

COMPUTER ANIMATION

WHAT IS MOTION?



Eadweard Muybridge - The Horse in Motion (1878)

TIME IN COMPUTER GRAPHICS

3D DIMENSIONAL GRAPHICS = GEOMETRY

4TH DIMENSION = TIME

OBJECT ATTRIBUTES CHANGE OVER TIME

RESULT = MOVIE



MOVIE

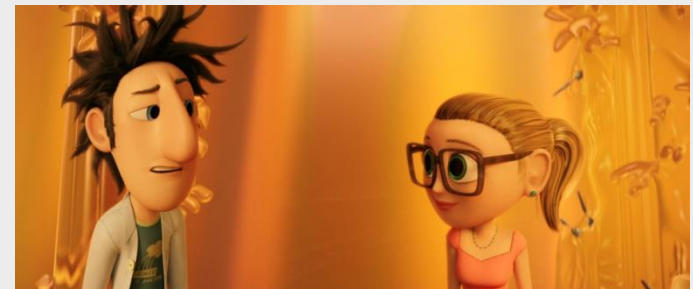
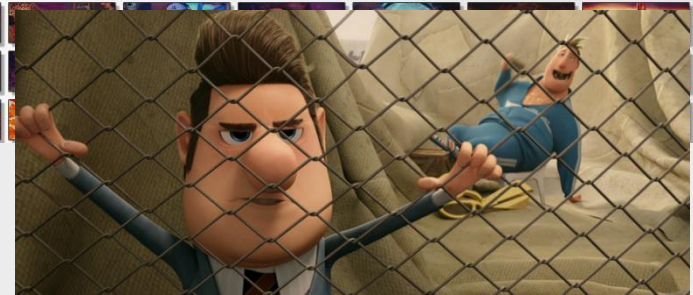
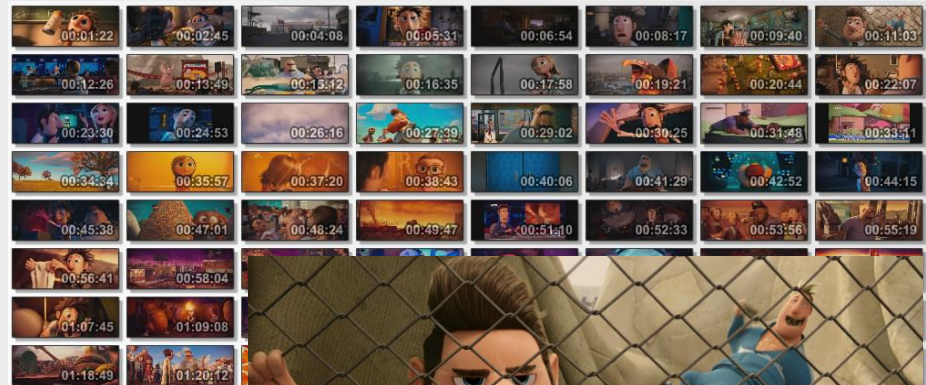
SEQUENCE OF FRAMES

FRAME RATE

~ 25FPS AND MORE
IS FLUENT

~ 10^5 FRAMES / MOVIE

E.G. 129 311 FRAMES →



FRAME RATES

FRAME RATE FOR MOVIES/TV

24 (Cinema, Blu Ray)

23.976, 29.97 (NTSC)

25 (PAL)

FRAME RATE FOR REAL TIME CG

30+

60hz = monitor frequency



COMPUTER ANIMATION

REAL-TIME

Speed is priority
Quality is second



OFFLINE

Quality is priority
Speed is second



WHAT CAN BE ANIMATED?

POSITION

ROTATION

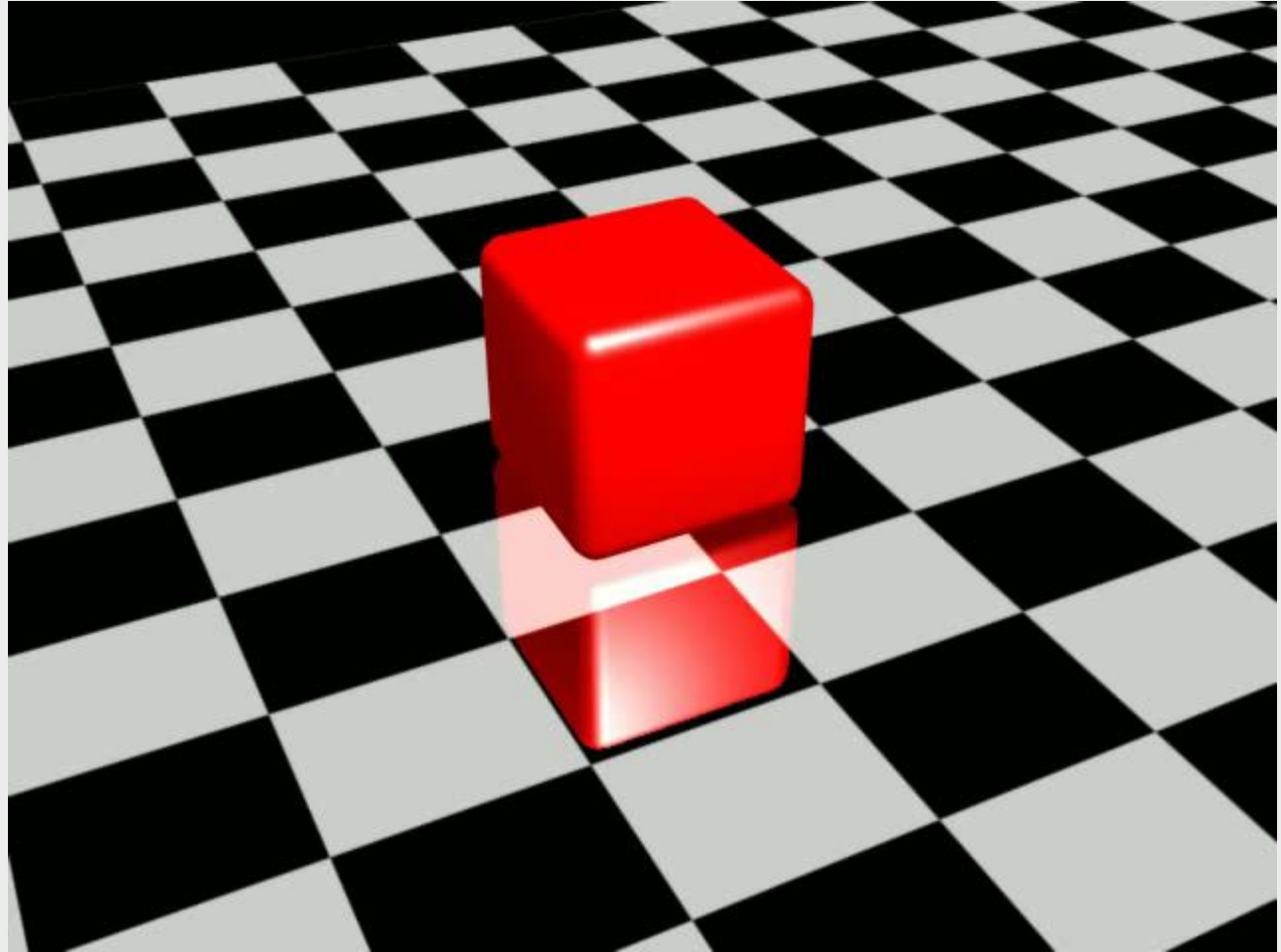
SCALE

GEOMETRY

TEXTURE

COLOR

TRANSPAR.



... ANY NUMERIC PARAMETER

HOW TO CREATE ANIMATION

CHANGE VALUES OVER TIME MANUALLY

Values are set for each individual frame

PROCEDURALLY

Values are computed by algorithm

KEYFRAMING

Important frames are manual, rest is interpolated

MOTION CAPTURE

Real world motion is scanned to computer

MANUAL ANIMATION

STOP-MOTION ANIMATION

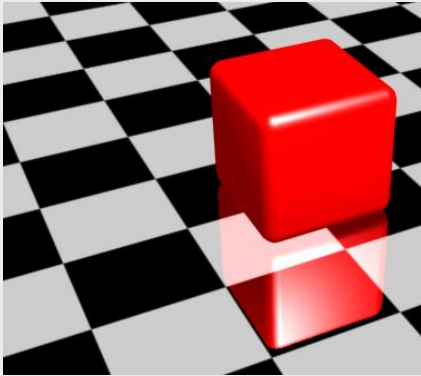
e.g. Coraline, Wallace & Gromit, etc.



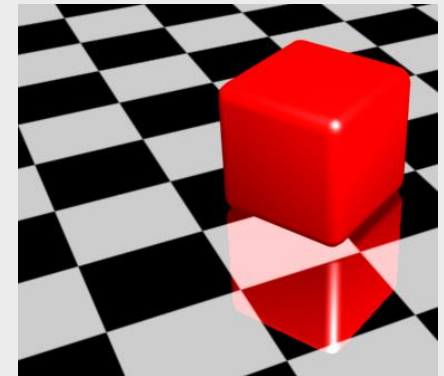
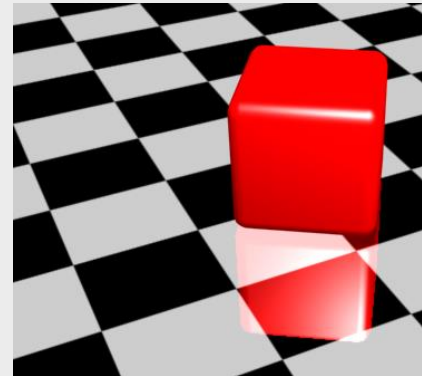
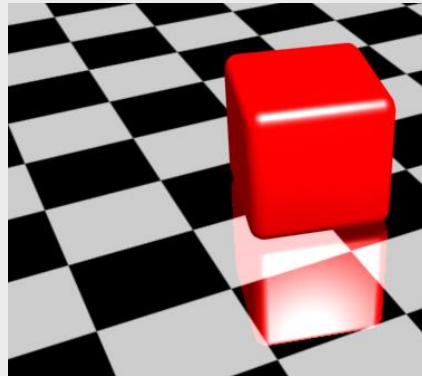
KEY-FRAME ANIMATION

