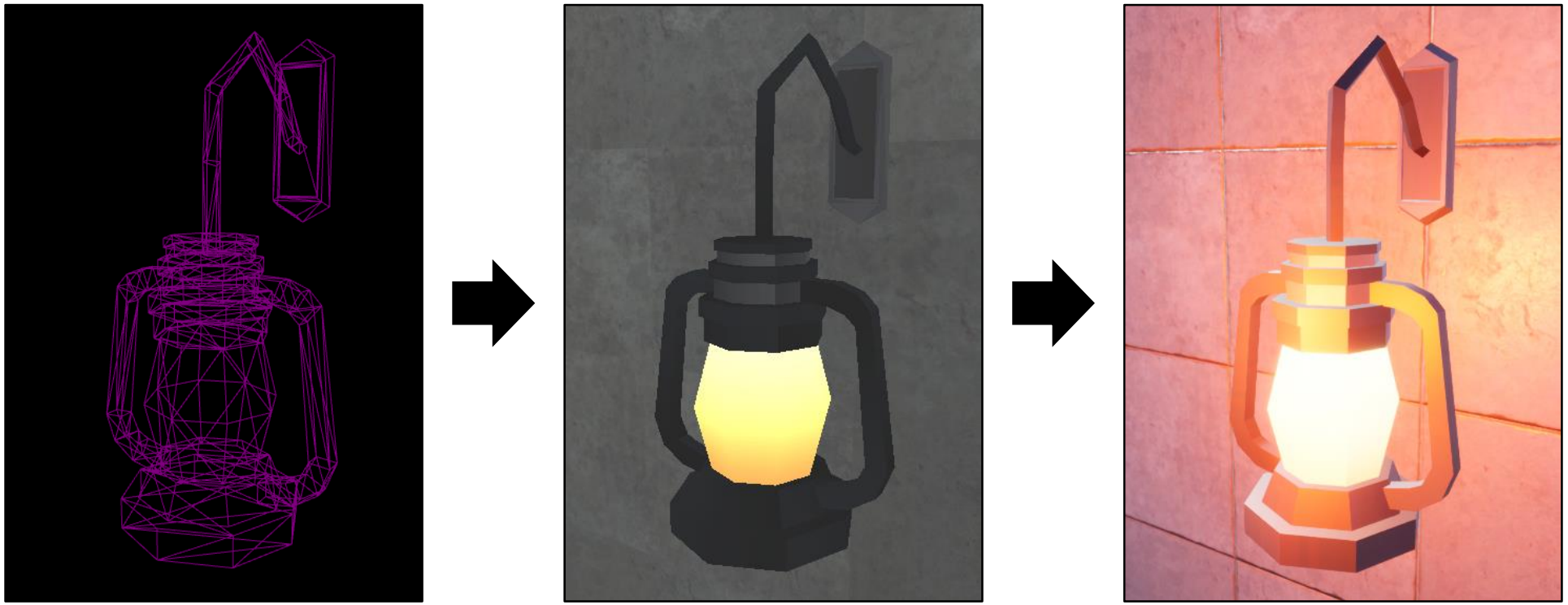
0. Introduction

Prof. HyeongYeop Kang
siamiz@khu.ac.kr
YouTube: HKang IIIXR LAB
IIIXR LAB

Introduction to 3D graphics

3D Graphics is a key technology for developing computer game.

- It takes as input 3D representations of objects and performs various calculations on them to produce images called *frames*.

