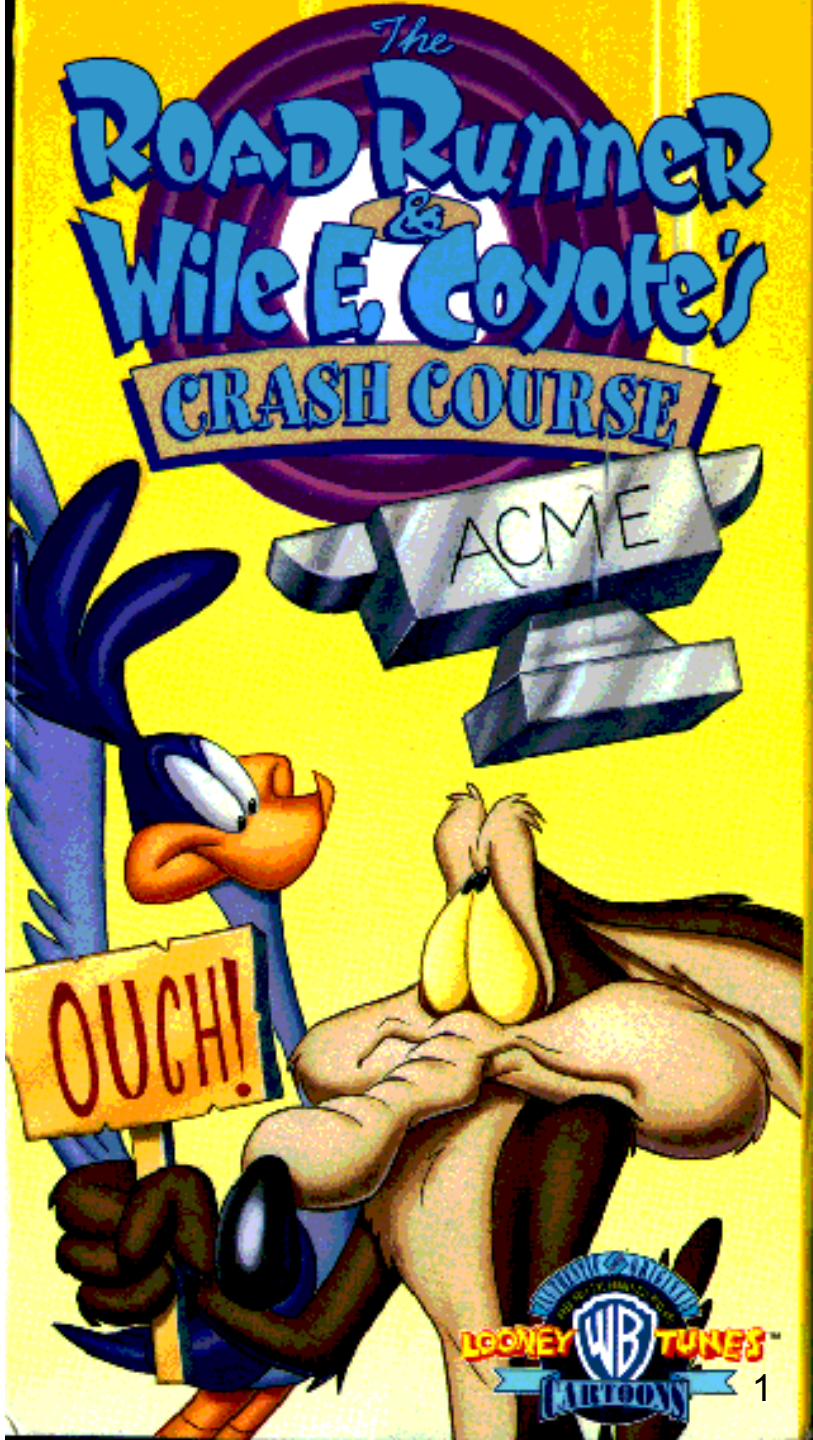
CS-C3100 Computer Graphics

Basics of Computer Animation

7.1 Introduction to Animation

Jaakko Lehtinen
Many slides courtesy of Jovan Popovic, Ronen Barzel, and Frédo Durand