ANIMATION KEY FRAMES

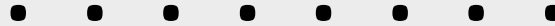
MANUAL SETTING OF PARAMETERS NOT FOR ALL FRAMES BUT ONLY FOR SOME PARTICULAR



Rotation = 0°

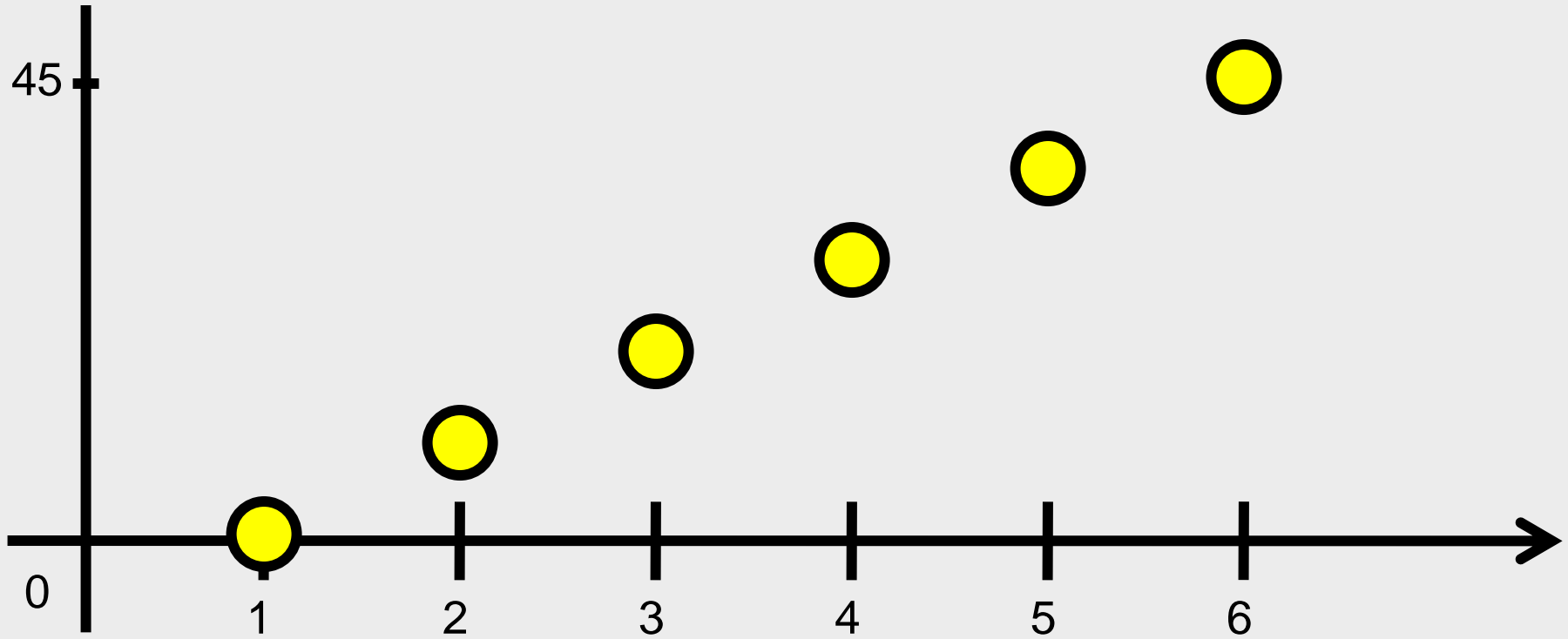


Rotation = 45°



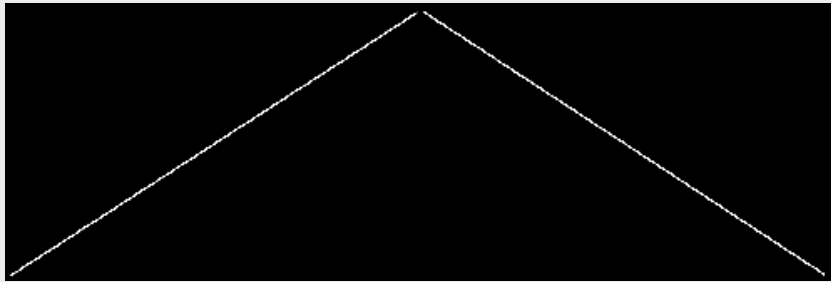
INBETWEENING (“TWEENING”)

COMPUTING MISSING VALUES BASED ON EXISTING SURROUNDING VALUES

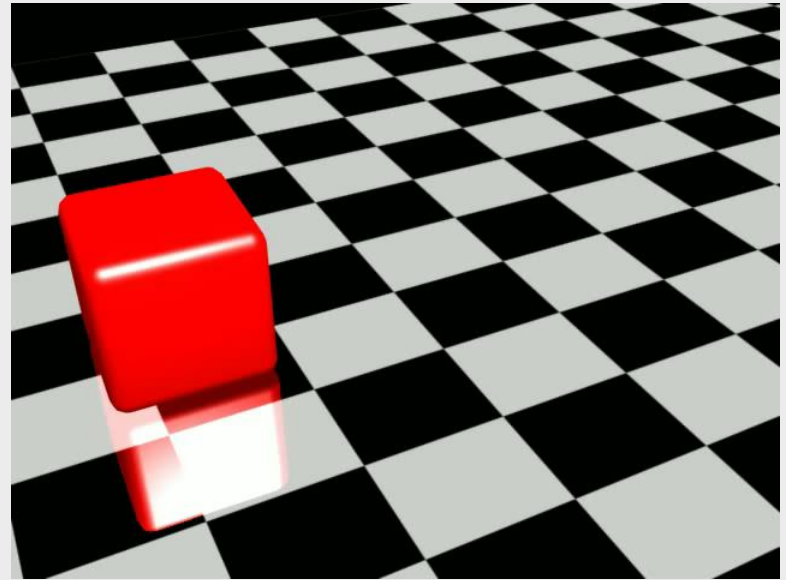
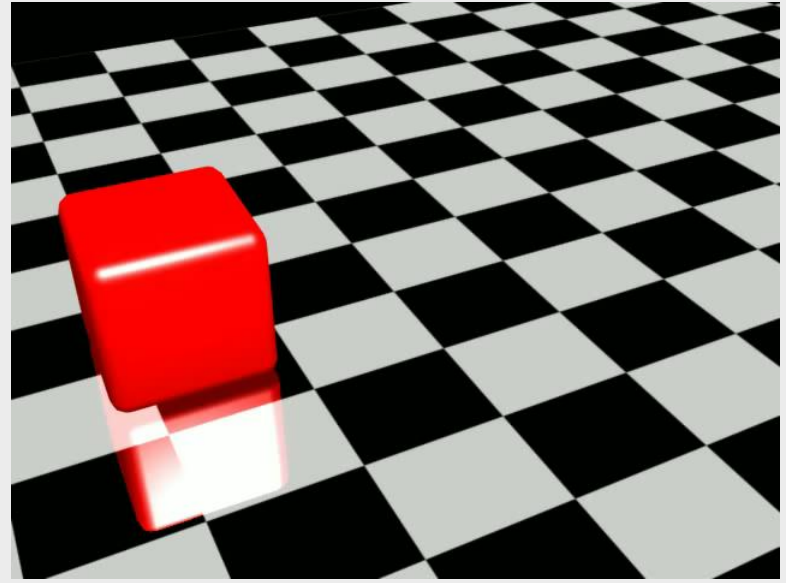
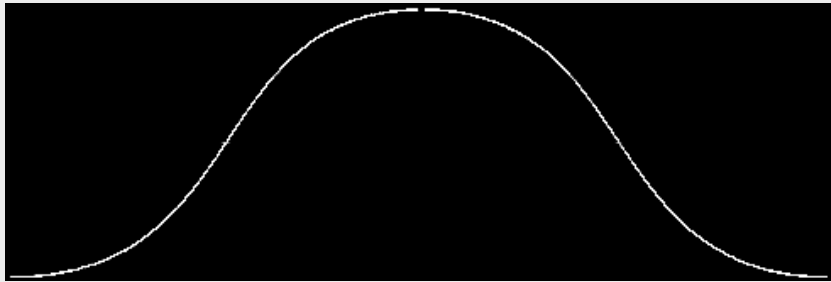


TWEENING

LINEAR (CONSTANT)



EASE-IN, EASE-OUT



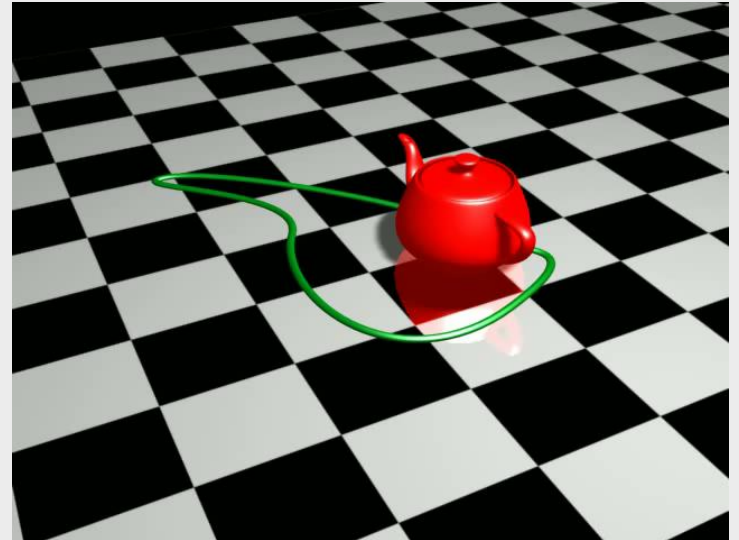
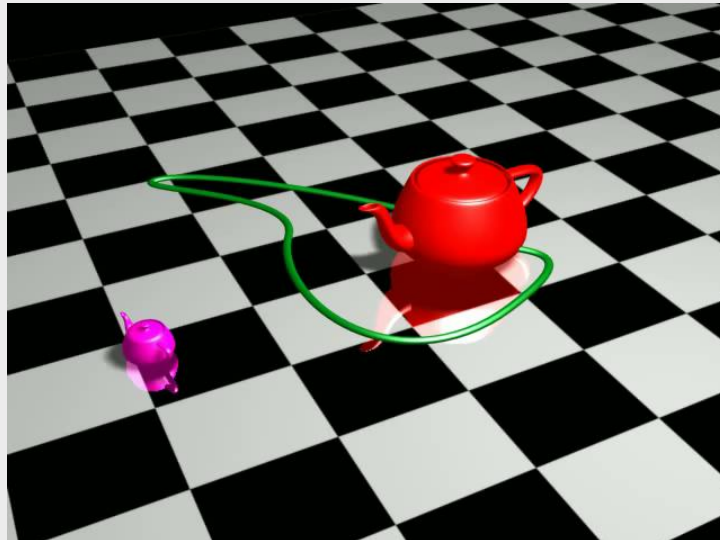
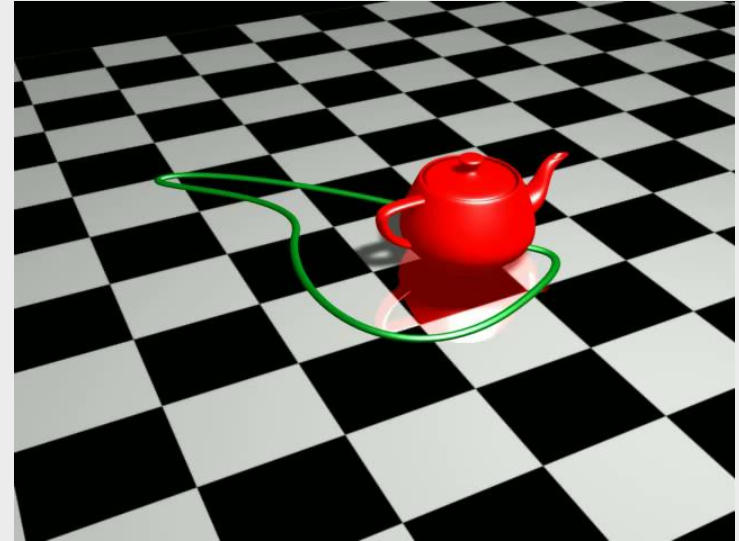
SIMPLE CONTROLLERS

