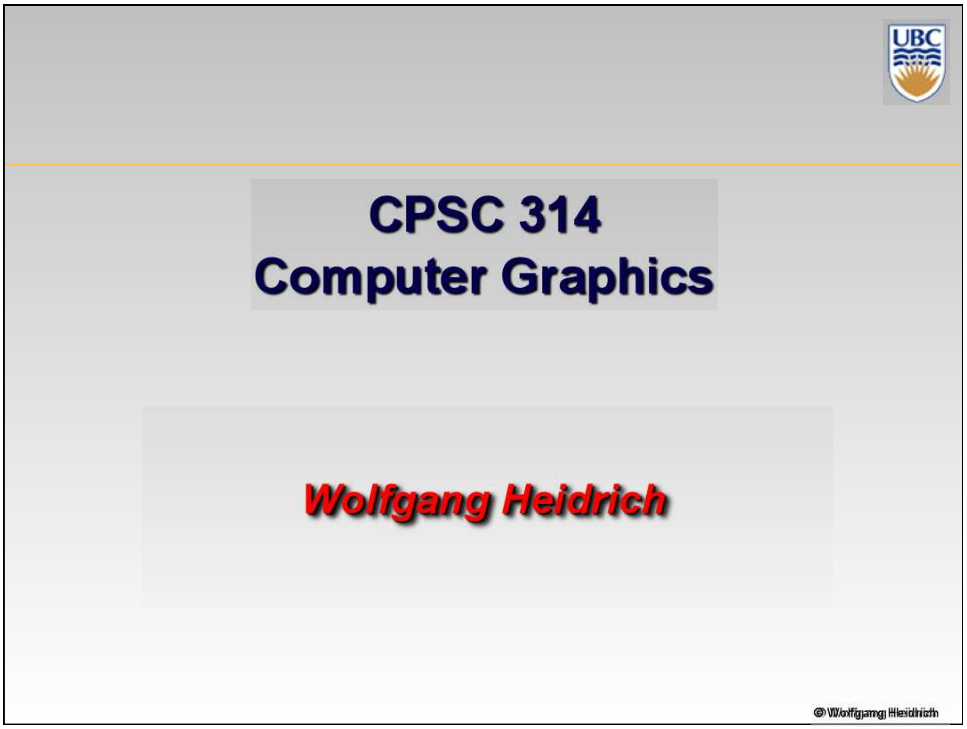
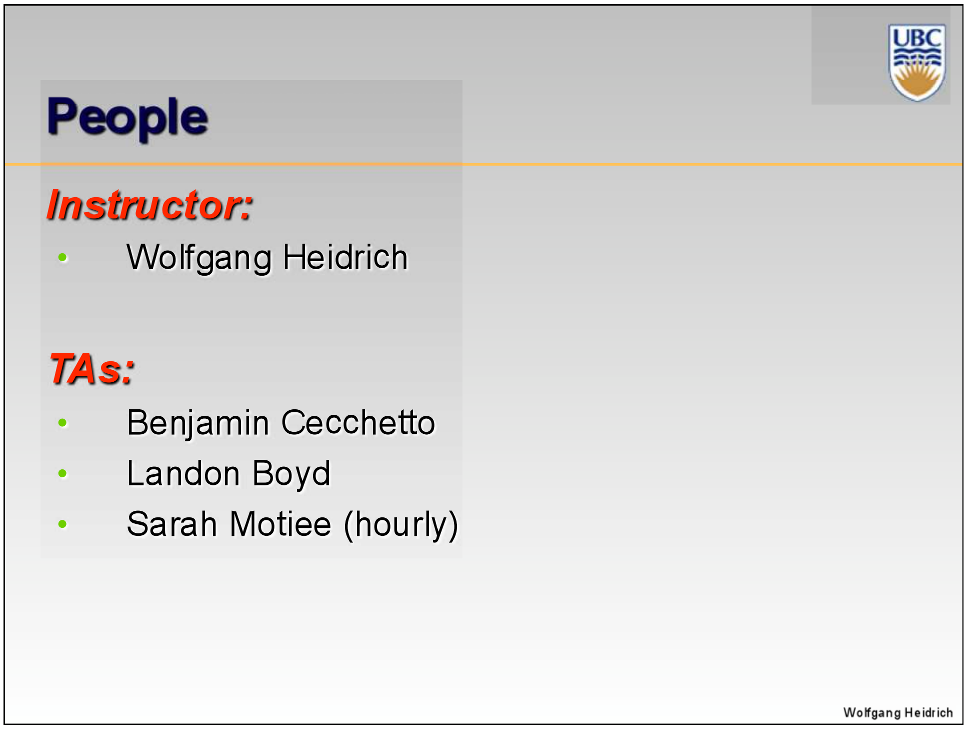


CPSC 314
Computer Graphics

Wolfgang Heidrich



People

Instructor:

- Wolfgang Heidrich

TAs:

- Benjamin Cecchetto
- Landon Boyd
- Sarah Motiee (hourly)

What is Computer Graphics?

Create or manipulate images with computer

- this course: algorithms for image generation

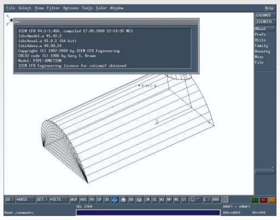
Wolfgang Heidrich

What is CG used for?

Graphical user interfaces

- Modeling systems
- Applications

Simulation & visualization



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ICEM CFD V4.1:1.466, compiled 17.08.2000 12:14:35 MES
libc4model.a V1.42.3
libc4eval.a V1.0.1 (64 bit)
libi4data.a V0.99.24
Copyright (C) 1997-2000 by ICEM CFD Engineering
CRC32 code (C) 1986 by Gary S. Brown
Model: PIPE-JUNCTION
ICEM CFD Engineering licence for catiamif obtained
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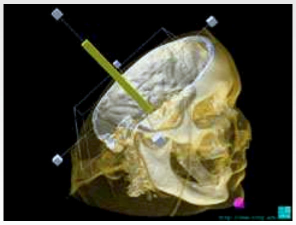


Wolfgang Heidrich

What is CG used for?

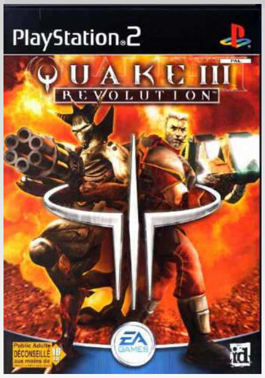
Movies

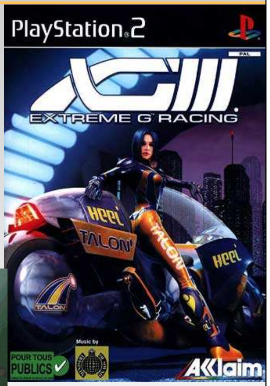
- Animation
- Special effects

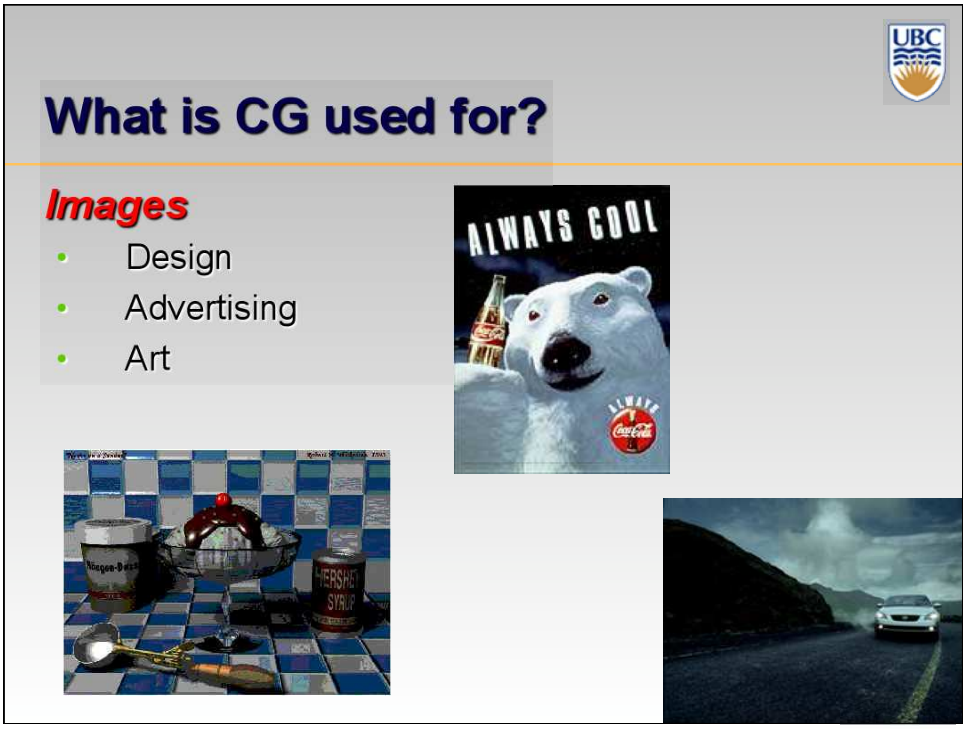
Inspector Gadget © 1999 Walt Disney Pictures
Visual Effects by Dream Quest Images

What is CG used for?

Computer games



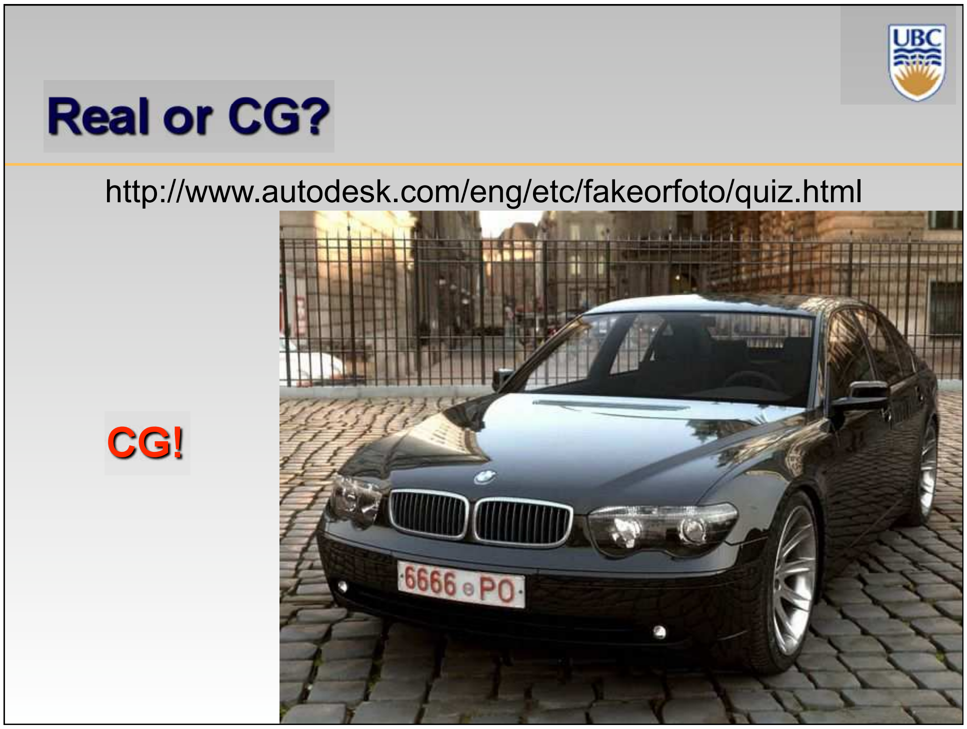




What is CG used for?