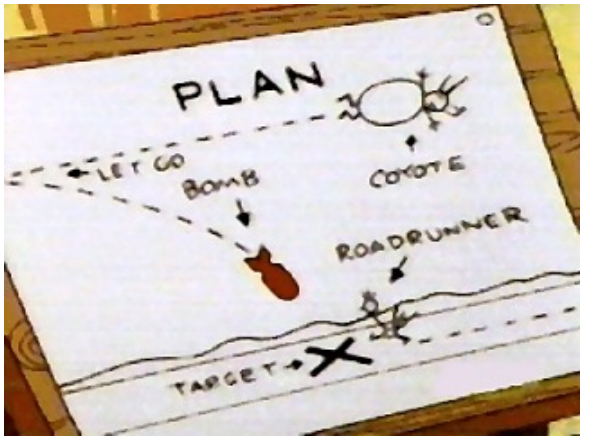
In This Video

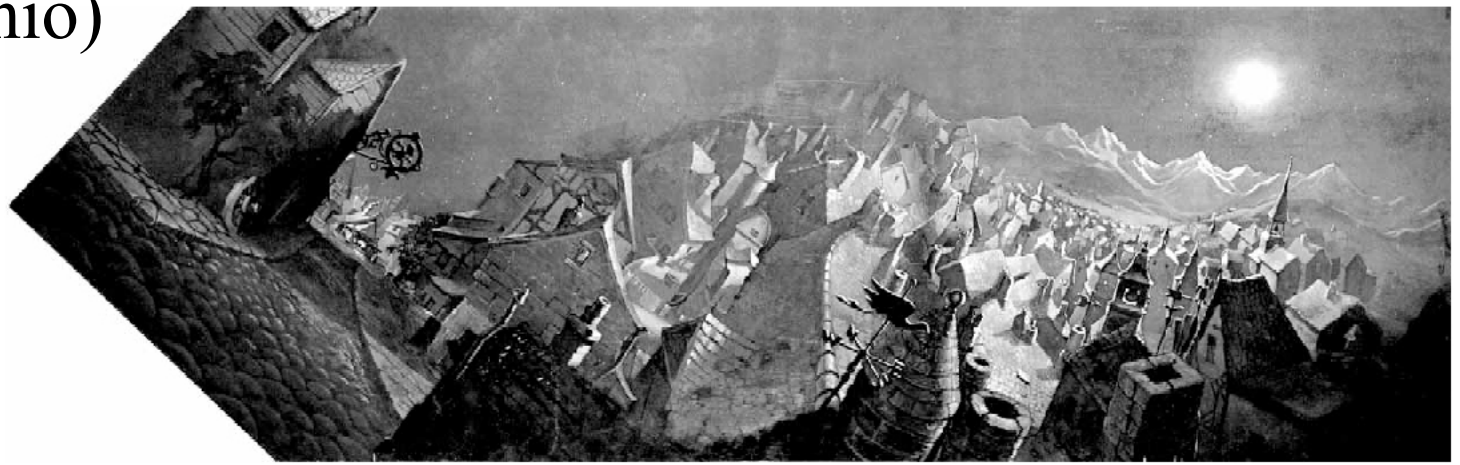
- What is Animation?
- On-line vs. off-line
- The Broad Categories of Computer Animation
  - Keyframing
  - Procedural
  - Physical Simulation

What is Animation?
Illusion of Motion from Sequence of Still Pictures

Traditional Animation

- Draw each frame by hand
  - great control, but tedious
- Reduce burden with cel animation
  - Layer, keyframe, inbetween, …
  - Example: Cel panoramas (Disney's Pinocchio)





ACM © 1997 "Multiperspective panoramas for cel animation"

3D & Traditional Animation Principles

Computer Graphics, Volume 21, Number 4, July 1987

PRINCIPLES OF TRADITIONAL ANIMATION APPLIED TO 3D COMPUTER ANIMATION

John Lasseter
Pixar
San Rafael
California

"There is no particular mystery in animation... it's really very simple, and like anything that is simple, it is about the hardest thing in the world to do." Bill Tytla at the Walt Disney Studio, June 28, 1937. [14]

ABSTRACT

This paper describes the basic principles of traditional 2D hand drawn animation and their application to 3D computer animation. After describing how these principles evolved, the individual principles are detailed, addressing their meanings in 2D hand drawn animation and their application to 3D computer animation. This should demonstrate the importance of these principles to quality 3D computer animation.

CR Categories and Subject Descriptors:
I.3.6 *Computer Graphics* : Methodology and Techniques - Interaction techniques;
I.3.7 *Computer Graphics* : Three-dimensional Graphics and Realism - Animation;
J.5 *Computer Applications* : Arts and Humanities - Arts, fine and performing.

General Terms: Design, Human Factors.

The last two years have seen the appearance of reliable, user friendly, keyframe animation systems from such companies as Wavefront Technologies Inc., [29] Alias Research Inc., [2] Abel Image Research (RIP), [1] Vertigo Systems Inc., [28] Symbolics Inc., [25] and others. These systems will enable people to produce more high quality computer animation. Unfortunately, these systems will also enable people to produce more bad computer animation.

Much of this bad animation will be due to unfamiliarity with the fundamental principles that have been used for hand drawn character animation for over 50 years. Understanding these principles of traditional animation is essential to producing good computer animation. Such an understanding should also be important to the designers of the systems used by these animators.

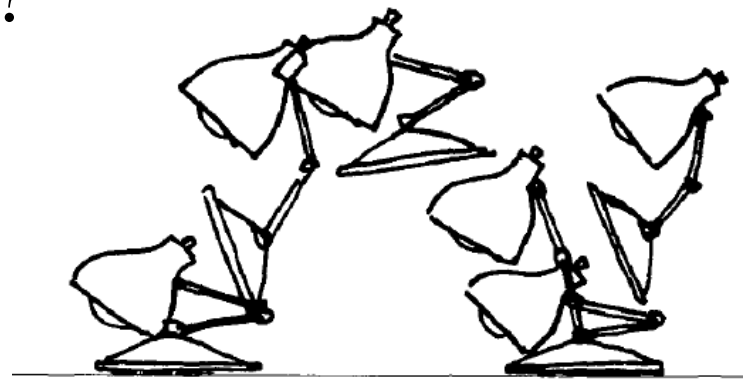
In this paper, I will explain the fundamental principles of traditional animation and how they apply to 3D keyframe computer animation.