POSITION

Follow path

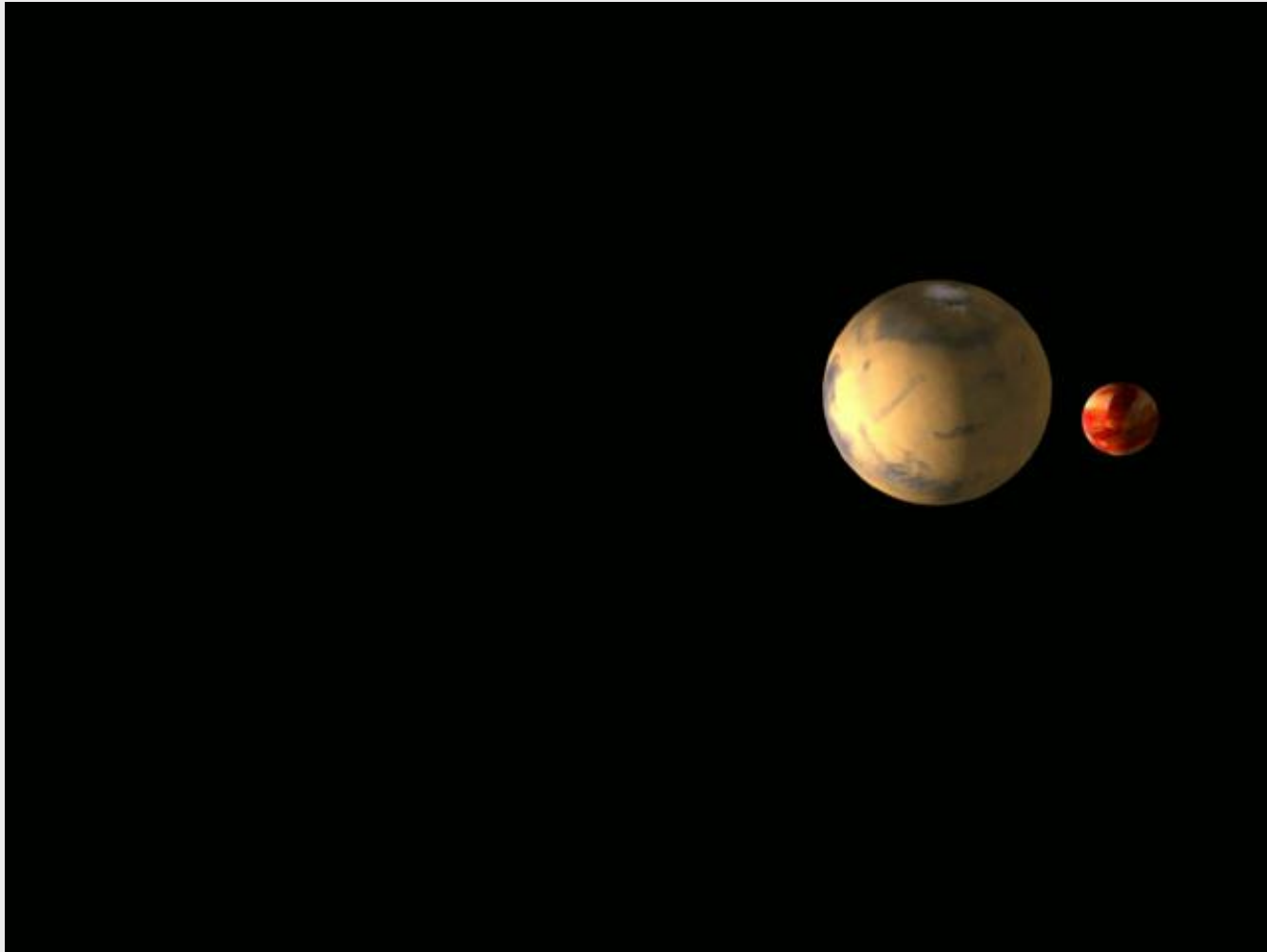
ROTATION

Follow path, Look at



ANIMATING COMPLEX OBJECTS

LOCAL COORDINATES - SIMPLE SYSTEM



ANIMATING COMPLEX OBJECTS

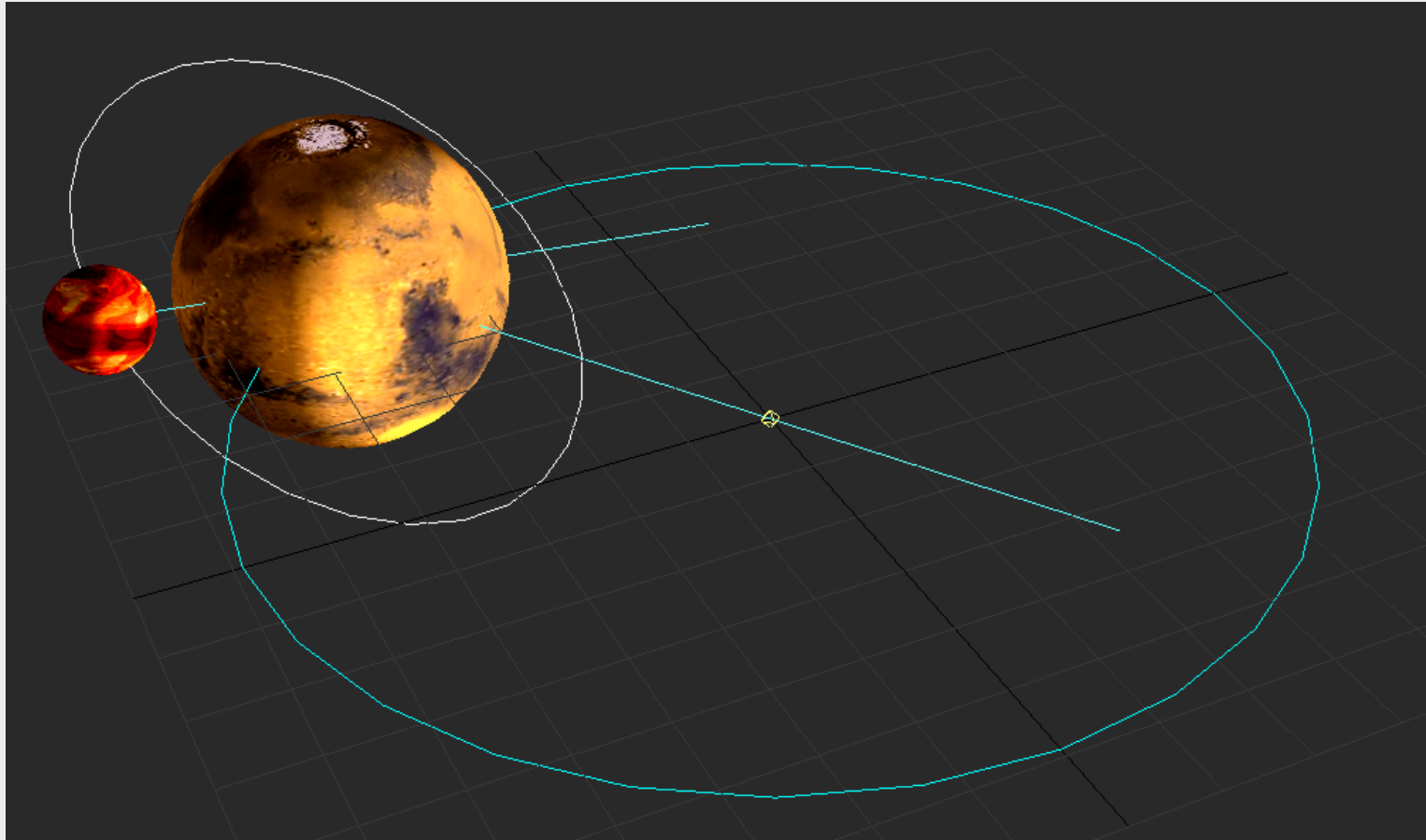
LOCAL COORDINATES - SIMPLE SYSTEM



ANIMATING COMPLEX OBJECTS

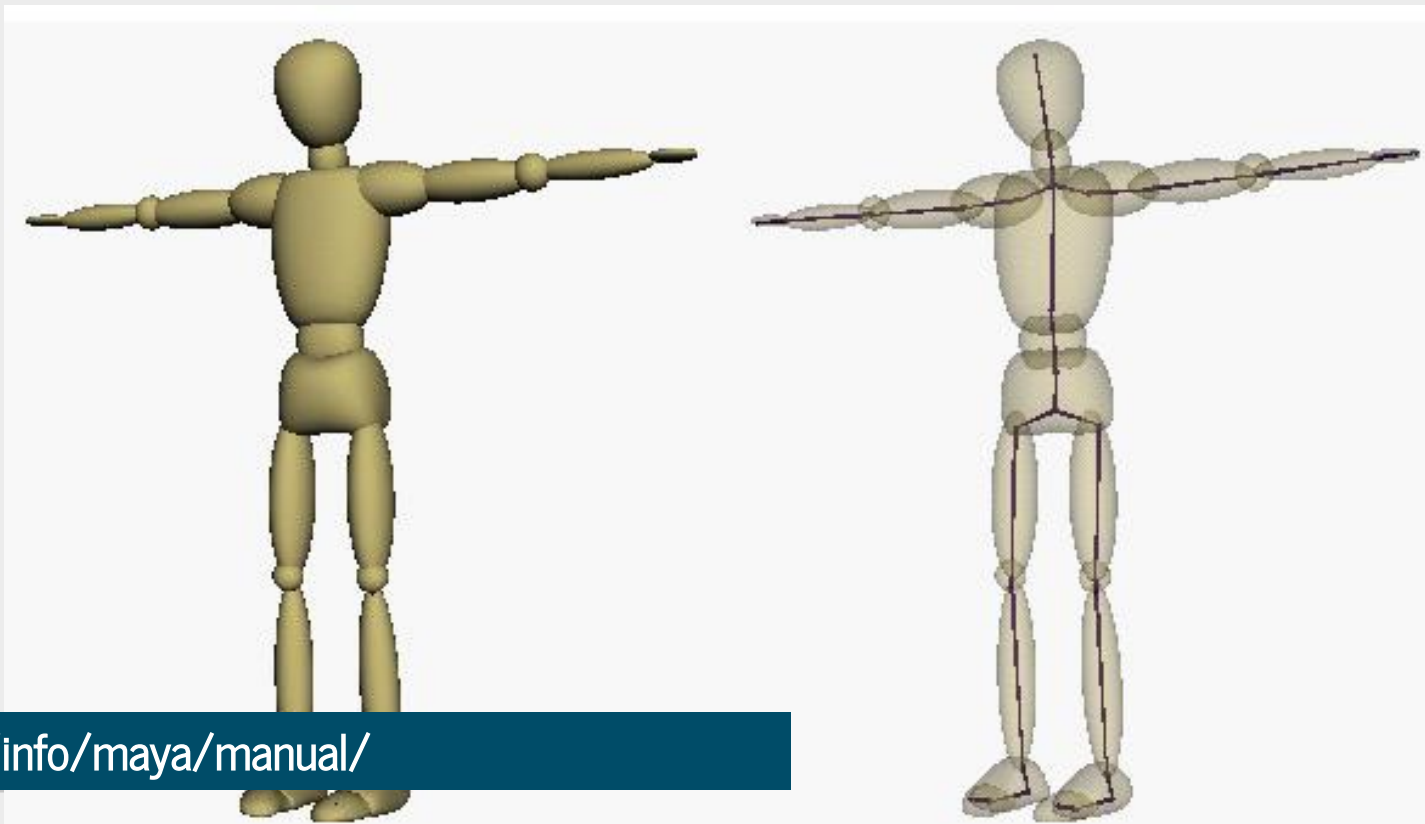
SKELETONS, CHAINS, SYSTEMS

Simulate physical constraints



ANIMATING COMPLEX MODELS

