

Visual Computing

Course 252-0206-00L



Prof. Dr. Markus Gross

Computer Graphics Laboratory
Institute for Visual Computing
ETH Zürich

Prof. Dr. Marc Pollefeys

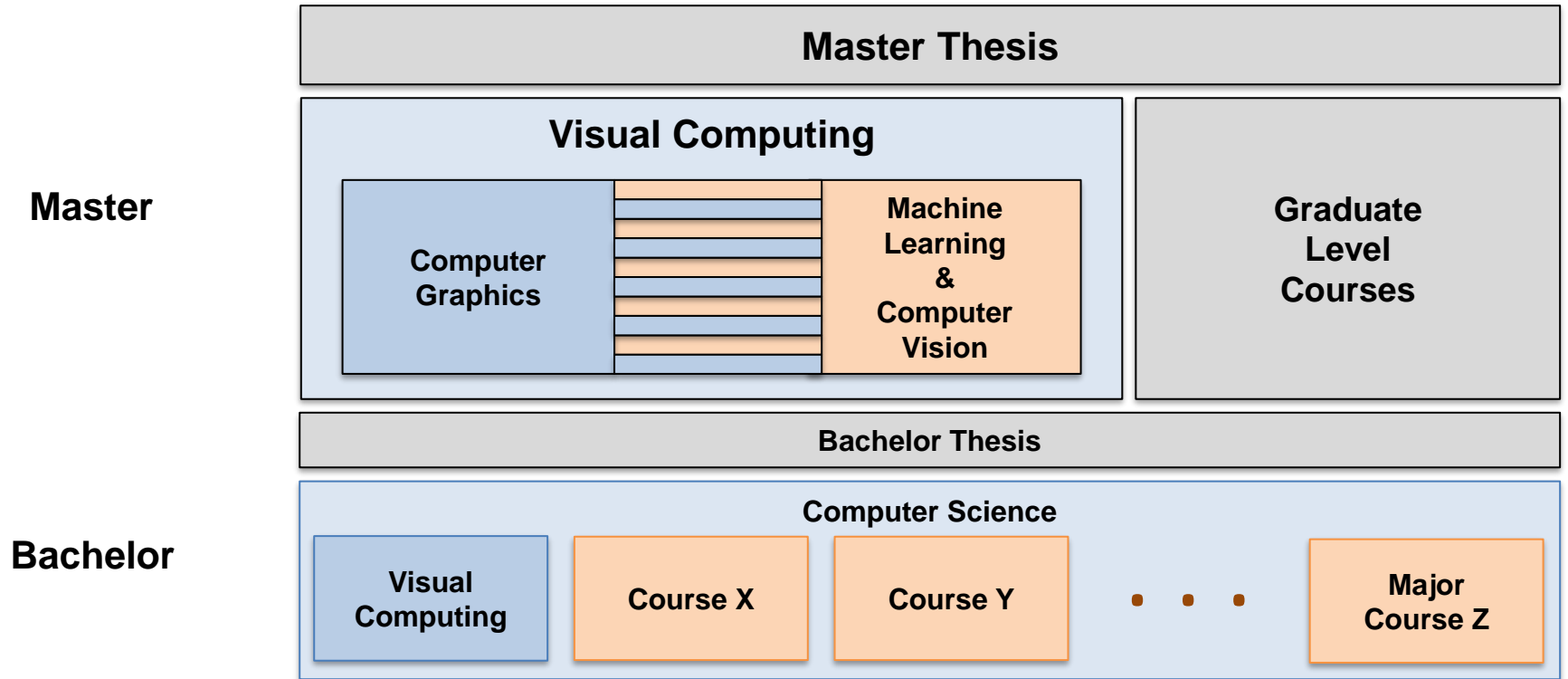
Computer Vision and Geometry Group
Institute for Visual Computing
ETH Zürich

Goals

- In-depth introduction to core concepts in **graphics**, **vision** and **machine learning**
- Basis of the specialization track in **visual computing**
- Entry point for a variety of specialized courses
- Both theoretical and practical issues



Structure



Computer Graphics Laboratory

- Founded in 1994 by Prof. Markus Gross

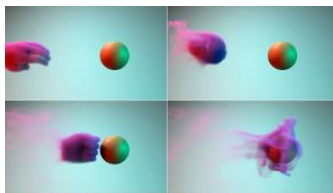


- 7 senior researchers
- 19 Ph.D. students
- Research partnership with Disney Research Zürich
 - Joint Ph.D. students
 - Lecturers from Disney

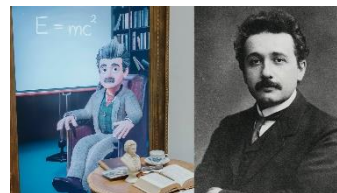


Disney
RESEARCH
S T U D I O S

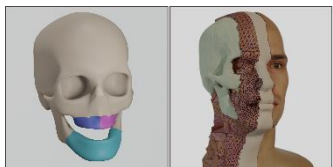
- Main research areas:



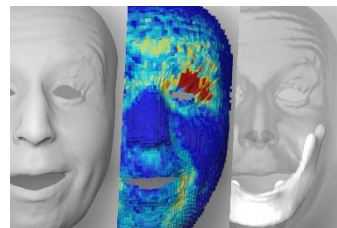
Animation & Simulation



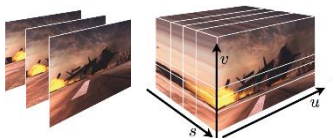
Digital Character AI



Medical

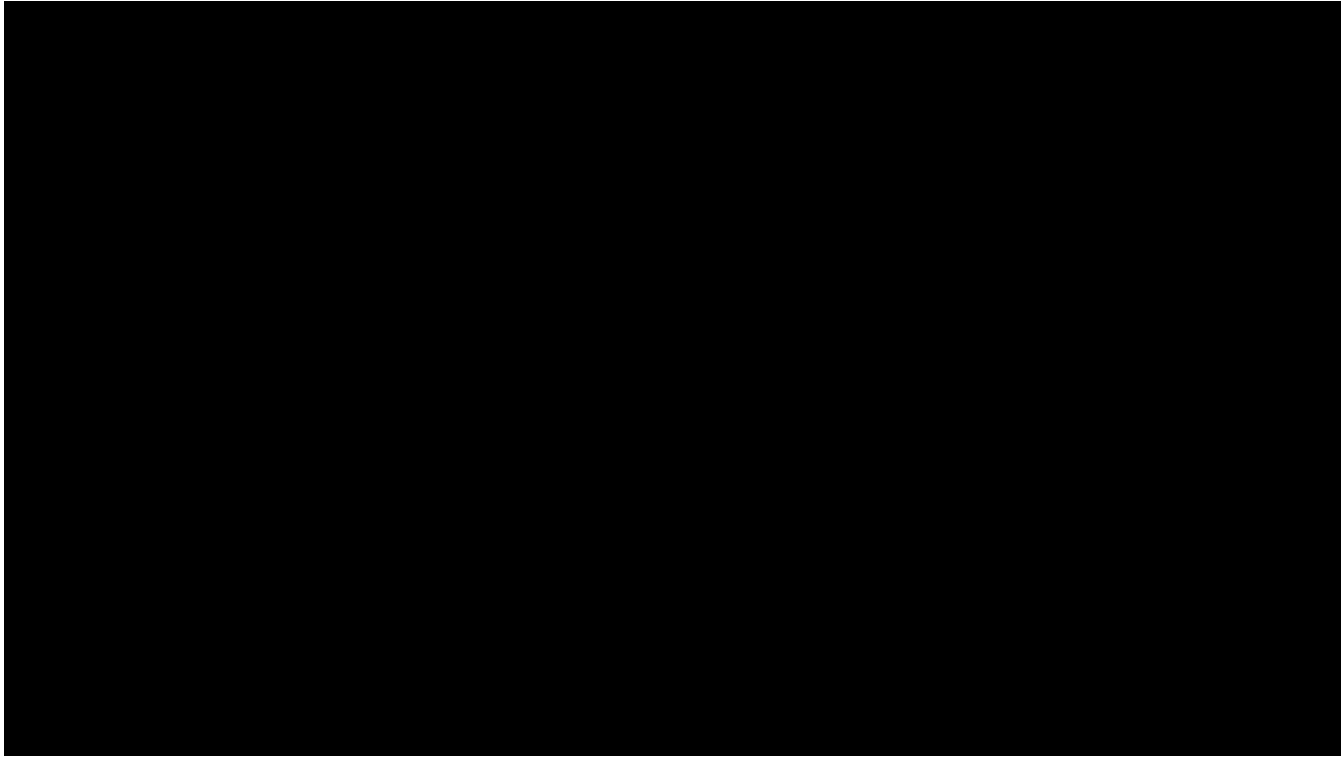


Digital Humans

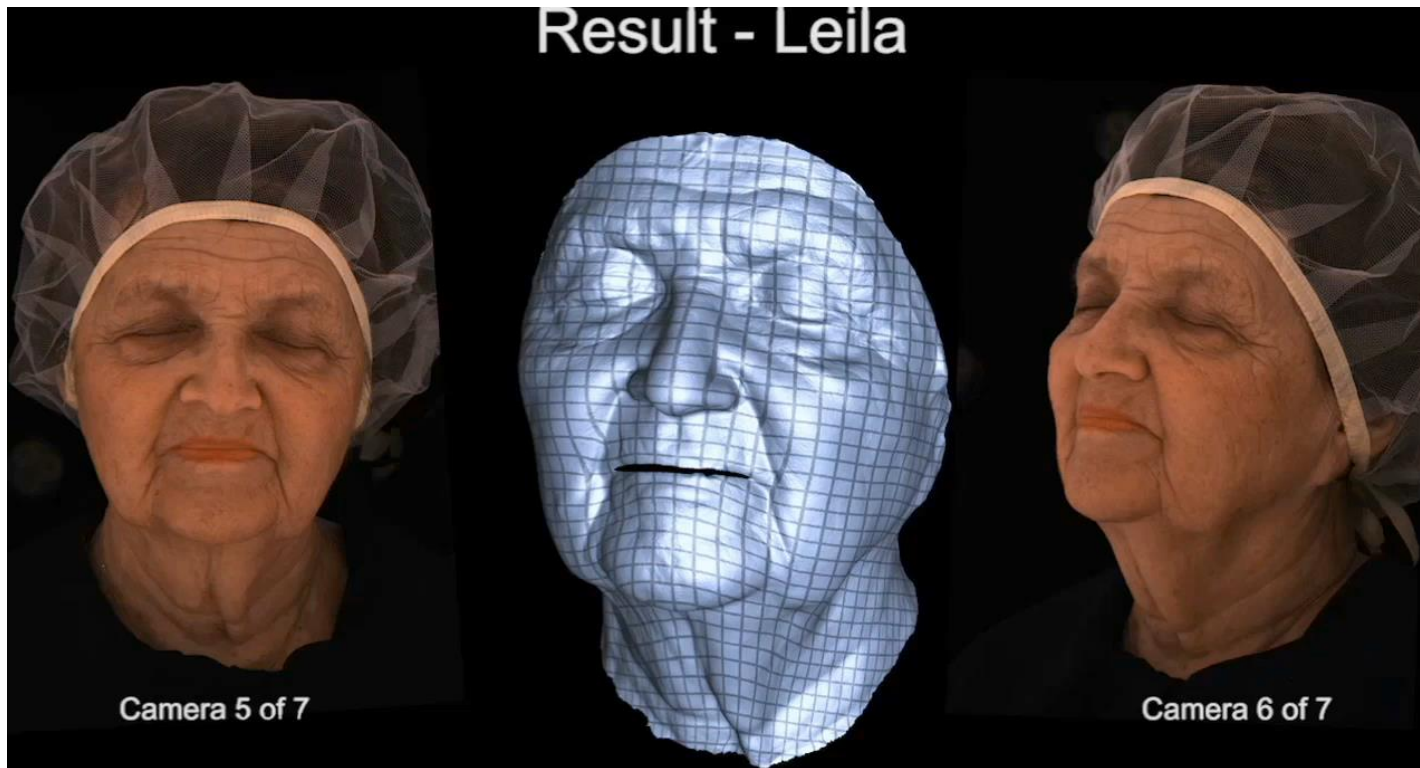


Rendering, Image, Video

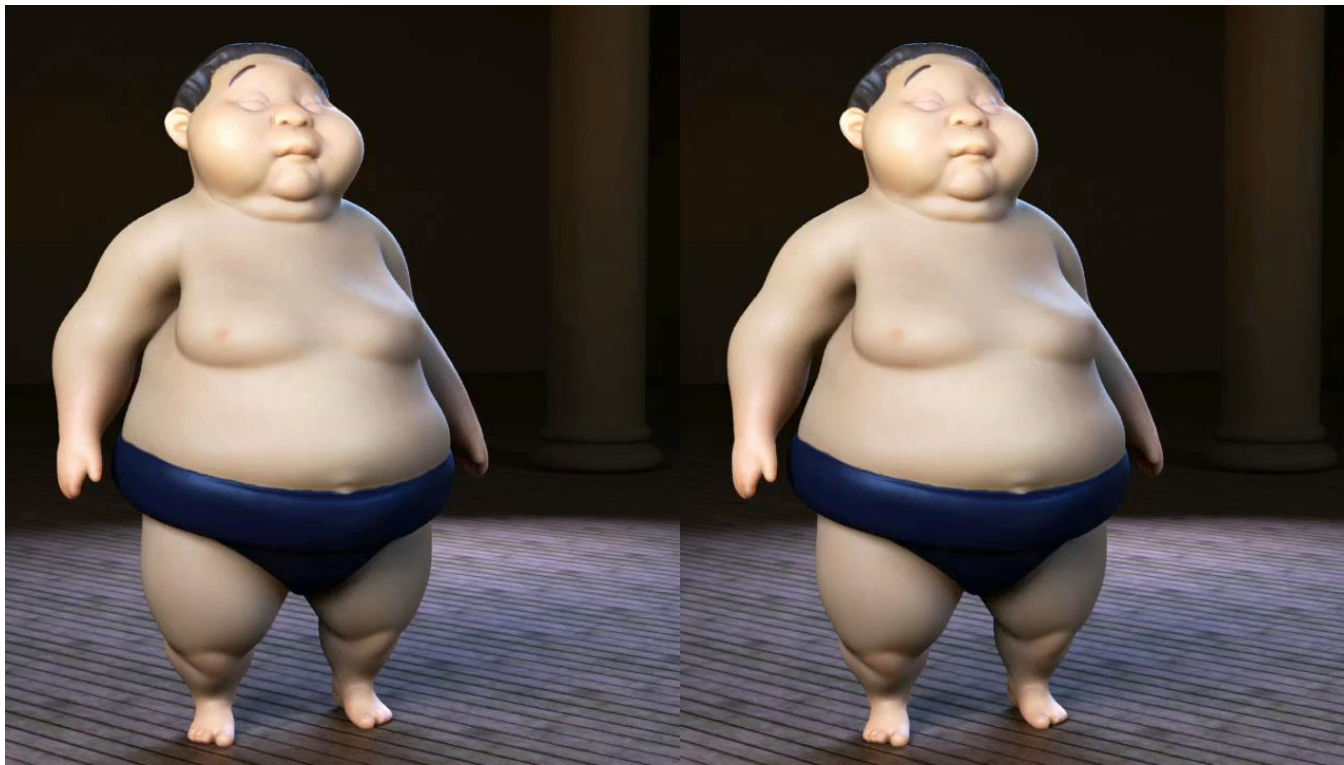
Digital Einstein



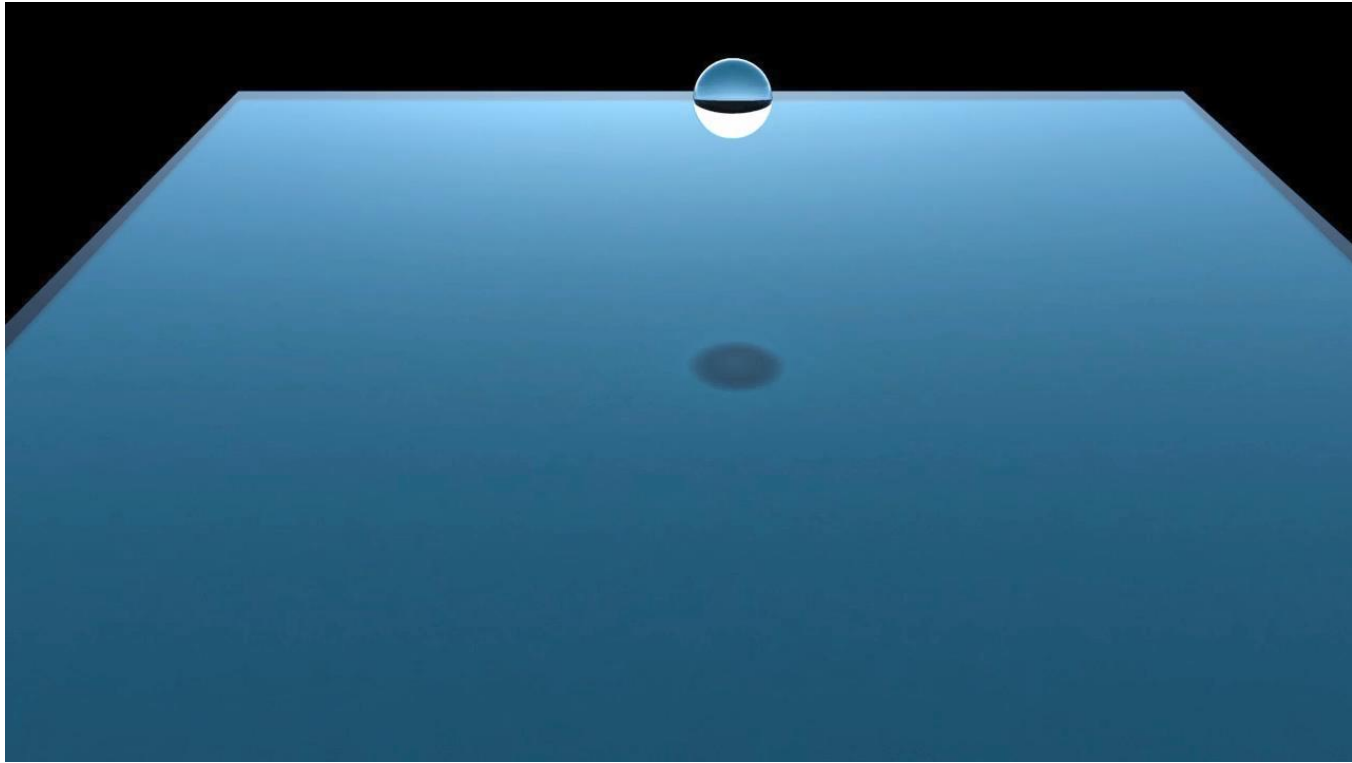
Performance Capture



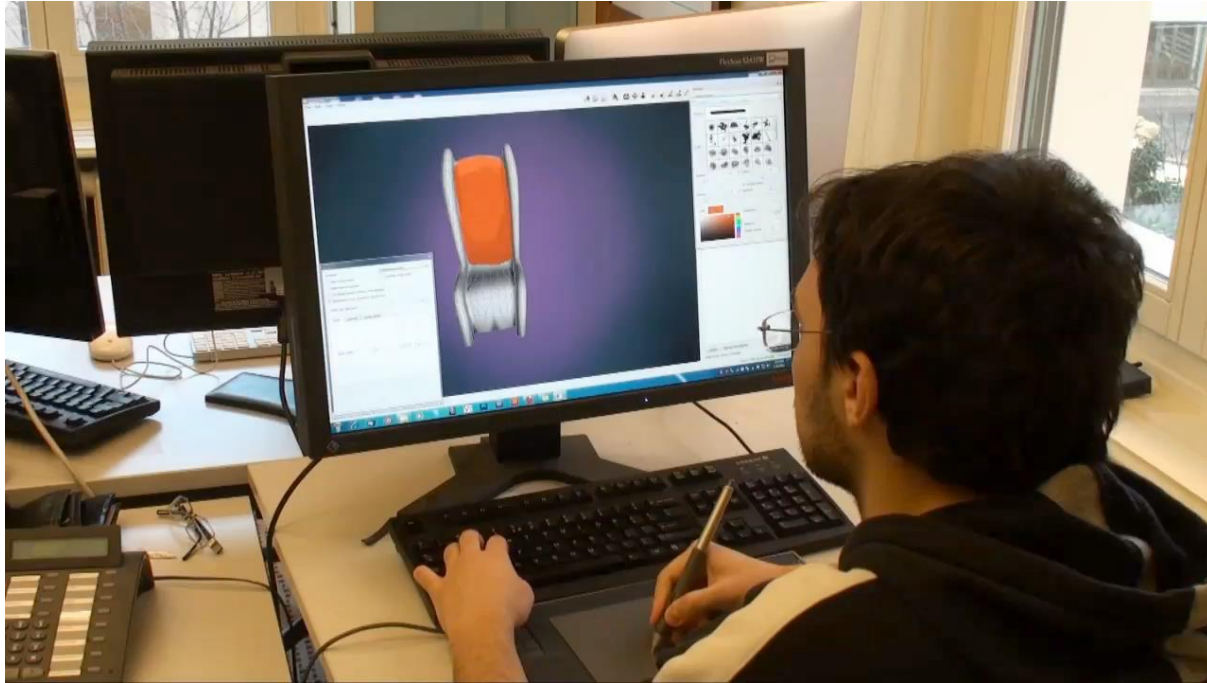
Secondary Motion in Rig-Space



Surface Tension



OverCoat

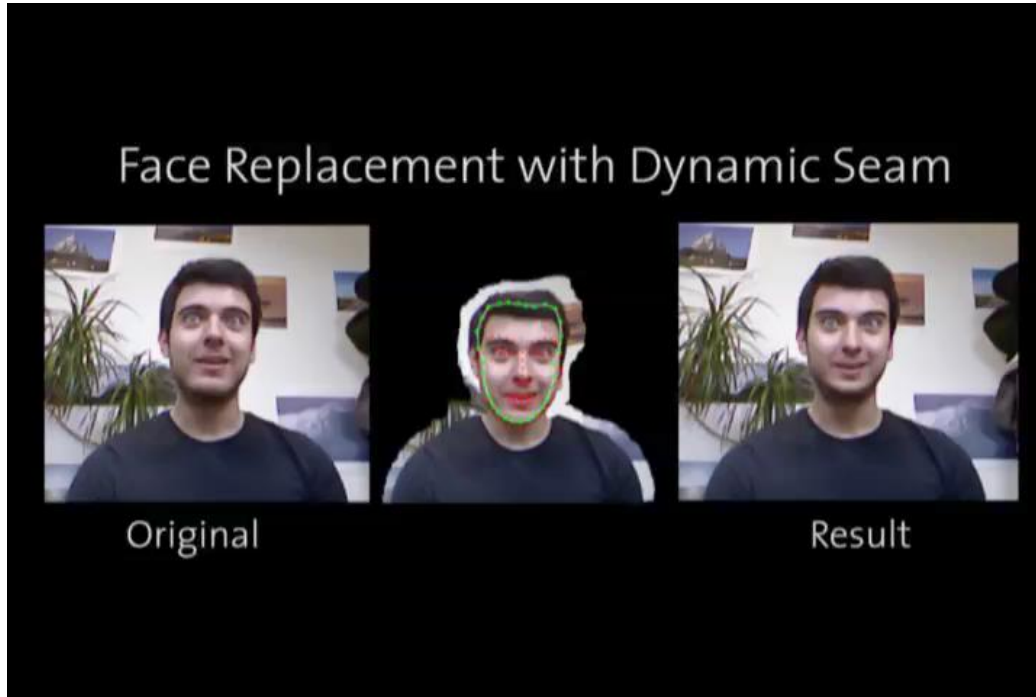


Balloons

Results

Bunny (Silicone)

Gaze Correction



Advanced Courses

- **Computer Graphics**
