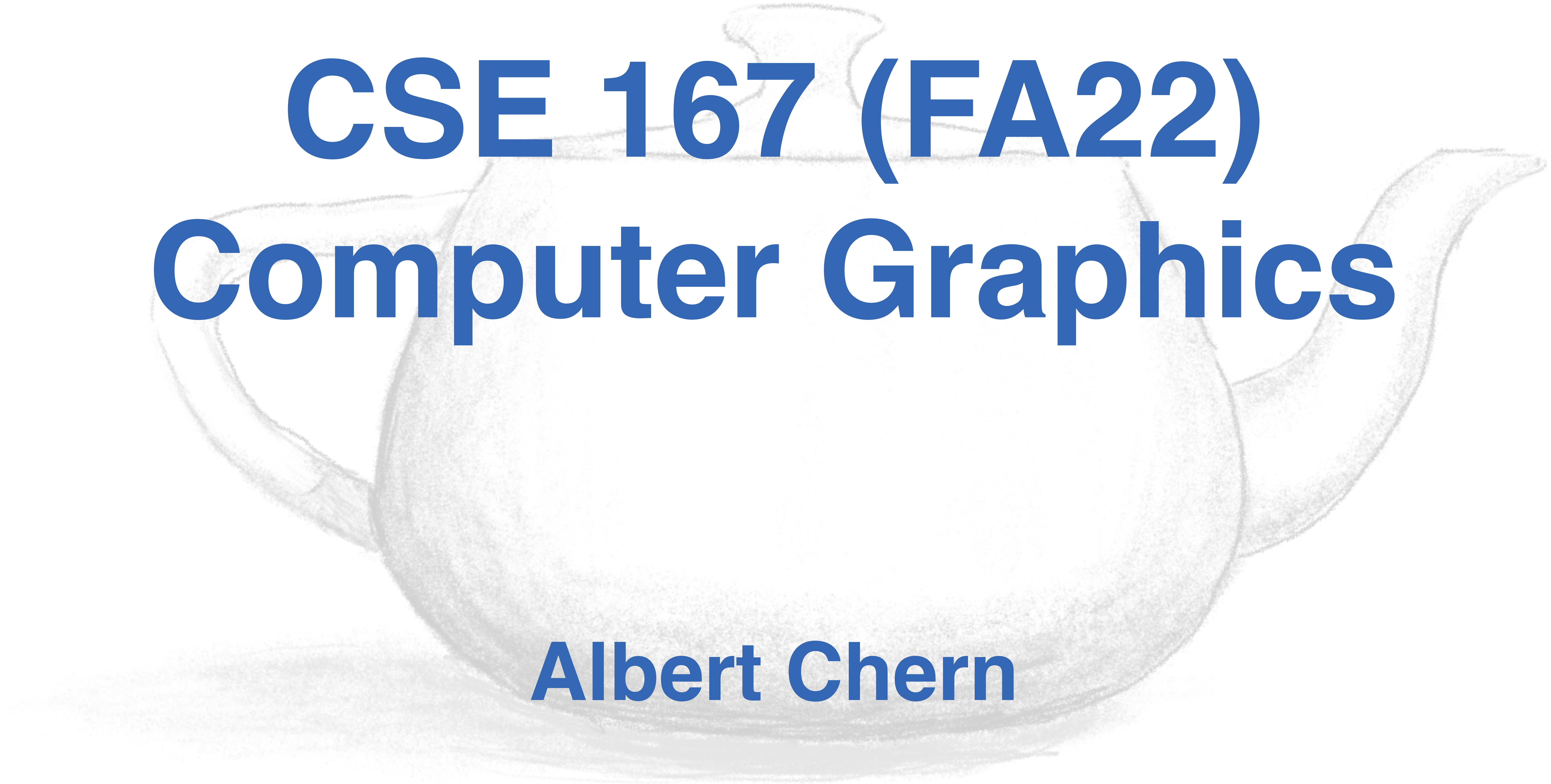


CSE 167 (FA22)
Computer Graphics

Albert Chern

UC San Diego
JACOBS SCHOOL OF ENGINEERING

Course Logistics

Lectures

- **Lectures (Albert Chern)**
  - Center Hall 115, In-person or remotely
- **Discussion (by the TAs)**
  - Fri 18:00–18:50, Center Hall 119 (starting from Week1: 9/30)
- **TAs**
  - Peter Wu
  - Sina Nabizadeh
  - Abhinav Gupta
  - Dylan Rowe
- **Tutors**
  - Flynn Sui
  - Evan Yao

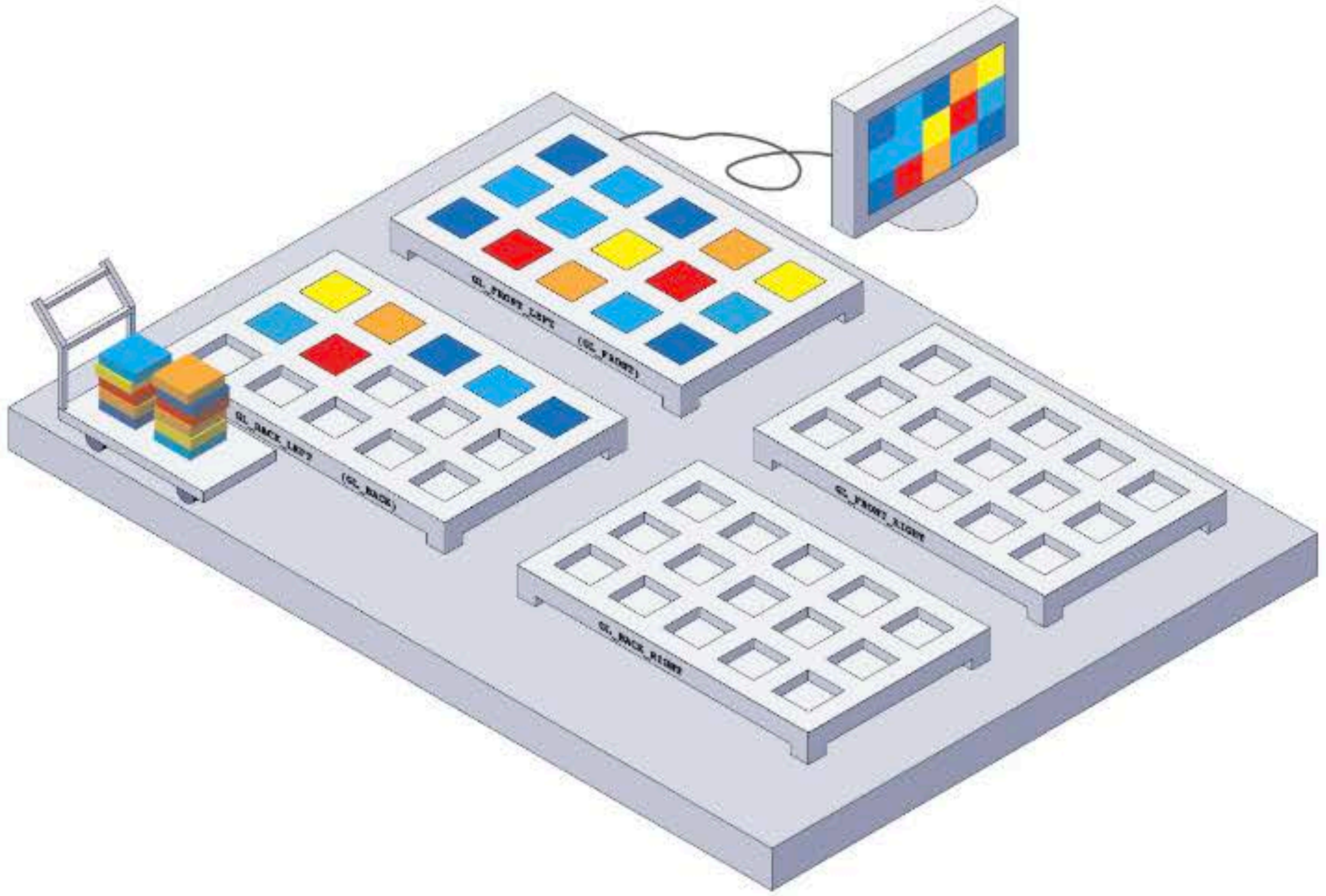
cseweb.ucsd.edu/~alchern/teaching/cse167_fa22/

CSE 167 (FA 2022) Computer Graphics

Welcome to CSE 167, Introduction to Computer Graphics.

- **Lecture:** Mon Wed Fri 15:00 - 15:50. Center Hall 115.
- **Discussion Session:** Fri 18:00-18:50. Center Hall 119.
- **Classroom:** You can also participate the class via Zoom.
- **Sites:**
    - **This page:** Slides, lecture notes, HW
    - **Canvas:** Link to Zoom (and Zoom recordings), link to Gradescope, and link back to this page.
    - **Piazza:** https://piazza.com/ucsd/fall2022/cse167 Q&A forum for the class.
    - **Gradescope:** https://www.gradescope.com/courses/444876 (log in with School credential, entry code: K3N5V7) HW submission.
- **Lecture note:** Introduction to Computer Graphics

  Visit Canvas (for all info including Zoom links), Gradescope (HW submission) and Piazza (Q&A).

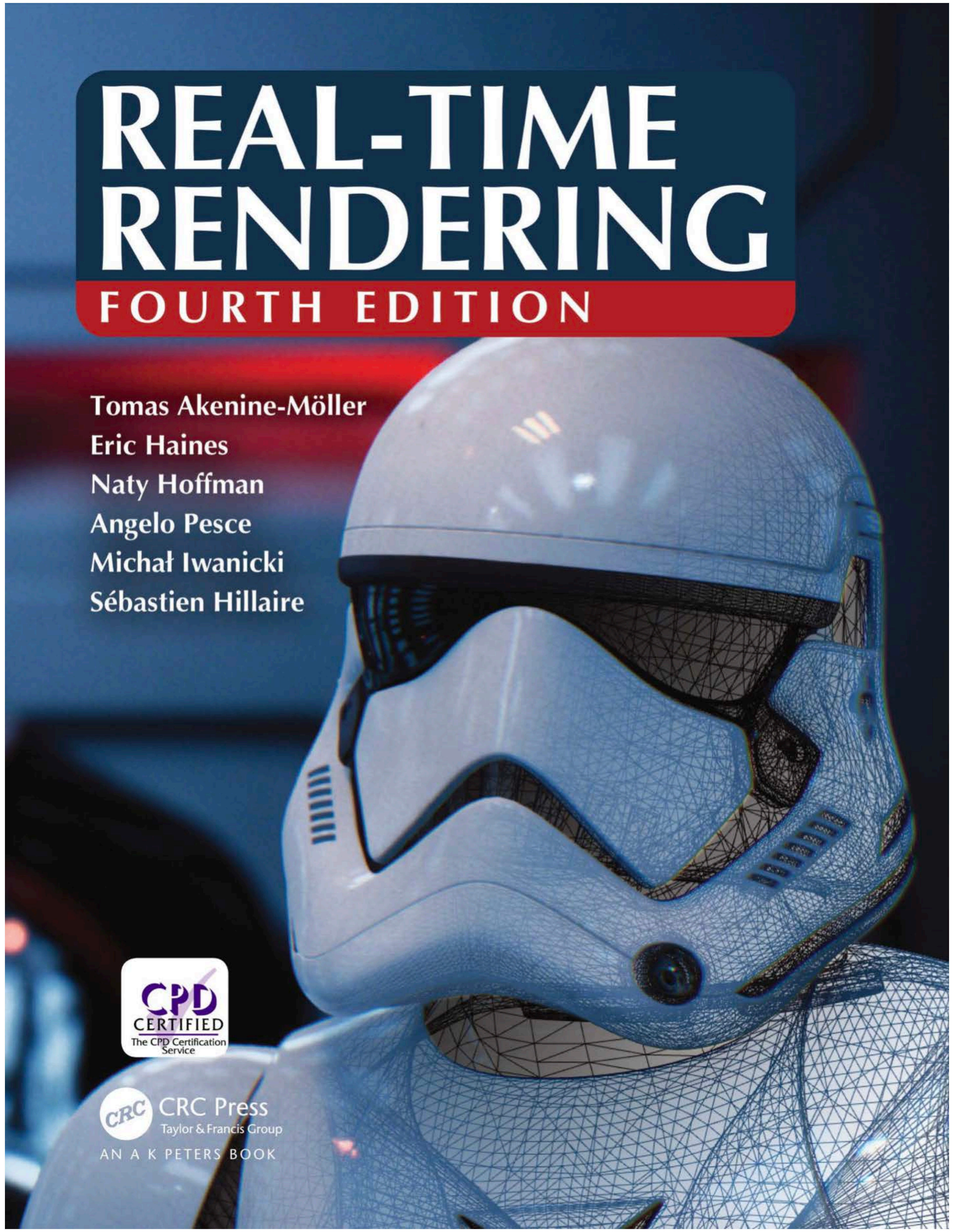


cseweb.ucsd.edu/~alchern/teaching/cse167_fa22/

		Office hour	OH location (all in CSE Building (EBU3B))	OS
Instructor	Albert Chern	Tue 3pm–4pm	4112	Mac
TA	Abhinav Gupta	Wed & Fri 8:30am–9:30am	B270A	Mac(Arm), Linux
TA	Mohammad "Sina" Nabizadeh	Tue 1pm–2pm	B215	Windows, Mac, Linux
TA	Dylan Rowe	Mon 10am–12pm	B275	Mac
TA	Baichuan "Peter" Wu	Thu 2pm–3pm & Fri 10am–11am	B240A	Windows, Mac, Linux
Tutor	Ziyan "Flynn" Sui	Fri 2pm–3pm	B215	Mac(Arm)
Tutor	Yunchao "Evan" Yao	Mon 5pm–6pm	B240A	Windows, Linux