SYSTEM DECOMPOSED INTO HIERARCHY
NODES, LINKS, CHAINS, JOINTS, SKELETON
MOTION CONSTRAINTS



SKELETON

HIERARCHY

Bones

- Rigid element

Joints

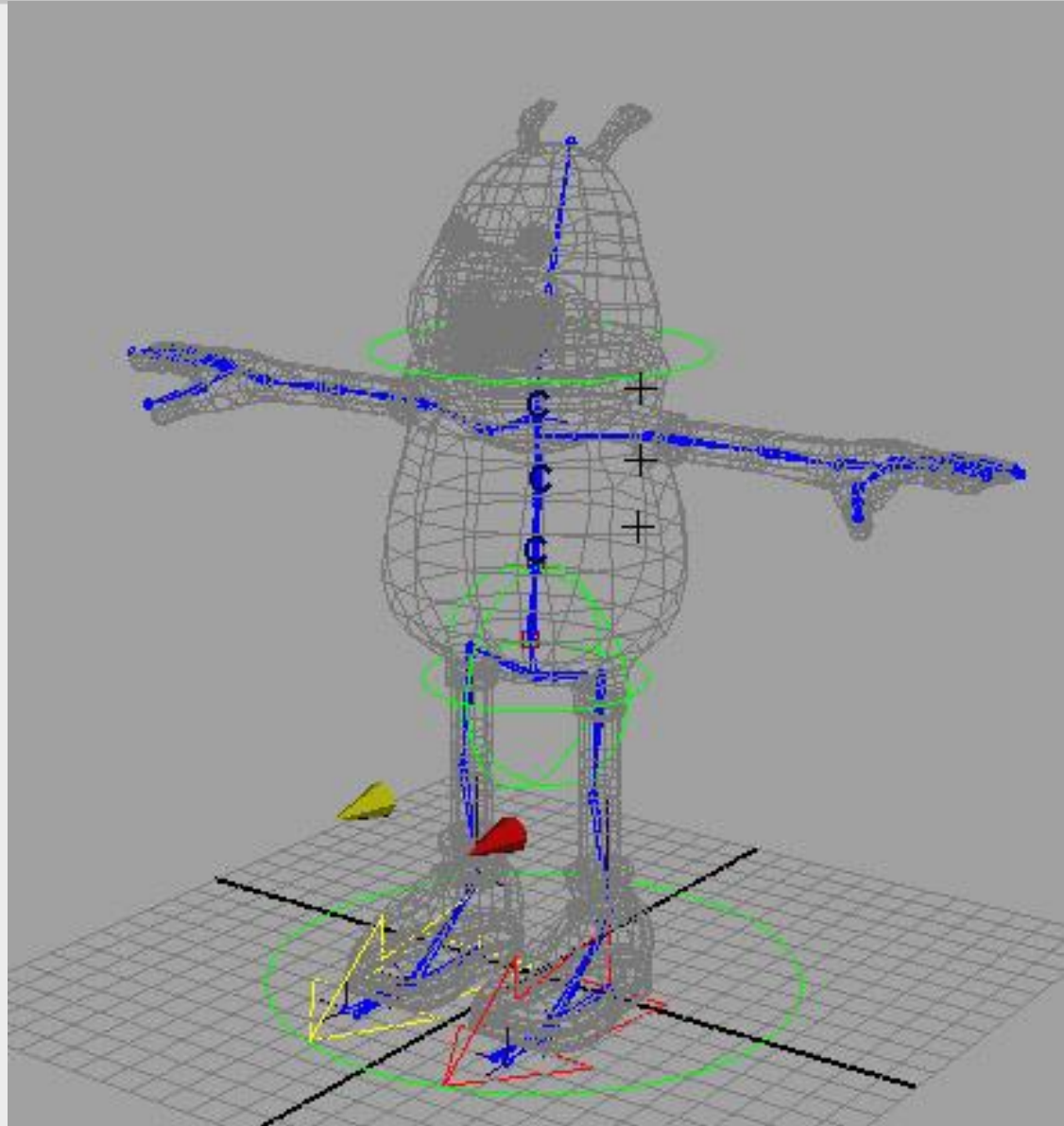
- Rotation
- Sliding

Springs

- Change length

CONTROLLERS

IT'S REUSABLE!



REUSABLE ANIMATION

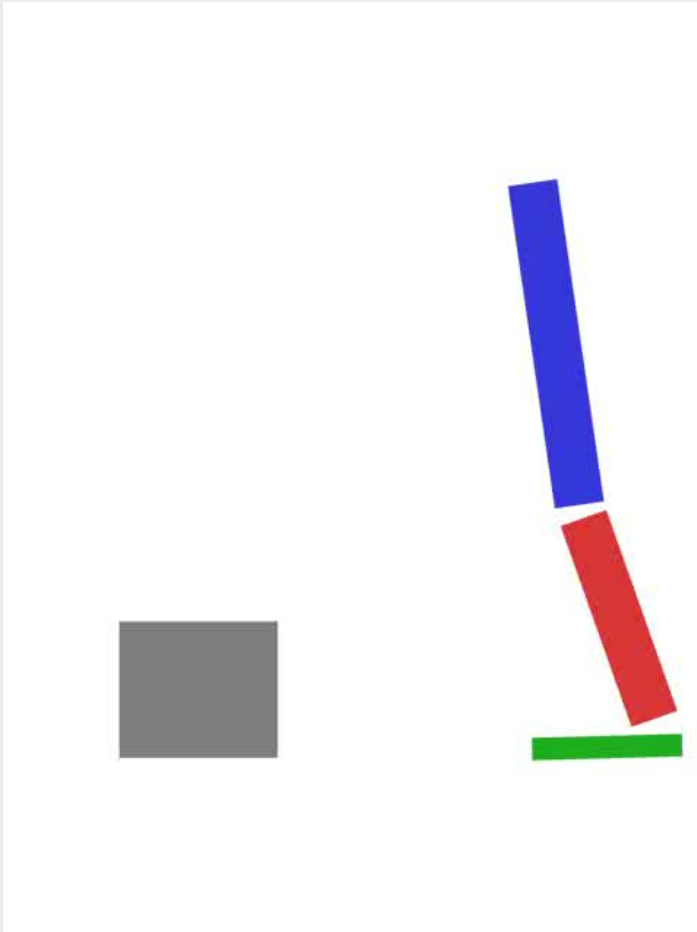
ONE SKELETON - DIFFERENT MODELS



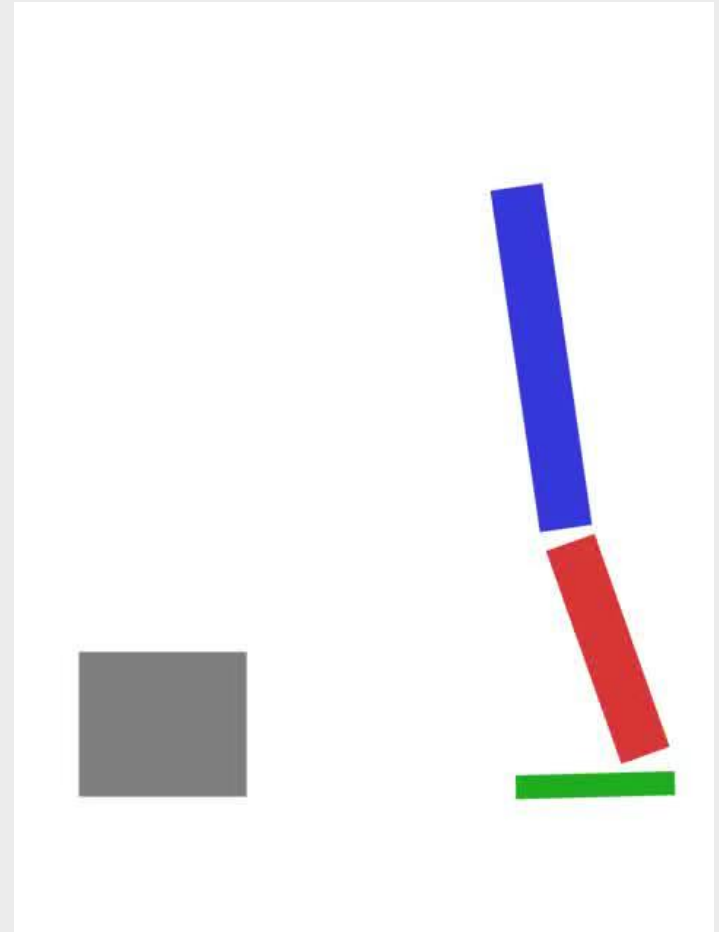
<http://www.studiopendulum.com/alterego/>

