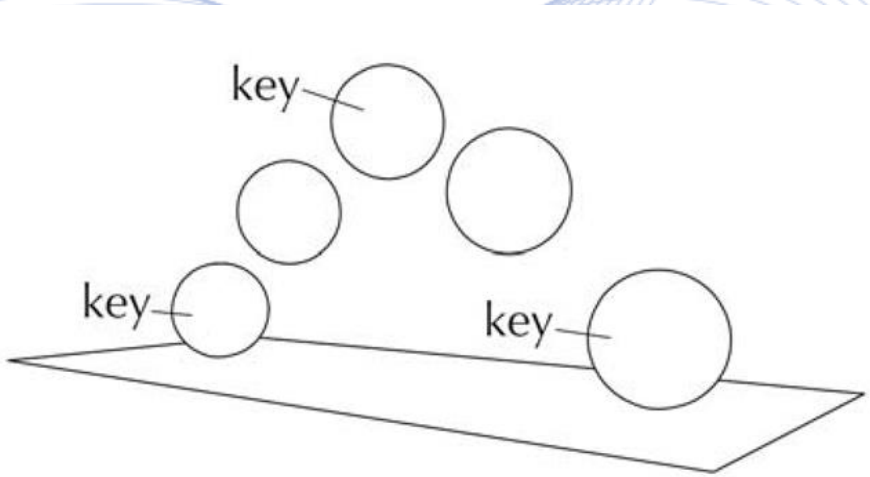
- ***Scripting:***
- Useful tool to create tasks and custom tools that can be reused.

- Avoid time-consuming processes, like creating shapes.

- Scripting languages in 3D Animation are C++, Python, JavaScript and Maya Embedded Language (MEL).

Essential parts of Animation

- ***Keyframing***:
- Keyframe is a drawing or a pose of an object or character displayed on a frame.
- Only the important frames are created, the motion will be filled by in-between frames created by computer.



Reference:[KEY]

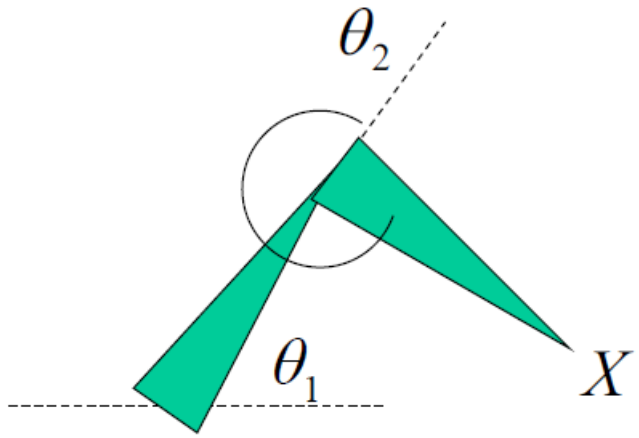
Essential parts of Animation

- ***Forward Kinematics***: Given the character's state, calculate its pose:

$$\mathbf{X} = (\mathbf{x}, \mathbf{y}) = f(\boldsymbol{\theta}).$$

- Full control, requires skilled animators:

$$\mathbf{X} = \begin{bmatrix} l_1 cos\theta_1 + l_2 cos(\theta_1 + \theta_2) \\ l_1 sin\theta_1 + l_2 sin(\theta_1 + \theta_2) \end{bmatrix},$$



where l_1 and l_2 are the lengths of the part of the body that moves and θ_1, θ_2 the angles.

Essential parts of Animation

- ***Inverse Kinematics:*** Given the character's pose, calculate its state:

$$\boldsymbol{\theta} = f^{-1}(\mathbf{X}).$$

- Applied in articulated objects, multiple solutions, requires motion constraints.
- Limited control.

$$\boldsymbol{\theta} = \begin{bmatrix} \dfrac{-(l_2 sin\theta_2)\mathbf{x} + (l_1 + l_2 cos\theta_2)\mathbf{y}}{(l_2 sin\theta_2)\mathbf{y} + (l_1 + l_2 cos\theta_2)\mathbf{x}} \\ cos^{-1}\dfrac{(\mathbf{x}^2 + \mathbf{y}^2 - l_1^2 - l_2^2)}{2l_1 l_2} \end{bmatrix}.$$