 - Modeling, rendering, raytracing
- **Mathematical Foundations of Computer Graphics and Vision**
 - Analysis of state-of-the-art algorithms in graphics and vision
- **Game Programming Laboratory**
 - Design & development of a game in small groups
- **Scientific Visualization**
 - Visualization of scientific and abstract data
- **Seminar: Digital Humans / Advanced Methods in CG**
 - State-of-the-art research papers

Overview

Lecturers

Prof. Dr. Markus Gross
Prof. Dr. Marc Pollefeys

Locations

Course: Tue. 10-12 HG G 3
Thu. 14-16 HG G 3
Exercises: Tue. 13-16 CHN G 42
Thu. 9-12 IFW A 36

Credits

8 credits

Team (Vision)

Marc Pollefeys	Dozent	marc.pollefeys@inf.ethz.ch
Philipp Lindenberger	Head TA	philipp.lindenberger@inf.ethz.ch
Linfei Pan	TA	linfei.pan@inf.ethz.ch
Paul-Edouard Sarlin	TA	psarlin@inf.ethz.ch

Team (Graphics)

Markus Gross	Dozent	grossm@inf.ethz.ch
Rafael Wampfler	Head TA	rafael.wampfler@inf.ethz.ch
Philine Witzig	TA	philine.witzig@inf.ethz.ch
Nikola Kovacevic	TA	nikola.kovacevic@inf.ethz.ch
Lingchen Yang	TA	lingchen.yang@inf.ethz.ch
Yingyan Xu	TA	yingyan.xu@inf.ethz.ch

Schedule

Lecture	Topic	Exercise
Nov. 7/9	Introduction, Graphics Pipeline	Ex. 6: WebGL Rendering
Nov. 14/16	Light and Colors, Transformations	Ex. 7: Light and Colors
Nov. 21/23	Lighting and Shading	Ex. 8: Transformations
Nov. 28/30	Geometry and Textures (I), Processing Signals	Ex. 9: Shaders in WebGL
Dec. 5/7	Geometry and Textures (II), Scan Conversion, Curves	Ex. 10: Lighting and Shading
Dec. 12/14	Surfaces, Visibility and Shadows Ray Tracing	Ex. 11: Curves & Surfaces
Dec. 19/21	Raytracing, Geometry Processing The Science of Special Effects in Film (Guest Lecture)	Q&A Session

Exercises

Tuesday, 13.15-16.00 @ CHN G 42

Thursday, 09.15-12.00 @ IFW A 36

- Both practical and theoretical exercises
- Weekly submissions
- Additional details on webpage