Images

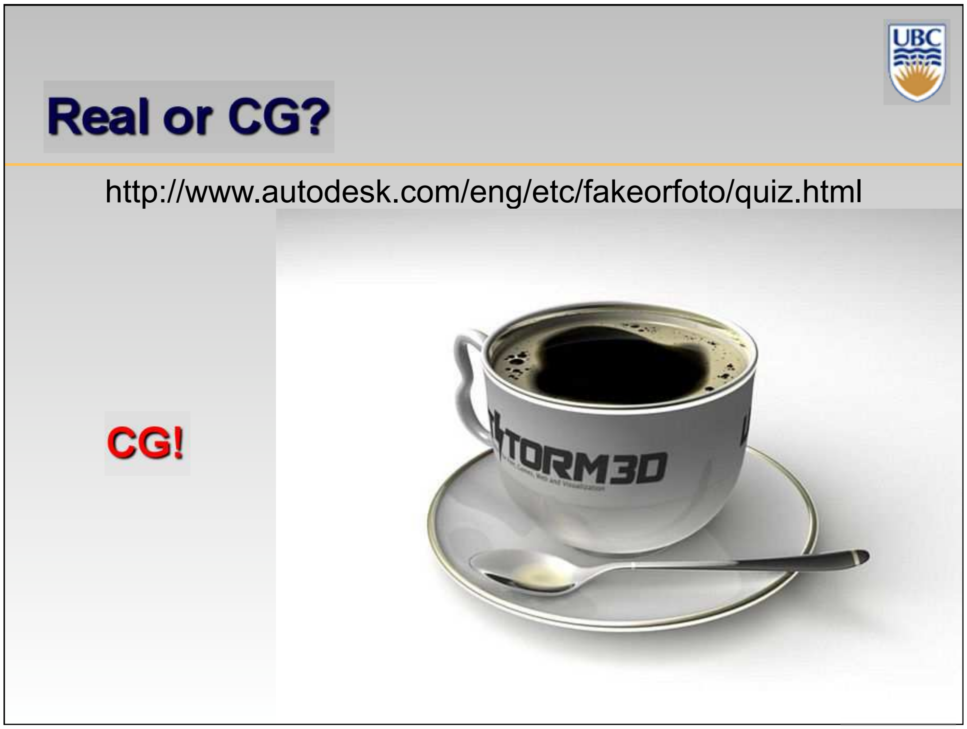
- Design
- Advertising
- Art



Real or CG?

http://www.autodesk.com/eng/etc/fakeorfoto/quiz.html

CG!



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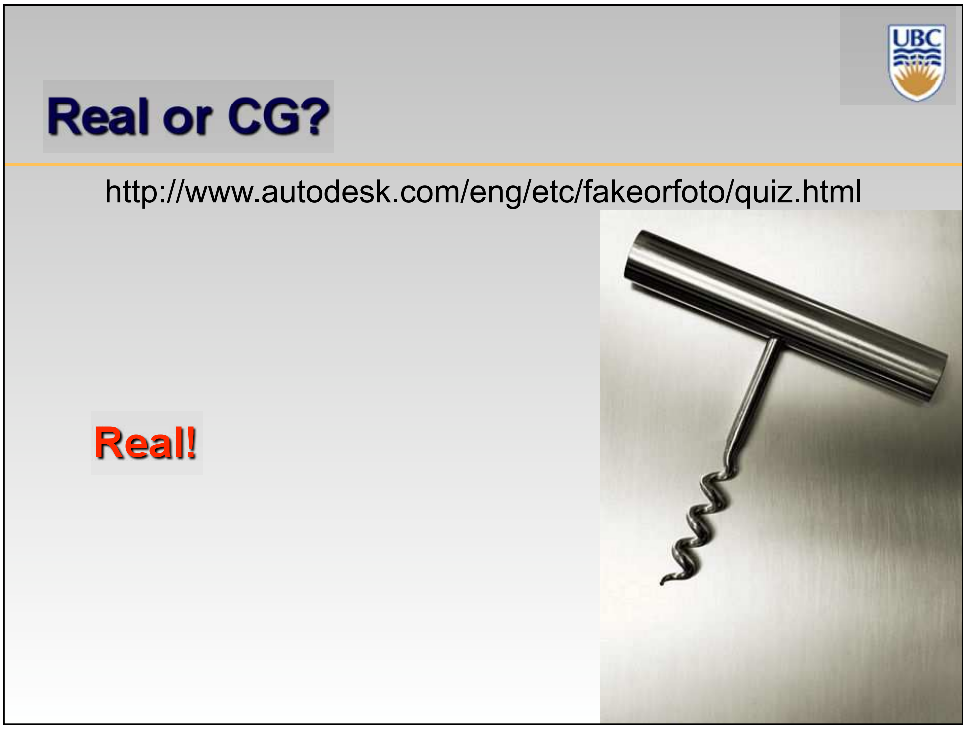
CG!



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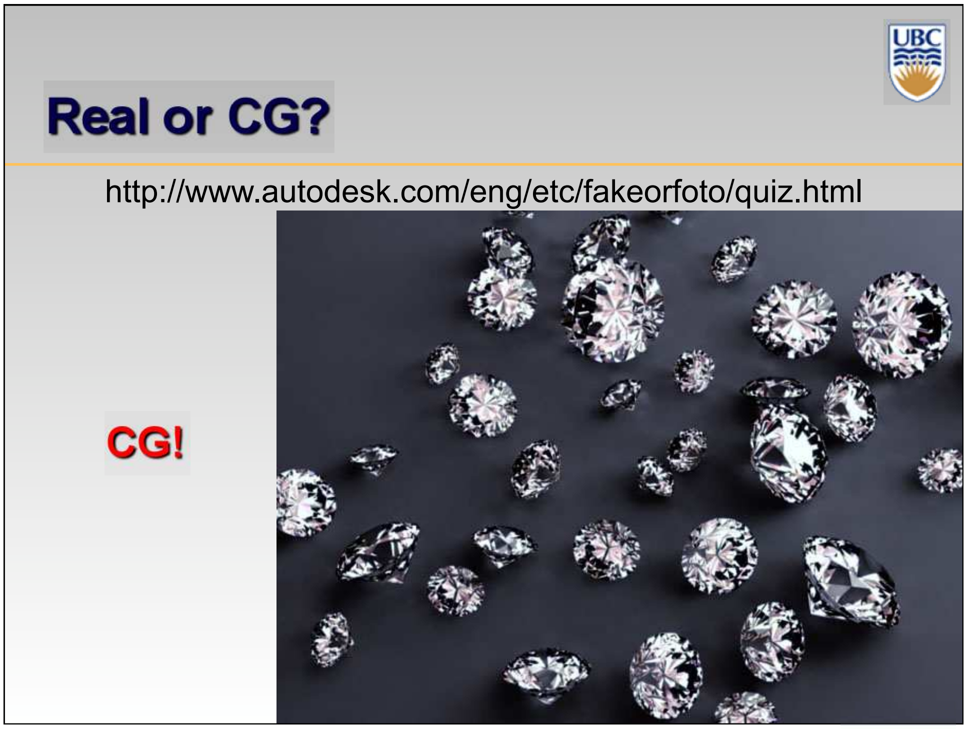
Real!



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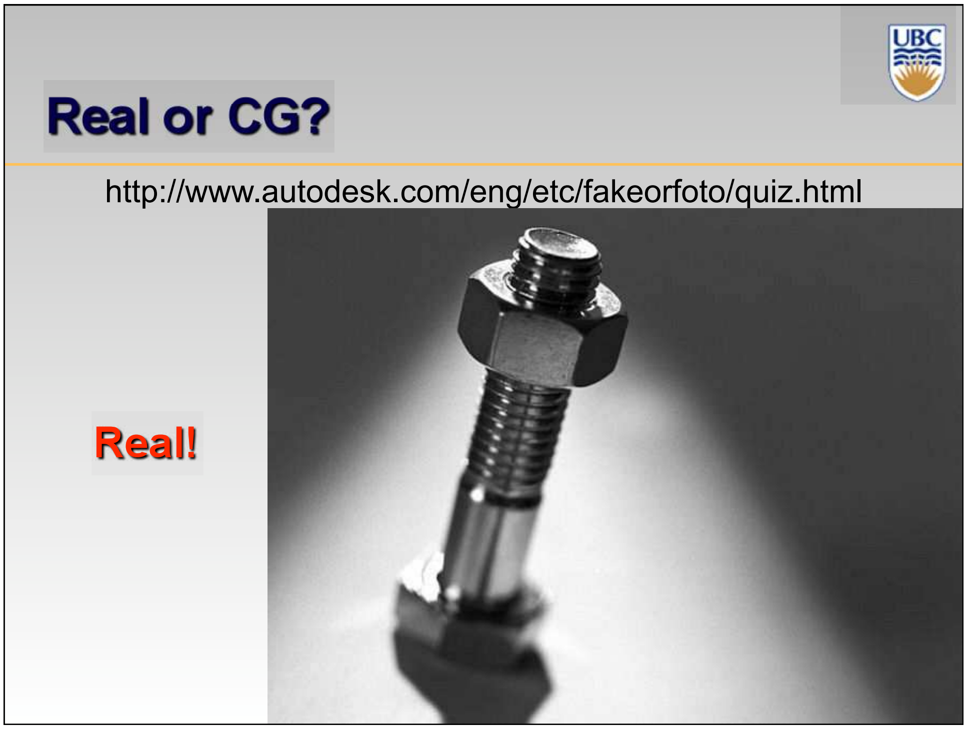
CG!



