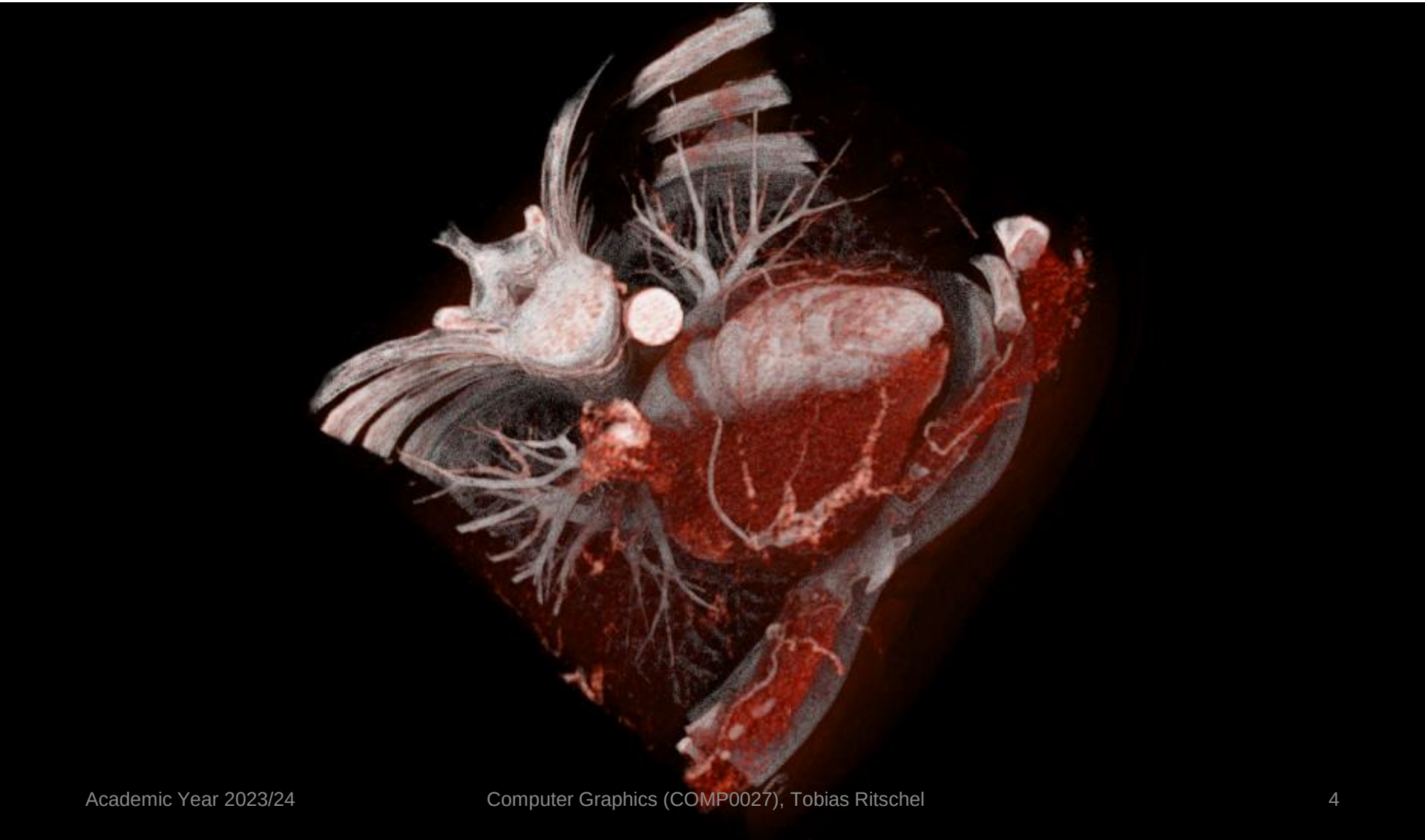
Computer Graphics (COMP0027) 2023/24

Introduction

Tobias Ritschel

UCL



Organization

Organizational

- Moodle
  - We will put slides as PDF
- Lecturecast
  - We are recording
- Assessment
  - Coursework (3 CWs)
  - Admins have not yet decided the dates, sorry

Timetable

- Lecture
  - Monday, two hours
  - Thursday, one hour
  - Proposal: Start sharp / Finish early
- Lab times
  - Details to be provided
  - I will take questions
  - TA will support you in doing the coursework

Team

- Tobias Ritschel *most lectures*
- Teaching assistants
  - Michael Fischer
  - Siddhant Prakash
  - Chen Liu

Coursework

- All done using our online system
  - No compiler and funny SDKs to setup
  - Ready-to-code sandbox from second one
  - Unique thing, developed for UCL by me & TAs
- `uclcg.github.io/uclcg/`
- GLSL, like a little C or Java snippet, but ran for every pixel

Me

- Graduated with a PhD from Max Planck in Germany in 2009
- Lecturer at UCL since 2015
- Full Professor of Computer Graphic since 2019
- See materials at http://www.homepages.ucl.ac.uk/~ucactri/ to learn more about work of my group and me

My style

- I show pictures and discuss
  - Occasional pseudocode
  - Some math, but really only 5-10 equations
  - Much more about concepts, “Computational Models”
- Slides might not have all information to get it
- I ask questions and I like to be asked

Course Overview

Content

- Introduction
- Linear Algebra
- Light & Sensors
- Projection
- Ray-tracing
- Bounding volume hierarchies
- Shading
- Physically-based rendering
- Monte Carlo techniques
- Spline surfaces and patches
- Graphics hardware
- OpenGL
- 3D worlds
- Animation
- Meshes

How about you?

- Undergrad/postgrad/PhD students?
- Random questions
  - I will not check, just raise hands if you think you can answer:
  - LA: What is a rotation matrix?
  - CG: What is Phong?
  - GPU: Coded in GLSL?