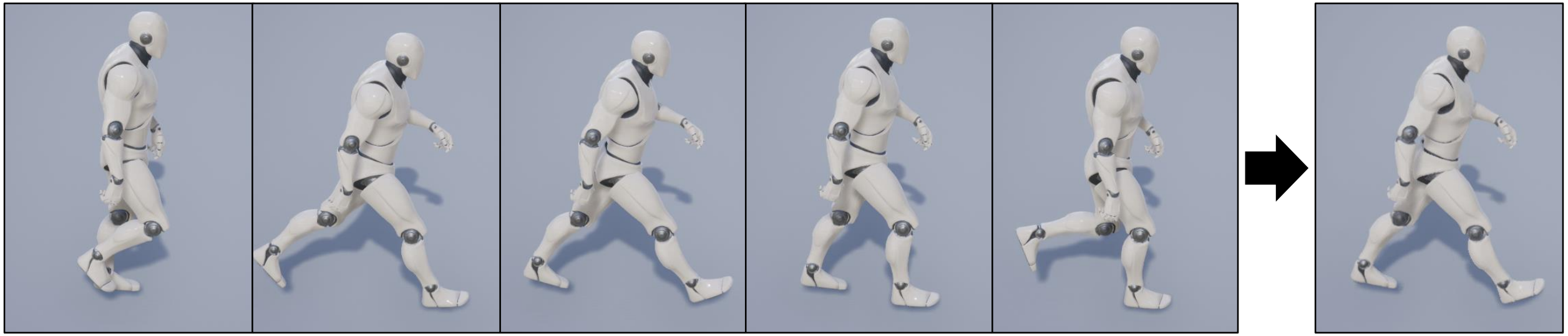


input 3D object texturing rendering

Introduction to 3D graphics

Consecutive changes of frames produce an illusion of movement (or motion).

- In film, producing a frame often takes as long as minute or hour for a single frame (off-line rendering). In return, photorealistic frames will be obtained.
- In game, at least 30 frames should be rendered in a second.



consecutive frames produce an illusion of movement

3D graphics

In video games, frames must be produced at a very high speed (at least 30 frames per second).

- We call this real-time rendering (or real-time computer graphics).
- The algorithms and techniques used in real-time graphics are fairly different from those in off-line graphics.
- For example, water simulation is easier to achieve in filmmaking than in games.
  - In filmmaking, we can theoretically spend an infinite amount of time rendering a single frame.
  - In games, we can spend up to 0.034 seconds rendering a single frame.

3D graphics

In video games, frames must be produced at a very high speed (at least 30 frames per second).

- A game requires real-time dynamics!

3D Graphics Production

The major steps in 3D computer graphics production.

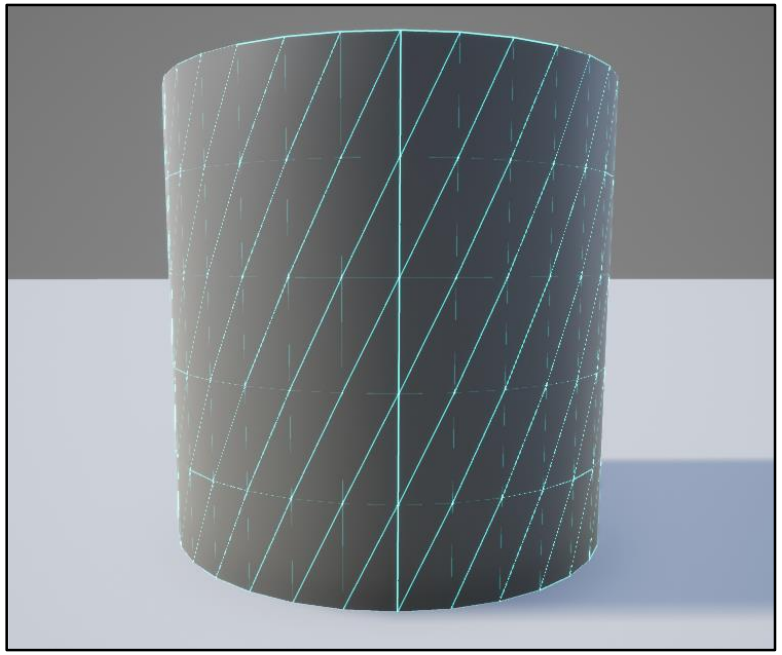
- Pre-Production: This includes ideation and design.
- Production: This includes Layout, Modeling, Texturing, Rigging, Animation, Lighting, and Rendering.
- Post-Production: This includes Additional VFX, Color correction, etc.