Essential parts of Animation

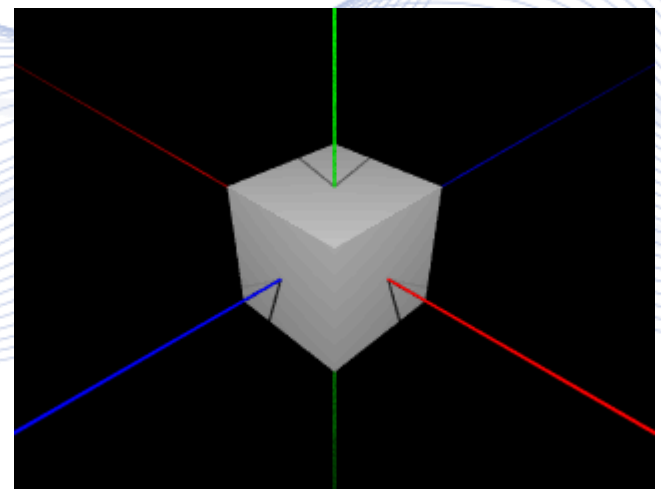
- ***Motion Capture***: Capture motion using a system that captures and uploads the data on a computer.
  - Marker system, an actor wears a suit with markers on it, that are tracked and triangulated by cameras to obtain 3D data set.
  - Markerless system, data are transmitted directly to computer.

- Facial performances are not motion-captured, the animator adds them.

Reference:[MOT]

Essential parts of Animation

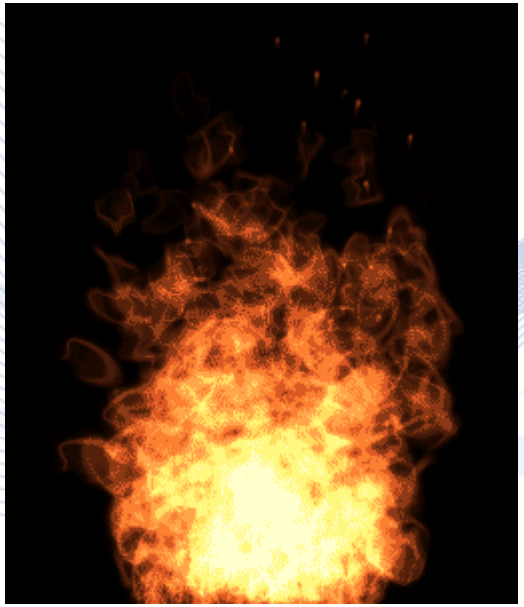
- ***Dynamics and Physics***: Define motion by using the laws of physics (Augmented laws of physics can also be used).
- It is a subset of procedural animation.
- Includes point masses, rigid bodies, deformable bodies and articulated objects.



Reference:[WIKI]

Essential parts of Animation

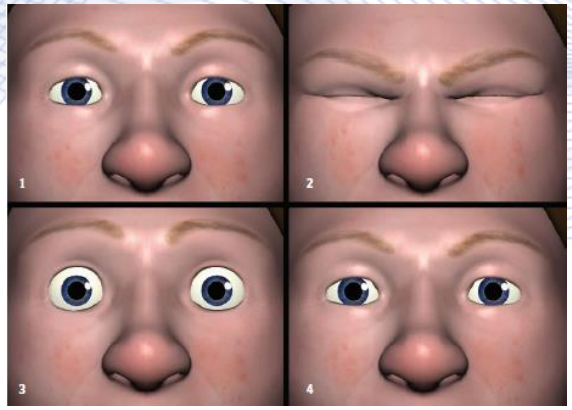
- Particles are objects modeled as point masses, while the collection of particles determines a particle system.
- Particle systems can represent fire, smoke, clouds, flocks etc.
- Particles contain local state:
  - Position
  - Velocity
  - Age
  - Lifespan
  - Rendering properties

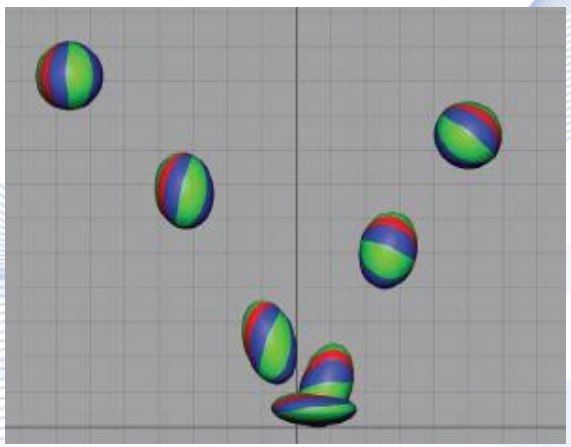


Reference:[SMO]

Principals of Animation

- ***Squash and stretch***: Find how the mass of an object changes when its shape is distorted during an action.
- It can be demonstrated as a deformation of a bouncing ball, that stretches before hitting the ground, squashes when it touches the ground and stretches back again after the bounce.
- Squash and stretch can be applied in a variety of movements, like a character's eye blink.