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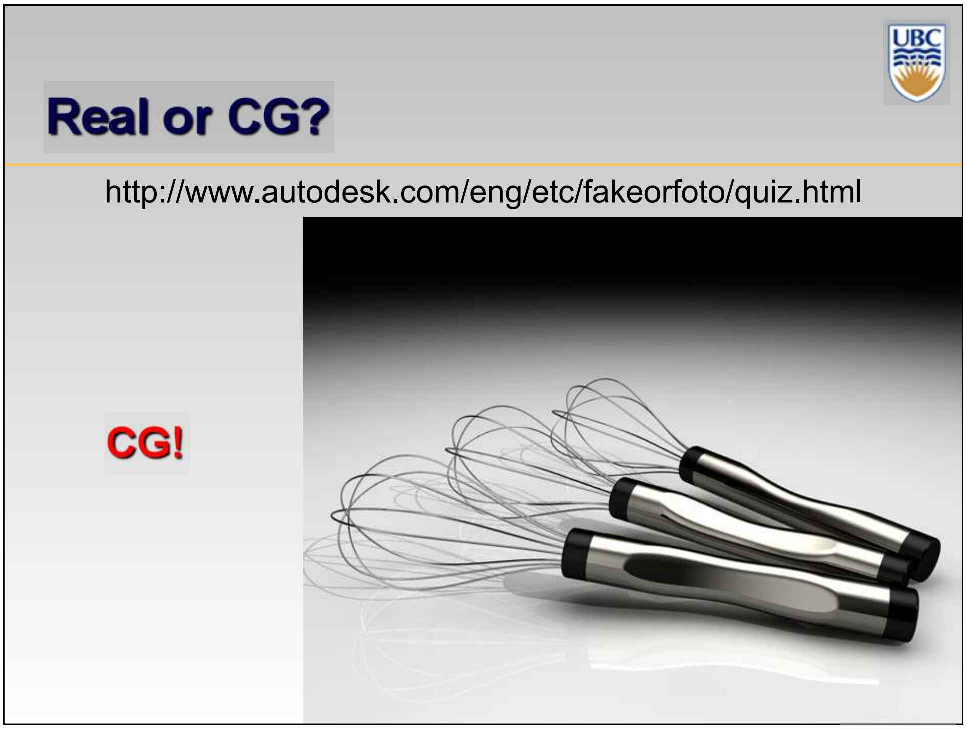
Real!



Real or CG?

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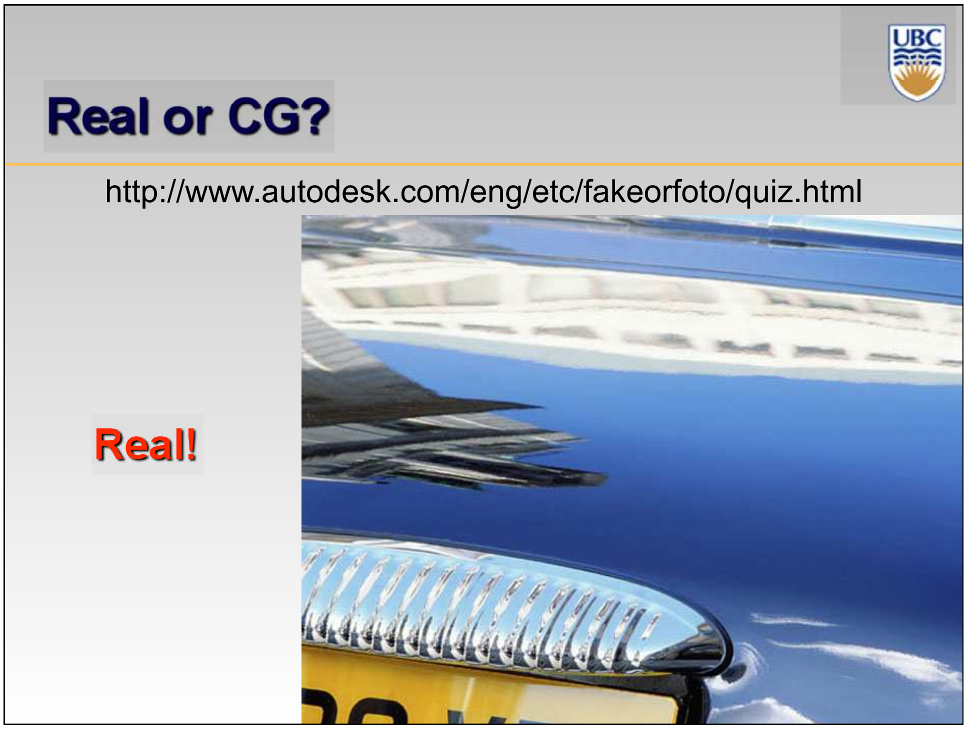
CG!



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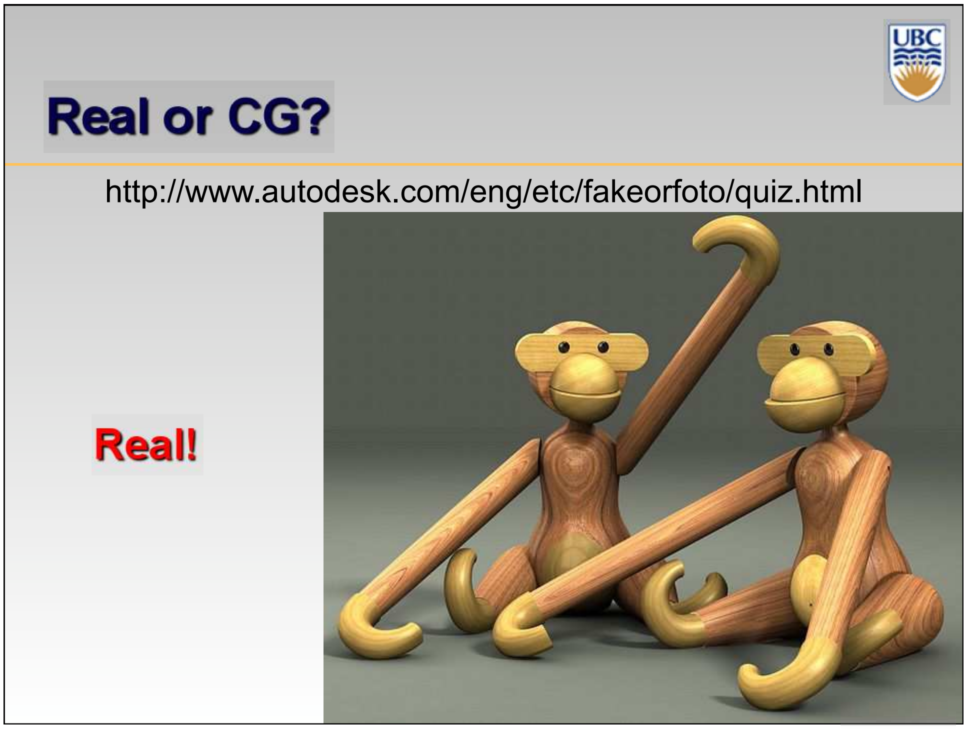
Real!



Real or CG?

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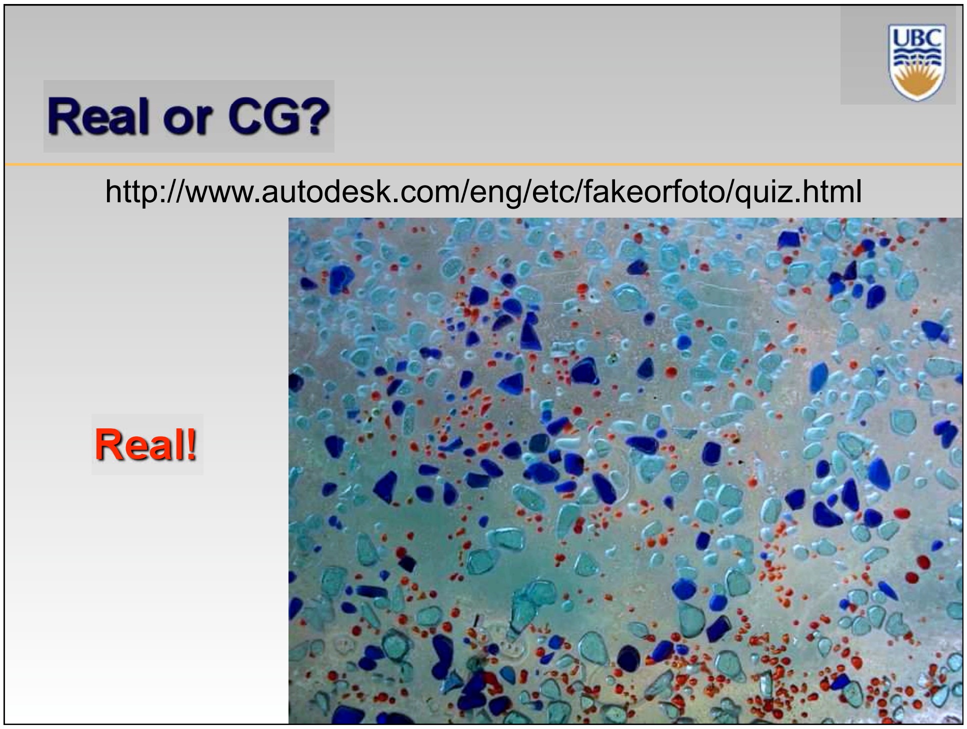
Real!



Real or CG?

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Real!

Real or CG?

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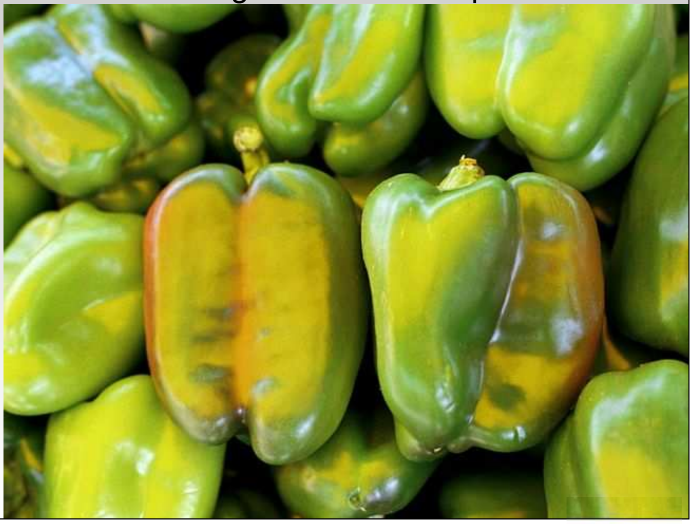
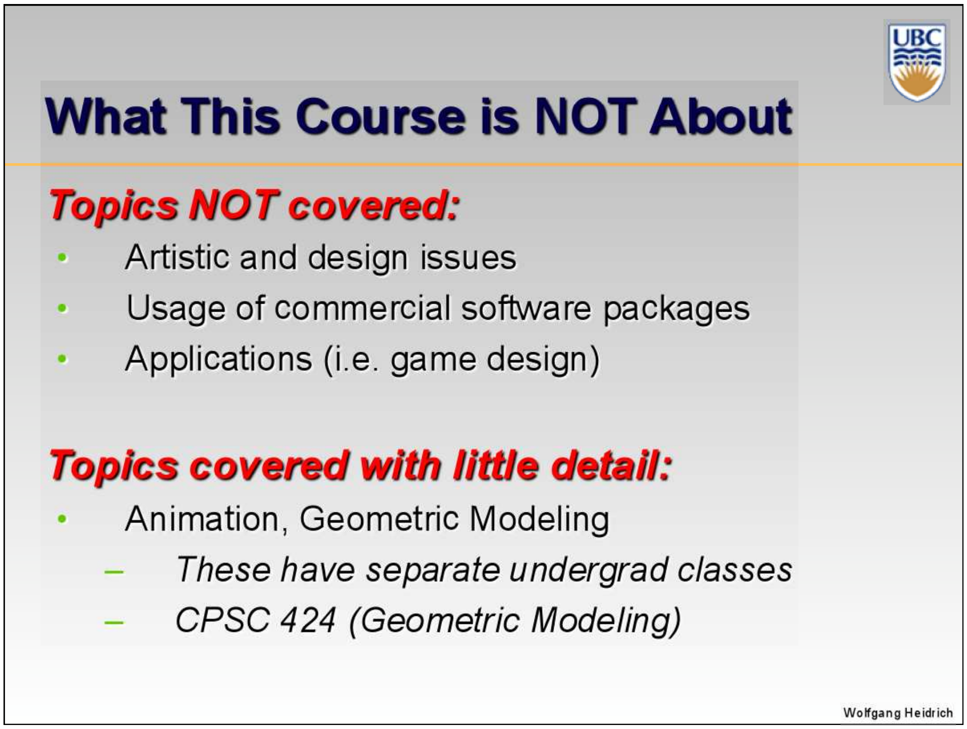
Real!



