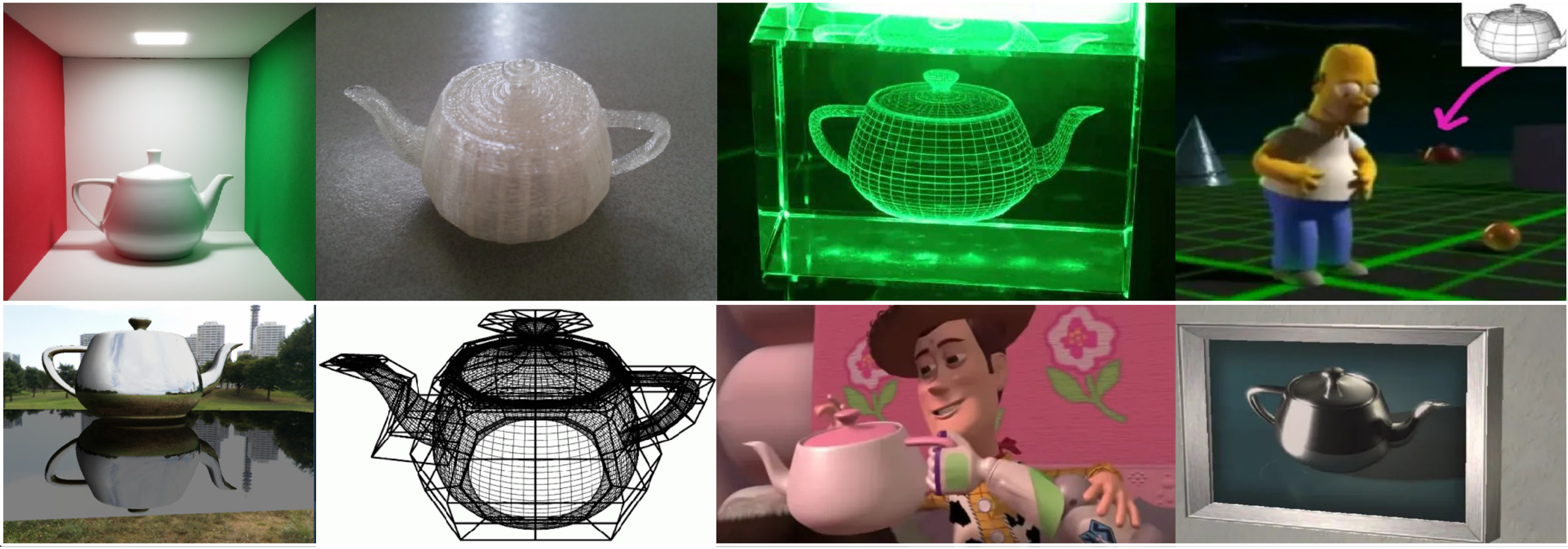
Visual Computing I:

Interactive Computer Graphics and Vision



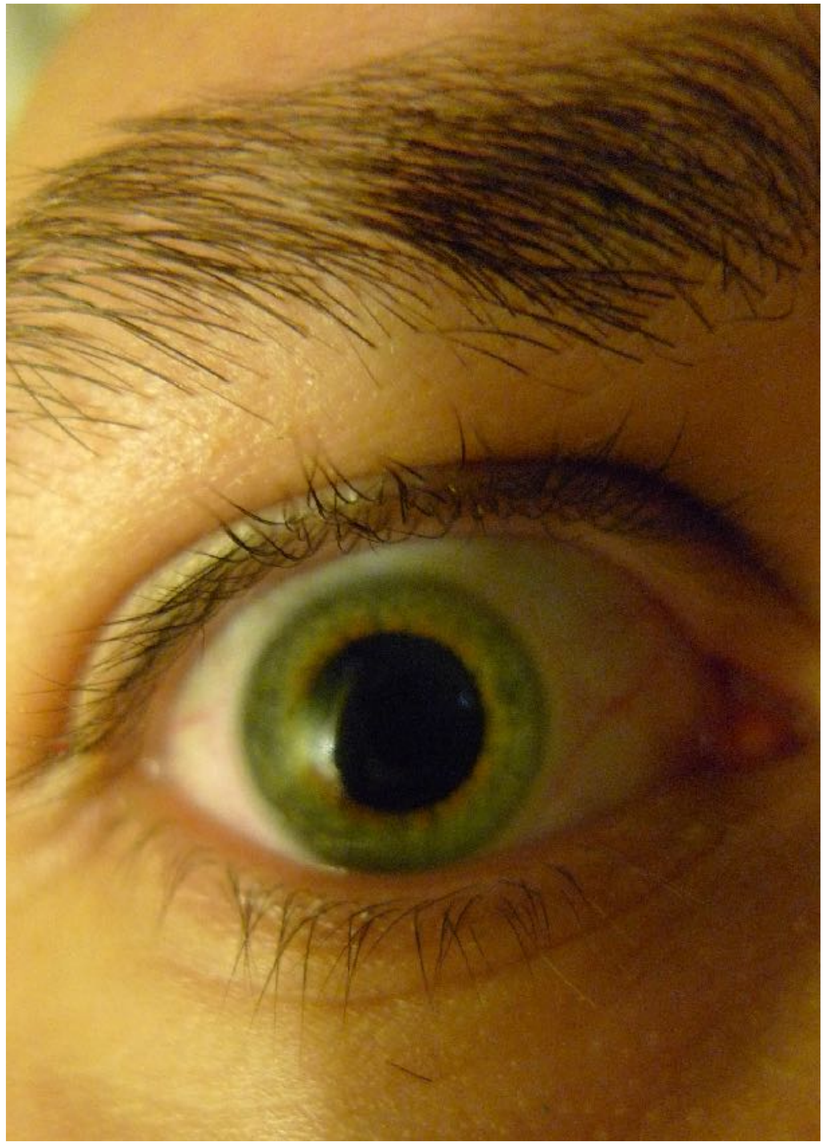
Intro

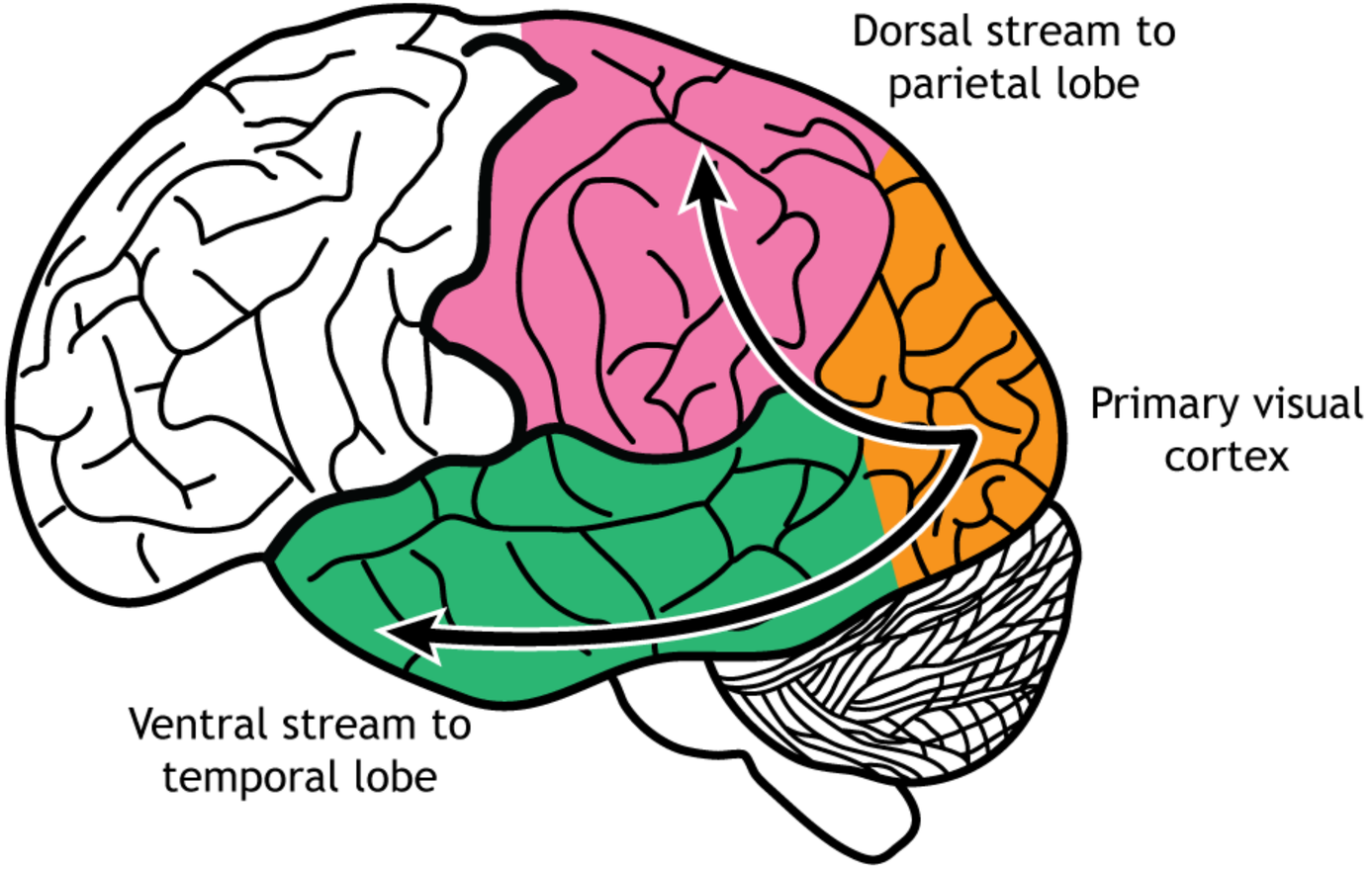
Stefanie Zollmann and Tobias Langlotz

Welcome!

What is Visual Computing

What is Visual Computing

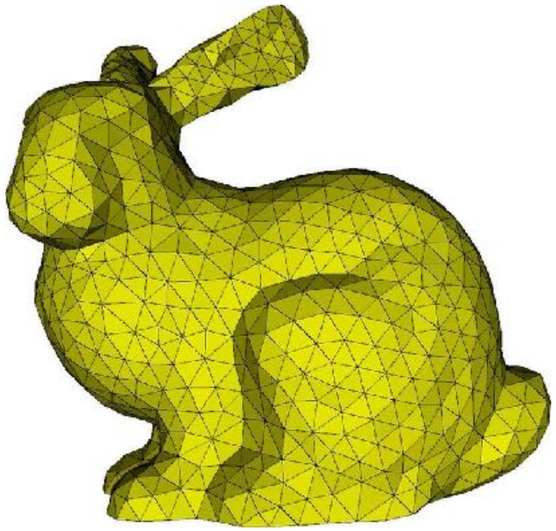


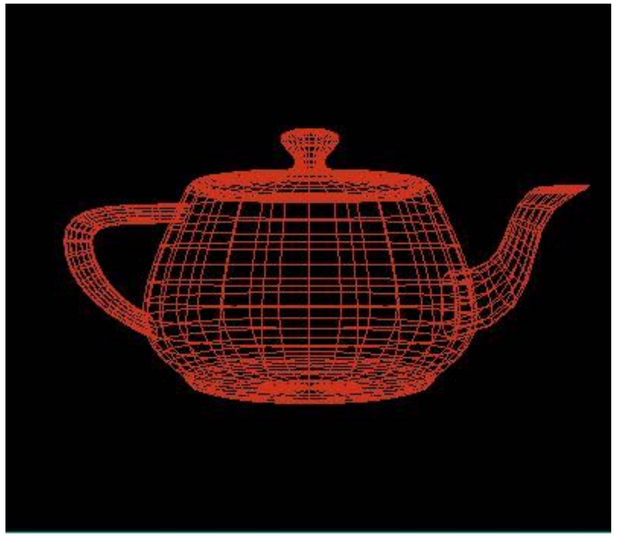


30% of our brain dedicated to visual processing

What is Visual Computing

Computer Graphics





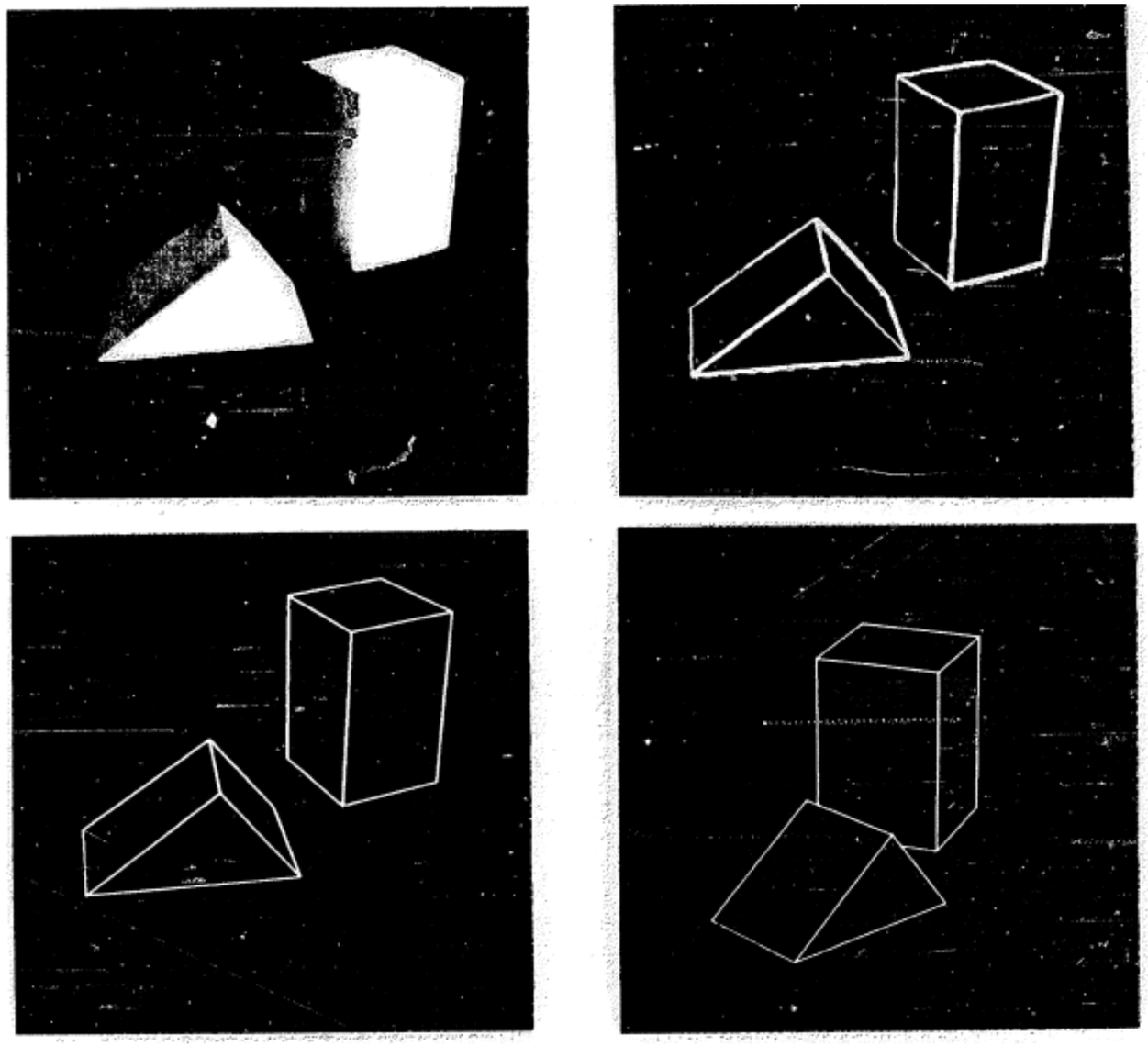
Stanford Bunny

Cornell box

Utah Teapot

What is Visual Computing

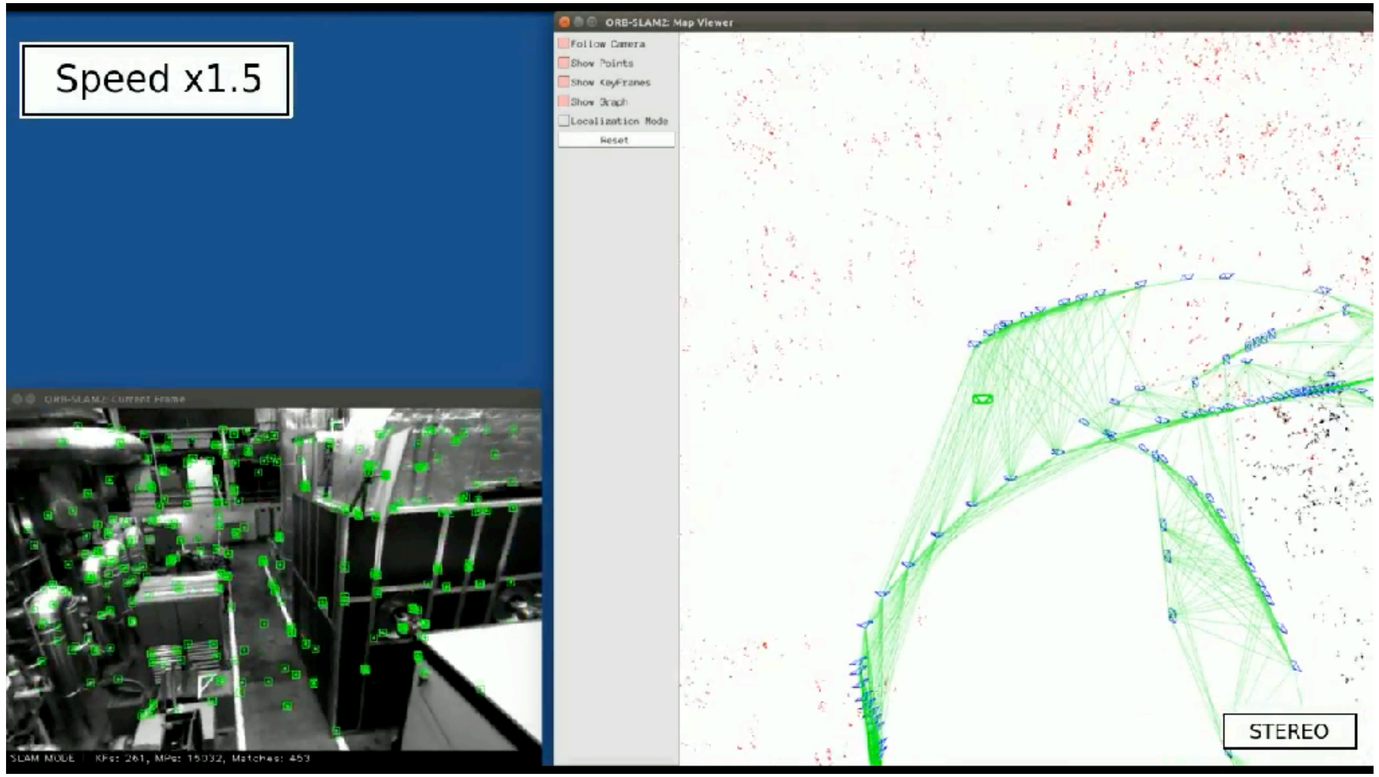
Computer Vision



Scene Reconstruction (Larry Roberts "*Machine Perception of Three-Dimensional Solids*")

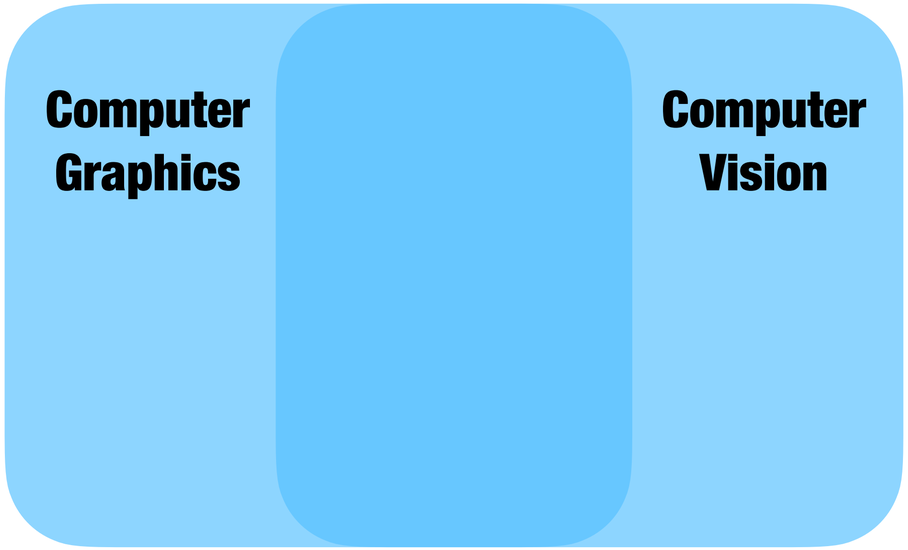
What is Visual Computing

Computer Vision



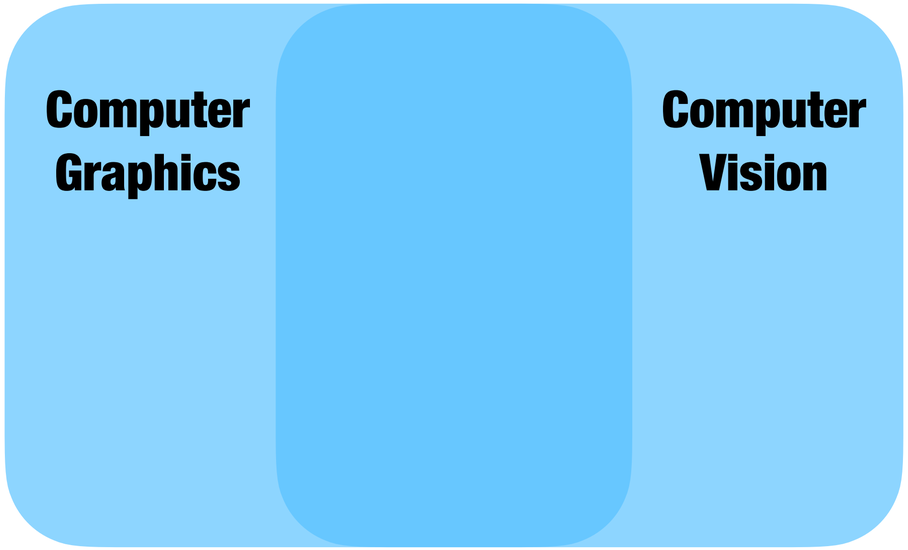
ORBSlam

What is Visual Computing



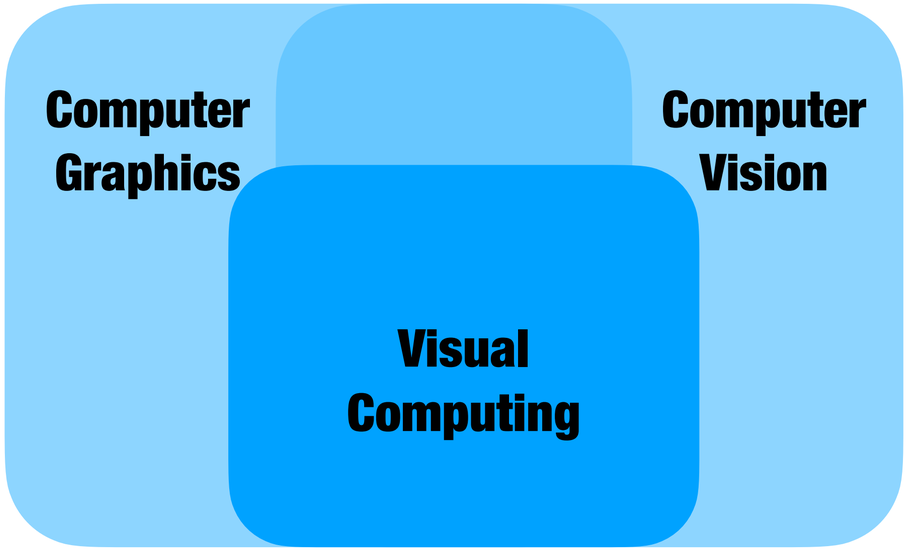
Movies (Avatar)

What is Visual Computing



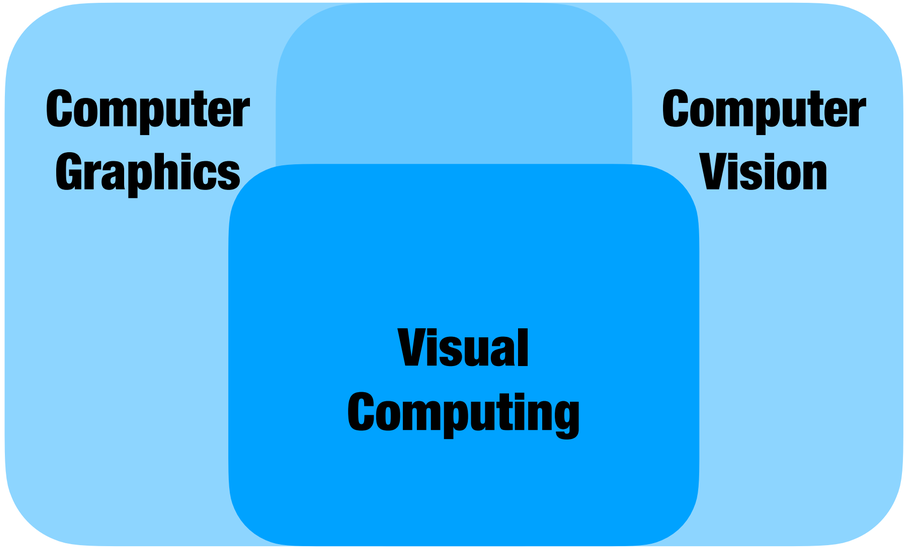
Movies (Motion Capturing / Andy Serkins)