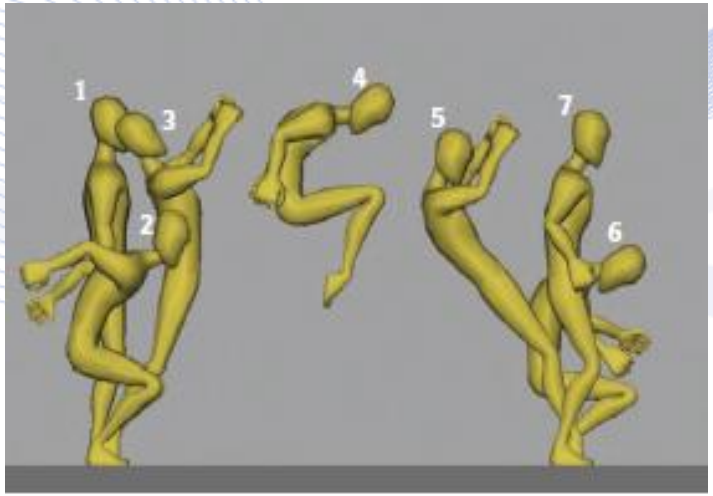




Reference:[BEA2012]

Principals of Animation

- In large scale motions the deformation is applied to the whole pose of a character:
  1. Character in standing position.
  2. Performs squash before the jump.
  3. Performs stretch by jumping forward and extending legs and arms.
  4. Squash again.
  5. Stretches to start landing.
  6. Squashes to land.
  7. Character again in standing position.



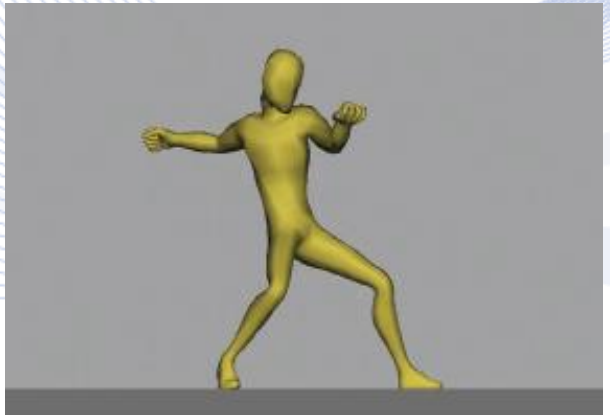
Reference:[BEA2012]

Principals of Animation

- ***Anticipation***: Direct the audience and their attention to understand a movement before it happens.

- The action is divided into preparation of movement (anticipation), the action and the end of the action.

- In anticipation the action is depicted usually by the opposite movement first.

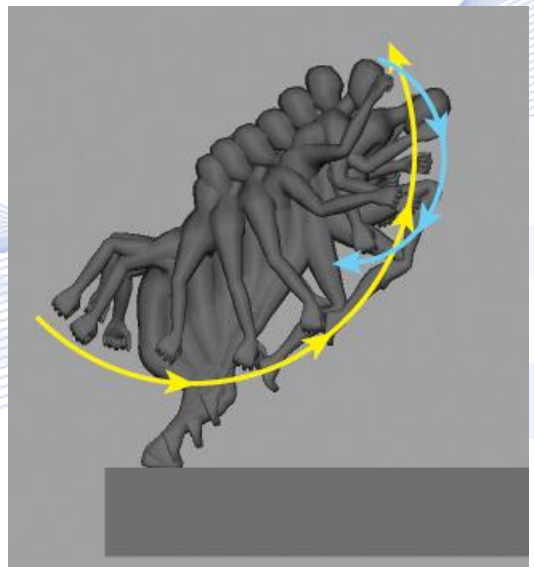


Reference:[BEA2012]

Principals of Animation

- ***Staging***: Defines the way an idea is presented to the audience in order to be clear and lead the viewers to the action.
- Props and objects must be set in ideal positions for the scene.

- ***Arcs***: Movement of objects is defined by arcs.
- For example the arms and legs are rotated around the joints.

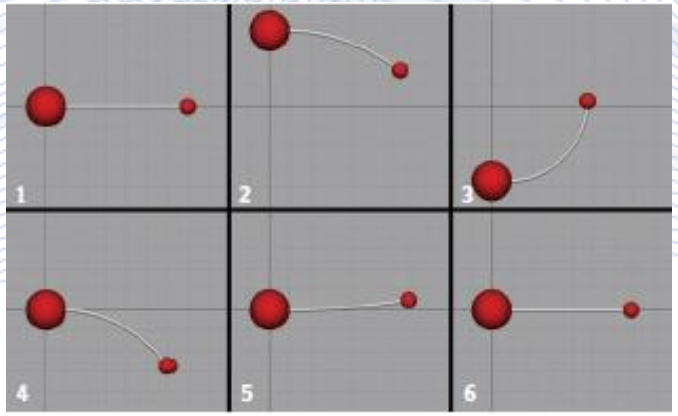


Reference:[BEA2012]

Principals of Animation

- ***Follow-Through***: Depicts the parts of the body that still move when the character has stopped, e.g., hair.