2. PRINCIPLES OF ANIMATION

Between the late 1920's and the late 1930's animation grew from a novelty to an art form at the Walt Disney Studio. With every picture, actions became more convincing, and characters were emerging as true personalities.

Computer Animation

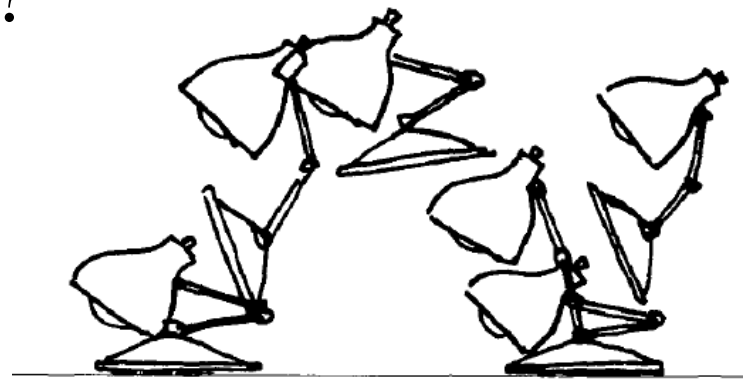
- How do we describe and generate motion of objects in the scene?



- Two very different contexts:
  - Production (offline)
  - Interactive (e.g. games, simulators)

Computer Animation

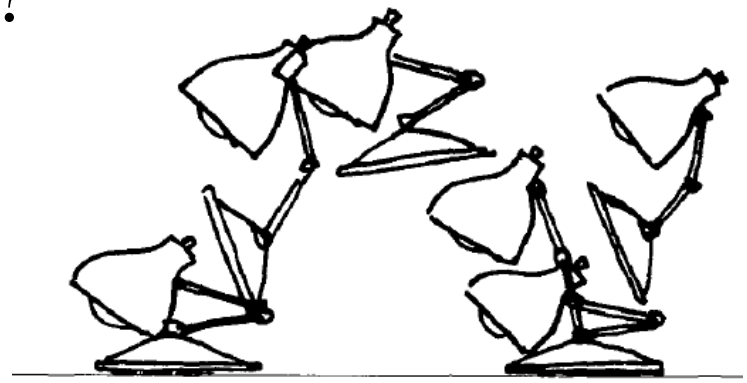
- How do we describe and generate motion of objects in the scene?



- Two very different contexts:
  - Production (offline)
    - **Can be hardcoded, entire sequence know beforehand**
  - Interactive (e.g. games, simulators)
    - **Needs to react to user interaction, sequence not known**

Computer Animation

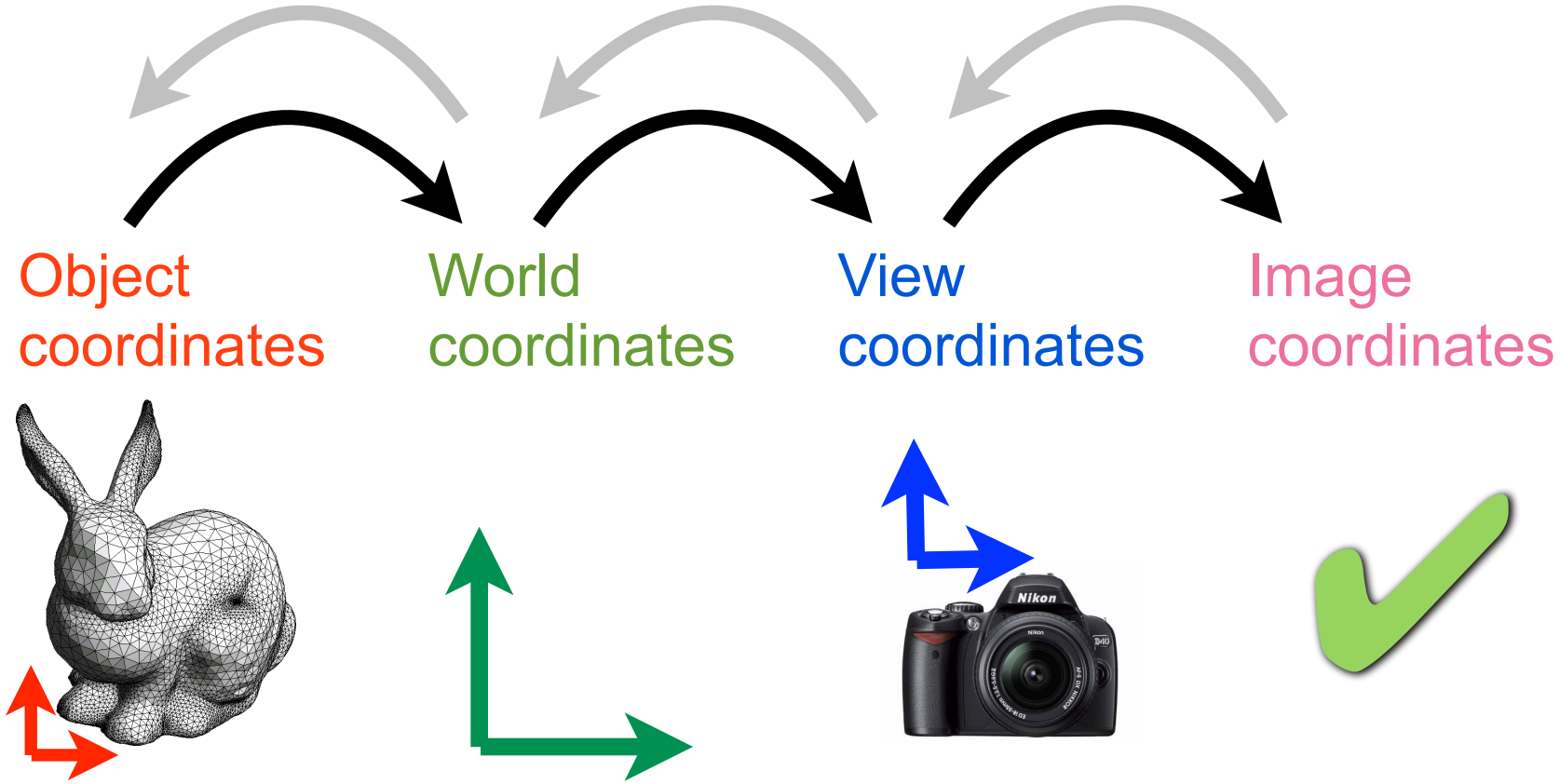
- How do we describe and generate motion of objects in the scene?



