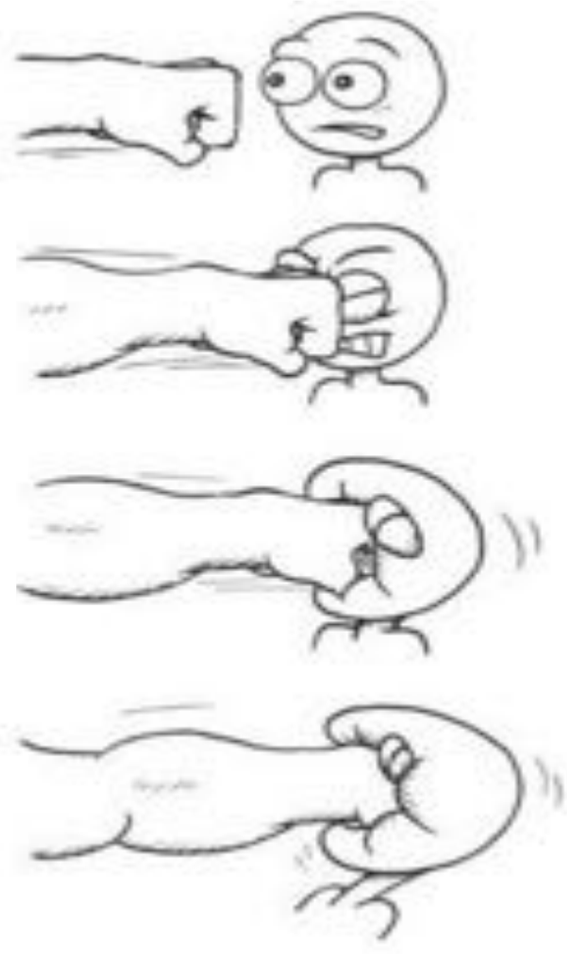
Computer Animation

Lesson 8 - Rigging and skinning

Remi Ronfard, Nov 2019

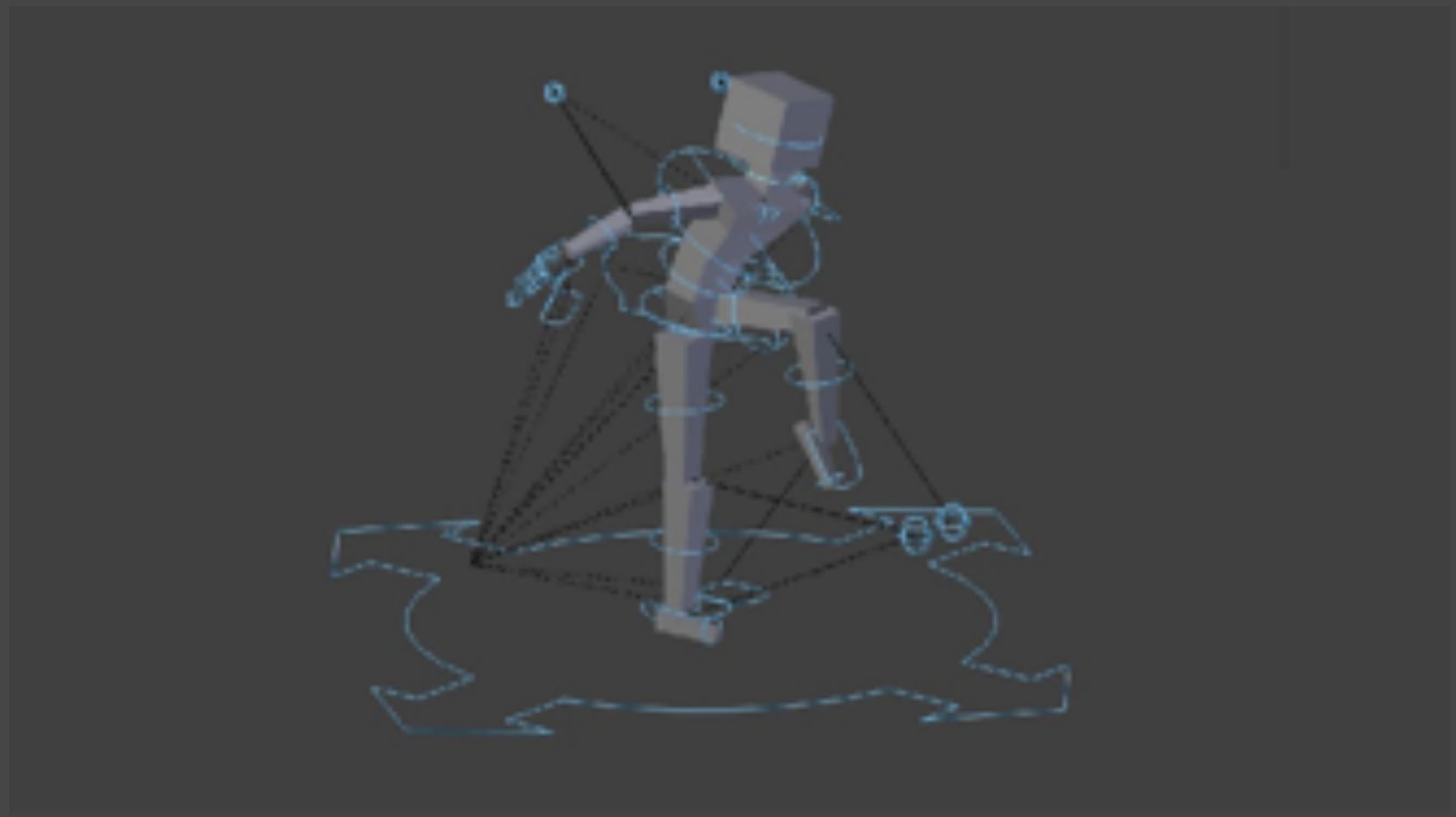
8 Exaggeration



The meaning of exaggeration is, in general, obvious. However, the principle of *exaggeration* in animation does not mean arbitrarily distorting shapes or objects or making an action more violent or unrealistic. The animator must go to the heart of anything or any idea and develop its essence, understanding the reason for it , so that the audience will also understand it. If a character is sad, make him sadder; if he is bright, make him shine; worried, make him fret; wild, make him frantic.