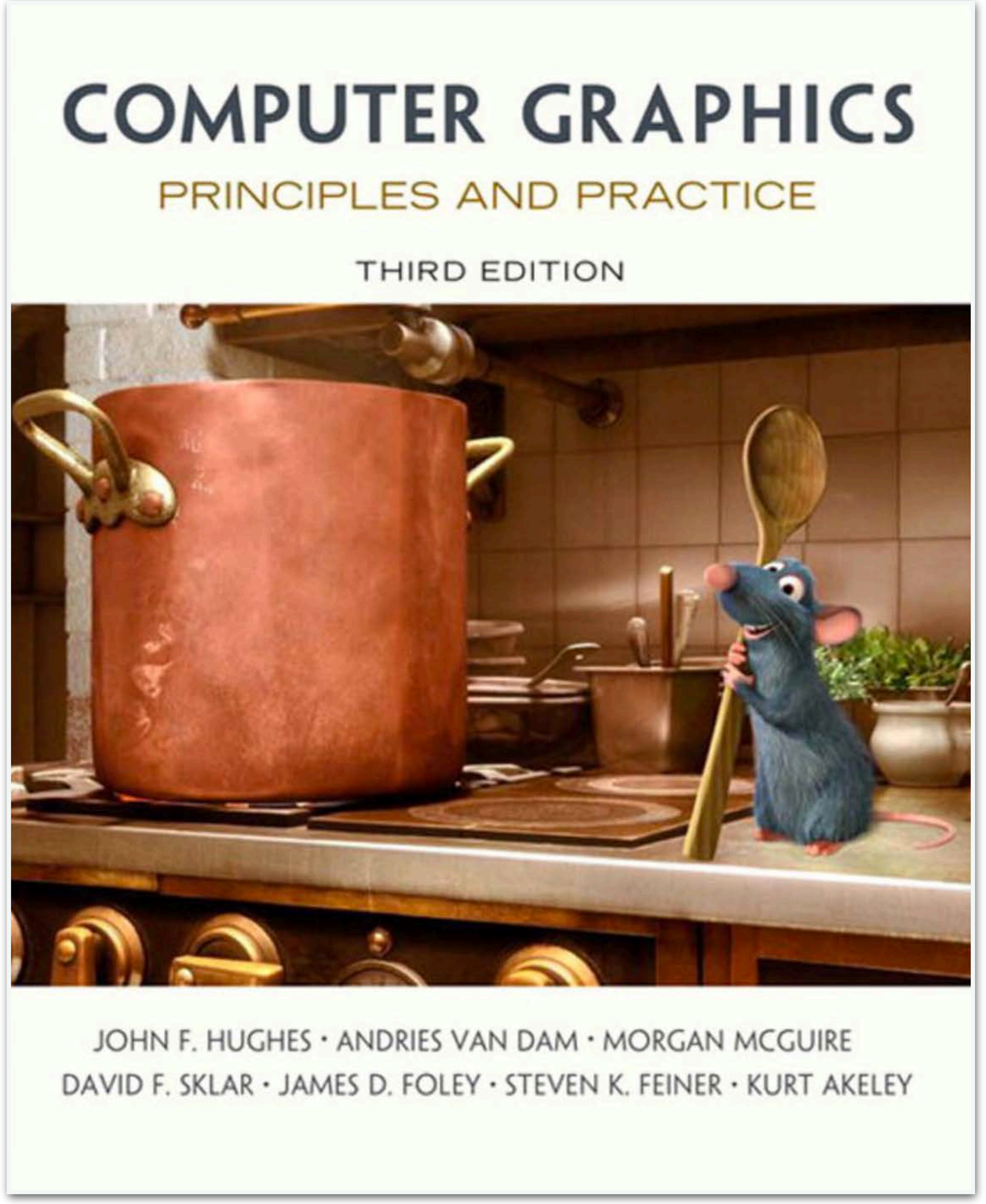
Lecture Note

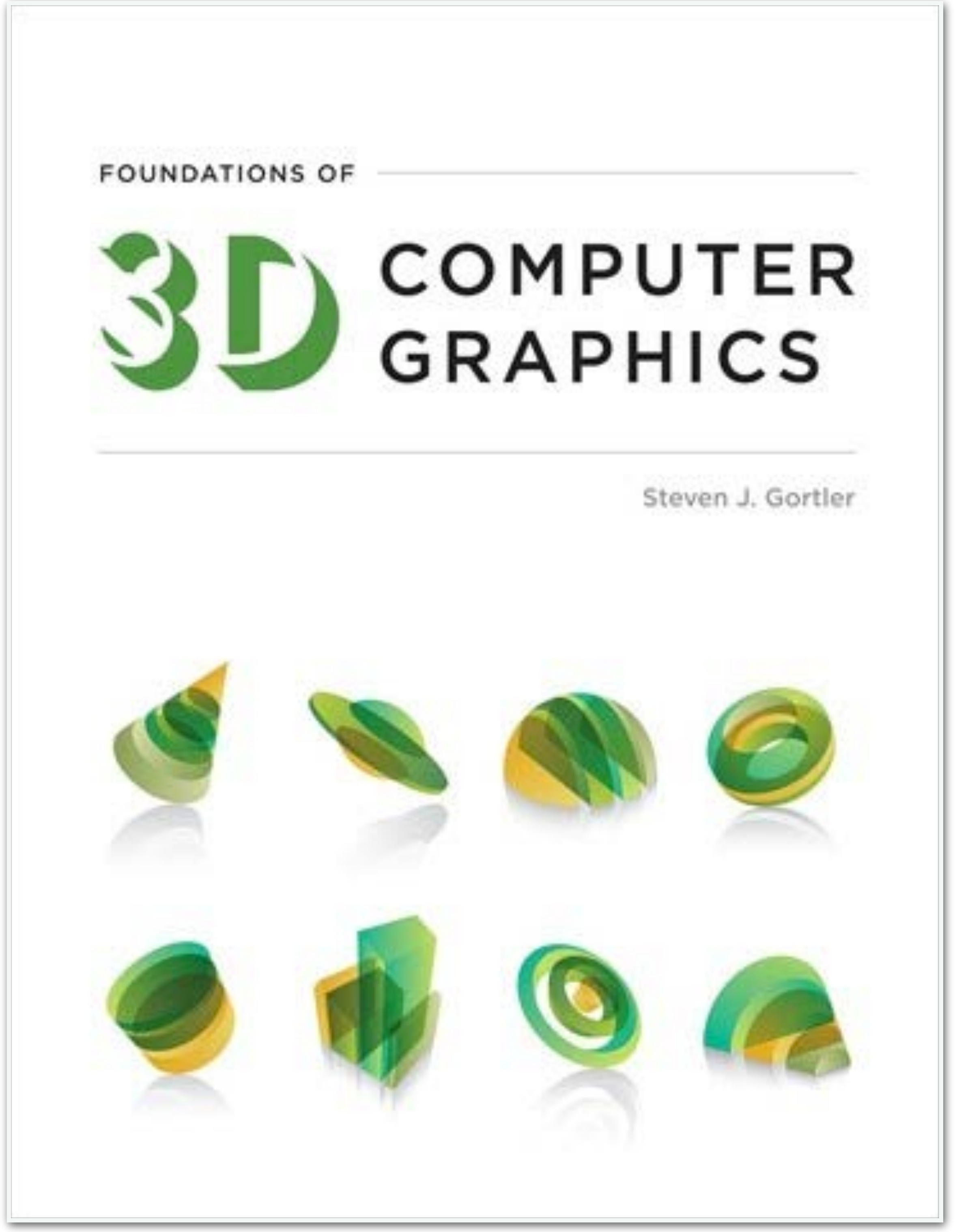
References

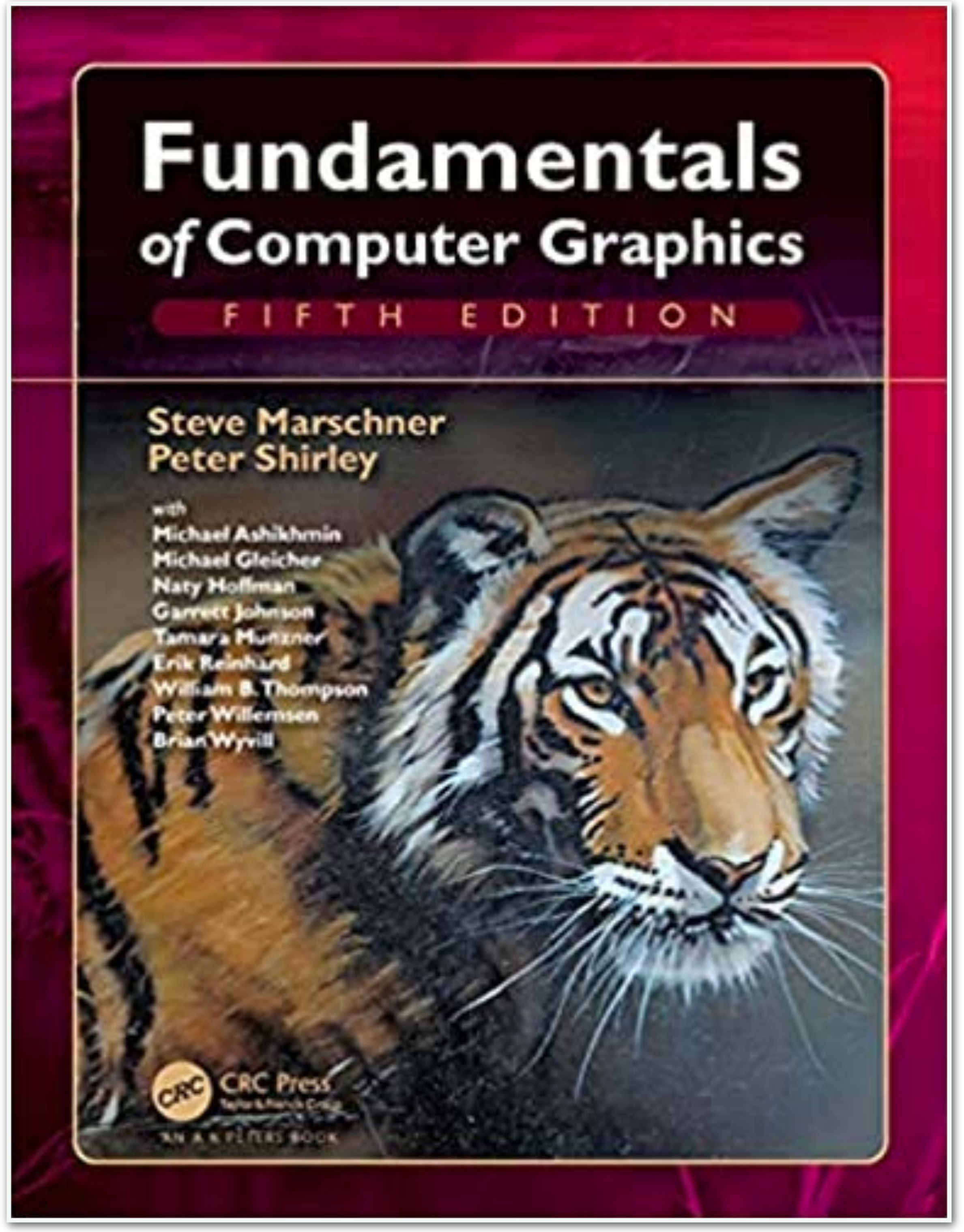


(Available online from UC Library)