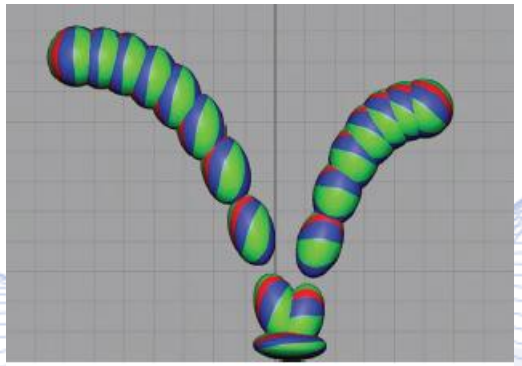
- ***Overlapping Action***: Indicate the parts of the body that move with a different speed than the rest of the body.



Reference:[BEA2012]

Principals of Animation

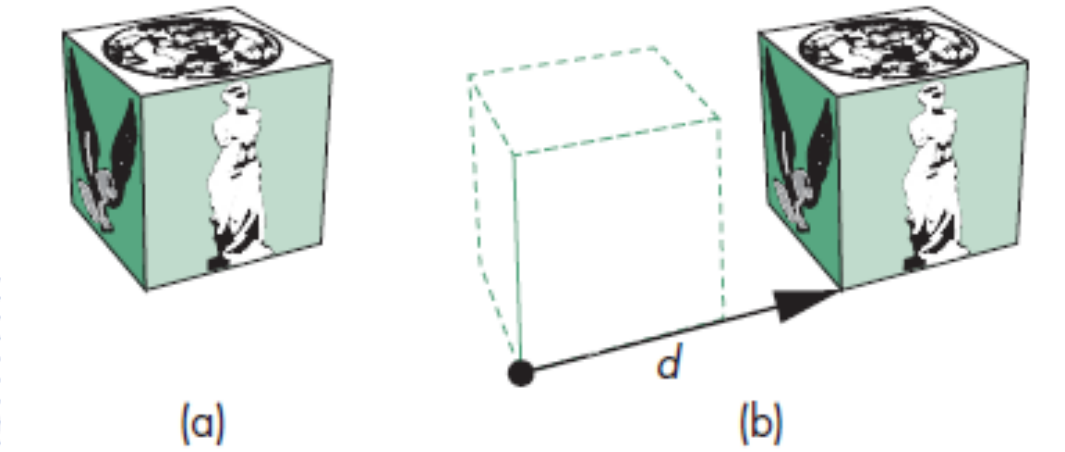
- ***Slow-In and Slow-Out***: Indicates the acceleration an object has when starting to move and the deceleration when it must stop.



Reference:[BEA2012]

- ***Secondary action***: Is used as a support to the primary action to add performance.

Transforms



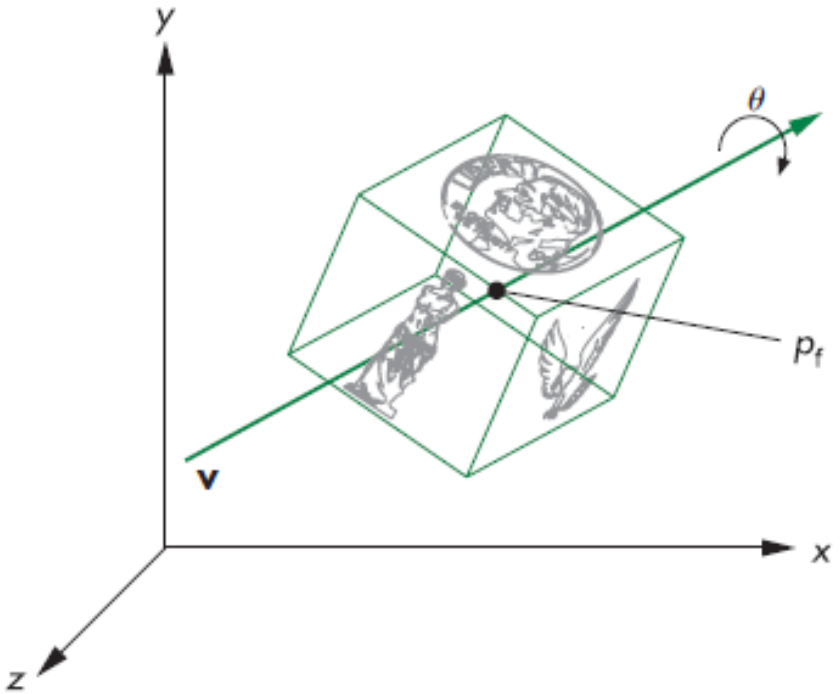
Reference:[ANG2005]

(a) Object in original position. (b) Object translated.