What This Course Is About

Topics covered

- Fundamental algorithms of computer graphics
- Interactive graphics:
  - *The rendering pipeline*
    - Abstract model for the functioning of graphics hardware and interactive graphics systems
  - *Color spaces and reflection models*
  - *Shadow algorithms*
- Ray-tracing, global illumination



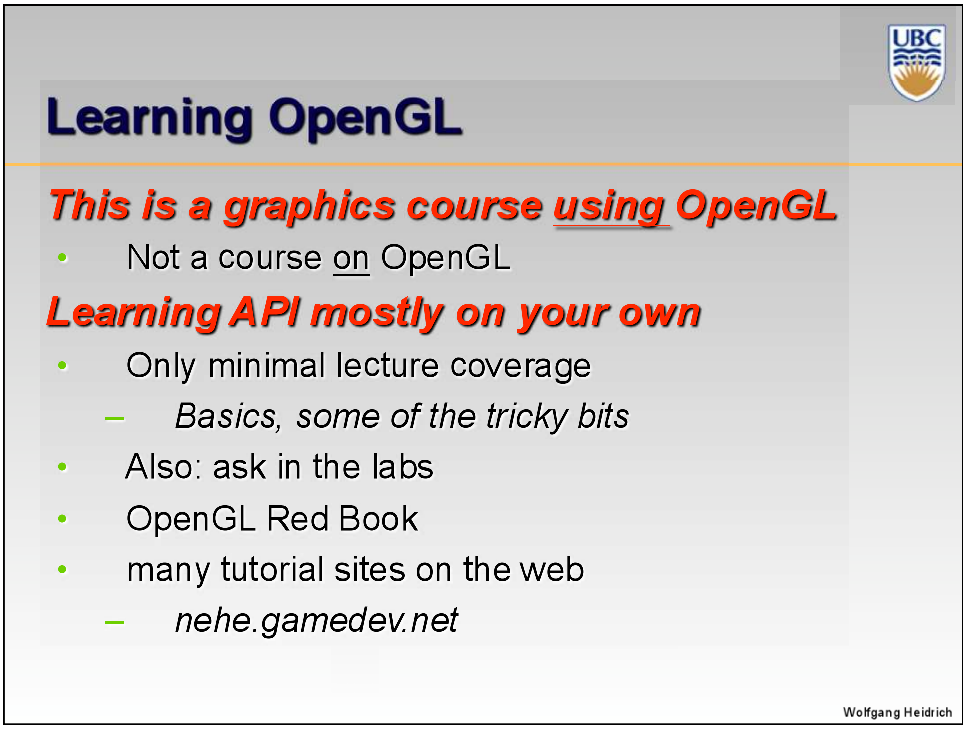
What This Course is NOT About

Topics NOT covered:

- Artistic and design issues
- Usage of commercial software packages
- Applications (i.e. game design)

Topics covered with little detail:

- Animation, Geometric Modeling
  - *These have separate undergrad classes*
  - *CPSC 424 (Geometric Modeling)*



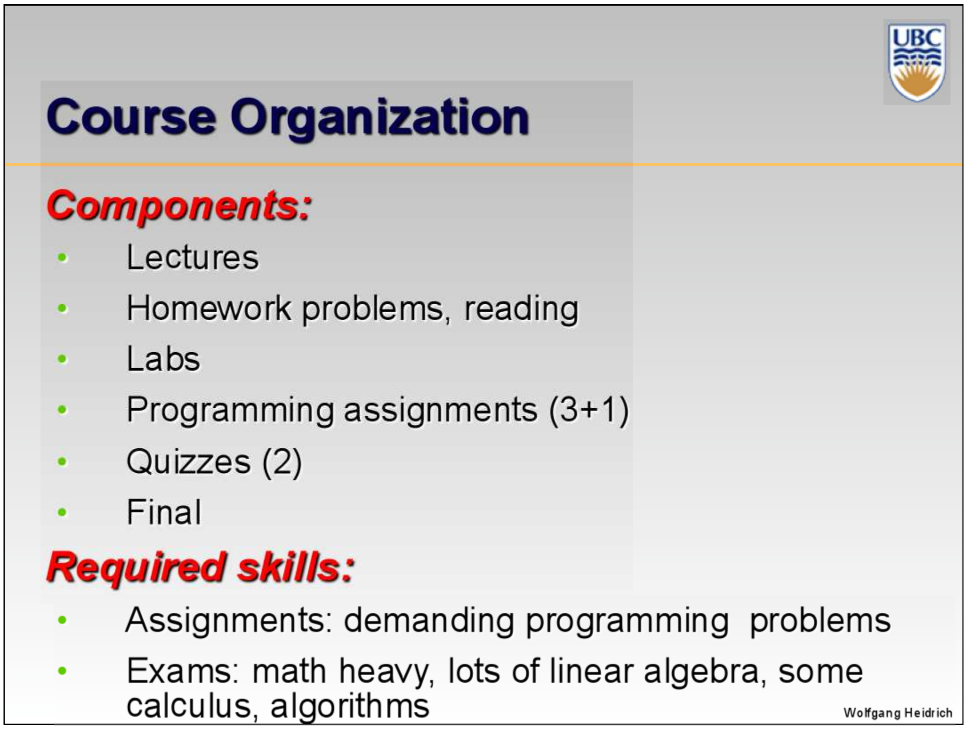
Learning OpenGL

This is a graphics course using OpenGL

- Not a course on OpenGL

Learning API mostly on your own

- Only minimal lecture coverage
  - *Basics, some of the tricky bits*
- Also: ask in the labs
- OpenGL Red Book
- many tutorial sites on the web
  - *nehe.gamedev.net*



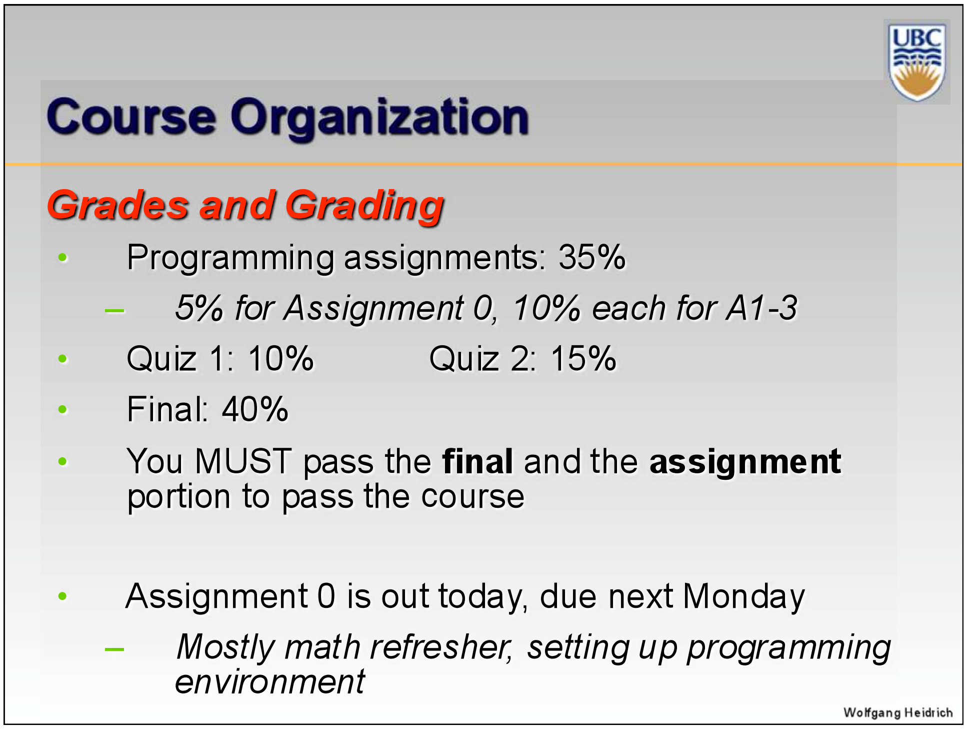
Course Organization

Components:

- Lectures
- Homework problems, reading
- Labs
- Programming assignments (3+1)
- Quizzes (2)
- Final

Required skills:

- Assignments: demanding programming problems
- Exams: math heavy, lots of linear algebra, some calculus, algorithms

