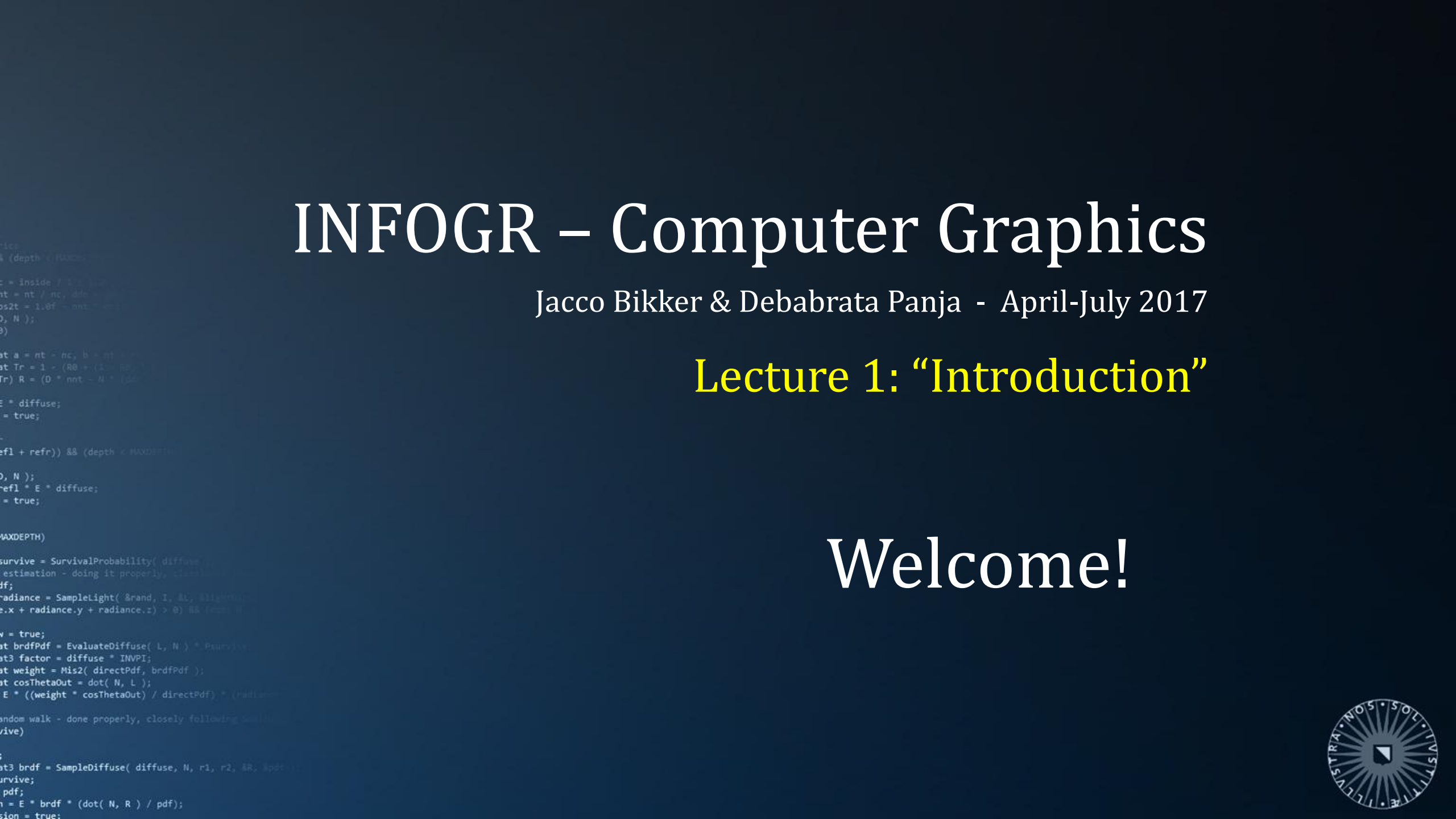
INFOGR – Computer Graphics

Jacco Bikker & Debabrata Panja - April-July 2017

Lecture 1: “Introduction”

Welcome!



Today’s Agenda:

- Graphics
- Course Introduction
- Field Study
- Rasters
- Colors

Introduction

Just Cause 3

Introduction

HALO 5

Introduction

GTA V

Introduction

Homeworld Remastered

Introduction

Crysis

Introduction

Crysis

Introduction

Lord of the Rings

Introduction

Furious 7 (Paul Walker)

