INFOGR – Computer Graphics

Jacco Bikker - April-July 2015 - Lecture 1: “Introduction”

Welcome!

Today’s Agenda:

- Topic Introduction
- Course Introduction
- Team
- Practical Details
- Assignments
- Field Study
- State of the Art

Introduction

Introduction

Introduction

Introduction

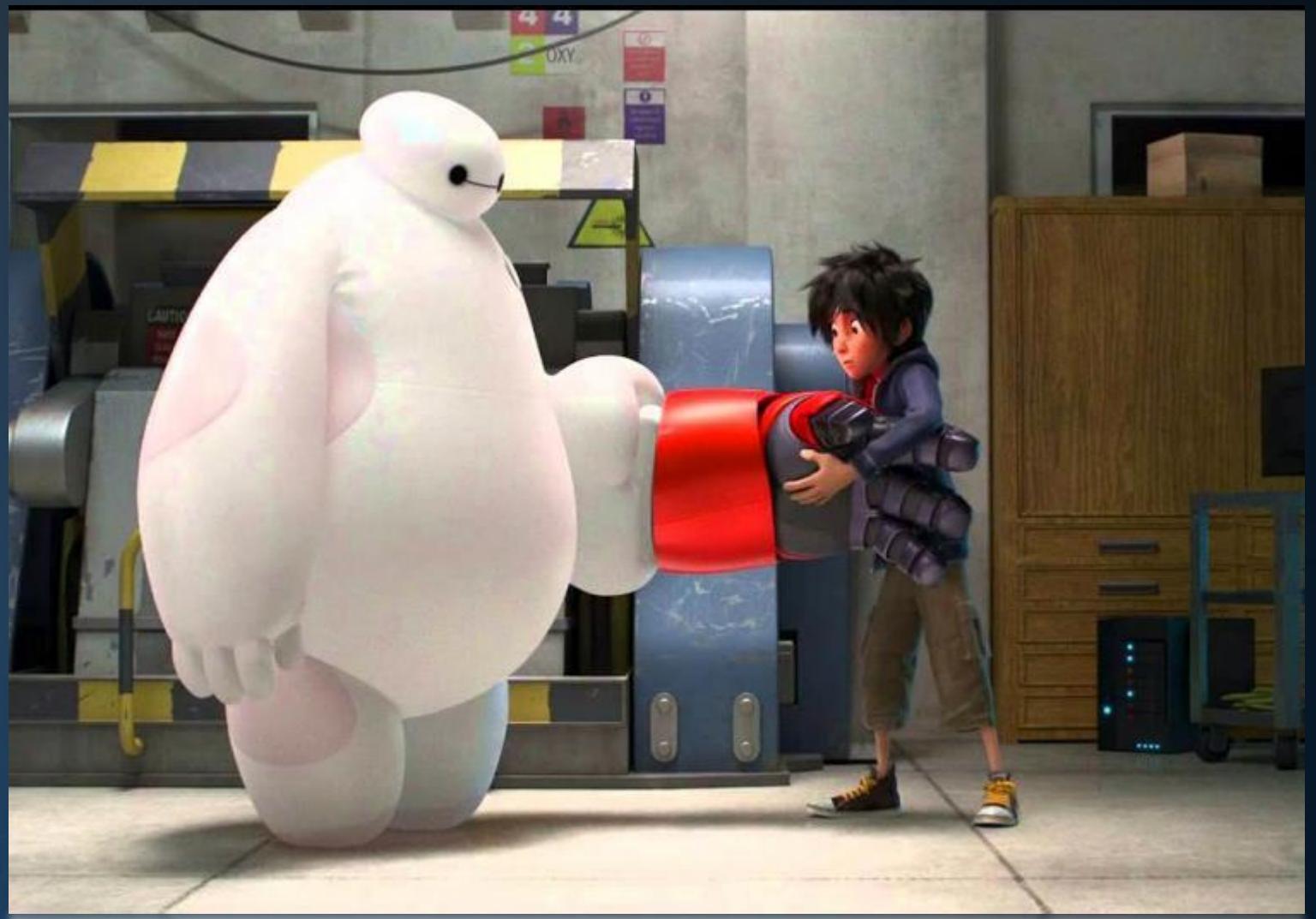
Introduction

Introduction

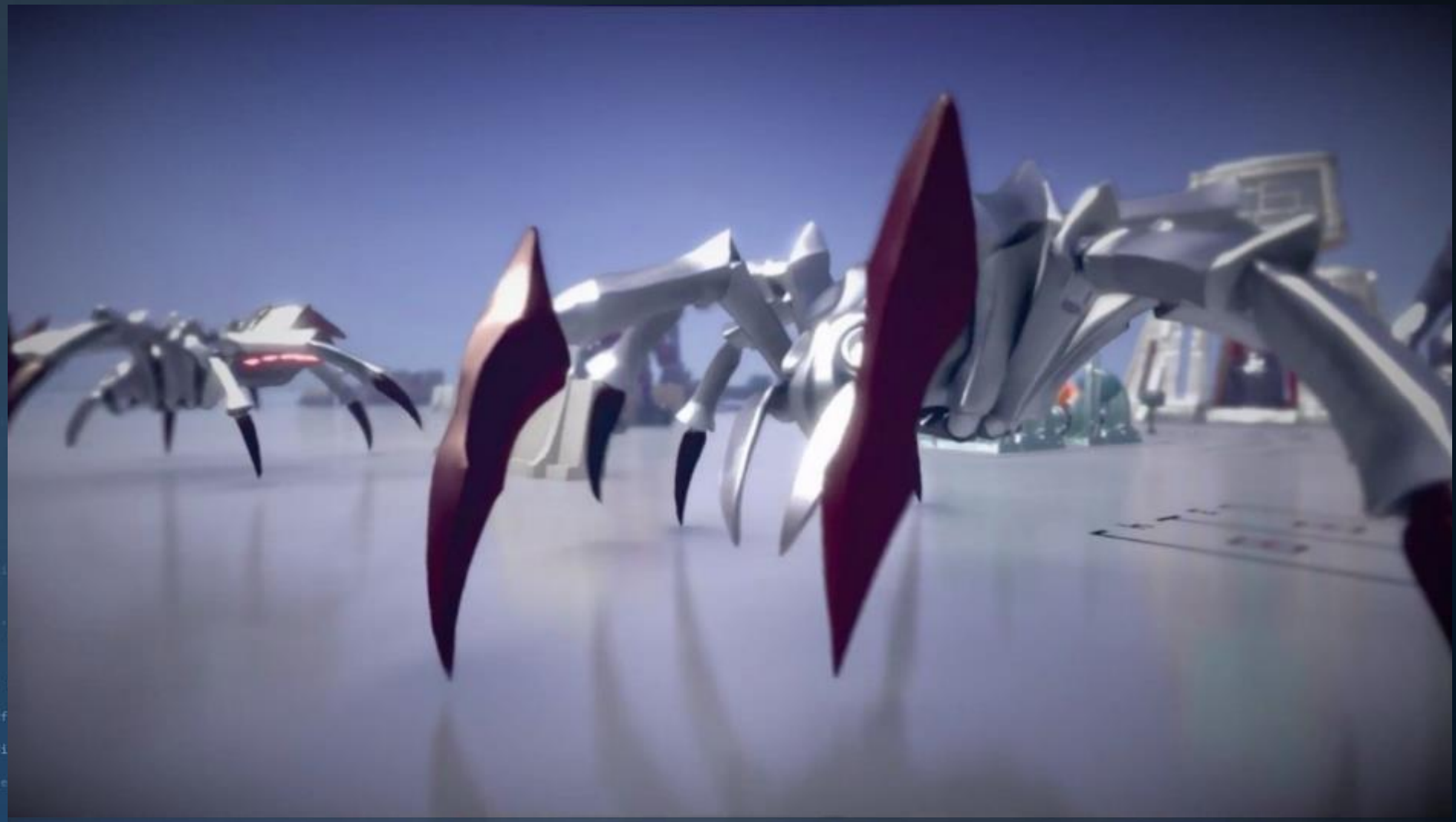
Introduction

Introduction

Introduction

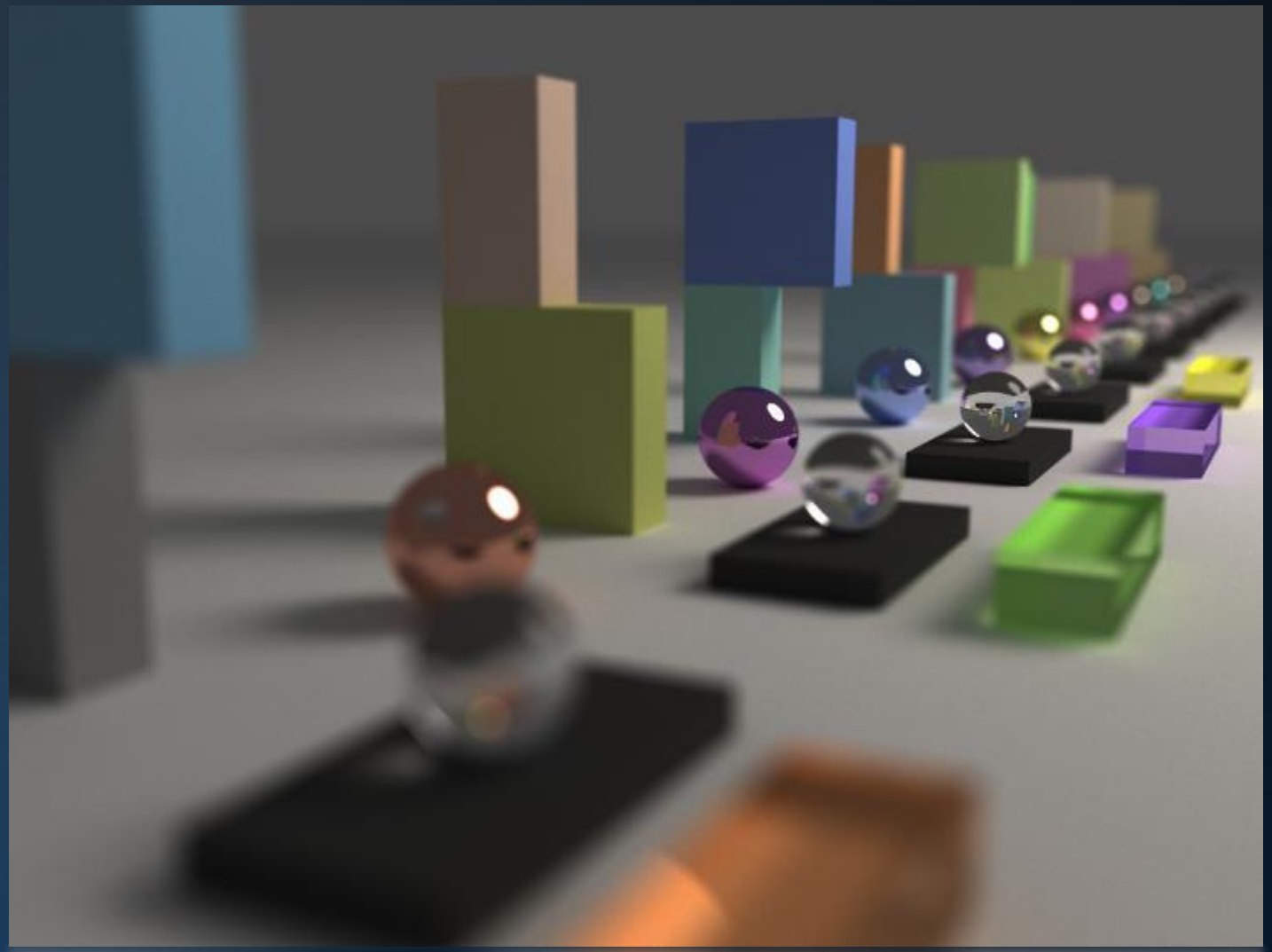


Introduction



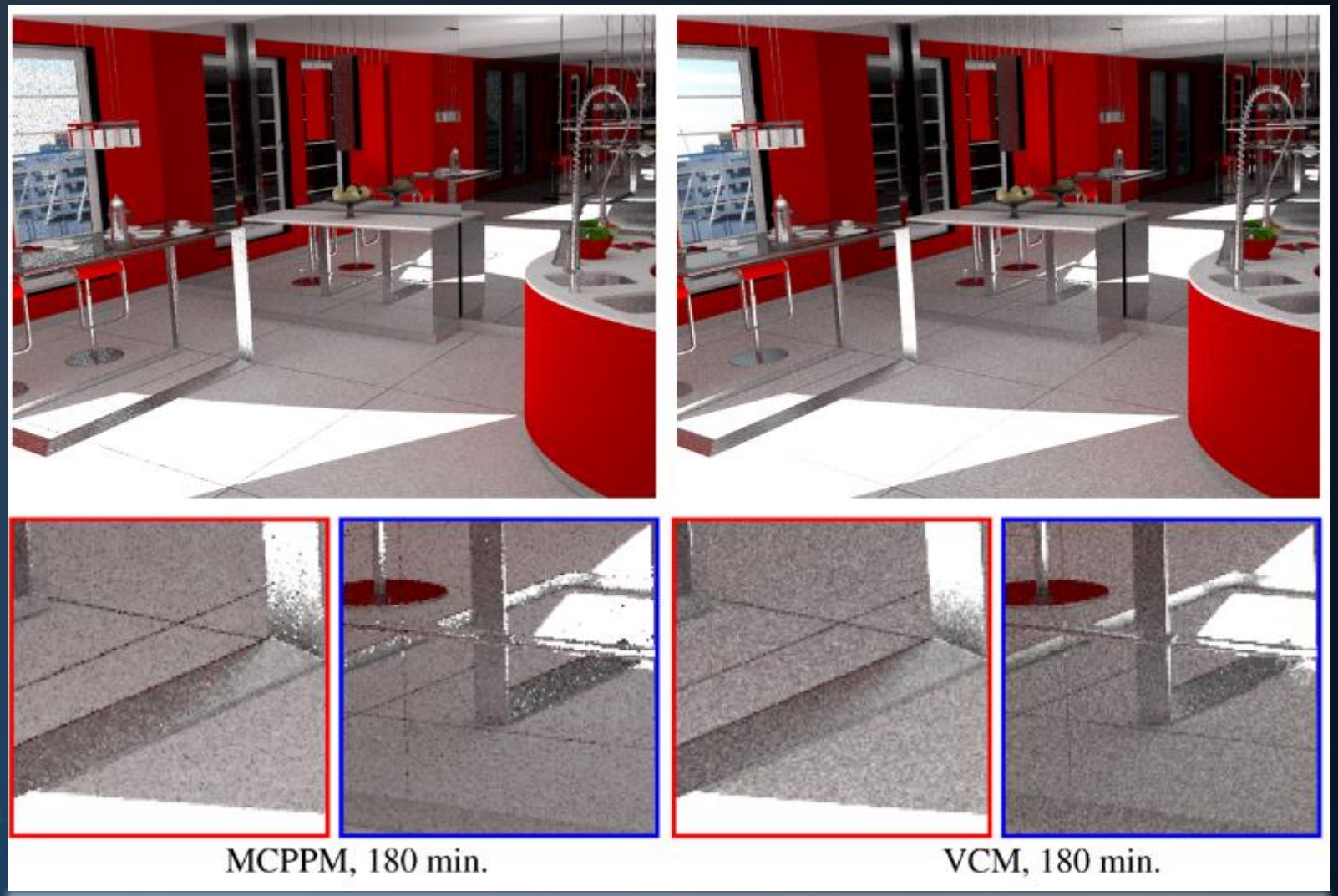
Introduction

Introduction

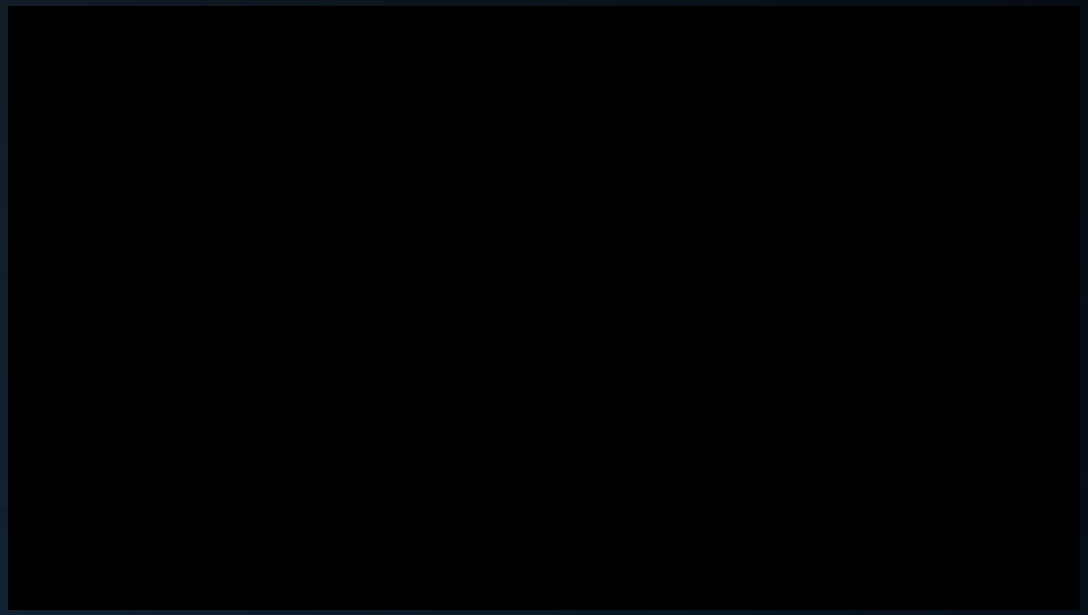


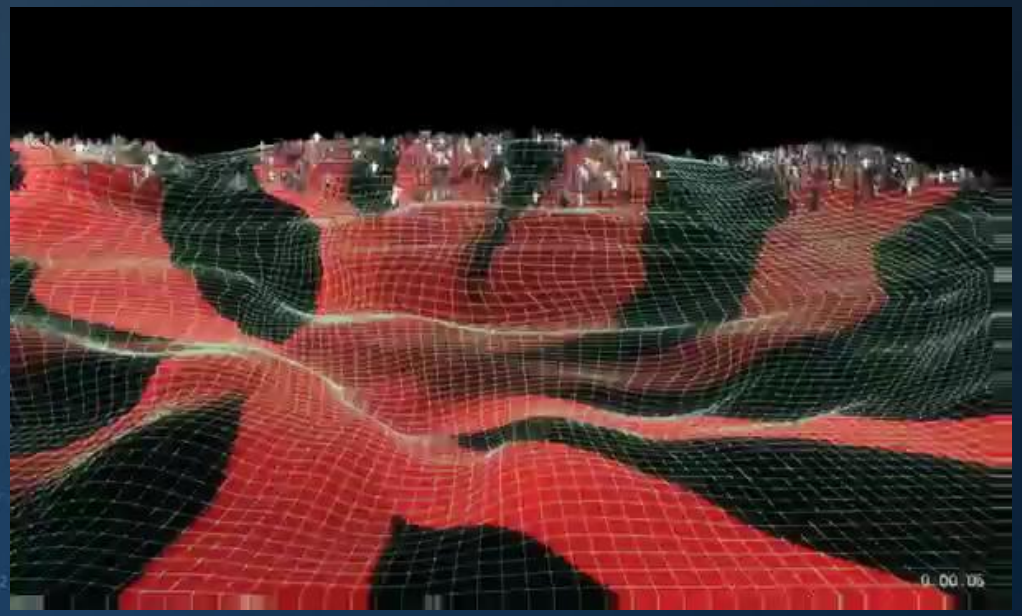
Introduction