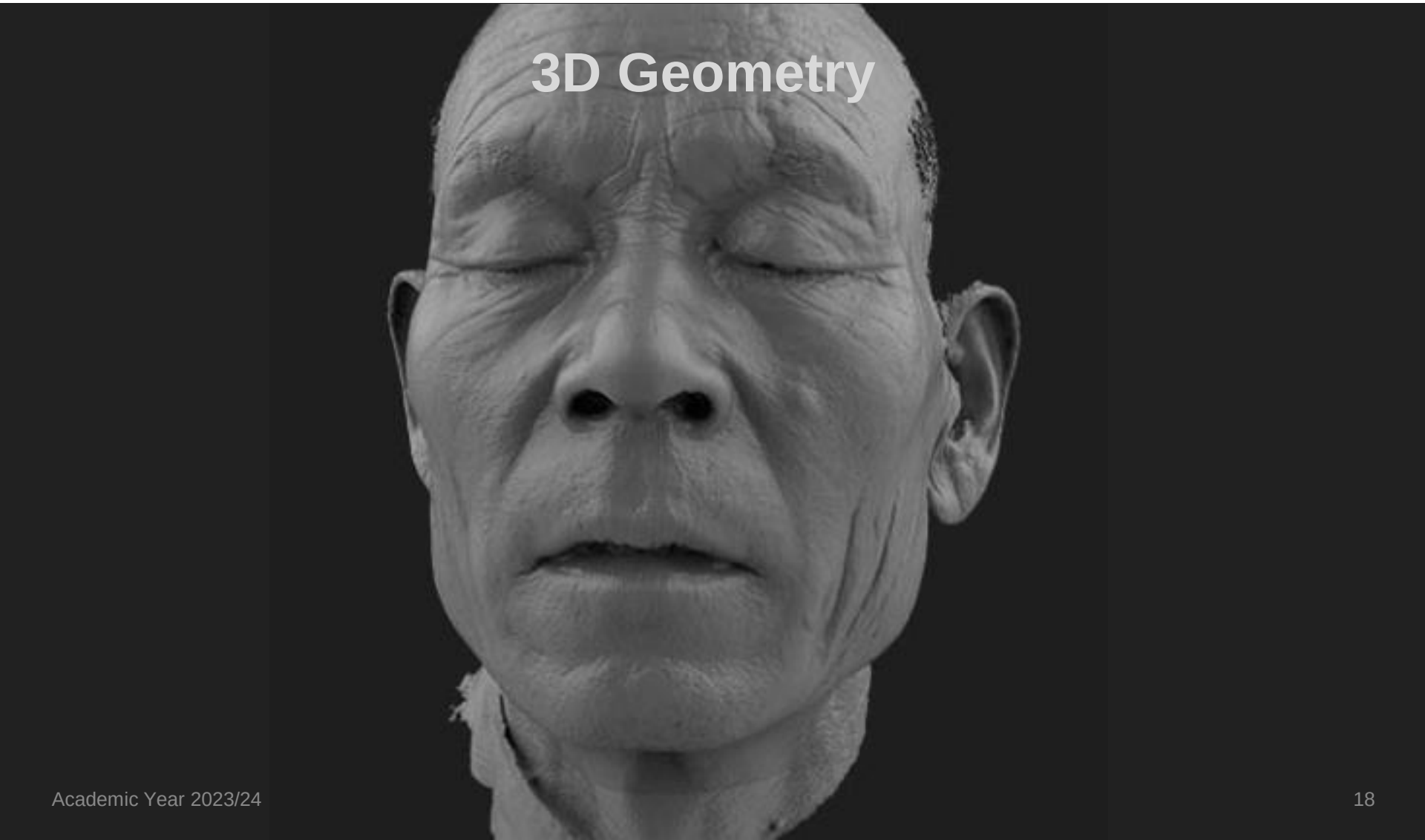
Today's Outline

1. Anatomy of an illusion
   - 3D Scene model
   - Light transport
   - Human Perception
2. Major concepts of Graphics
3. Linear algebra reminder

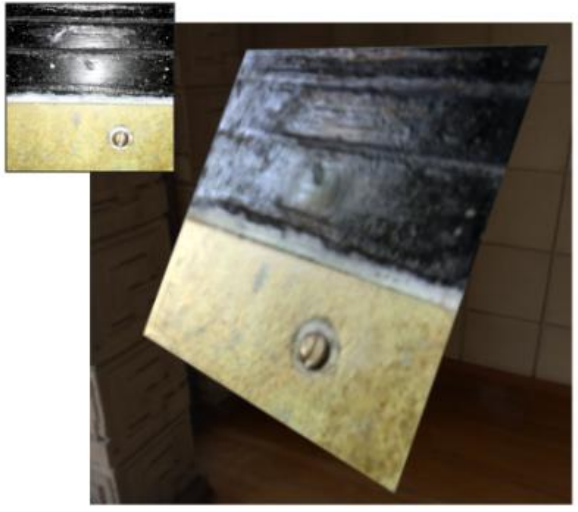
3D Scene Model

- **Geometric** properties
  - Size, shape
  - Coordinate frame
- **Appearance** properties
  - Color, material, look & feel
  - Appearance models
- **View** (where is the observer)
- **Illumination** (where does light come from)