Introduction

Star Wars

Introduction

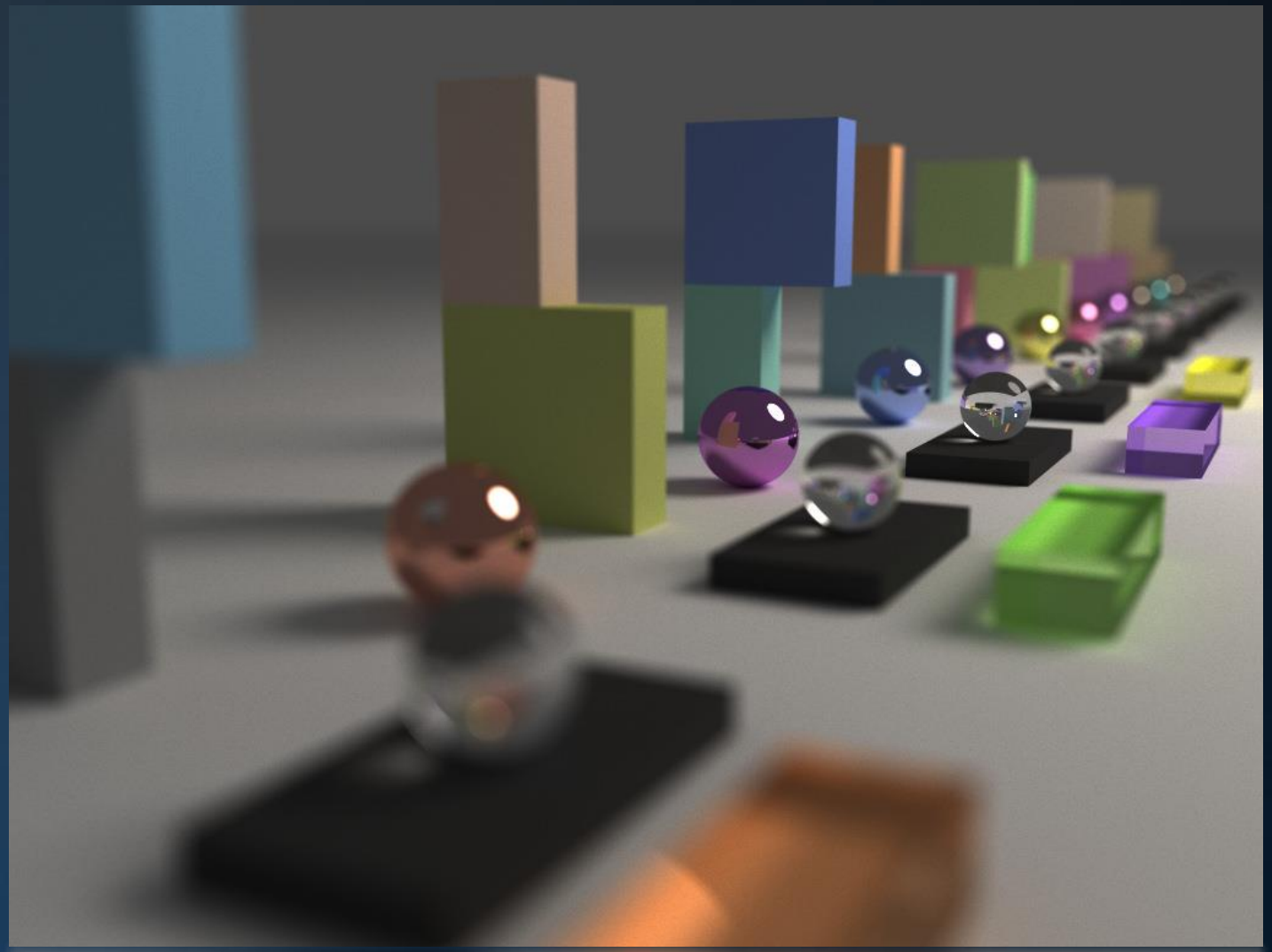
Zootopia

Introduction

Introduction

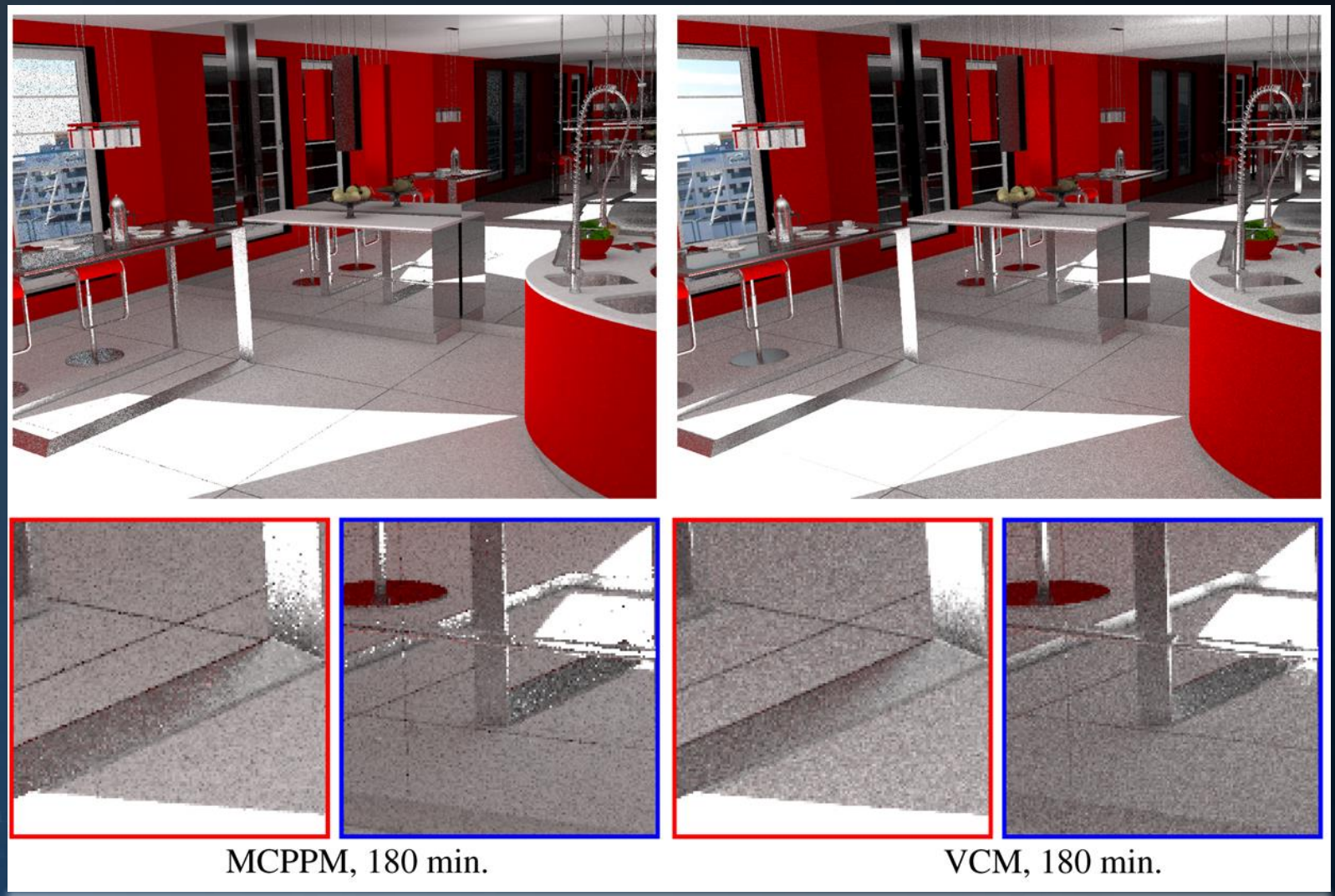
Just Cause 3

Introduction

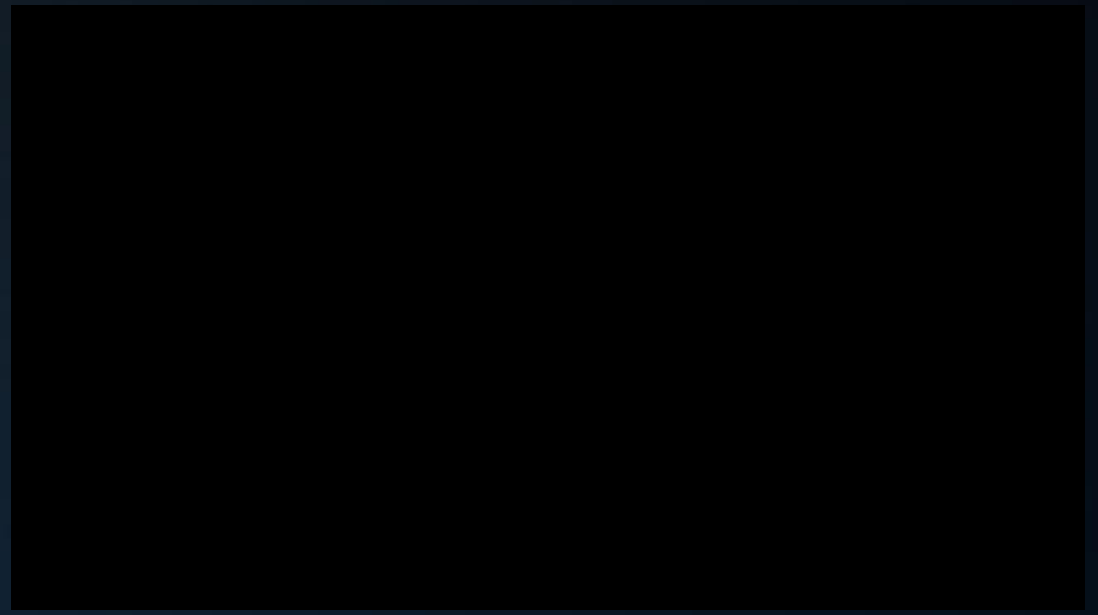


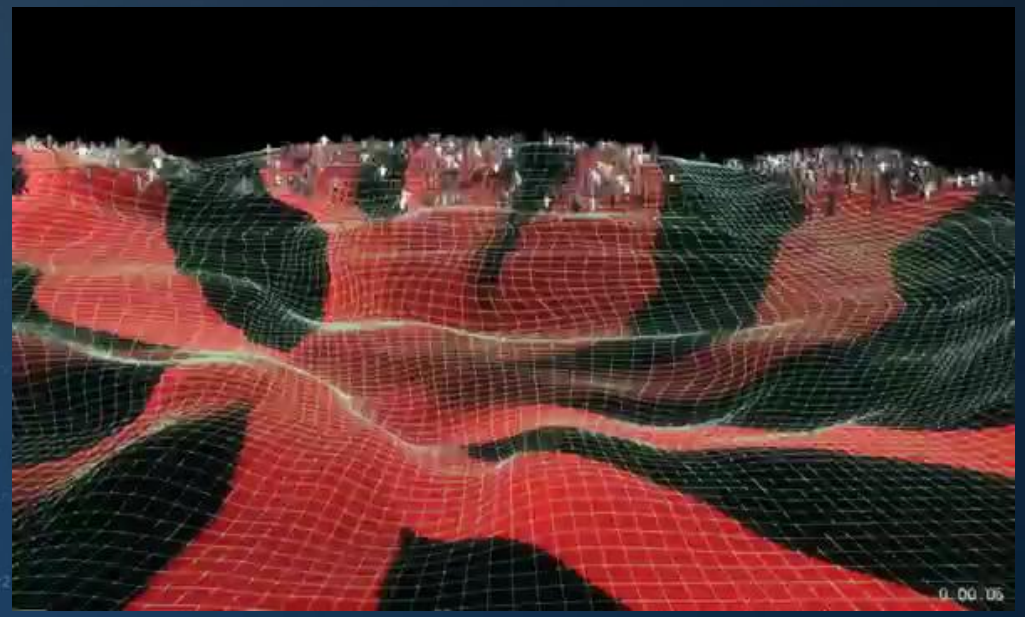
Introduction

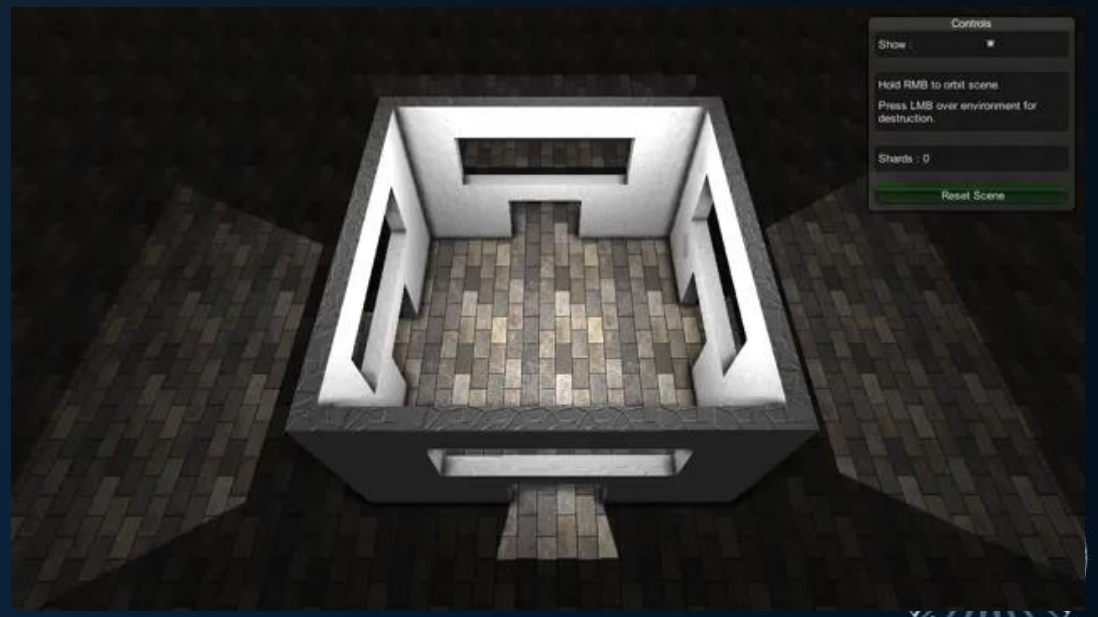
Introduction



Introduction





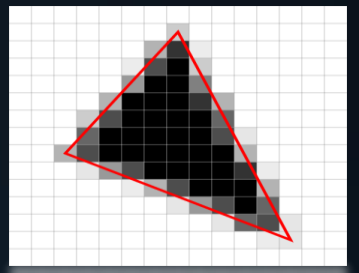


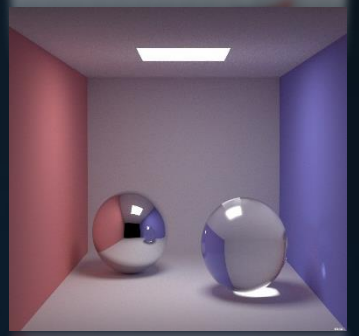
Introduction

Computer Graphics 2017:

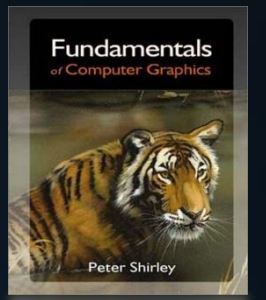
Looking for realism (in several wrong places):

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 4th, or 2nd, or 1st).