Modeling & Texturing

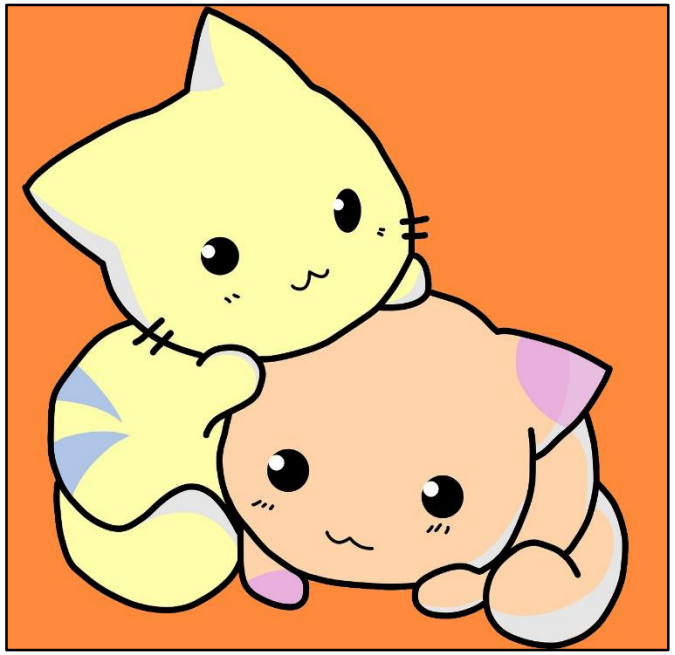
A *model* is referred to as a computer representation of an object such as a polygon mesh, and *modeling* is the process of creating the objects comprising the virtual scenes.

- The scope of modeling includes creating *textures*.

Texturing is referred to as a work of paving a texture onto an object's surface.