Transforms

- If $\mathbf{R}$ is orthogonal we have the following property:

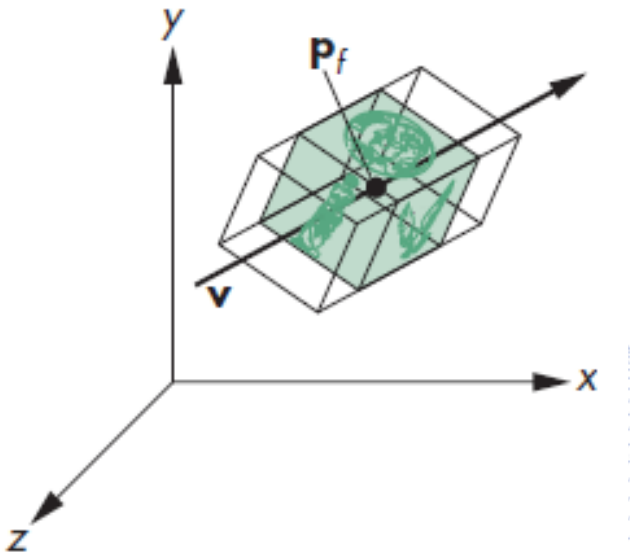
$$\mathbf{R}^{-1}(\theta) = \mathbf{R}^{T}(\theta) = \mathbf{R}(\theta).$$



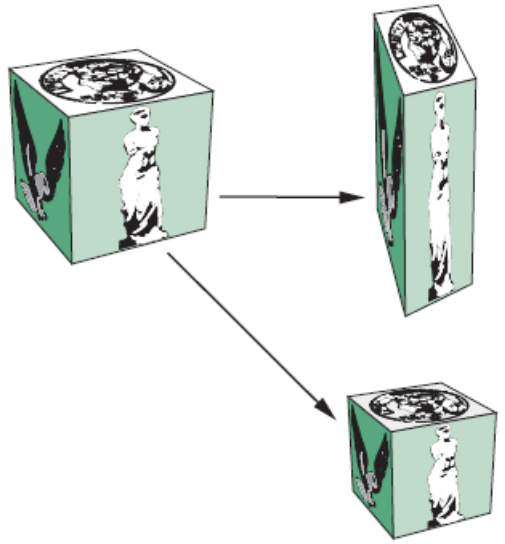
3D rotation around point $\mathbf{p}_f$.

Reference:[ANG2005]

Transforms



Scale factor



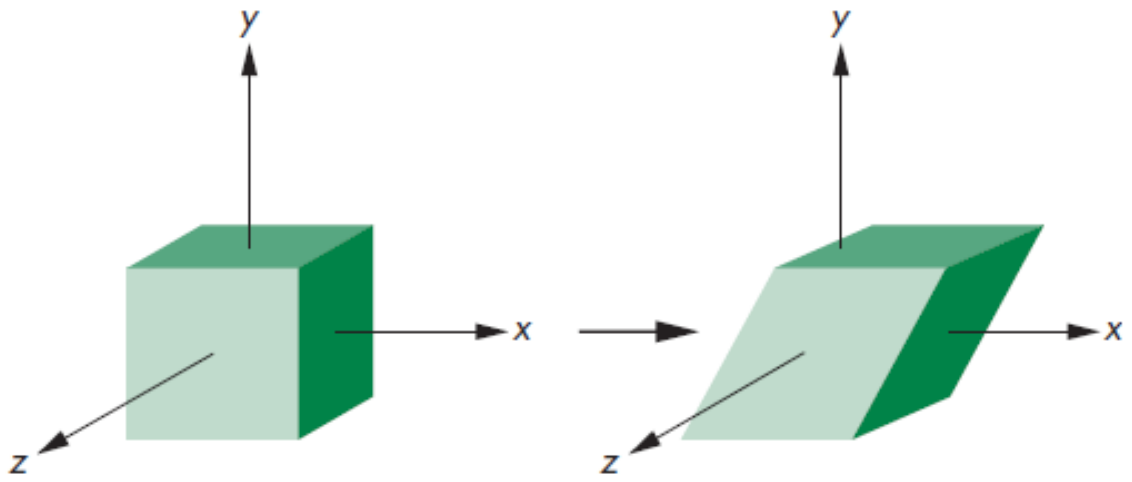
Uniform (down) and non-uniform (up) scaling

Reference:[ANG2005]