- Two very different contexts:
  - Production (offline)
    - **=> Can require multiple tries, enough if one works**
  - Interactive (e.g. games, simulators)
    - **=> Must work all the time**

Modeling/Viewing Pipeline

To first order, Computer Animation is achieved by changing these mappings as functions of time.

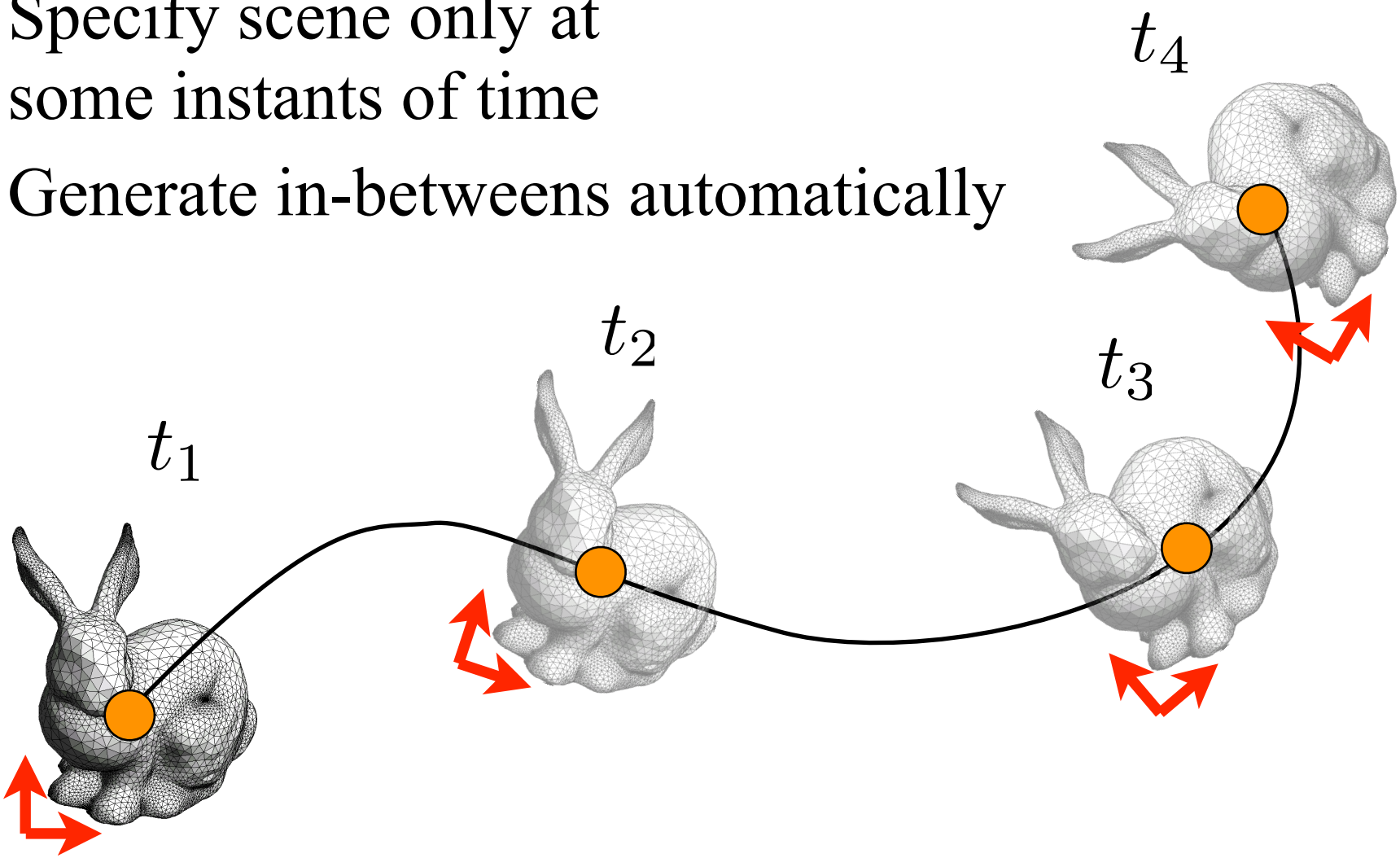


Types of Animation (Overview)