What is Visual Computing



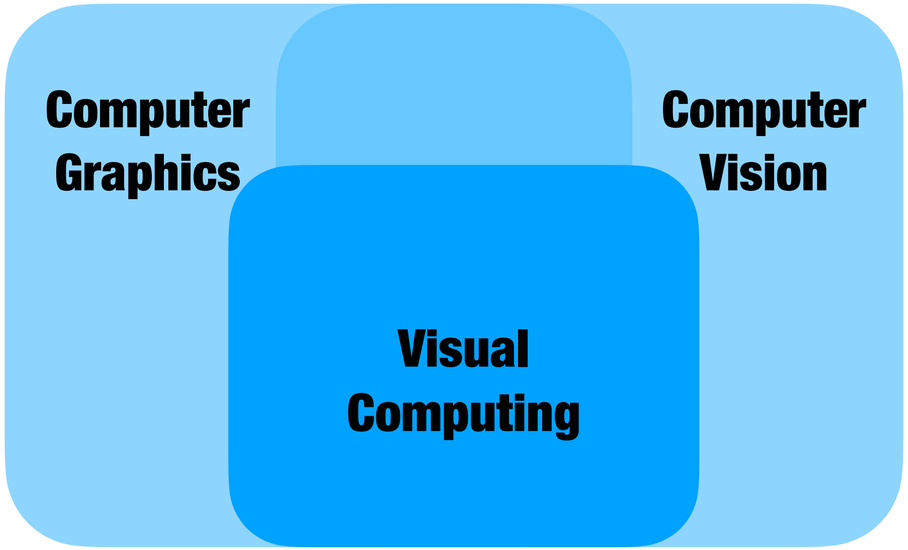
Games (Unreal Engine Demo)

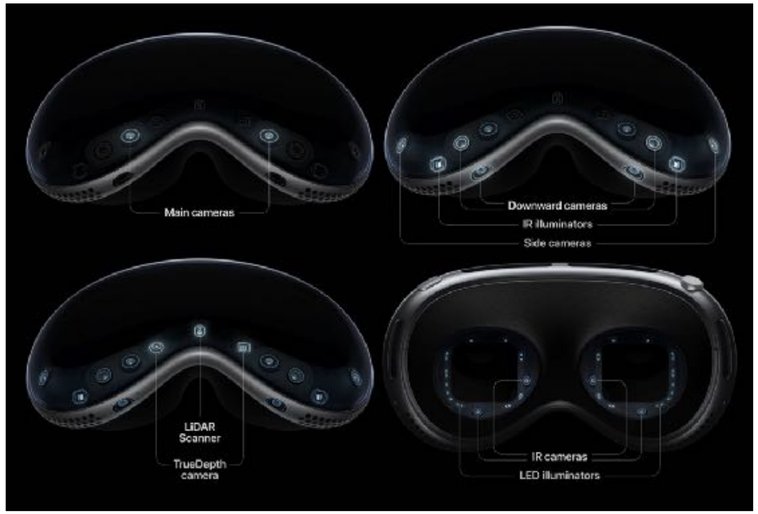
What is Visual Computing

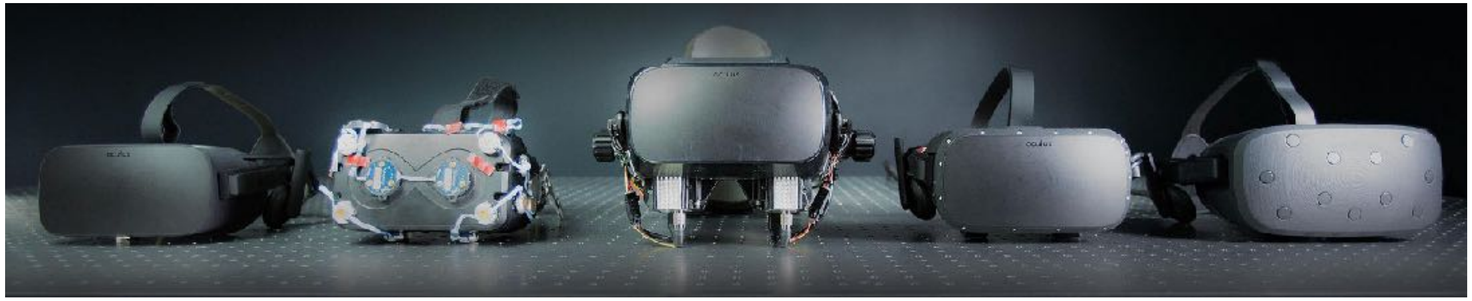


Ubiqitious Cameras

What is Visual Computing

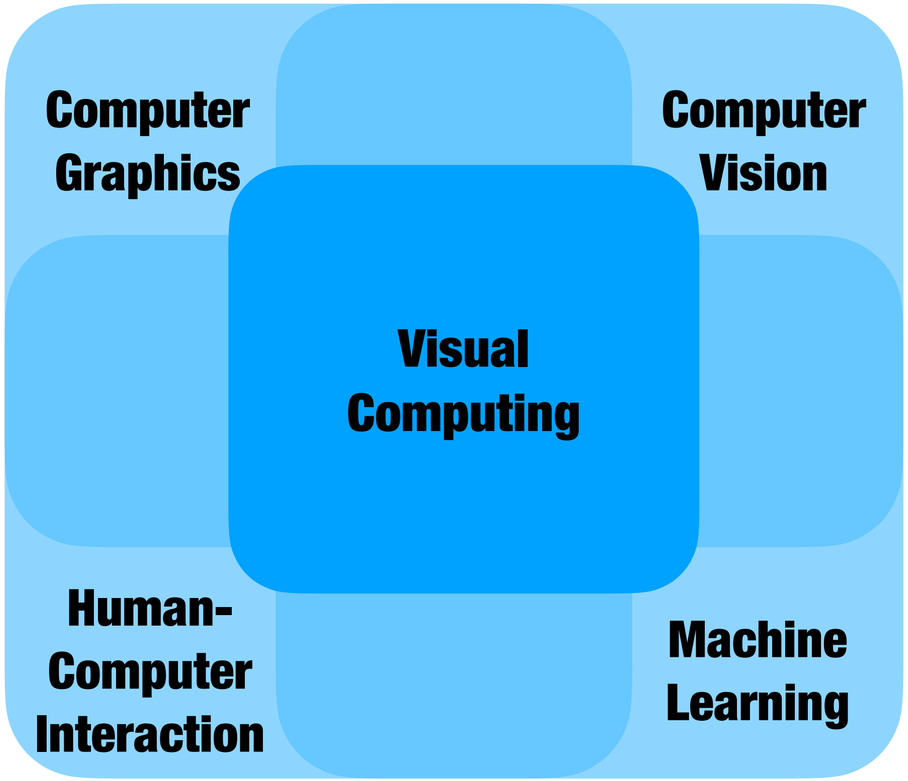


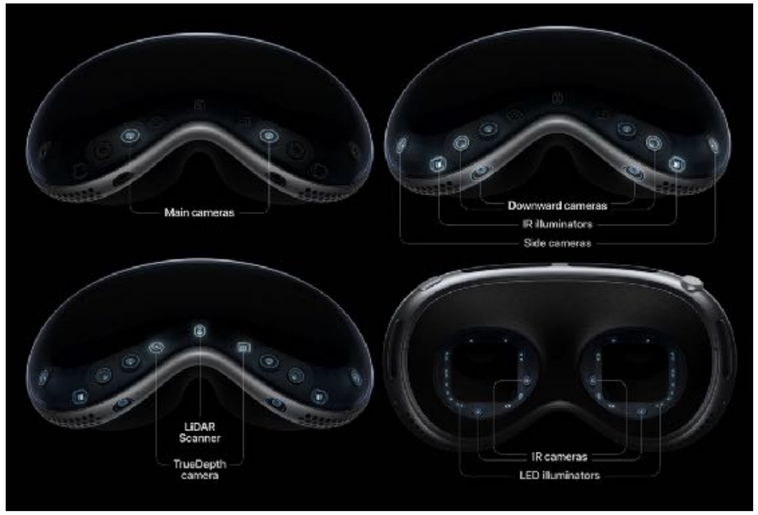


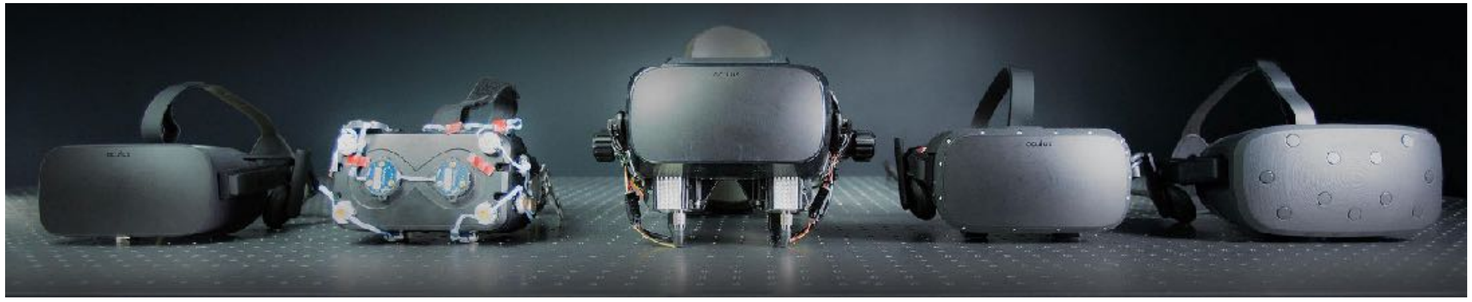


Virtual and Augmented Reality

What is Visual Computing

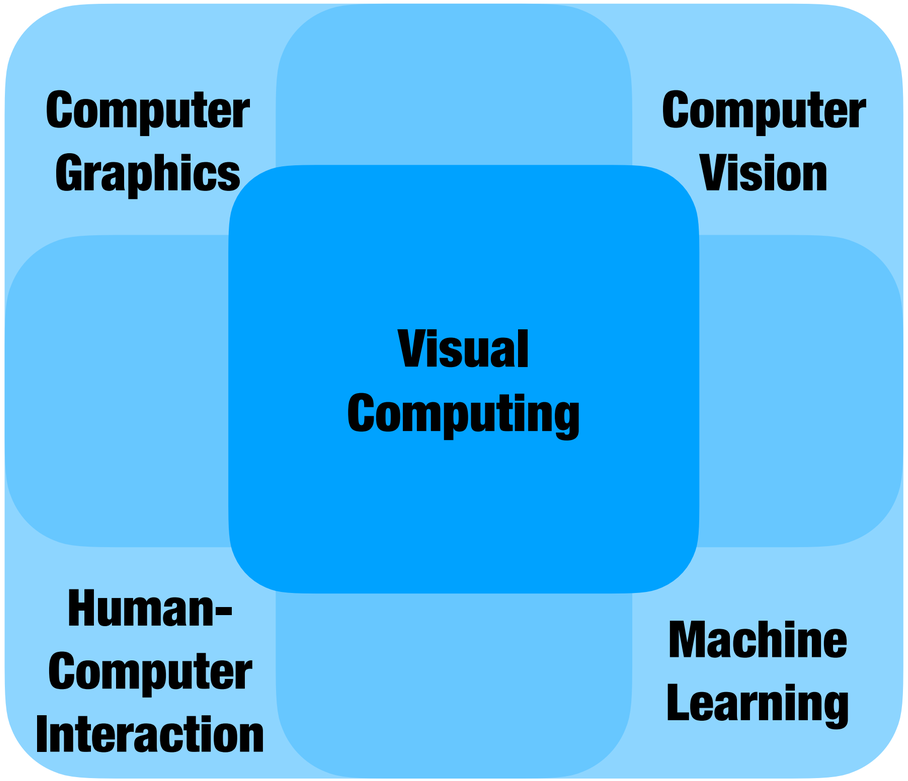






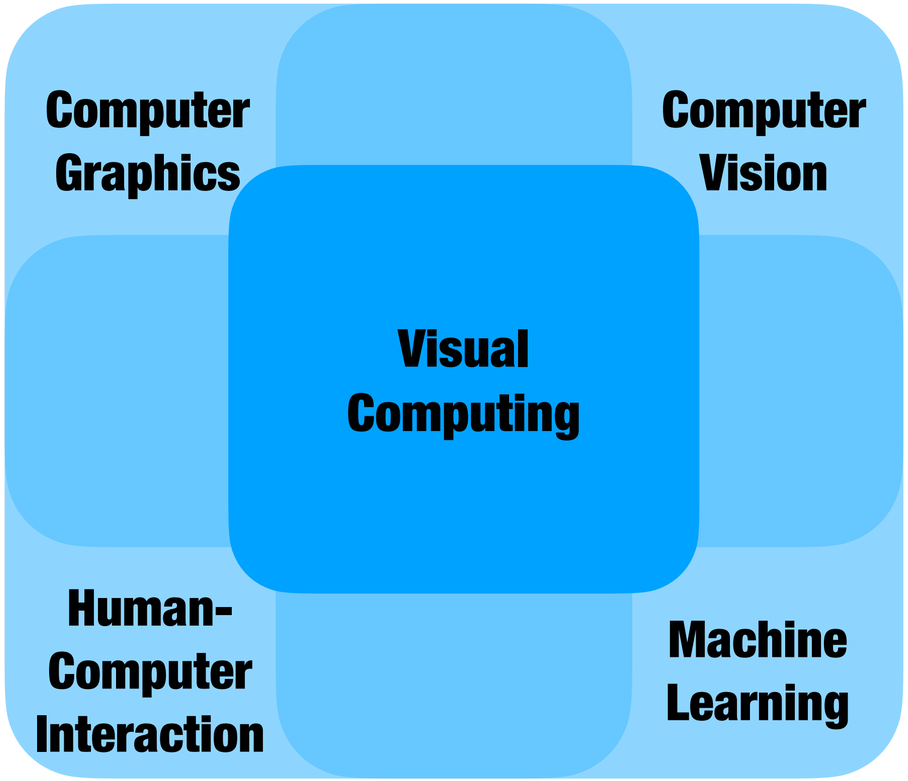
Virtual and Augmented Reality

What is Visual Computing



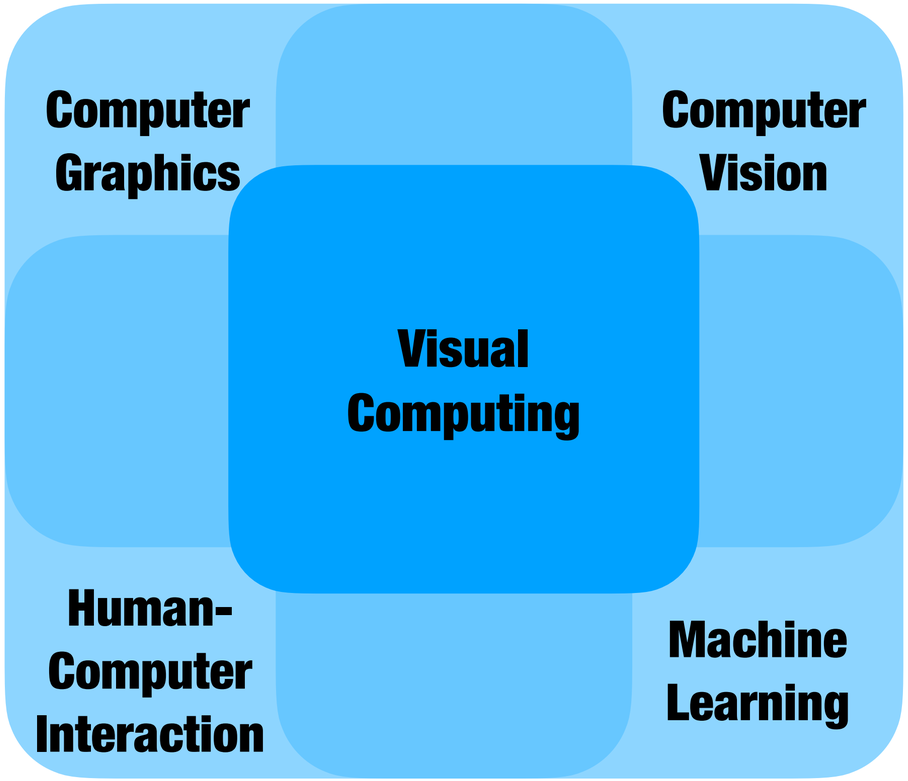
Virtual and Augmented Reality
(Infrared Tracking / Source Reddit)

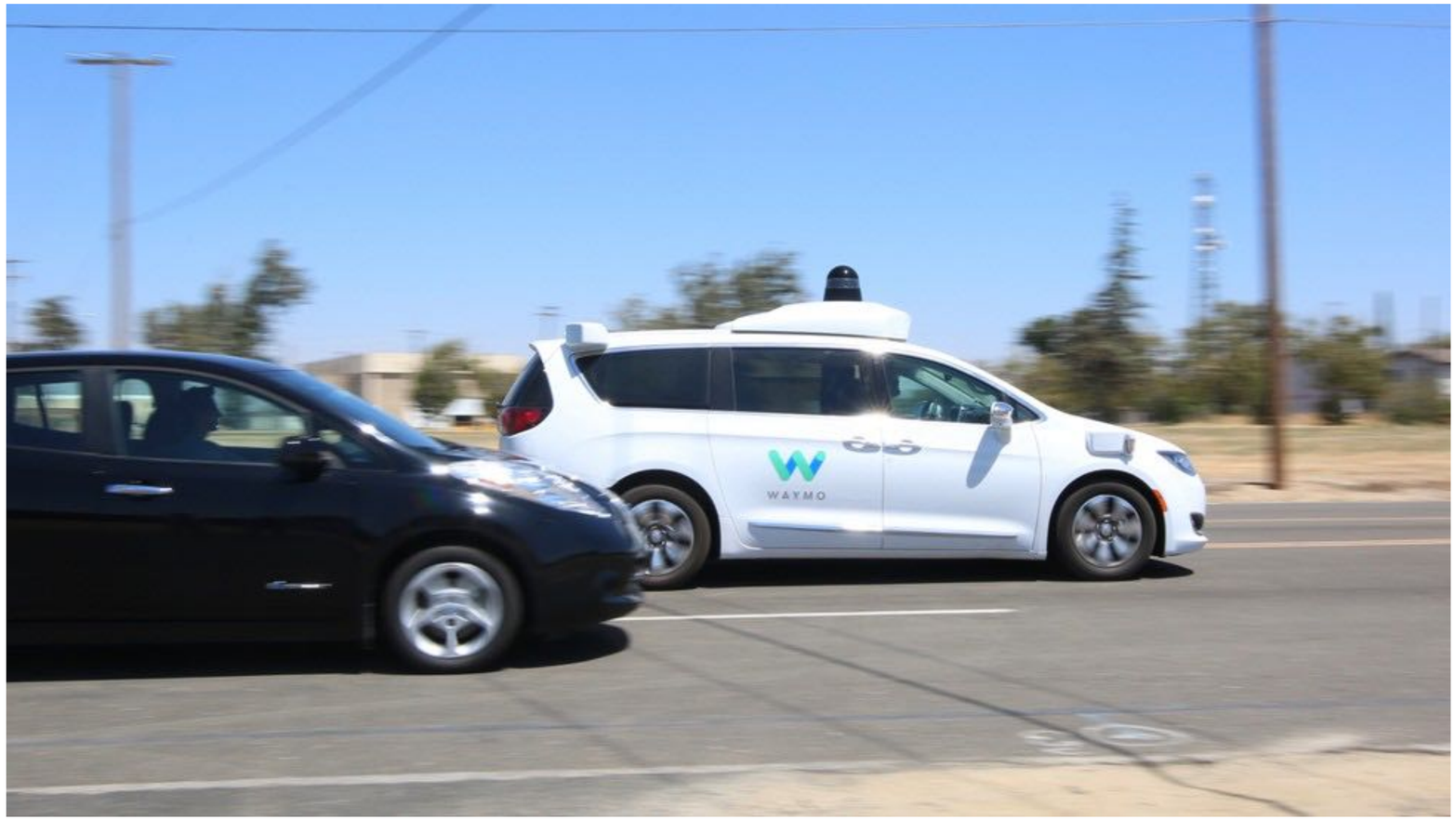
What is Visual Computing



Graphical User Interfaces
(Mac OS / iOS 26)

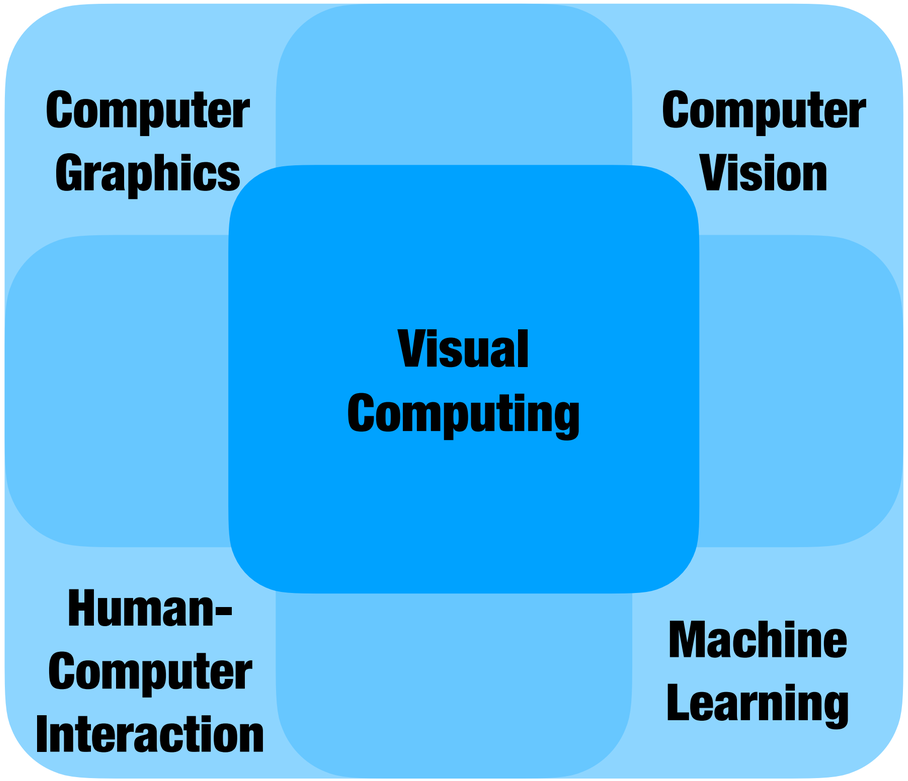
What is Visual Computing

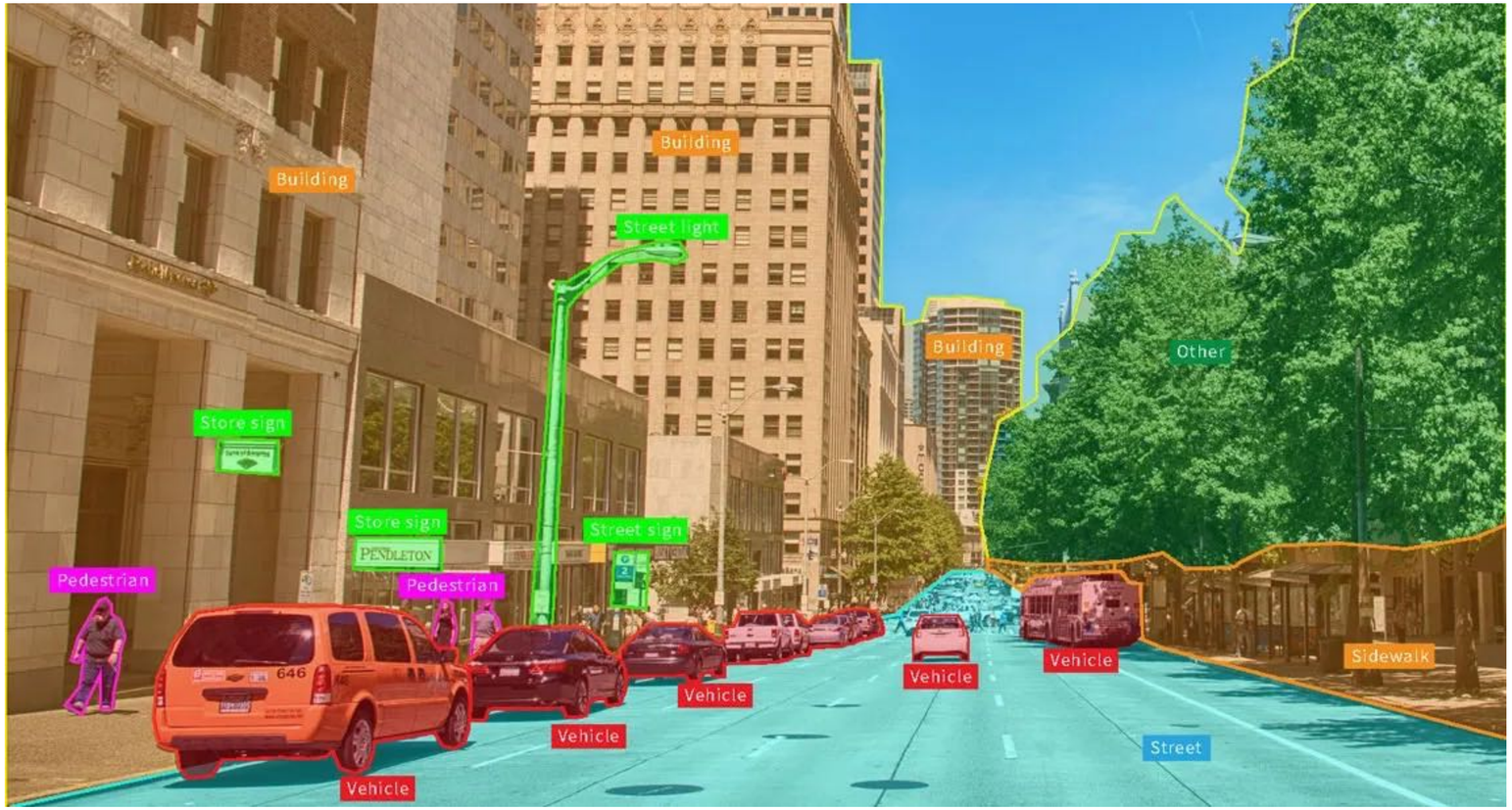




World Scale Models and Autonomous Driving
(Waymo)