3D Geometry



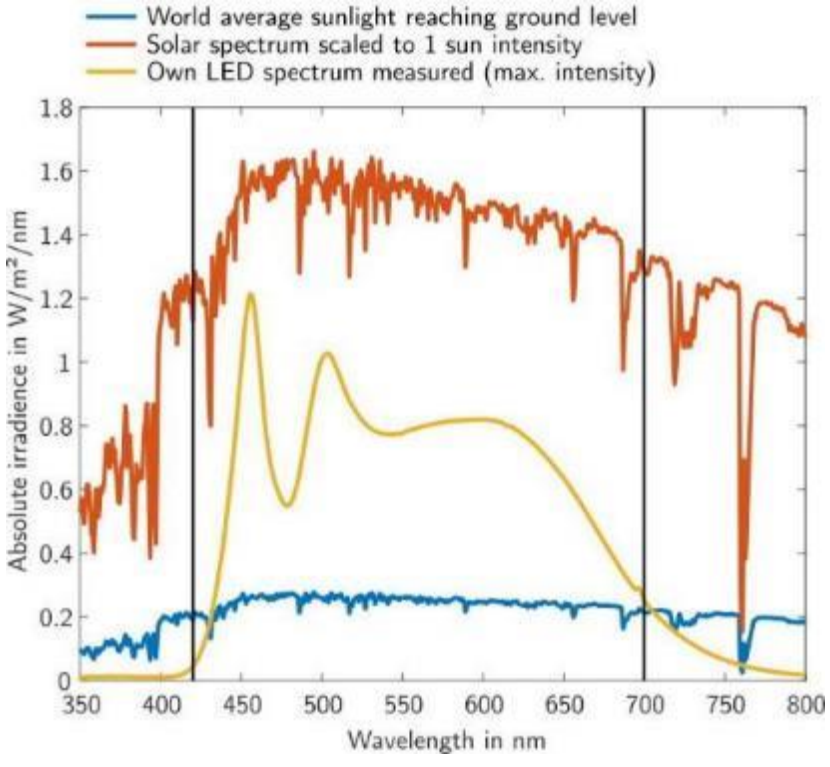
Appearance



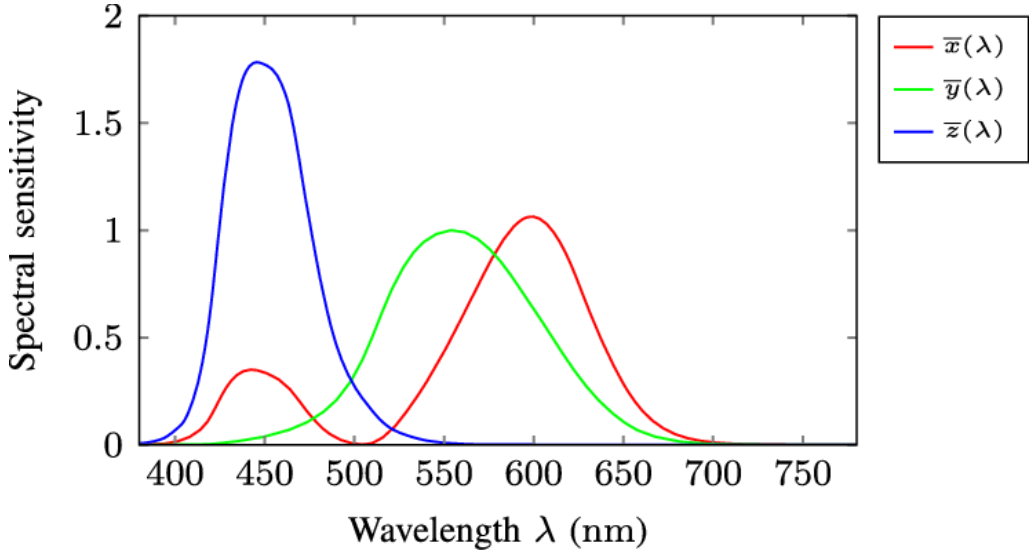
View

Illumination

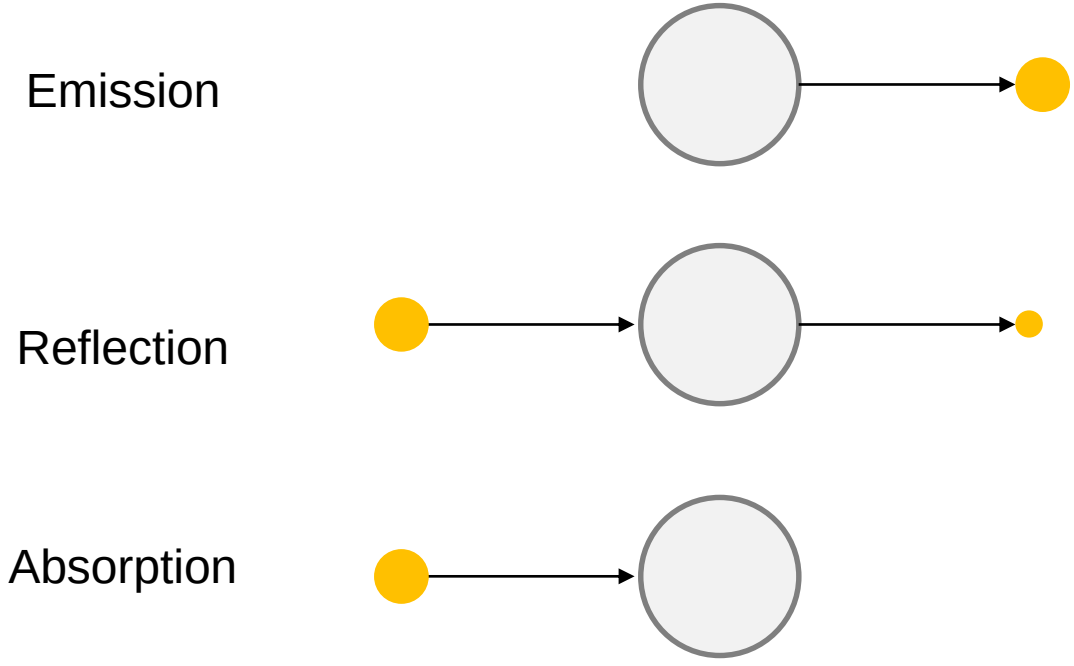
Light spectrum