3D model



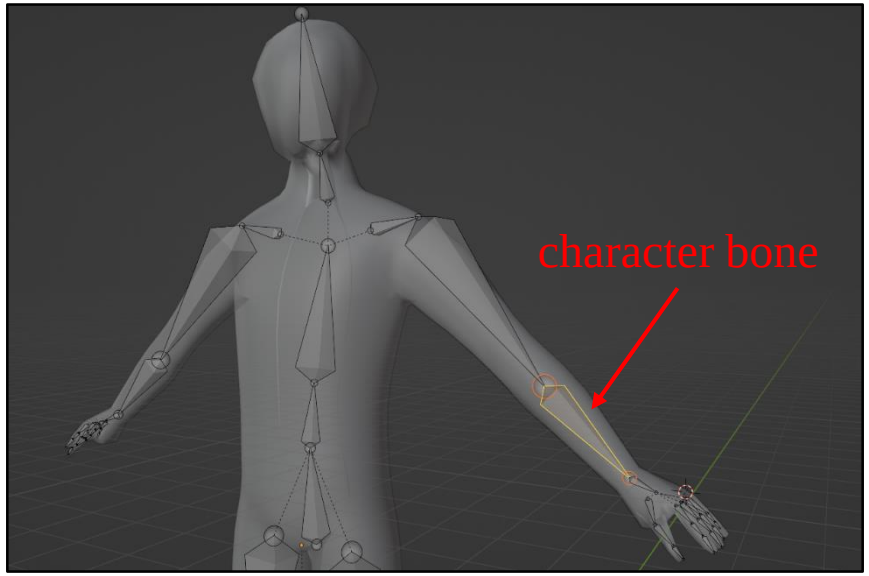
texture

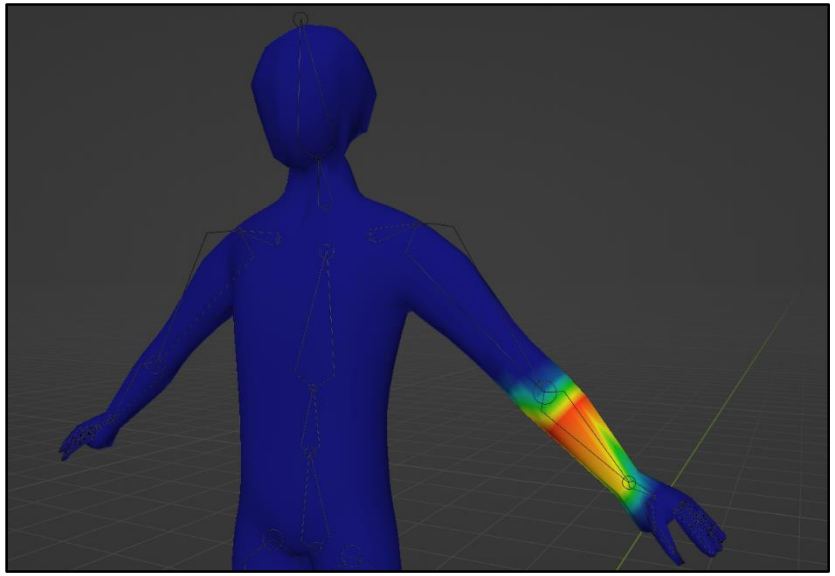
texturing

Rigging

Let’s imagine that we want to render a baseball player.

- A baseball player should be able to hit a ball, run, and slide into a base, i.e., we need to animate the player.
  - For this purpose, we usually specify the skeleton of the player.
  - We then define how the skeletal motion deforms the player’s polygon mesh.
  - For example, the polygons of the arm are made to move when the arm bone is lifted.
  - This process is often referred to as rigging.