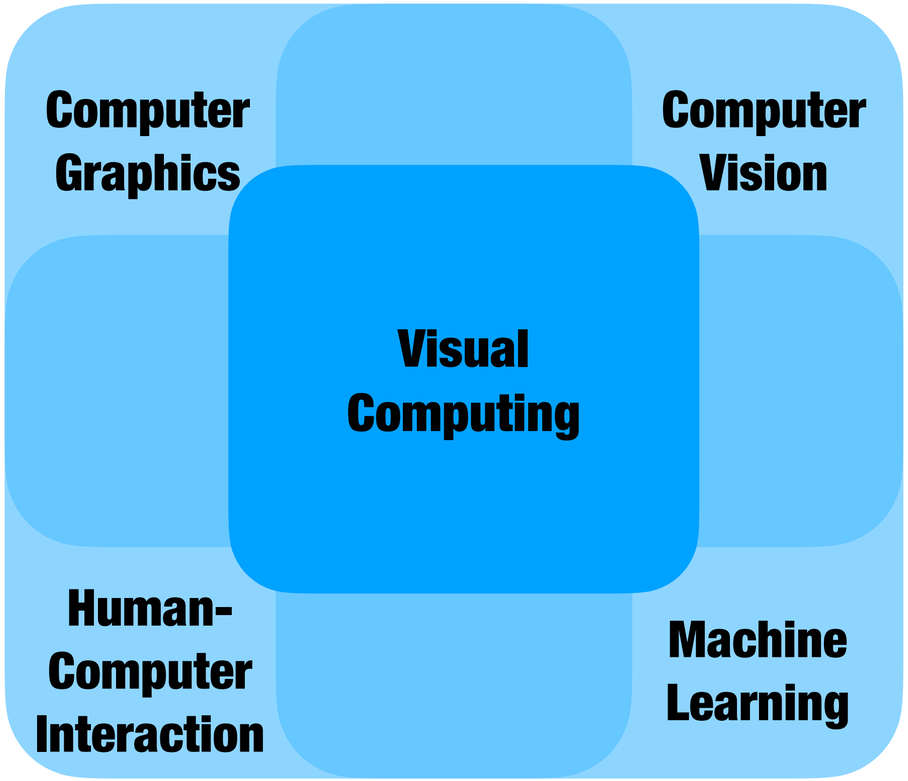
What is Visual Computing

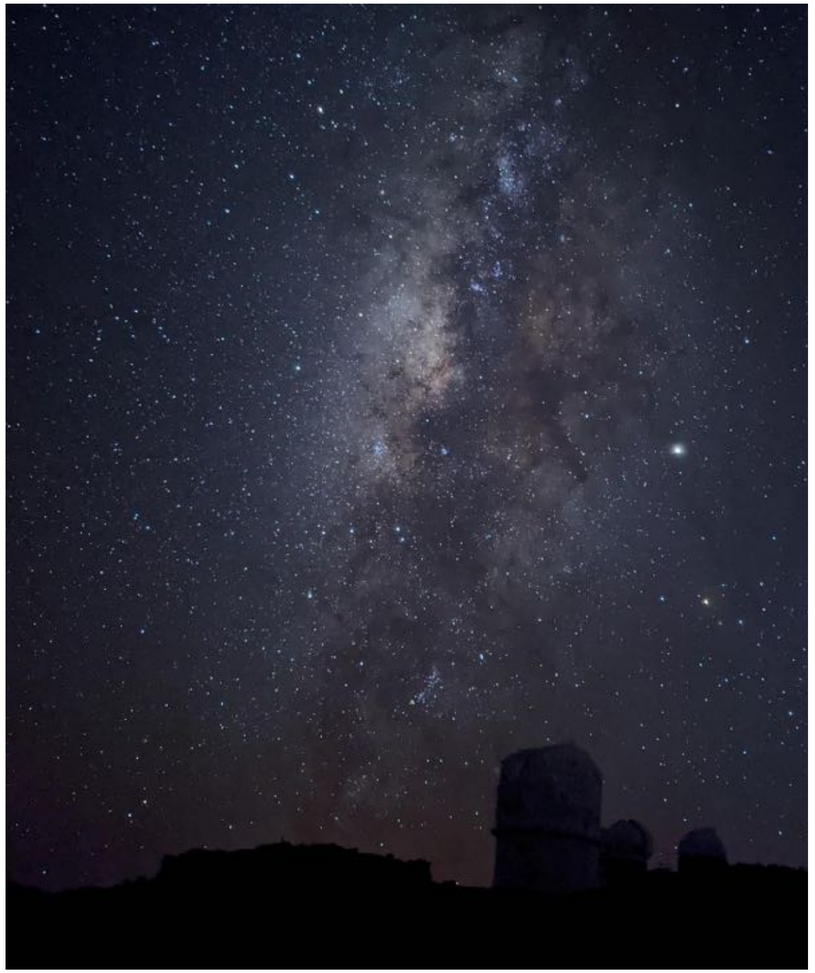


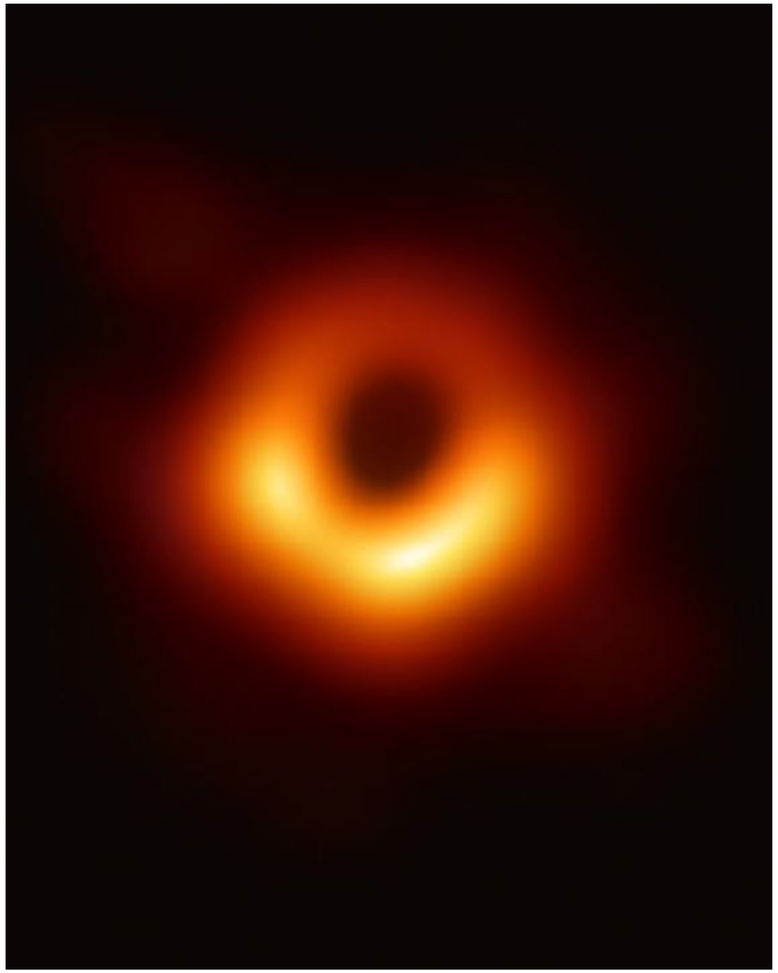


World Scale Models and Autonomous Driving

What is Visual Computing



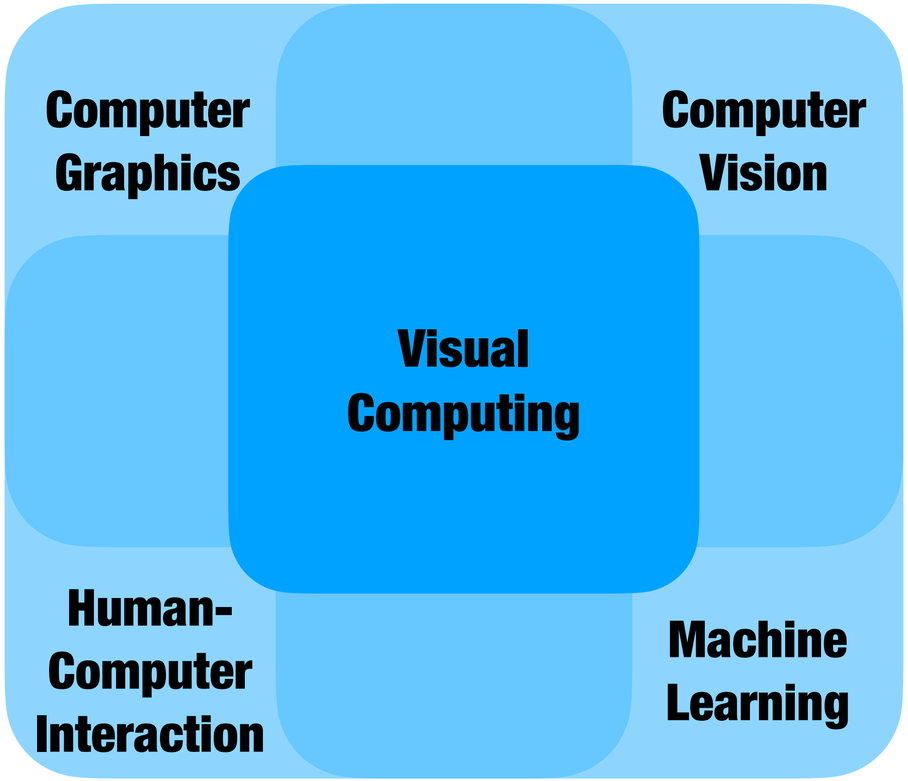




Computational Photography

(Astro Photography with Google Pixel 4 / Google Research
M87, First picture of a black hole / Event Horizon Telescope)

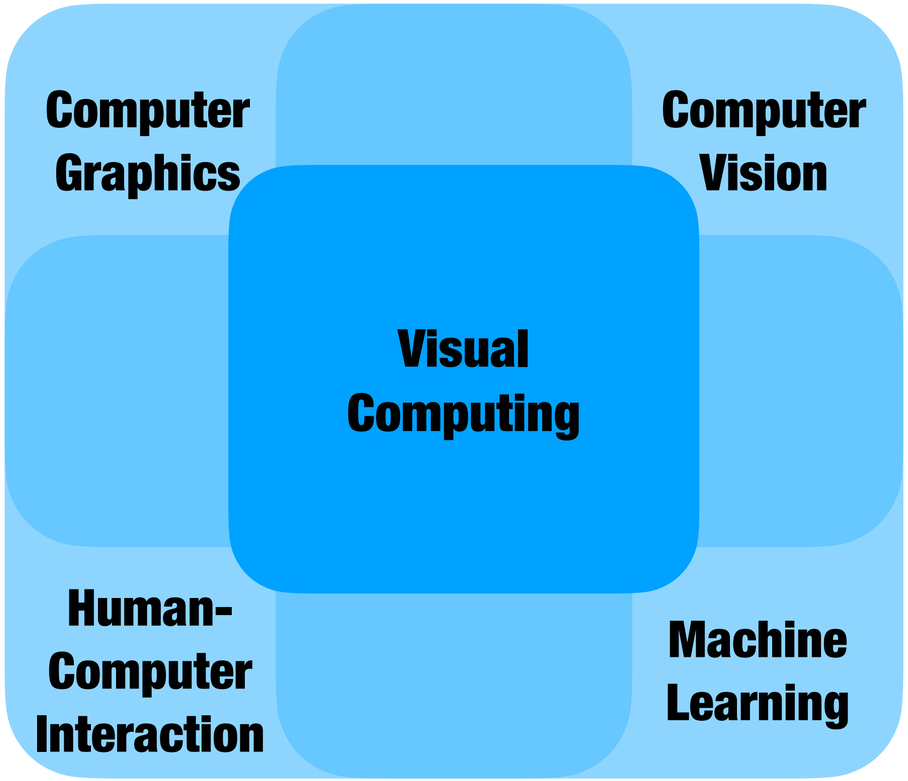
What is Visual Computing

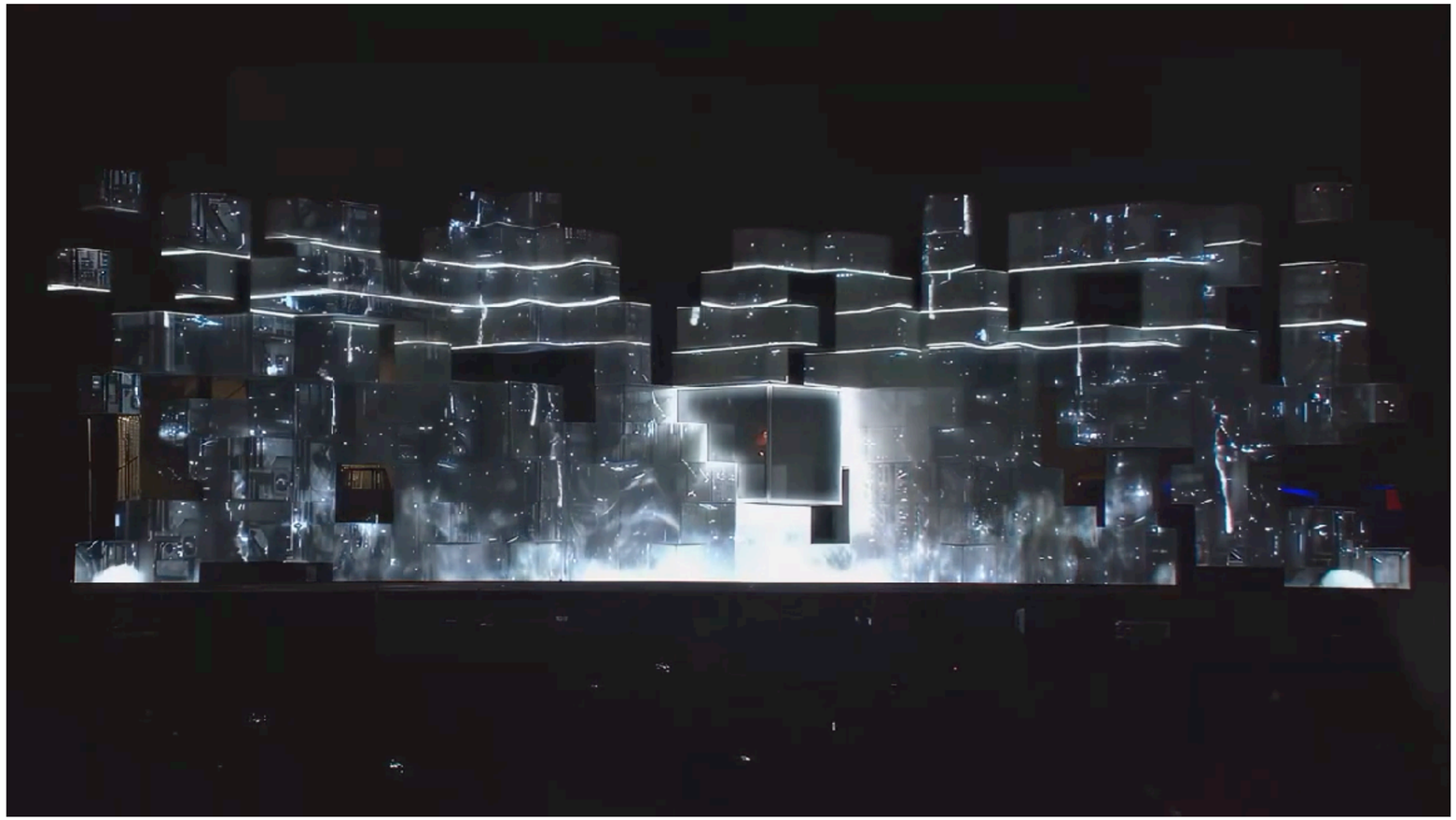


Computational Photography / Neural Rendering

(3D Gaussian Splatting, Kerbl et al. 2023)

What is Visual Computing

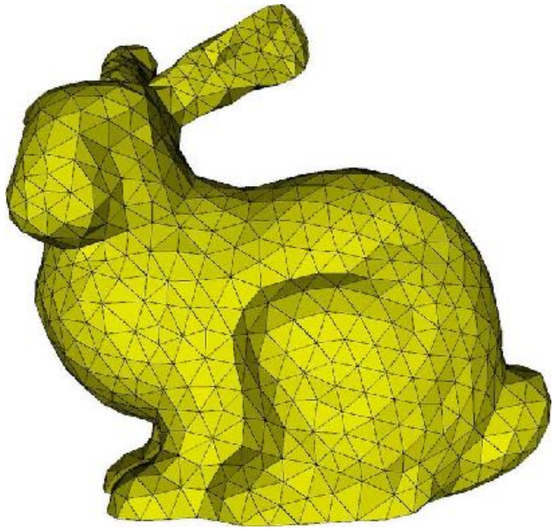


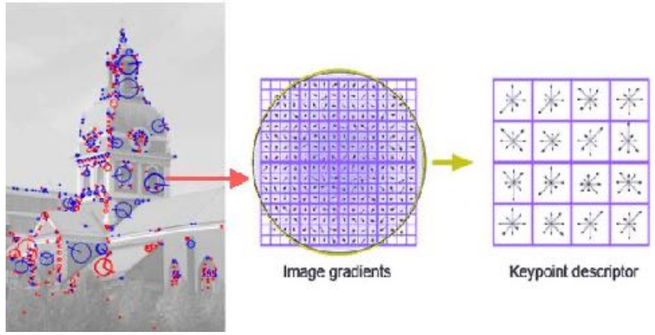


Art

(Amon Tobin "*ISAM*" Projection Mapping)

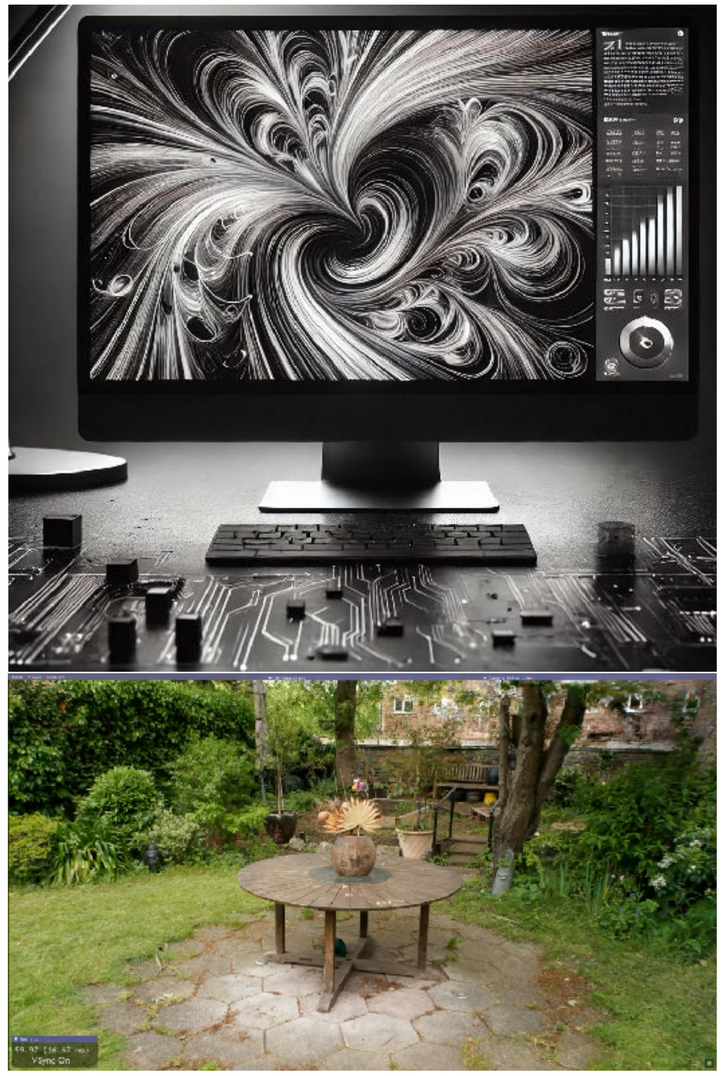
Master Specialisation in Visual Computing





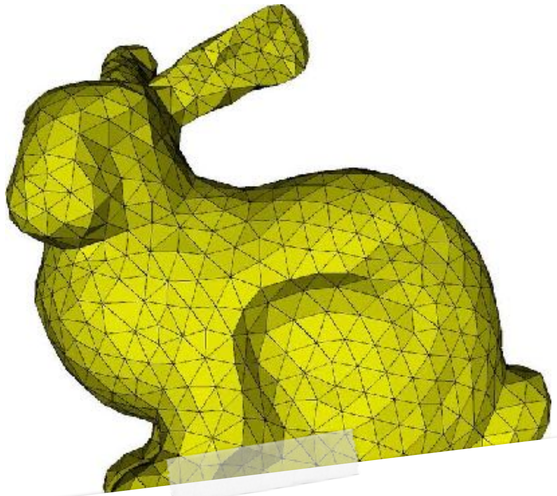
New! Visual Computing 1 (Fall 25)

New! Visual Computing 2 (Spring 26)

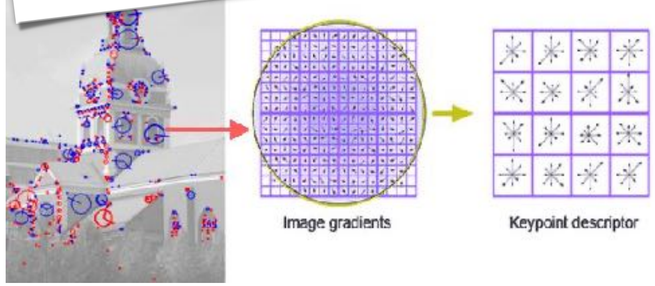


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

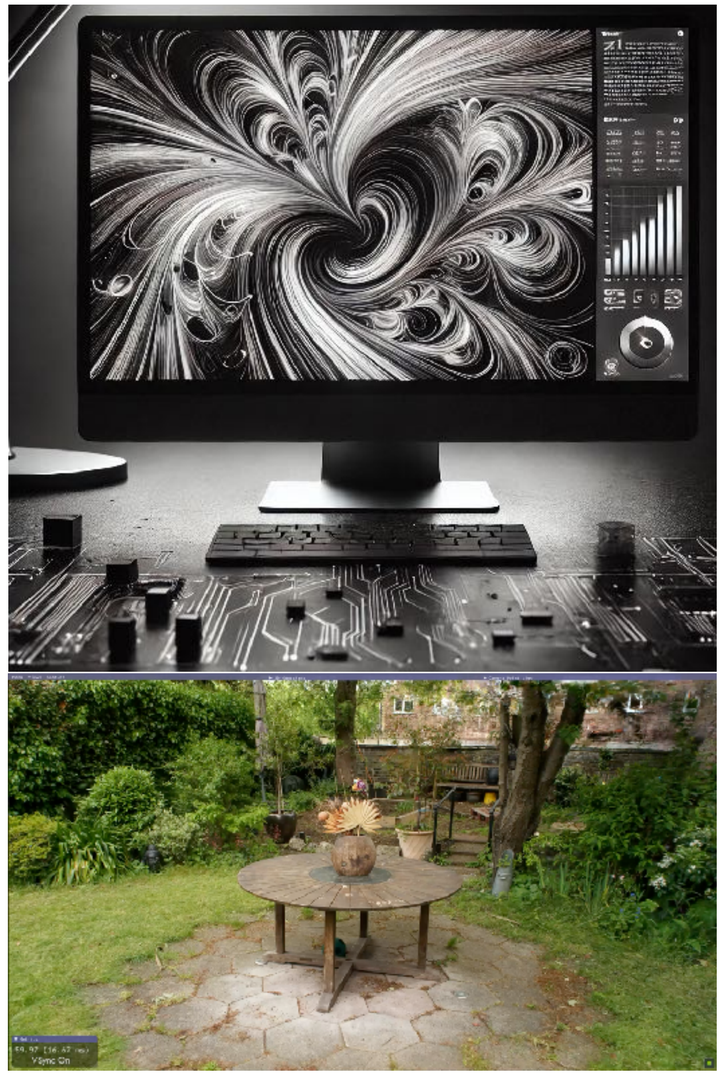


The Foundations of Visual Computing



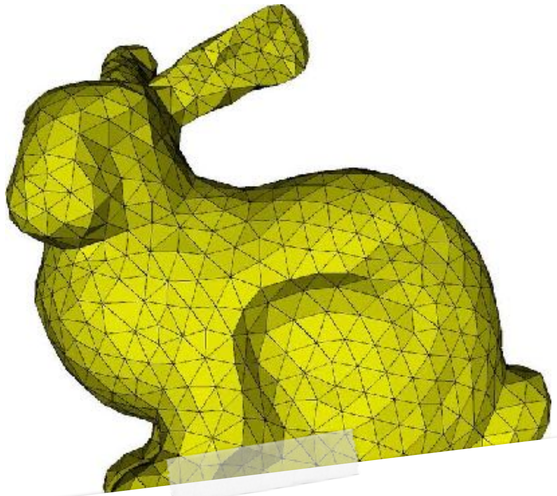
New! Visual Computing 1 (Fall 25)

New! Visual Computing 2 (Spring 26)