10. Exaggeration

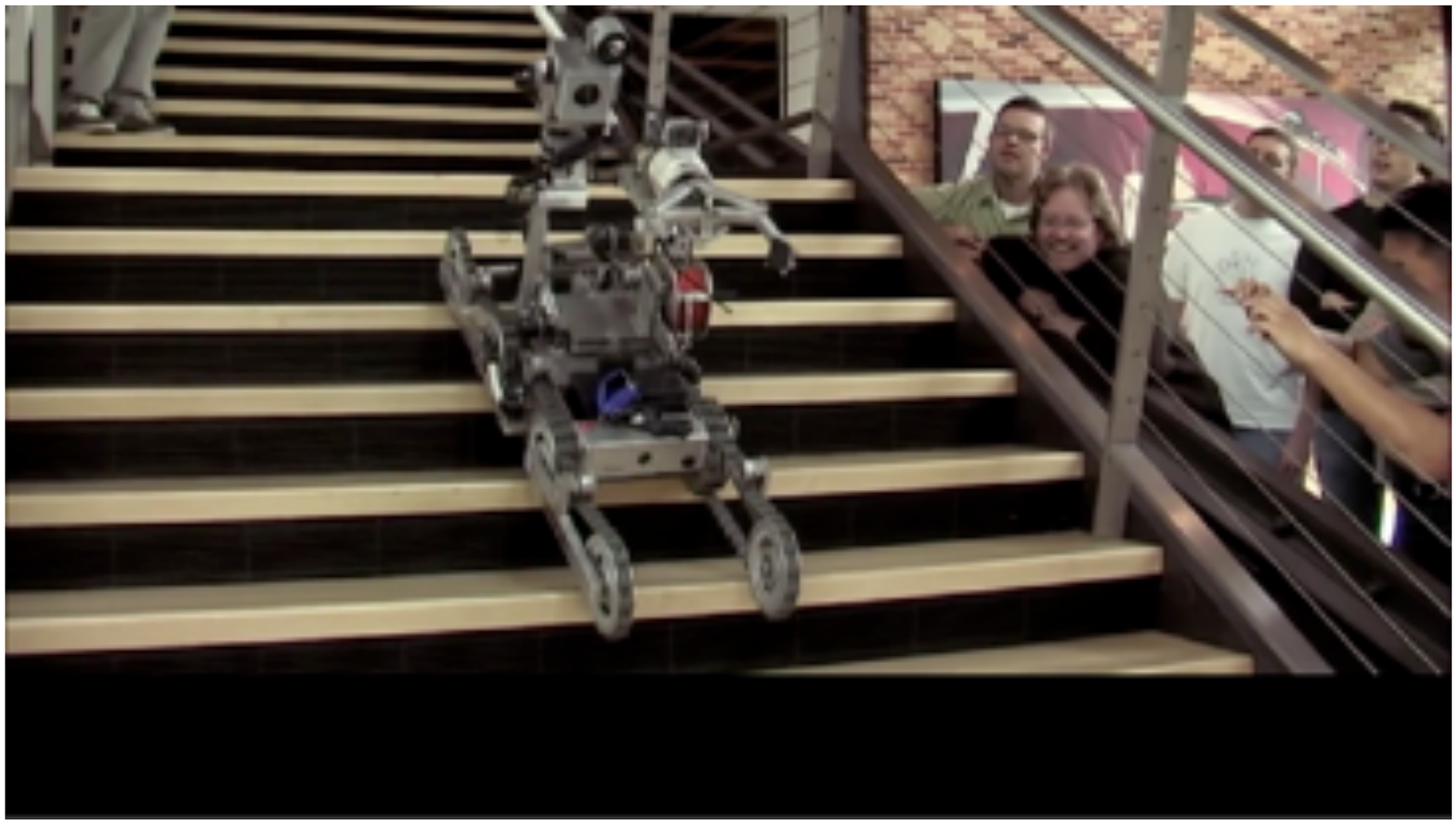
RIGGING AND SKINNING



Rigging and skinning

- How do we animate complex characters?
  - Skeleton/armature: rigging
  - Skin and flesh: skinning, smooth skinning, muscles, fat, wrinkles
  - Clothing : particle systems, finite elements

Rigging introduction



Rigging a lamp (part 1)

Rigging a lamp (part 2)

Rigging a lamp (part 3)

Rigging a lamp (part 4)

Rigging a human character

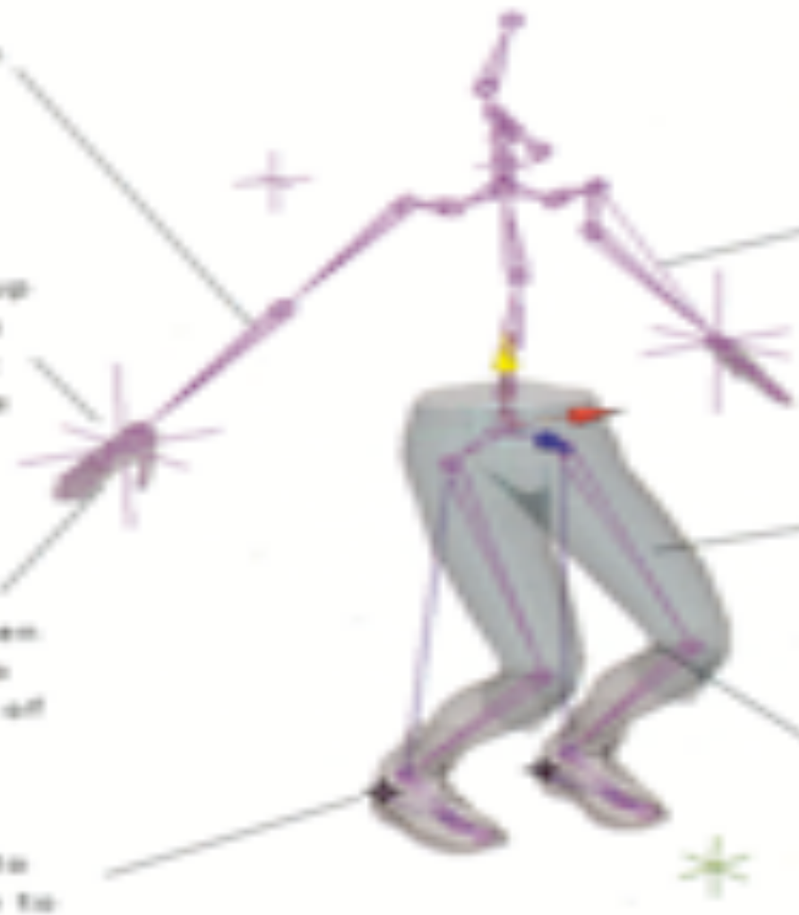
Skeleton = “bones”

Geometry = “skin”

Typical Character

- Mechanics of movement must be convincing
- Skin and clothing moves & bends appropriately
- This process of preparing character controls is called rigging
  - Fully rigged character has
    - Skeleton joints, surfaces, deformers, expressions, Set Driven Key, constraints, IK, Blendshapes, etc

Typical Character Rig



Skeleton Joints

Joints are used to create a framework for a character's hierarchy. The rotation of the skeleton joints defines the motion of the character; you can use inverse kinematics for even more control.

Character Controls

Using animation techniques such as Set Driven Key and expressions, you can set up attributes for controlling different parts of a character. For example, a hand joint could have attributes used to control the different finger joints.

Constraints

It is possible to constrain the kinematic controls of a skeleton to objects in your scene or even simple locators. You can then animate the constraint weights to make a character pick something up or grab hold of a fixed object.

Selection Handles

Selection handles give you quick access to parts of a character's hierarchy that are to be animated. This makes it easier to work with a character after it has been rigged up for animation.

Facial Animation

To animate facial features, you can use deformers such as Blend Shape to create facial poses that can be used for talking and for showing emotion.

Kinematics

To control your skeleton joints, you can choose from forward or inverse kinematics. Forward kinematics allows you to set the joint rotations directly. It allows you to position IK handles, which rotates the joints.

Bound Surfaces

Surfaces of a character's skin and clothing can be either parented or bound to the skeleton joints to make them move together. Binding places points from a surface into clusters that are then associated with particular joints.