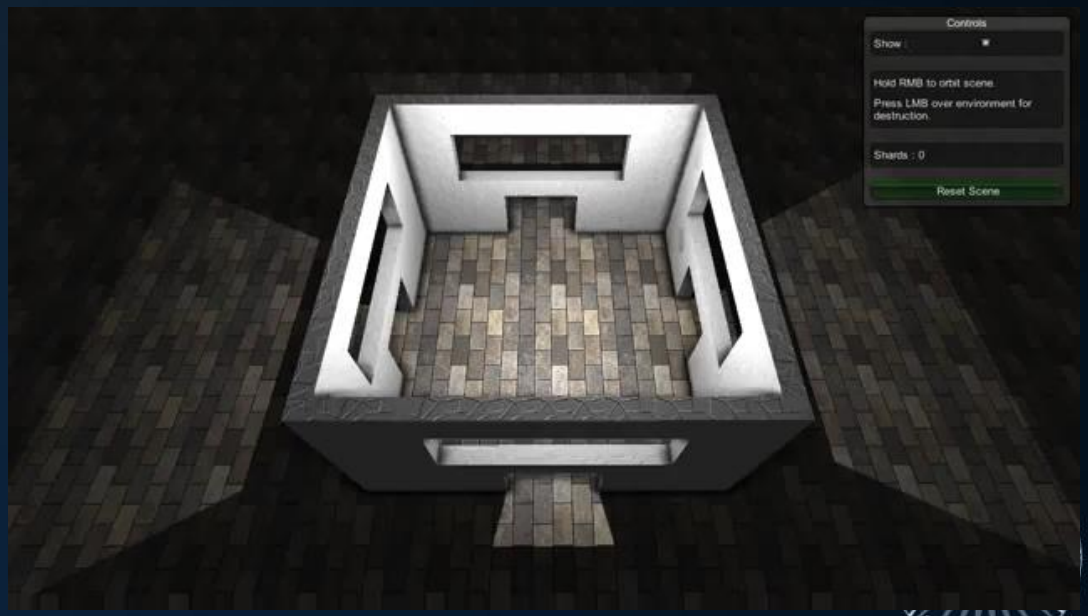
Introduction



Introduction





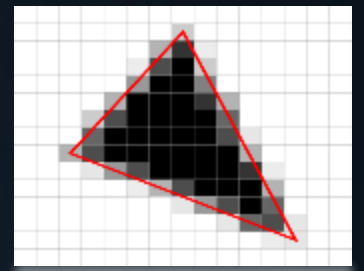


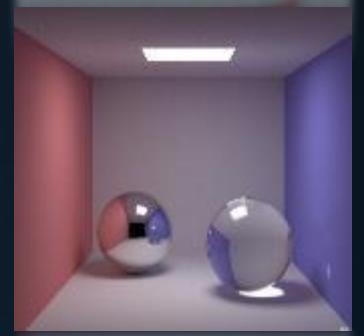
Introduction

Computer Graphics 2015:

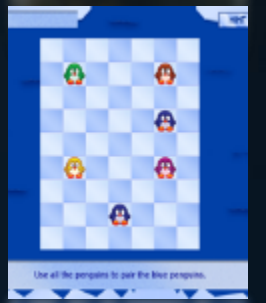
Looking for realism (in several wrong places):

1. Rasterization
   - Geometry
   - Textures, shaders
   - Clipping, culling
   - Post processing
   - …
2. Ray tracing
   - Ray/triangle intersections
   - Bounding volume hierarchy
   - Snell, Fresnel, Beer
   - Whitted, Cook, Kajiya
   - …
3. Mathematics
   - Vectors
   - Matrices
   - Transformations





Introduction



Language: English,
because of reasons.

Prerequisites: C#.