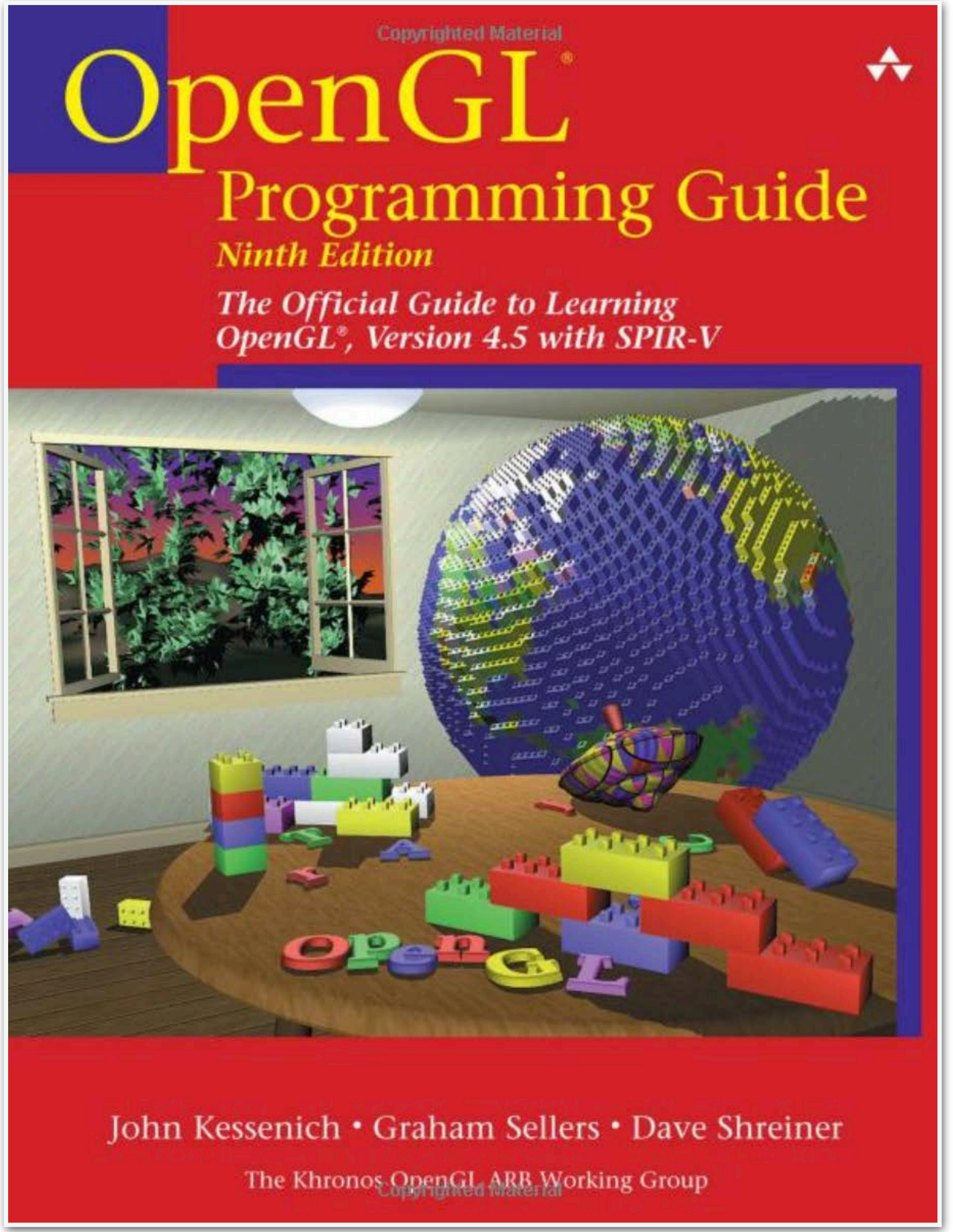
References

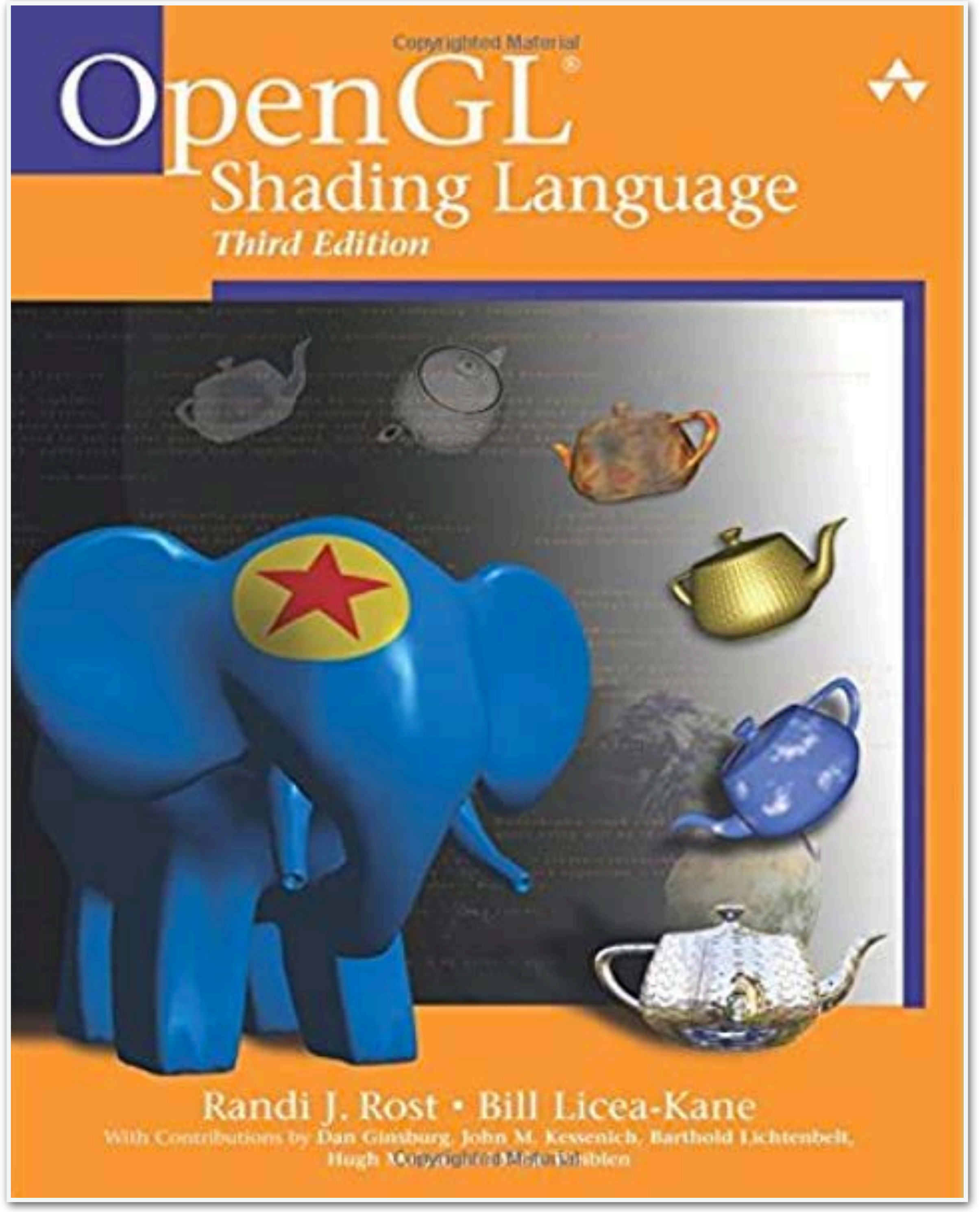

COMPUTER GRAPHICS
PRINCIPLES AND PRACTICE
THIRD EDITION
JOHN F. HUGHES · ANDRIES VAN DAM · MORGAN MCGUIRE
DAVID F. SKLAR · JAMES D. FOLEY · STEVEN K. FEINER · KURT AKELEY


FOUNDATIONS OF
3D COMPUTER GRAPHICS
Steven J. Gortler


Fundamentals
of Computer Graphics
FIFTH EDITION
Steve Marschner
Peter Shirley
with
Michael Ashikhmin
Michael Gleicher
Naty Hoffman
Garrett Johnson
Tamara Munzner
Erik Reinhard
William B. Thompson
Peter Willemsen
Brian Wyvill
CRC Press

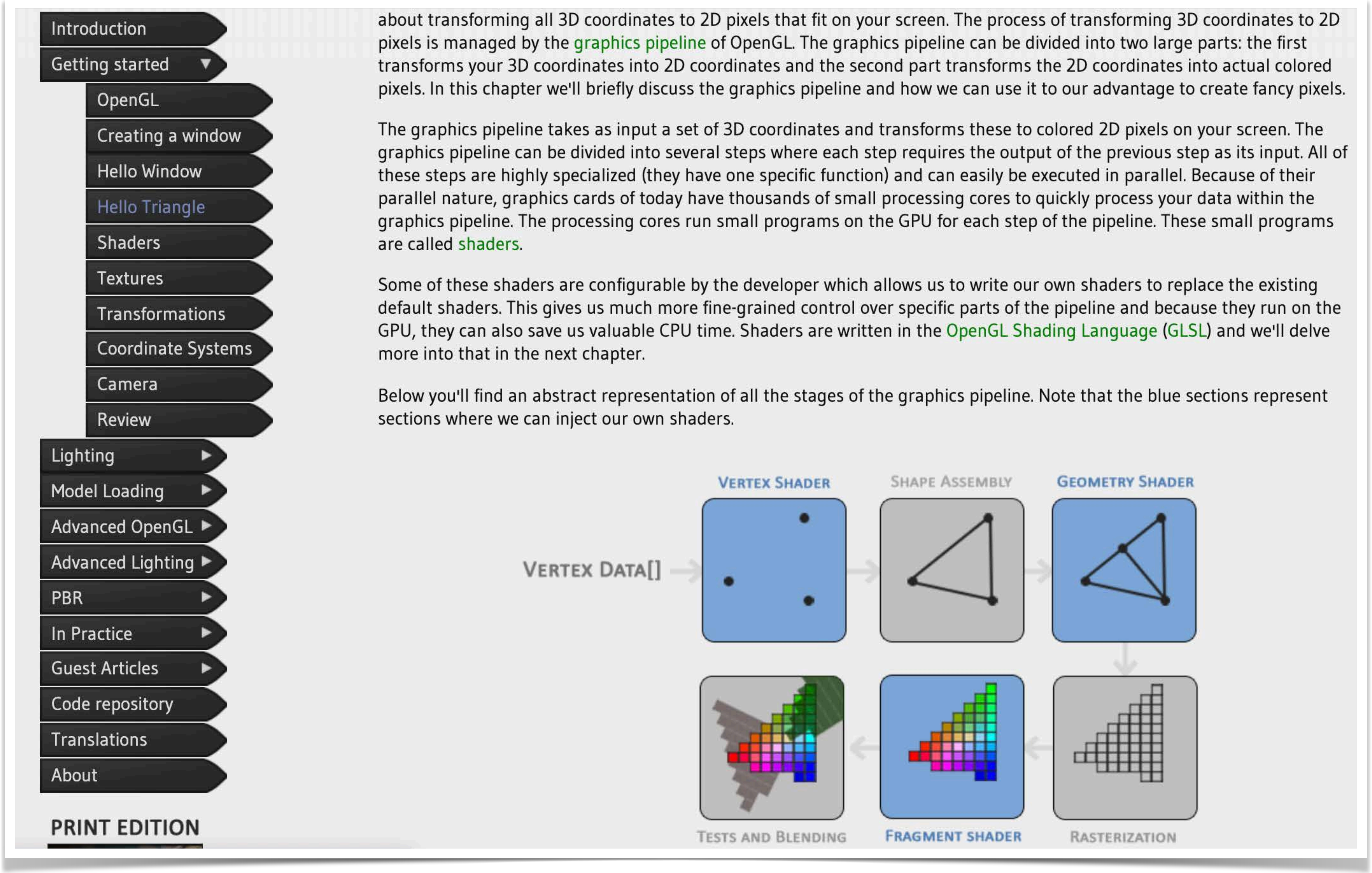
References


OpenGL
Programming Guide
Ninth Edition
The Official Guide to Learning
OpenGL®, Version 4.5 with SPIR-V
John Kessenich • Graham Sellers • Dave Shreiner
The Khronos OpenGL ARB Working Group


OpenGL
Shading Language
Third Edition
Randi J. Rost • Bill Licea-Kane

References

https://learnopengl.com



Grades

- **No quiz or exam**
- **Weekly written exercise 40%** *individual work*
- **Programming HW 60%**
  - HW0–4: 40% *individual work*
  - Final HW: 20% *group of 1 or 2*

- **Passing grade: 70%**
- **Curve letter grade condition:** 3/4 of the class complete the CAPE course evaluation in Week 9,10.

Prerequisite and some expectation

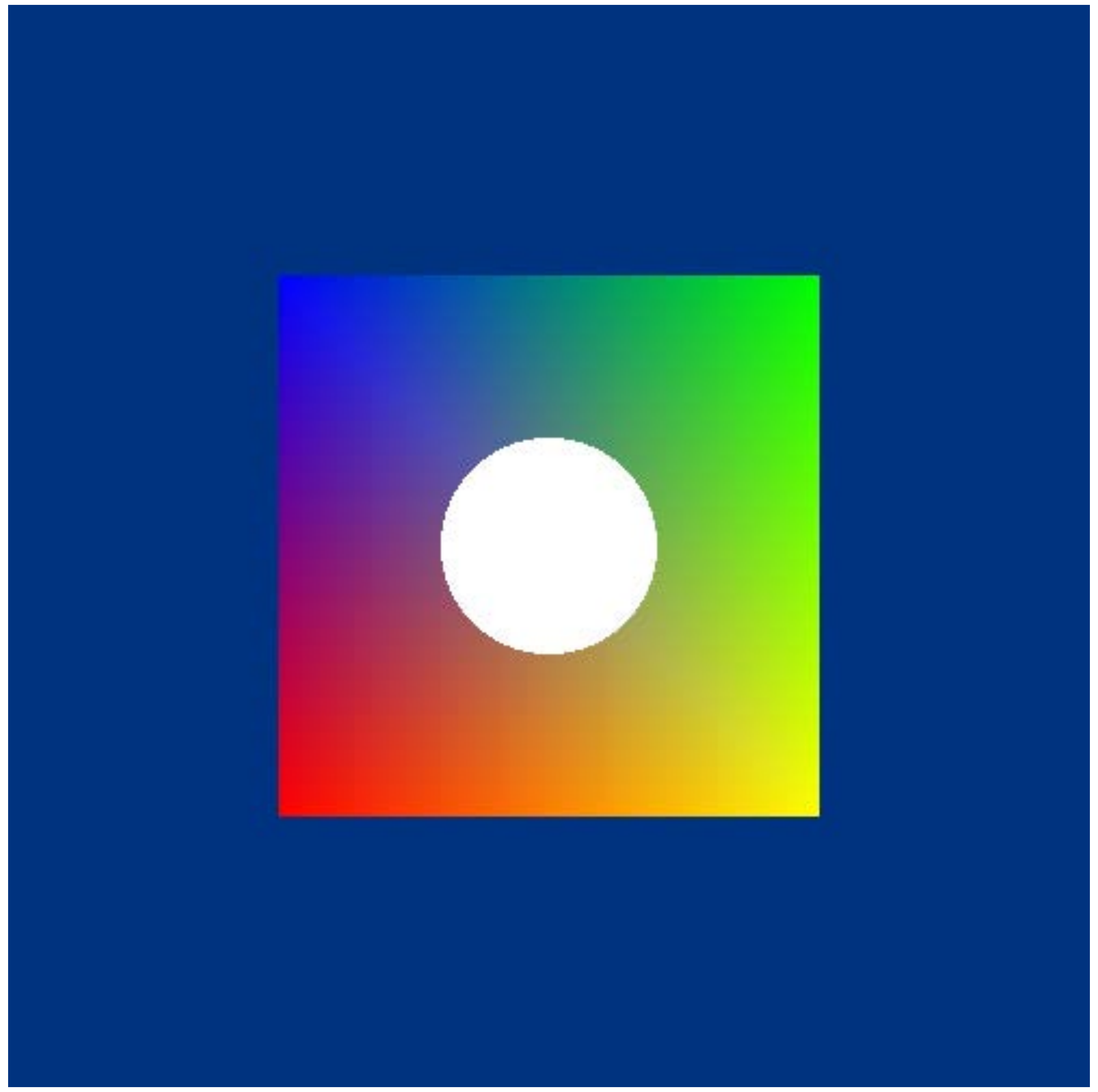
- **Experience with**
  - basic linear algebra (matrix & vector)
  - C++

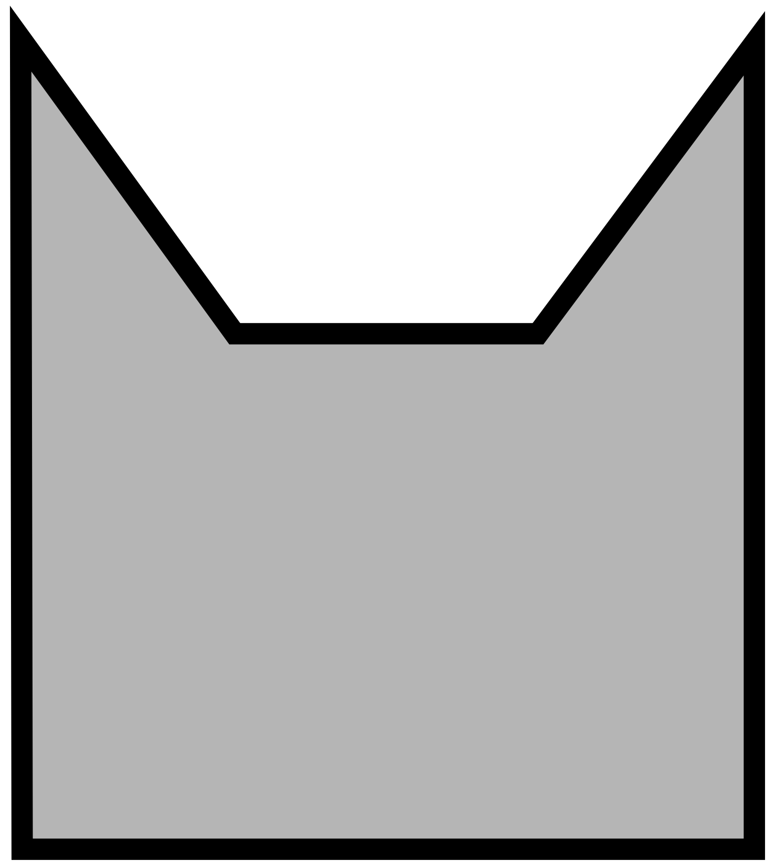
- **You can expect that you will**
  - Command and run programs on GPUs (using OpenGL)
  - Deal with lots of floating point numbers (continuous math)
  - Think of problems geometrically
  - View math operators “structurally”
  - See some physics (optics, mechanics)

Getting Started

Getting started

- Next week, we will start working with **OpenGL**
- HW0 & Exer1 are due 9/30
  - Compile, run, and upload the result (should look like this Fig).
  - Modify the code to get the cat/fox shape
  - Compilation problem: office hour (see TA/tutor's platform) or piazza.
  - Next week, we explain what happens in the code.