15 lectures.

Supporting math tutorials on Tuesdays (starting week 2).
Supporting working lectures on Thursdays (starting week 2).

For rooms: see schedule.

Introduction

Exams:

- Mid-term: May 23th.
- End of term: June 29th.
- Retake: July 13th.

Attendance:

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

*Obviously, attendance is highly recommended.

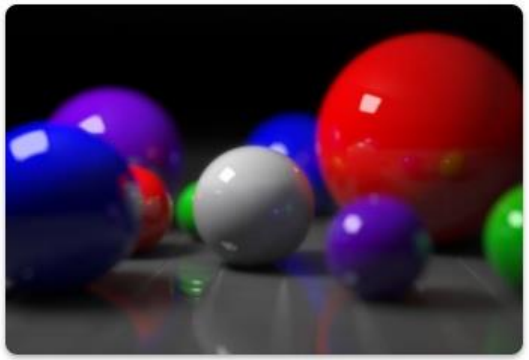
www.cs.uu.nl/docs/vakken/gr/2017/index.html

gmail news tech games misc playlists coding research tools INFOGR Netflix Zermelo Portal Inlogg postprocessing (14) CGI & VFX Breakc

Graphics

UNIVERSITEIT UTRECHT - INFORMATION AND COMPUTING SCIENCES

academic year 2016/17 – 4th period



Navigation

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

Course Overview | Schedule | Practica | Literature & Links

News

https://infogr2017.slack.com/signup

Slack - infogr2017

Ctrl+1 Ctrl+2 Ctrl+3 Ctrl+4

infogr2017
jbikker
All Threads
CHANNELS (2)
general
random
DIRECT MESSAGES
slackbot
jbikker (you)
+ Invite people

#general
1 | 0 | Company-wide announcements and work-based matt...
Search

https://infogr2017.slack.com/signup

use uu.nl e-mail address

#general

You created this channel today. This is the very beginning of the #general channel. Purpose: *This channel is for team-wide communication and announcements. All team members are in this channel.* (edit)

+ Add an app or custom integration Invite people to **infogr2017**

Today

jbikker 9:55 AM
joined #general

Message #general

Introduction

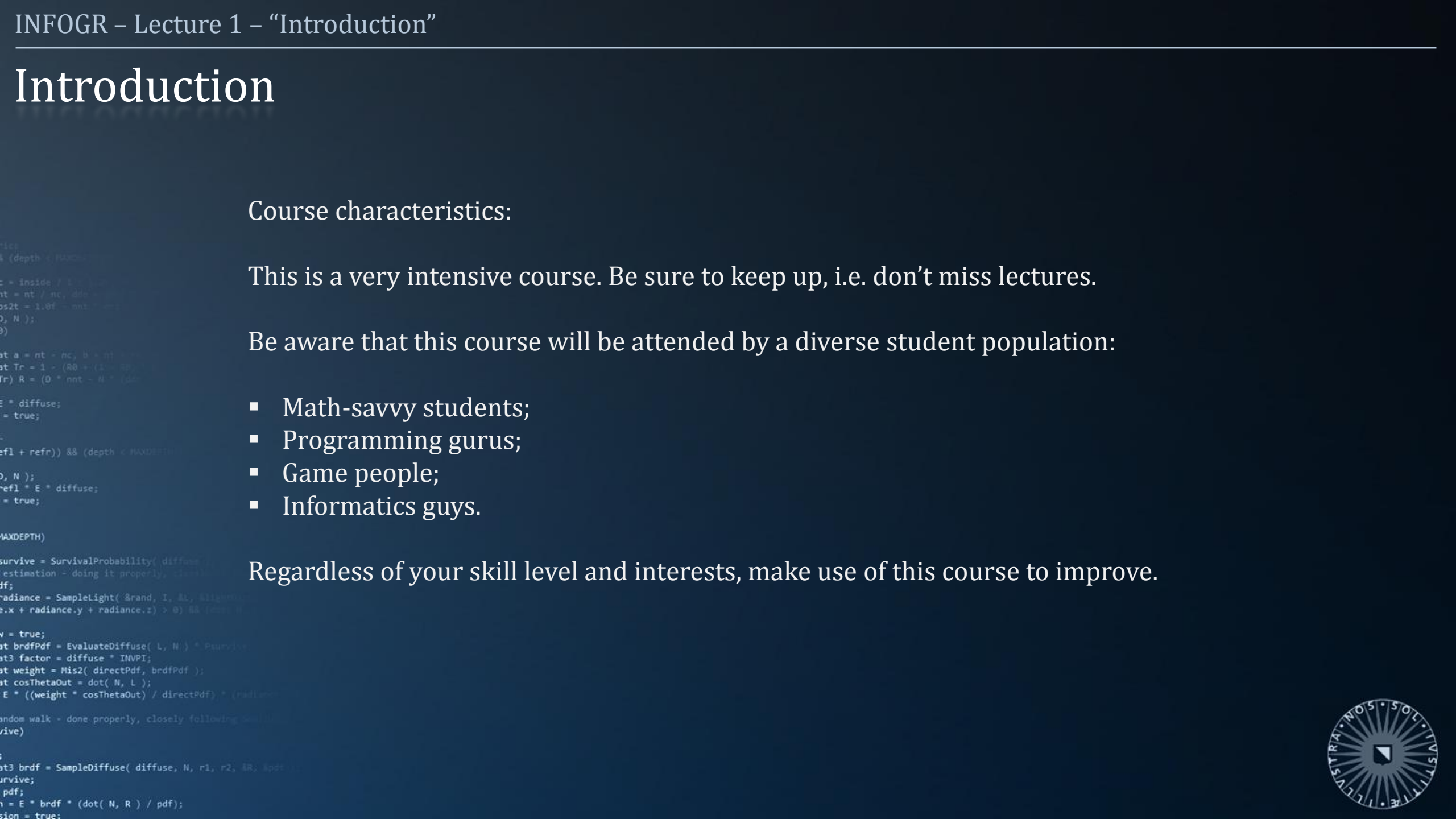
Course characteristics:

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.

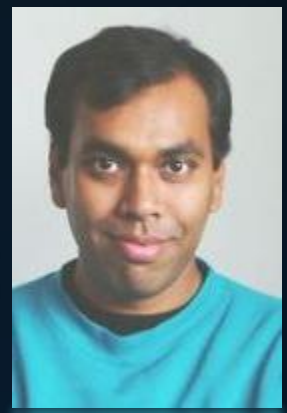


Team

Lecturers:

Jacco Bikker
bikker.j@gmail.com / j.bikker@uu.nl
Office: BBL 424

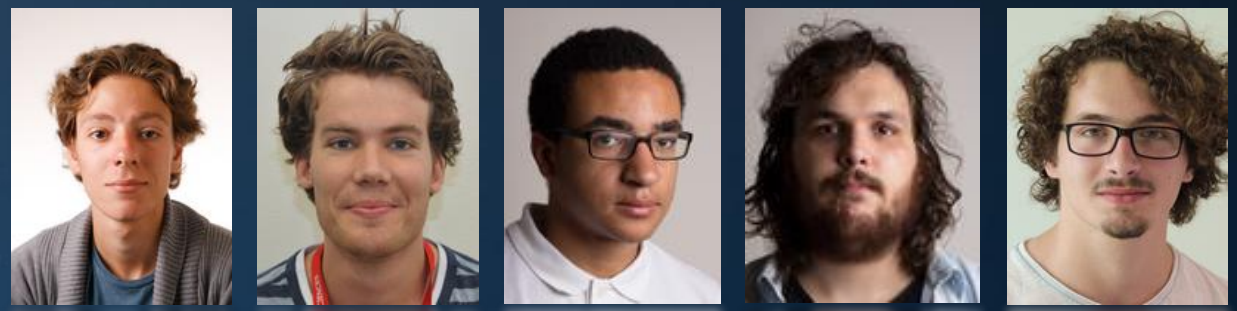
Debabrata Panja
d.panja@uu.nl
Office: BBL 511



Team

Student Assistants:

1. Kevin van Mastrigt
2. Sander Vanheste
3. Zino Onomiwo
4. Hugo Hogenbirk
5. Niek Mulleners



Practical Details

Assignment Overview:
i. P1: “Tutorial”;
ii. P2: Ray Tracing;
iii. P3: Rasterization.
Final practicum grade is 0.2 * P1 + 0.4 * P2 + 0.4 * P3.