Literature: Fundamentals of Computer Graphics (3rd edition), by Peter Shirley and Steve Marschner (or 2nd, or 1st).

13 lectures (due to Liberation Day, Ascension Day and retakes).

Supporting practica in all lecture weeks:

- On Tuesdays,
- In BBG-112, -175, -106, -109, -103

Introduction

Supporting tutorials in all lecture weeks:

- On Thursdays
- In BBG-083, -169, -165 and -079.

Exams:

- Mid-term: May 21st.
- End of term: June 23rd.
- Retake: July 9th.

Attendance:

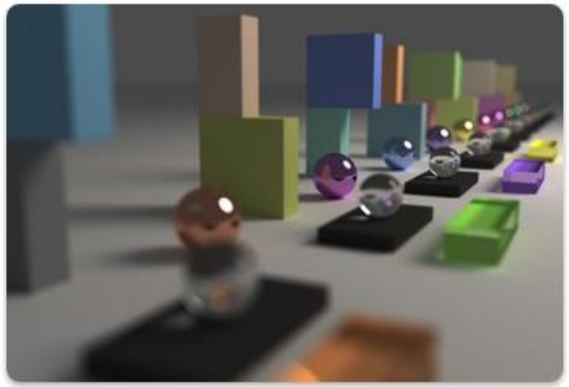
You are not required to attend any of the lectures / tutorials / practica (i.e., if you are here, it’s because you want to).*

*Obviously, attendance is highly recommended.