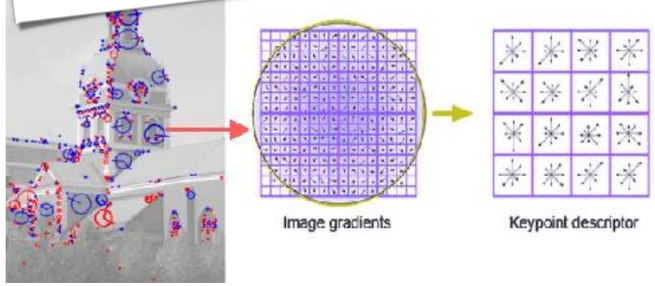


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

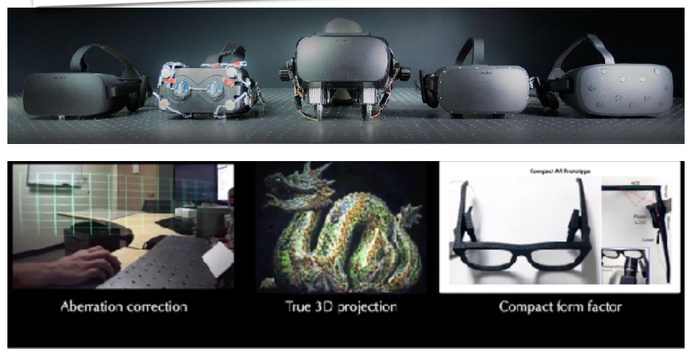


The Foundations of Visual Computing

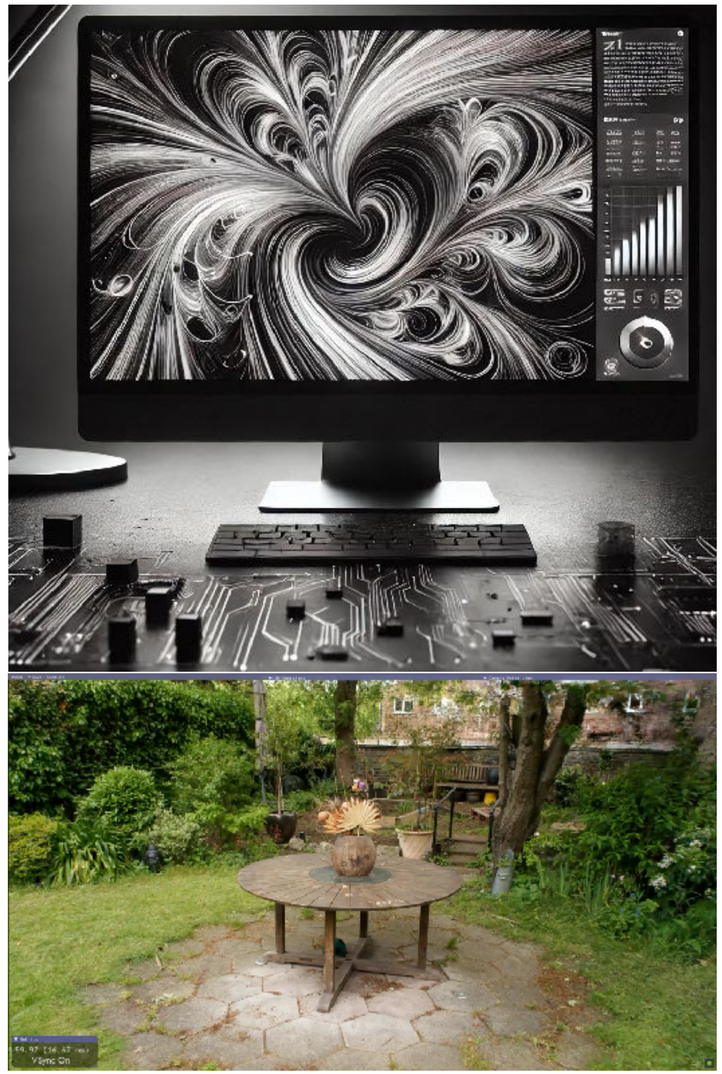


New! Visual Computing 1 (Fall 25)

Visual Computing and Immersive Technologies

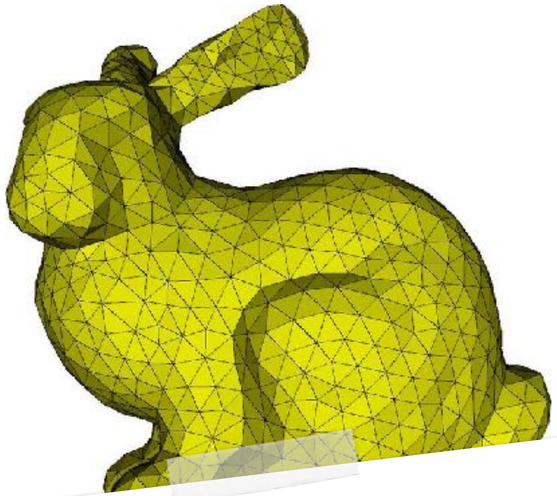


New! Visual Computing 2 (Spring 26)

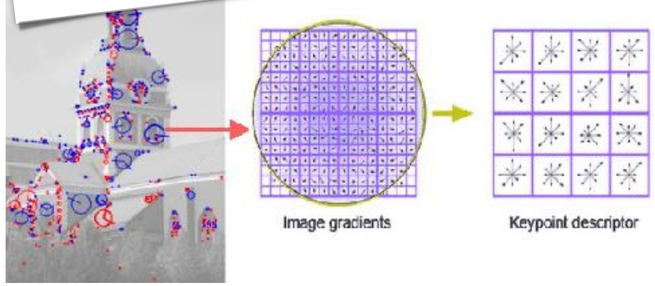


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

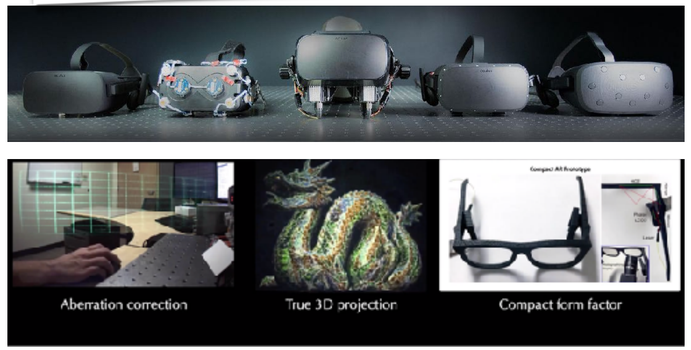


The Foundations of Visual Computing



New! Visual Computing 1 (Fall 25)

Visual Computing and Immersive Technologies



New! Visual Computing 2 (Spring 26)

Computational Photography and Neural Rendering

New! Visual Computing 3 (Fall 26)

Who are we?

Tobias Langlotz

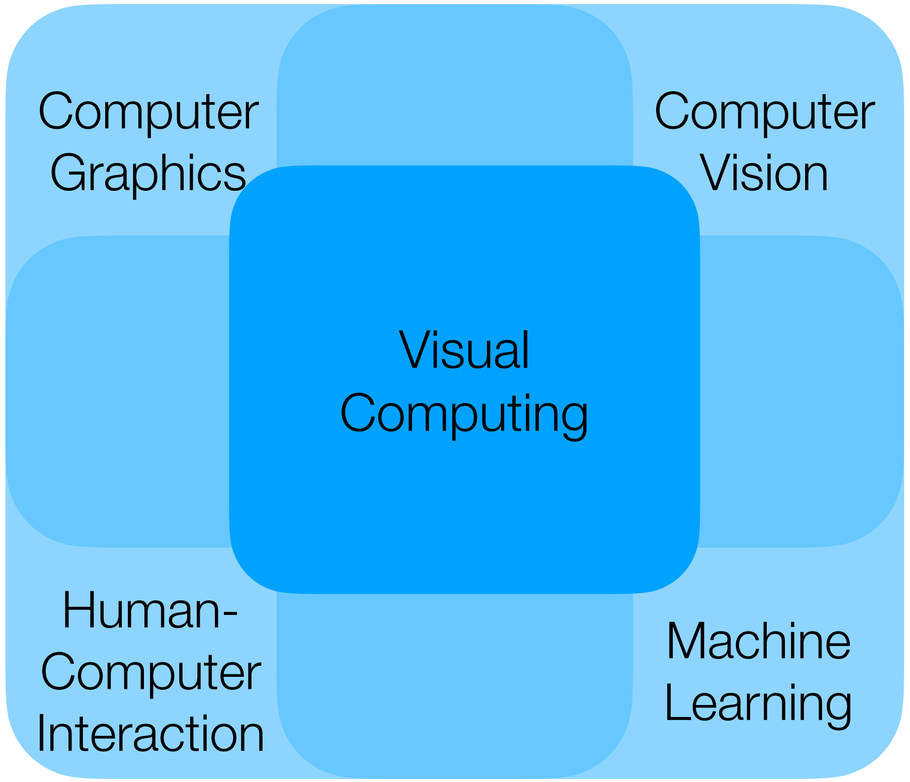
- (MSc) Bauhaus University Weimar, Germany

Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria

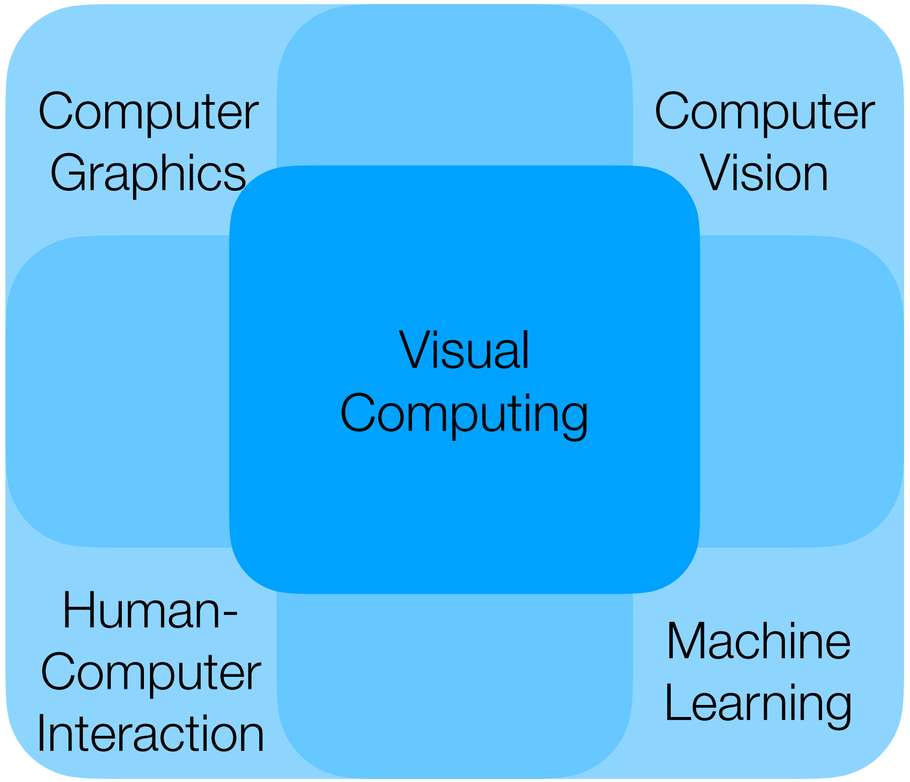
Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR

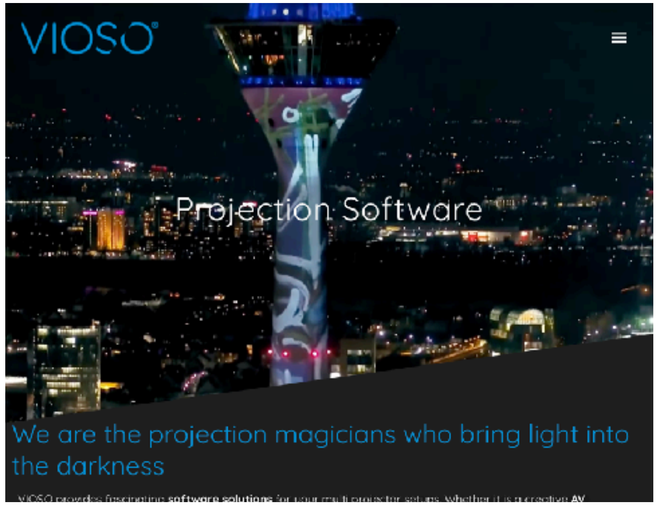


Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR

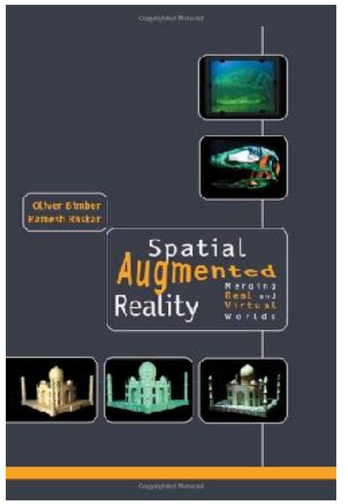


Projector-Camera Systems/Spatial Augmented Reality (2003)



Comercialised through Vioso Inc.

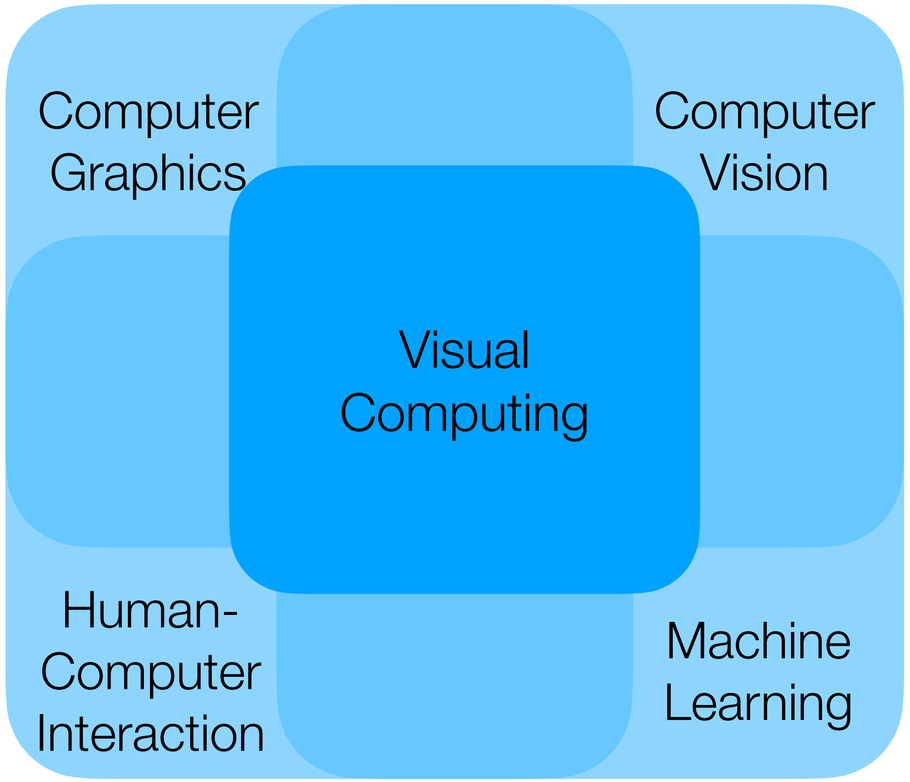
Holographics



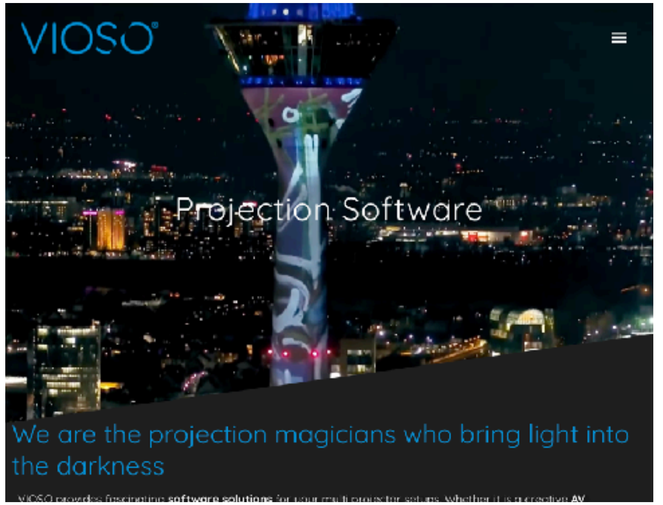
Spatial Augmented Reality

Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR

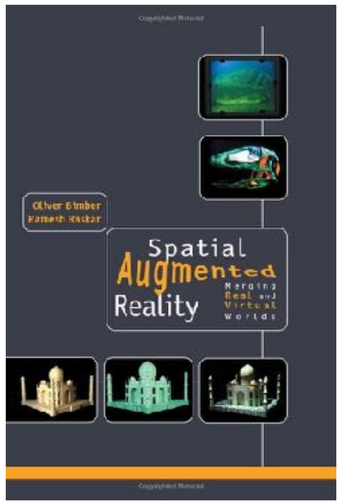


Projector-Camera Systems/Spatial Augmented Reality (2003)



Comercialised through Vioso Inc.

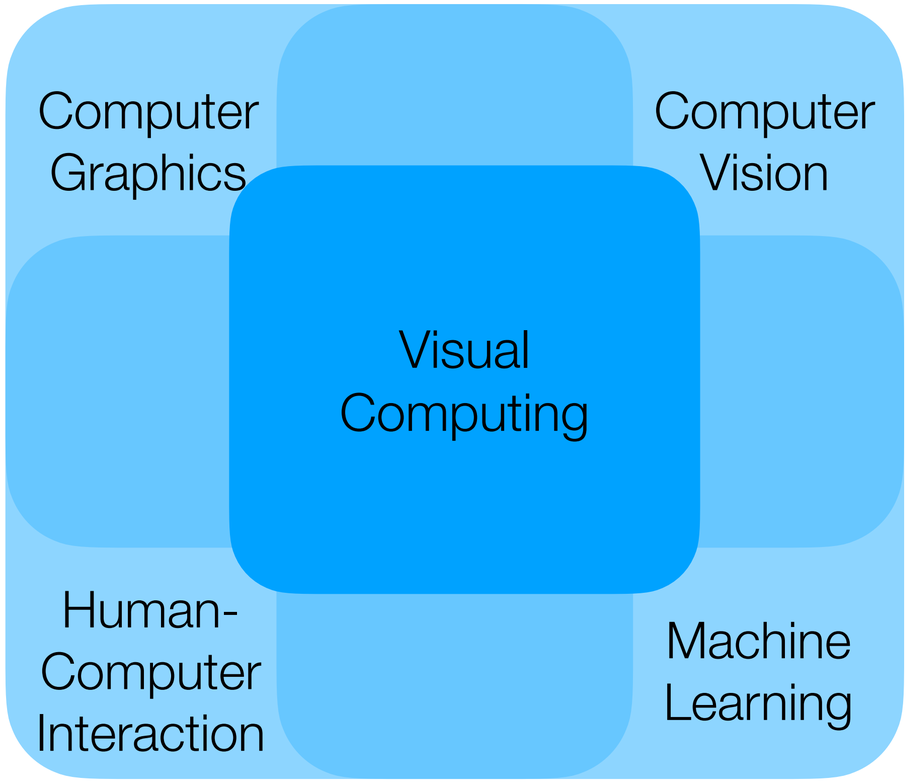
Holographics



Spatial Augmented Reality

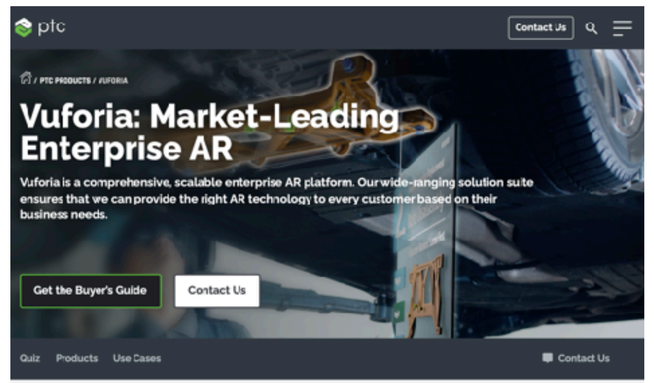
Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR



4D Barcodes (2007)

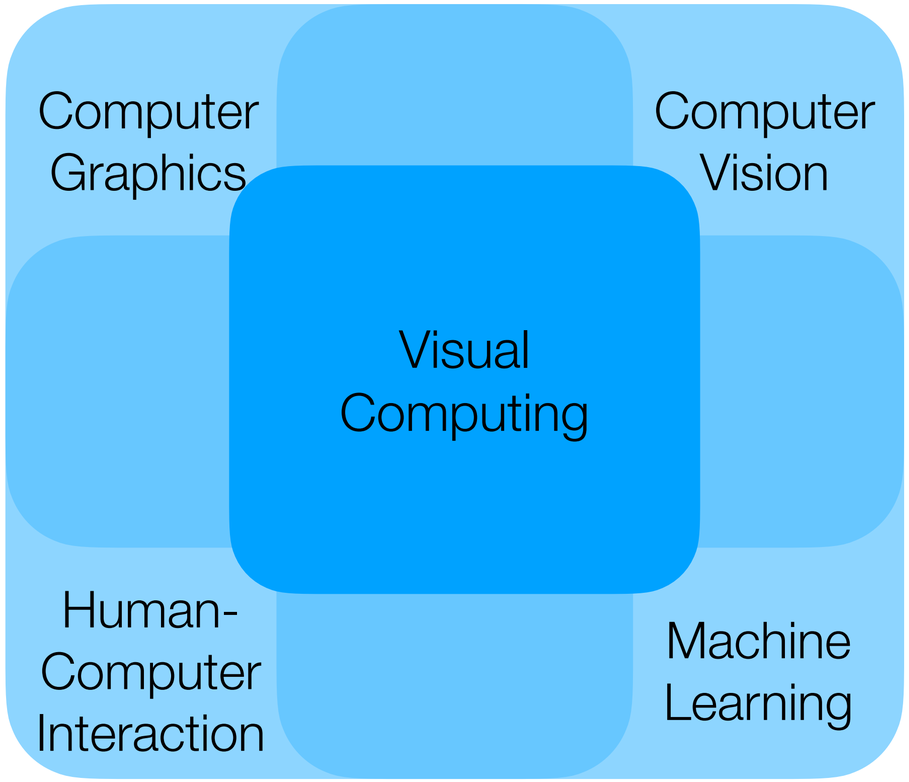
Handheld Augmented Reality (2010)

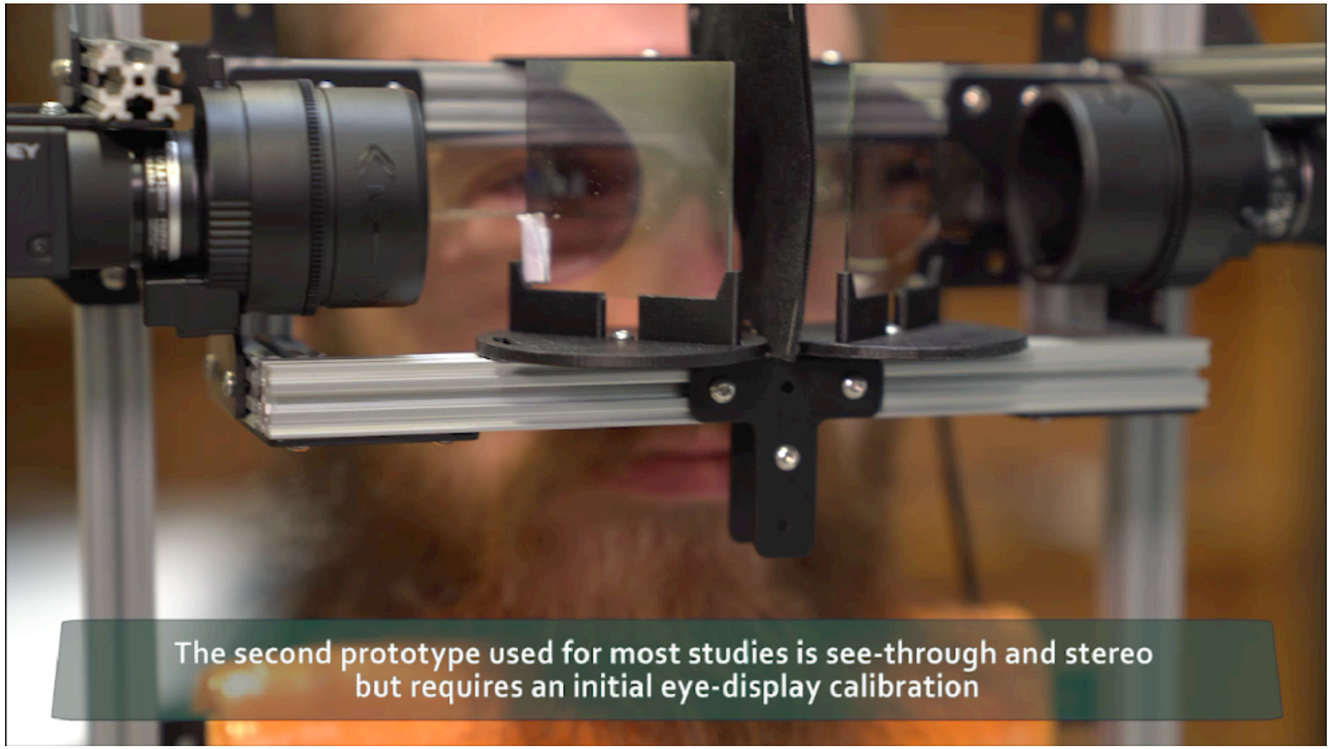


Commercialised through Qualcomm/PTC Vuforia

Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR





Vision Augmentations

Virtual Tourism

Tobias Langlotz

- (MSc) Bauhaus University Weimar, Germany
- (PhD) Graz University of Technology, Austria
- Visual Computing with focus on AR/MR/VR
- 2014-2024 Professor, Otago University, New Zealand
- Research stays at the HITLab NZ, Osaka University, Institute of Science Tokyo, Tokyo University, Lancaster University, Snap, …
- Since 12/2024 Professor at Aarhus University