- Keyframing
- Procedural
- Physically-based

Types of Animation: Keyframing

- Specify scene only at some instants of time
- Generate in-betweens automatically



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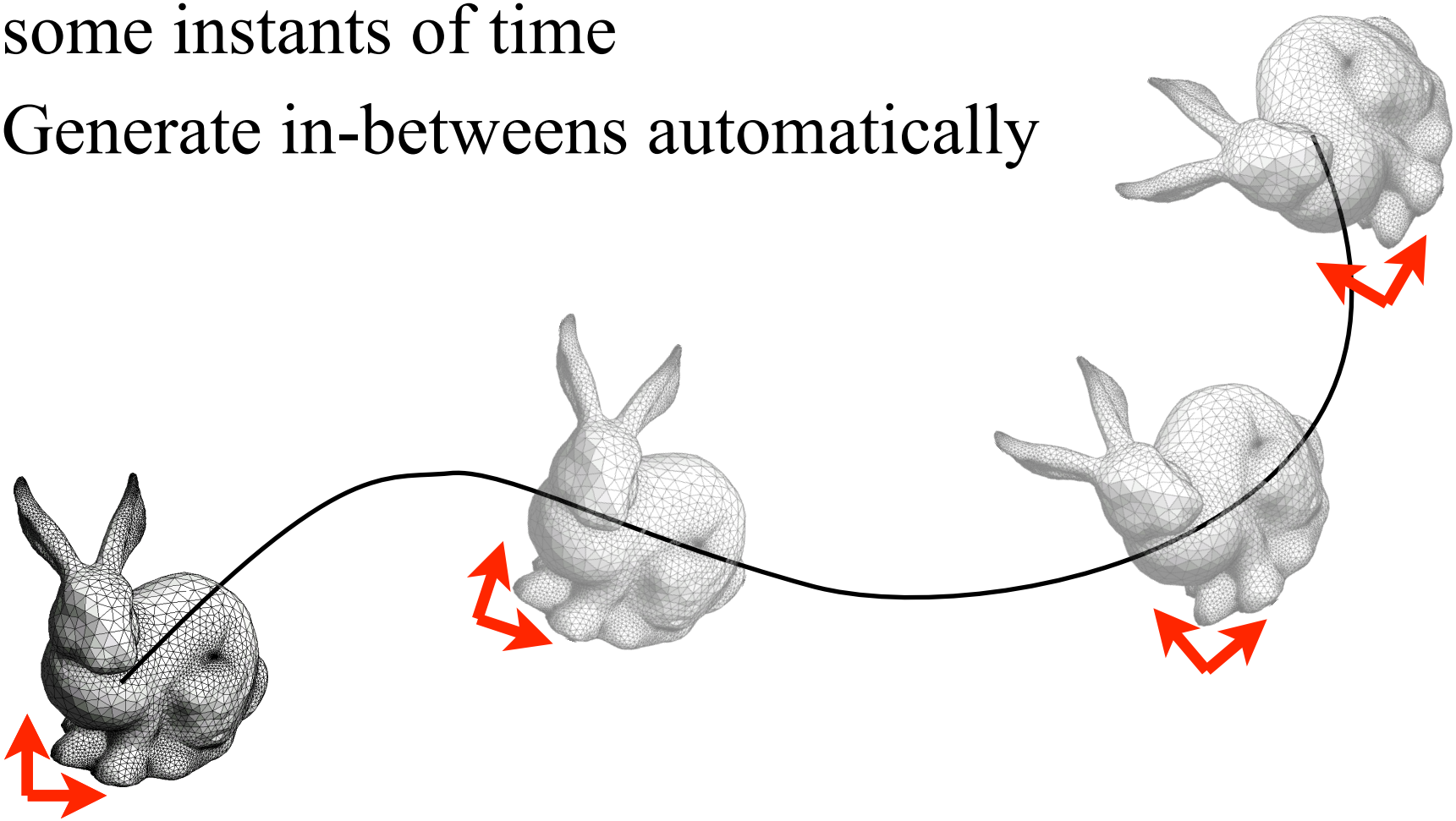