TWO TYPES OF KINEMATICS

FORWARD

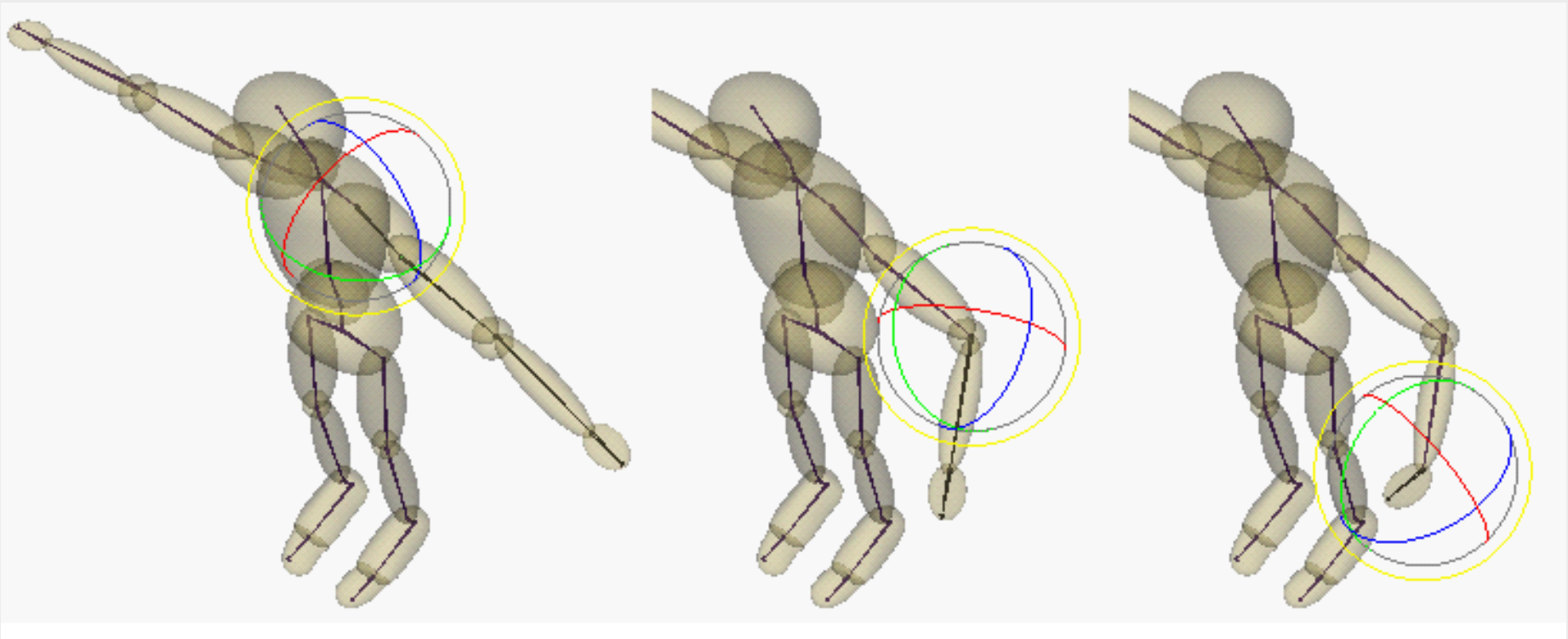


INVERSE



FORWARD KINEMATICS

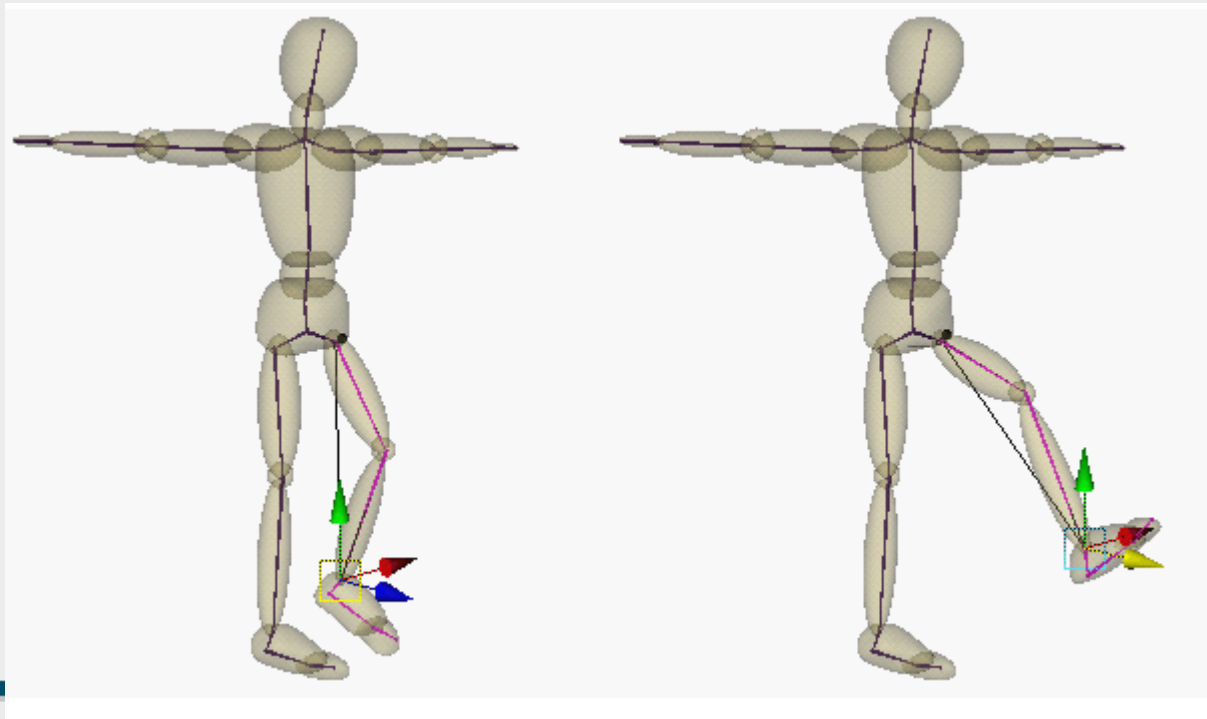
MOTION IS INITIATED ON TOP OF THE HIERARCHY AND PROPAGATES DOWNWARDS IN THE HIERARCHY



INVERSE KINEMATICS

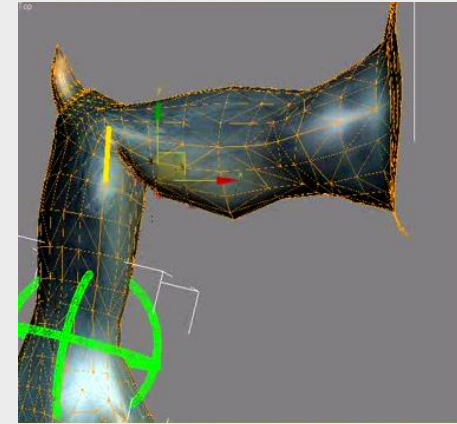
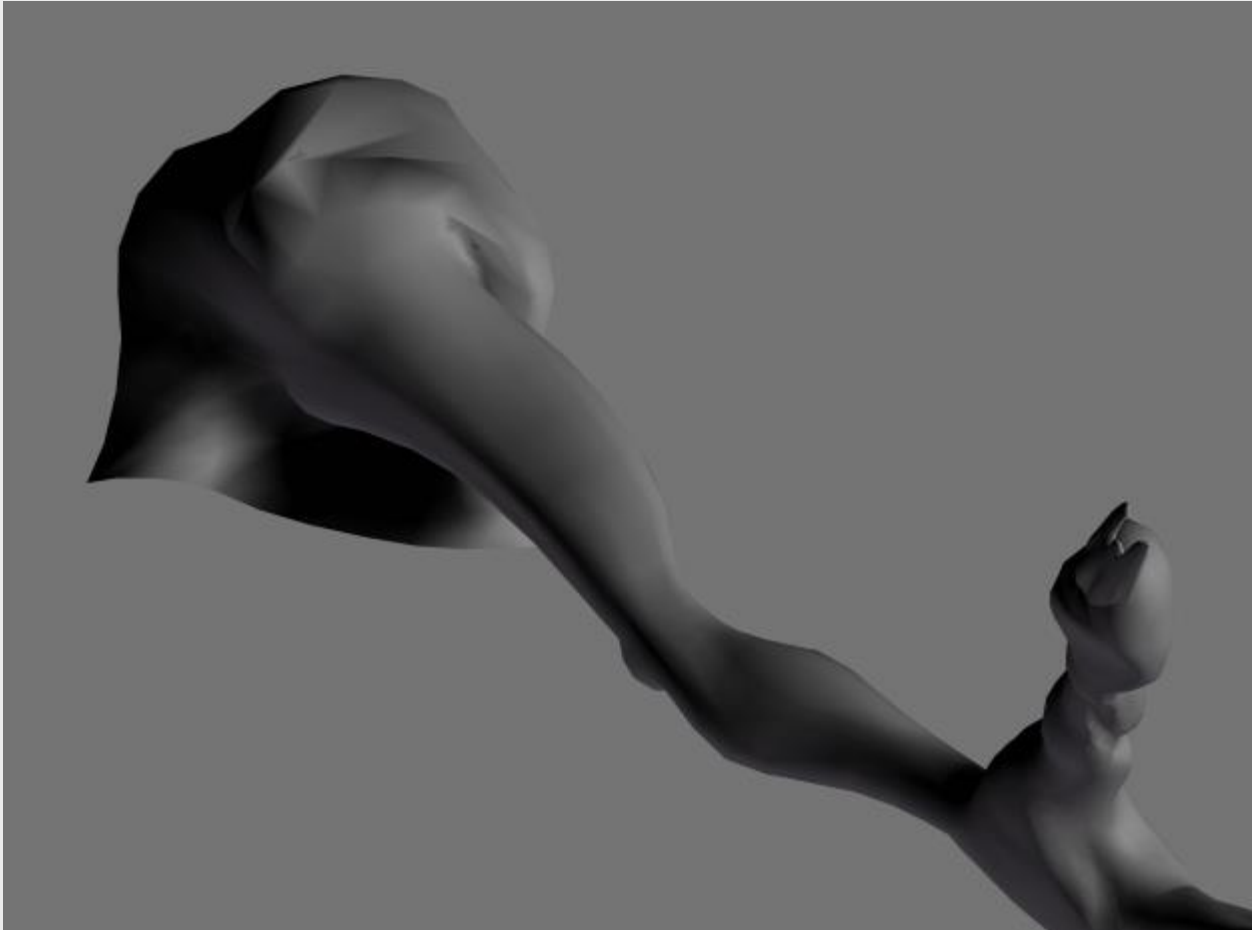
MOTION IS INITIATED ON THE BOTTOM OF THE HIERARCHY AND PROPAGATES UPWARDS