Transforms

- Matrix $\mathbf{H}$ has the following property:

$$\mathbf{H}_{x_y}^{-1}(\theta) = \mathbf{H}_{x_y}(\theta).$$

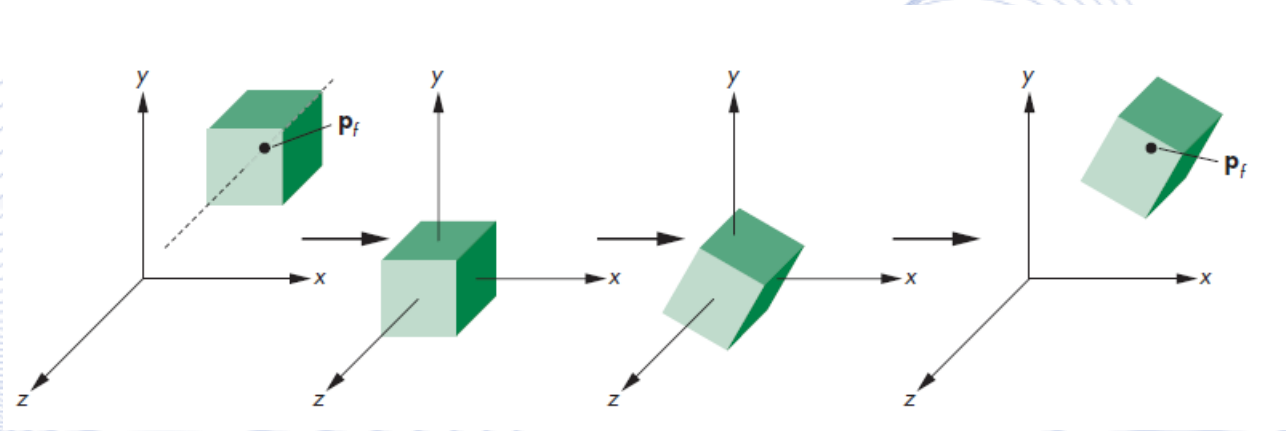


Reference:[ANG2005]

Shear

Composition of Transformations

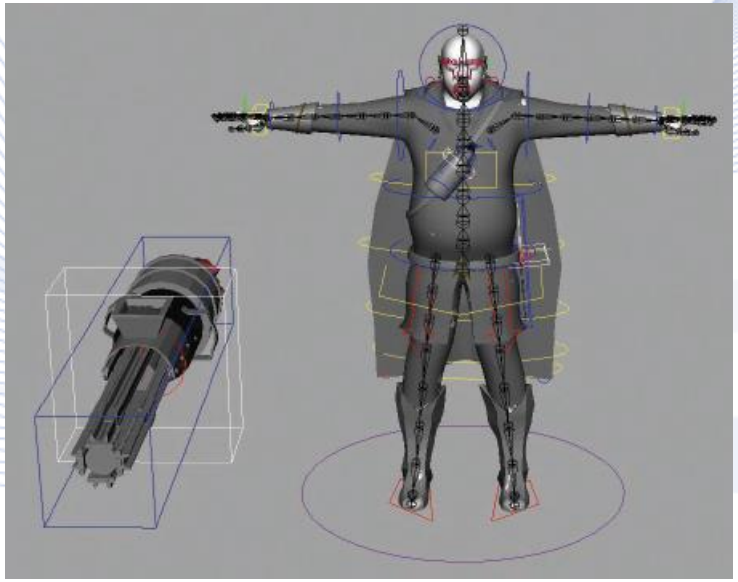
- Move the cube in the beginning $(0,0,0)$: $\mathbf{T}(-\mathbf{p})$.
- Rotate around axis z: $\mathbf{R}_z(\theta)$.
- Move cube to the initial position: $\mathbf{T}(\mathbf{p})$.



Reference:[ANG2005]

Rigging system

- In rigging a control system is created to allow animators control and move characters and objects.
- Controllers enable the translation and rotation of joints.
- Deformers are also used to connect the geometry of the system and allow the character to move in a realistic way.



Reference:[BEA2012]

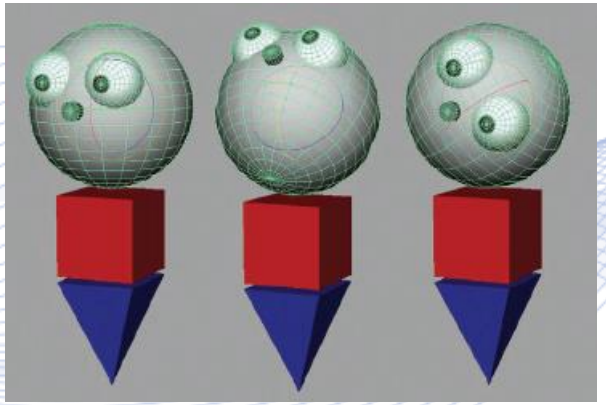
Hierarchy system

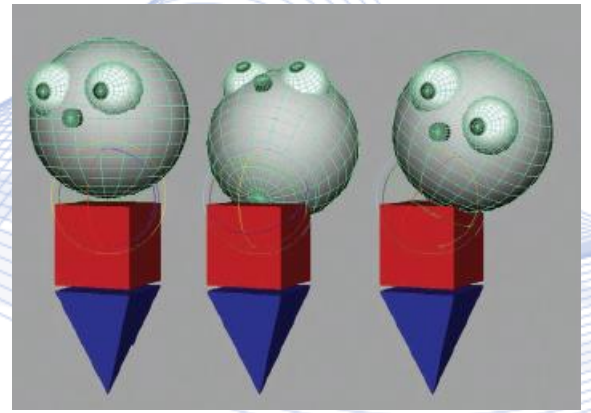
- The use of a hierarchy system enables the control of an object in a sequential manner.

