

Procedural Animation

Computer Graphics Seminar

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Coming up today

- Keyframe animation
- Procedural animation for basic character animation
 - Procedural animation with keyframe animation
 - Inverse kinematics
- Procedural animation as a broader field
 - Artificial life animation
 - Physics based modelling and animation

Basic keyframe animation

- Animator draws or models the starting and ending points of a transition, called keyframes, and sets their position in time
- The remaining frames inbetween 2 keyframes are interpolated from them
- The animator is in control of everything at every point in time



Basic keyframe animation problems

- Transitions in interactive setting
 - Blend walking and running animation?
 - Create a walk \leftrightarrow run transition animation?
 - 15 animations - 105 blends required
- Unrealistic movement
 - No proper feedback from the environment
 - Not acceptable anymore



Procedural Animation

- a type of computer animation, used to automatically generate animation in real-time to allow for a more diverse series of actions than could otherwise be created using predefined animations
- Animator not in control of everything anymore
- a) Integrated with keyframe animation
 - Roughly follows keyframes
 - Change dynamically
 - e.g. getting hit while running, going up the stairs
- b) Fully procedural animation
 - Initial parameters and some sort of input parameters are provided to control the animation
 - Initial position; forces, torques in time

Keyframe + procedural animation

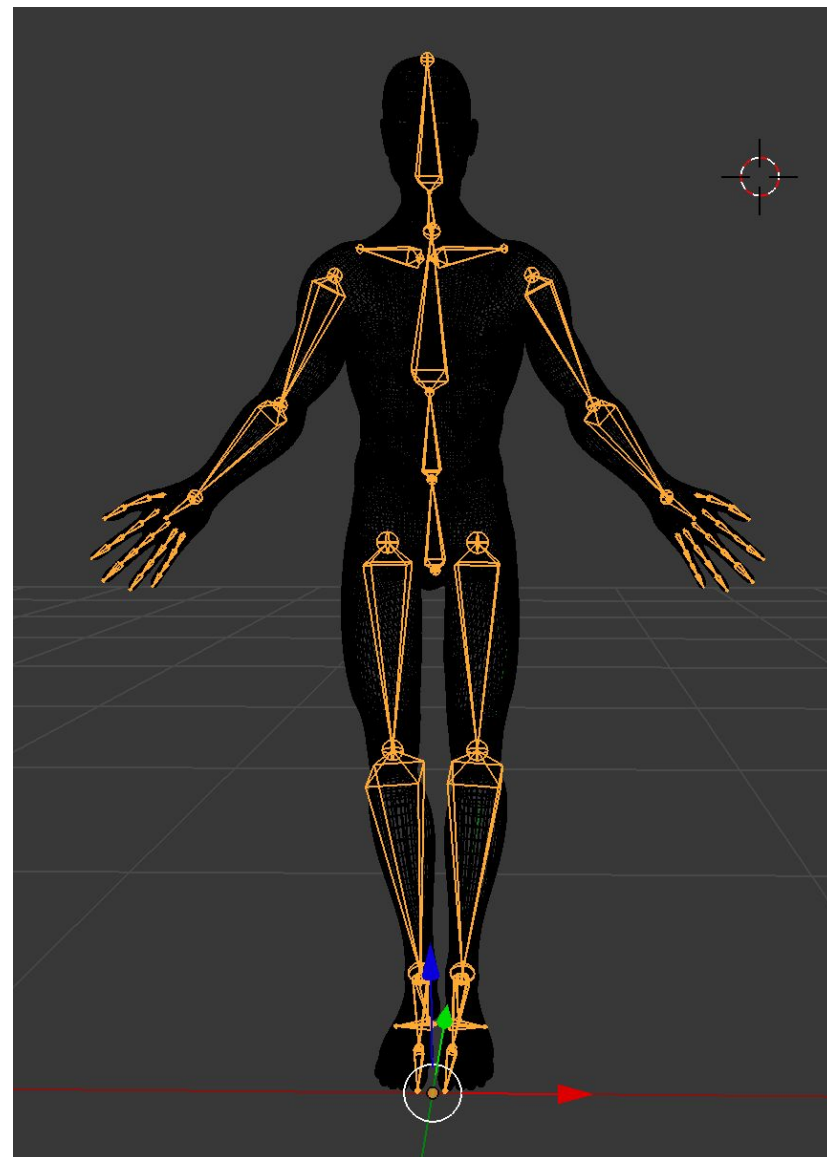
- Dynamic combining of multiple animations
 - Lower body running
 - Upper body swinging a sword
 - Body recoiling to a blow
- What you can achieve with just 14 keyframes and procedural animation:
 - http://www.gamasutra.com/view/news/216973/Video_An_indie_approach_to_procedural_animation.php [4:00-10:00]