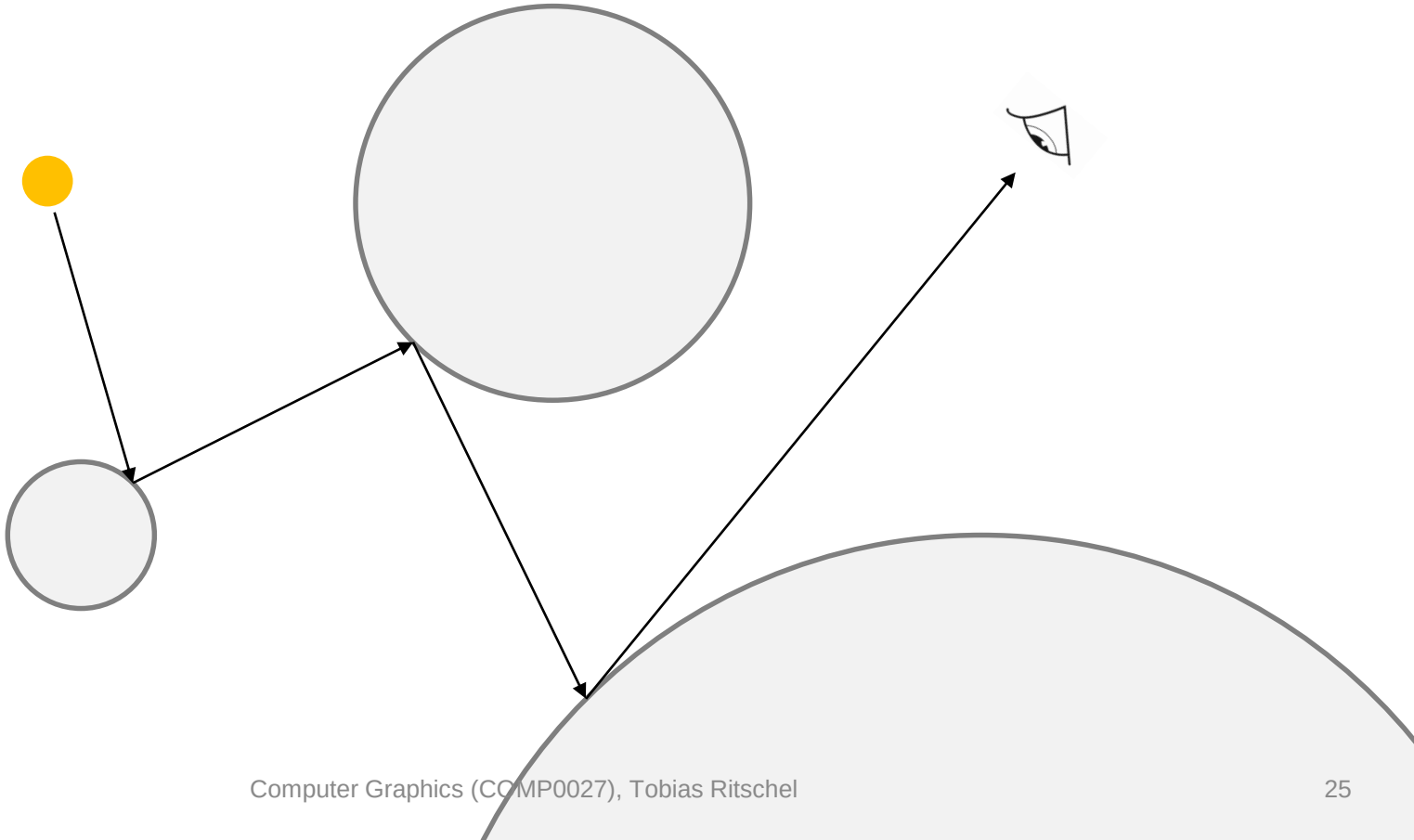
What is RGB?


Spectral sensitivity
2
1.5
1
0.5
0
400
450
500
550
600
650
700
750
Wavelength λ (nm)
$\overline{x}(\lambda)$
$\overline{y}(\lambda)$
$\overline{z}(\lambda)$