Today

Computer Graphics

Today

Computer Graphics

- What is computer graphics? (brief history)
- Topics of this course
- How to draw programmatically? (computer graphics pipeline)

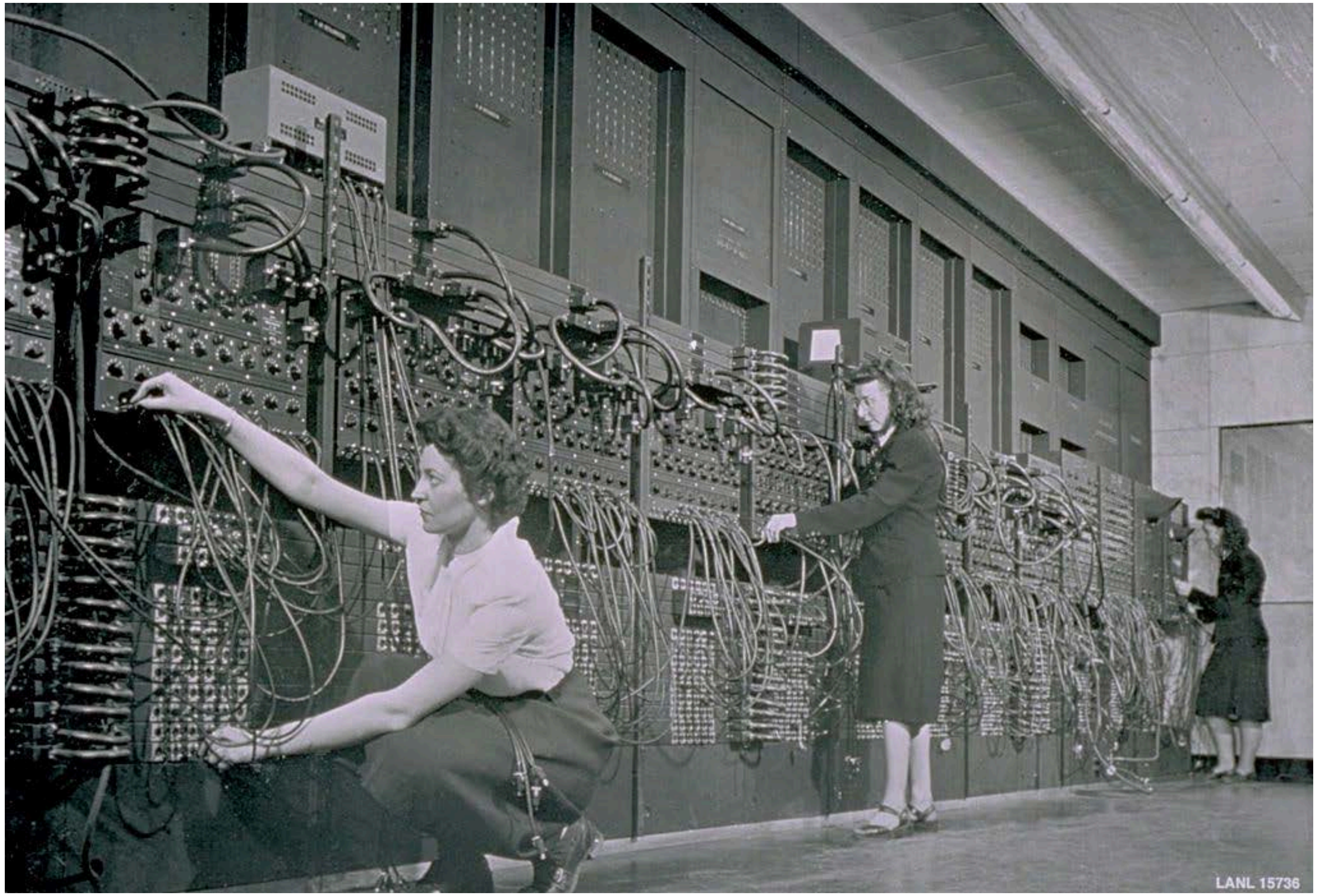
What is Computer Graphics?

What is Computer Graphics?

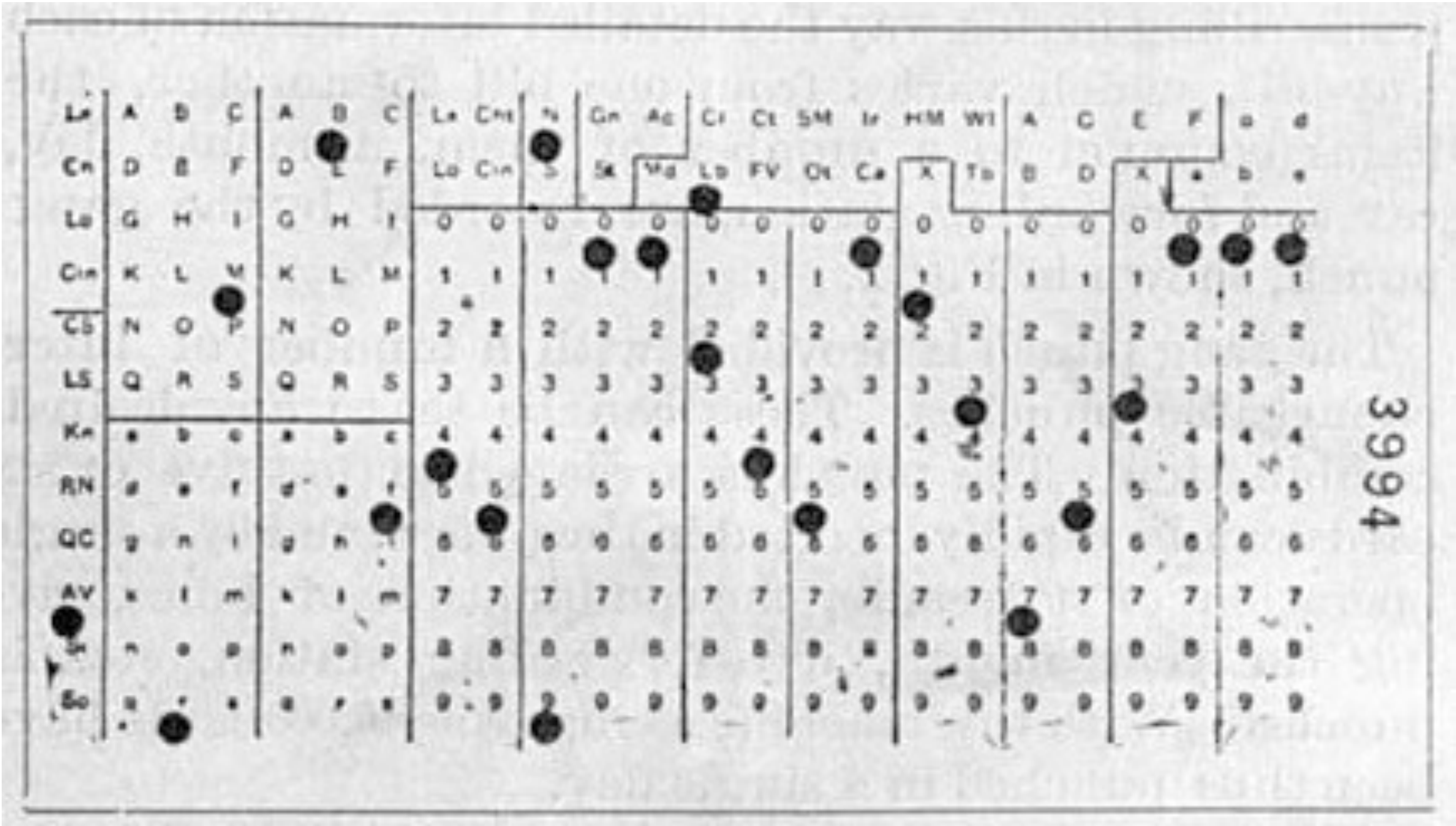
Jurassic Park 1993

Ratatouille 2007

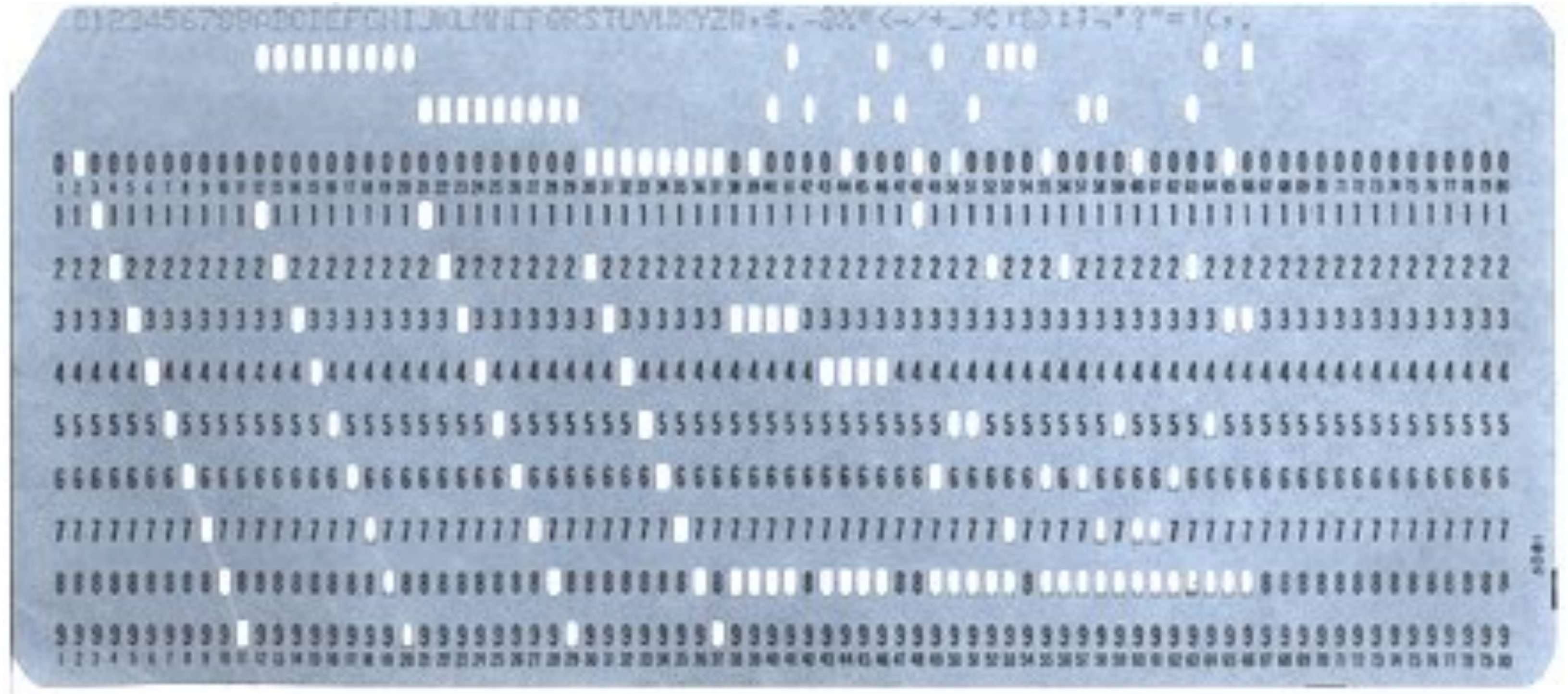
Why Computer Graphics?



early computer (ENIAC) 1945



punched card 1890's



ENIAC I/O 1945

Why Computer Graphics?