Graphics

UNIVERSITEIT UTRECHT - INFORMATION AND COMPUTING SCIENCES

academic year 2014/15 – 4th period



Navigation

http://www.cs.uu.nl/docs/vakken/gr

Course Overview | Schedule | Practicals | Literature & Links

News

Introduction

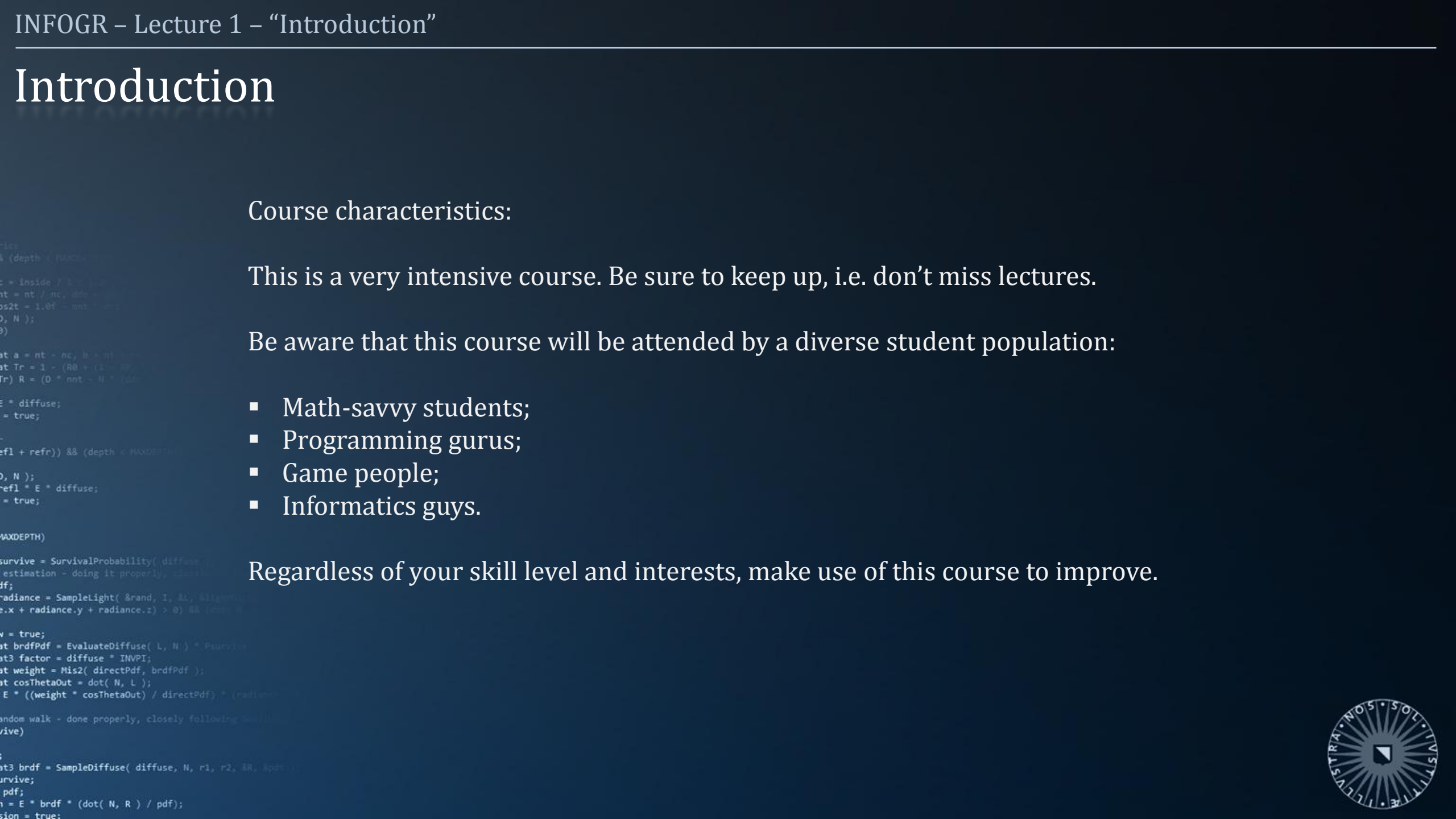
Course characteristics:

This is a very intensive course. Be sure to keep up, i.e. don’t miss lectures.

Be aware that this course will be attended by a diverse student population:

- Math-savvy students;
- Programming gurus;
- Game people;
- Informatics guys.

Regardless of your skill level and interests, make use of this course to improve.



Today’s Agenda:

- Topic Introduction
- Course Introduction
- Team
- Practical Details
- Assignments
- Field Study
- State of the Art

Team

Lecturer:

Jacco Bikker

bikker.j@gmail.com / j.bikker@uu.nl
Office: BBL 425

Background:

Gamedev:

- Lost Boys
- Davilex
- Green Dino
- Overloaded
- Vanguard

Academia:

- IGAD

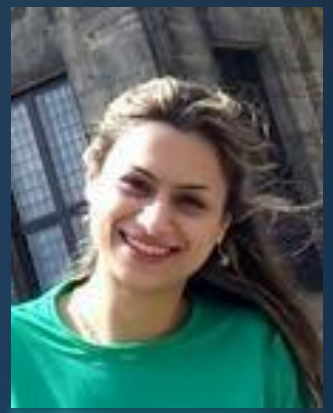
Education:

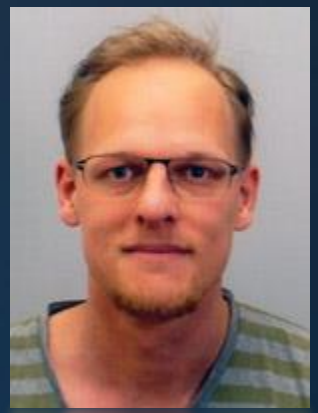
- HBO
- Doctoral
  (Delft; Ray Tracing in Games, 2012)

Team

Teaching Assistants:

1. Forough Madehkhaksar
2. Coert van Gemeren
3. Anna Aljanaki





Team

Student Assistants:

1. Tigran Gasparian
2. Jordi Vermeulen
3. Casper Schouls
4. Sander Vanheste
5. Jan Posthoorn

Today’s Agenda:

- Topic Introduction
- Course Introduction
- Team
- Practical Details
- Assignments
- Field Study
- State of the Art

Practical Details

Assignment Overview:

i. P1: Tutorial;
ii. P2: Basic shader programming;
iii. P3a: Advanced shader programming, or:
iv. P3b: Ray Tracing.

Final practicum grade is 0.2 * P1 + 0.4 * P2 + 0.4 * max(P3a, P3b).

Exam overview:

i. T1: Mid-term exam;
ii. T2: Final exam.

Final exam grade is 05 * T1 + 0.5 * T2.

Final grade: (2T + P) / 3

Passing criteria:

Final Grade ≥ 6.0 (after rounding); both T and P ≥ 5.0 (after rounding).

Practical Details

How to hand in assignments:

- http://www.cs.uu.nl/docs/submit

Retake:

- You must have submitted all programming assignments
- You must have participated in both exams
- Your total grade must be at least a 4.0 (after rounding)
- Retake covers whole course, and replaces min(T1, T2).

Today’s Agenda:

- Topic Introduction
- Course Introduction
- Team
- Practical Details
- Assignments
- Field Study
- State of the Art

Assignments

PART 1: Mathematics

Tutorial 1 will be available on Thursday, April 23th.
TA assistance is available on April 30th in rooms
BBG-083, -169, -165 and -079.

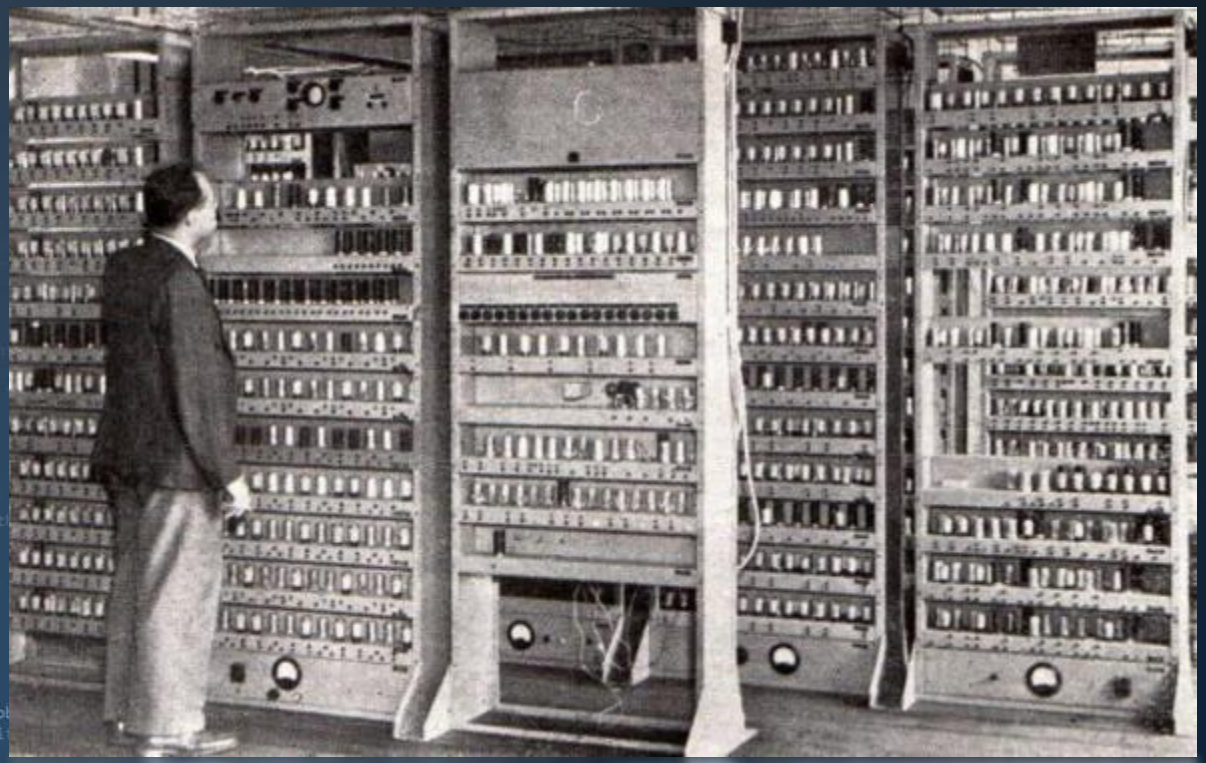
PART 2: Programming assignment

P1 (XNA tutorial) is now available from the website.
Assistance is available on Tuesday, April 28th in rooms
BBG-112, -175, -106, -109 and -103.