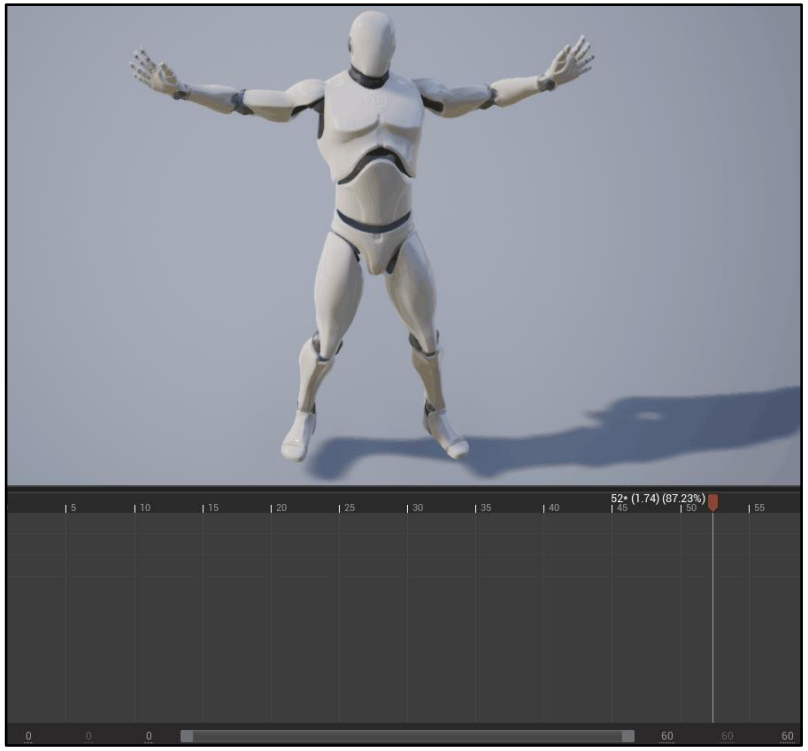




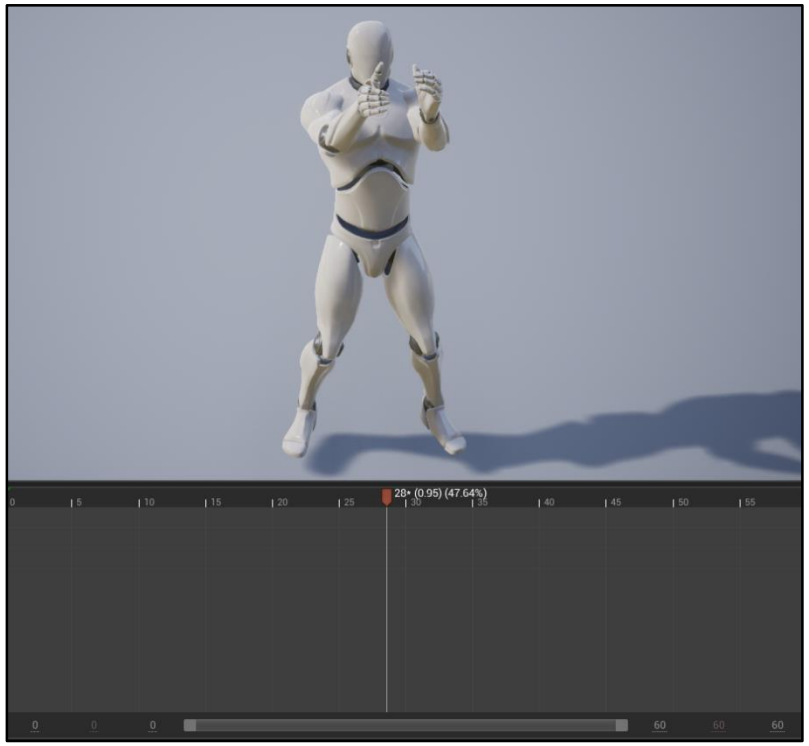
Animation

The graphics artist creates a sequence of motions.

- A widely used approach is a key frame animation.
- It defines a set of positions and performs smooth transitions between them.



keyframe 1



keyframe 2


0* (0.03) (1.4%)
5
10
15
20
25
30
35
40
45
50
55
0
0
0
60
60
60

Rendering

Rendering is the process of generating a 2D image from a 3D scene.

- Rendering is similar to taking a picture with a camera.
- Multiple models can be specified in a single scene.
- Then the scene is captured with a virtual camera.
- Rendering includes many computational process such as lighting and texturing.

3D object in a scene

rendering result

Post-production

As an optional step, post-production uses a set of special operations to give additional effects to the rendered images.

- This includes adding VFX, color correction, etc.

post-production enhances the quality of the scene

Advanced topics

So far, we have overviewed major steps in 3D graphics production.

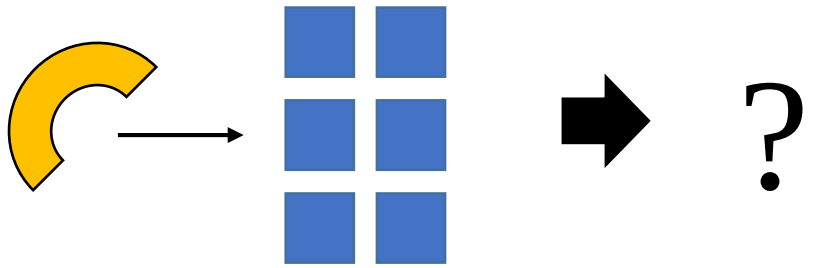
- In each step, there are many challenges to producing realistic scenes faster.
- For example, producing a photorealistic frame requires more than a minute. This is impractical for games.
- Reducing the workload on graphic designers is also actively researched. (for modeling, rigging, animation, etc.)

Then, let’s take a look at the advanced topics.

Physics simulation

Physics is one of the key components to reproduce realistic scenes in the game.

- The key task in simulation is solving the physics equations.
- Unfortunately, it is impossible to accurately calculate all the physical quantities present in a scene.
- Therefore, rather than accurately simulate the game world, it aims to provide approximate simulation in real-time.