Exam overview:
i. T1: Mid-term exam;
ii. T2: Final exam.
Final exam grade is 0.3 * T1 + 0.7 * T2.

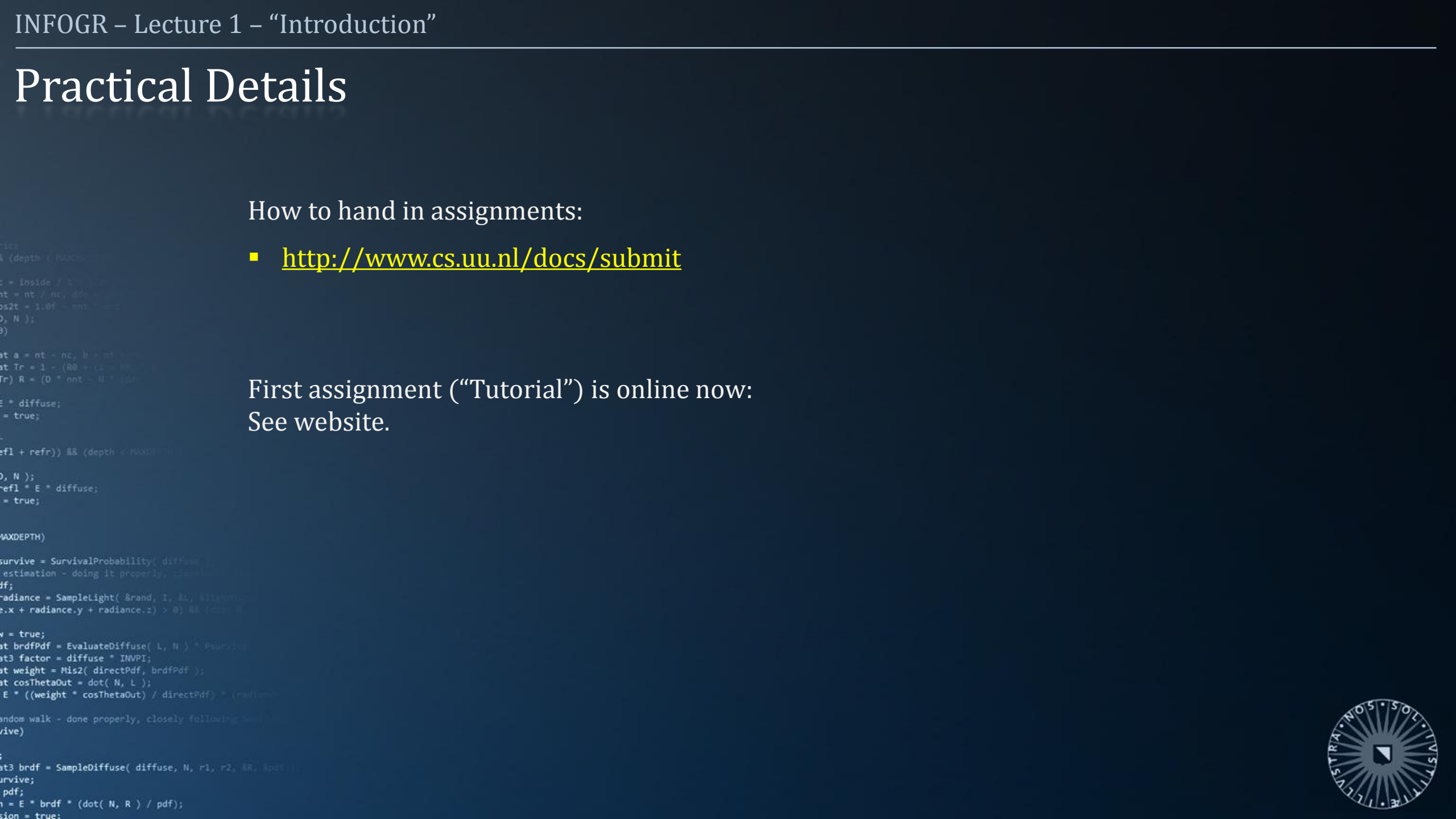
Final grade: (T + P) / 2
Passing criteria:
Final Grade ≥ 6 (after rounding); both T and P ≥ 5.0 (before rounding).

Practical Details

How to hand in assignments:

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

First assignment (“Tutorial”) is online now:
See website.



Practical Details

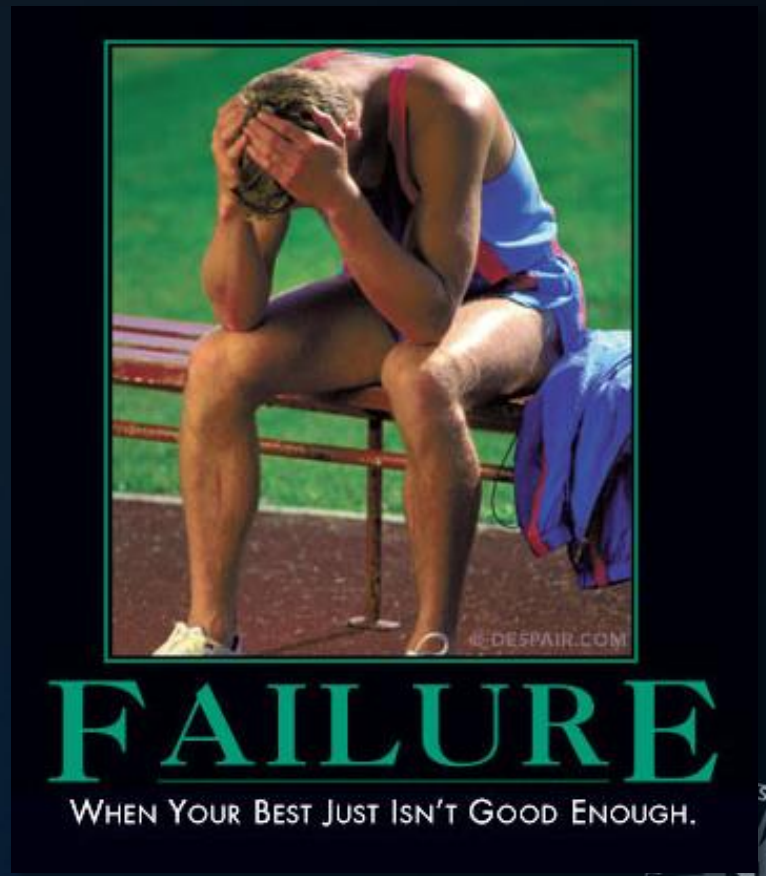
Retake: only if you failed the course, and scored at least a 4.0 (before rounding).

Retake / Theory:

- Retake covers all theory and replaces min(T1, T2).

Retake / Practical:

- Retake replaces min(P1, P2, P3).
  Topic will be assigned individually.



Assignments

PART 1: Mathematics

Tutorial 1 will be available on Thursday, April 28th.

PART 2: Programming assignment

P1 (OpenTK Tutorial) is now available from the website.
Assistance is available on Tuesday, May 3rd in rooms BBG-079, -083, -109 and -112.