Today’s Agenda:

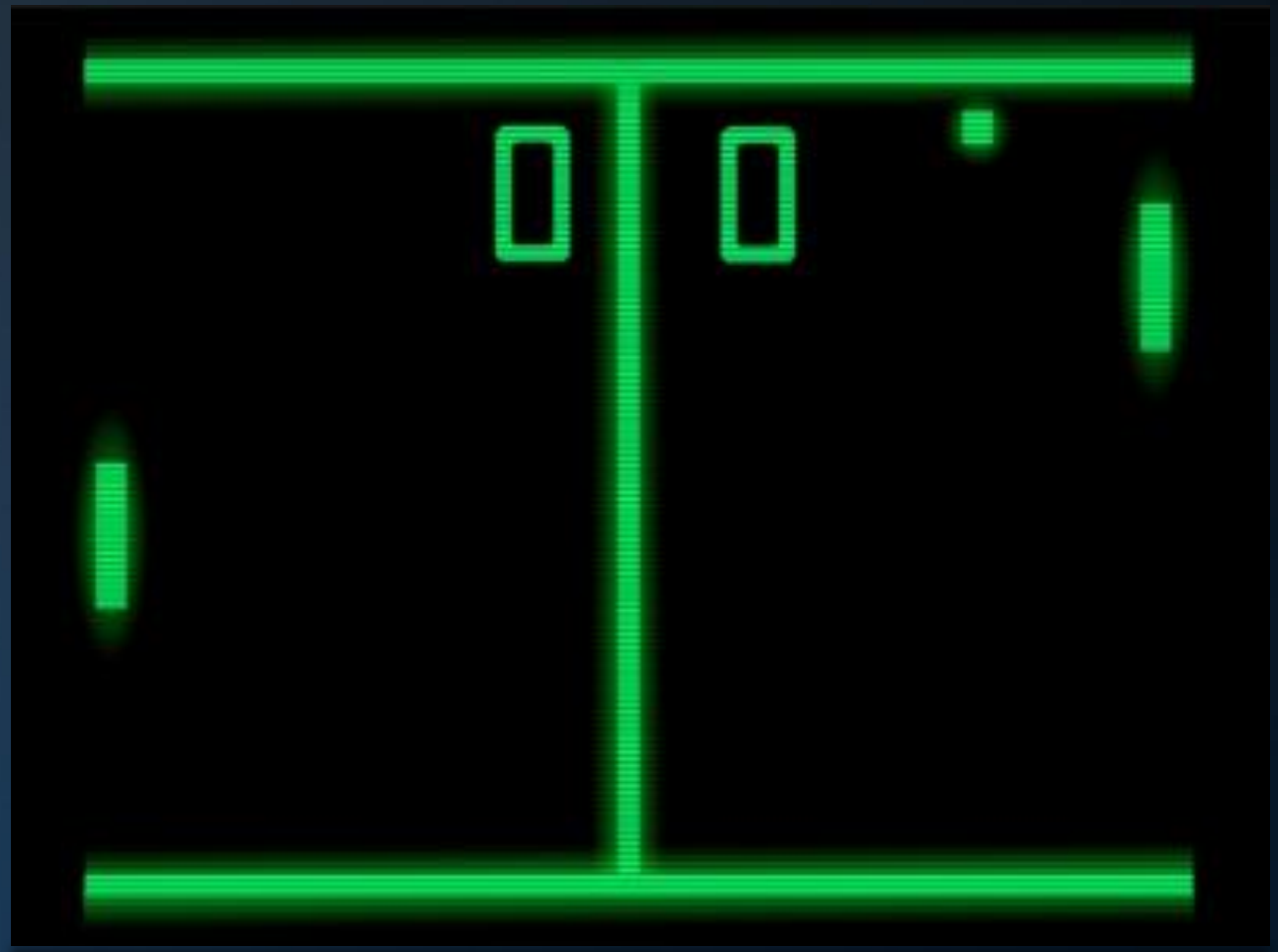
- Topic Introduction
- Course Introduction
- Team
- Practical Details
- Assignments
- Field Study
- State of the Art

Field Study



A. S. Douglas. Noughts and Crosses. EDSAC, 1952.

Field Study



Field Study

1981

1982

1982

Field Study

1985

1987

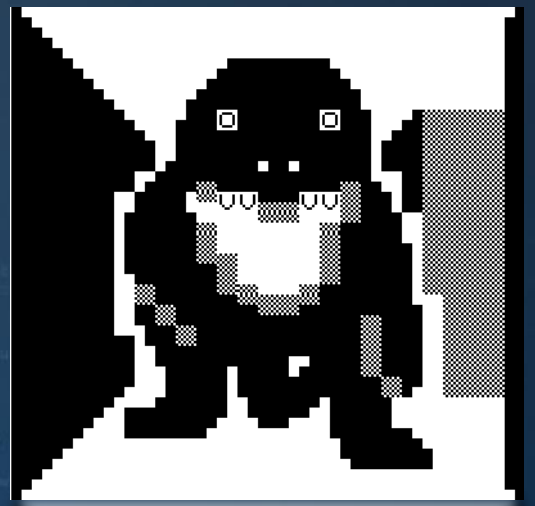
1990

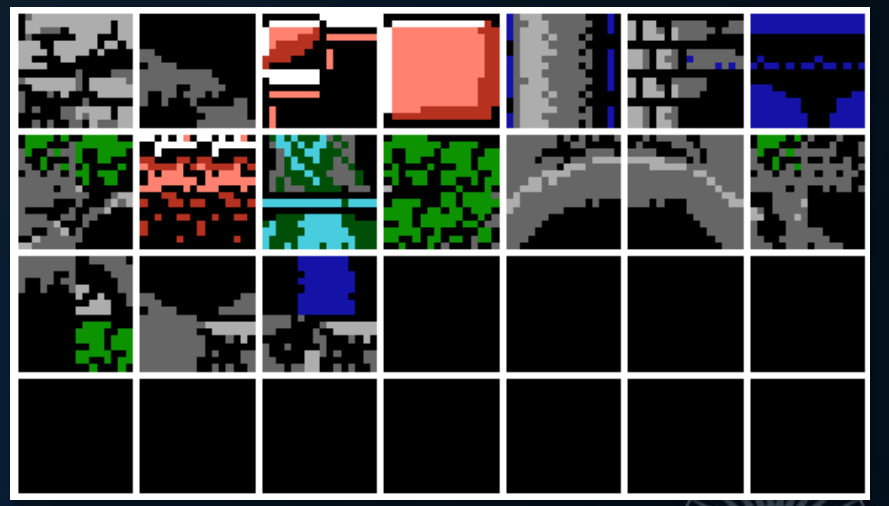
Field Study

Early graphics:

2D, with limitations

- Tiles
- Few colors
- Sprites





Field Study


```
at brdfPdf = EvaluateDiffuse( L, N ) * PI;
at3 factor = diffuse * INVPI;
at weight = Mis2( directPdf, brdfPdf );
at cosThetaOut = dot( N, L );
 E * ((weight * cosThetaOut) / directPdf) * (1.0f / PI);

andom walk - done properly, closely following Sm
vive)

at3 brdf = SampleDiffuse( diffuse, N, r1, r2, &R, &pdf );
urvive;
 pdf;
 = E * brdf * (dot( N, R ) / pdf);
sion = true;
```

Field Study

History of Graphics


50
AMMO
100%
HEALTH
2 3 4
5 6 7
ARMS
2%
ARMOR
BULL 50 / 200
SHEL 0 / 50
RCKT 0 / 50
CELL 0 / 300


SE
S

Field Study

Game production:

Code
Art

Crysis:

> 1M lines of code; 85k shaders

Unreal 3 engine:

2M lines of code

Frostbite:

“10x Unreal 3”

Minecraft:

< 200k lines of code.