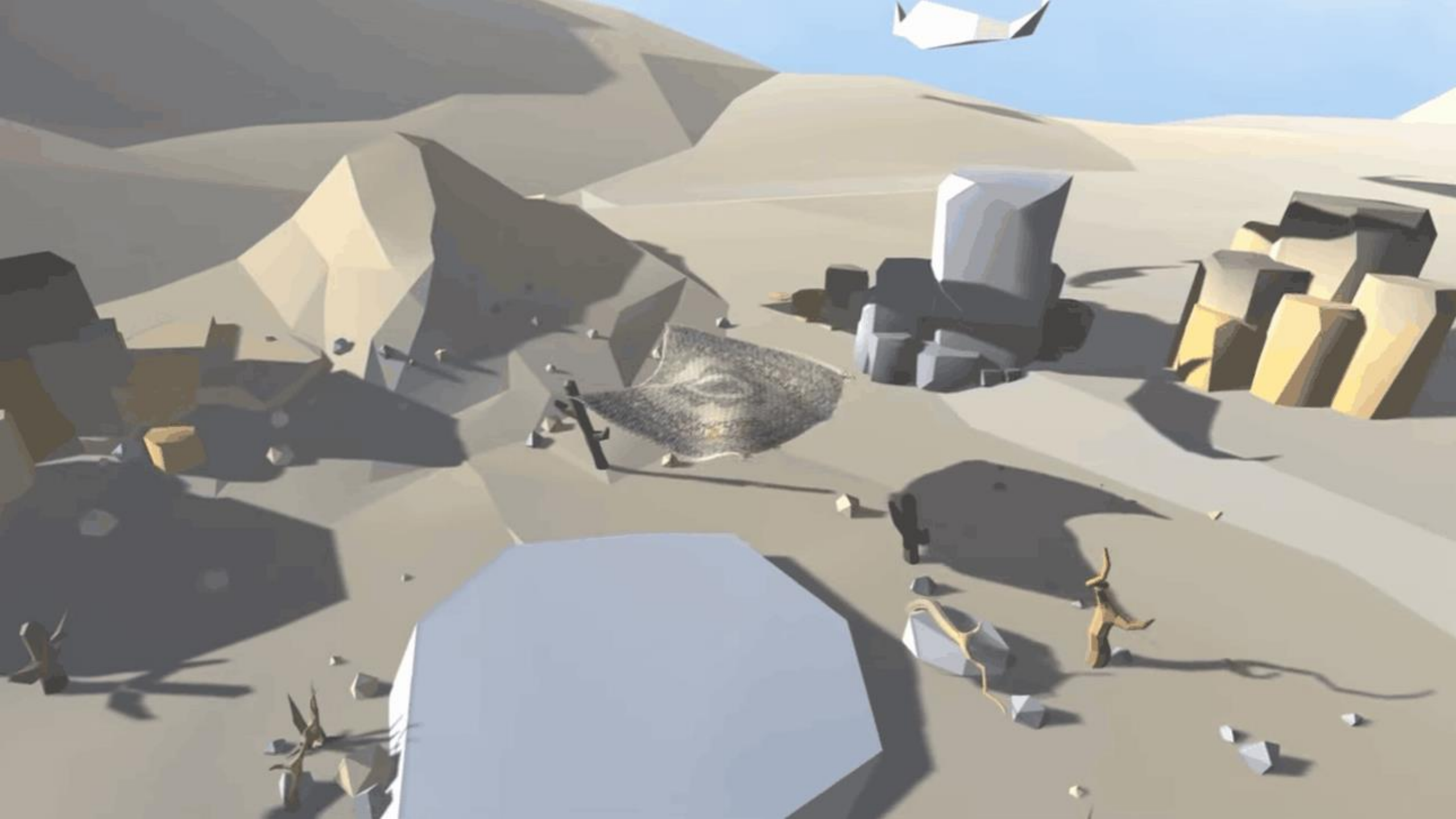


what happens next?