To actually feel connected to the world...

- animated objects must physically be connected to it
 - Feet position should depend on the surface
 - Running into a wall
 - Climbing an object
- To do this, a technique called inverse kinematics is used
- First, we must understand what are rigging and kinematic chains

Rigging

- Digital skeleton
 - Parts that do not move relative to themselves
 - Joints connecting the parts
- Has an hierarchy called kinematic chain
 - E.g. abdomen → torso → left shoulder → left upper arm → left lower arm → palm → thumb



Inverse kinematics

- The mathematical process of recovering the movements of an object in the world from some other data
- When a finger is repositioned, what should rest of the body do?
 - Jacobian transpose method
 - Pseudoinverse method
 - Damped least squares method
 - Singular value decomposition method
- <https://www.youtube.com/watch?v=NxoloW0mRtg>

Fields of procedural animation

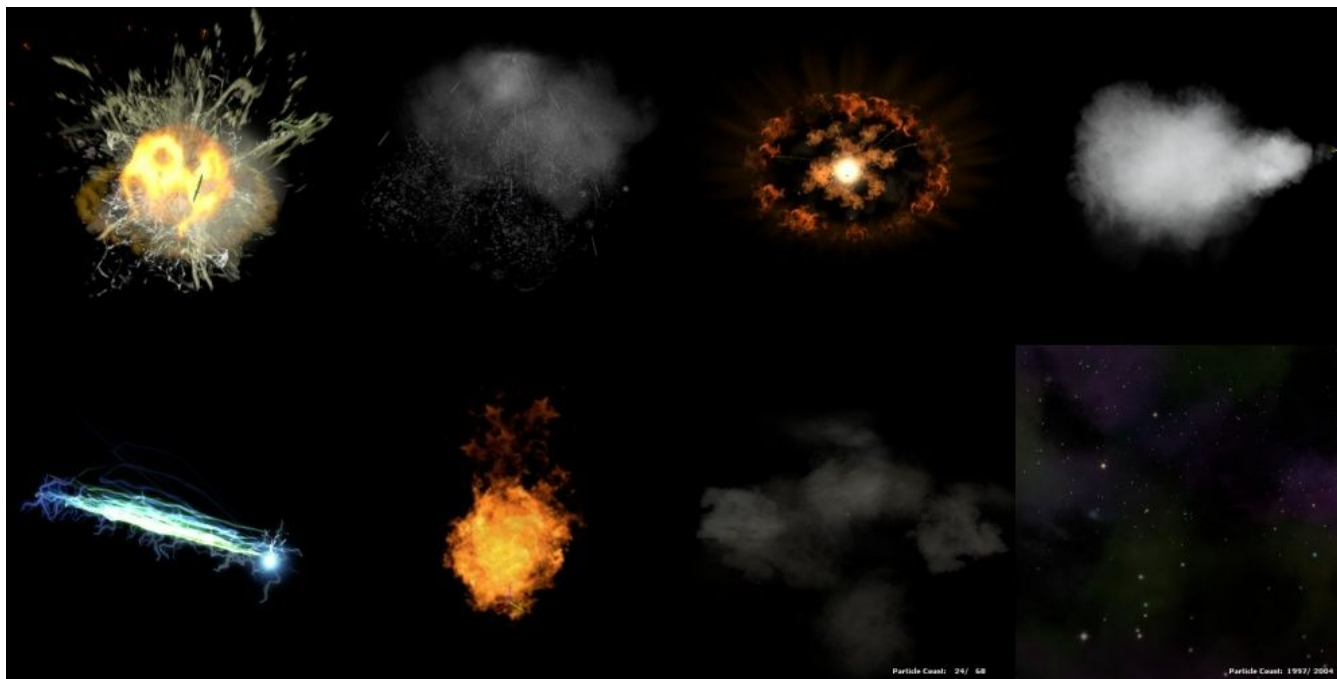
- Artificial life
 - Behavioral animation
 - Artificial evolution
 - Branching object generation
 - Facial features
- Physics-based modeling and animation
 - Particle systems
 - Rigid body dynamics
 - Fluid dynamics
 - **Fur & hair dynamics**
 - **Flexible dynamics**
 - **Cloth**
 - **Ragdolling**