30% of the brain is devoted to visual processing

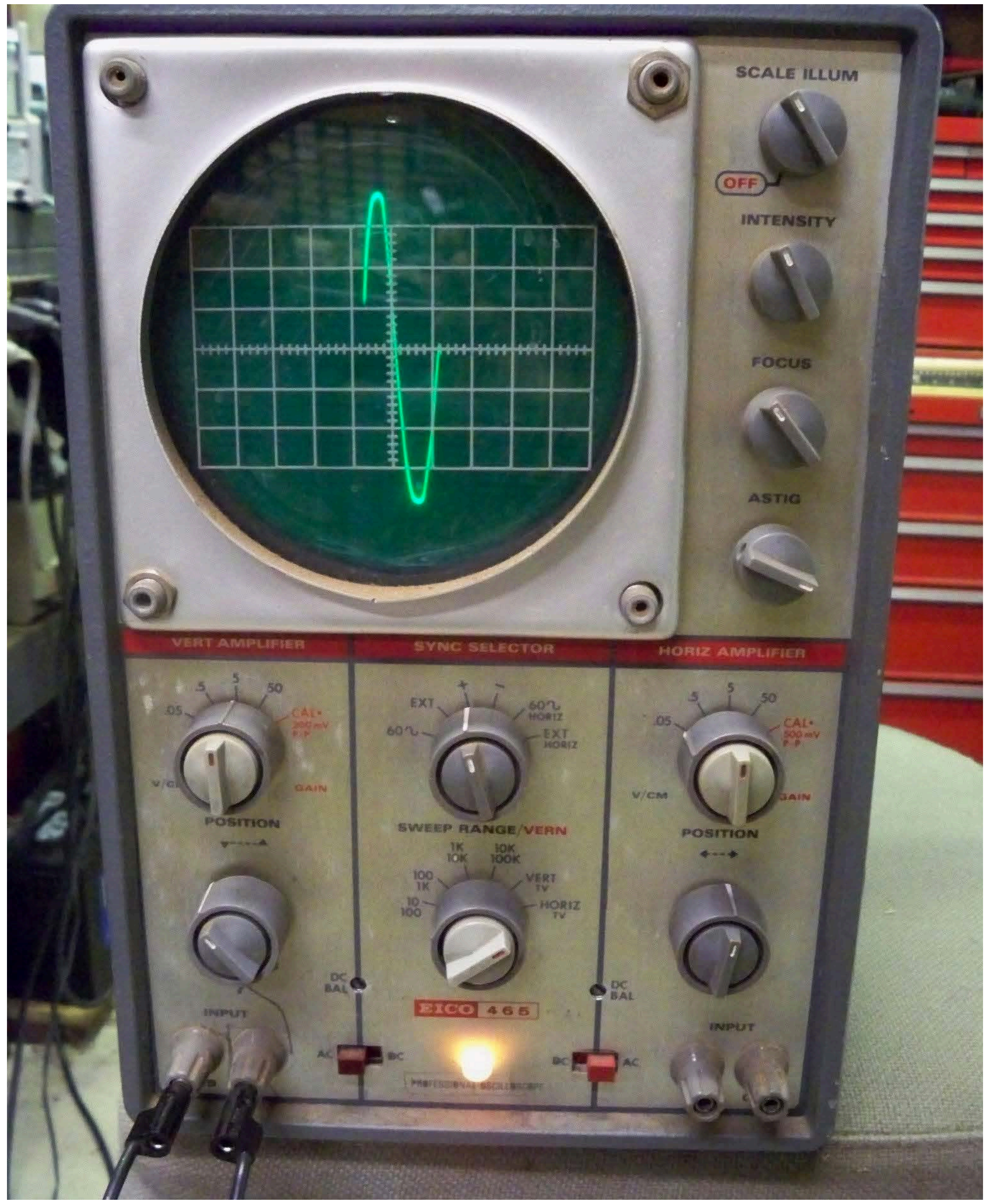
Most efficient way to receive information is in the form of visual data

Computer Graphics

Computer graphics

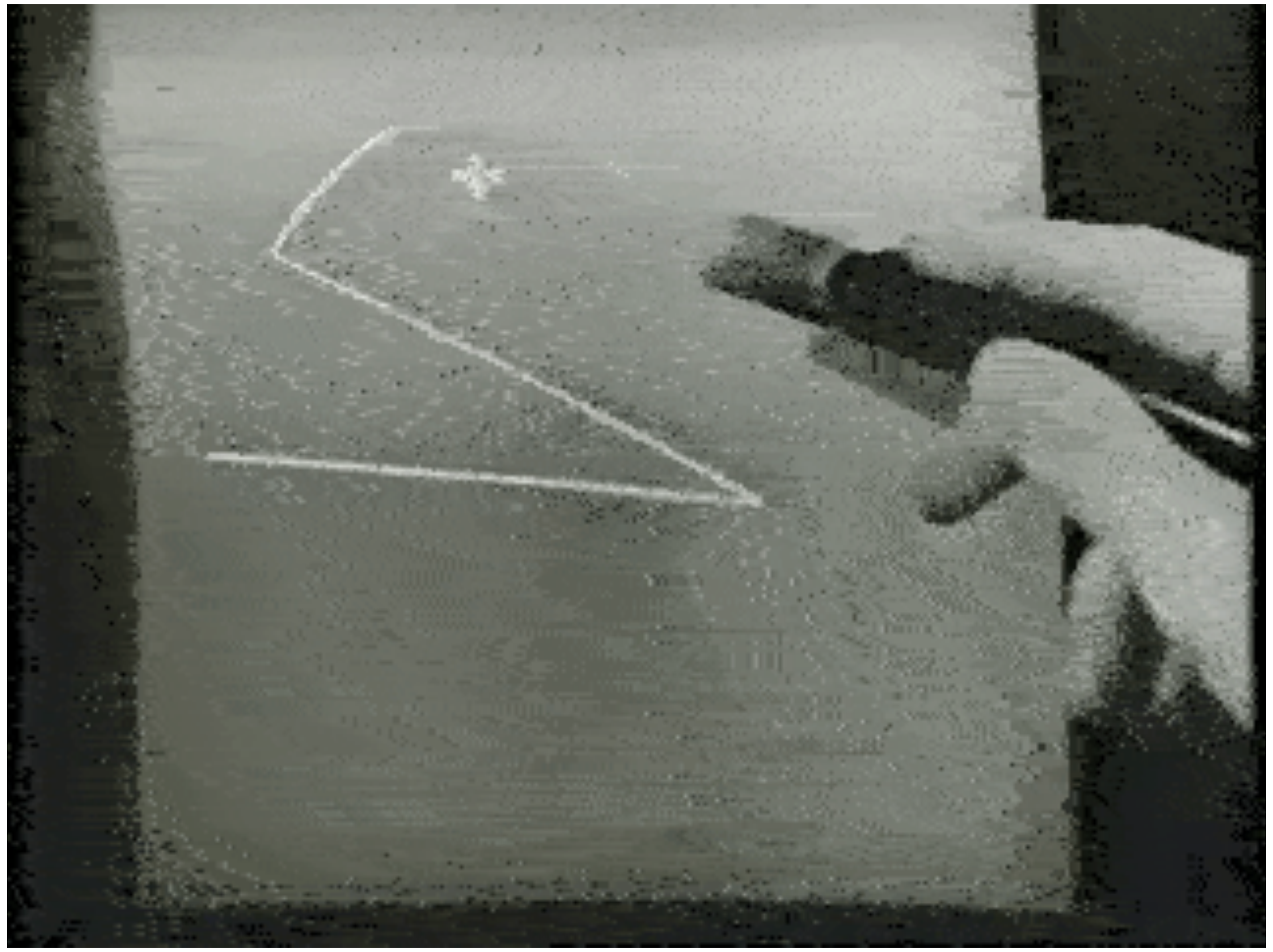
The use of computer to synthesize visual informations.