Tobias Langlotz

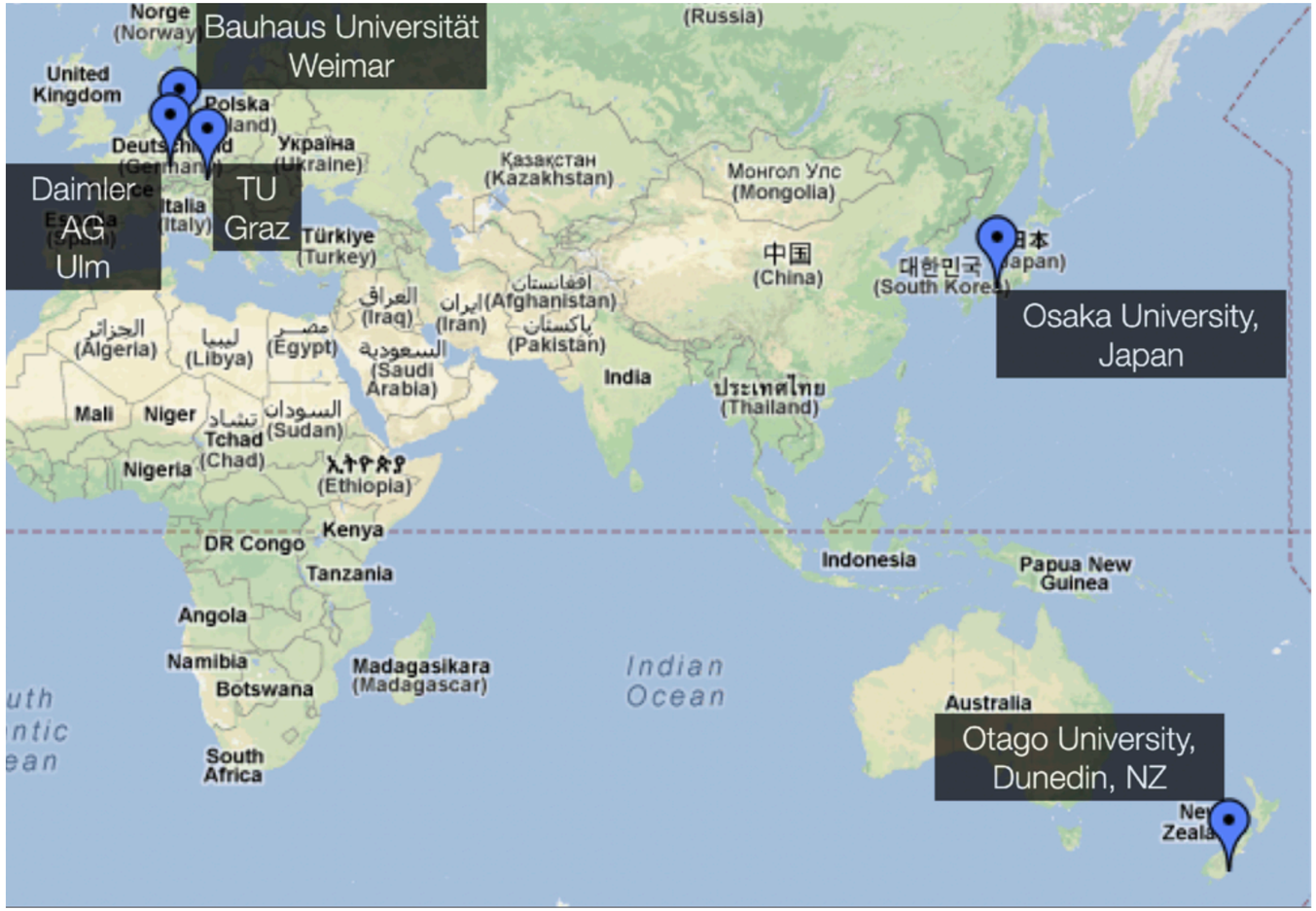
German English

New Zealand English

The “best” of both accents ;)

Stefanie Zollmann

- Diploma/Masters Computer Science for Media in Weimar, Germany
- PhD program Daimler AG
- PhD Computer Science, Graz University of Technology
- Animation Research Limited ARL
- Associate Professor at University of Otago, New Zealand
- Associate Professor at Aarhus University since December 2024




STANDINGS
FREERIDE WORLD TOUR
1 DUCROZ 88.5
2 BARKERED 88.1
3 RODNEY 87.8
4 HEITZ 87.5
5 TABKE 85.0
Bec des Rosses
FRA
Ducroz
15.0 km/h
Start1
Finish
ANIMATION RESEARCH LTD

ANIMATION RESEARCH LTD


Back
Stadium AR
ESAC
CalderStewart
Reset
Manual
Camera
VIS

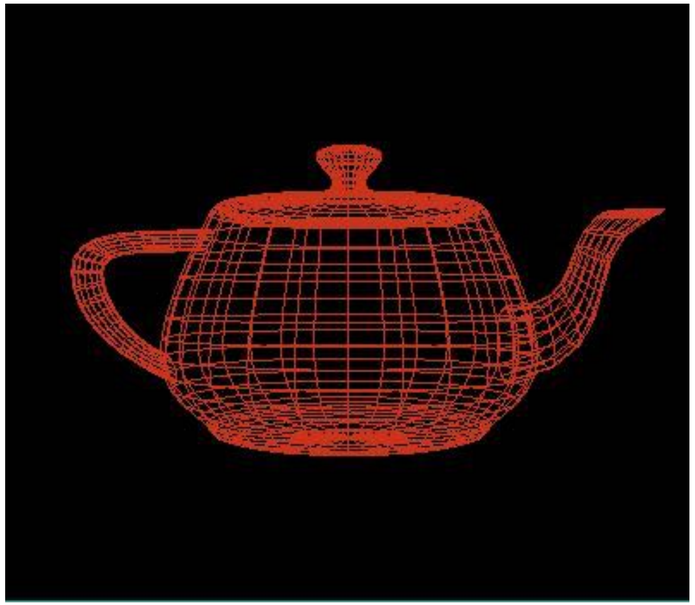
Lauren Zerbin

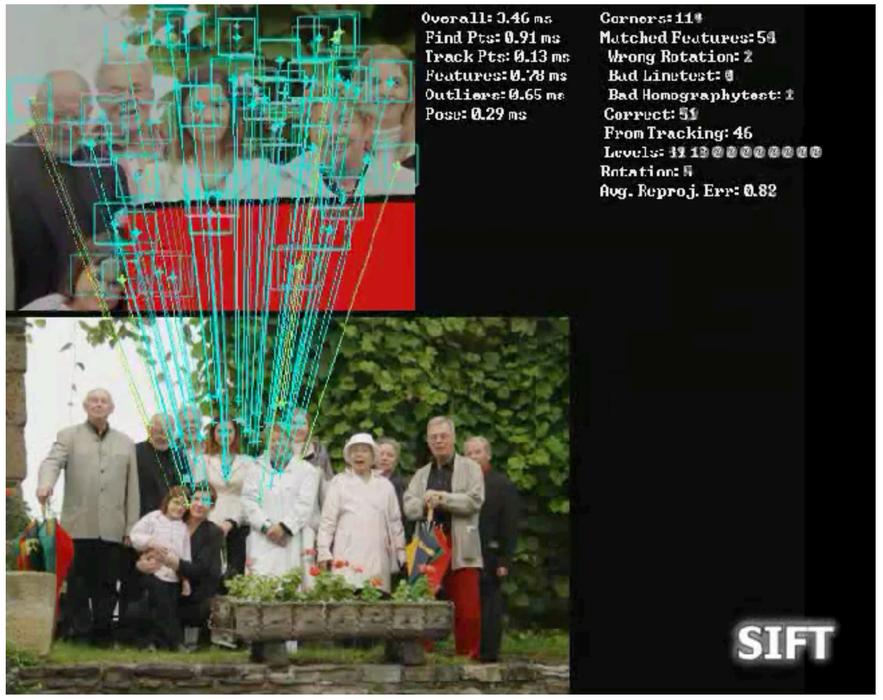
- Teaching Assistant
- Master’s Student Computer Science
- Bachelor’s Degree University of Hamburg

Structure of the Course

Topics

- 2D Digital Images
  - Images and colour models
  - 2D transformations
- Computer Vision
  - Feature detection and matching
  - Image stitching
  - Camera models and calibration
  - 3D transformations
  - 3D models from stereo images
- Computer Graphics
  - Graphics pipeline
  - OpenGL
  - Shaders and shader programming
  - Lighting, shadows, and textures





Times

Semester Week	Week	Dates	Lecture #1 Topic	Lecture #2 Topic	Deadlines
1	35	Aug 25–Aug 29	Introduction	Colour Models (Image Processing)	
2	36	Sep 1–Sep 5	2D Geometry and Transformations	Image Filters	
3	37	Sep 8–Sep 12	Image Features	Panoramic Mapping & Image Stitching	
4	38	Sep 15–Sep 19	Homographies – 2D Image Transforms	3D Transforms (3D Computer Vision)	
5	39	Sep 22–Sep 26	3D Camera Models & Camera Transforms	Intro Stereo Vision	Assignment 1
6	40	Sep 29–Oct 3	Fundamental Matrix & Essential Matrix	Dense Stereo (3D Computer Vision)	
7	41	Oct 6–Oct 10	Relative Pose	Multiview Geometry	
	42	**Oct 13–Oct 17**	**Autumn Break – No Lectures**	—	
8	43	Oct 20–Oct 24	Rendering Introduction	Intro OpenGL	
9	44	Oct 27–Oct 31	Shader Programming	Transformation/Viewing	Assignment 2
10	45	Nov 3–Nov 7	Illumination Models	Texturing	
11	46	Nov 10–Nov 14	Shadow Mapping	Advanced Shading Techniques	
12	47	Nov 17–Nov 21	Web-Based Graphics	Scene Graphs & Rendering Frameworks	
13	48	Nov 24–Nov 28	Raytracing	Special Topic	
14	49	Dec 1–Dec 5	Recap/Exam Prepration		Project

Times

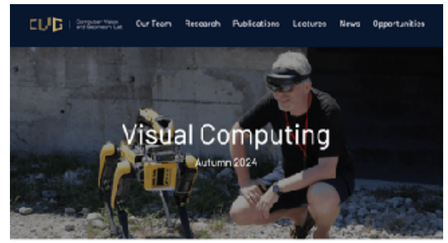
	Mon 25 Aug	Tue 26 Aug	Wed 27 Aug	Thu 28 Aug	Fri 29 Aug
8:00					
9:00					
10:00			**10:00 - 12:00** **Visual Computing: Interactive Computer Graphics and Vision** 5510-104 Lille Auditorium Forelæsning *Student group(s): F-VISCOM-E25* Stefanie Zollmann Tobias Langlotz		**10:00 - 12:00** **Visual Computing: Interactive Computer Graphics and Vision** 5510-104 Lille Auditorium Praktisk *Student group(s): F-VISCOM-E25* Stefanie Zollmann Tobias Langlotz
11:00					
12:00					
13:00					
14:00	**14:00 - 16:00** **Visual Computing: Interactive Computer Graphics and Vision** 5123-111 Seminarrum Forelæsning *Student group(s): F-VISCOM-E25* Stefanie Zollmann Tobias Langlotz				
15:00					
16:00					

Design of the course

Design of the course

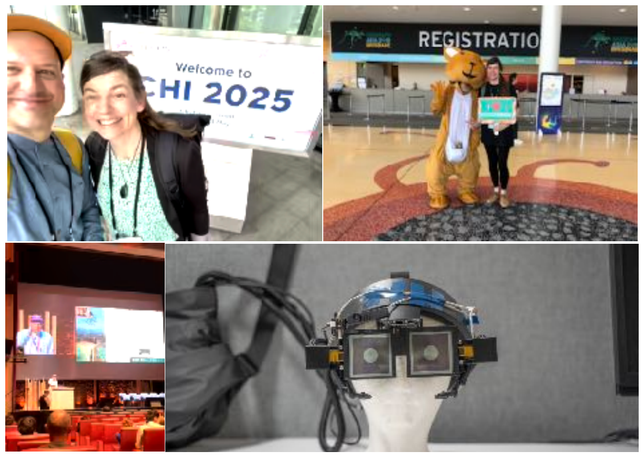
Expert Societies

Industry Experience and Examples

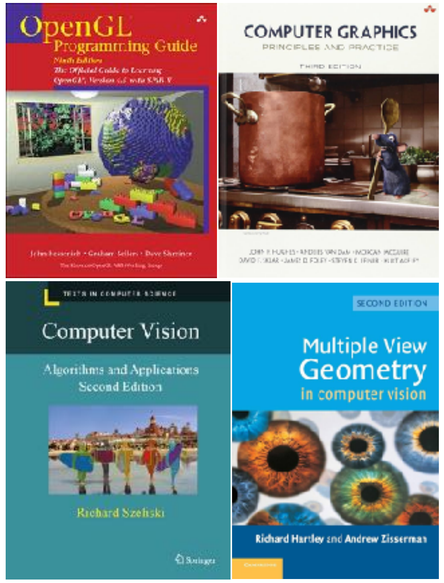


Similar Courses

Visual Computing I: Interactive Computer Graphics and Vision



Academic Background

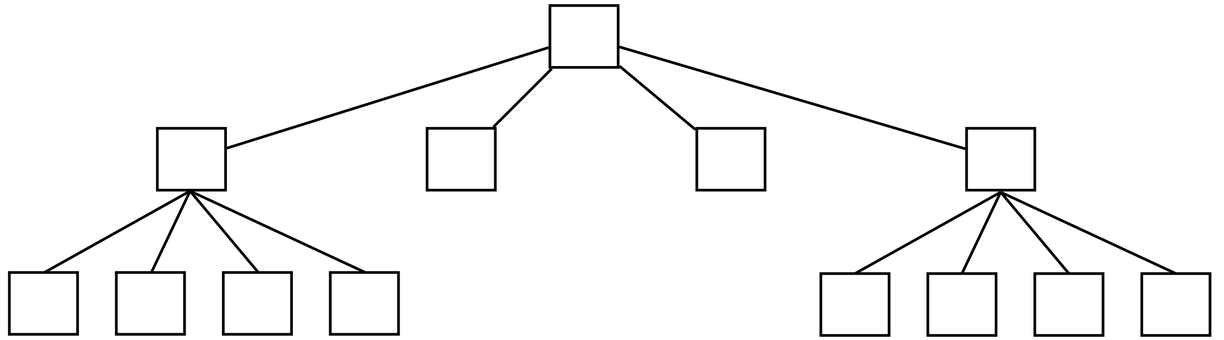


Literature

Expected Background

Expected Background

- Algorithms & Data Structures
  - We expect you to be able to code
  - Knowledge of OO principles
  - Data structures – trees and graphs



- Mathematics
  - Basic mathematical ability
  - Trigonometry, vectors, matrices

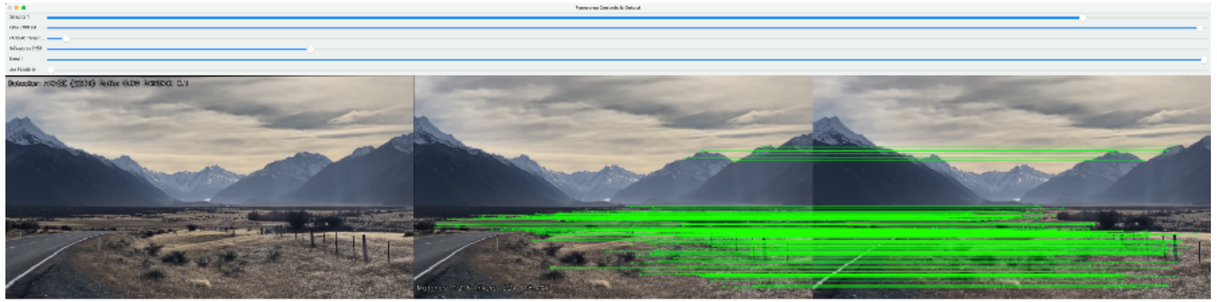
$$\mathbf{u} = \mathrm{K}[\mathrm{R} \mid \mathbf{t}]\mathbf{x}$$

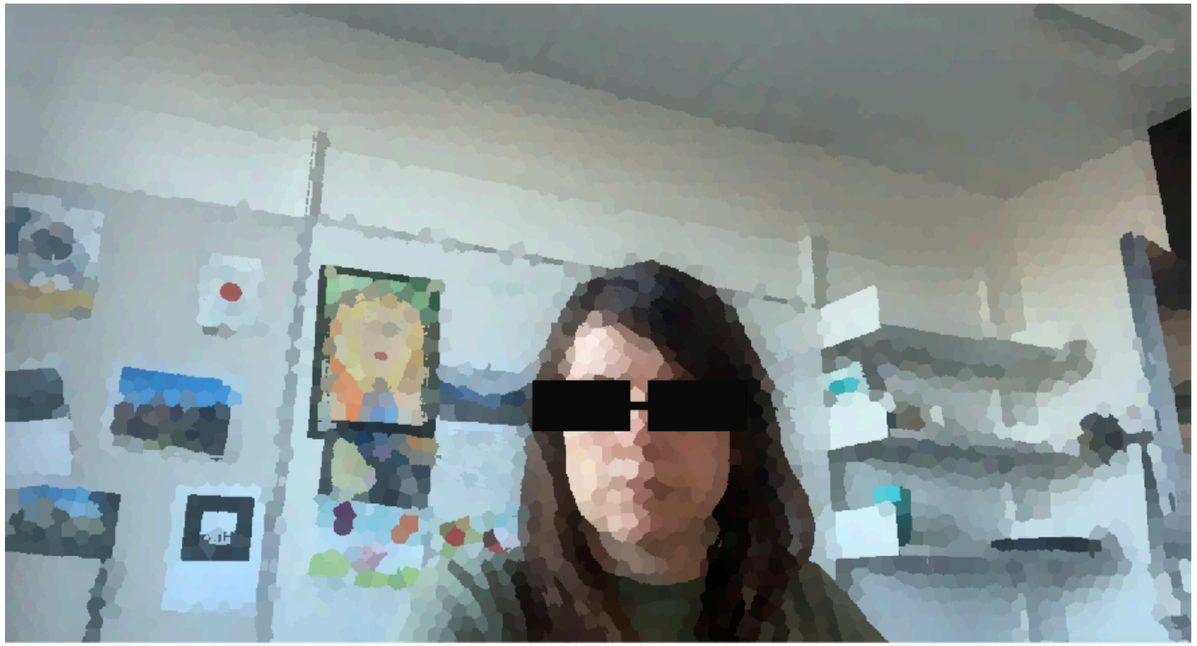
$$\mathrm{K} = \begin{bmatrix} f_u & s & c_u \\ 0 & f_v & c_v \\ 0 & 0 & 1 \end{bmatrix}$$

Assessment

Assessment

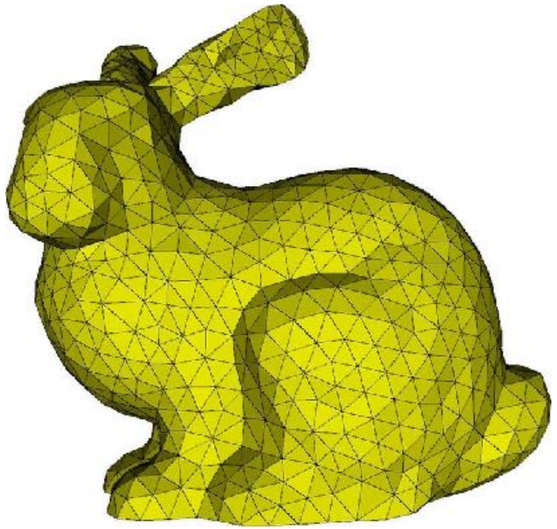
- Assignments:
  - Assignment 1(due week 5 of semester)
  - Assignment 2 (due week 9 of semester)
  - Both assignments are prerequisites for examination participation
- Project (Take home assignment) worth 50%
- Written Exam worth 50%

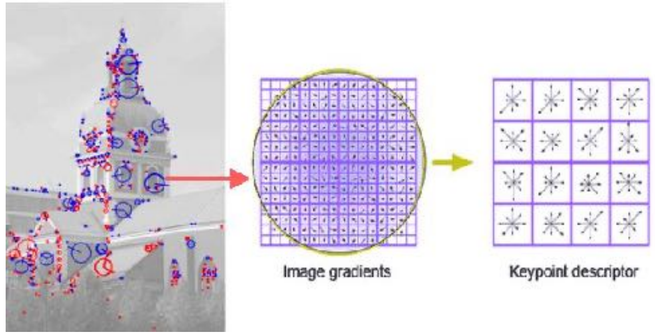




What comes next?

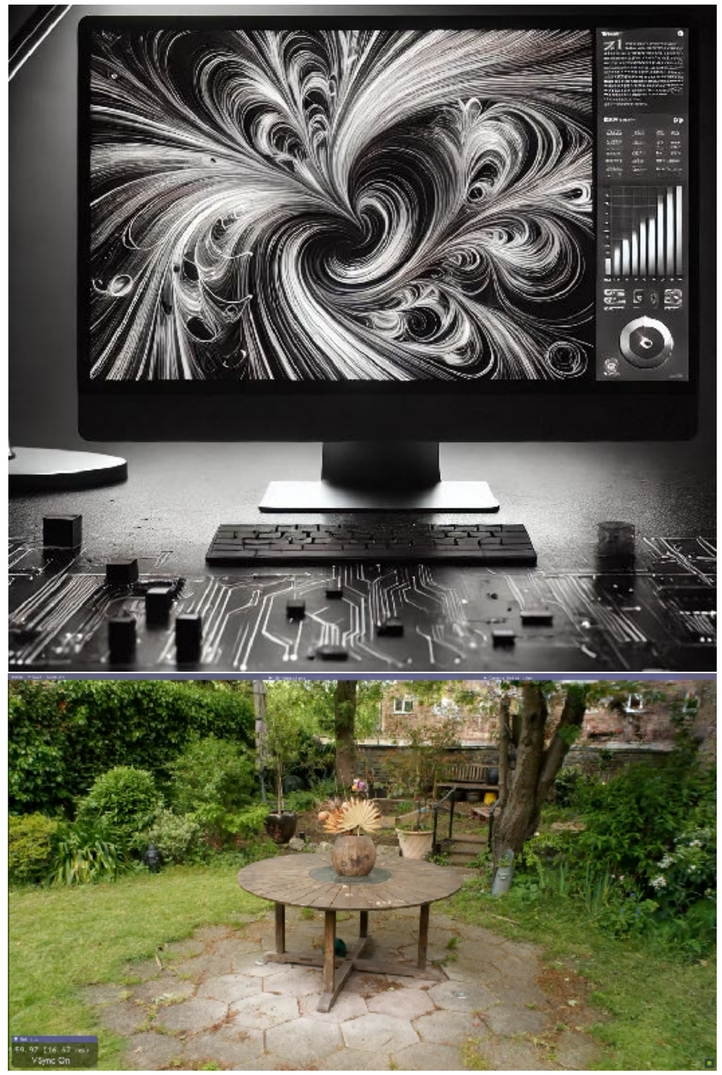
Master Specialisation in Visual Computing





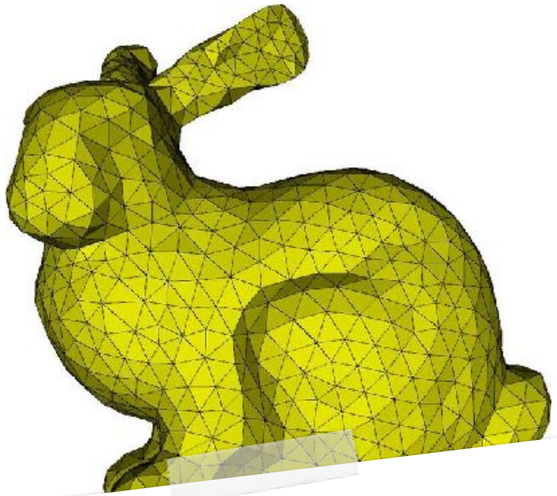
New! Visual Computing 1 (Fall 25)

New! Visual Computing 2 (Spring 26)

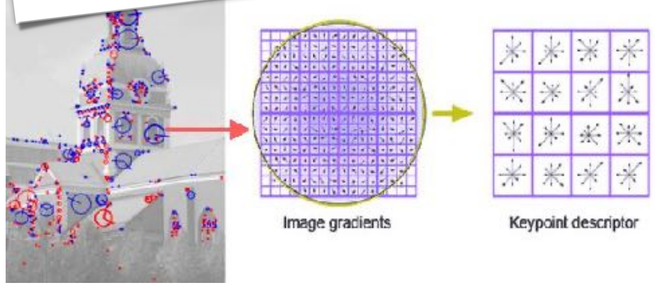


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

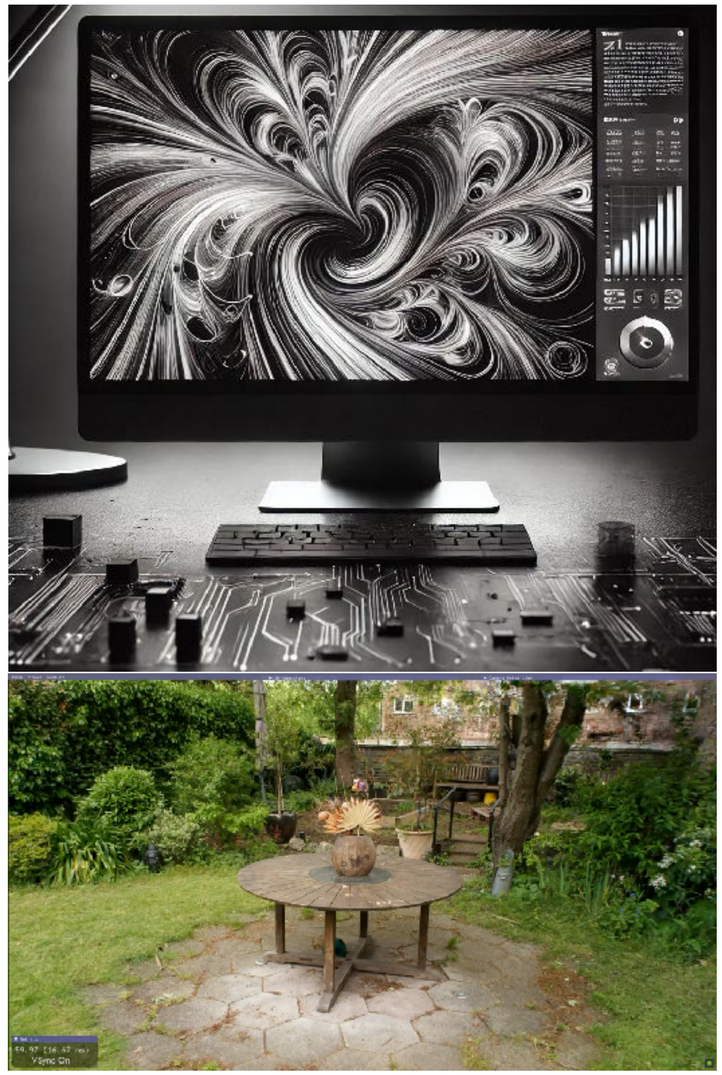


The Foundations of Visual Computing



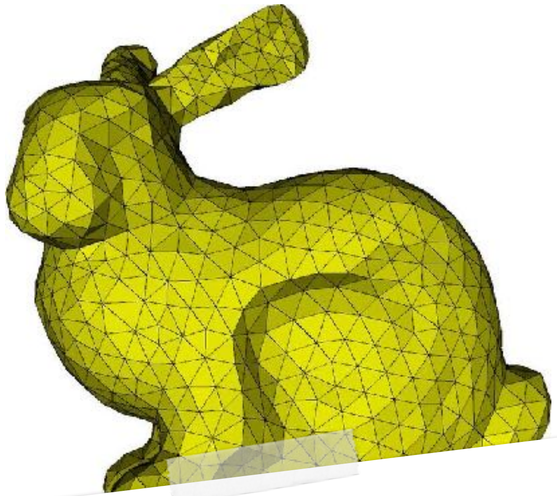
New! Visual Computing 1 (Fall 25)