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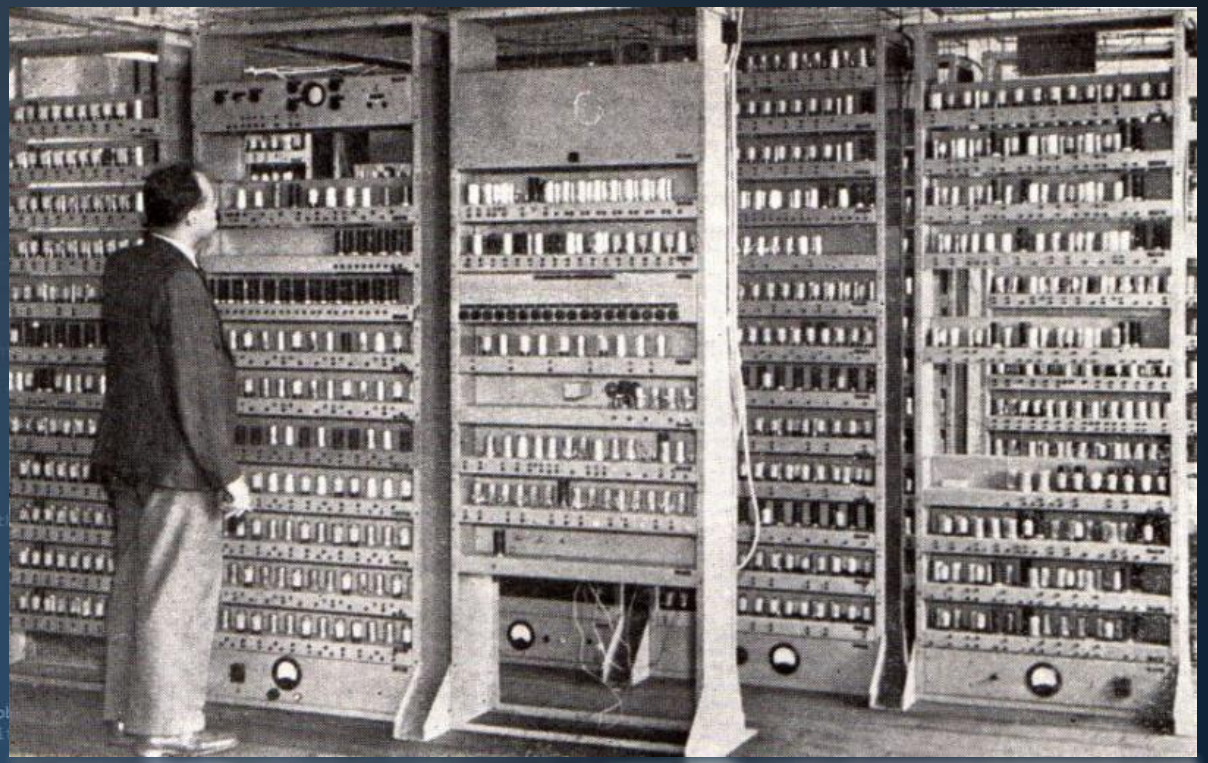
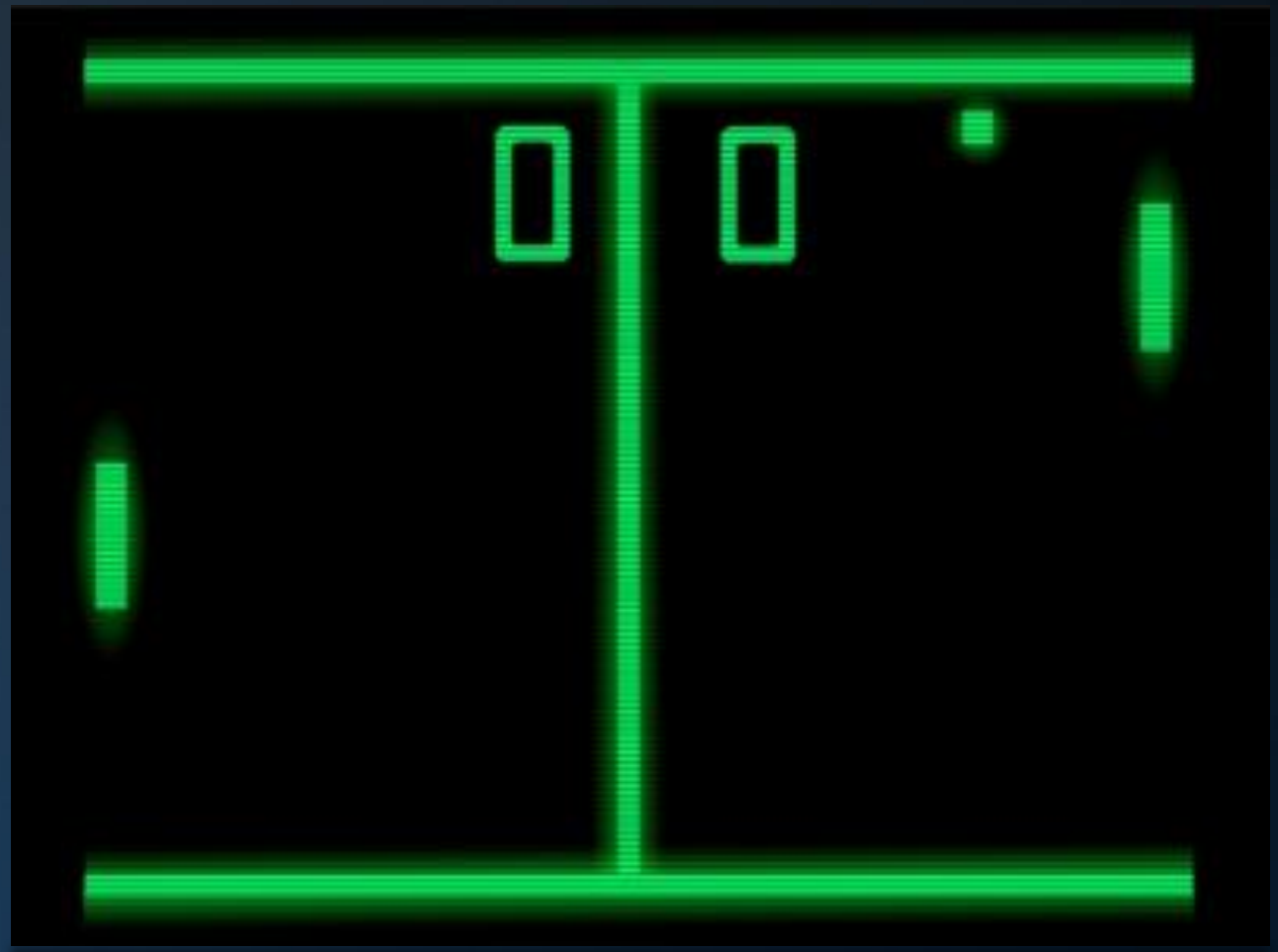
- Field Study
- Rasters
- Colors

Field Study



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

Field Study



Field Study

1981

1982

1982

Field Study

1985

1987

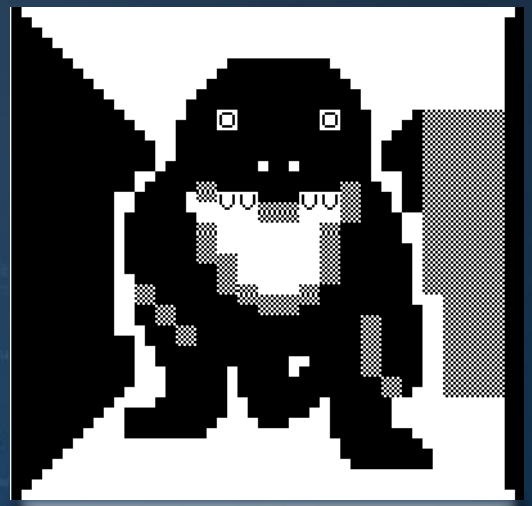
1990

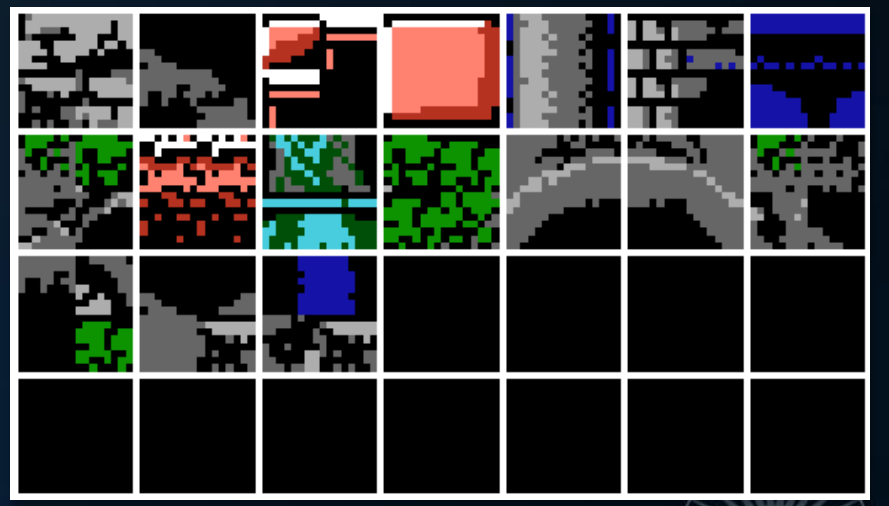
Field Study

Early graphics:

2D, with limitations

- Tiles
- Few colors
- Sprites





Field Study


```
at brdfPdf = EvaluateDiffuse( L, N ) * Pdf();
at3 factor = diffuse * INVPI;
at weight = Mis2( directPdf, brdfPdf );
at cosThetaOut = dot( N, L );
 E * ((weight * cosThetaOut) / directPdf) * (radiance
andom walk - done properly, closely following Smi
vive)
at3 brdf = SampleDiffuse( diffuse, N, r1, r2, &R, &pdf );
urvive;
 pdf;
 = E * brdf * (dot( N, R ) / pdf);
sion = true;
```