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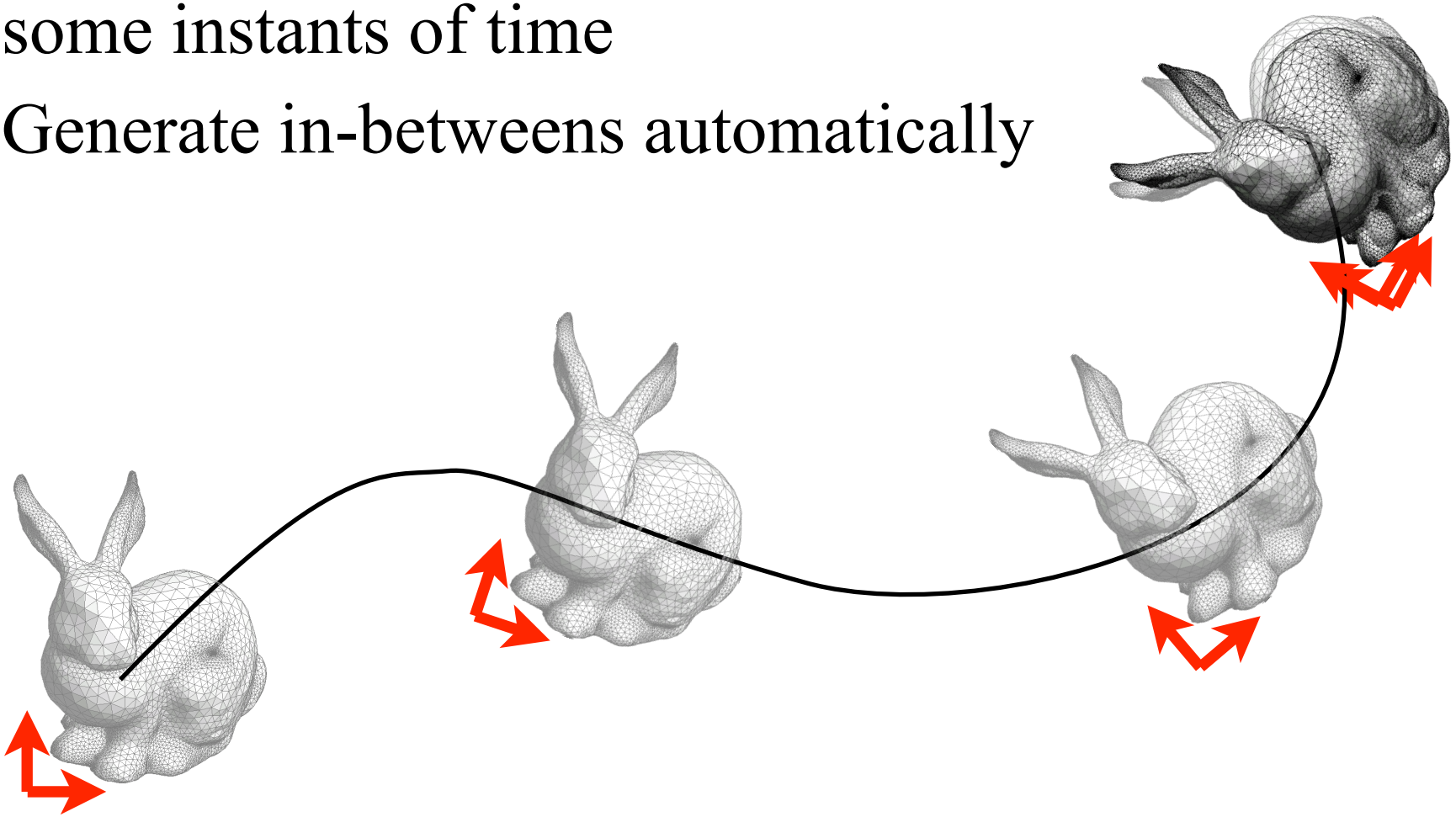

Types of Animation: Procedural

- Describes the motion algorithmically
- Express animation as a function of small number of parameters
- Example
  - a clock with second, minute and hour hands
  - express the clock motions in terms of a "seconds" variable
    - the clock is animated by changing this variable
- Another example: Grass in the wind, tree canopies, etc. (VIDEO)

From 3DMark 2003 by Futuremark

No physical simulation: all motion code is ad-hoc

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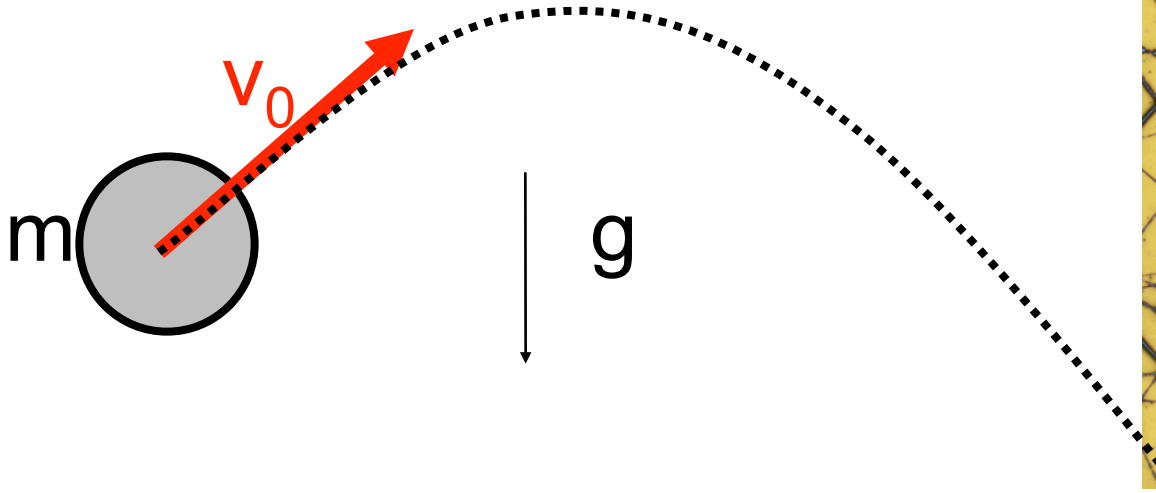
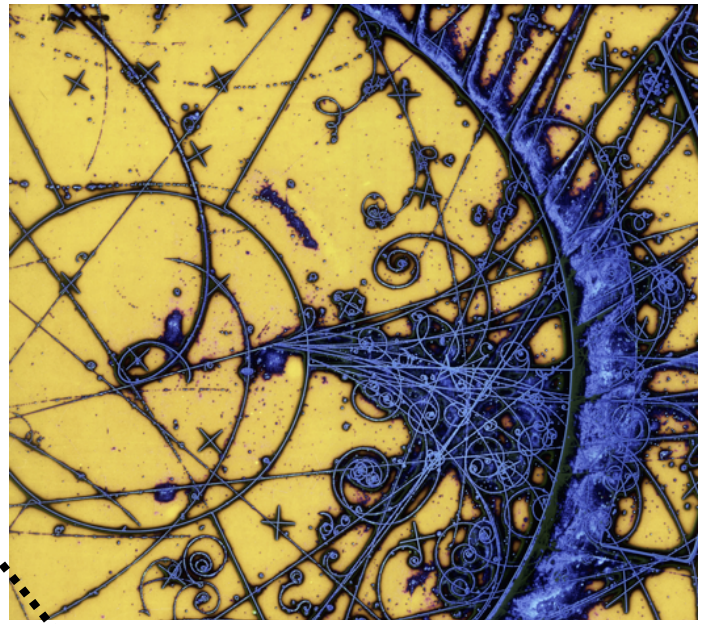
No physical simulation: all motion code is ad-hoc