History of Graphics: Visual output



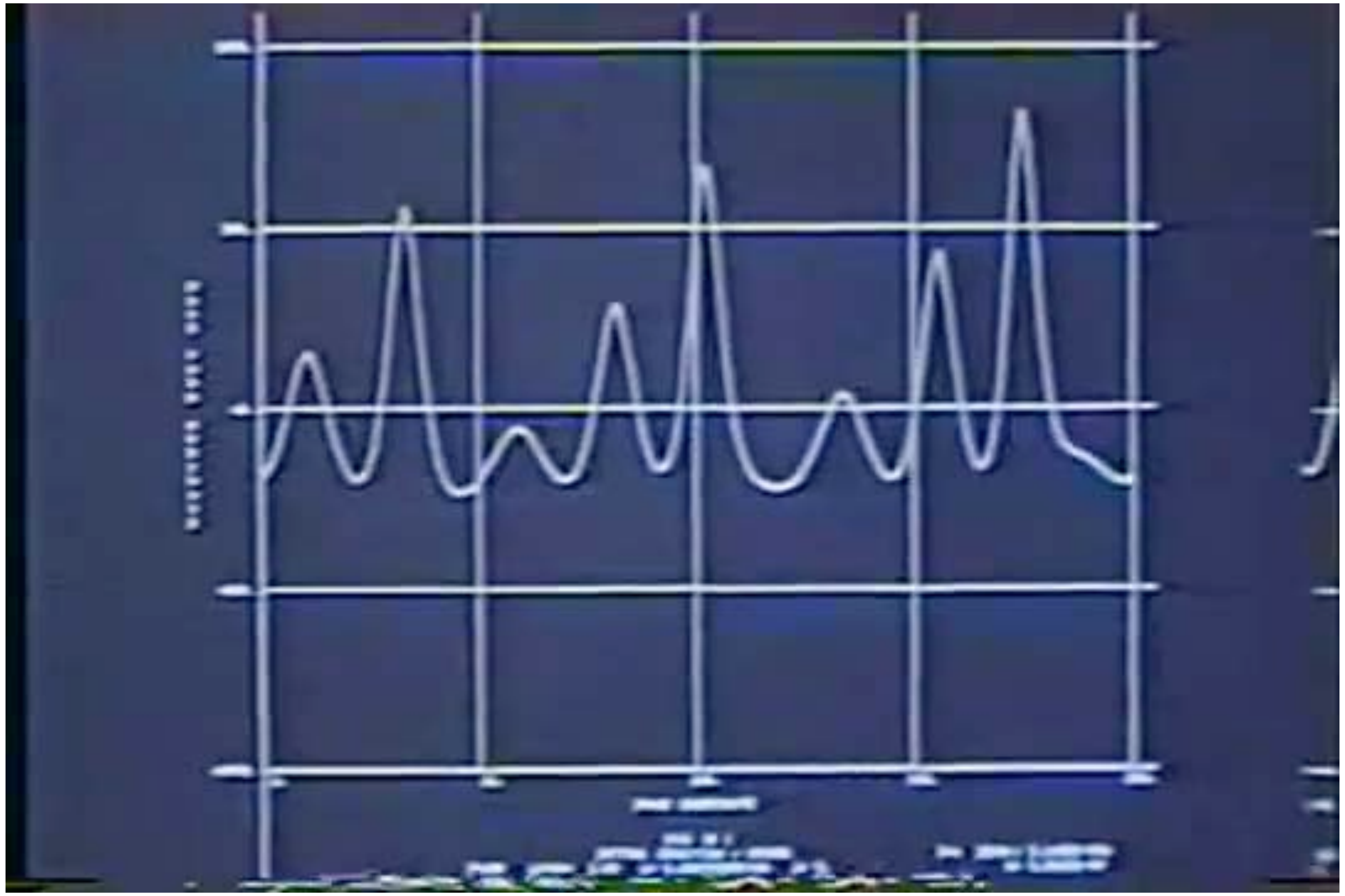
CRT monitors 1950’s–1960’s

History of Graphics: Visual input



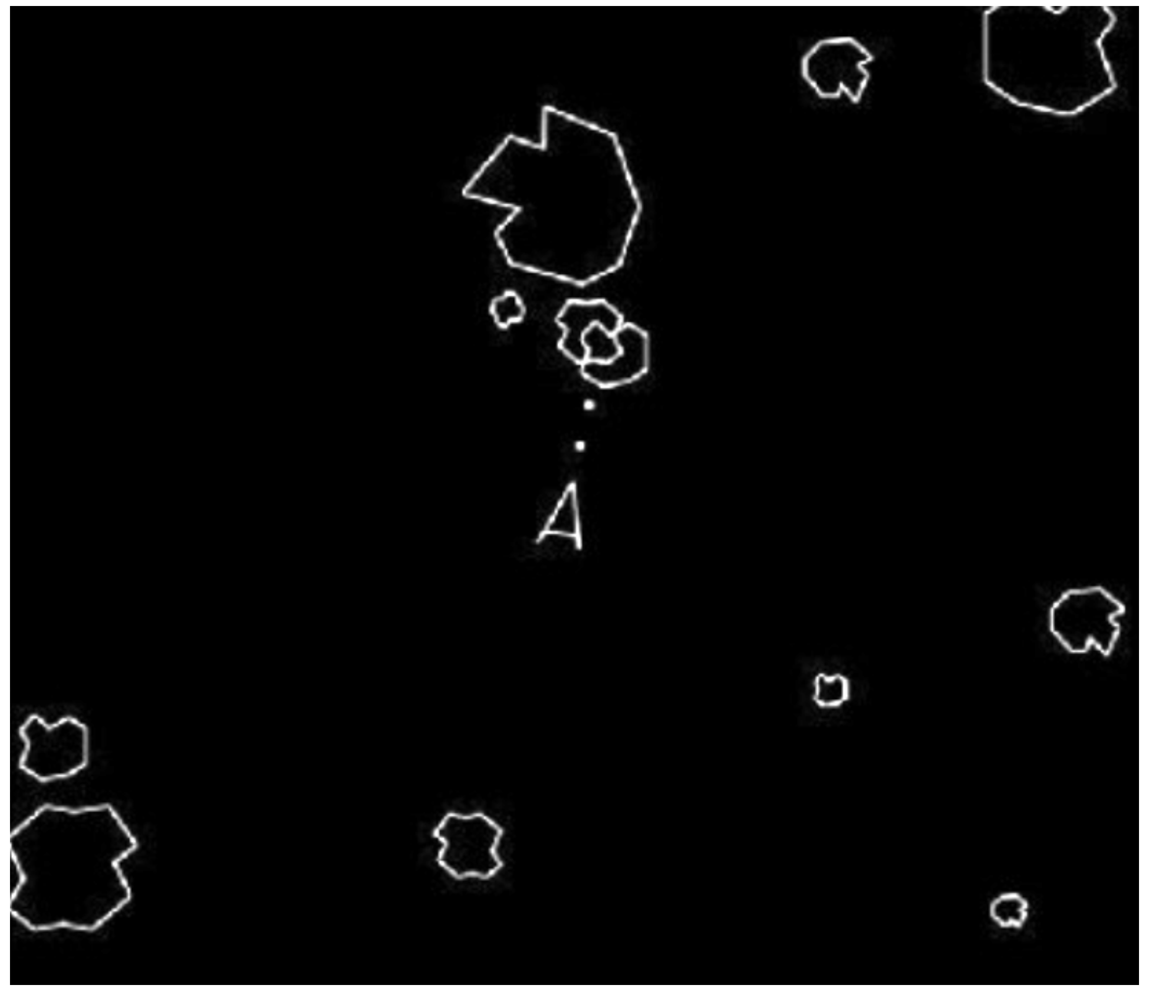
“Sketchpad” – Ivan Sutherland 1963

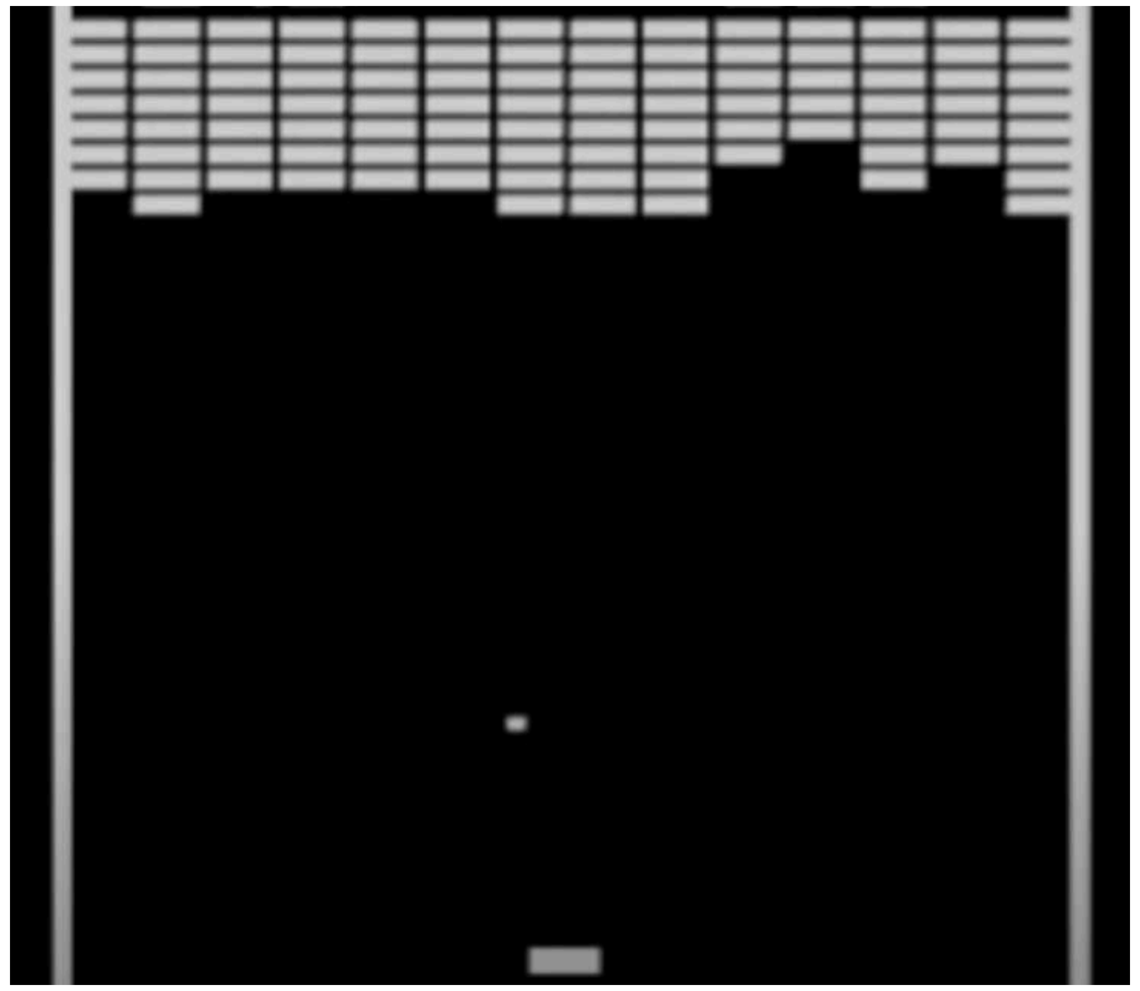
History of Graphics: Visualizing math



Discovery of “solitons” in the Korteweg–de Vries (KdV) equation by Zabusky & Kruskal in 1965 while making the above film