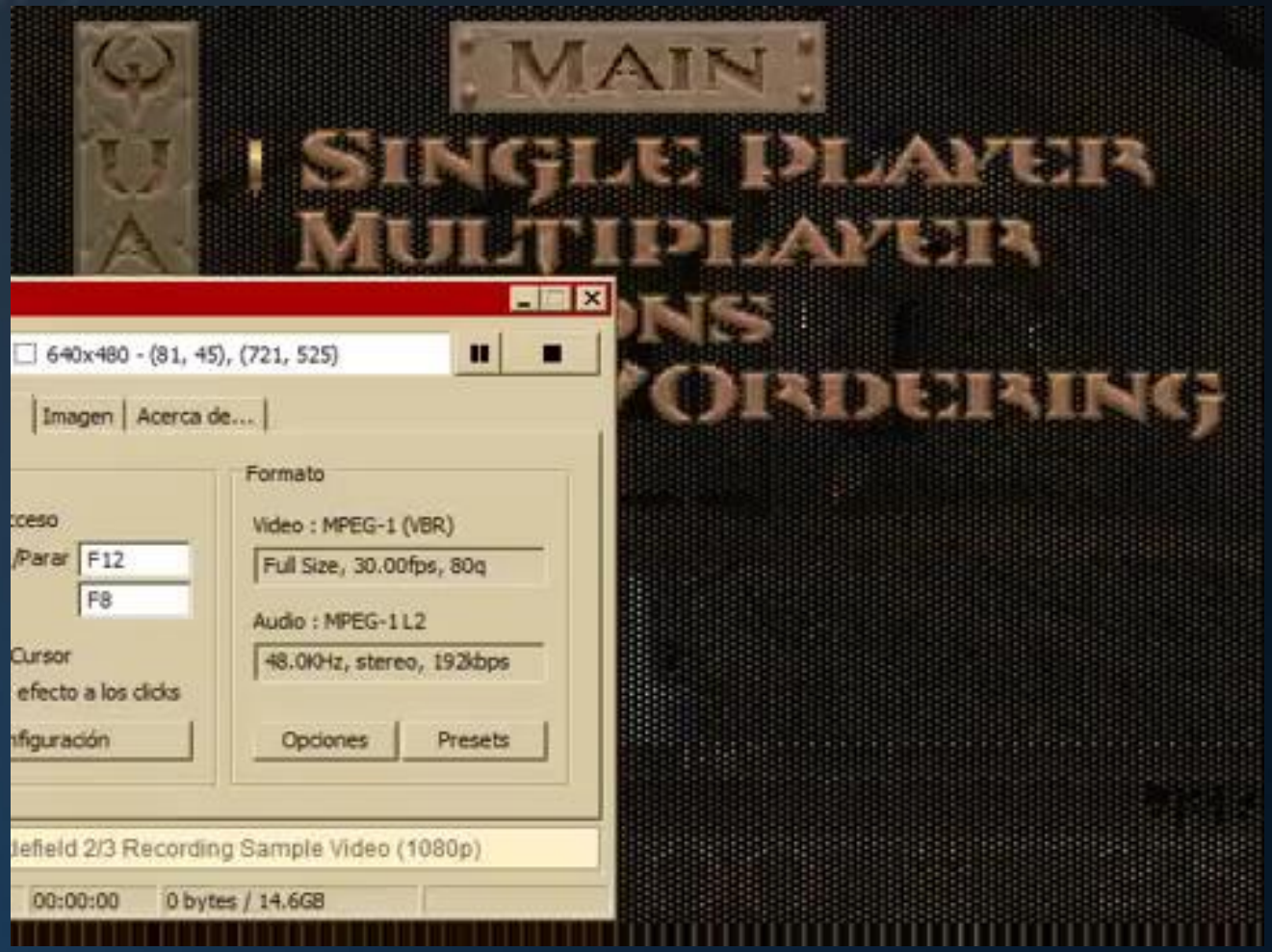
Field Study


THE FLIP Channel
A500
OPERATIONS MANUAL
AMIGA
CAPTURED PRINCESS
EXIT
HIDDEN TREASURE
TODO:
- BUY SHIP
- FIND BIG WHOOP
- DEFEAT LECHUCK
- MARRY ELAINE!
SECTOR 56
GEAR
BRAKES
CHAFF 09 FLARE 09
Commodore 1084X


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

History of Graphics

History of Graphics

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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.

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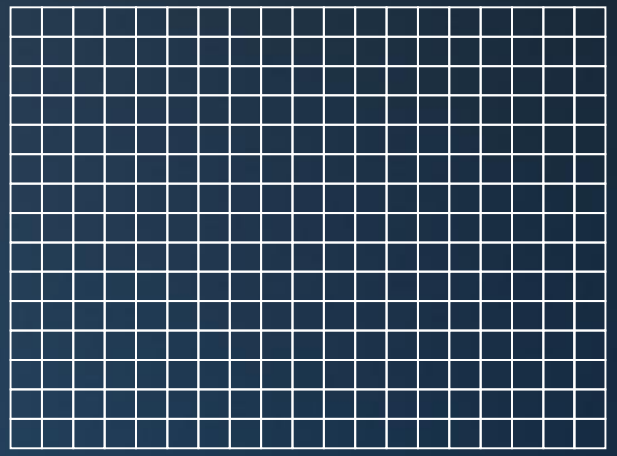
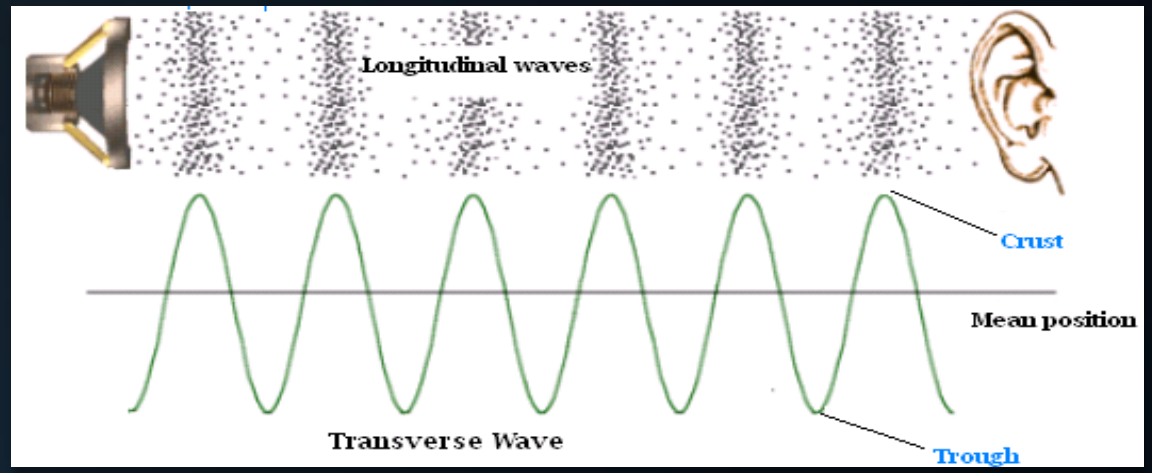
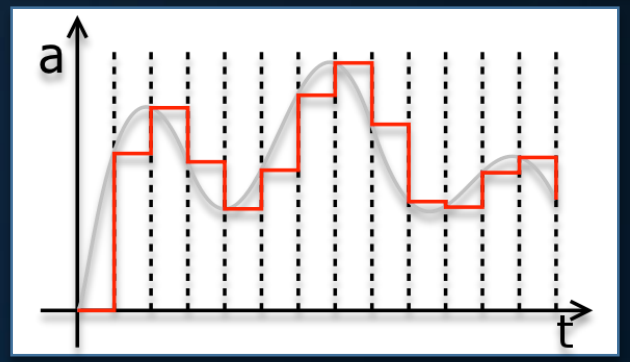
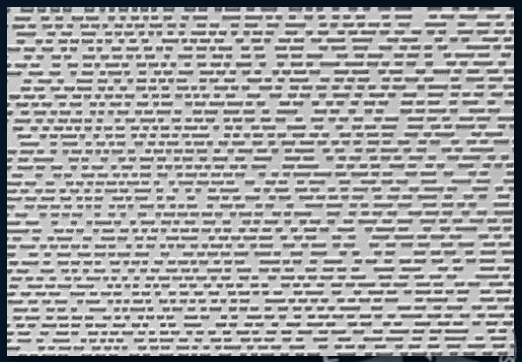
Raster Displays

Discretization



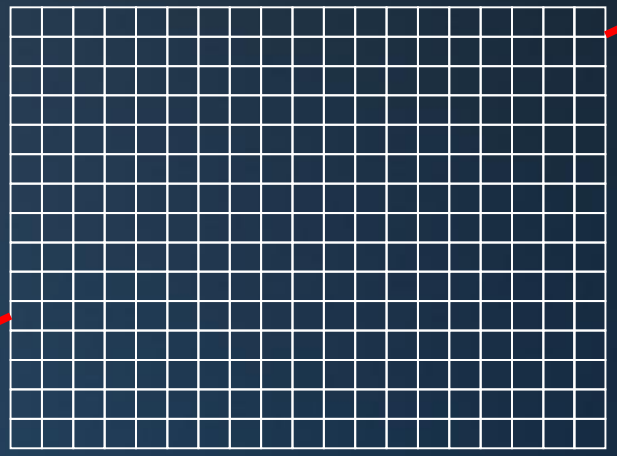






Raster Displays

Discretization



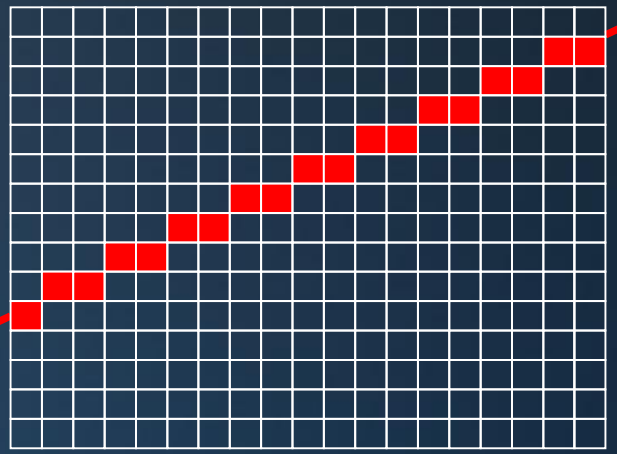
Rasterization:

“Converting a vector image into a raster image for output on a video display or printer or storage in a bitmap file format.”