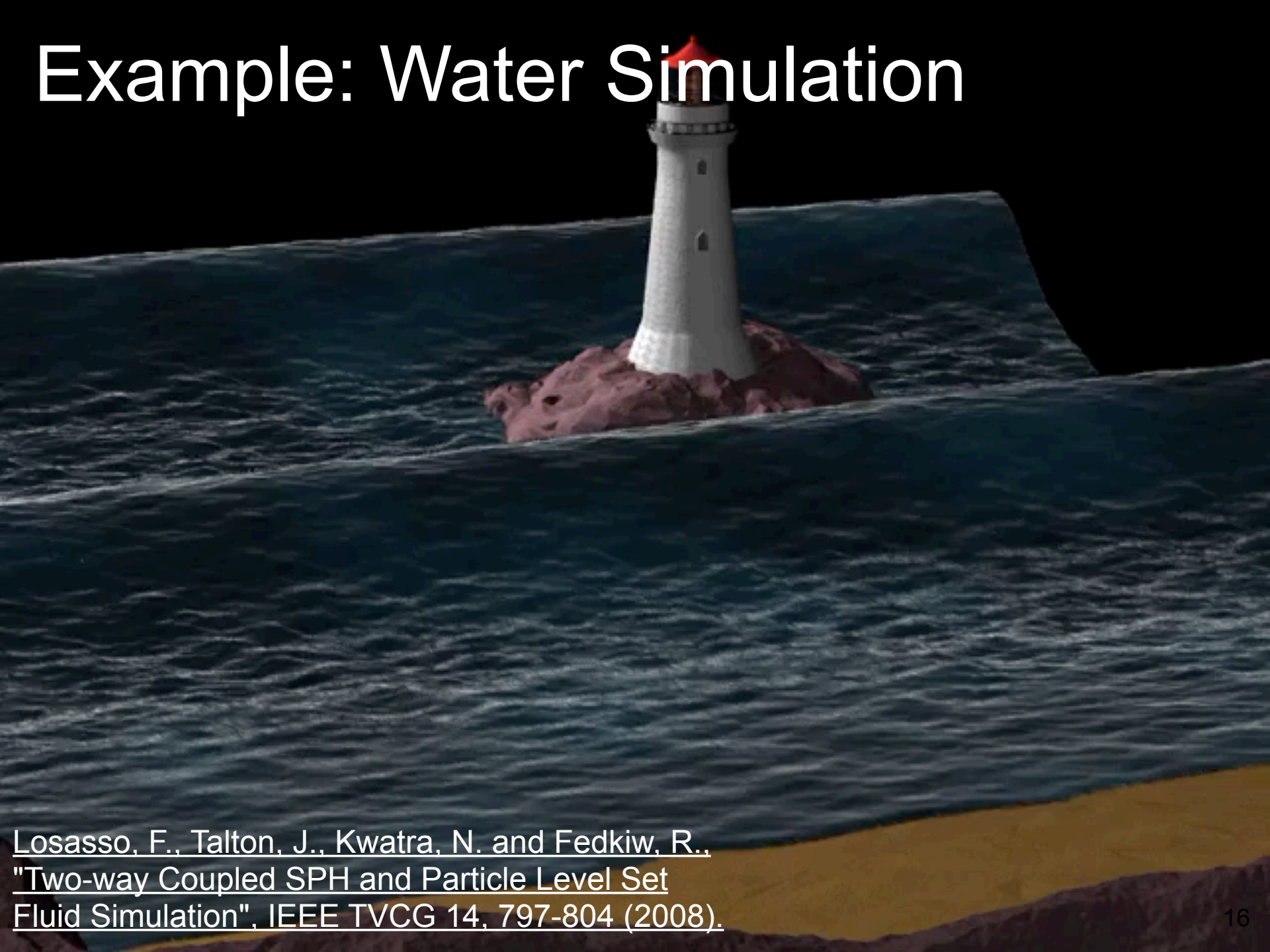
Types of Animation: Physically-Based

- Assign physical properties to objects
  - Masses, forces, etc.
- Also procedural forces (like wind)
- Simulate physics by solving equations of motion
  - Rigid bodies, fluids, plastic deformation, etc.
- Realistic but difficult to control