History of Graphics: 1970's



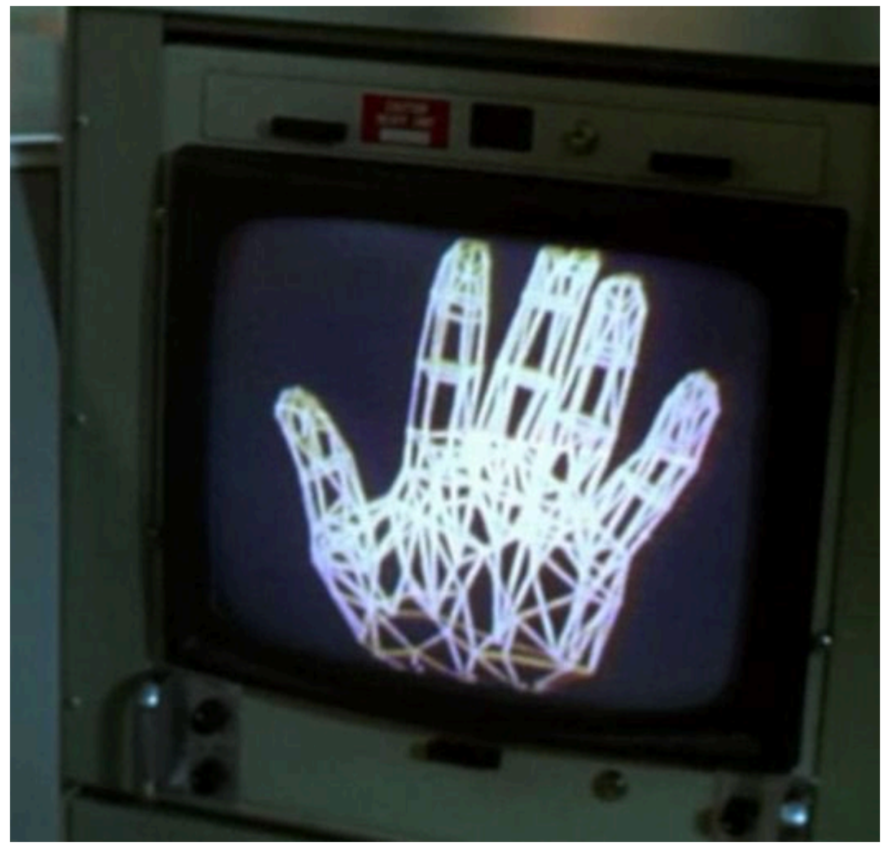


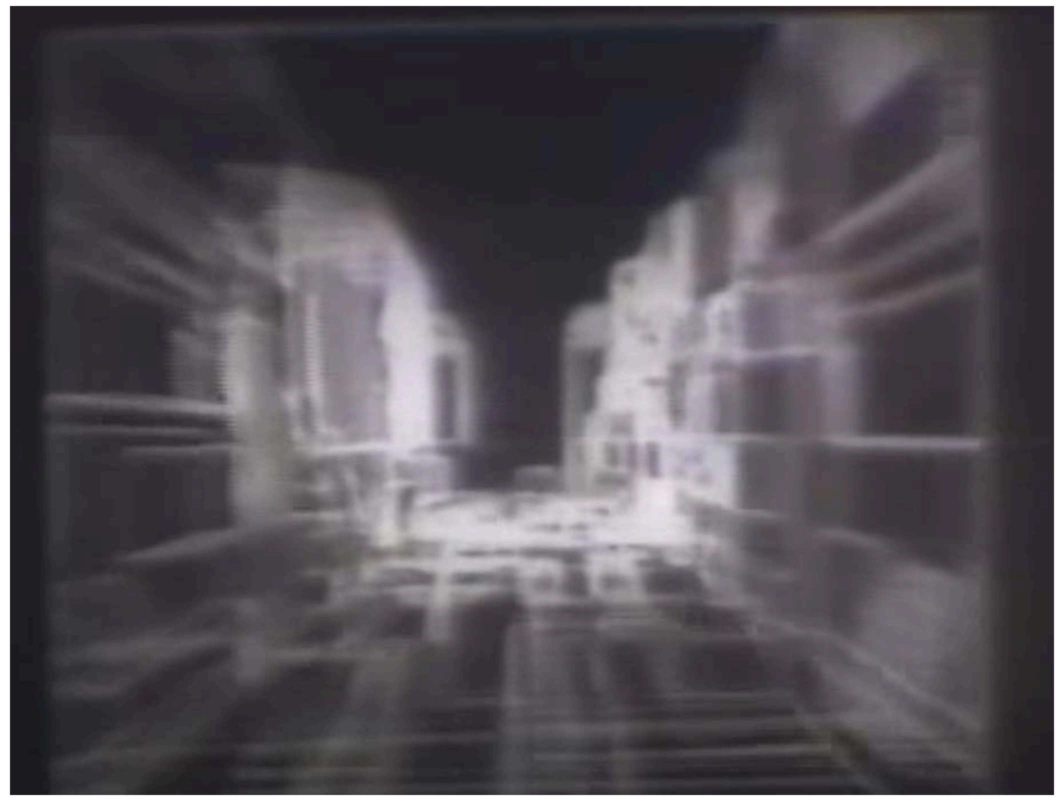
Arcade games 1970's

- Raster (pixel) graphics
- Graphic processing unit (GPU)
- Realtime

3DCG: Ed Catmull & others in Utah

- Z-buffering
- Texture mapping
- Subdivision

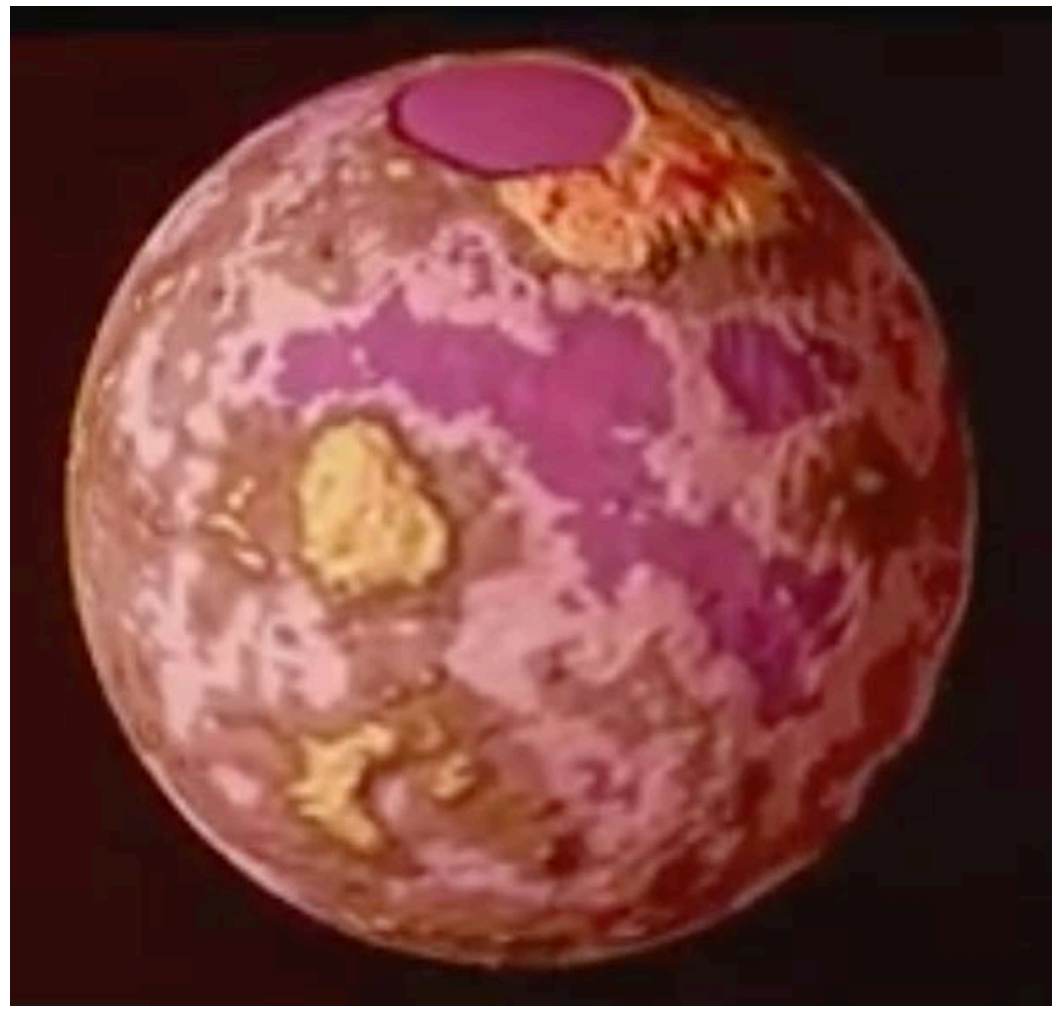




Lucasfilm *Star Wars IV* 1977

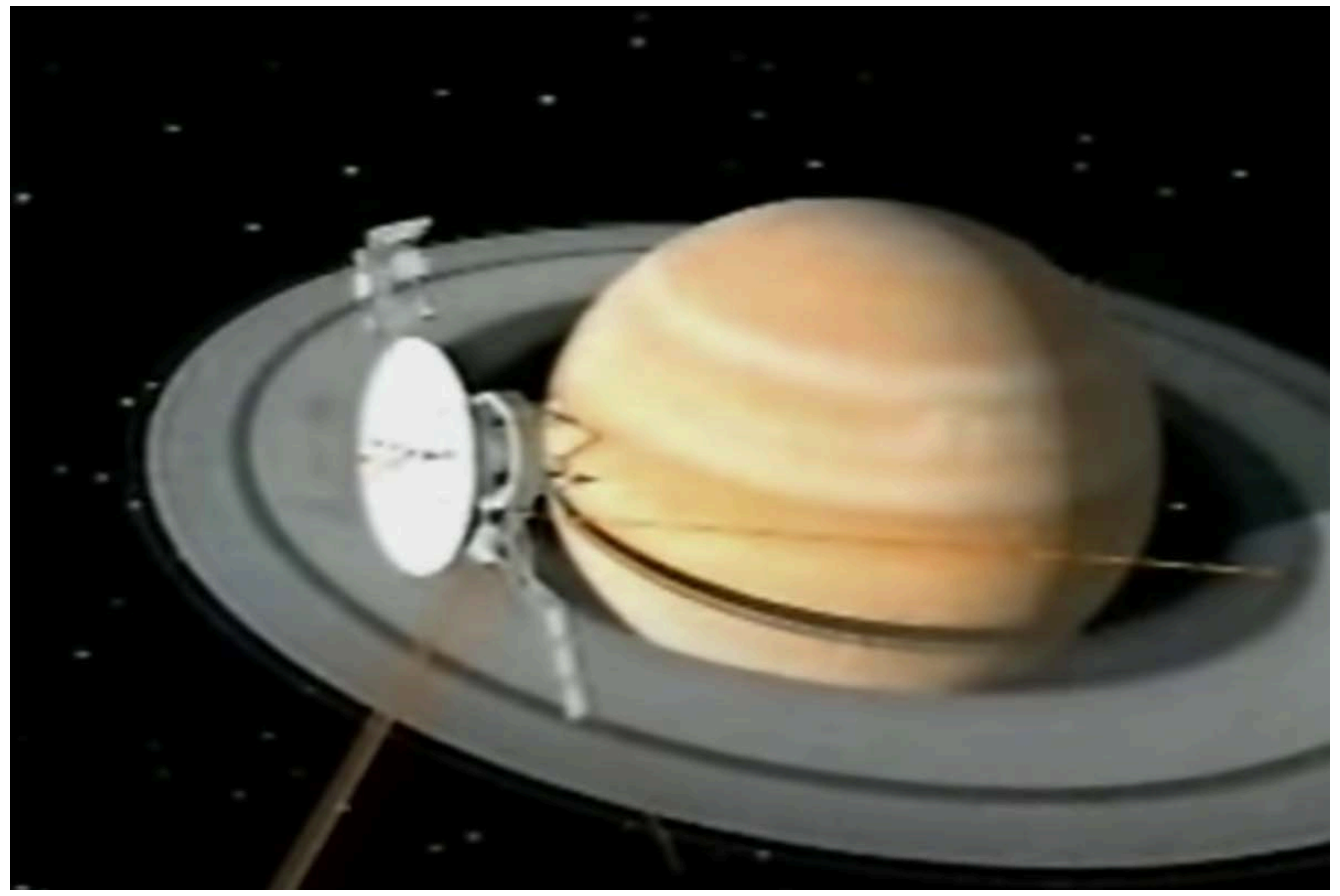
- Computer graphics in blockbusters

History of Graphics: Voyagers & Cosmos



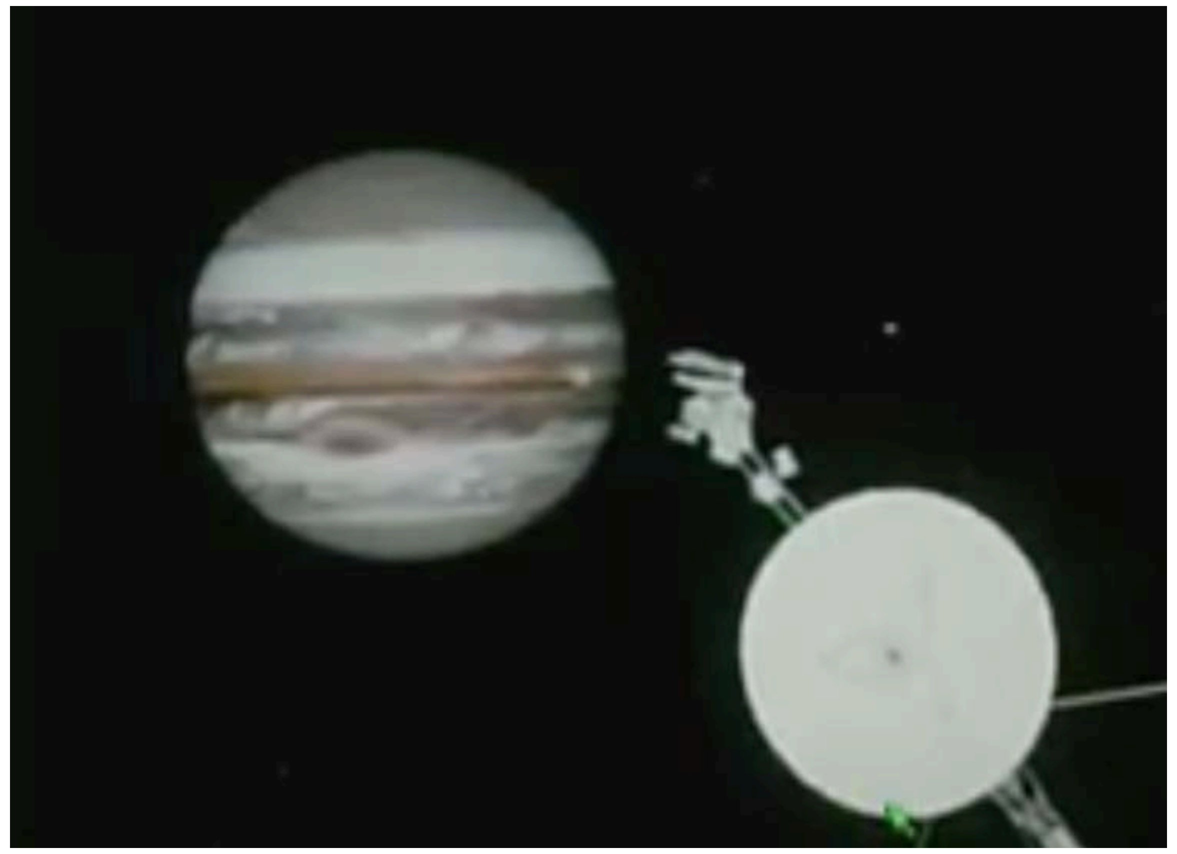
Bump map for Venus 1978

Texture reconstruction for moons of Jupiter

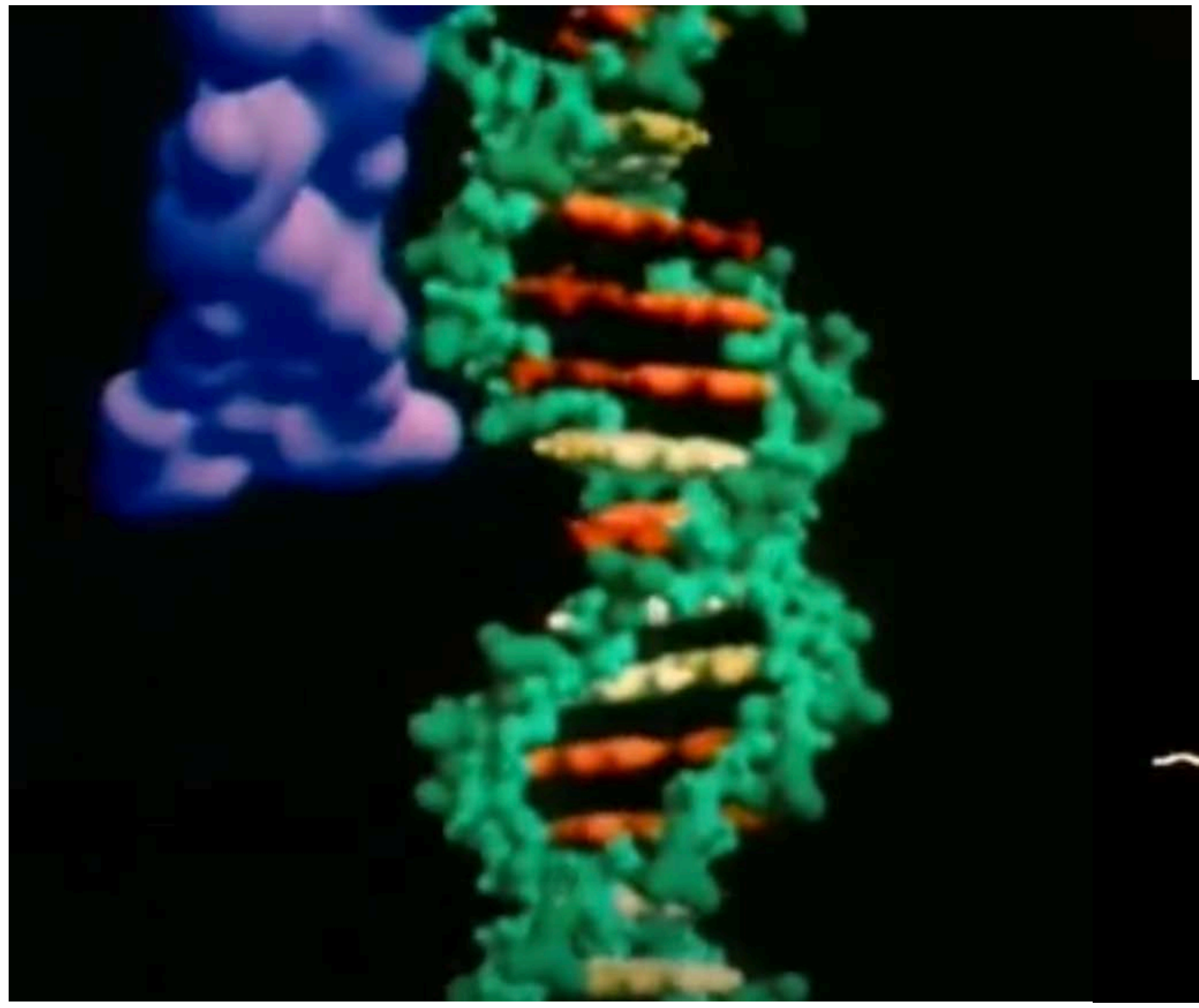


V2 Saturn flyby 1981

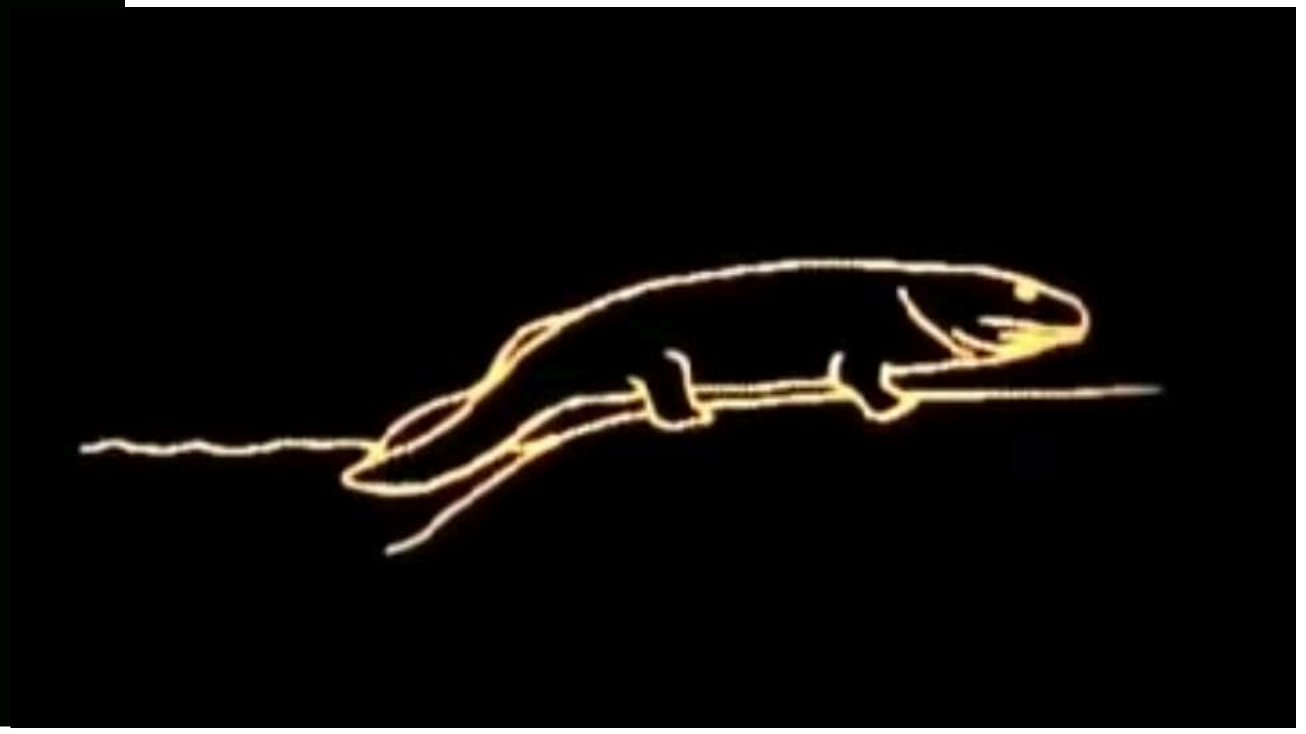
James Blinn



V1 Jupiter flyby 1979