Deformers

To help the surfaces bend realistically at joints, deformers such as flexors and influence objects can be used.

Character Resolution

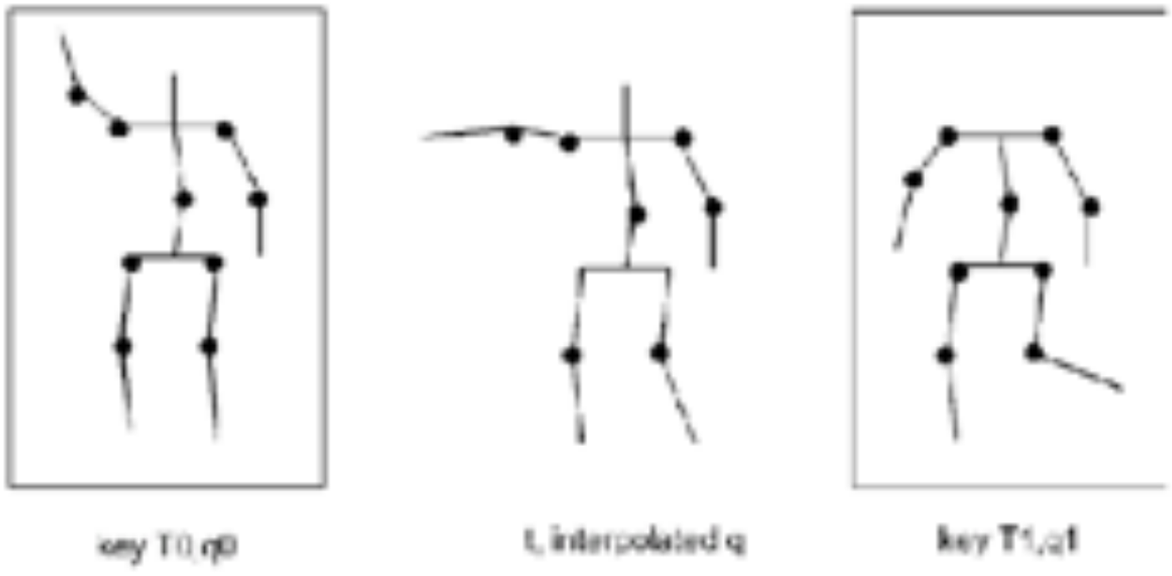
- Use low resolution character that has surfaces “parented” to skeleton
  - Allows interactive animations
  - Switch to full resolution character later

Typical Character Animation Workflow

- Character Design
- Model
- Skeleton Rigging
- Binding
- Animation
- Integration
- Rendering