MOTION CONSTRAINTS NEED TO BE SET



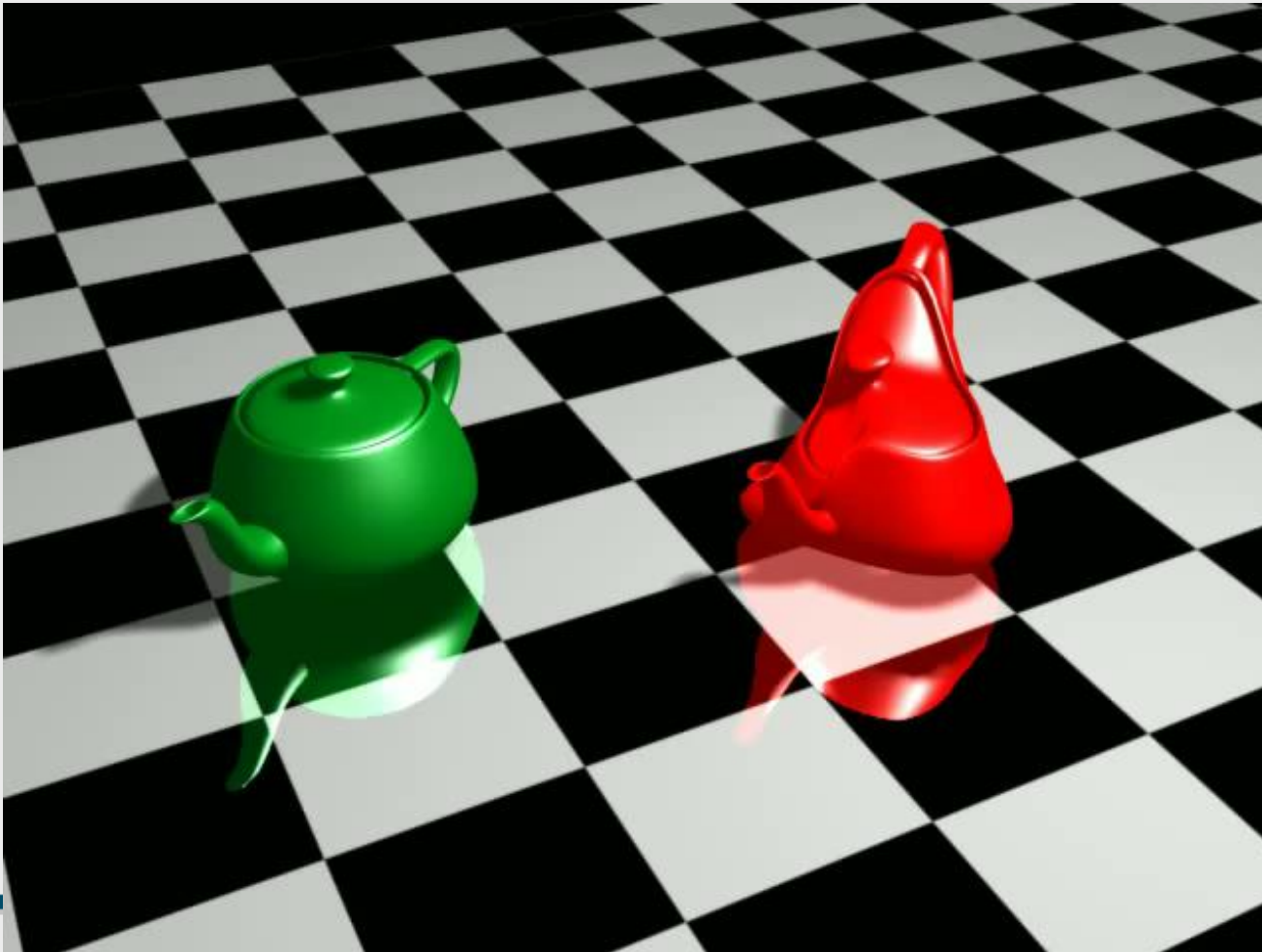
SKINNING

SKELETON + DEFORMABLE GEOMETRY



MORPHING

TWEENING BETWEEN DEFORMATIONS OF THE SAME MODEL



FACIAL ANIMATION

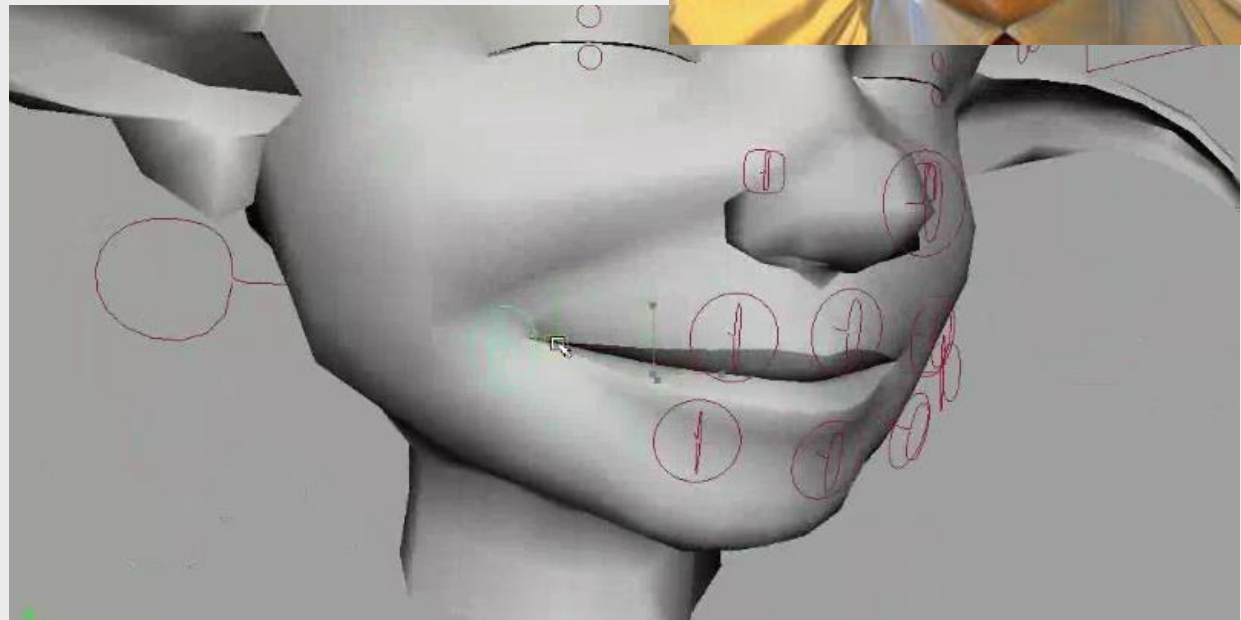
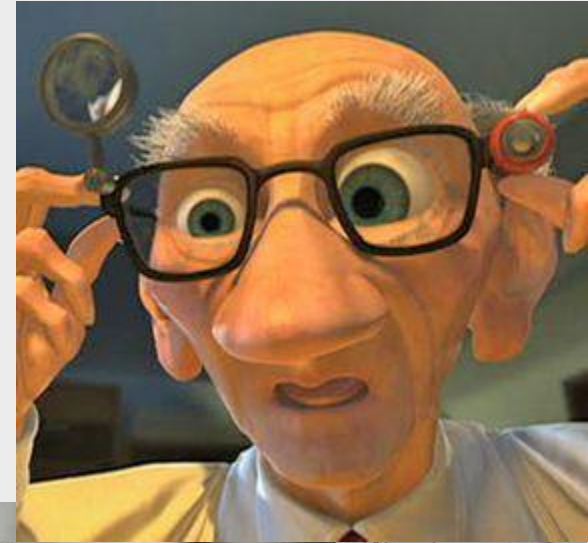
FACIAL EXPRESSIONS

LIPS TO SPEECH
SYNCHRONIZATION

CONTROLLERS

SKINNING

MORPHING



ANIMATION BLENDING

SEPARATE ACTIVITIES
DONE SIMULTANEOUSLY

e.g. walking and
shooting

SMOOTH TRANSITIONS
BETWEEN ACTIVITIES

e.g. standing up
and walking



PROCEDURAL AND PHYSICALLY-BASED ANIMATIONS

MOTIVATION

CAN WE MANUALLY (BY KEYFRAMES) ANIMATE THE MOVEMENT OF WATER, HAIR, SMOKE?



PHYSICALLY BASED ANIMATION

LAWS OF PHYSICS

→ ALGORITHMS

Gravity, wind, friction, collisions

RIGID BODIES

No geometry deformation

Collision response

SOFT BODIES

Allow for deformation

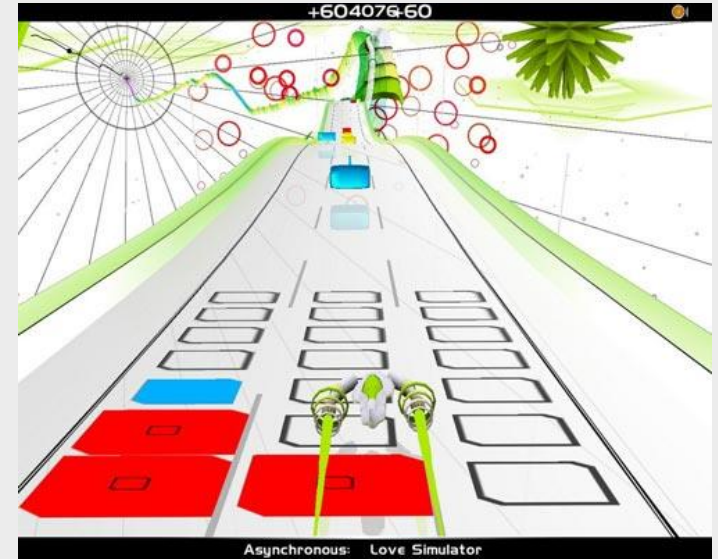
Energy damping



PROCEDURAL ANIMATION

PROGRAMMED RULES
FOR CHANGING
PARAMETERS OF
THE ANIMATED
OBJECTS

e.g. according to
music,
physics,
psychology,
etc.



PROCEDURAL ANIMATION CONSTRUCTION

SET BODY PROPERTIES

Mass, elasticity, friction, ...

SET PHYSICAL RULES

Gravity, collisions, wind, ...

SET INITIAL STATE

Position, velocity, direction, ...

RUN SIMULATION / ANIMATION

PARTICLE SYSTEM

EMITTER

direction, speed, frequency

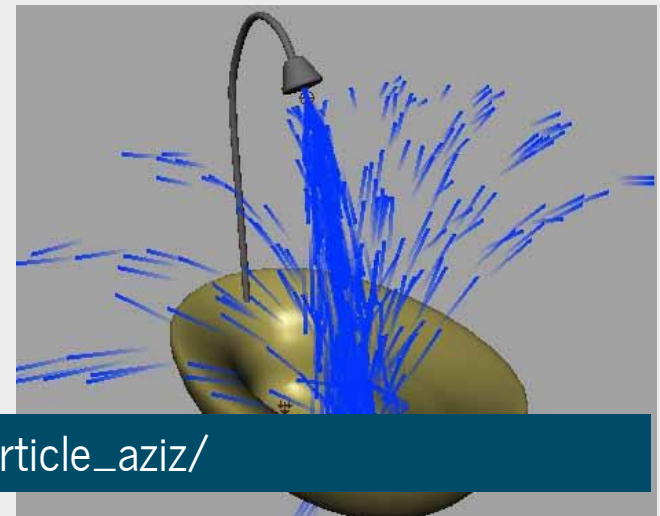
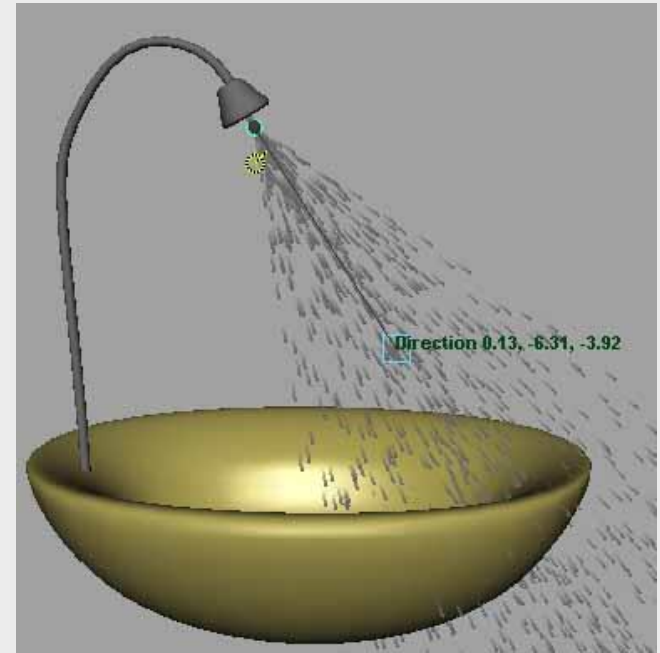
FORCES

gravity, collision, wind

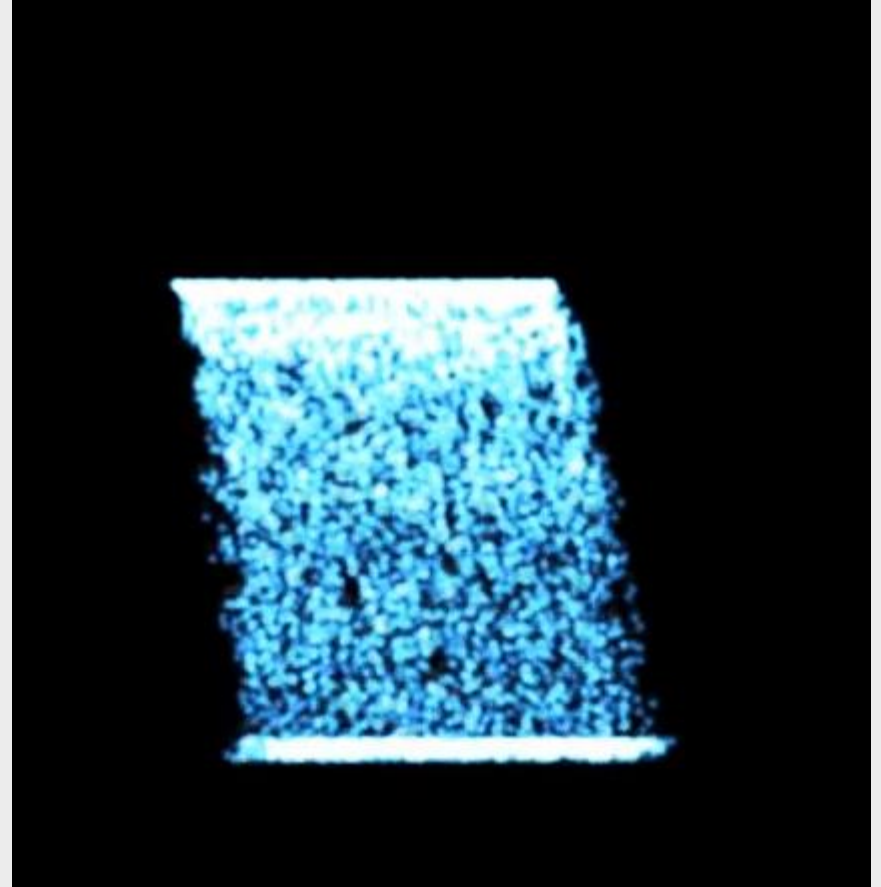
PARTICLE TYPE

simple object (ball, drop)

complex object (model)