Material

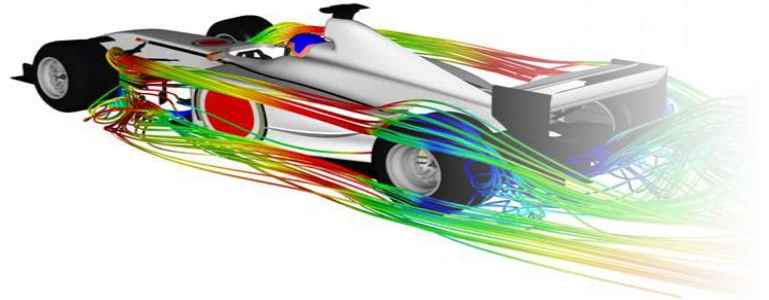
- Lecture notes:
 - Covering second part of the lecture
 - Slide set in PDF format
- Course webpage:
<http://cvg.ethz.ch/teaching/Visual-Computing/>

Support

- Assistants during exercise sessions
- Assistants via email

Part II: Graphics

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«Almost everything on computers that is not text or sound.»

«A picture is worth a thousand numbers!»

Part II: Graphics

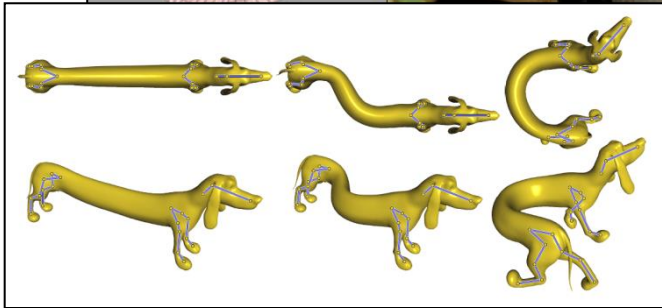
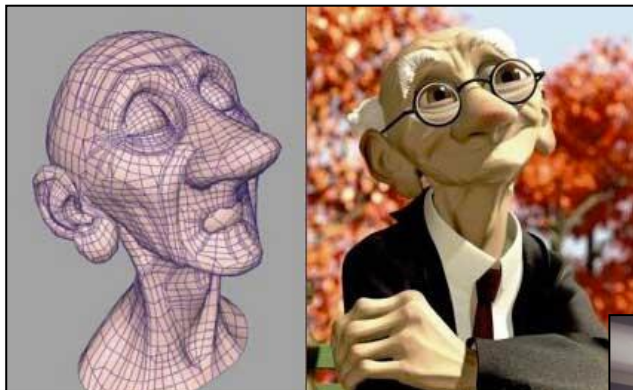
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02ea5450  b1 93 39 aa 97 b5 c6 8a a9 66 8a c3 08 aa 44 f4
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is a sub-field of computer science which studies methods for digitally synthesizing and manipulating visual content. It also encompasses two-dimensional graphics and image processing.

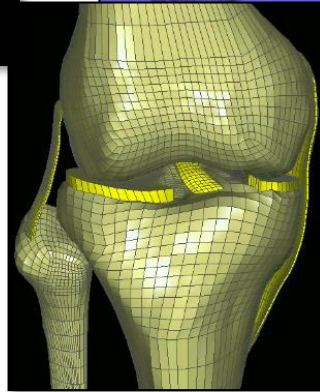
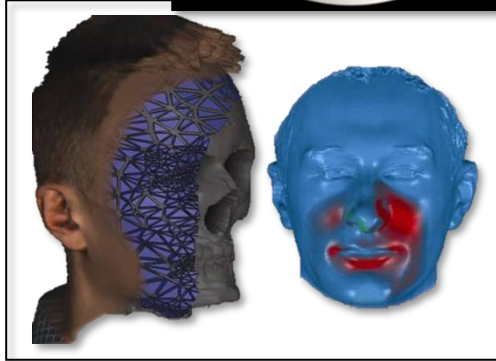
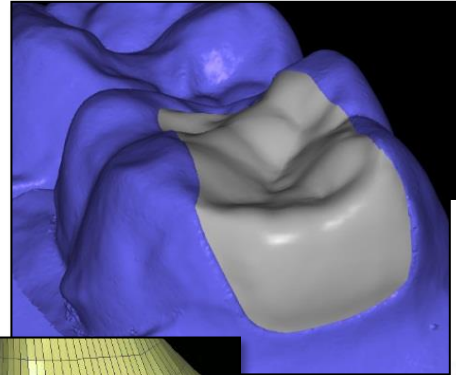
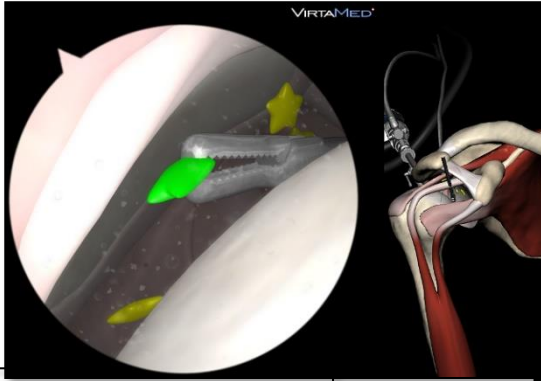
Applications