- The child of an object can move, rotate and scale independently from the parent, whereas when the parent moves the children must follow the same move.

Pivot Position

- Pivot positions are points on an object where rotation is possible.
- In 3D animation movement and scale is available in pivot points.





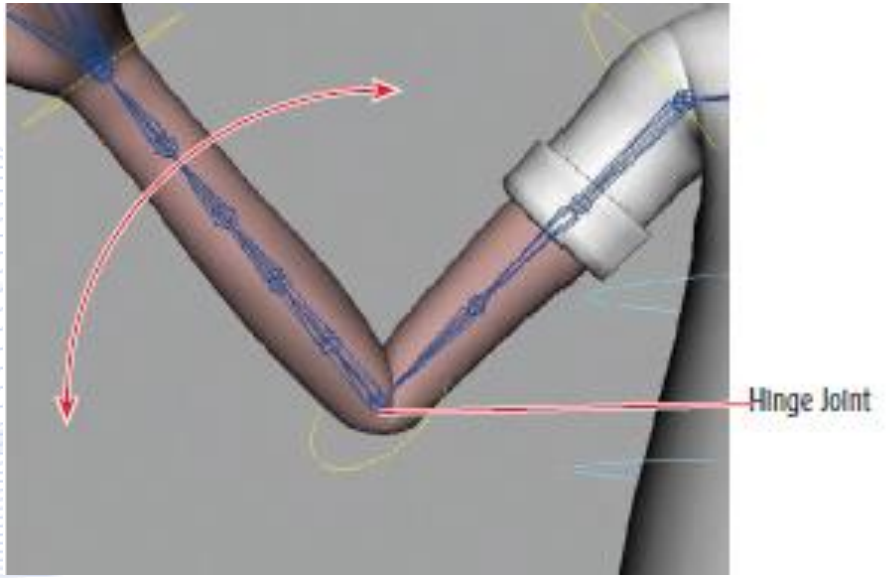
Reference:[BEA2012]

Pivot position: Unrealistic articulation

Proper articulation

Skeleton system

- A skeleton system contains pivot points in a hierarchical way on which deformers can be applied.

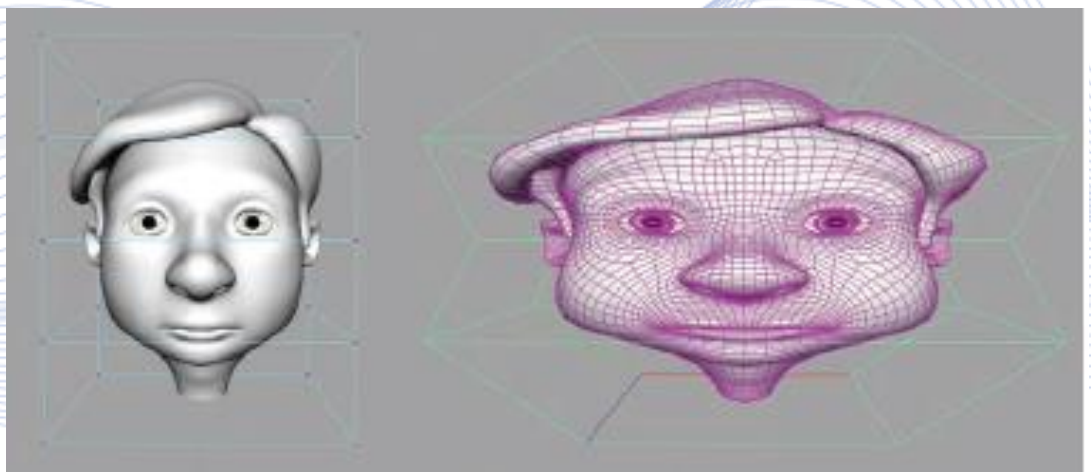


Reference:[BEA2012]

Deforms

- ***Lattice***: It is a geometry of vertices including another geometry in it and deforms a mesh smoothly.