Life and death of a photon

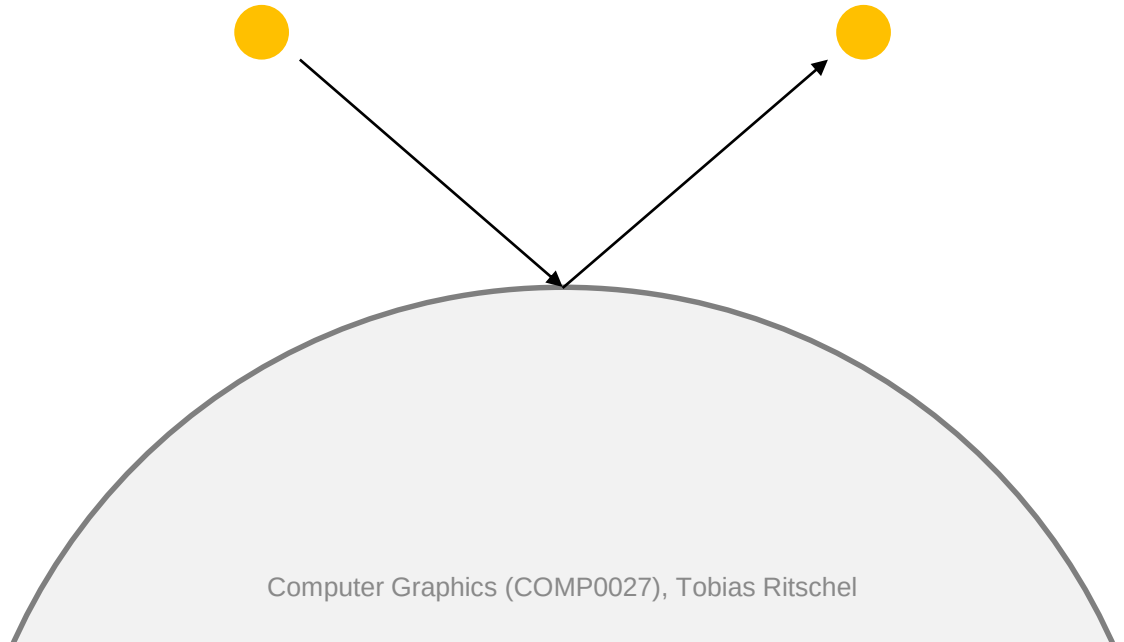


Lighting is a global problem



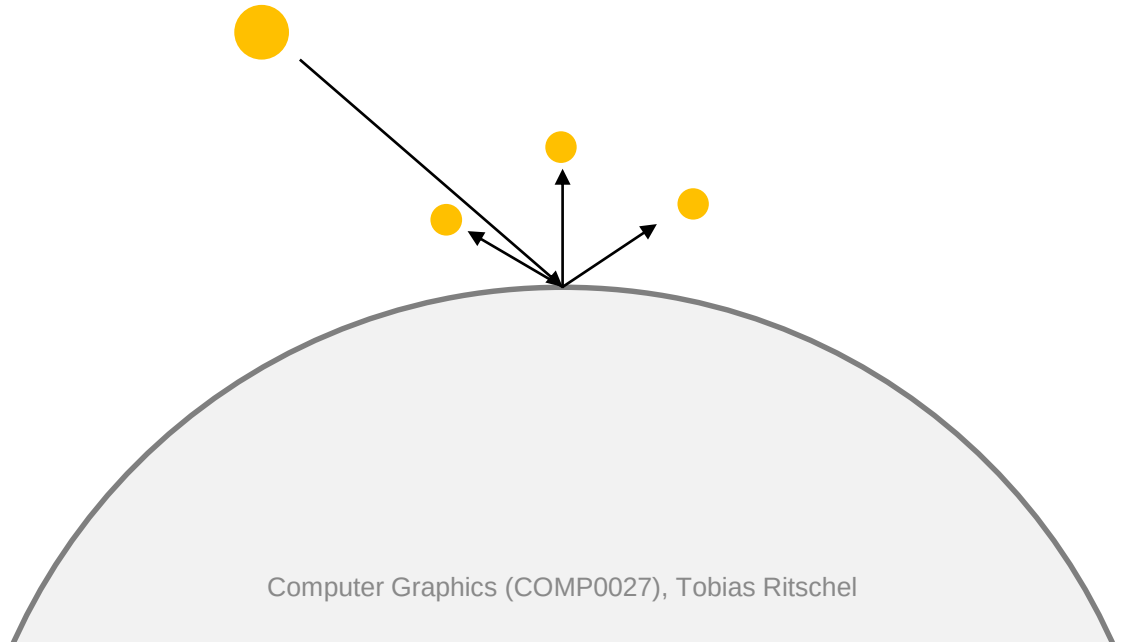
Surfaces are rarely mirrors

Specular surface



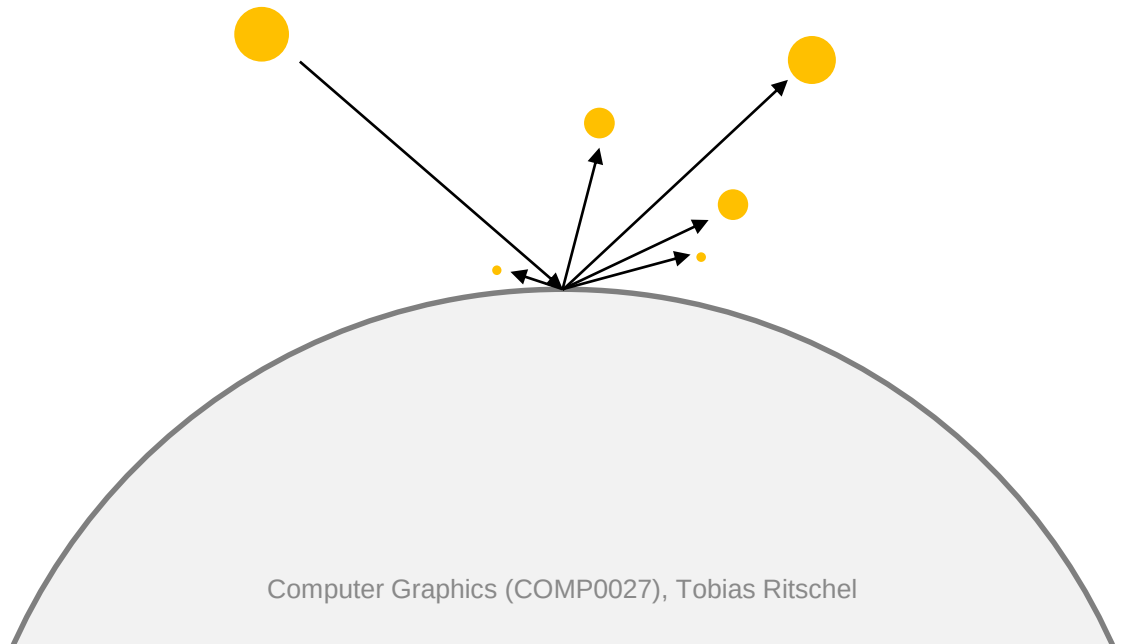
Surfaces are rarely mirrors

Diffuse surface



Surfaces are rarely mirrors

Glossy surface

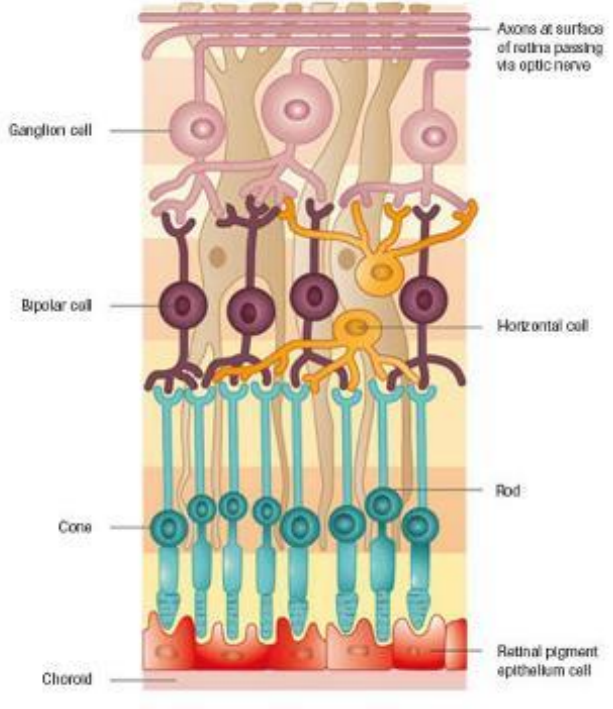


Simplifying assumptions

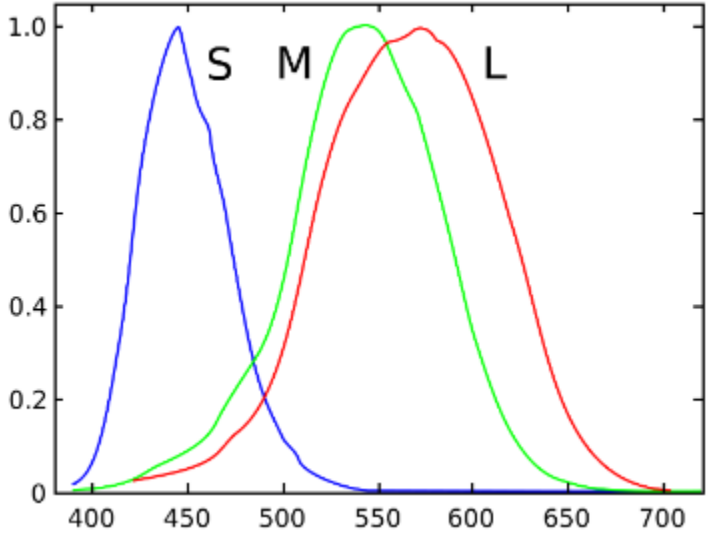
- Wavelength independence
  - No
- Time invariance
  - No
- Light transport in a vacuum
  - No participating media
- Objects are isotropic (for now only)
  - Reflectances are constant over the surface

Physiology of the eye

- 6 million **cones** in the fovea
  - cones sense red, green or blue light
  - colour perception region is very small