Field Study

History of graphics in games, digest

Initially fast progression:

- from 2D to 3D,
- from monochrome to true-color,
- from wireframe to shaded,
- from sparse to highly detailed.

But also:

- from reasonably efficient to produce to extremely labor-intensive.

State of the Art

Industry example: Unreal Engine 4

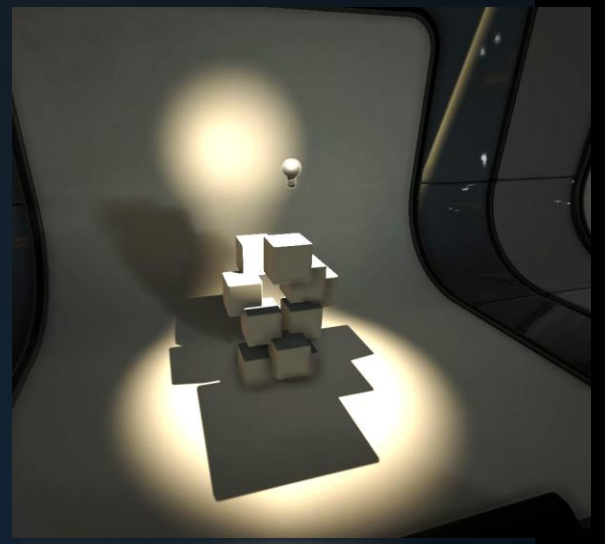
- Lights
- Shadows
- Reflections
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping

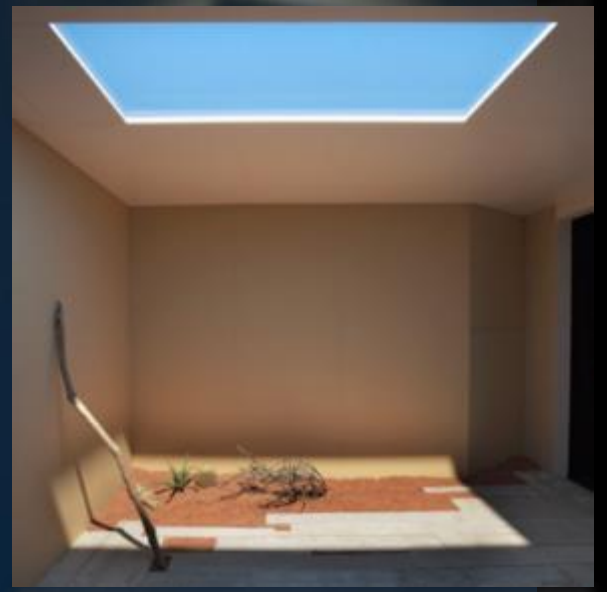
- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

State of the Art

Industry example: Unreal Engine 4

- **Lights**
- Shadows
- Reflections
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping



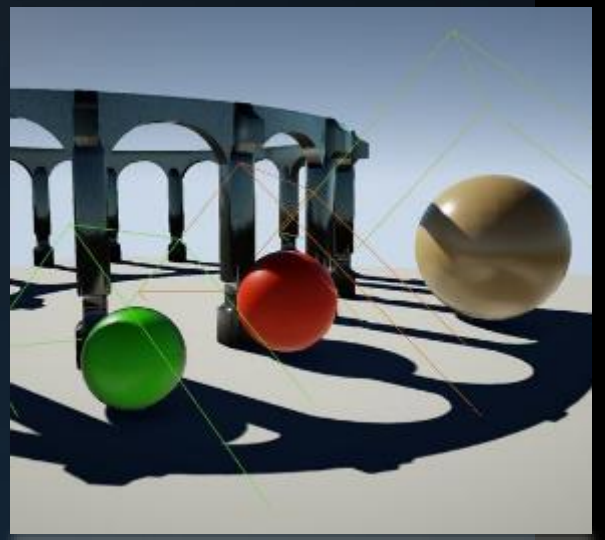


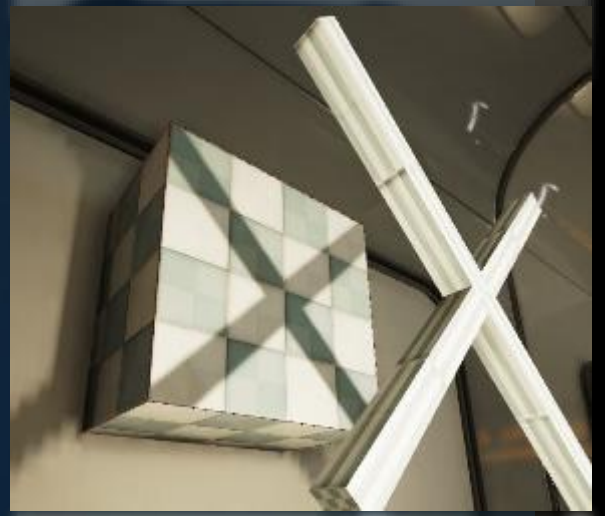
- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

State of the Art

Industry example: Unreal Engine 4

- Lights
- **Shadows**
- Reflections
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping



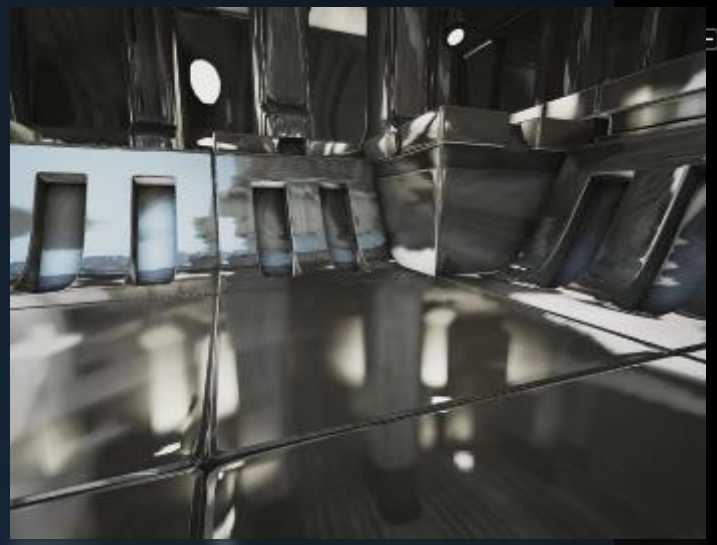


- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- **Reflections**
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping

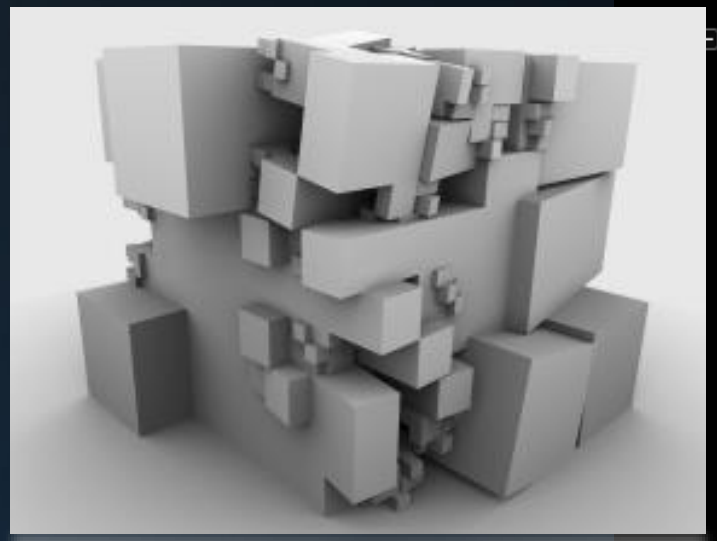


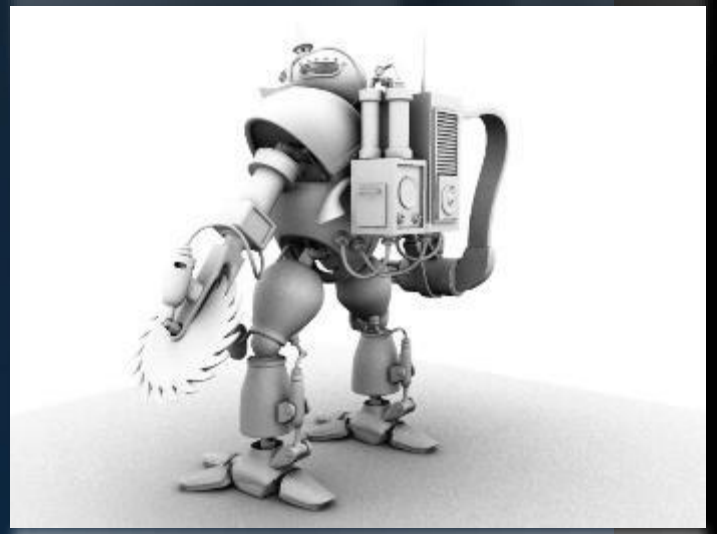
- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