Example: Water Simulation



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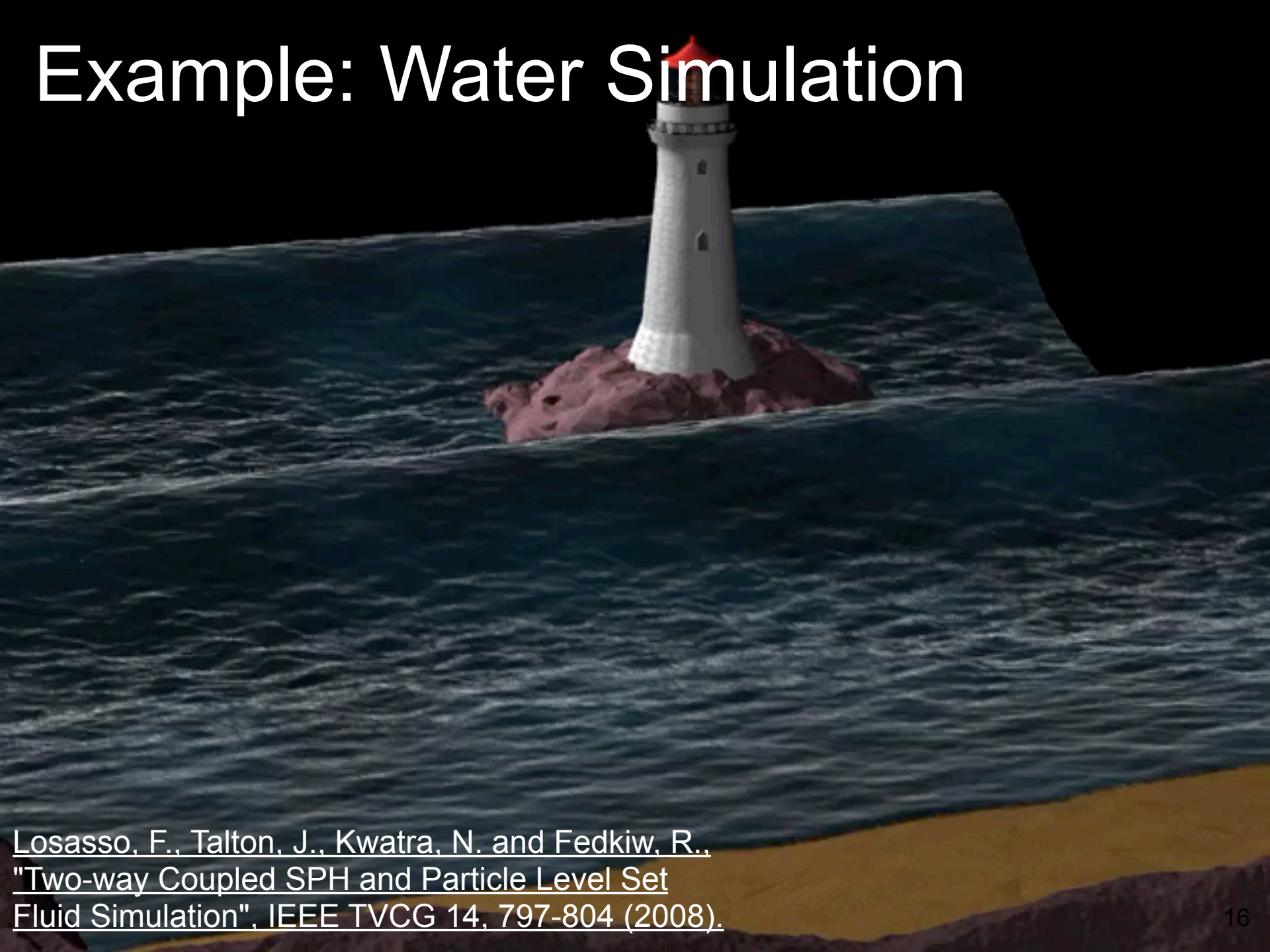

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Physically-Based Character Animation

- Specify keyframes, solve for physical motion that interpolates them by "spacetime optimization"

- E.g. Anthony C. Fang and Nancy S. Pollard, 2003. Efficient Synthesis of Physically Valid Human Motion, ACM Transactions on Graphics 22(3) 417-426, Proc. SIGGRAPH 2003.
  - http://graphics.cs.cmu.edu/nsp/projects/spacetime/spacetime.html

Physically-Based Character Animation

- State of the Art research from Aalto
  - Prof. Perttu Hämäläinen & group
- Project webpage
  - PDF
  - Video 1
  - Video 2
  - **Source code**

Online Control of Simulated Humanoids Using Particle Belief Propagation

Simple Application of Previous

- Video
- MSc thesis (diplomityö) of Jussi Perämäki (2016)
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That's All

- Next up: Animation Controls