Modeling & Image Generation



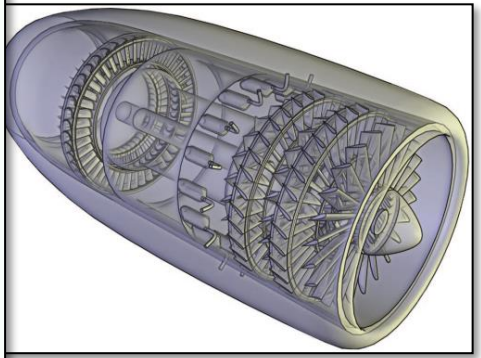
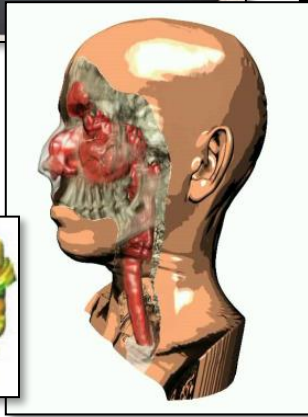
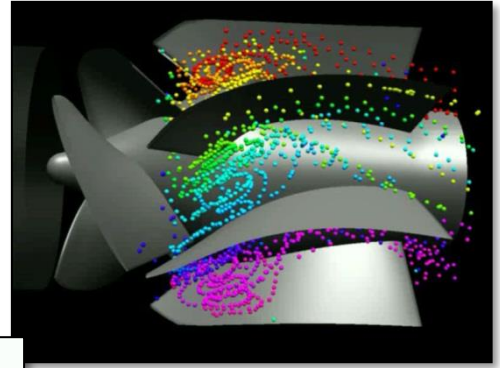
Applications

Medical Simulations



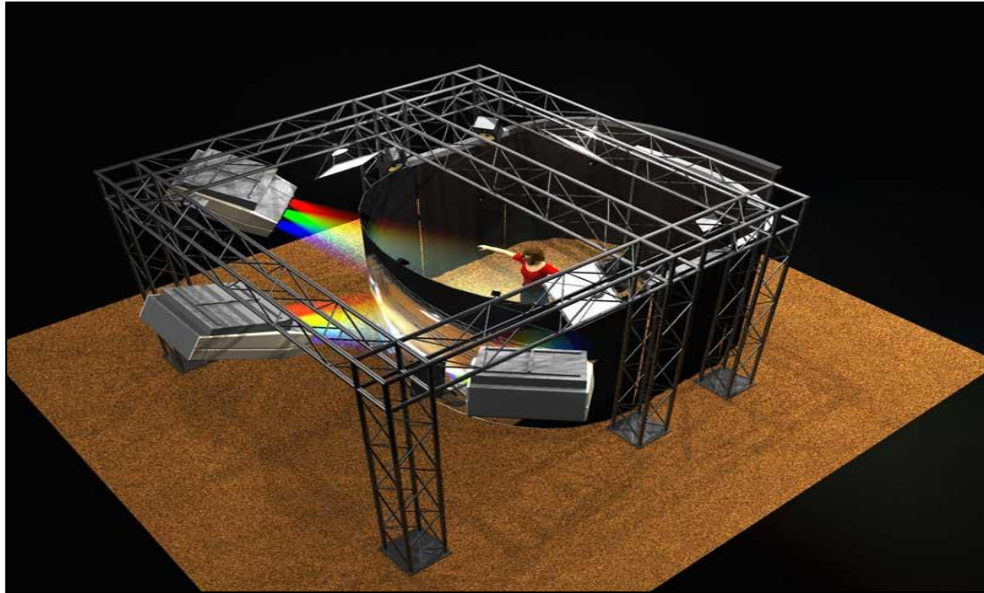
Applications

Scientific Visualization



Applications

Collaborative VE



The Blue-C

Markets

Feature Films



Markets Games



Course Goals

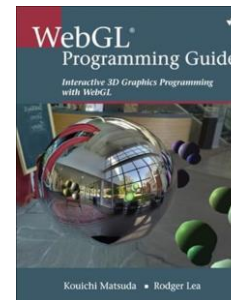
- Introduction to the **fundamentals of 3D Computer Graphics** and image generation (The Math)
- A trip down the **Graphics Pipeline** (Programming Model)
- Introduction to the **WebGL** graphics API (Programming Tools)

Further Readings

- D. F. Rogers:
Procedural Elements of Computer Graphics
2nd edition, McGraw-Hill, 1997.
- A. Watt:
3D Computer Graphics
3rd edition, Addison-Wesley, 1999.
- J. Foley, A. van Dam, S. Feiner, J. Hughes:
Computer Graphics – Principles and Practice
Addison-Wesley, 1990.
- J. Encarnacao, W. Strasser, R. Klein:
Graphische Datenverarbeitung
4th edition, Oldenburg, 1996.

Further Readings

- T. Akenine-Möller, E. Haines:
Real-time Rendering
3rd edition, A. K. Peters Ltd, 2007.
<http://www.realtimerendering.com>
- K. Matsuda, R. Lea:
WebGL Programming Guide
1st edition, Addison Wesley, 2013.
WebGL Version 1.0



A Brief History of Computer Graphics

A Summary of Wayne Carlson's
A Critical History of Computer Graphics

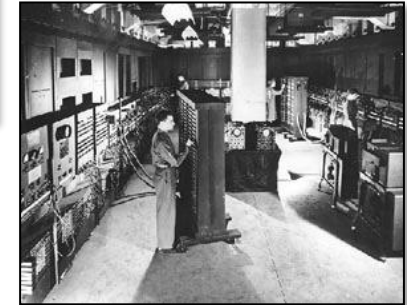
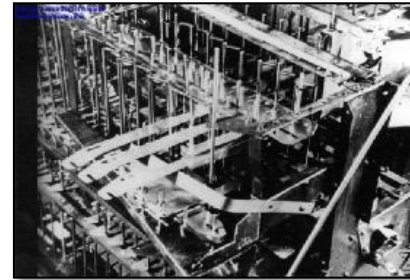
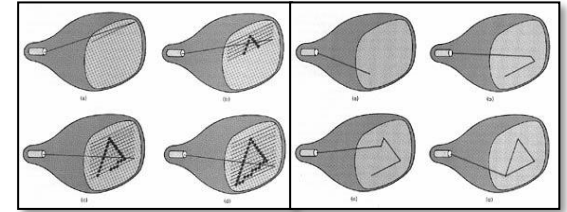
***The discipline is so **recent** in its
early developments
and so **rapidly changing**
that we are in fact living it,
and it **evolves as we speak.*****

Wayne Carlson

Any given program, when
running, is obsolete.