- 120 million **rods** over the whole eye
  - peripheral vision – motion sensitive



Response functions



Real-time graphics, assume:

- Ignore spectral distribution
- Take three discrete ~~wavelengths~~ basis functions
  - Red, green and blue
- Approximation
- Metamerism
  - Different spectrum
  - Same percept
  - Same RGB

Major concepts of Graphics

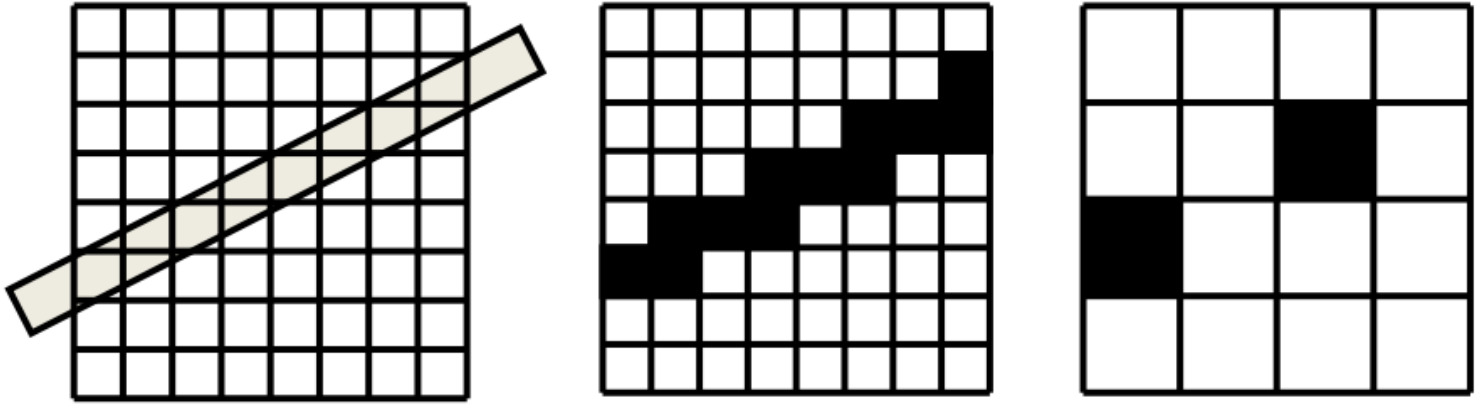
- Rendering = Convert scene definition into image
- Separation of concerns
  - Scene definition (independent of view)
  - View (independent of light or geometry)
  - Independence of rendering method

View

- A view position and a virtual window open up a **view volume**
- Will come up with some linear algebra to do this very soon
- **Clipping** is the process of reducing the world definition to this part