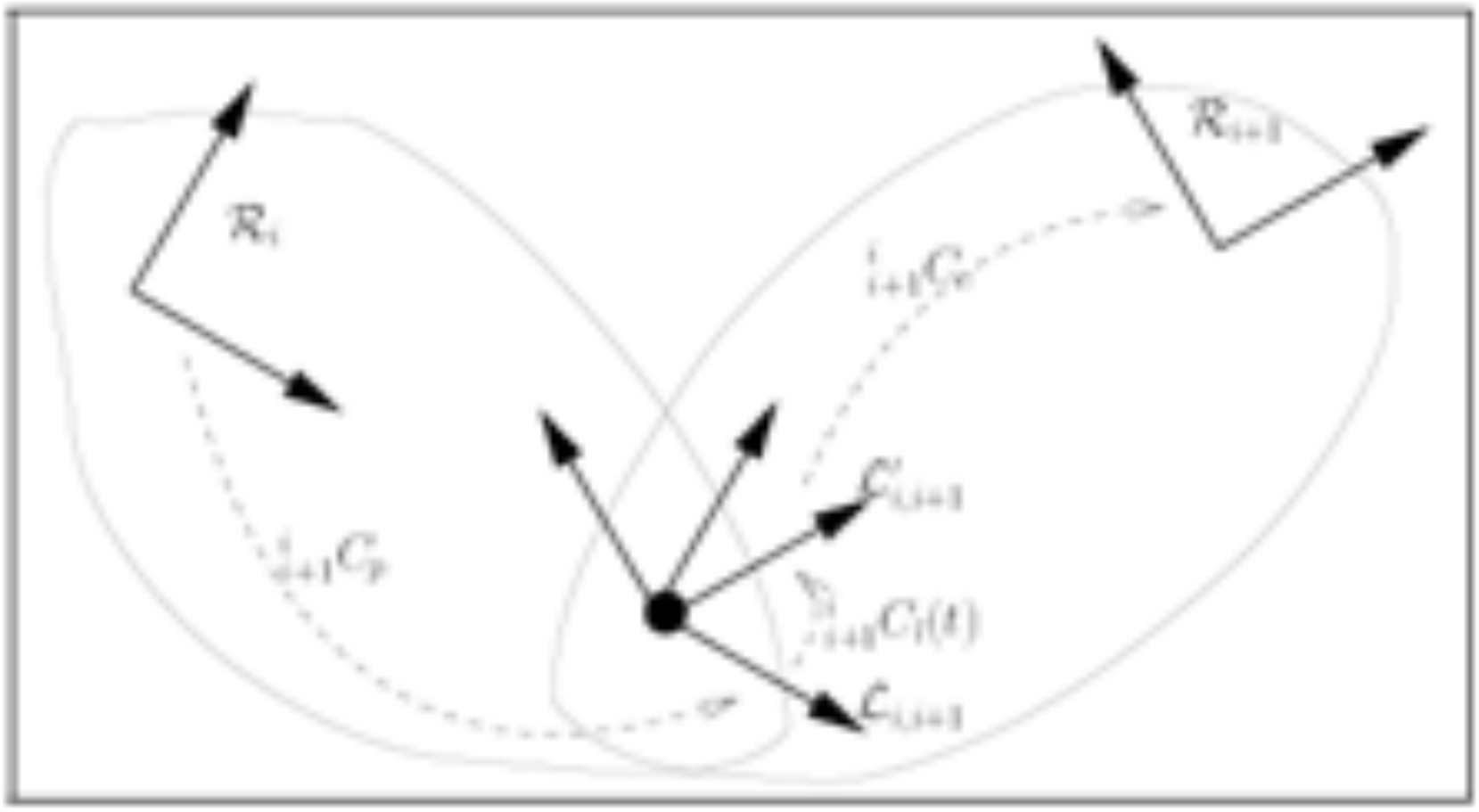
Animation and interpolation

- Series of pairs (time, parameter values)
- interpolate inbetween

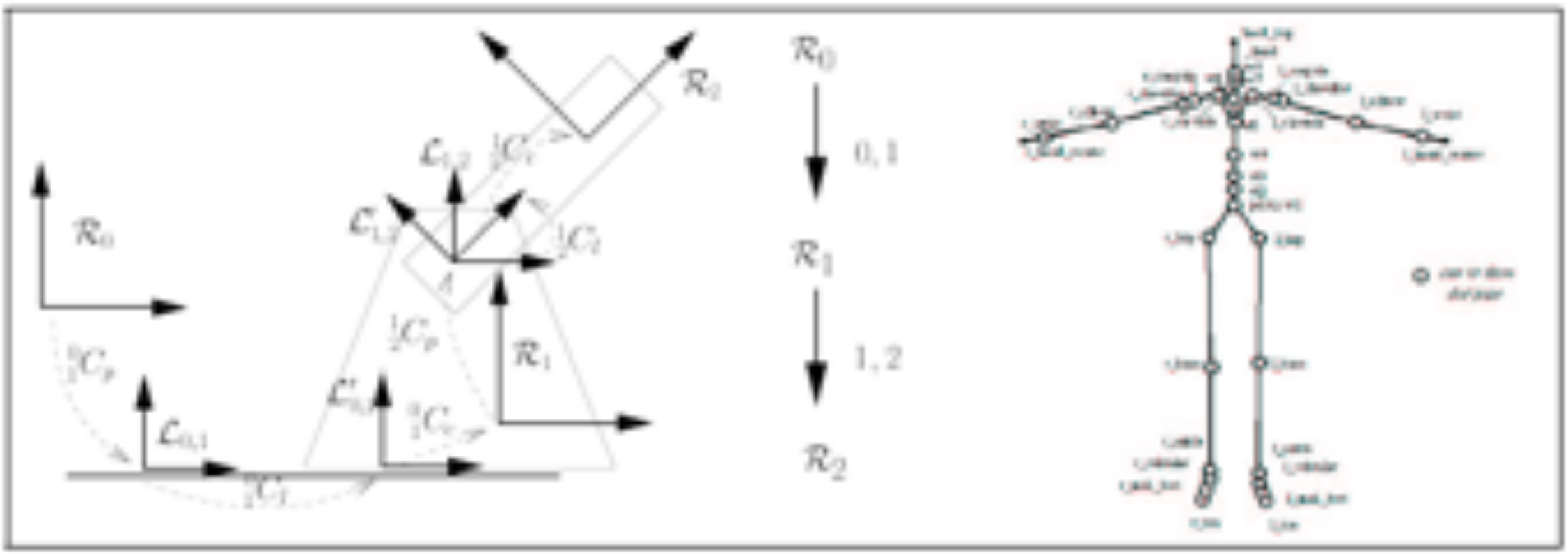


- Keyframe animation
- How to interpolate motion between key-frames

Articulated motion



Articulated motion



Articulated and rigid motion

- Motion of body part is rigid
  - In the parent's frame
  - In the word frame
- Rigid motion can be represented as a 3 x 4 matrix

$$M_{b,f} = (S_{b,f} R_{b,f} T_{b,f})\, M_{p,f} \qquad S_{b,f} R_{b,f} T_{b,f} = \begin{pmatrix} S_x R_{11} & S_x R_{12} & S_x R_{13} \\ S_y R_{21} & S_y R_{22} & S_y R_{23} \\ S_z R_{31} & S_z R_{32} & S_z R_{33} \\ T_x & T_y & T_z \end{pmatrix}$$