New! Visual Computing 2 (Spring 26)

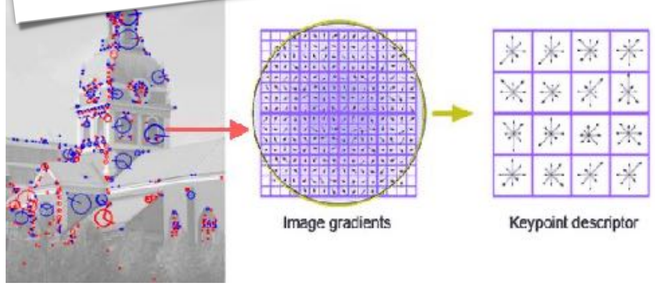


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

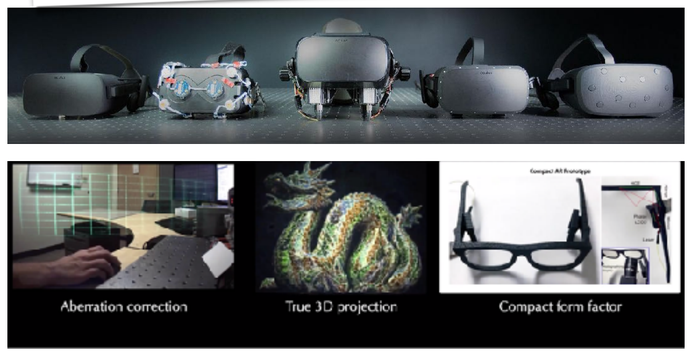


The Foundations of Visual Computing

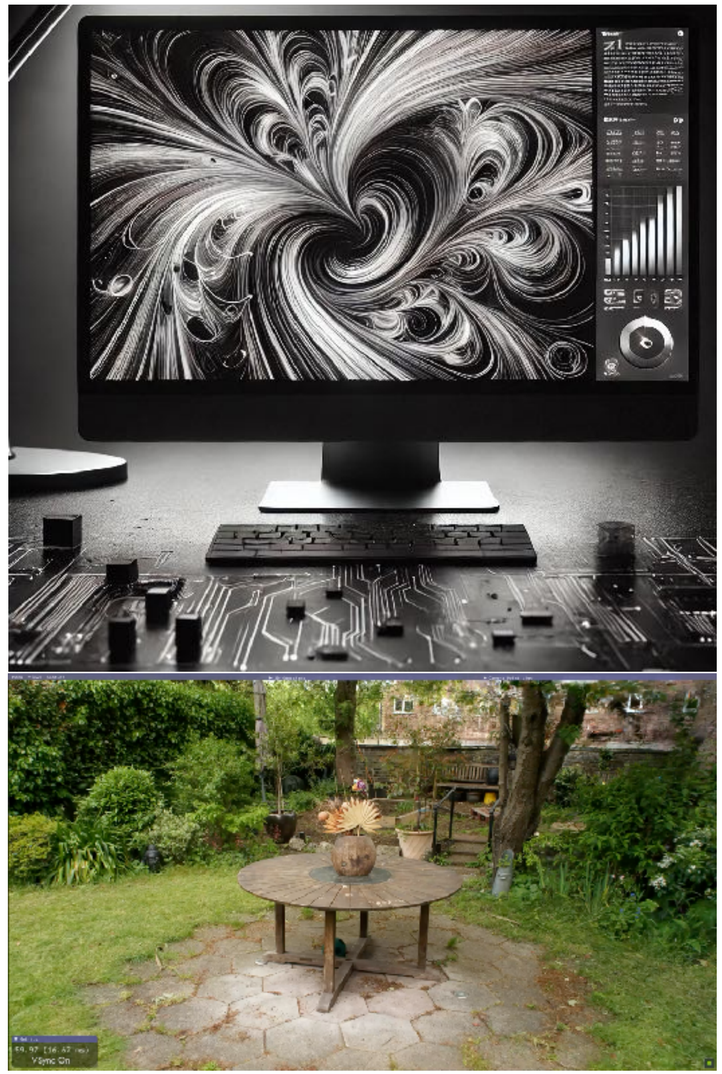


New! Visual Computing 1 (Fall 25)

Visual Computing and Immersive Technologies

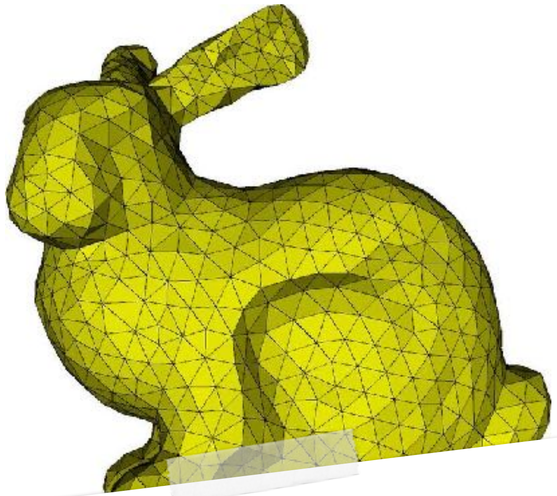


New! Visual Computing 2 (Spring 26)

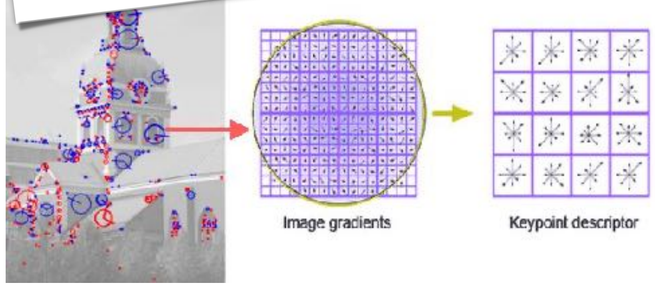


New! Visual Computing 3 (Fall 26)

Master Specialisation in Visual Computing

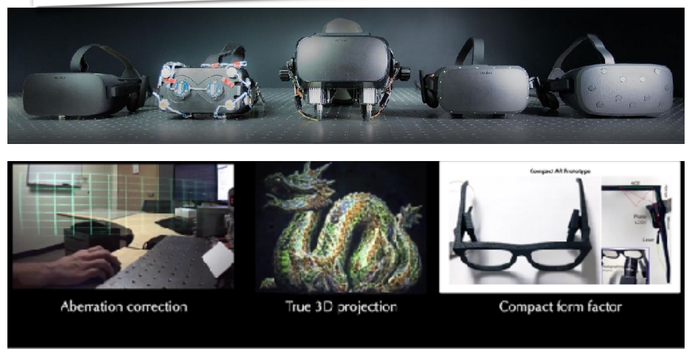


The Foundations of Visual Computing

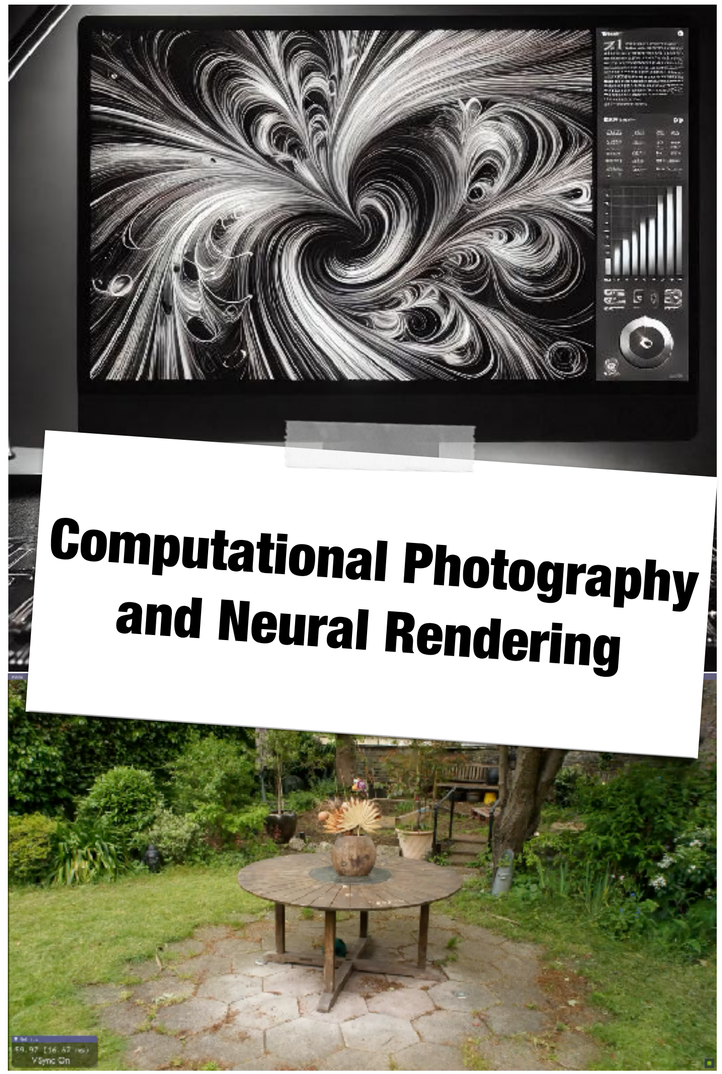


New! Visual Computing 1 (Fall 25)

Visual Computing and Immersive Technologies



New! Visual Computing 2 (Spring 26)



Computational Photography and Neural Rendering

New! Visual Computing 3 (Fall 26)

Questions?

A Short History of Visual Computing

A Short History of Visual Computing

A LOGICAL CALCULUS OF THE IDEAS IMMANENT IN NERVOUS ACTIVITY

WARREN S. MCCULLOCH AND WALTER PITTS

FROM THE UNIVERSITY OF ILLINOIS, COLLEGE OF MEDICINE,
DEPARTMENT OF PSYCHIATRY AT THE ILLINOIS NEUROPSYCHIATRIC INSTITUTE,
AND THE UNIVERSITY OF CHICAGO

Because of the "all-or-none" character of nervous activity, neural events and the relations among them can be treated by means of propositional logic. It is found that the behavior of every net can be described in these terms, with the addition of more complicated logical means for nets containing circles; and that for any logical expression satisfying certain conditions, one can find a net behaving in the fashion it describes. It is shown that many particular choices among possible neurophysiological assumptions are equivalent, in the sense that for every net behaving under one assumption, there exists another net which behaves under the other and gives the same results, although perhaps not in the same time. Various applications of the calculus are discussed.

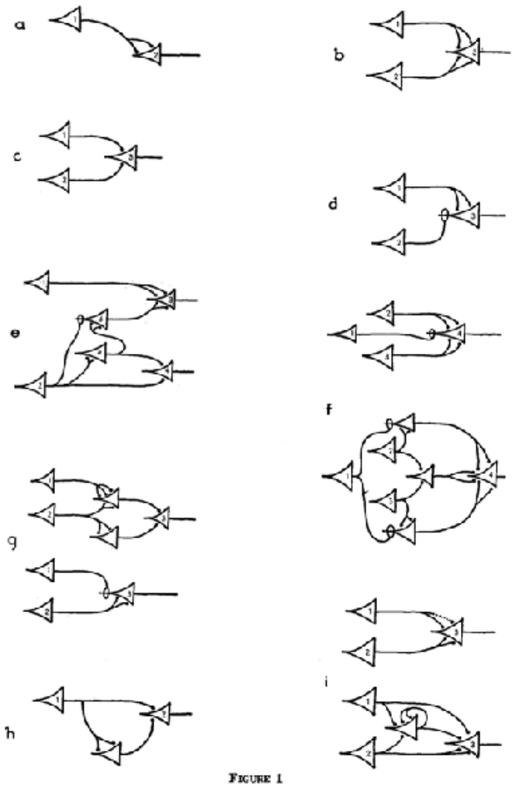
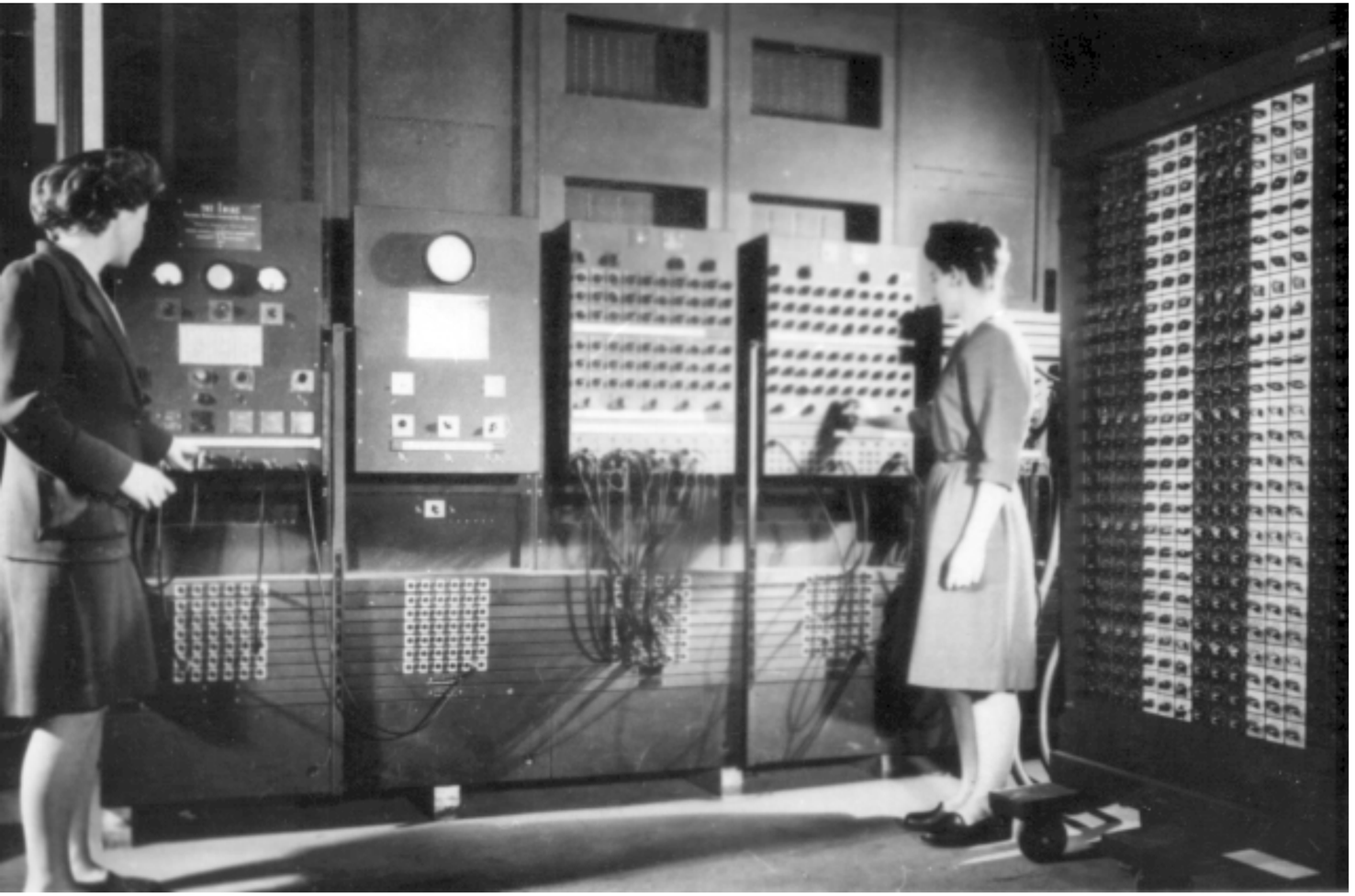
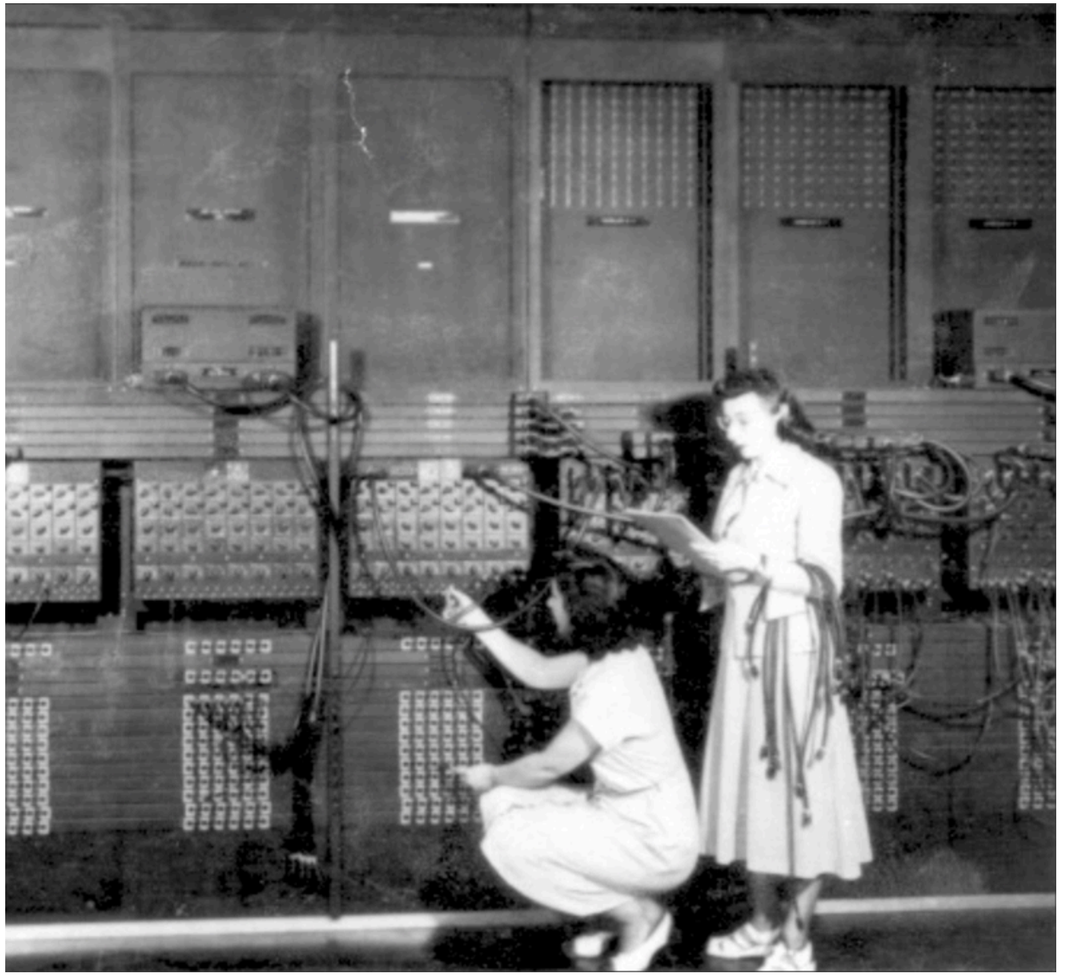


FIGURE 1

Artificial neuron network was invented in 1943

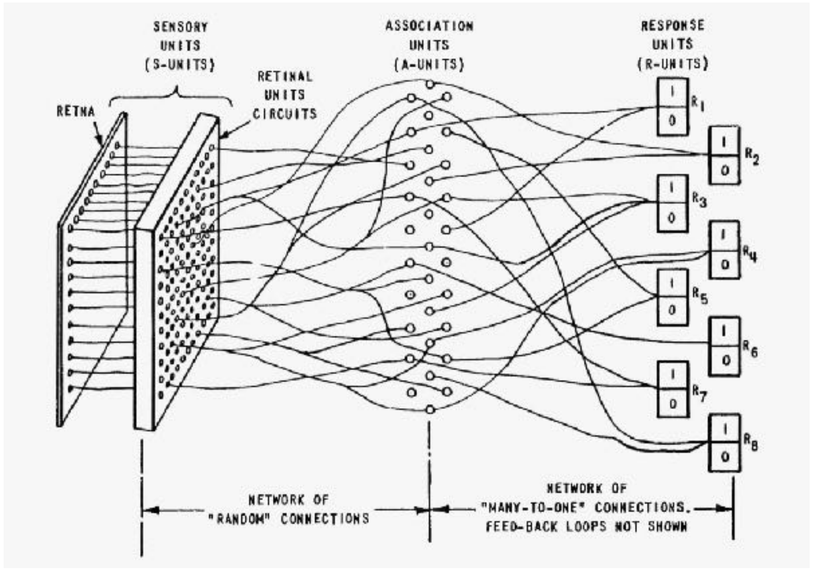
A Short History of Visual Computing

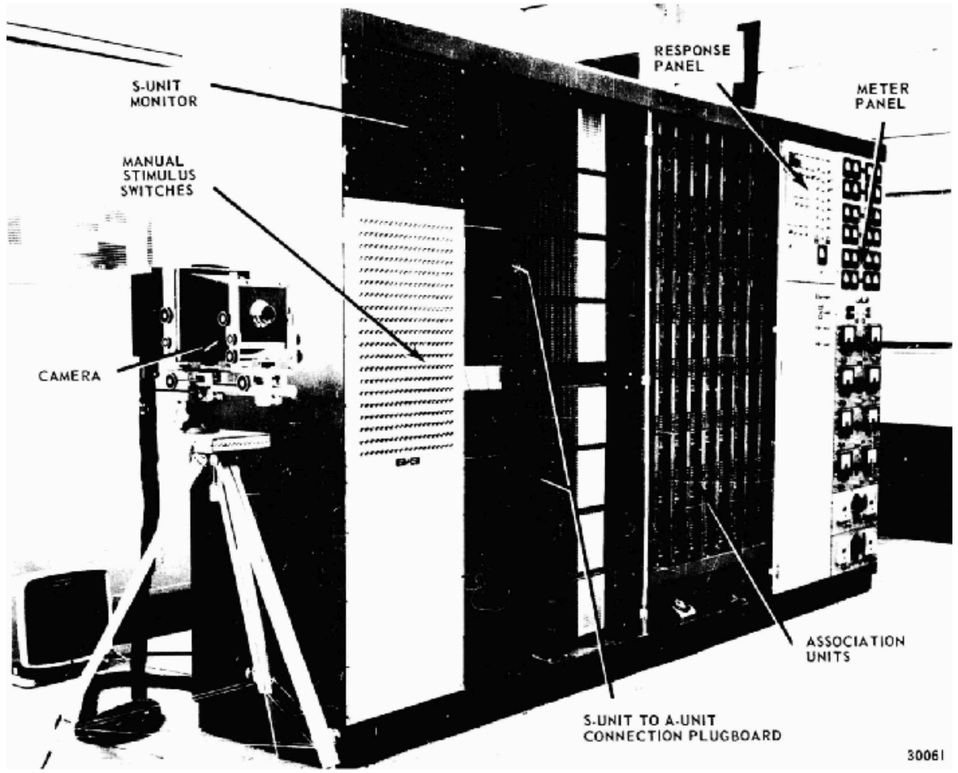


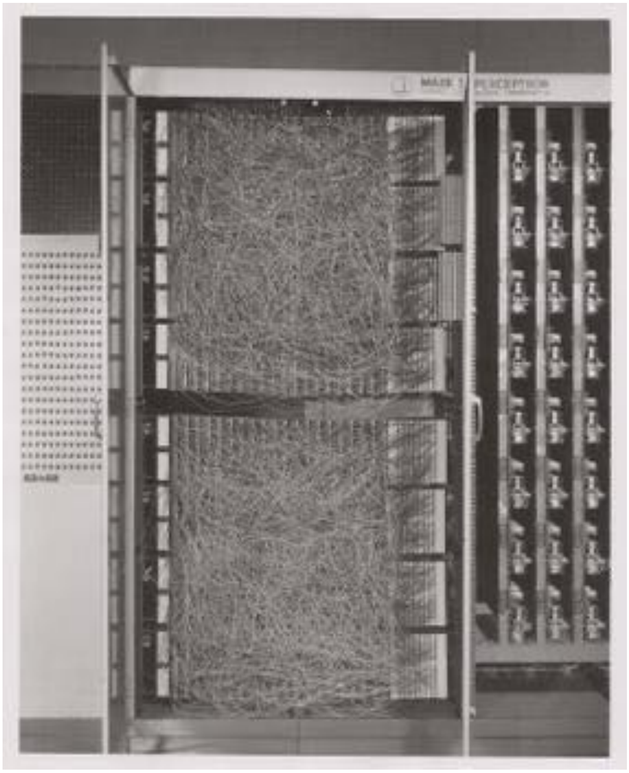


ENIAC (one of the first programmable, electronic computers) 1946, and the first six programmers:
Kay McNulty, Betty Jennings, Betty Snyder, Marlyn Meltzer, Fran Bilas, and Ruth Lichterman

A Short History of Visual Computing







Frank Rosenblatt's

Perceptron 1950s

A Short History of Visual Computing

The first digital scanner, used to make the first digital photo in 1957

First digital scan. a picture of Kirsch's three-month-old son, 30,976 pixels (176 × 176 pixel)

A Short History of Visual Computing

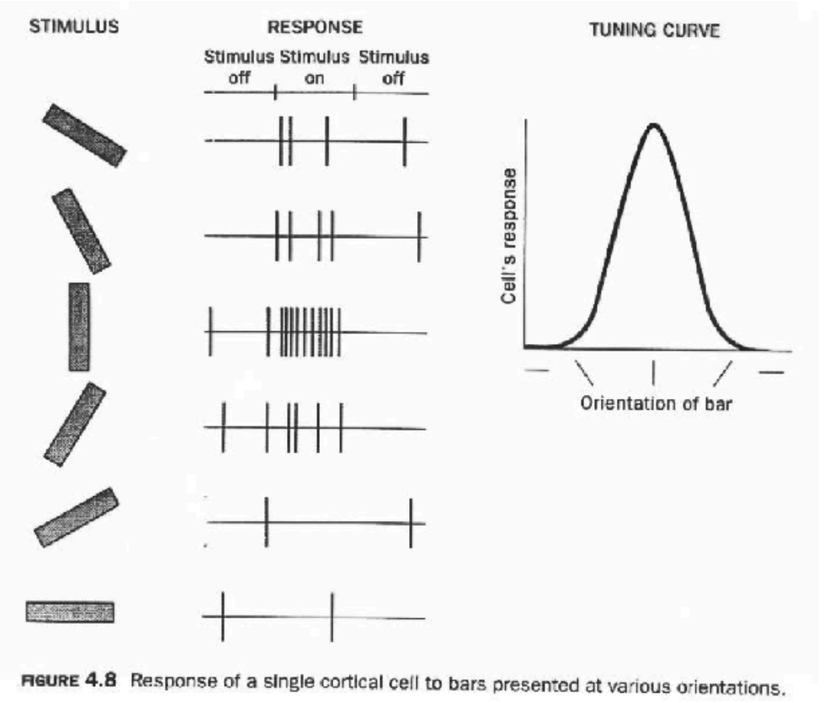


FIGURE 4.8 Response of a single cortical cell to bars presented at various orientations.