PARTICLE SYSTEMS DEMO



<http://www.youtube.com/watch?v=bYttMMXZw38>

PROFESSIONAL EXAMPLES

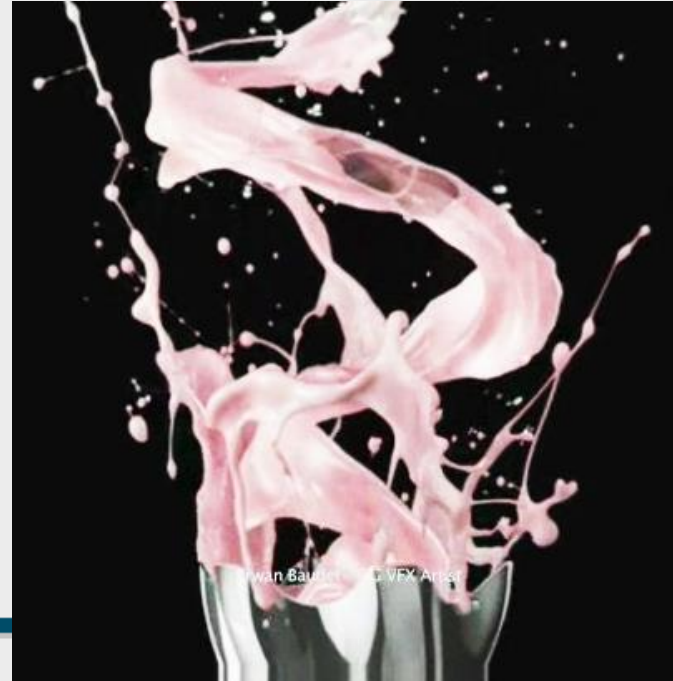
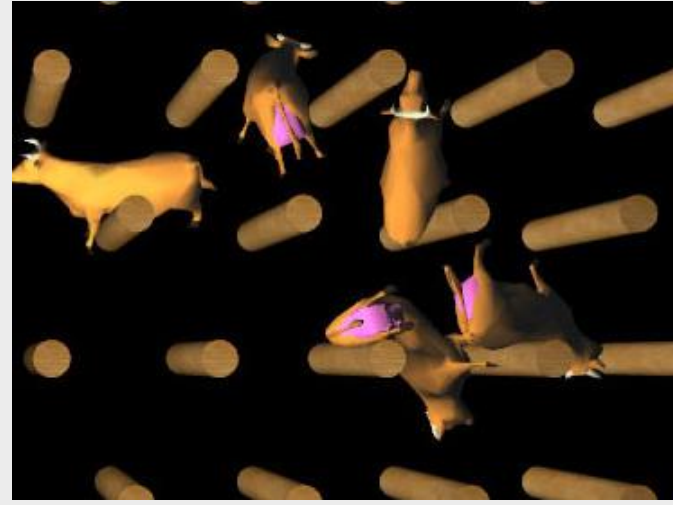
www.realmatter.com

www.realflow.com

www.massivesoftware.com

www.audio-surf.com

www.lagoatechnologies.com



MOTION CAPTURE

REAL WORLD ACTION CAPTURED

MARKERS ON BODY
+ SENSORS

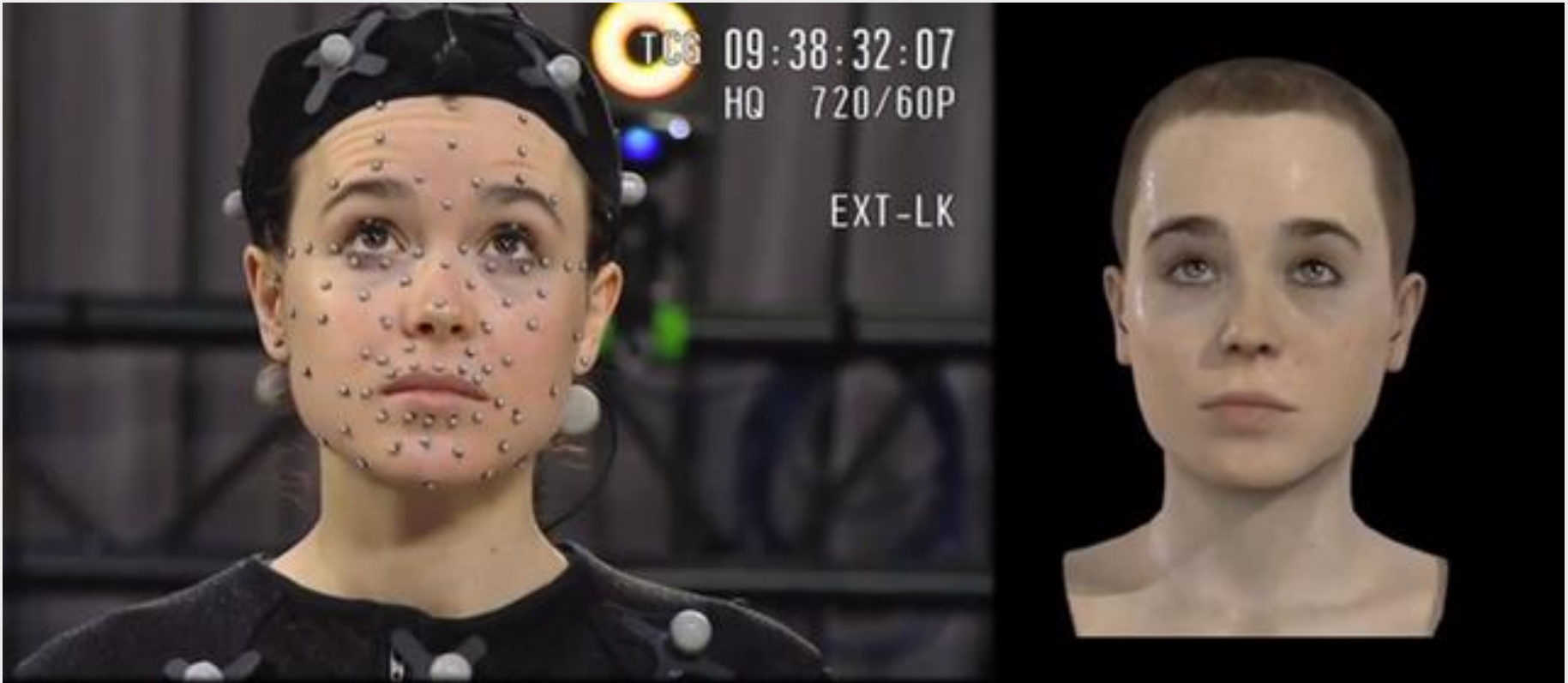
Optical
Magnetic
Kinetic

RECONSTRUCTION
OF SKELETON IN 3D

MOTION MAPPING
TO VIRTUAL CHARACTER



FACIAL MOTION CAPTURE



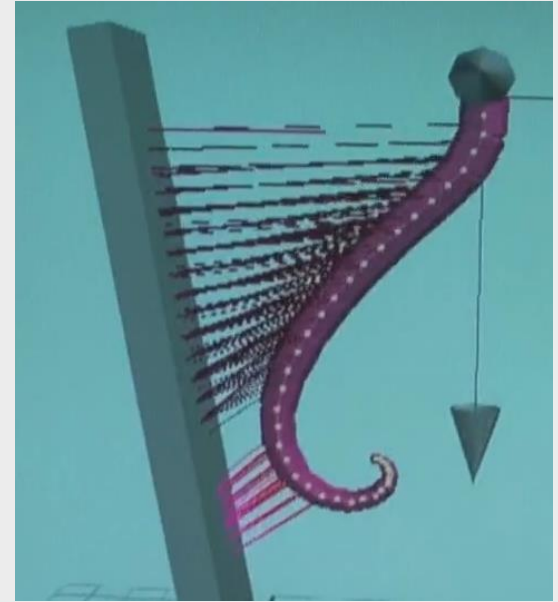
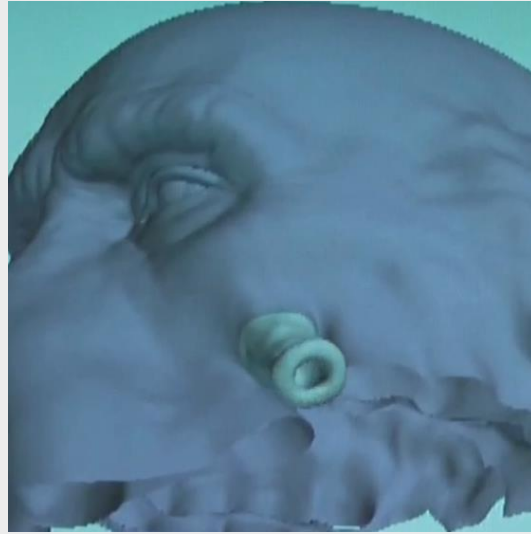
<http://www.pop-gamer.com/2012/07/making-beyond-two-souls-with-performance-capture/>

EVERYTHING TOGETHER

KEY-FRAMED
ANIMATION

PROCEDURAL
ANIMATION

MOTION
CAPTURE



WHAT DO WE DO
WHEN SPEED
IS THE PRIORITY?

REAL-TIME RENDERING

SPRITES (BILLBOARDS)