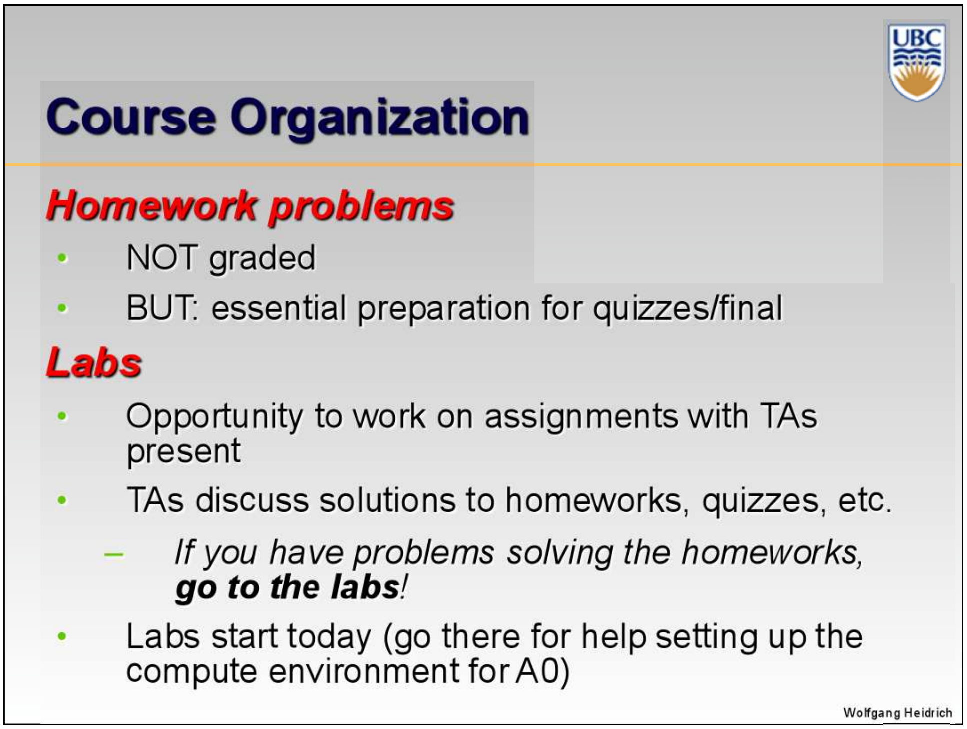


Course Organization

Grades and Grading

- Programming assignments: 35%
  - *5% for Assignment 0, 10% each for A1-3*
- Quiz 1: 10%   Quiz 2: 15%
- Final: 40%
- You MUST pass the **final** and the **assignment** portion to pass the course

- Assignment 0 is out today, due next Monday
  - *Mostly math refresher, setting up programming environment*



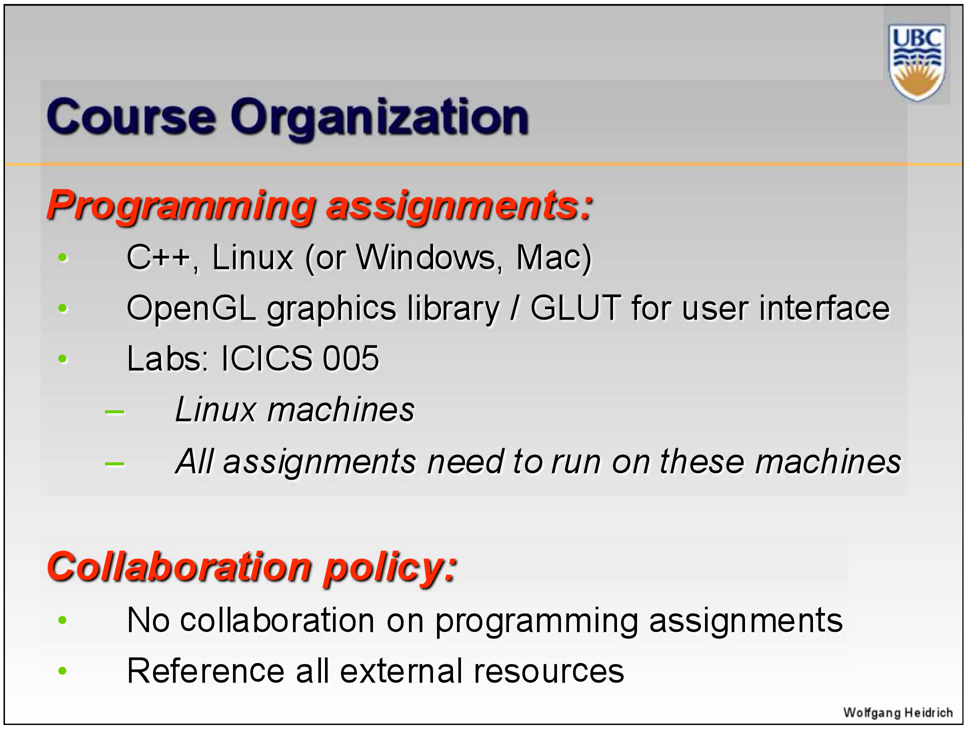
Course Organization

Homework problems

- NOT graded
- BUT: essential preparation for quizzes/final

Labs

- Opportunity to work on assignments with TAs present
- TAs discuss solutions to homeworks, quizzes, etc.
  - *If you have problems solving the homeworks, **go to the labs**!*
- Labs start today (go there for help setting up the compute environment for A0)



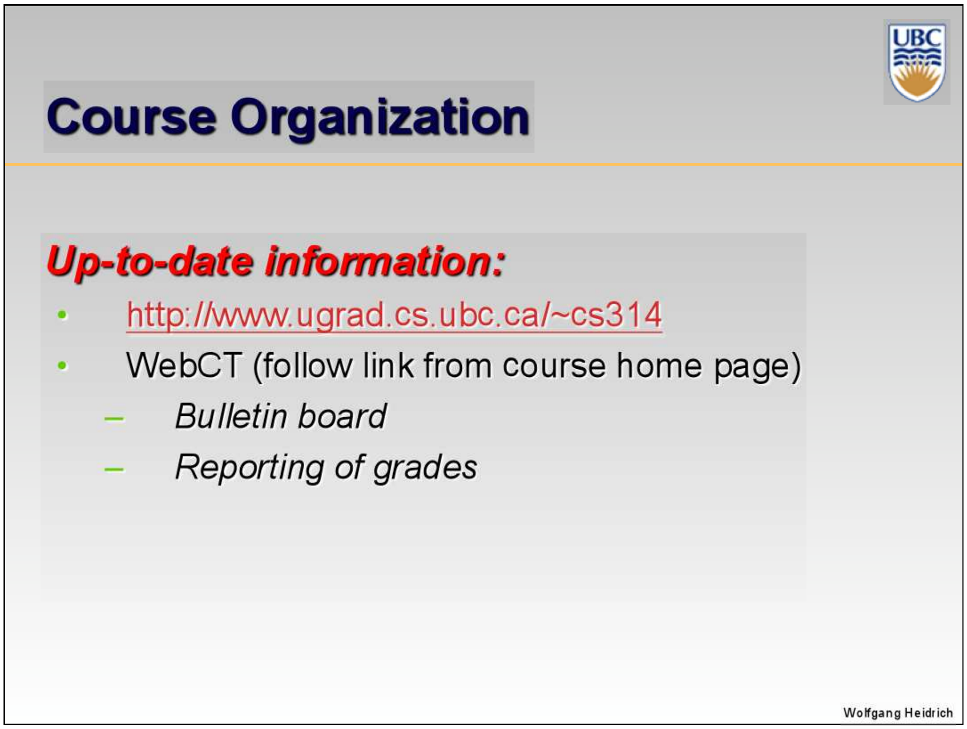
Course Organization

Programming assignments:

- C++, Linux (or Windows, Mac)
- OpenGL graphics library / GLUT for user interface
- Labs: ICICS 005
  - *Linux machines*
  - *All assignments need to run on these machines*

Collaboration policy:

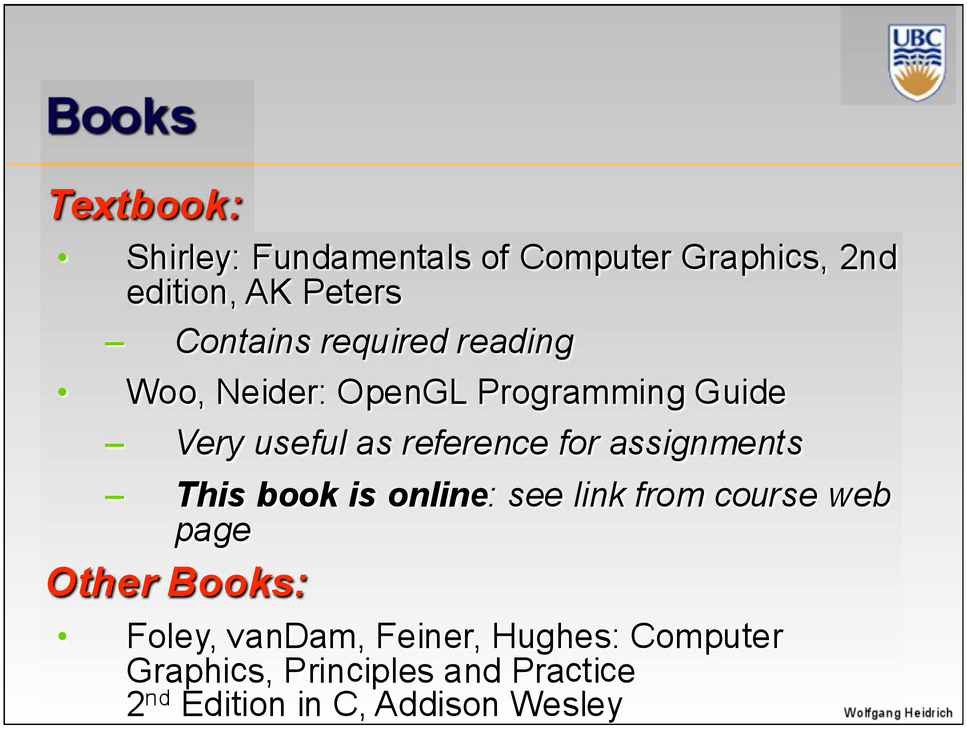
- No collaboration on programming assignments
- Reference all external resources



Course Organization

Up-to-date information:

- http://www.ugrad.cs.ubc.ca/~cs314
- WebCT (follow link from course home page)
  - *Bulletin board*
  - *Reporting of grades*



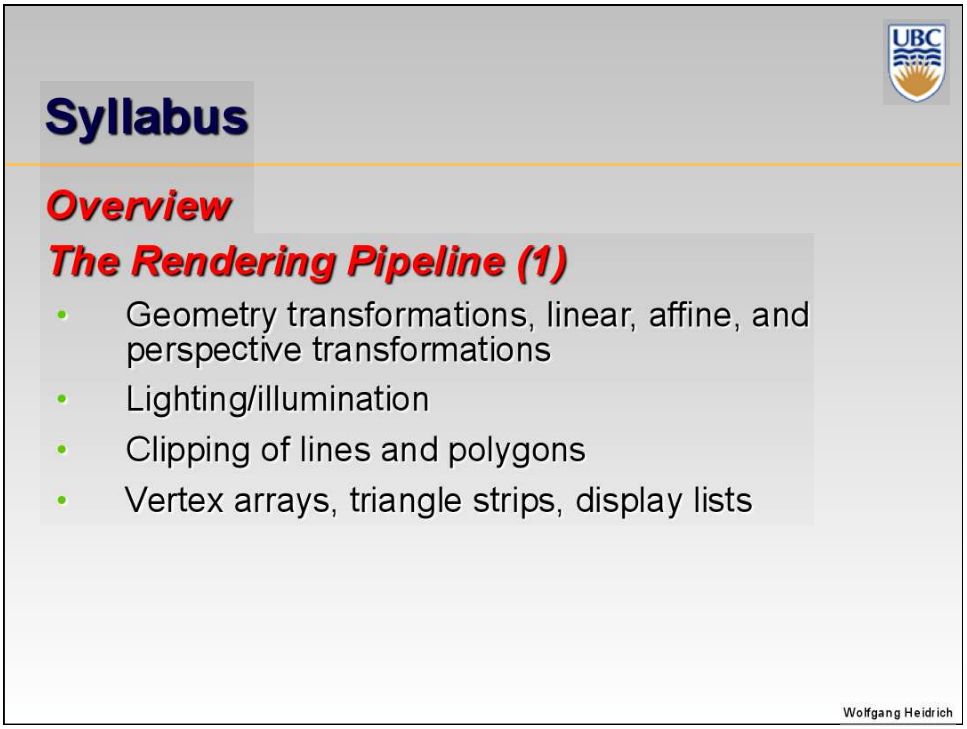
Books

Textbook:

- Shirley: Fundamentals of Computer Graphics, 2nd edition, AK Peters
  - *Contains required reading*
- Woo, Neider: OpenGL Programming Guide
  - *Very useful as reference for assignments*
  - ***This book is online**: see link from course web page*

Other Books:

- Foley, vanDam, Feiner, Hughes: Computer Graphics, Principles and Practice 2nd Edition in C, Addison Wesley



Syllabus

Overview

The Rendering Pipeline (1)

- Geometry transformations, linear, affine, and perspective transformations
- Lighting/illumination
- Clipping of lines and polygons
- Vertex arrays, triangle strips, display lists

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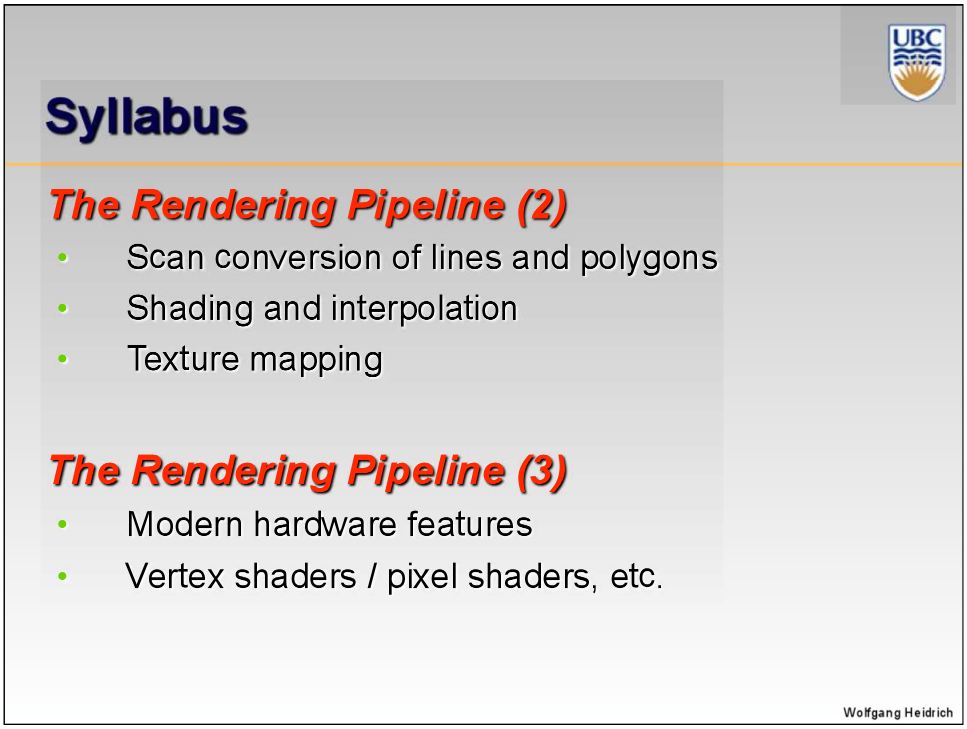

Syllabus

The Rendering Pipeline (2)

- Scan conversion of lines and polygons
- Shading and interpolation
- Texture mapping

The Rendering Pipeline (3)

- Modern hardware features
- Vertex shaders / pixel shaders, etc.

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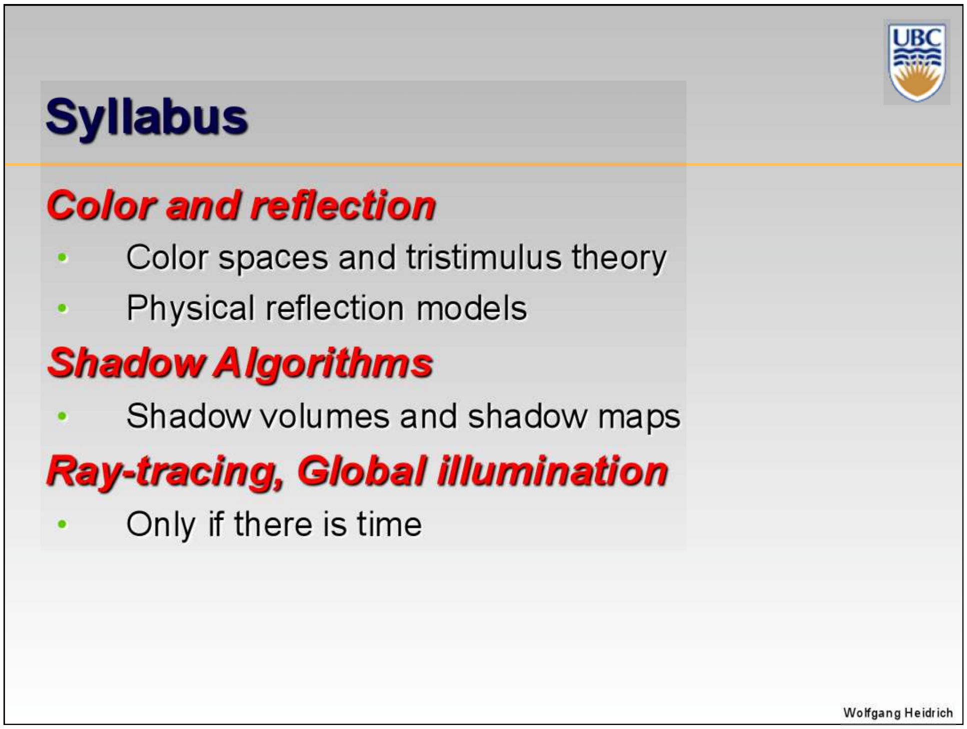

Syllabus

Color and reflection

- Color spaces and tristimulus theory
- Physical reflection models

Shadow Algorithms

- Shadow volumes and shadow maps

Ray-tracing, Global illumination

- Only if there is time

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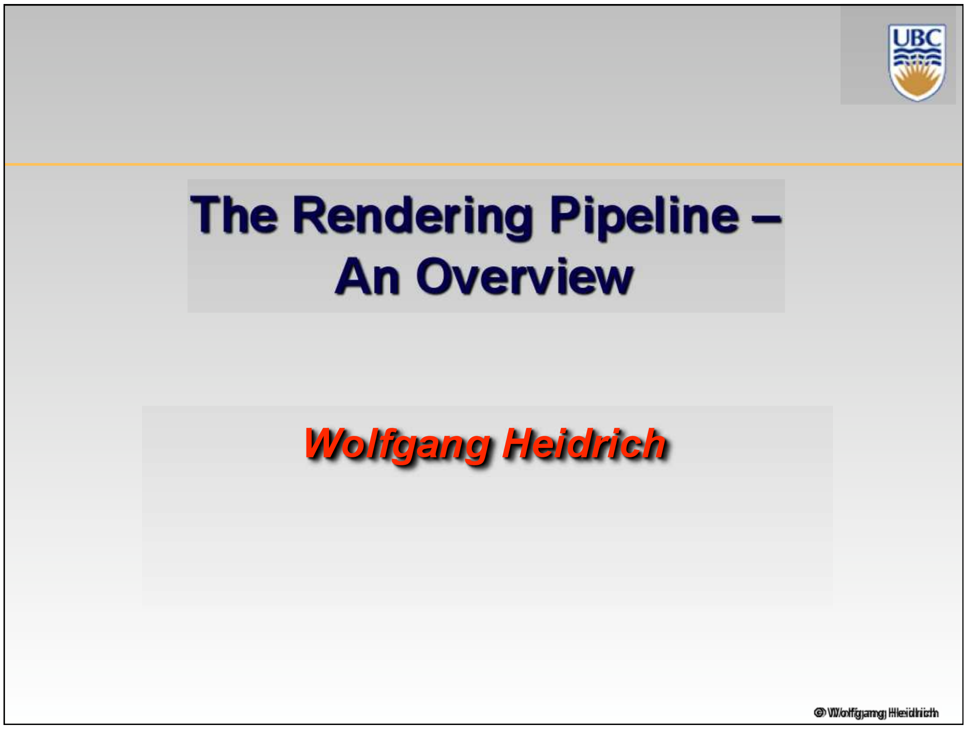
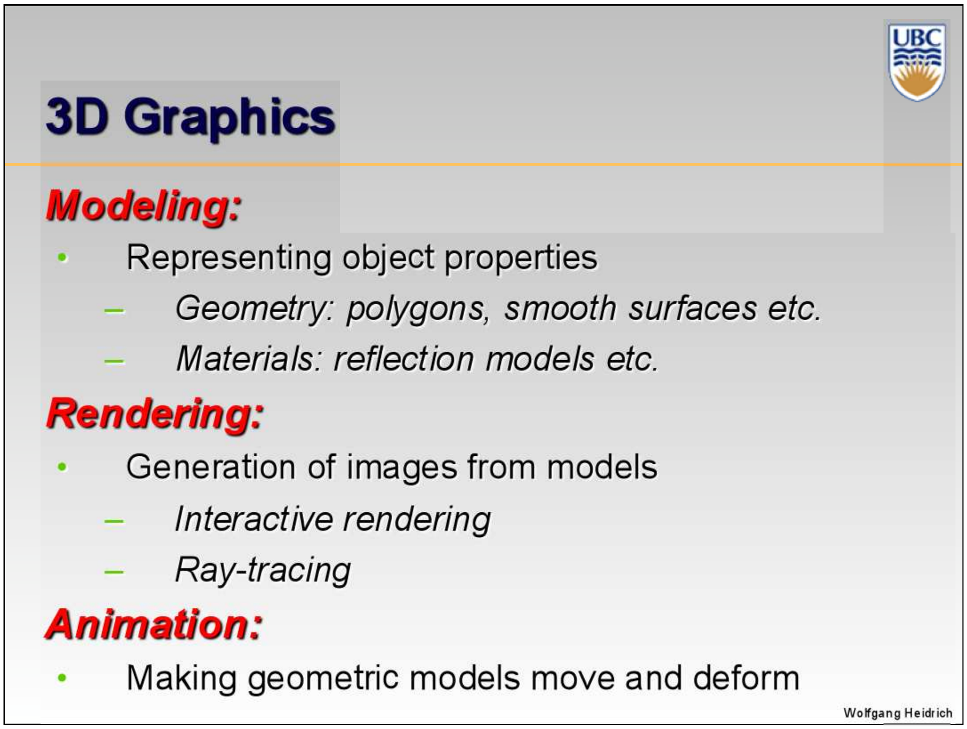