A Brief History of CG

- 1885 Invention of **CRT**
(Cathode Ray Tube)
- 1927 First 60-line raster scanned
image by Philo Farnsworth
- 1938 First mechanical computer
Z1 by Konrad Zuse
- 1946 **ENIAC: Electronic Numerical
Integrator And Computer**
based on vacuum tubes



A Brief History of CG

- 1946 MIT: Whirlwind computer, first computer with real-time display airplanes on **vector CRT**, **interaction** with light pen
- 1947 Invention of **transistor** (transfer resistor)
- 1959 TX-2 developed at MIT first **transistor-based** computer with 9 inch CRT + light pen



A Brief History of CG

1961 **Spacewar** first computer game at MIT

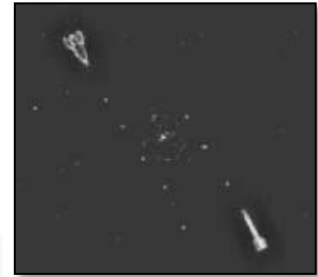
1963 Sketchpad on TX-2 by **Ivan Sutherland**
“grandfather” of interactive computer graphics

1968 Douglas Engelbart invents
computer **mouse**

1969 ACM **Siggraph** founded

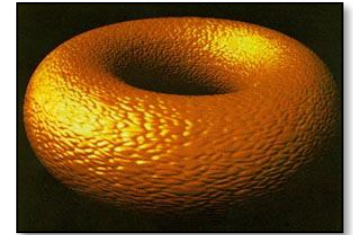
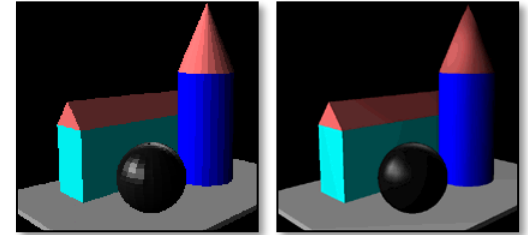
1969 First **frame buffer** at Bell Labs

1969 First **GUI** by Alan Kay (Xerox)



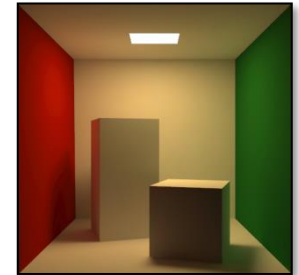
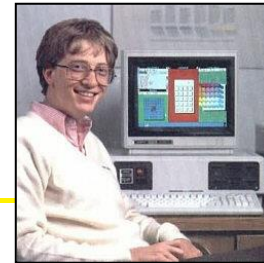
A Brief History of CG

- 1971 Henri **Gouraud**: Interpolated shading
- 1974 Ed Catmull: **Texture** mapping, Z-buffer
- 1974 Sutherland: Polygon **clipping**
- 1975 Bui-Tuong **Phong**: Normal interpolation shading
- 1975 Martin Newell: **Utah Teapot**
- 1976 Jim Blinn: **Environment** mapping
- 1977 Jack **Bresenham**:
Scan conversion algorithms
- 1978 Blinn: **Bump** mapping



A Brief History of CG

- 1980 Turner Whitted: Ray tracing
- 1982 Silicon Graphics (SGI) founded
- 1982 TRON (Disney) 15 minutes of computer generated images
- 1983 Apple Lisa: First PC with GUI
- 1984 Goral et. al: Radiosity
- 1985 Microsoft Windows 1.01
- 1986 MIT: X-Window System



A Brief History of CG

- 1992 OpenGL released by SGI
- 1994 Greg Turk scans Stanford Bunny
- 1995 Toy Story: First full-length computer animated film
- 1996 3Dfx Voodoo: First 3D accelerator for PCs, textured triangles
- 1997 GeForce256: Transformation & Lighting (T&L)
- 1999 PC graphics outperform SGI graphics workstations



A Brief History of CG

- 2001 GeForce3: Programmable T&L
- 2001 Final Fantasy: Human actors replaced by CG models
- 2005 Sony PS3, Cell chip (ca. 500 GFLOPS)
- 2008 Nvidia presents CUDA
- 2009 Avatar: Highest-grossing film
Mainstream resurgence of 3D films
- 2013 GeForce GTX Titan, Radeon HD 8970 (ca. 4.5 TFLOPS)



A Brief History of CG

- 2001 Virtual Reality Resurgence
VR headsets (Oculus Rift, HTC Vive)
- 2016 Augmented Reality goes mainstream
Pokémon Go, AR mobile gaming
- 2018 Real-time Ray Tracing (Nvidia RTX)
RTX 2080 ti (ca. 13.5 TFLOPS)
- 2021 Metaverse and Web3
- 2022 Real-time Digital Humans