OBJECTS FAKED
BY A PICTURE

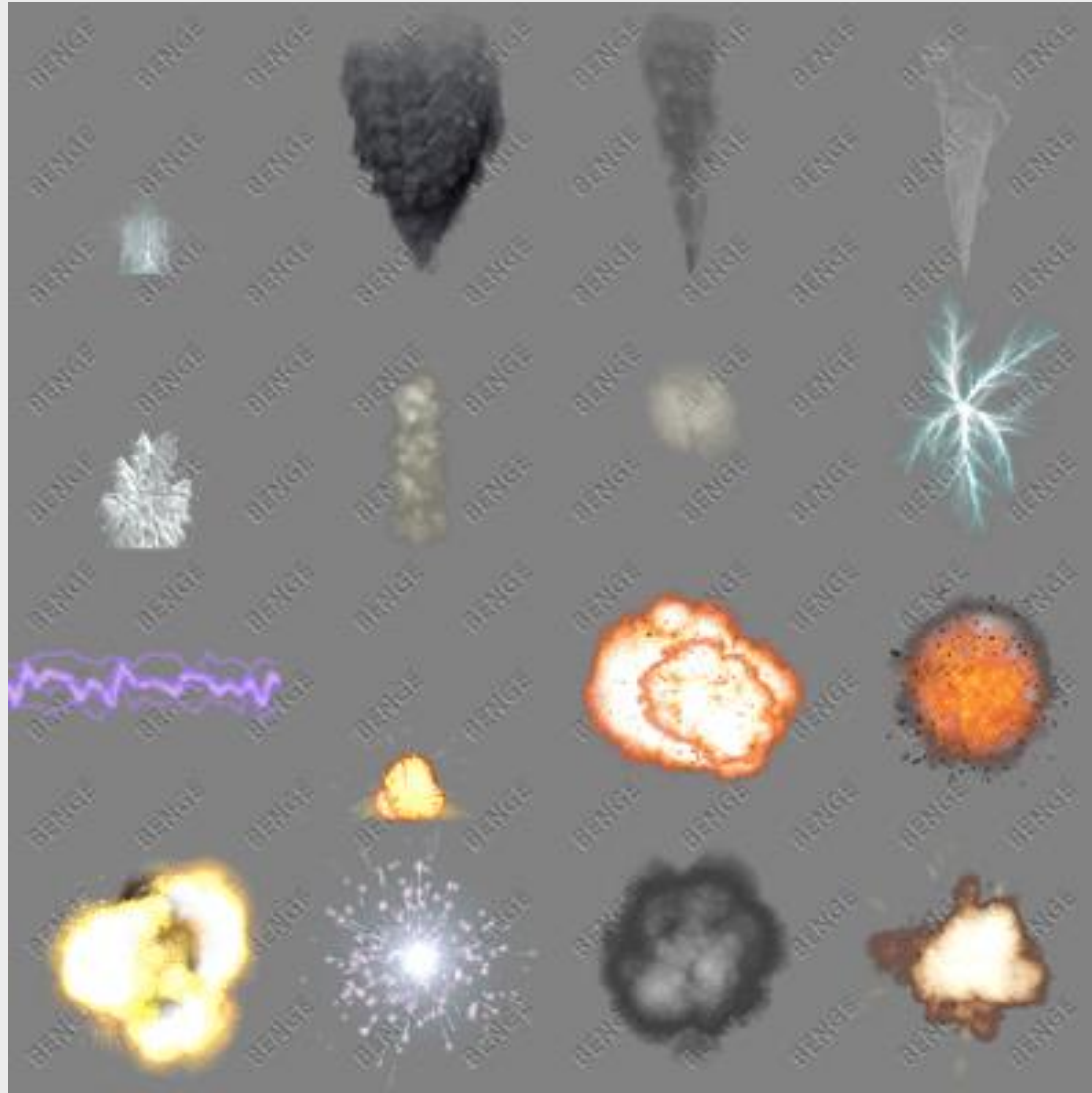
TREES, GRASS

FIRE, SMOKE

LIGHT EFFECTS

DISTANT OBJECTS

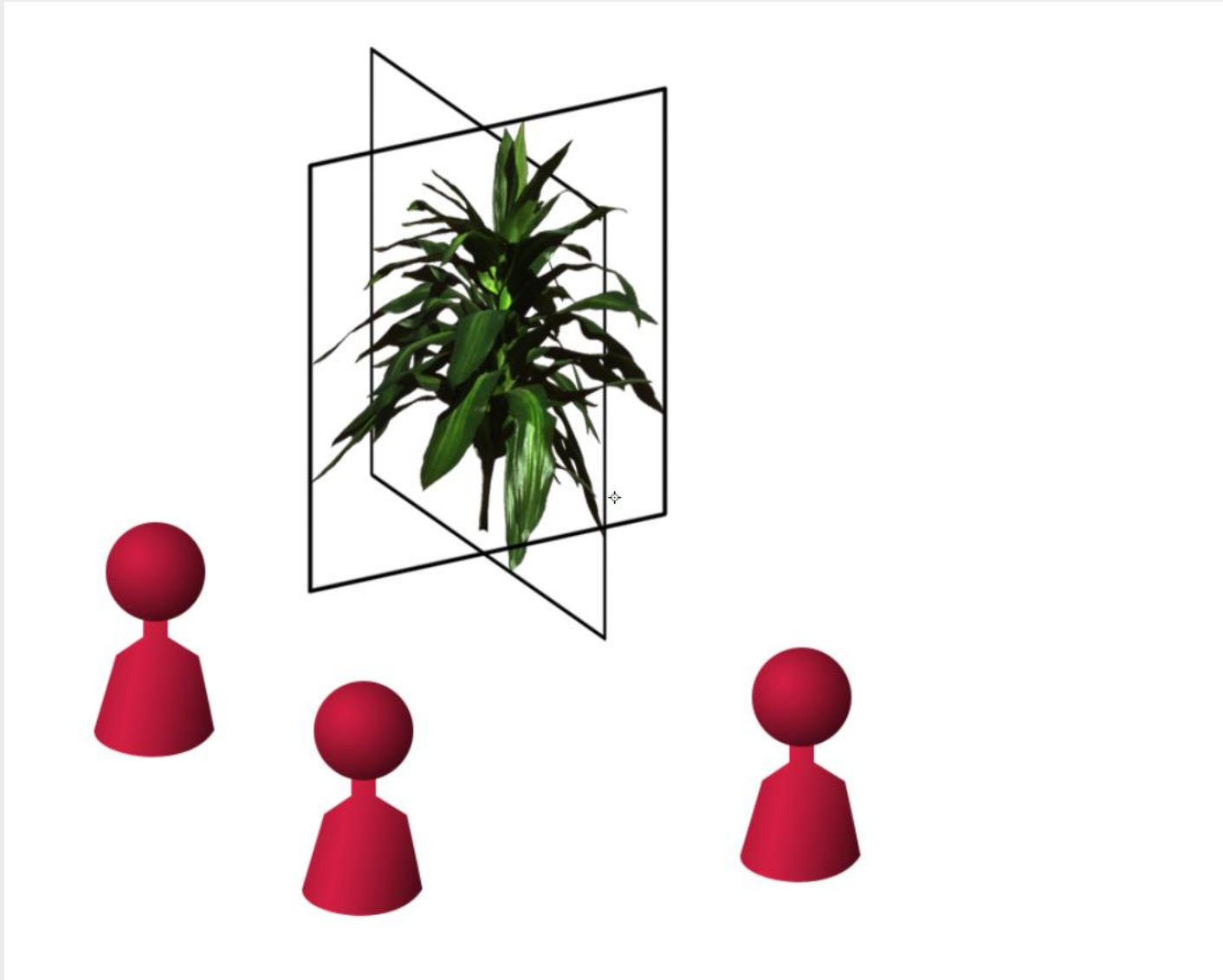
CAN BE ANIMATED



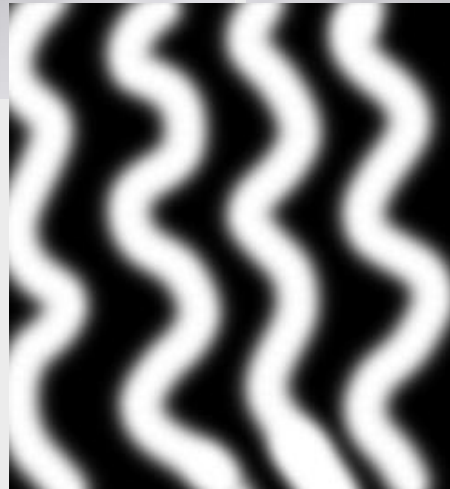
BILLBOARD TREE



MULTIPLE SPRITES



FAKING GEOMETRY – BUMP MAPPING



FAKING GEOMETRY – NORMAL MAPPING



30,000 polys

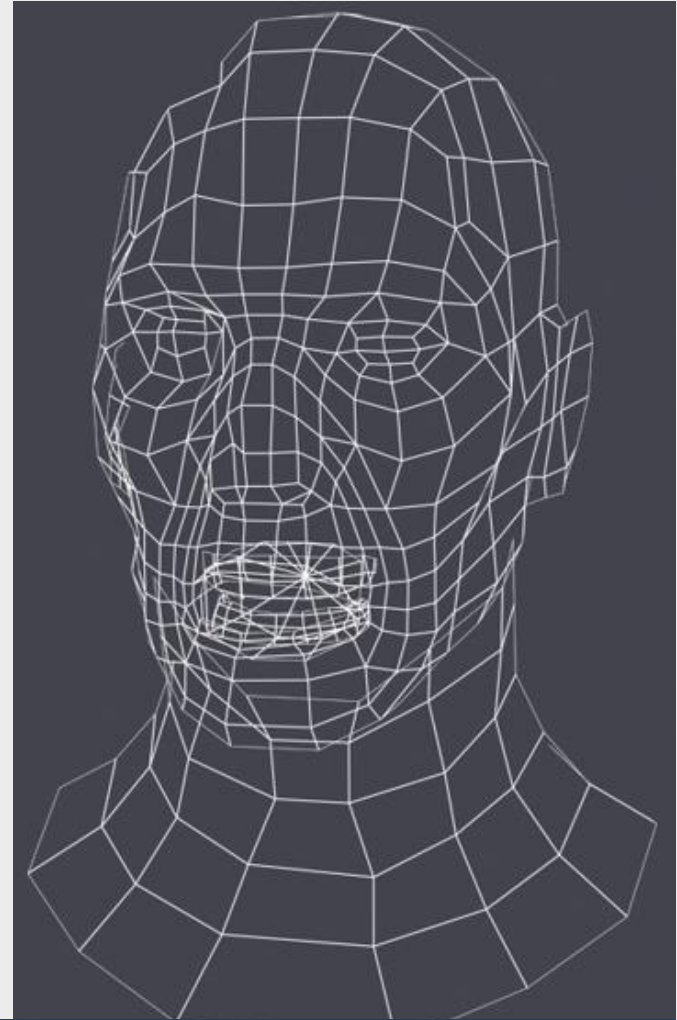
632 polys

632 polys + normal map



NORMAL MAPPING EXAMPLE

531
POLYGONS
+
NORMAL
MAP



www.tomas-studio.com

ADVANCED EFFECTS

PARALLAX OCCLUSION MAPPING

TESSELLATION

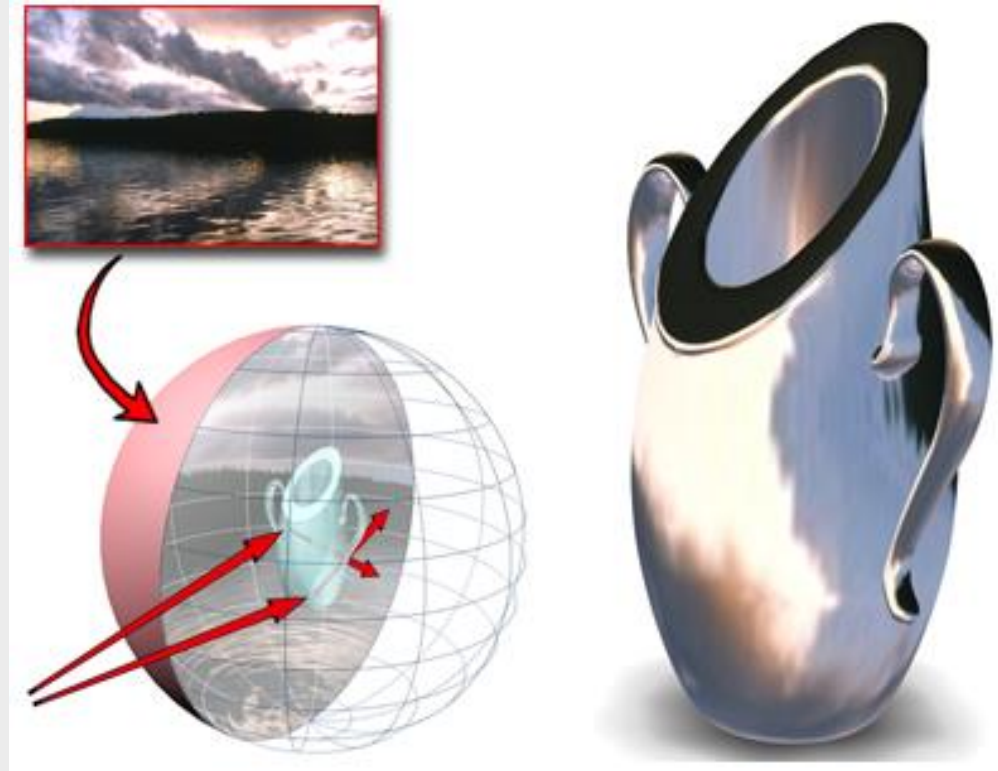


PRE-COMPUTED REFLECTIONS

ENVIRONMENT MAPPING

APPROXIMATES
REFLECTIONS

TEXTURE APPLIED
TO A SURROUNDING
SPHERE TO
SIMULATE WORLD
REFLECTIONS



PRE-COMPUTED LIGHTING



LIGHT MAPS

PRE-COMPUTED HIGH-QUALITY LIGHTING
STORED INTO SPECIAL TEXTURE (LIGHT MAP).
LIGHT MAP COMBINED WITH THE TEXTURE
TEXTURE BAKING (PERMANENT)