The Rendering Pipeline – An Overview

Wolfgang Heidrich

© Wolfgang Heidrich



3D Graphics

Modeling:

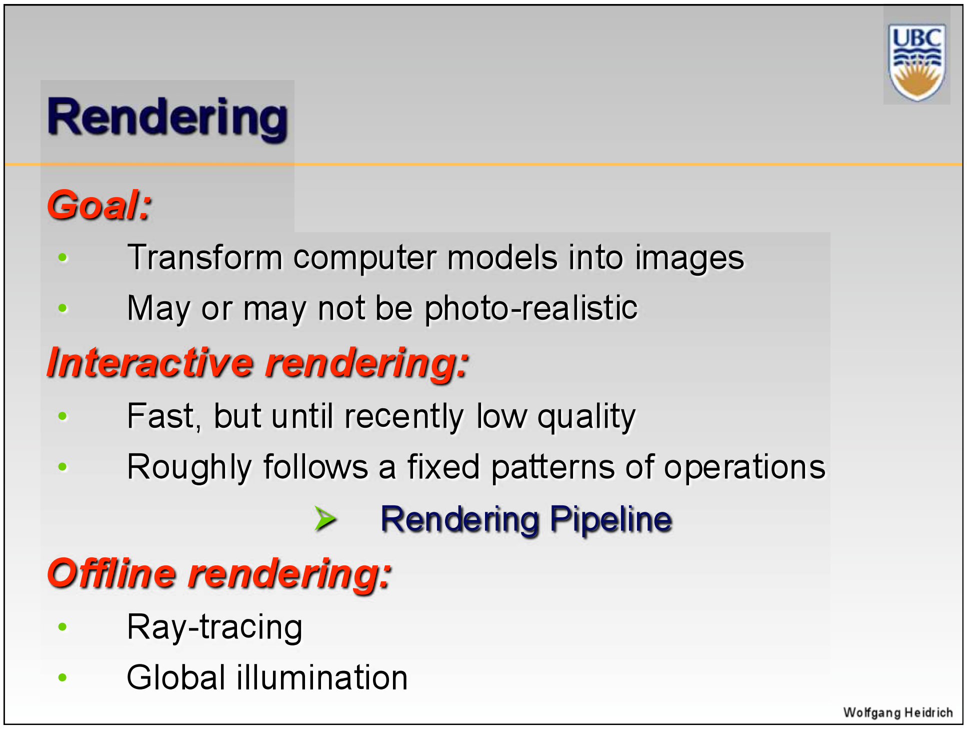
- Representing object properties
  - *Geometry: polygons, smooth surfaces etc.*
  - *Materials: reflection models etc.*

Rendering:

- Generation of images from models
  - *Interactive rendering*
  - *Ray-tracing*

Animation:

- Making geometric models move and deform



Rendering

Goal:

- Transform computer models into images
- May or may not be photo-realistic

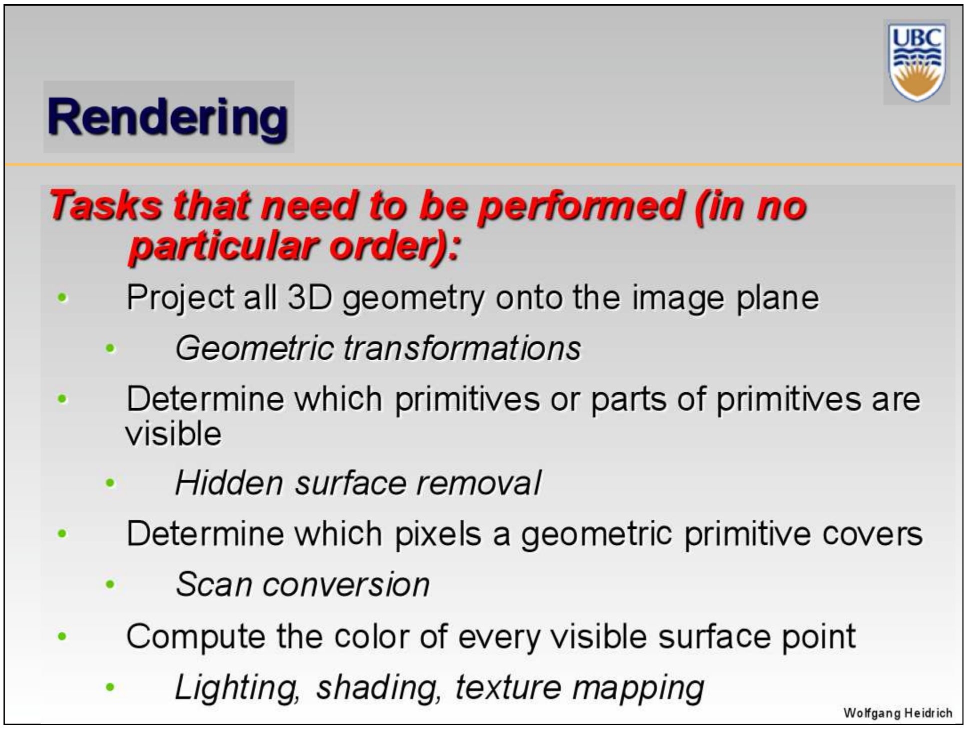
Interactive rendering:

- Fast, but until recently low quality
- Roughly follows a fixed patterns of operations

  ➢ Rendering Pipeline

Offline rendering:

- Ray-tracing
- Global illumination



Rendering

Tasks that need to be performed (in no particular order):

- Project all 3D geometry onto the image plane
  - *Geometric transformations*
- Determine which primitives or parts of primitives are visible
  - *Hidden surface removal*
- Determine which pixels a geometric primitive covers
  - *Scan conversion*
- Compute the color of every visible surface point
  - *Lighting, shading, texture mapping*

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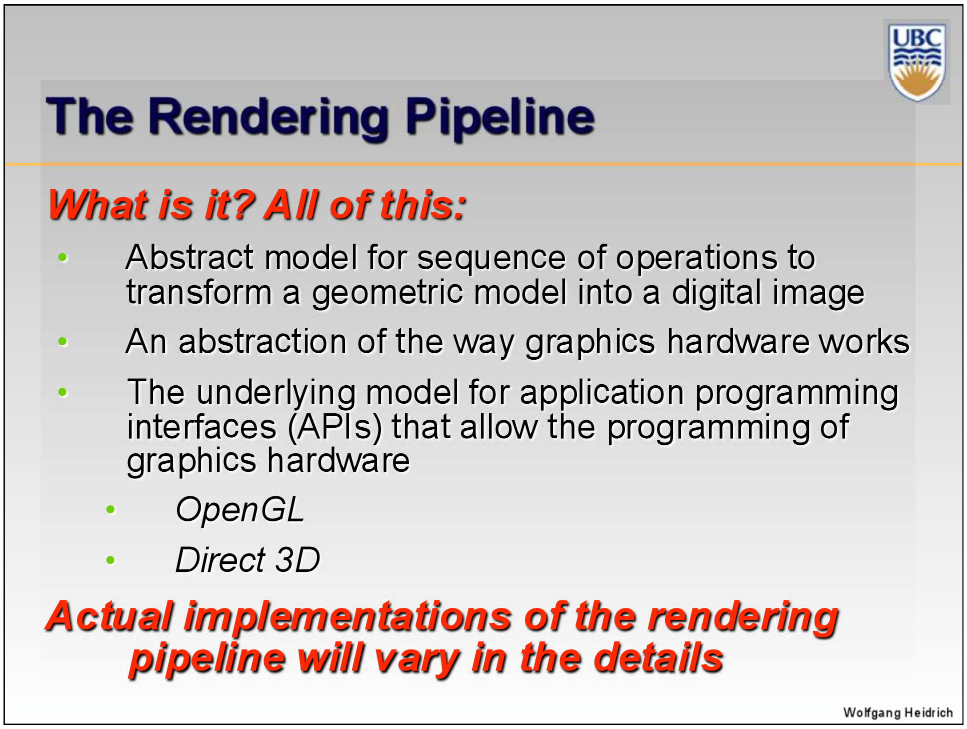

The Rendering Pipeline

What is it? All of this:

- Abstract model for sequence of operations to transform a geometric model into a digital image
- An abstraction of the way graphics hardware works
- The underlying model for application programming interfaces (APIs) that allow the programming of graphics hardware
  - *OpenGL*
  - *Direct 3D*

Actual implementations of the rendering pipeline will vary in the details

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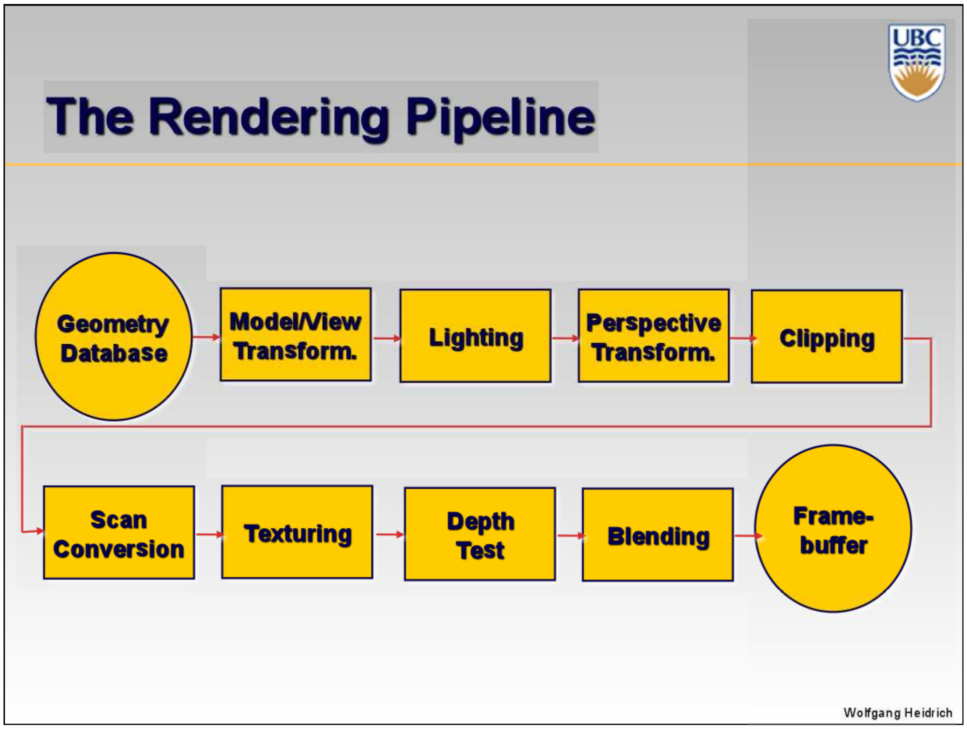

The Rendering Pipeline

Geometry Database

Model/View Transform.