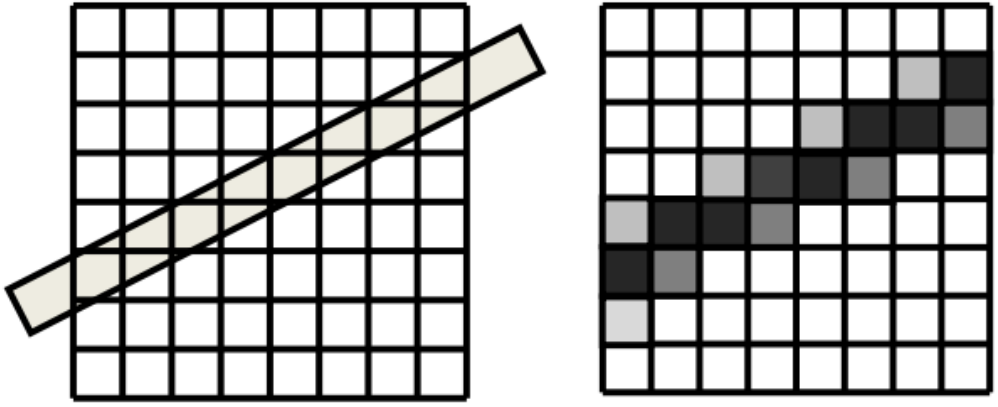
Major concepts: Aliasing

- Aliasing



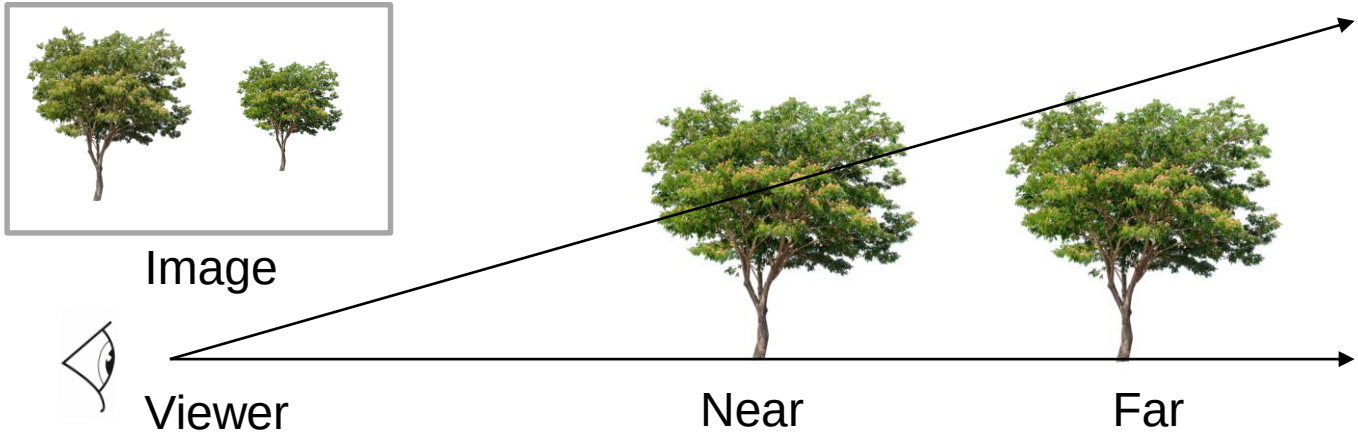
Major concepts: Aliasing

- Anti-aliasing



Major concepts: Projection

- Perspective projection
  - Size depends on distance (but how exactly?)



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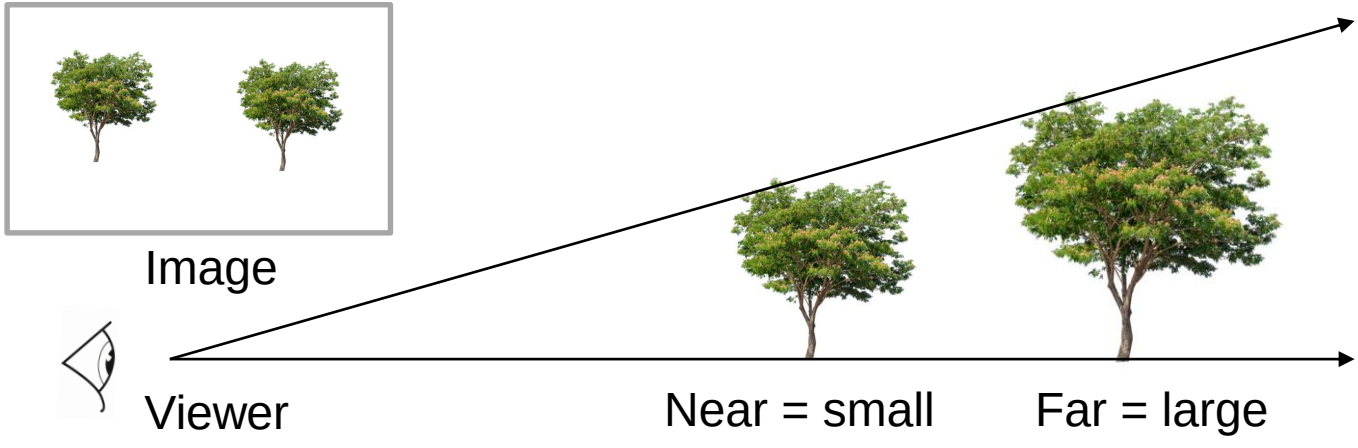
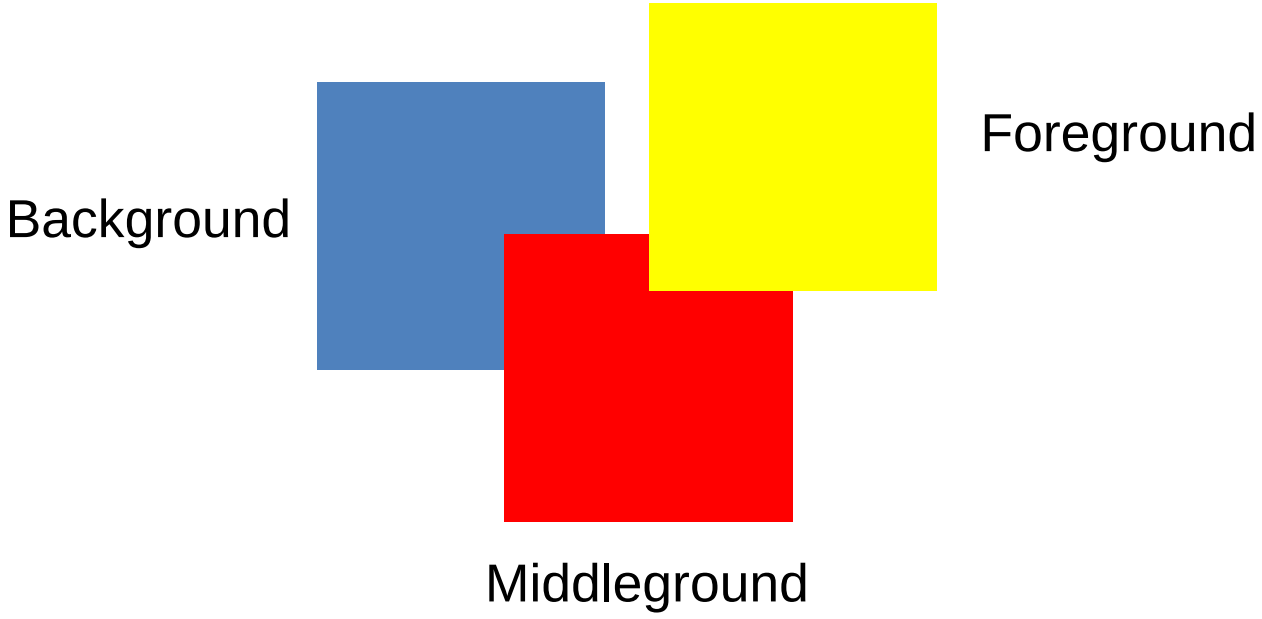