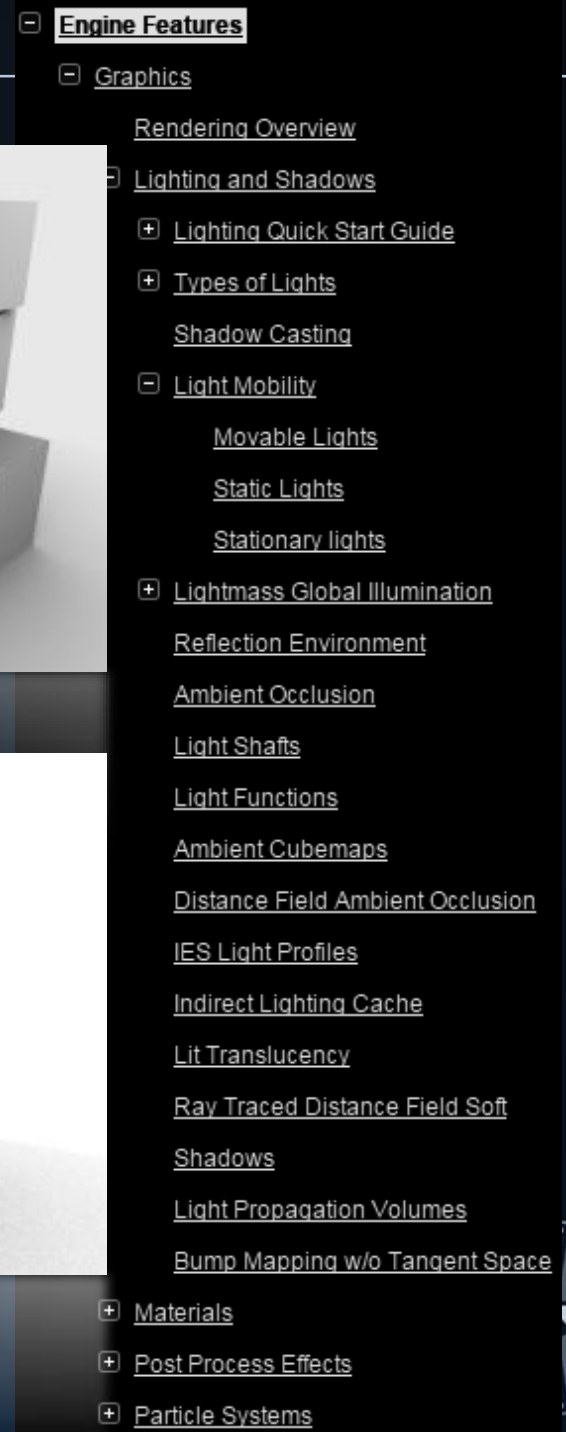
State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- Reflections
- **Ambient occlusion**
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping



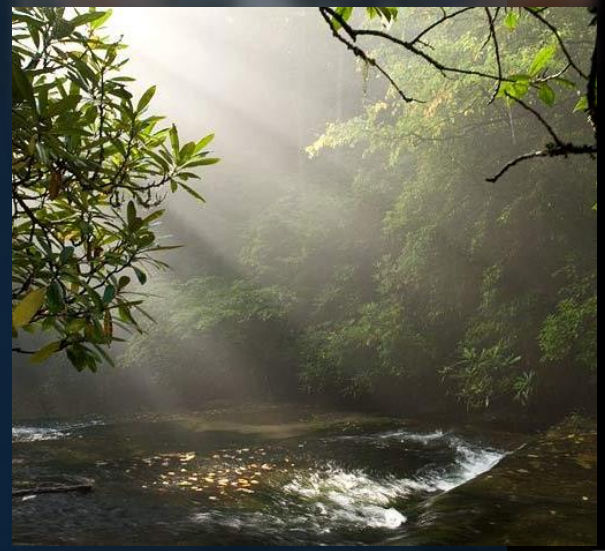




State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- Reflections
- Ambient occlusion
- **Light shafts**
- Indirect lighting cache
- Ray traced soft shadows
- Bump mapping

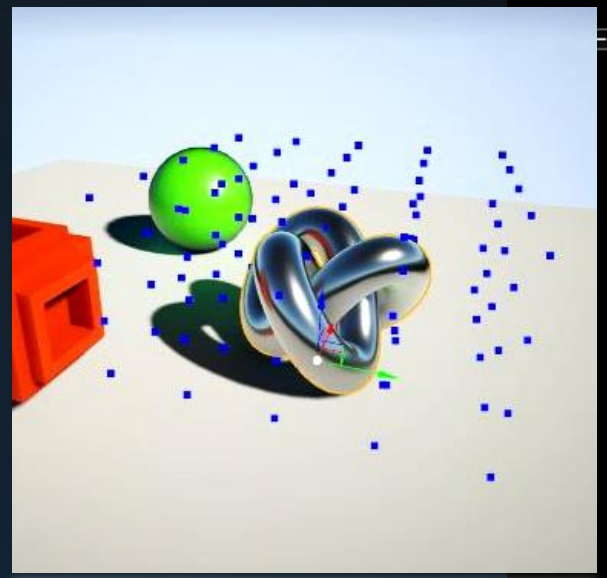


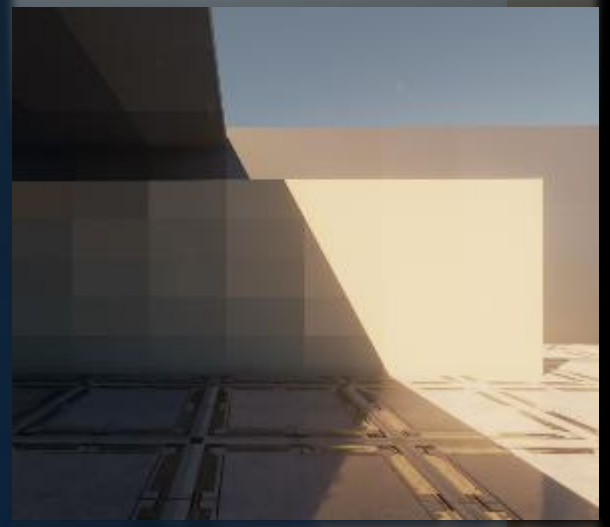
- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- Reflections
- Ambient occlusion
- Light shafts
- **Indirect lighting cache**
- Ray traced soft shadows
- Bump mapping



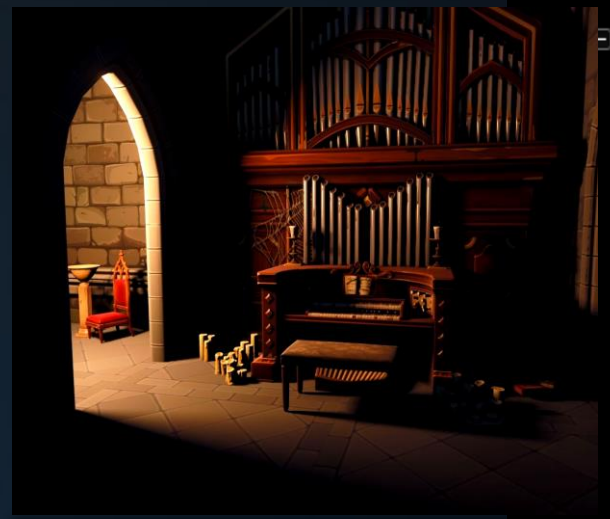


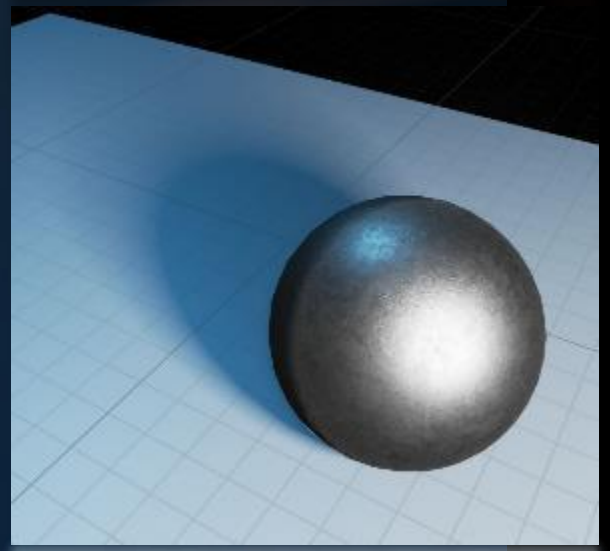
- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