Lighting

Perspective Transform.

Clipping

Scan Conversion

Texturing

Depth Test

Blending

Frame-buffer

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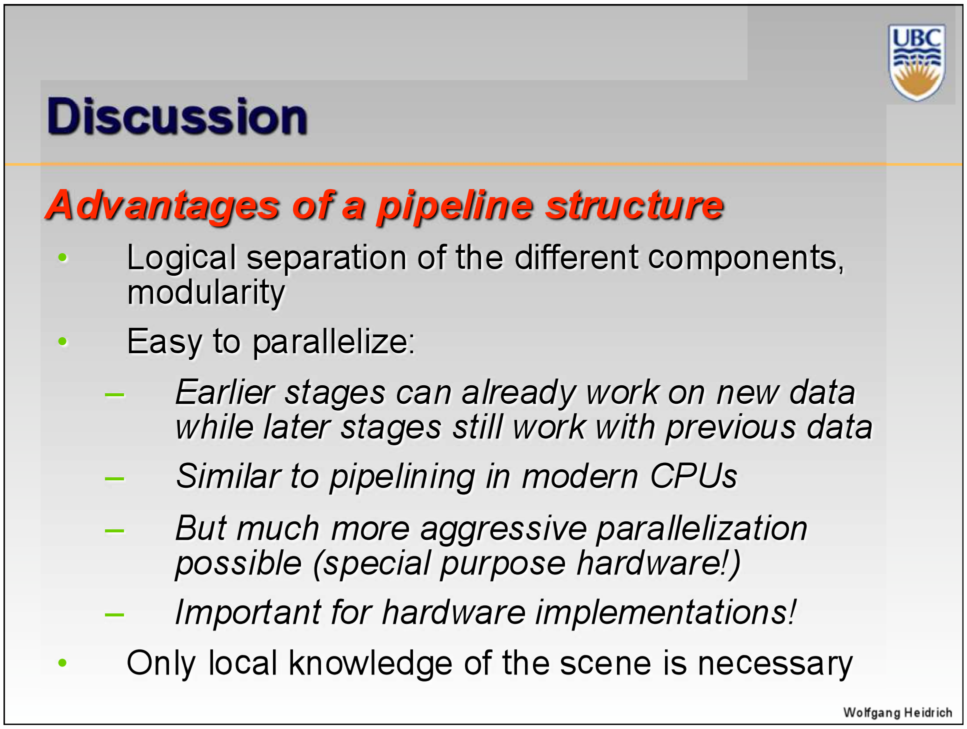

Discussion

Advantages of a pipeline structure

- Logical separation of the different components, modularity
- Easy to parallelize:
  - *Earlier stages can already work on new data while later stages still work with previous data*
  - *Similar to pipelining in modern CPUs*
  - *But much more aggressive parallelization possible (special purpose hardware!)*
  - *Important for hardware implementations!*
- Only local knowledge of the scene is necessary

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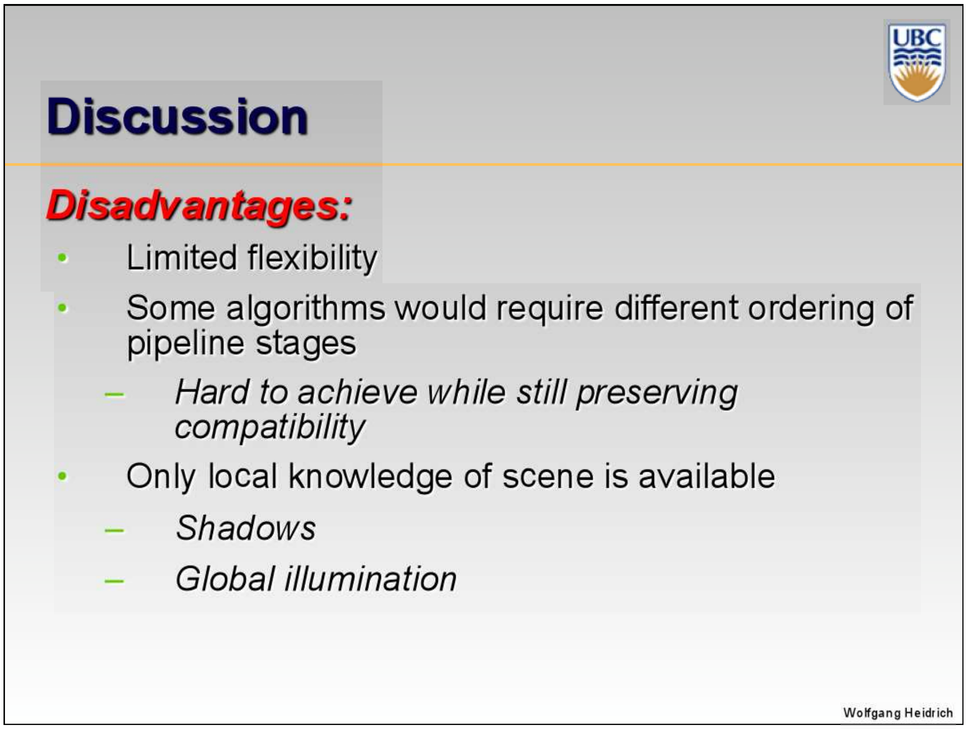
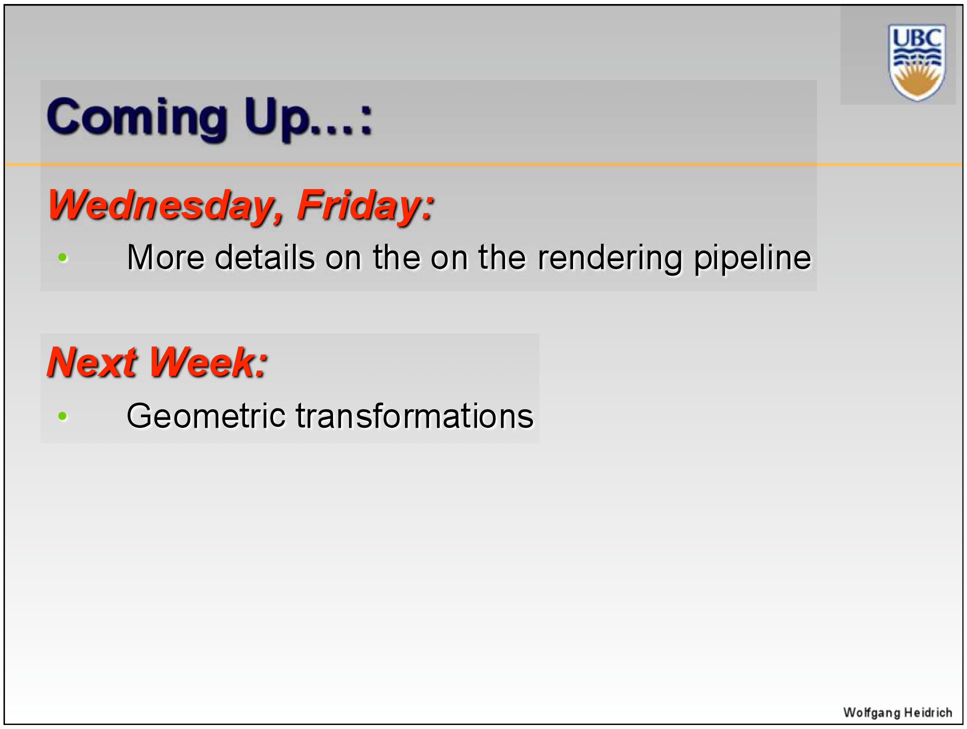


Discussion

Disadvantages:

- Limited flexibility
- Some algorithms would require different ordering of pipeline stages
  - *Hard to achieve while still preserving compatibility*
- Only local knowledge of scene is available
  - *Shadows*
  - *Global illumination*



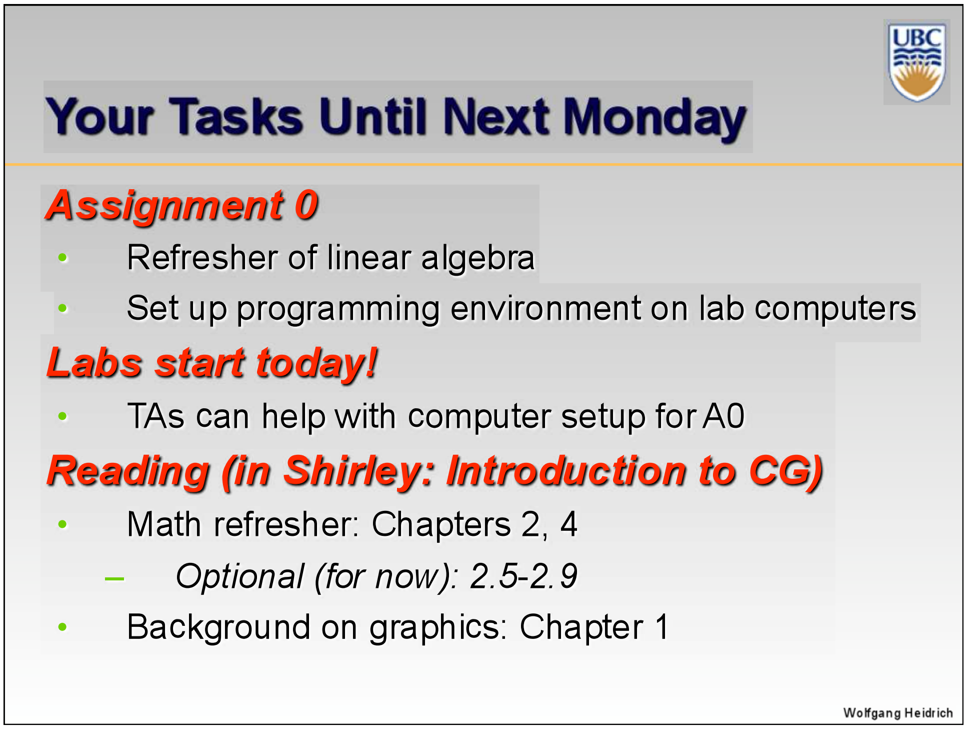
Coming Up…:

Wednesday, Friday:

- More details on the on the rendering pipeline

Next Week:

- Geometric transformations



Your Tasks Until Next Monday

Assignment 0

- Refresher of linear algebra
- Set up programming environment on lab computers

Labs start today!

- TAs can help with computer setup for A0

Reading (in Shirley: Introduction to CG)

- Math refresher: Chapters 2, 4
  - *Optional (for now): 2.5-2.9*
- Background on graphics: Chapter 1

Wolfgang Heidrich