Physics simulation

Computational cost increases as the accuracy of physics engine increases.

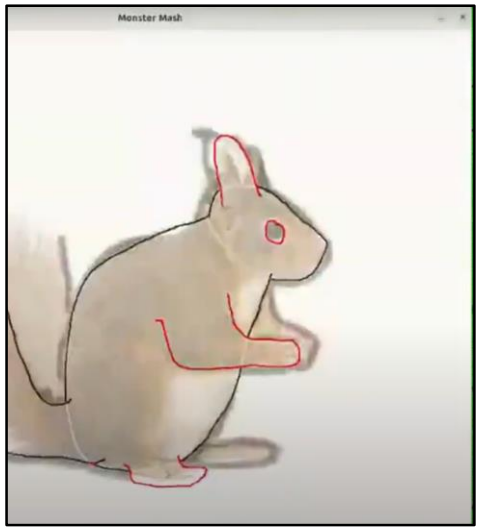
- Physics engines usually perform approximate simulations.
  - Instead of calculating the physical quantities of all objects, a constant approximation value is sometimes used.
  - Minor physical quantities are sometimes ignored.
- However, this inevitably produces unrealistic simulation results.



Mesh and animation generation

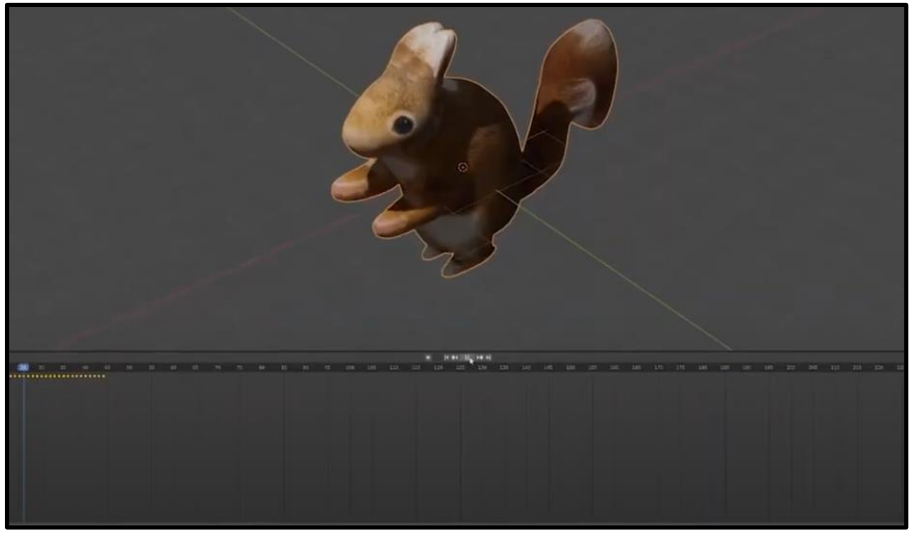
Generating mesh and animation usually requires animator's intensive labor.

- This problem could be mitigated by using automatic generation techniques.
- These days, deep neural network and reinforcement learning techniques have widely been used.