(Wikipedia)

Raster Displays

Rasterization

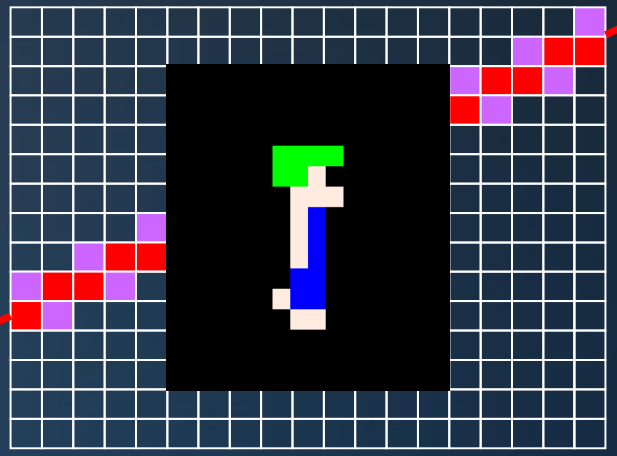


Improving rasterization:

1. Increase resolution;

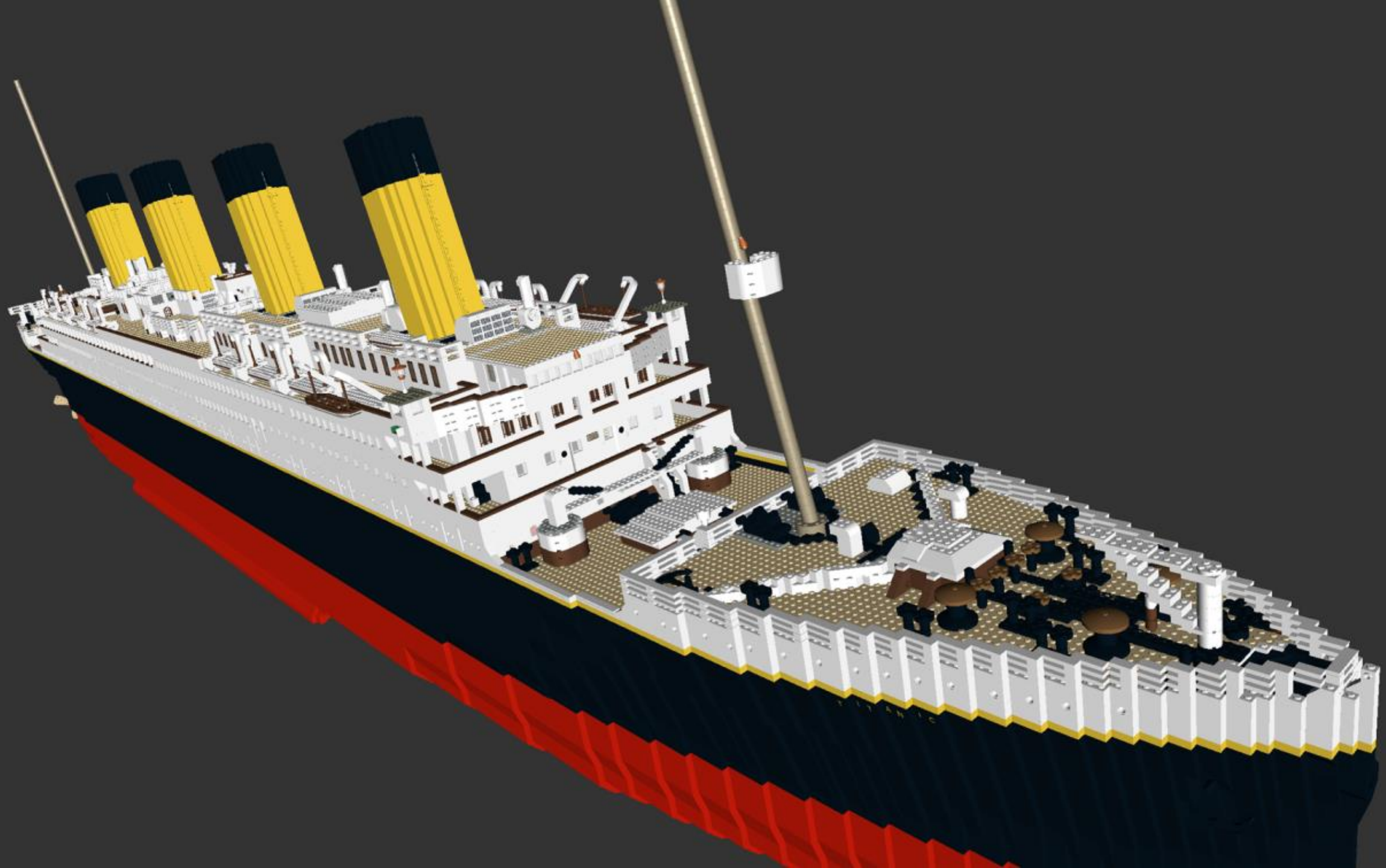
Raster Displays

Rasterization



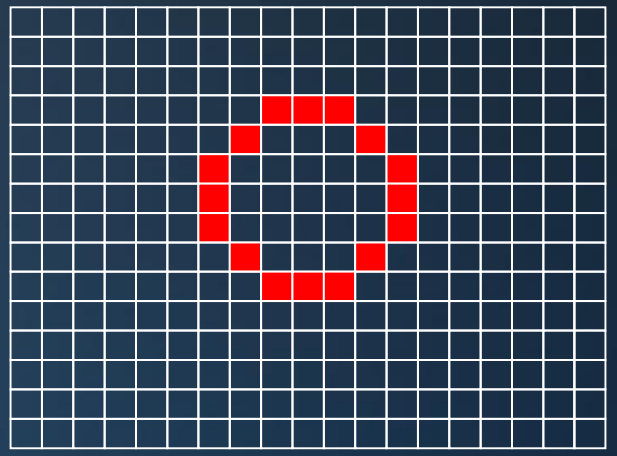
Improving rasterization:

1. Increase resolution;
2. Anti-aliasing;
3. Animation.



Raster Displays

Discretization



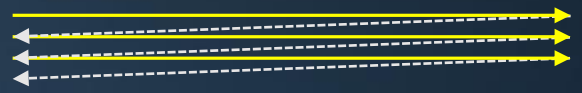
$$\pi = 4$$

$$a^2 + b^2 = c^2$$

$$a^1 + b^1 = c^1$$

Raster Displays

CRT – Cathode Ray Tube

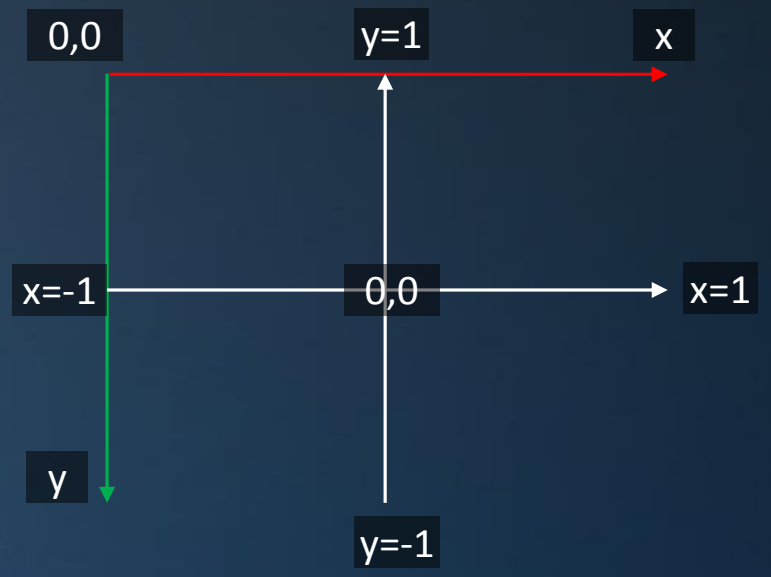


Physical implementation – origins

Electron beam zig-zagging over a fluorescent screen.

Raster Displays

CRT – Cathode Ray Tube



Physical implementation – consequences

- Origin in the top-left corner of the screen
- Axis system directly related to pixel count

Not the coordinate system we expected…

Raster Displays

Frame rate

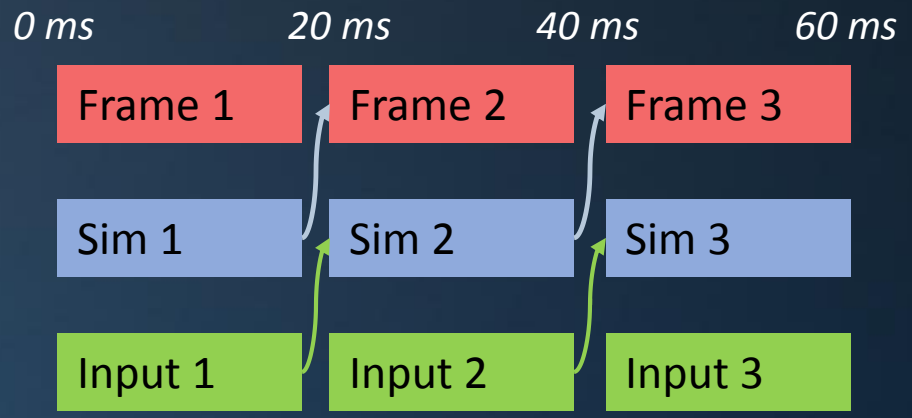
PAL: 25fps
NTSC: 30fps (actually: 29.97)
Typical laptop screen: 60Hz
High-end monitors: 120-240Hz
Cartoons: 12-15fps

Human eye:
‘Frame-less’
Not a raster.