Artificial life

- *Deals with things that are virtually alive*
- Behavioral animation
 - Simulates interactions of artificial lives
 - Flocking, predator-prey, virtual human behaviors
 - <https://www.youtube.com/watch?v=M028vafB0I8>
- Artificial evolution
 - Evolution of artificial life forms
 - Artificial life forms reproduce and mutate over time
 - https://archive.org/details/sims_panspermia_1990
- Branching object generation
 - Generating plants, trees etc and simulating their behaviour
 - L-systems, BOGAS
- Facial features
 - Mostly replaced with mo-cap and post-editing

Physics based modeling and animation

- *Deals with things that are not alive*
- Particle systems
 - Simulate behaviors of fuzzy objects, such as clouds, smoke, fire and water
- <https://www.youtube.com/watch?v=MPV3B4kTFL>



Physics based modeling and animation

- Rigid body dynamics
 - Simulates dynamic interaction among rigid objects
 - Takes into account various physical characteristics
 - Elasticity, friction, mass
 - <https://www.youtube.com/watch?v=VSQhvu8fZ0U>
- Fluid dynamics
 - Simulates flows, waves and turbulence of water and other liquids
 - <https://www.youtube.com/watch?v=U3acQ5dDKEs>

Fur & hair dynamics

- It's hard to get it right:

<https://www.youtube.com/watch?v=FexDVPd08qY>

- For real time: AMD's TressFX and NVIDIA's HairWorks

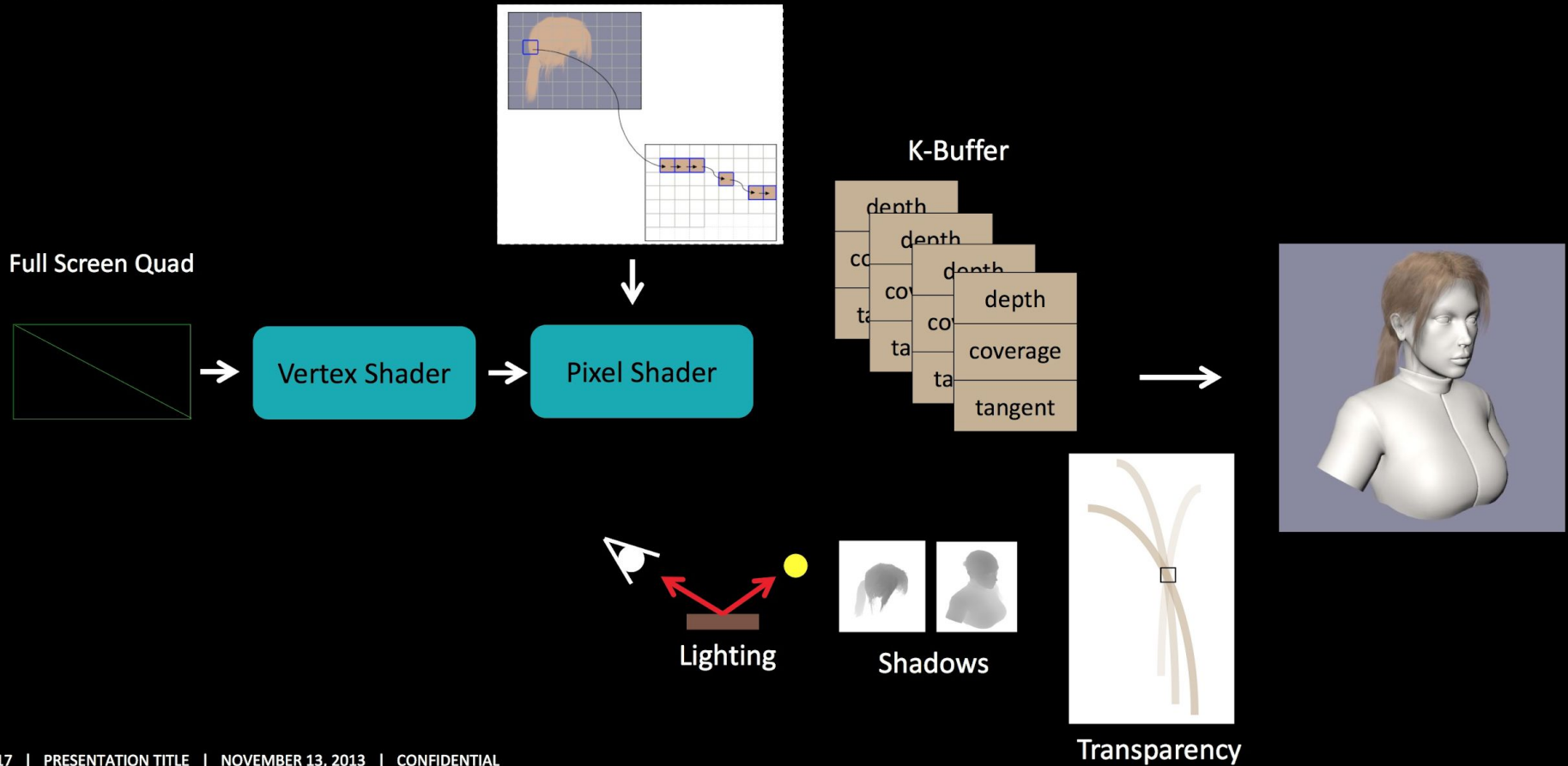
- https://www.youtube.com/watch?time_continue=83&v=qXRJZ1z3Fsg



TressFX

TressFX 2.0 RENDERING

K-BUFFER PASS



HairWorks

- <https://www.youtube.com/watch?v=VFWr44ZIEZc>



Flexible dynamics: cloth

- Simulates behaviors of flexible objects, e.g. clothes
- Geometric method
 - Only good for static frames
 1. Cloth divided into vertices
 2. Vertices positions are calculated
 3. Vertices are connected with curves
- Physical method
 - Cloth is treated as a vertex grid connected by springs
 - Each vertex has a point mass
 - Mechanical equilibrium is applied
- Particle/energy method
 - Advancement of physical method
 - All vertices interact with each other directly
 - Energy interactions determine the shape
- <https://www.youtube.com/watch?v=KBfxnaylIOY>

Flexible dynamics: ragdolling

- Commonly used in place of static animations for falling/death etc
- Verlet integration
 - Bones have simple constraints to bones further away
- Inverse kinematics
 - Animation is played, at end IK applied to force a valid position
- Blended ragdolling
 - Animation blended with physics
- Fully procedural
 - Multi-layered physical models
 - Unique every time
- <https://www.youtube.com/watch?v=6rtOWhF6iw8>

Some more videos

- Animating a very realistic horse

<https://www.youtube.com/watch?v=YncZtLaZ6kQ>

- Fully procedurally animated and evolving bipedal creatures (no keyframes):

<https://www.youtube.com/watch?v=pgaEE27nsQw>

- CGI animation breakdown

<https://www.youtube.com/watch?v=on21u4BsuK0>

Thanks for listening!

<https://www.youtube.com/watch?v=bYI7N4U-JMI>