Skinning

- We have a structure of bones, organized as a kinematic tree
- Problem : how do we animate the « skin » of the characters given the motion of their bones ?
- Rigid skinning : each body part is modeled as a rigid body
  - $P(v_i) = T_f P_0(v_i)$ where T is the bone transformation

Smooth skinning

- Also known as « Skeleton Subspace Deformation »
- Skin vertices move as a result of several body part motions
  - $P(v_i) = (\text{sum\_f } w_{if} T_f) P_0(v_i)$
  - Normalized weights : $\text{sum\_f } w_{if} = 1$)
  - Vertex weights can be computed automatically
  - For example $w_{if} = 1/d_{if}^2$
- Or weights can be drawn by « painting » the skin

Interpolation of matrices

- Transformation matrix $T_f = [SR|t]$ with 12 parameters
- Non independent
- 3 translations, 3 rotations, 3 re-scalings
- Better to control them separately
- Automatic weight computation
- Wang et Philips, Multi-weight enveloping: least-squares approximation techniques for skin animation, SCA 2002

Dual quaternion interpolation

- Skinning with Dual Quaternions
  Ladislav Kavan, Steven Collins, Jiri Zara, Carol O'Sullivan.
  Symposium on Interactive 3D Graphics and Games, 2007.

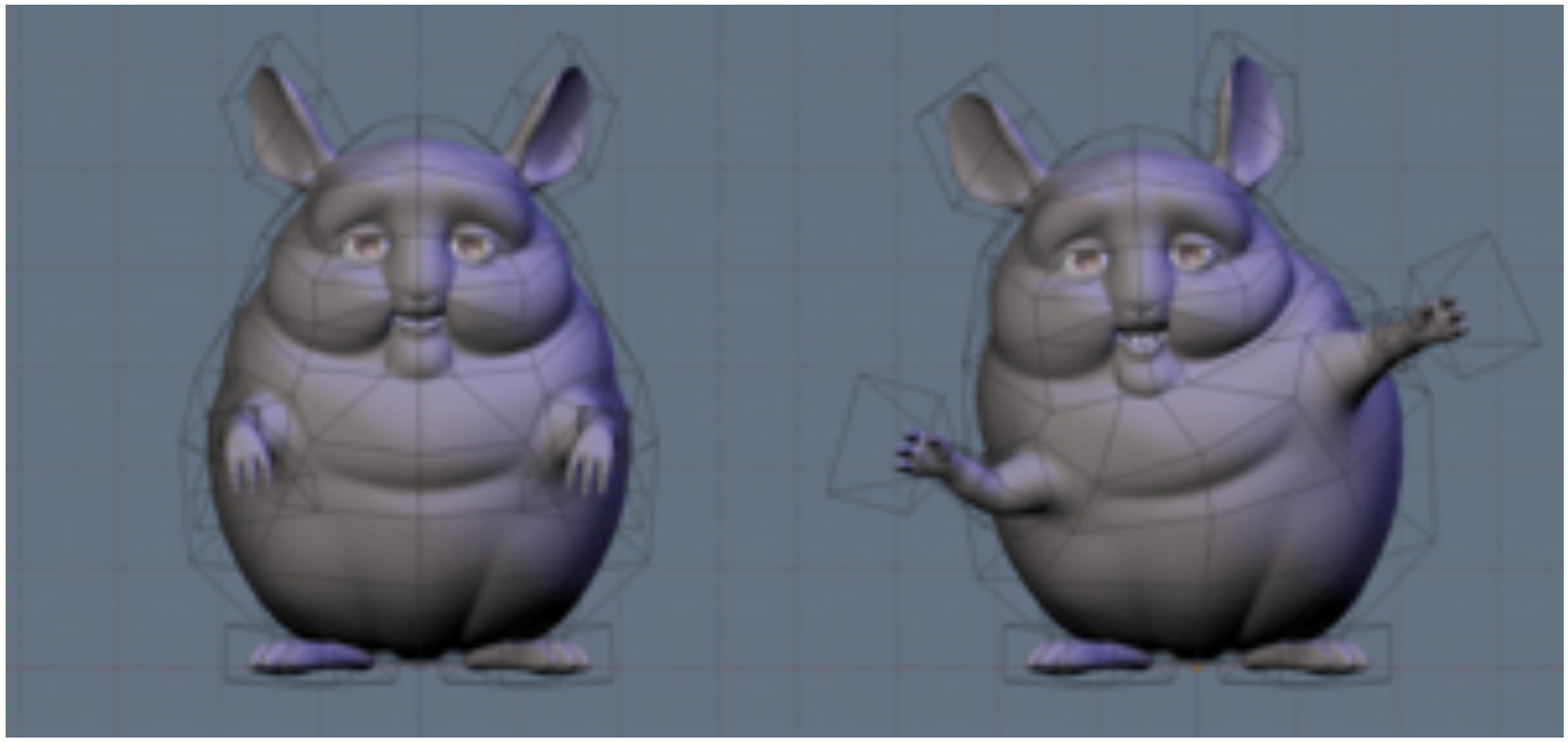
Skinning with Dual Quaternions

L. Kavan, S. Collins, J. Zara, C. O'Sullivan

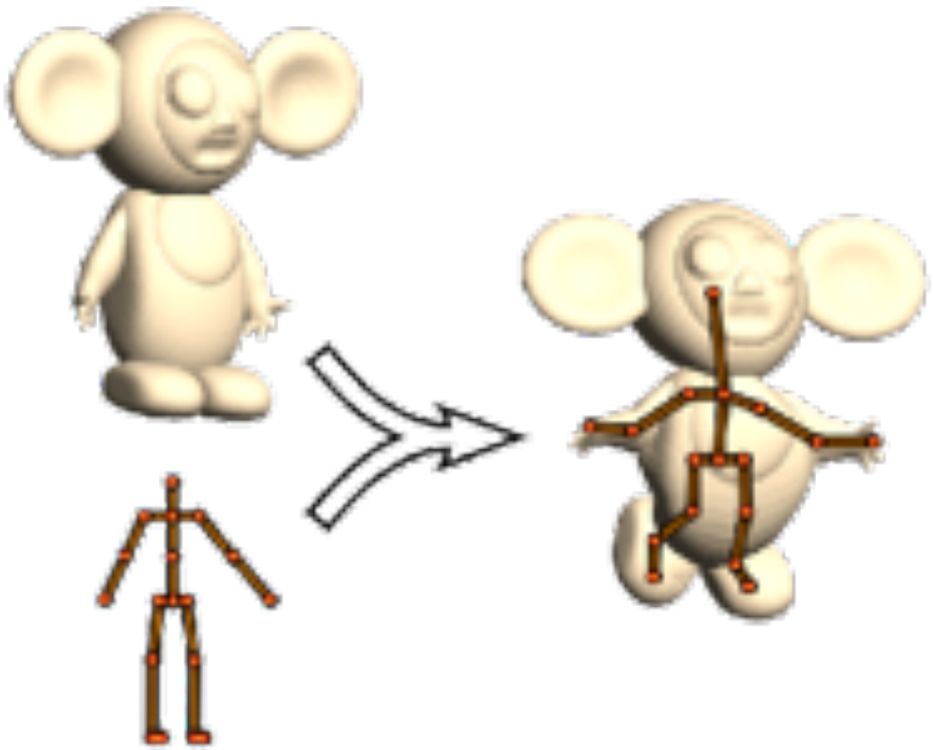
Trinity College Dublin
Czech Technical University in Prague

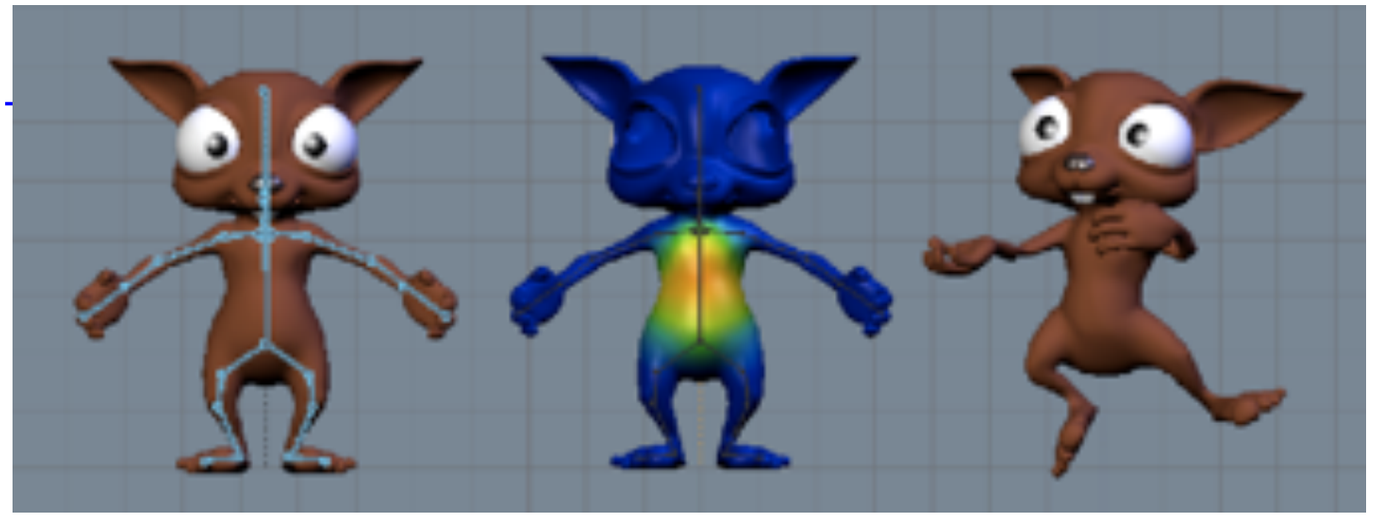
Cage deformations

- Build a cage around bones (armatures)