How many fps / megapixels is ‘enough’?

Raster Displays

Frame rate



Even 100 frames per second may result in a noticeable delay of 30ms.

A very high frame rate minimizes the response time of the simulation.

Raster Displays

Generating images

Rendering:
“The process of generating an image on a raster from a 2D or 3D model by means of a computer program.”
(Wikipedia)

Two main methods:

1. Ray tracing: for each pixel: what color do we assign to it?
2. Rasterization: for each triangle, which pixels does it affect?

Today’s Agenda:

- Graphics
- Course Introduction
- Field Study
- Rasters
- Colors

Colors

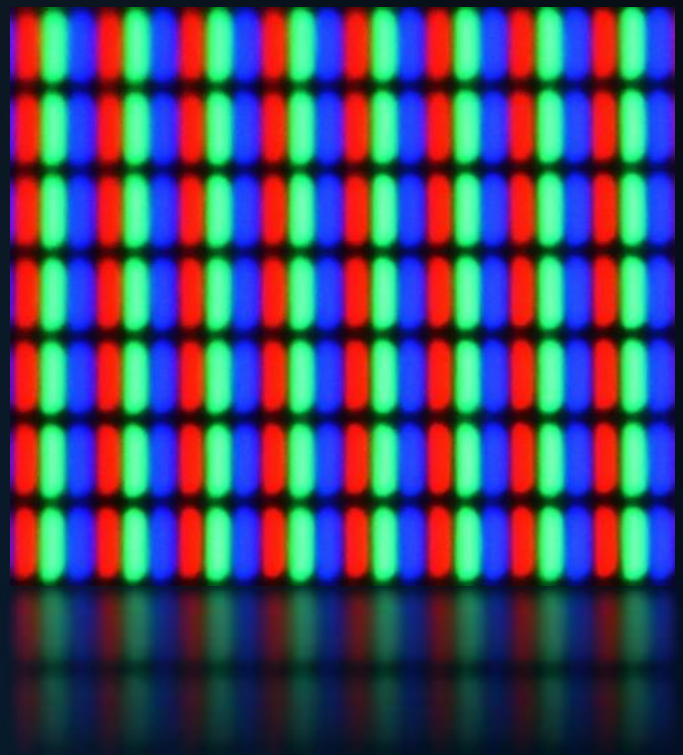
Color representation

Computer screens emit light in three colors: red, green and blue.

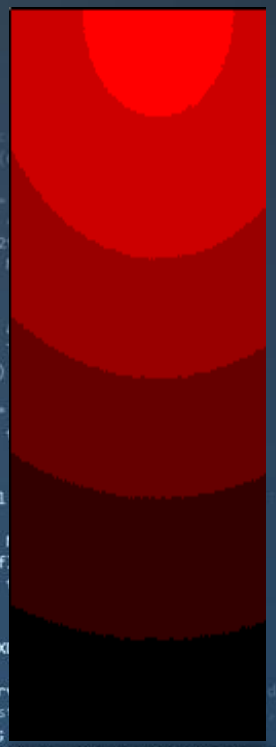
By additively mixing these, we can produce most colors: from black (red, green and blue turned off) to white (red, green and blue at full brightness).

In computer graphics, colors are stored in discrete form. This has implications for:

- Color resolution (i.e., number of unique values per component);
- Maximum brightness (i.e., range of component values).



Colors

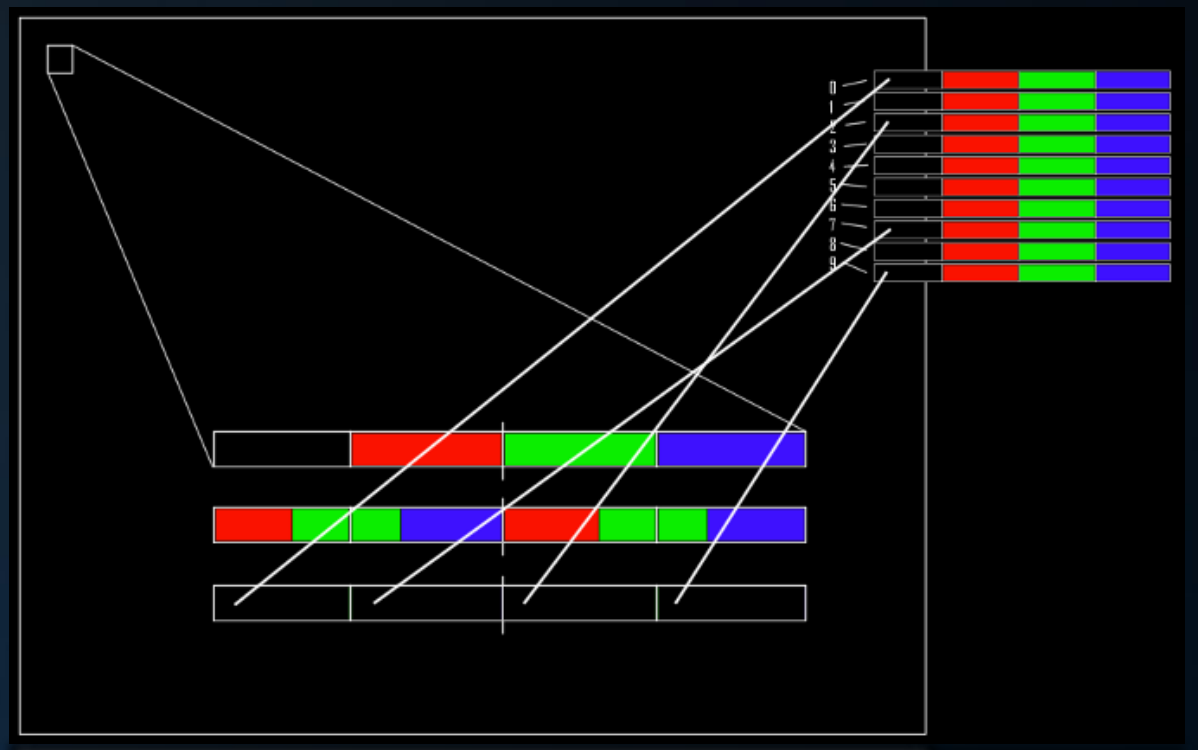


Color representation

The most common color representation is 32-bit ARGB, which stores red, green and blue as 8 bit values (0..255).

Alternatively, we can use 16 bit for one pixel (RGB 565),

or a color palette. In that case, one byte is used per pixel, but only 256 unique colors can be used for the image.



Colors

Color representation

Colors

Color representation

Colors

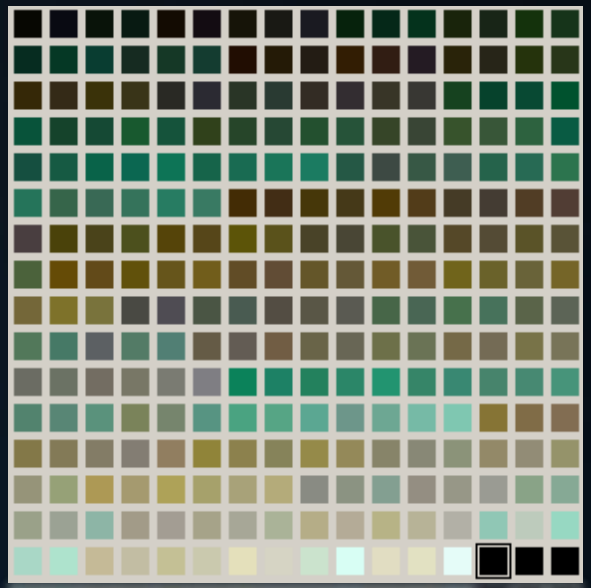
Color representation

Colors

Color representation

Textures can typically safely be stored as palletized images.

Using a smaller palette will result in smaller compressed files.



Colors

Color representation

Using a fixed range (0:0:0 … 255:255:255) places a cap on the maximum brightness that can be represented:

- A white sheet of paper: (255,255,255)
- A bright sky: (255,255,255)

The difference becomes apparent when we look at the sky and the sheet of paper through sunglasses.

(or, when the sky is reflected in murky water)

Colors

Color representation

For realistic rendering, it is important to use an internal color representation with a much greater range than 0..255 per color component.

HDR: High Dynamic Range;

We store one float value per color component.

Including alpha, this requires 128bit per pixel.

Today’s Agenda:

- Graphics
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- Colors

Next Time:

- Ray Tracing
  - Primitives
  - Vectors
  - Coordinate systems
  - Projections

INFOGR – Computer Graphics

Jacco Bikker & Debabrata Panja - April-July 2017

END OF lecture 1: “Introduction”

Next lecture: “Ray Tracing”