David H Hubel and Torsten N Wiesel study the visual cortex
(specifically optical system of a cat) ~1960

A Short History of Visual Computing

A Proposal for the

DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE

June 17 - Aug. 16

We propose that a 2 month, 10 man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

The following are some aspects of the artificial intelligence problem:

1) Automatic Computers

If a machine can do a job, then an automatic calculator can be programmed to simulate the machine. The speeds and memory capacities of present computers may be insufficient to simulate many of the higher functions of the human brain, but the major obstacle is not lack of machine capacity, but our inability to write programs taking full advantage of what we have.

2) How Can a Computer be Programmed to Use a Language

It may be speculated that a large part of human thought consists of manipulating words according to rules of reasoning

Dartmouth Summer Research Project 1955

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group — July 7, 1966

Vision Memo. No. 100.

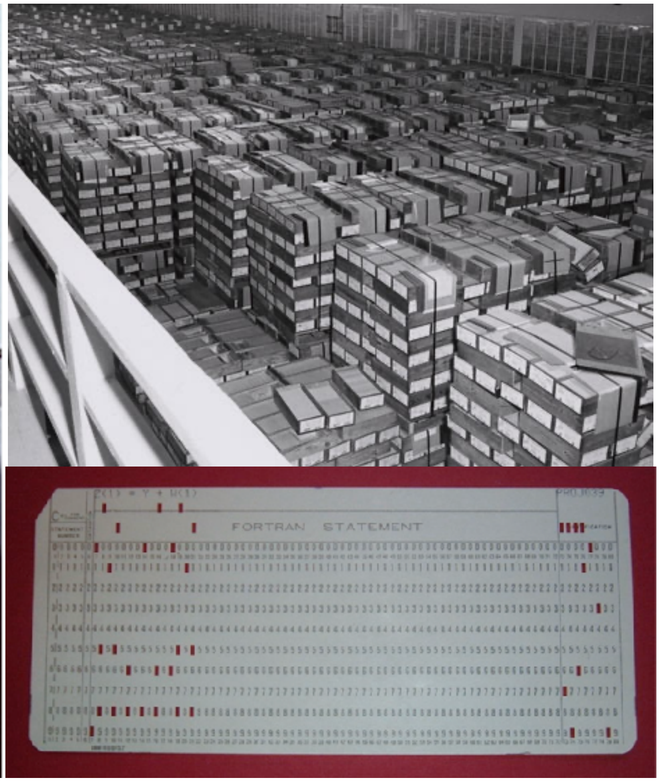
THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet participate in the construction of a system complex enough to be a real landmark in the development of "pattern recognition".

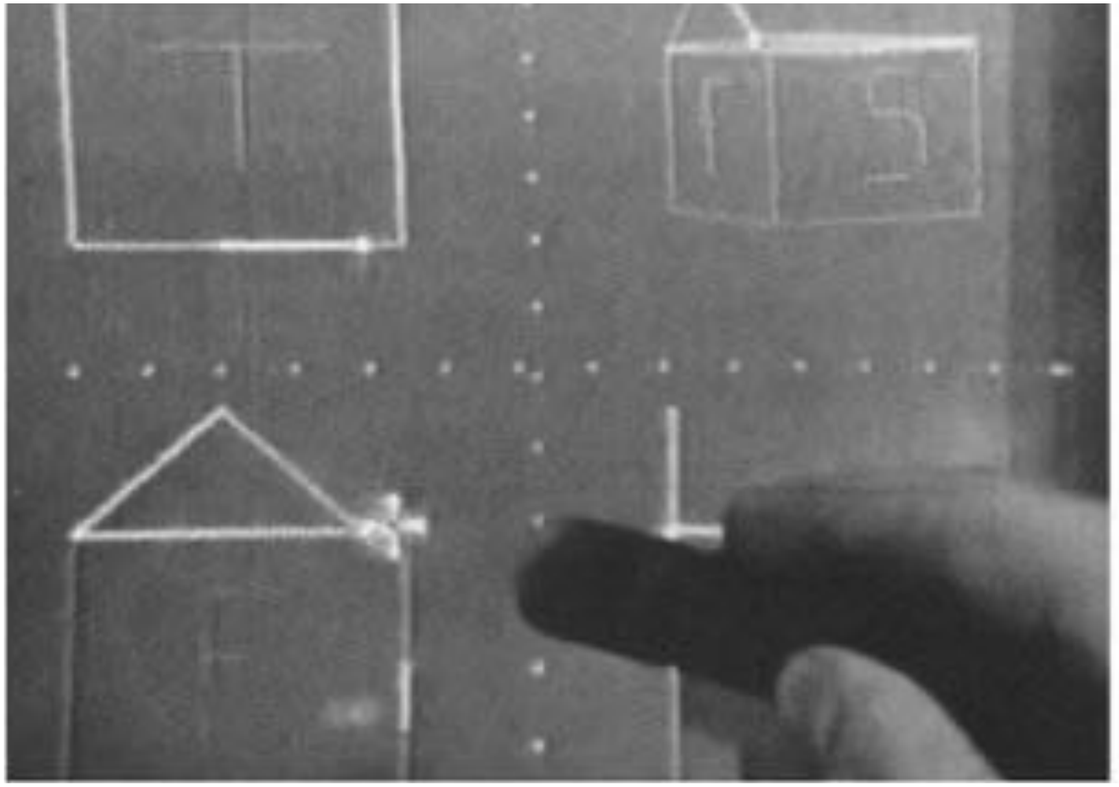
The *Summer Vision Project* 1966

A Short History of Visual Computing



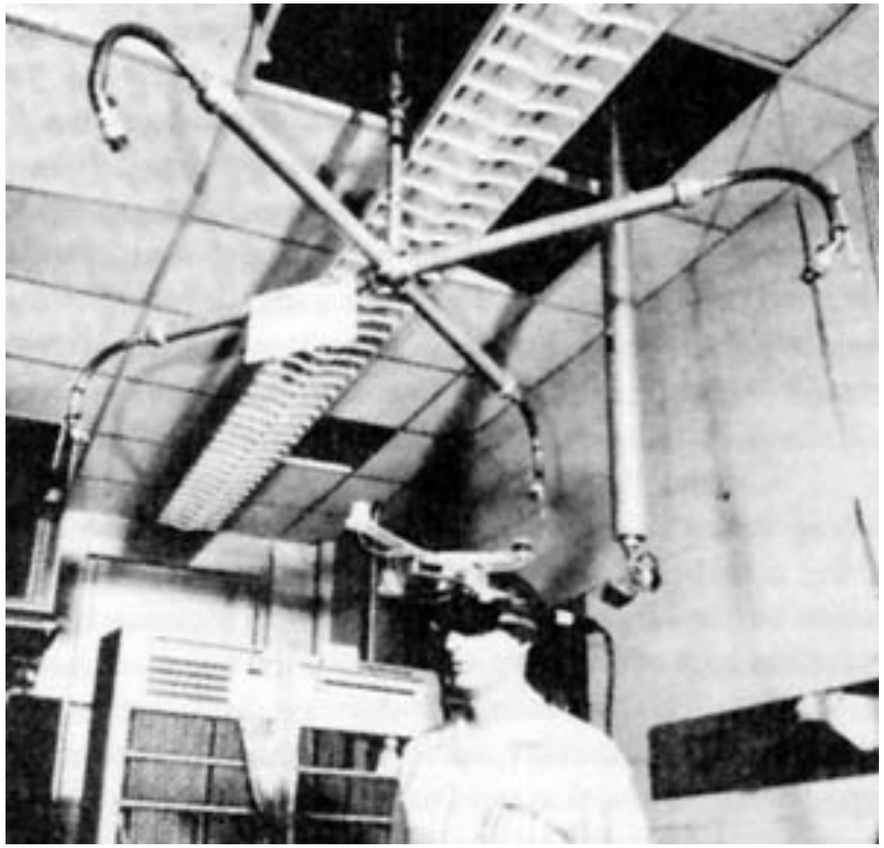
Batch processing using punch cards, still not interactive (1950s -1970s)

A Short History of Visual Computing



Ivan Sutherland, *Sketchpad, a Man–Machine Graphical Communication System*,1963

A Short History of Visual Computing

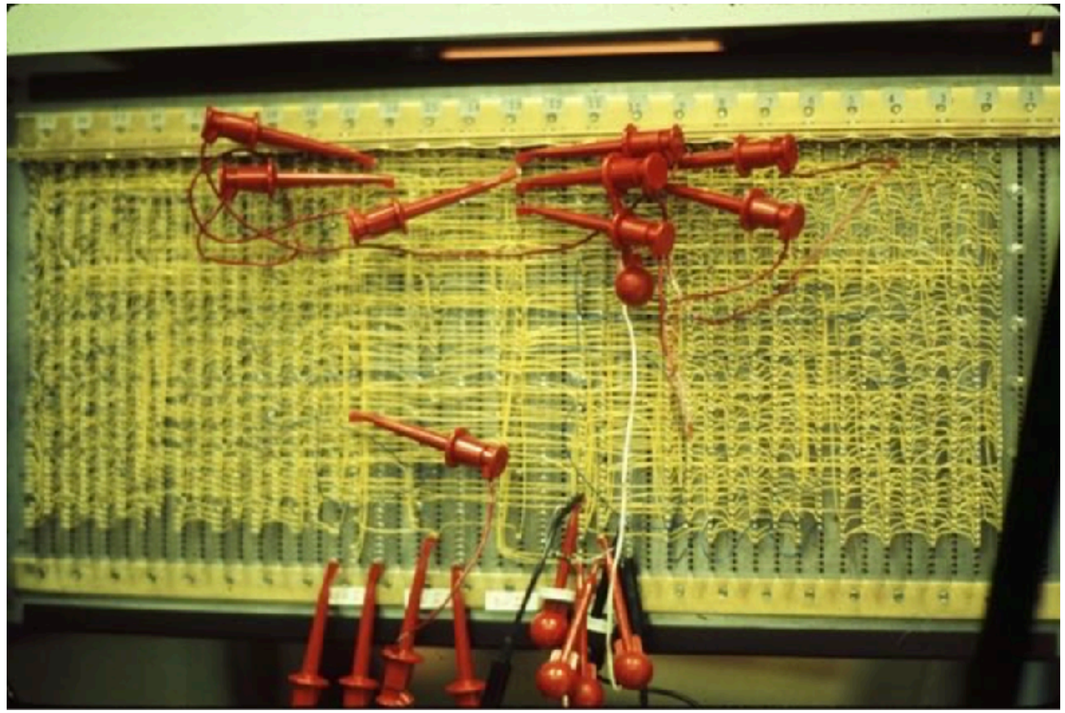


Ivan Sutherland, 1968 “A head-mounted three dimensional display”

What is Visual Computing

IBM System/360 (mainframe computer in the 70s), Altair 8800 (one of the first home computers)

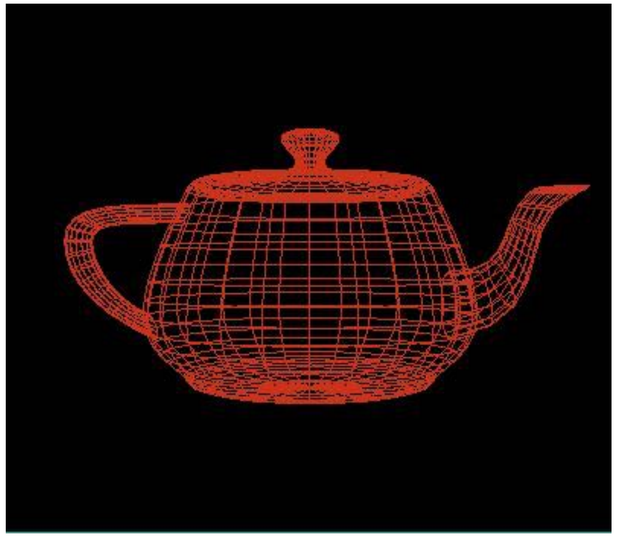
A Short History of Visual Computing



Xerox Parc Super Frame, First Frame Buffer, 1972

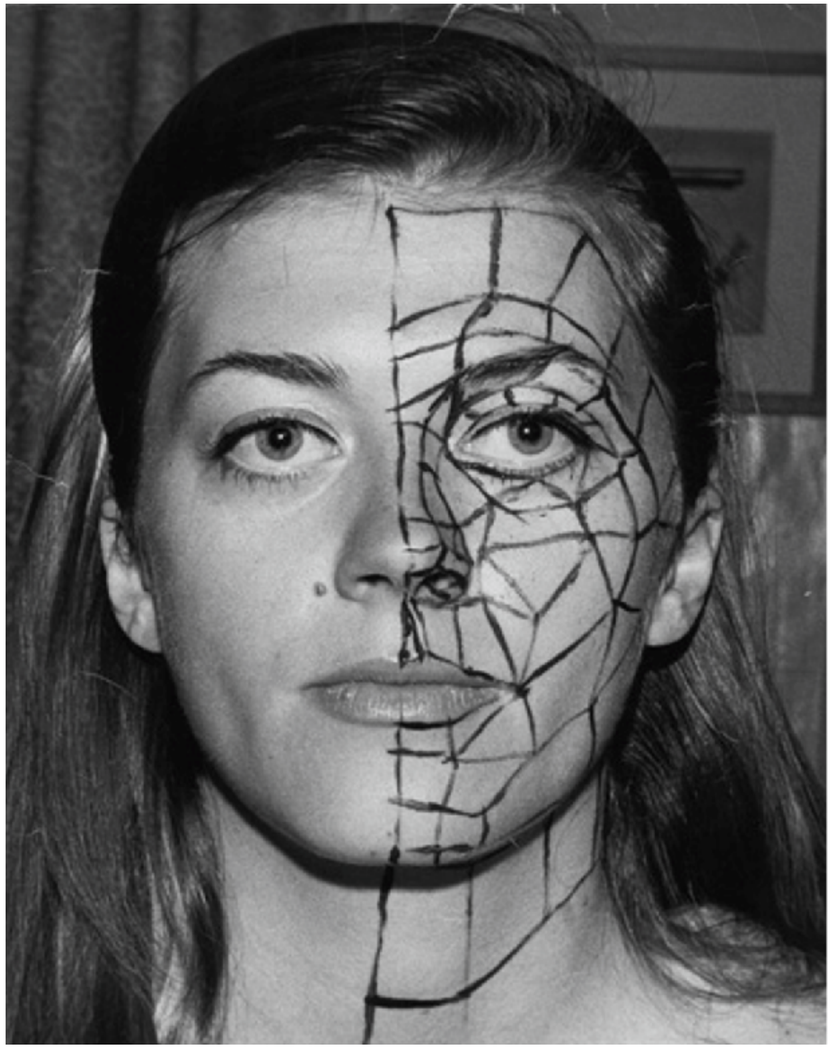
Xerox Parc Super Frame, First Image Stored in Frame Buffer

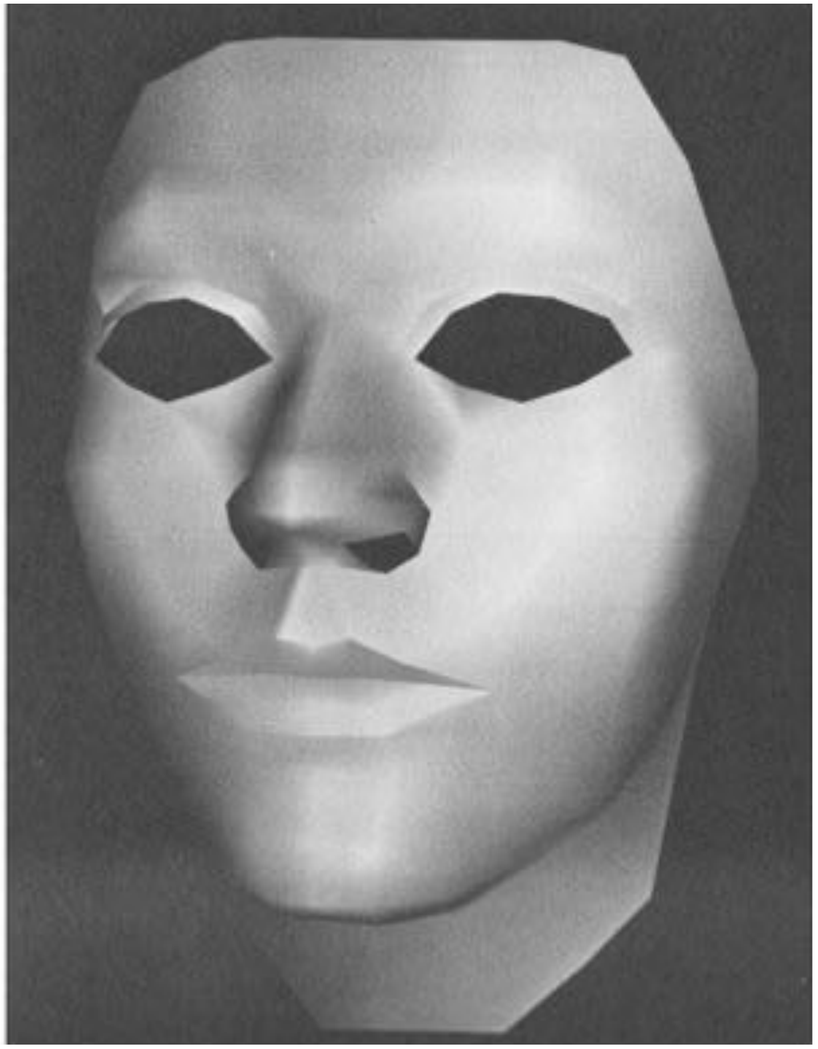
A Short History of Visual Computing



Graphic Group at University of Utah [back, left] Nolan Bushnell, Bob Sproull, Martin Newell, John Warnock, Fred Parke, Gary Watkins, Alvy Ray Smith, Henri Gouraud, Ed Catmull, [front, left] Robert Schumacker, Ivan Sutherland, Jim Blinn, and Henry Fuchs 1960-1970s

A Short History of Visual Computing

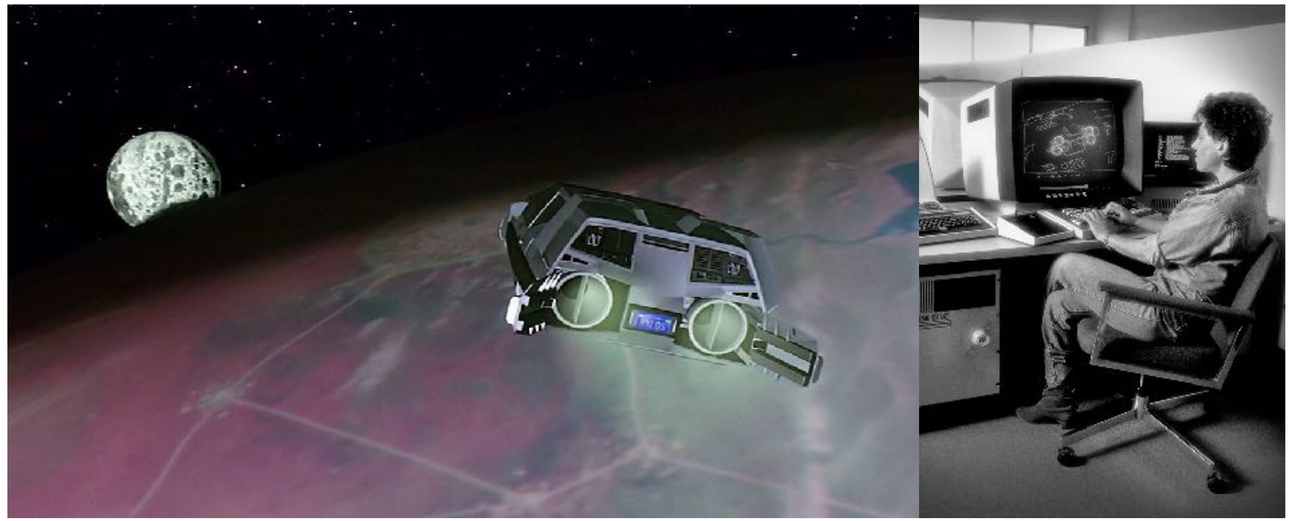




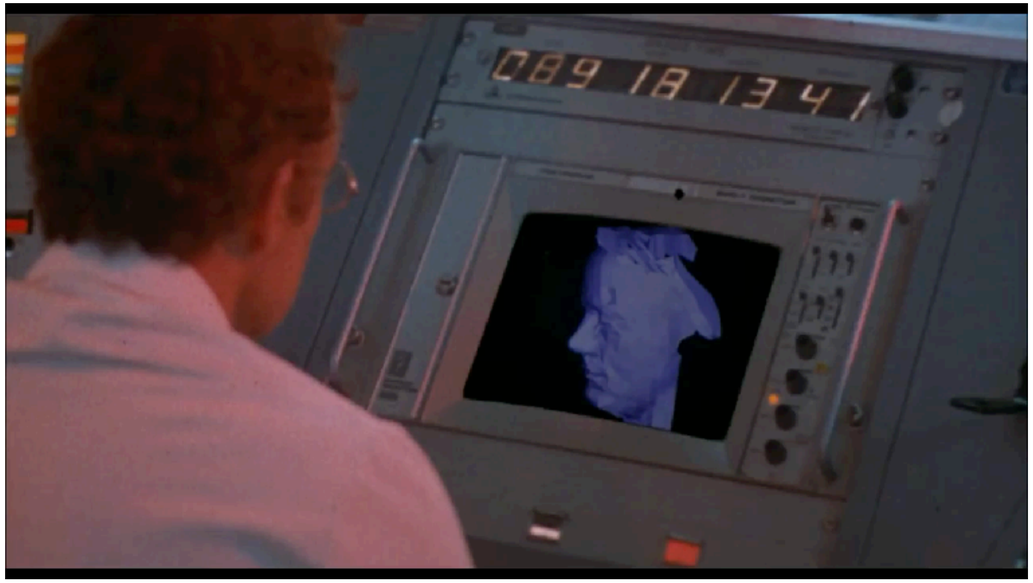
Gouraud shading algorithm 1971

A Short History of Visual Computing

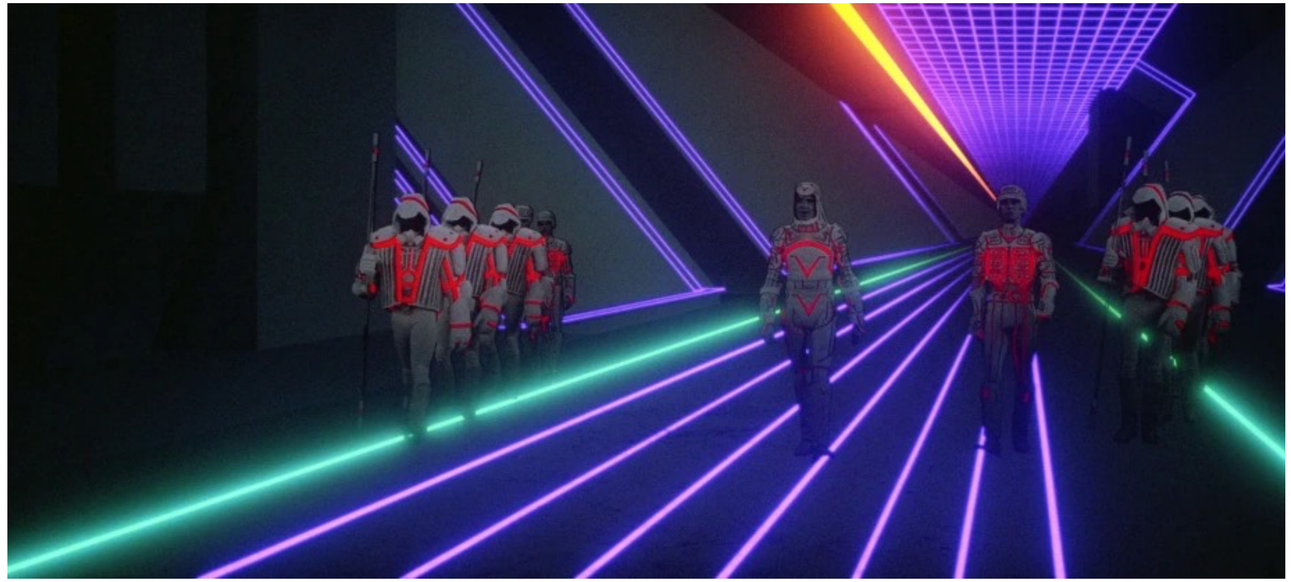
“Westworld” (1973)