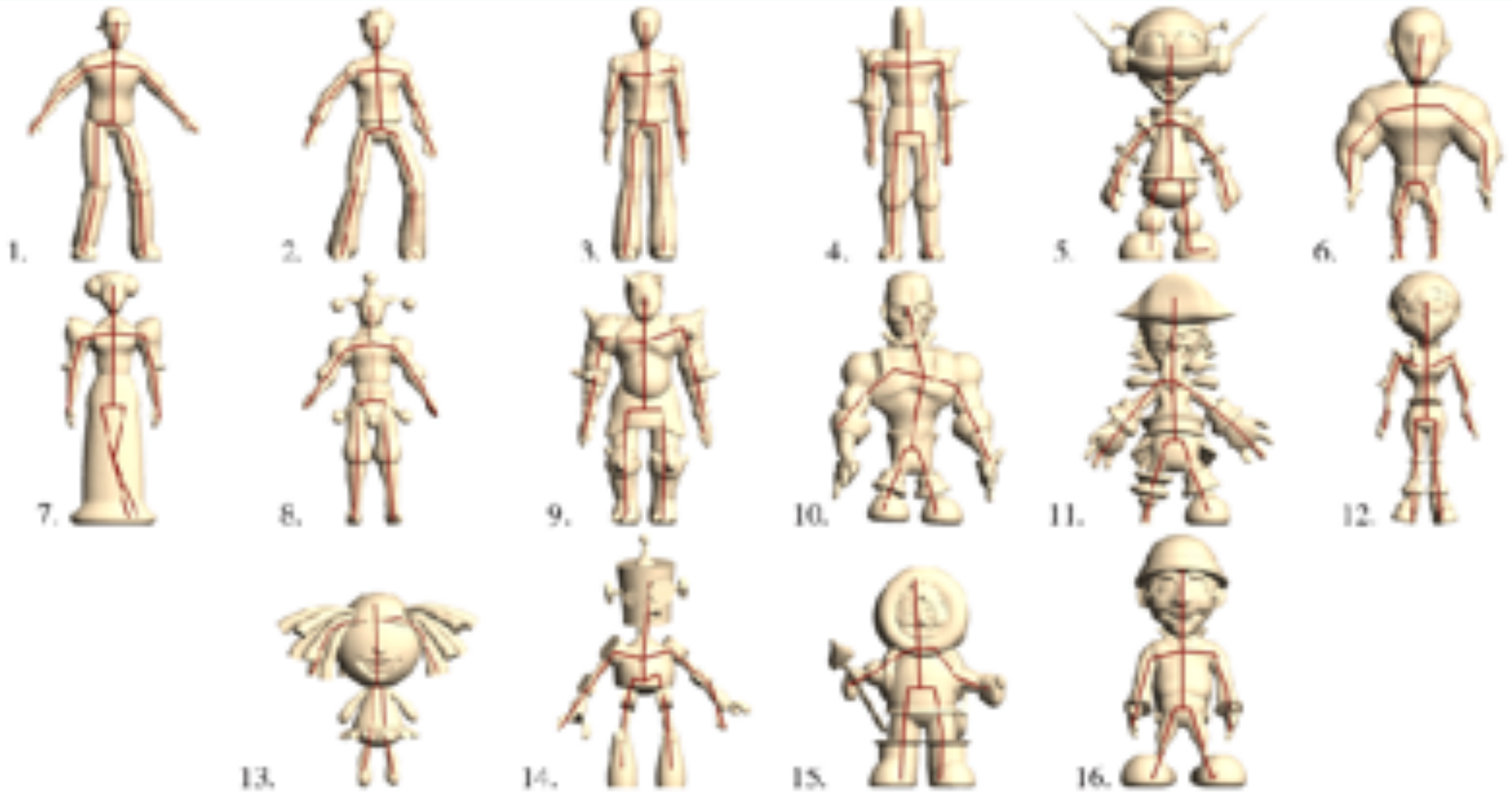
Paper 8 – Automatic rigging and skinning: Bone Heat Weighting





- [Automatic Rigging and Animation of 3D Characters](#)
  Ilya Baran and Jovan Popovic, SIGGRAPH 2007.

Examples



Pinocchio

Automatic Rigging and Animation of 3D Characters

SIGGRAPH 2007

papers_0030