Major concepts: Occlusion

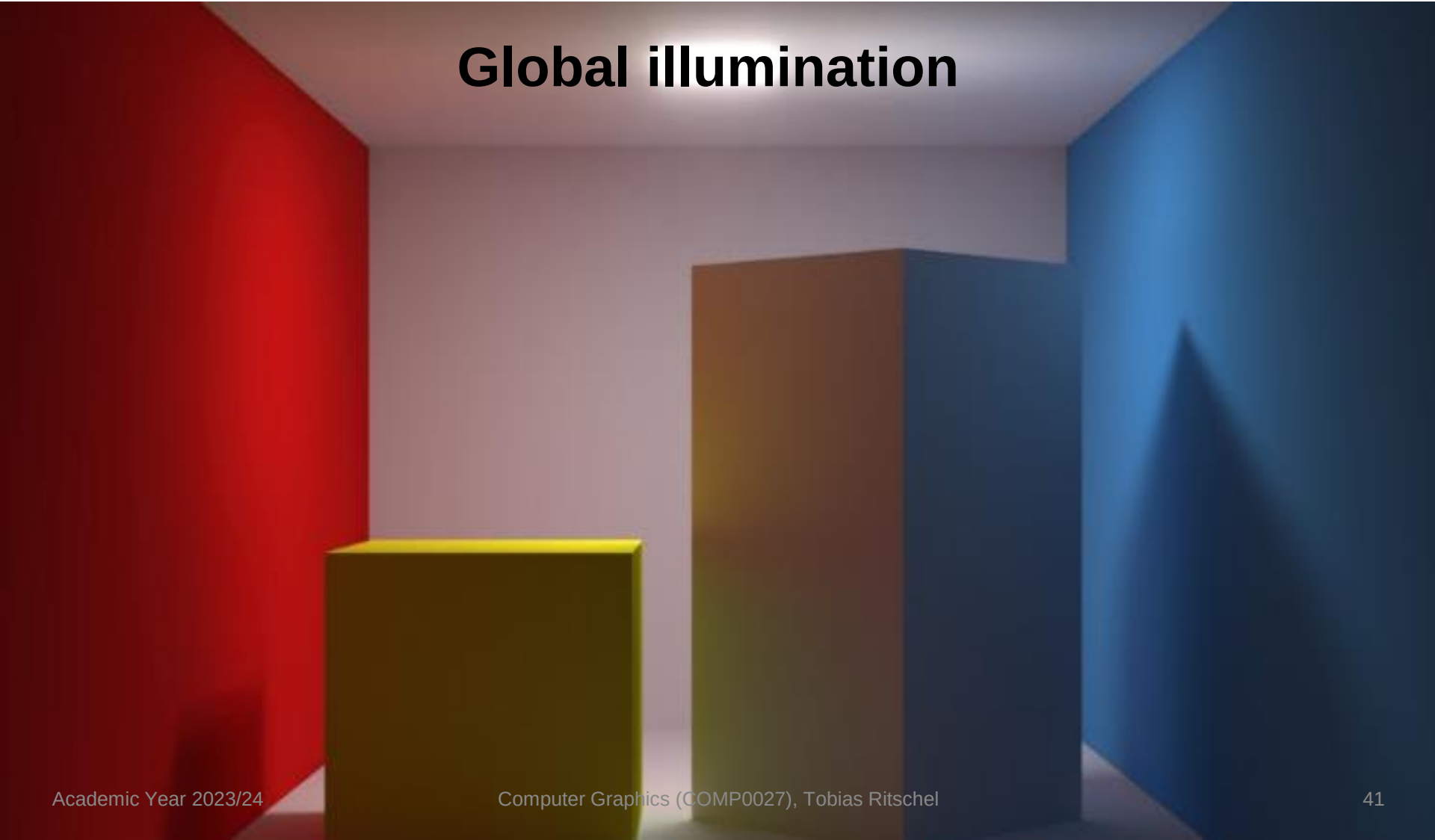
- Occlusion: Visible surface determination



Major concepts: Lighting

- Lighting
  - What we discussed before somewhat easy, this really hard
  - **Global** illumination: All surfaces exchange light
  - **Local** illumination: Only a handful of light sources

Global illumination



Summary

- Brief look at general problem of simulating visual world
- Limits of human perception
- Parts of virtual world
  - Geometry
  - Material
  - Illumination
  - Viewer

In this course we will develop

- More formal 3D scene description
  - Needs some math
- Methods to process them
  - Needs some algorithms
- All this with computational efficiency in mind
  - Needs new tools (OpenGL) & machines (GPUs)