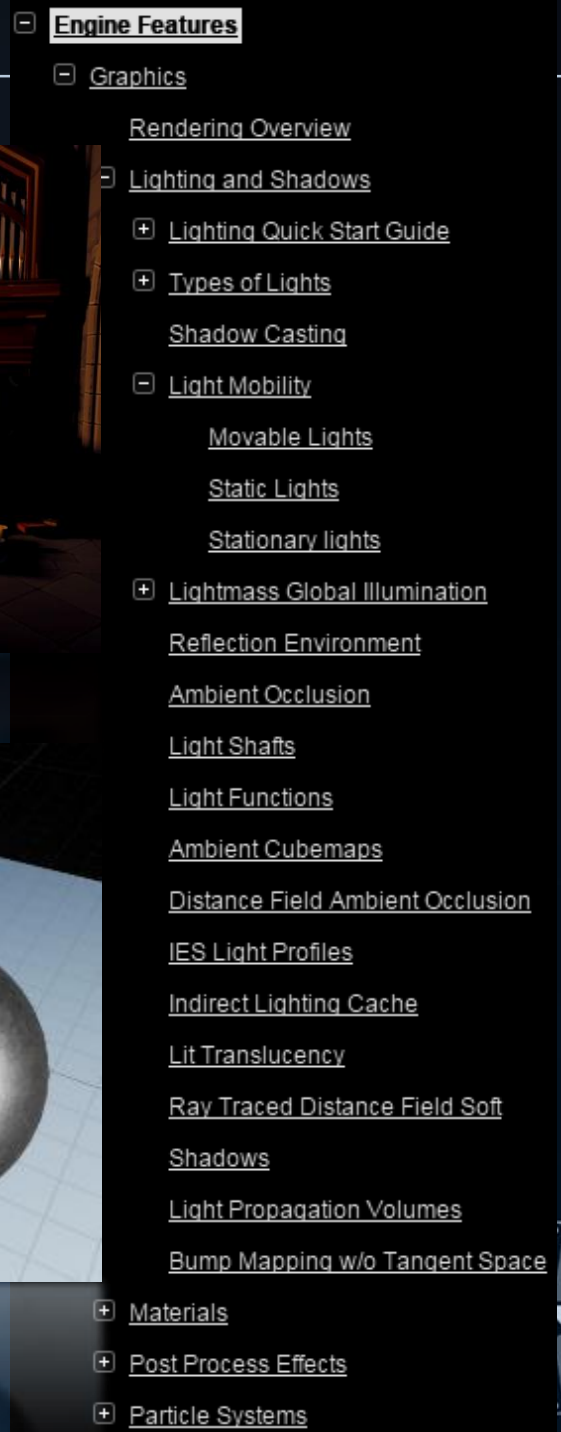
State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- Reflections
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- **Ray traced soft shadows**
- Bump mapping







State of the Art

Industry example: Unreal Engine 4

- Lights
- Shadows
- Reflections
- Ambient occlusion
- Light shafts
- Indirect lighting cache
- Ray traced soft shadows
- **Bump mapping**

- Engine Features
  - Graphics
    - Rendering Overview
    - Lighting and Shadows
      - Lighting Quick Start Guide
      - Types of Lights
      - Shadow Casting
      - Light Mobility
        - Movable Lights
        - Static Lights
        - Stationary lights
      - Lightmass Global Illumination
      - Reflection Environment
      - Ambient Occlusion
      - Light Shafts
      - Light Functions
      - Ambient Cubemaps
      - Distance Field Ambient Occlusion
      - IES Light Profiles
      - Indirect Lighting Cache
      - Lit Translucency
      - Ray Traced Distance Field Soft Shadows
      - Light Propagation Volumes
      - Bump Mapping w/o Tangent Space
    - Materials
    - Post Process Effects
    - Particle Systems

State of the Art

Modern rendering in games:

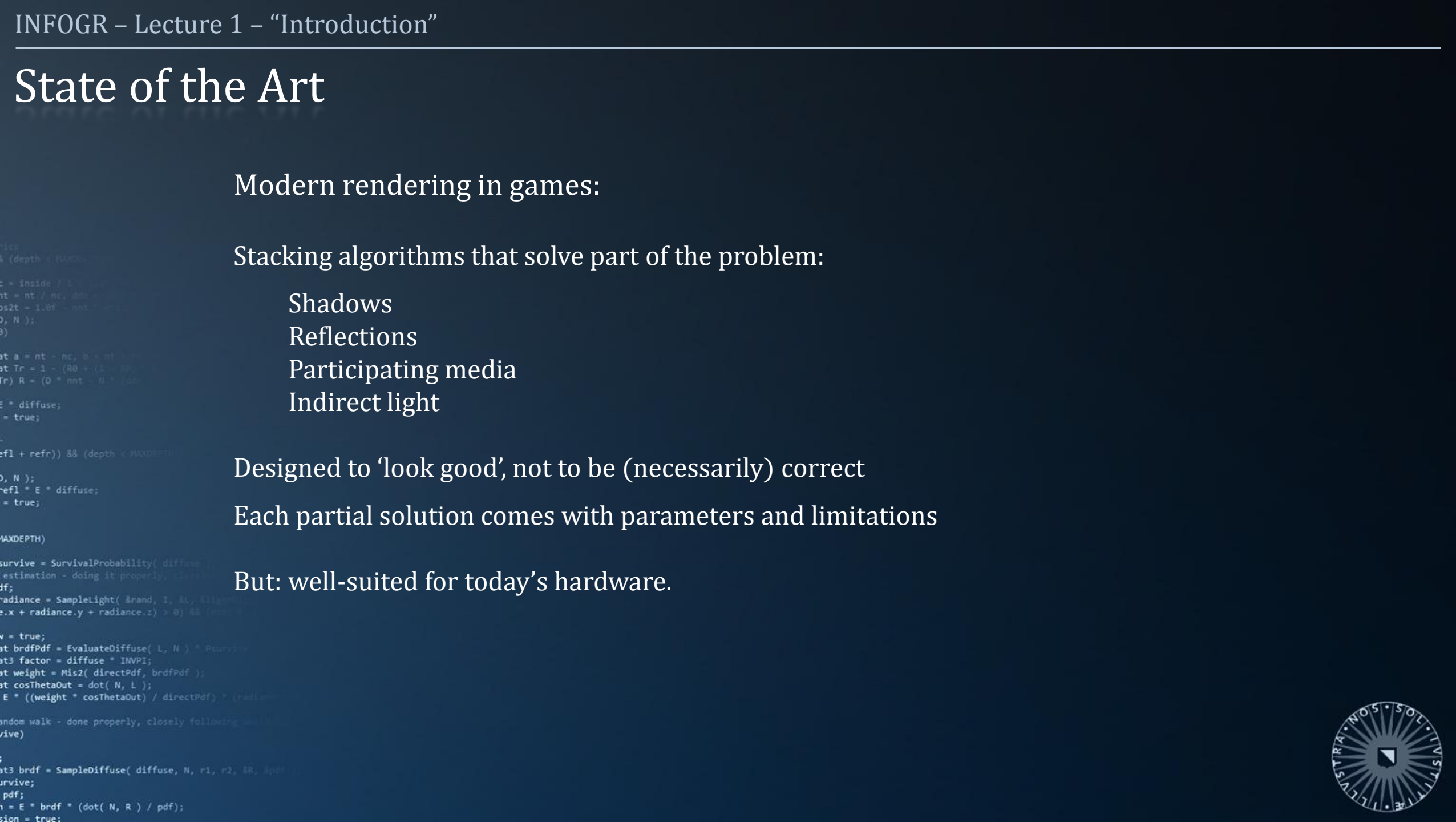
Stacking algorithms that solve part of the problem:

- Shadows
- Reflections
- Participating media
- Indirect light

Designed to ‘look good’, not to be (necessarily) correct

Each partial solution comes with parameters and limitations

But: well-suited for today’s hardware.



Next week:

Foundation

INFOGR – Computer Graphics

Jacco Bikker - April-July 2015 - Lecture 1: “Introduction”

END of “Introduction”

next lecture: “Graphics Fundamentals”