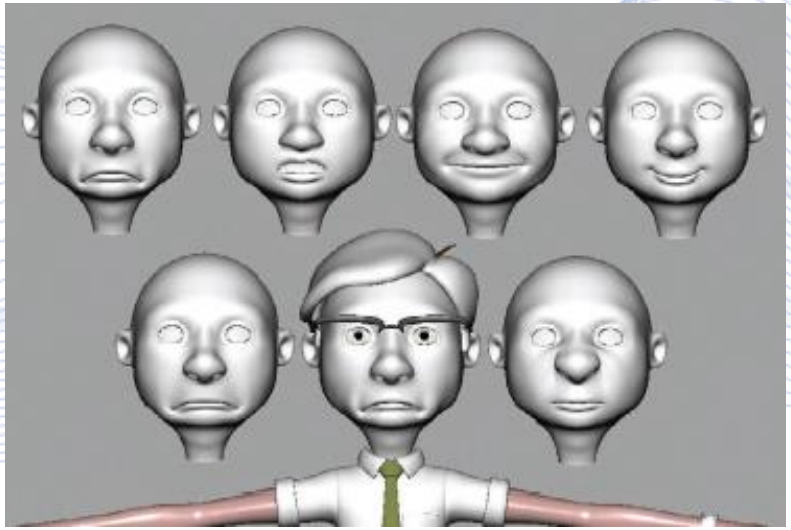
- A lattice can deform one or various meshes simultaneously.



Reference:[BEA2012]

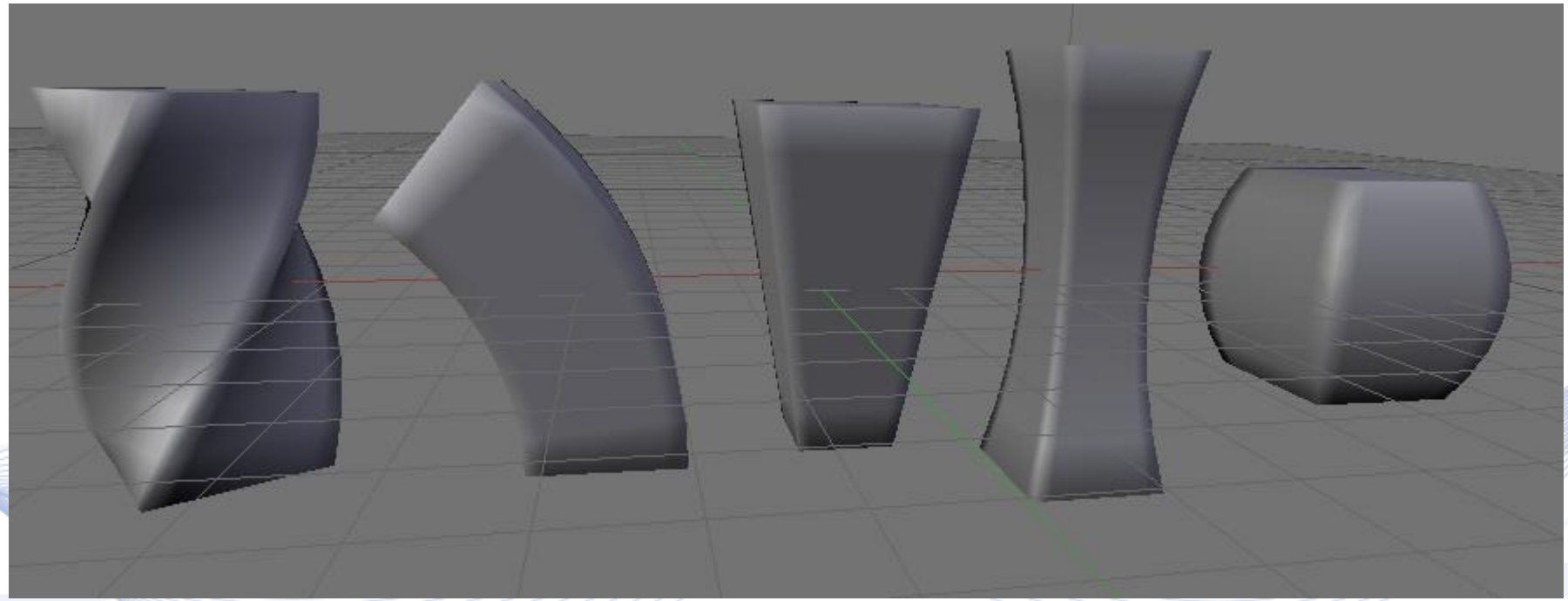
Deforms

- ***Blendshapes***: Deformers that allow the creator to duplicate an original object and change it, in order to make it a target shape.
- It is usually used for the creation of faces.



Reference:[BEA2012]

Deforms



Reference:[BLEND]

a. Twist, b. Bend, c. Taper, d. Taper, e. Skew.

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Q & A

Thank you very much for your attention!

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