input sketch

3d mesh

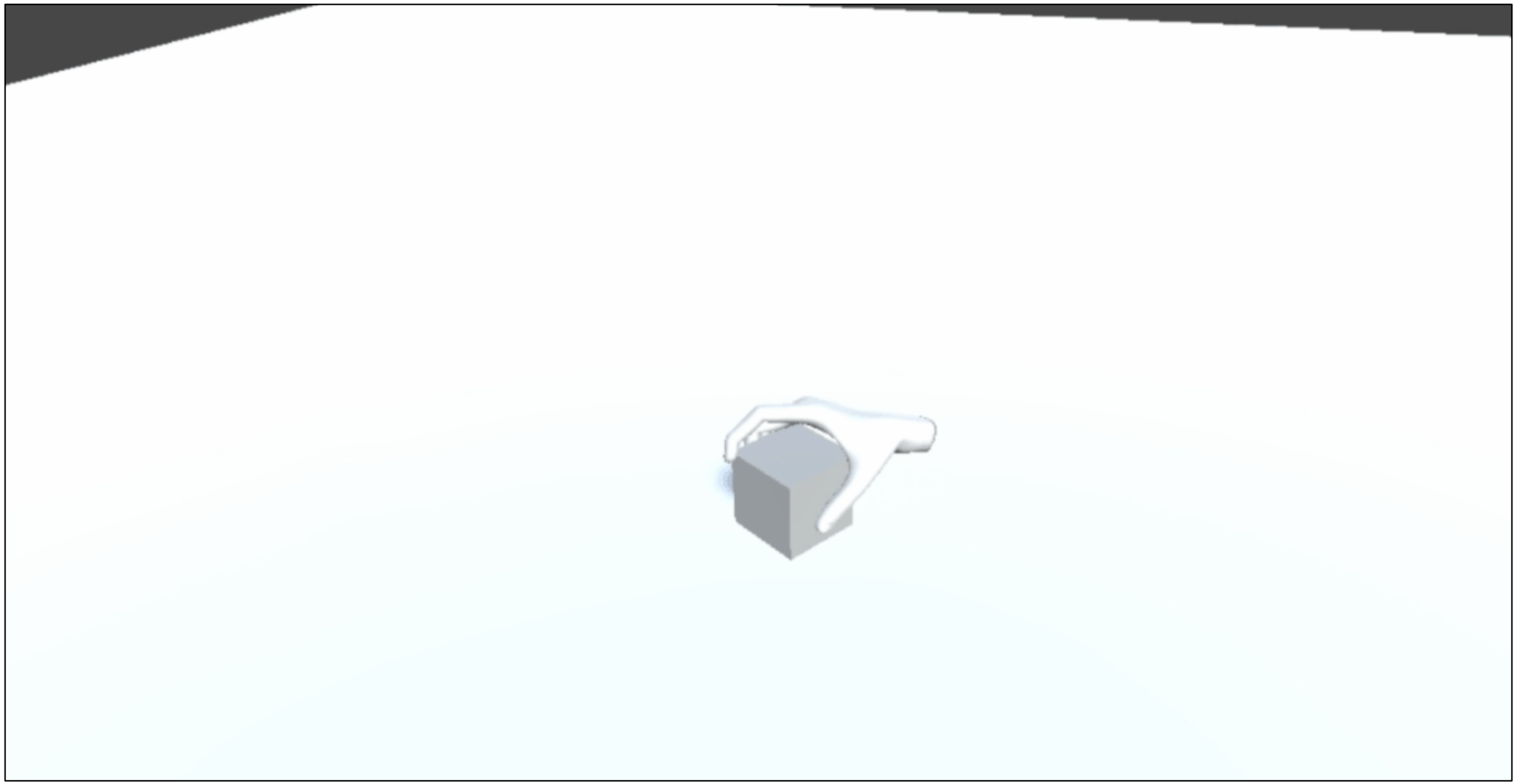


animating


Mass Matching

Data-driven Animation

Data-driven animation can produce a large variety of animations without the animator’s intensive labor.



Data-driven Animation

Data-driven animation can produce a large variety of animations without the animator’s intensive labor.

- When grasping a 3D object, the animation should be changed depending on the geometry and usage of the object.
- However, it is impossible to create the appropriate animations for all kinds of objects.
- To resolve this problem, a data-driven animation approach has been introduced.

Image, Texture, and Mesh Synthesis

Synthesis is the process of creating new contents from some form of contents description.

- These days, neural network based techniques have shown photorealistic results.

End

This class aims to teach students about basic theories of 3D computer graphics.

- We will focus more on real-time graphics.
- The GPU architecture will also be briefly introduced.

I hope you enjoy this class ^^!

- More 3D game graphics related videos can be found in IIIXR LAB YouTube.