“The last Starfighter” and Shelley Lake (1984)

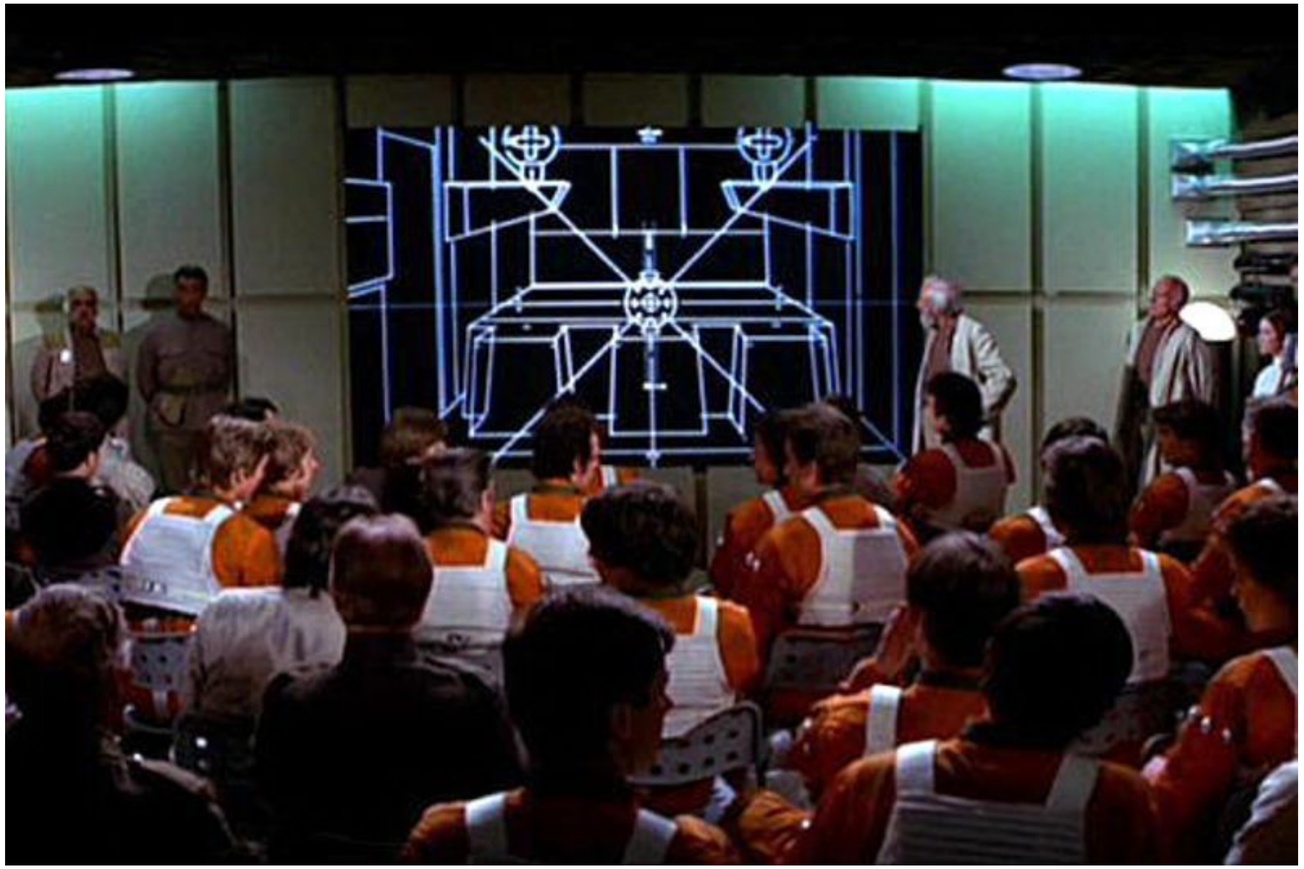


“Futureworld” (1976)



“Tron” (1982)

A Short History of Visual Computing



Star Wars 1977

Star Trek “Genesis effect” rendering 1982

A Short History of Visual Computing

Star Trek “Genesis effect” rendering

A Short History of Visual Computing

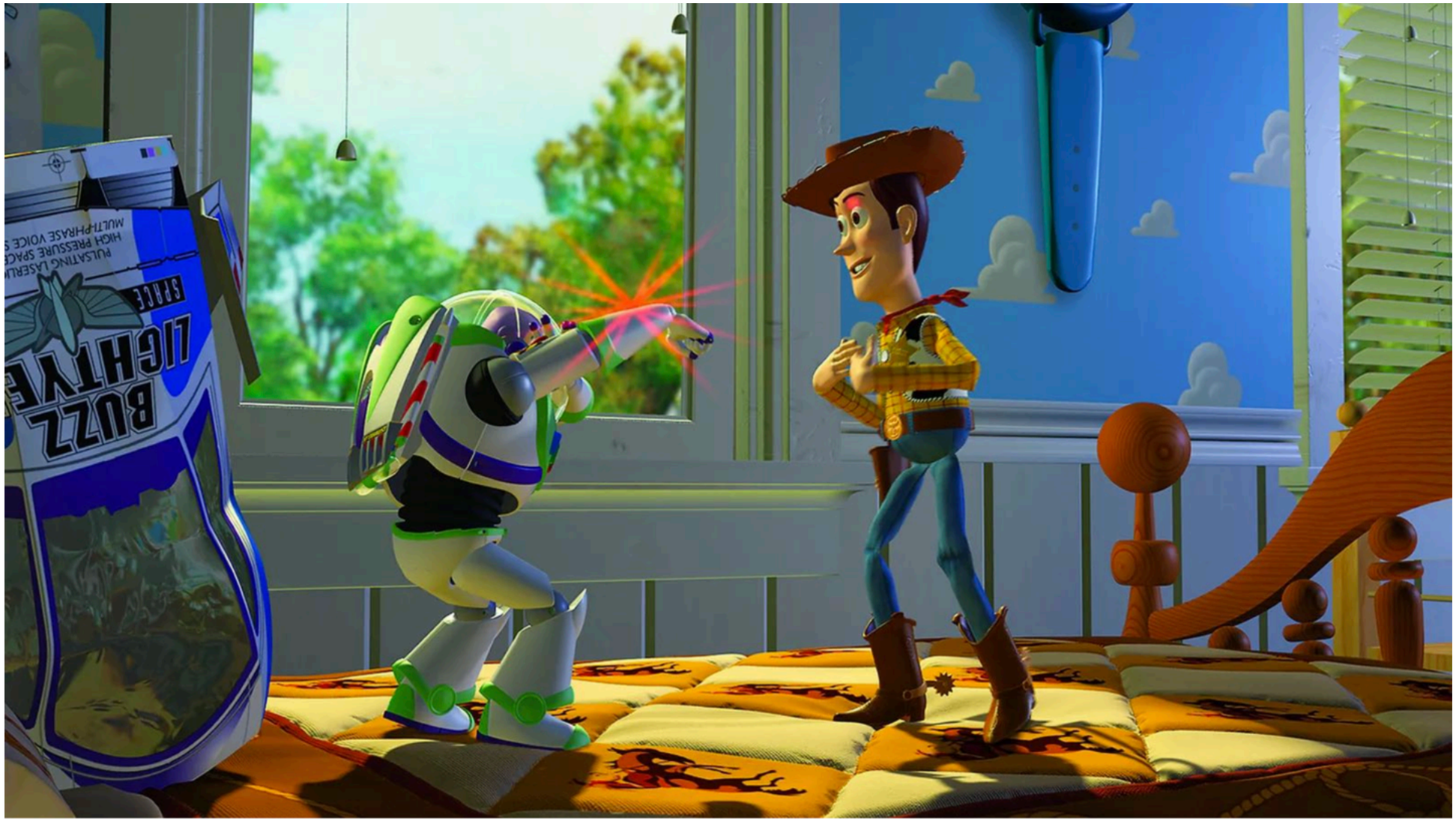
“Road to Pt. Reyes” LucasFilm (1983) took a month to render (2048x2048 pixel)

A Short History of Visual Computing

OpenGL®

1992 SGI release OpenGL (Open Graphics Library)

A Short History of Visual Computing



Pixar's Toy Story, 1995

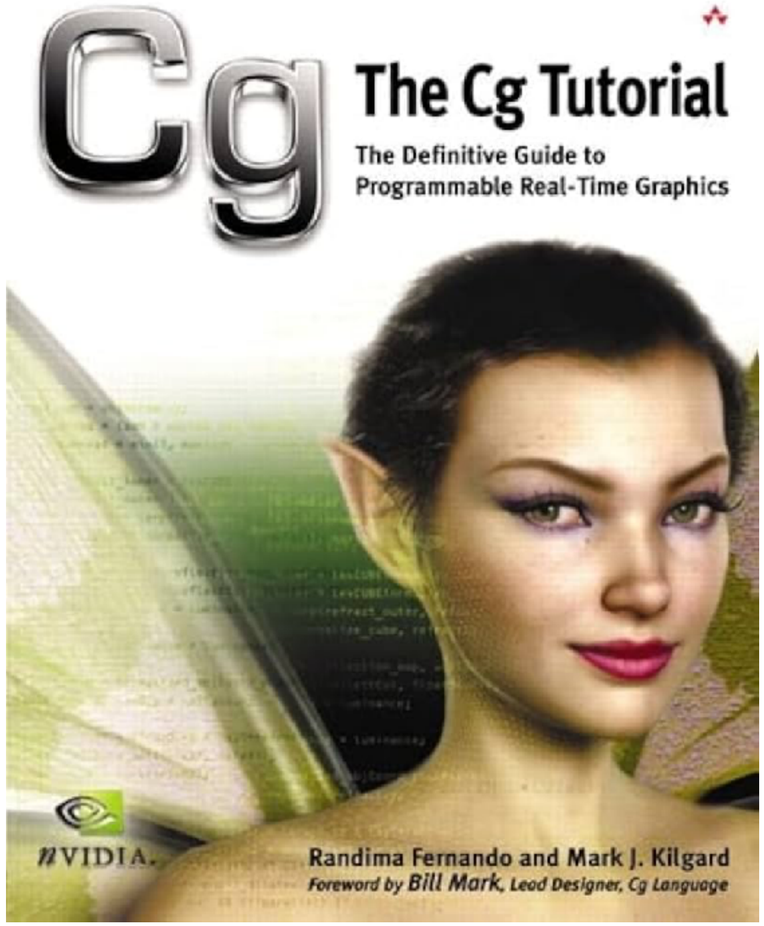
"We take an average of three hours to draw a single frame on the fastest computer money can buy."

- Steve Jobs

A Short History of Visual Computing

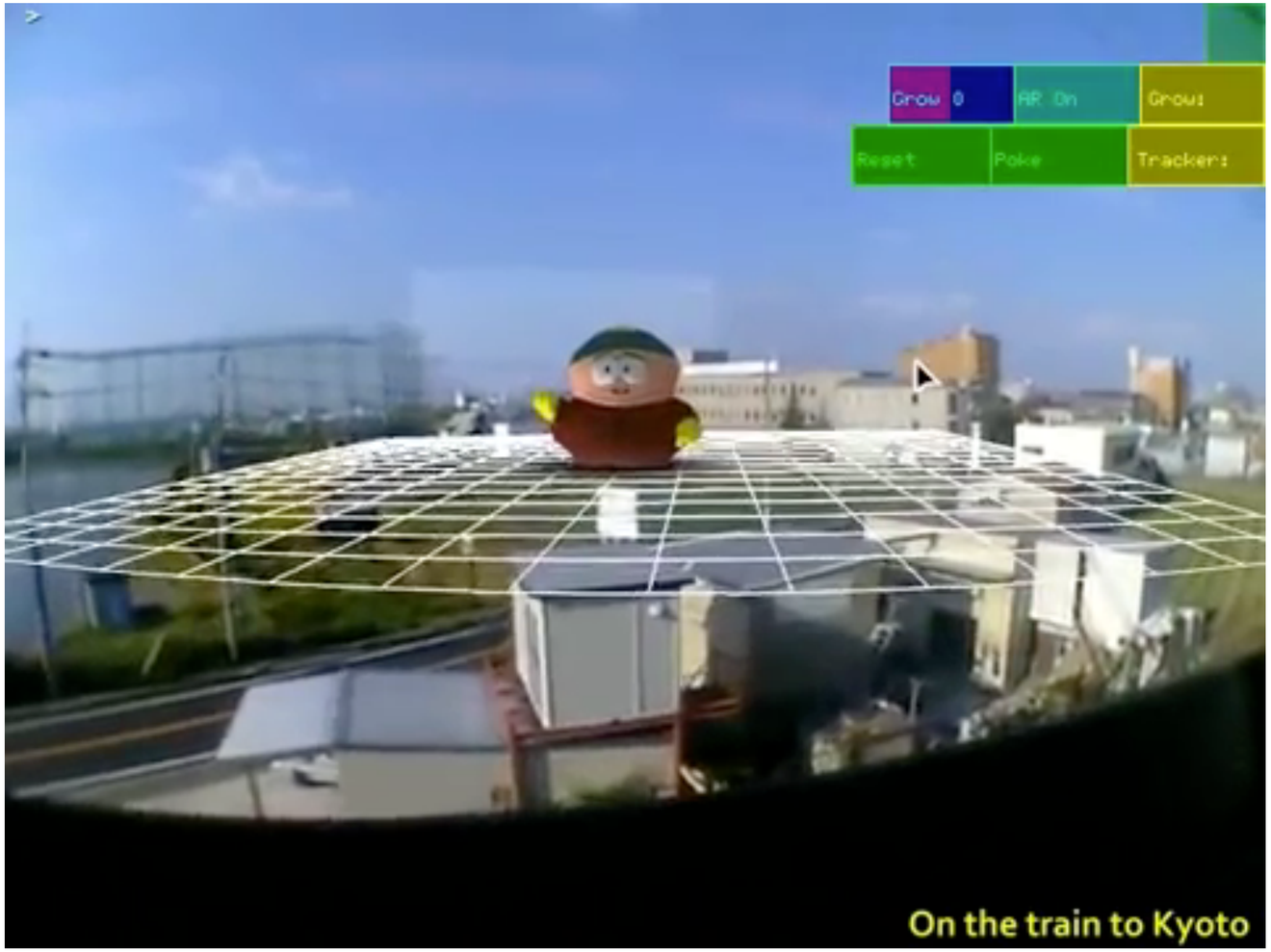
SIFT by David G. Lowe “Object Recognition from Local Scale-Invariant Features” (1999)

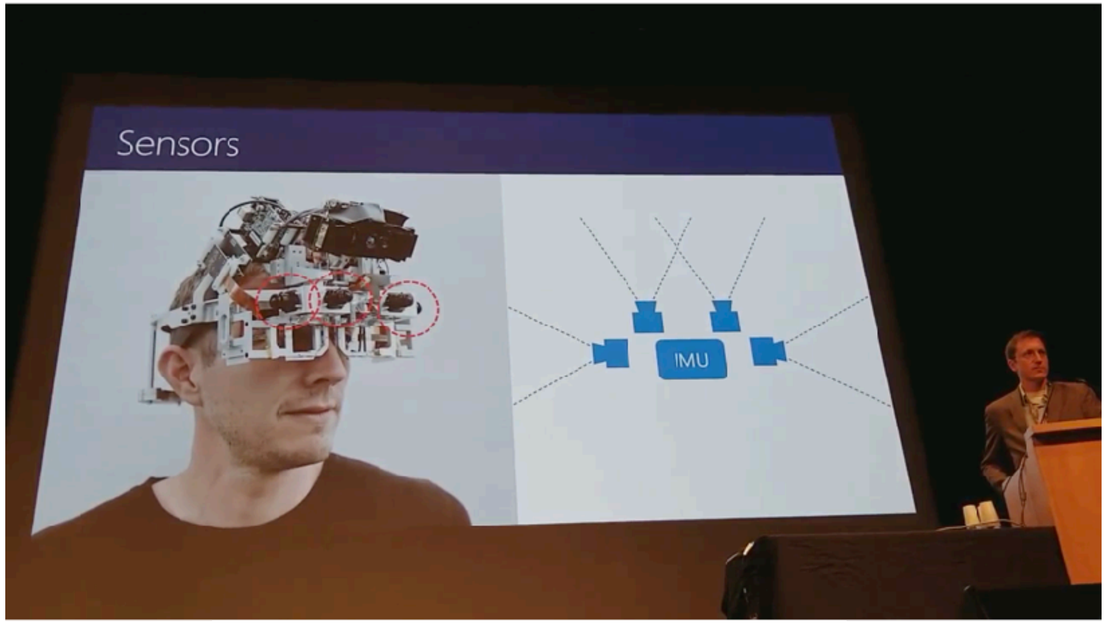
A Short History of Visual Computing



2001 NVidia Releases C for Graphics (CG) and the first fully programmable GPU(Geforce FX/5000) in 2003

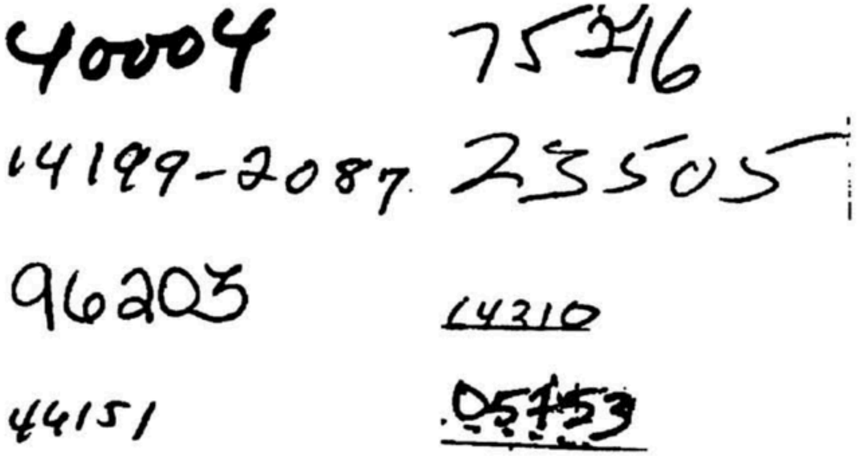
A Short History of Visual Computing

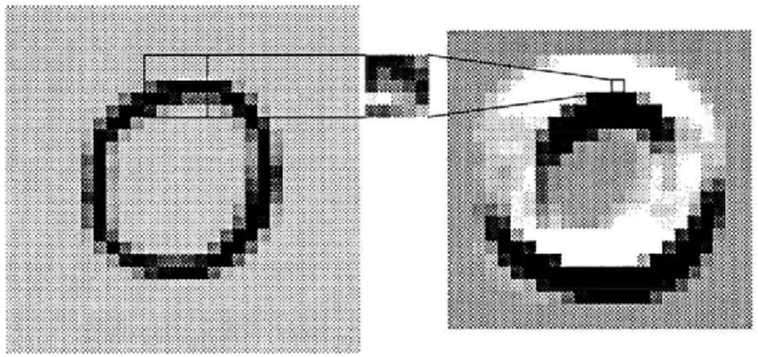


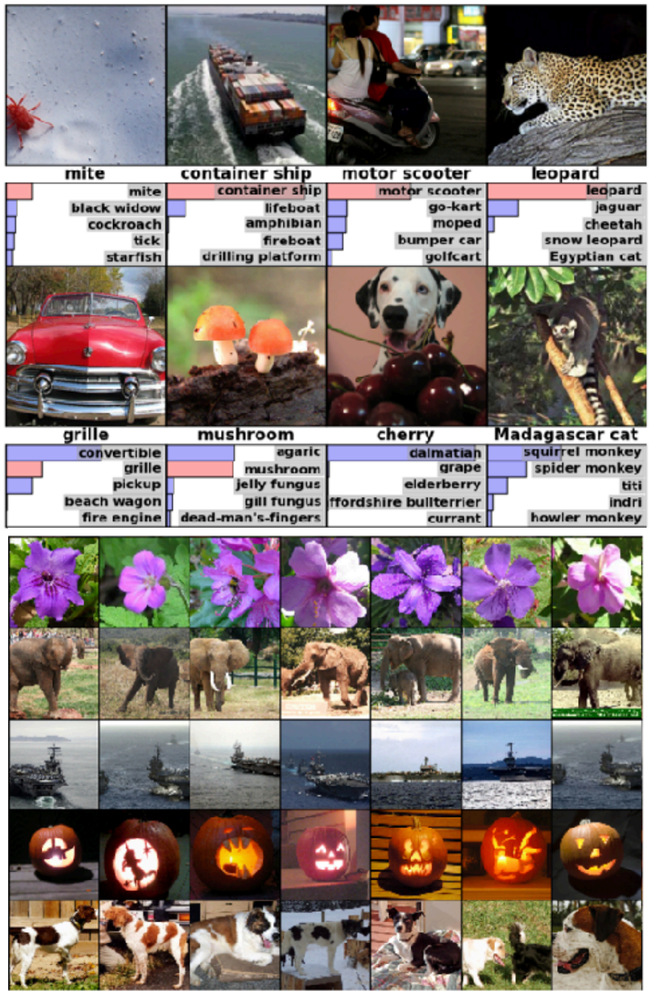


George Klein “Parallel tracking and mapping for small AR workspaces” (PTAM, 2007)

A Short History of Visual Computing

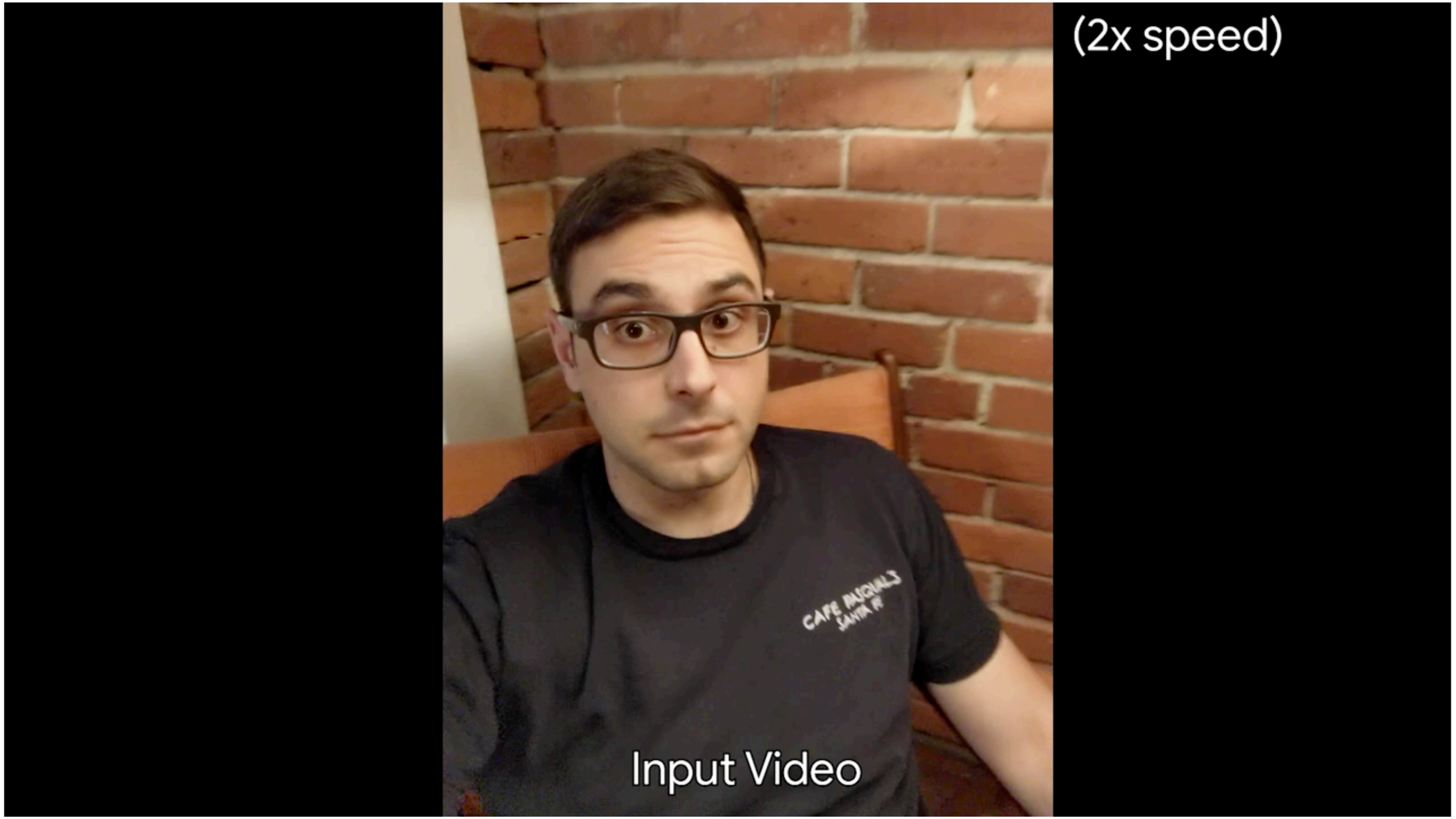






Deep Learning e.g. Convolutional Neural Network by Le Cun et al. (“Handwritten Digit Recognition with a Back-Propagation Network”, 1998) or Deep Neural Networks on GPUs (AlexNet “ImageNet Classification with Deep Convolutional Neural Networks”, 2012)

A Short History of Visual Computing



Neural Rendering (original paper: “Nerf: Representing scenes as neural radiance fields for view synthesis” (2020)) here: ”Nerfies: Deformable Neural Radiance Fields” (2021)

Next time:
2D images and colour representations

The end!