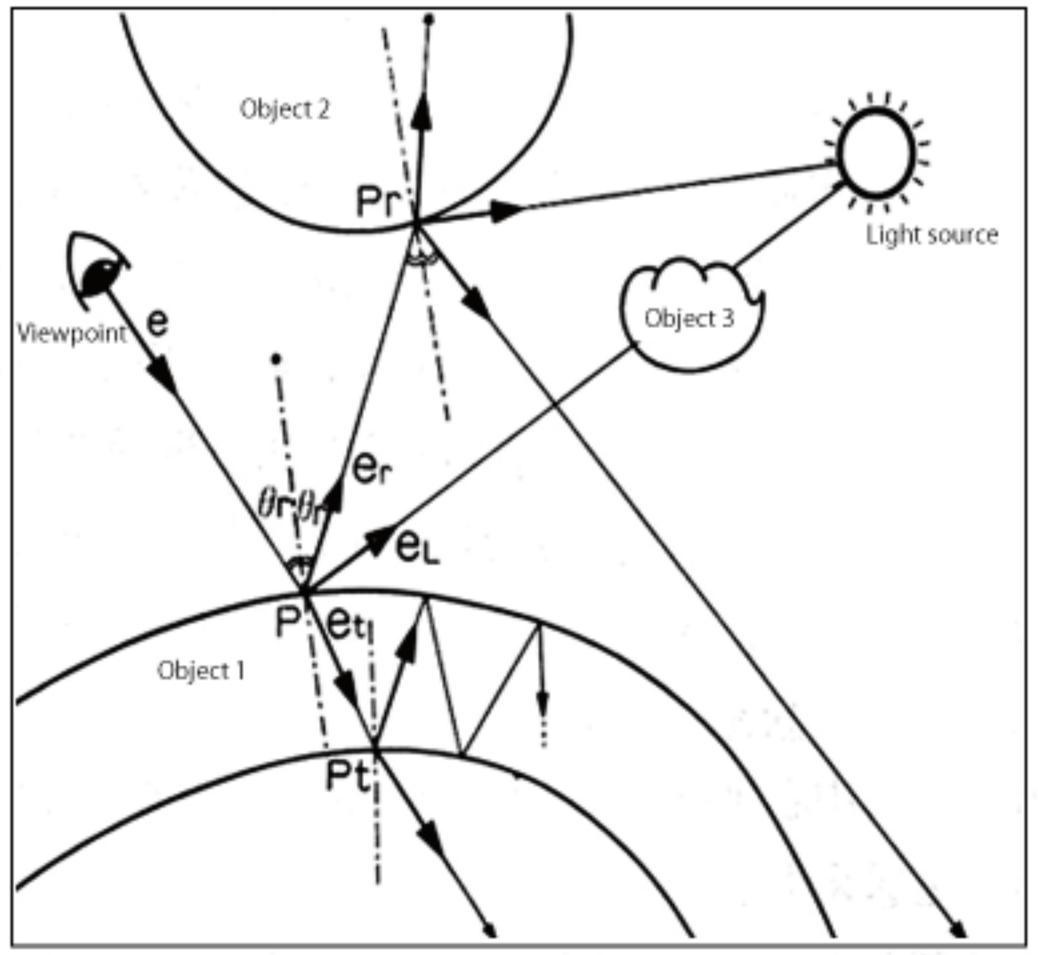
Cosmos “DNA” 1980

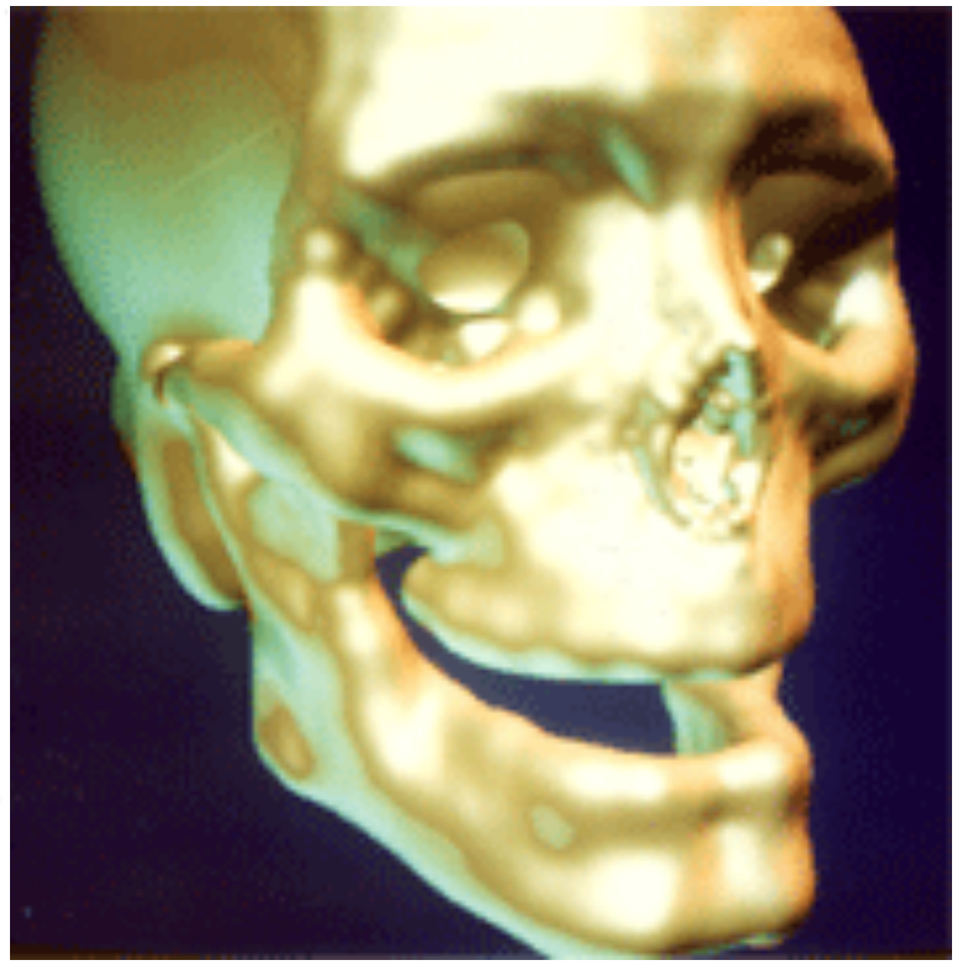


Cosmos “evolution” 1980

History of Graphics: 1980's

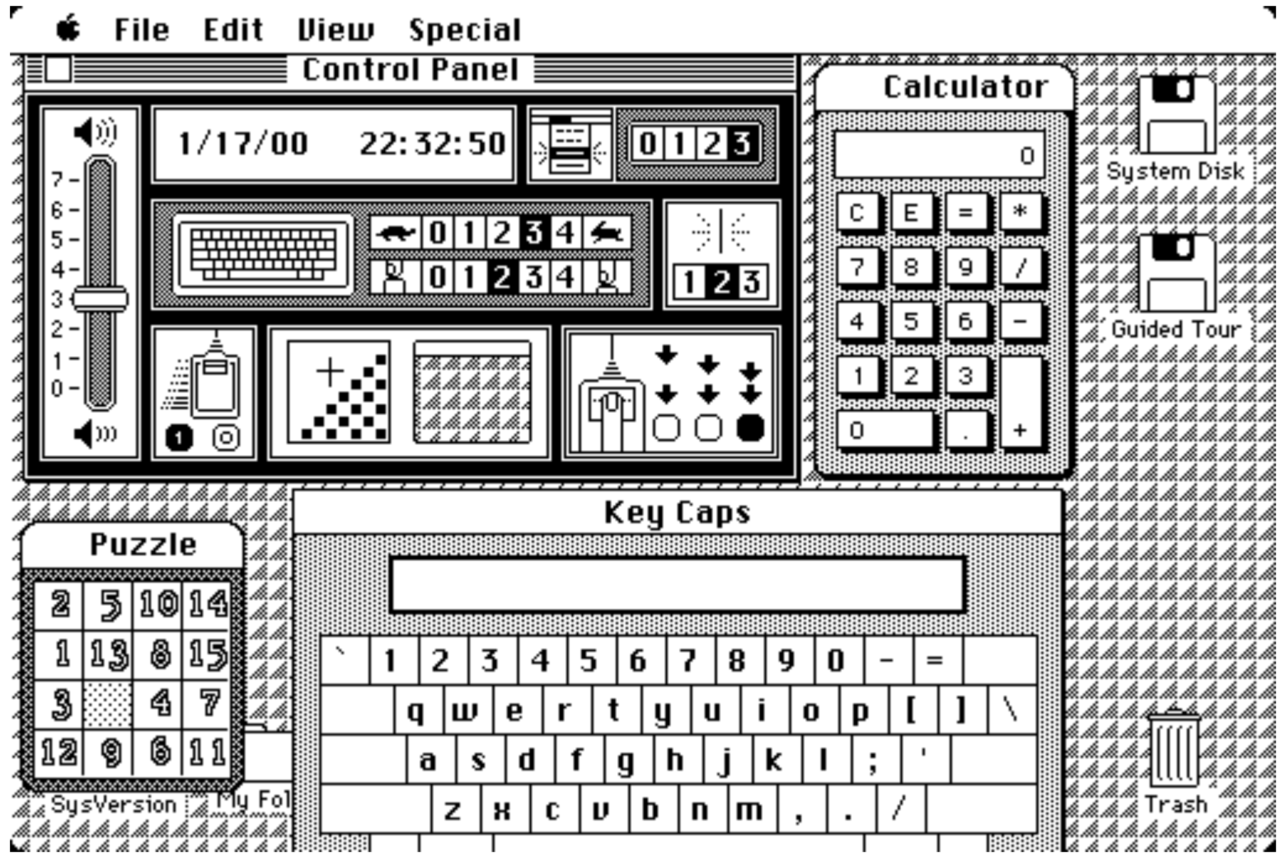
Nintendo 1981





$I(P) = Io(P) + src(\theta r) \cdot I(Pr) + t \cdot I(Pt)$

LINKS-1 CG System 1983



Macintosh 1984
PC graphics

Pixar *Luxo Jr.* 1986

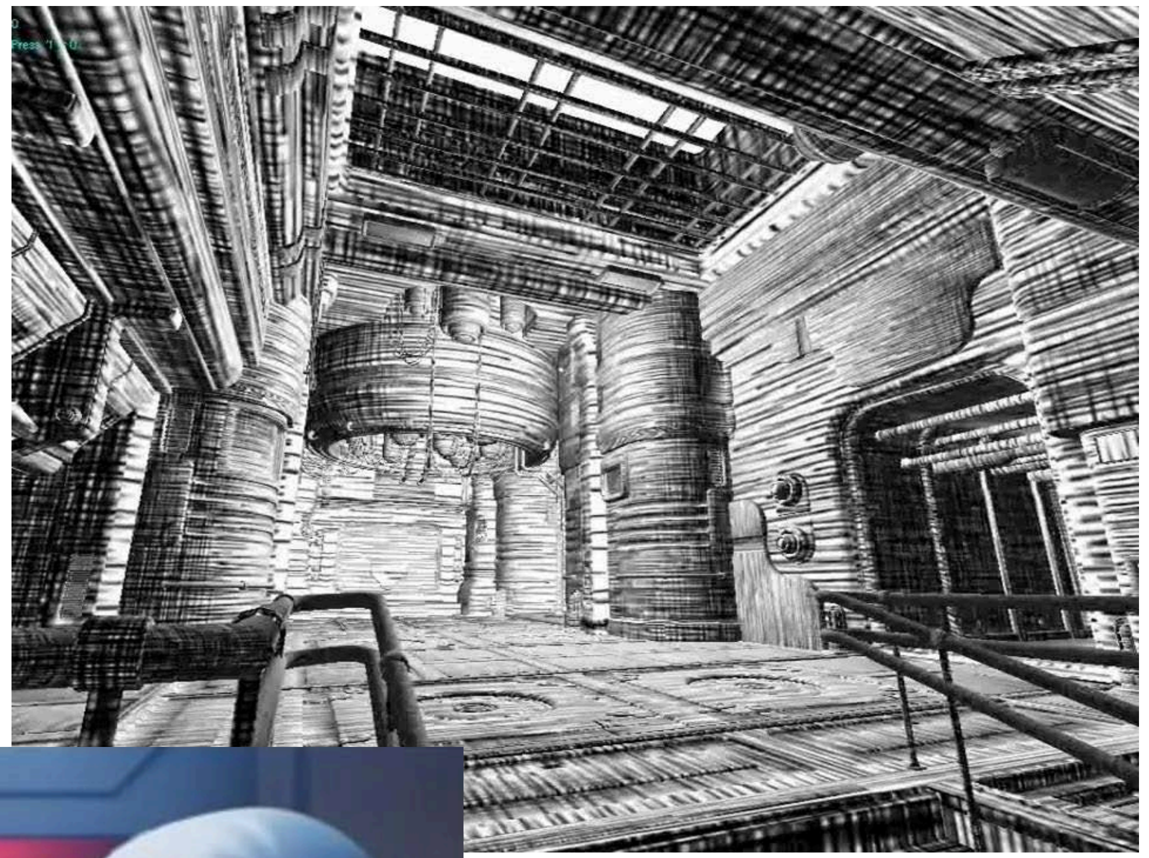
History of Graphics: interface with GPU

Graphics API's 1990s

- Simple to tell GPU to draw
- Hardcoded fixed function for drawing (fast but not flexible).

Graphics API's after mid 2000–10s

- Drawing stages are programmable.
- Flexible shading.
- General purpose parallel computing.



New era of graphics 2020

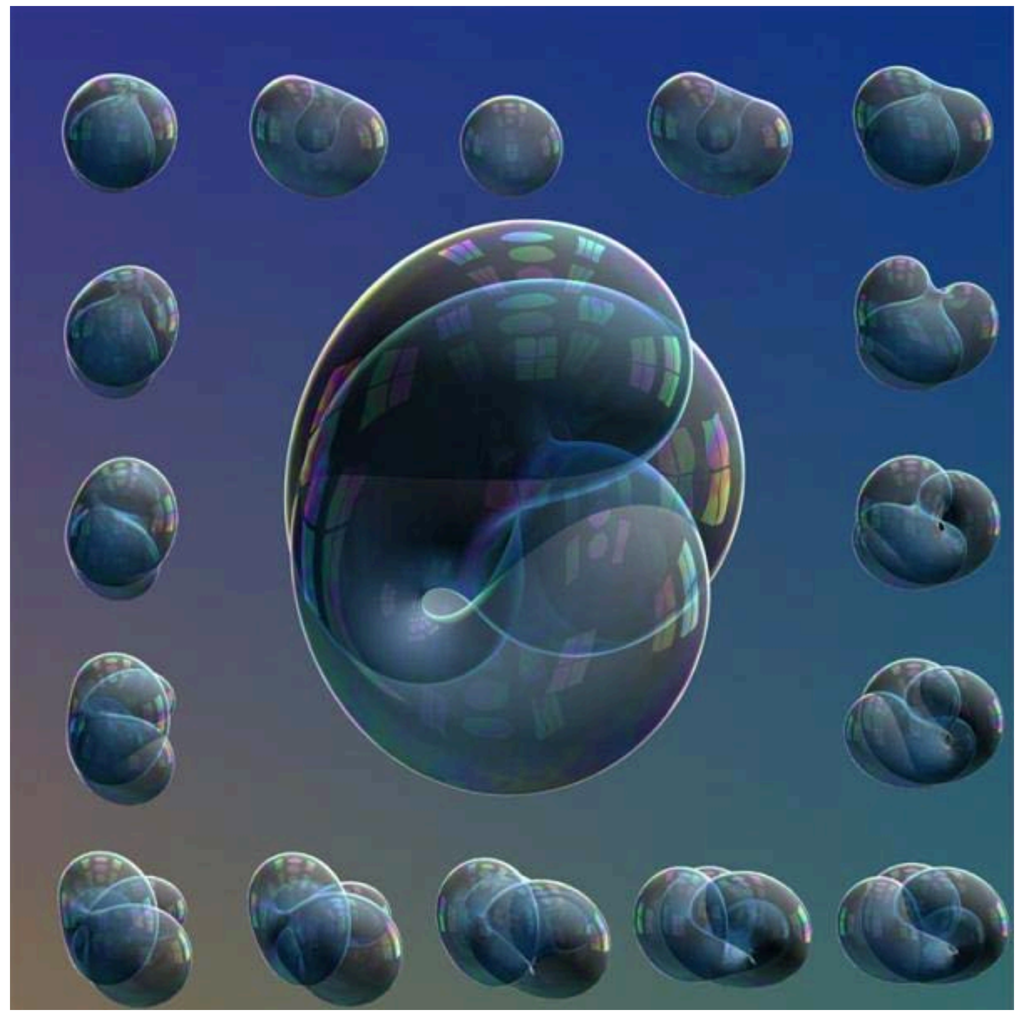
- Realtime photorealism

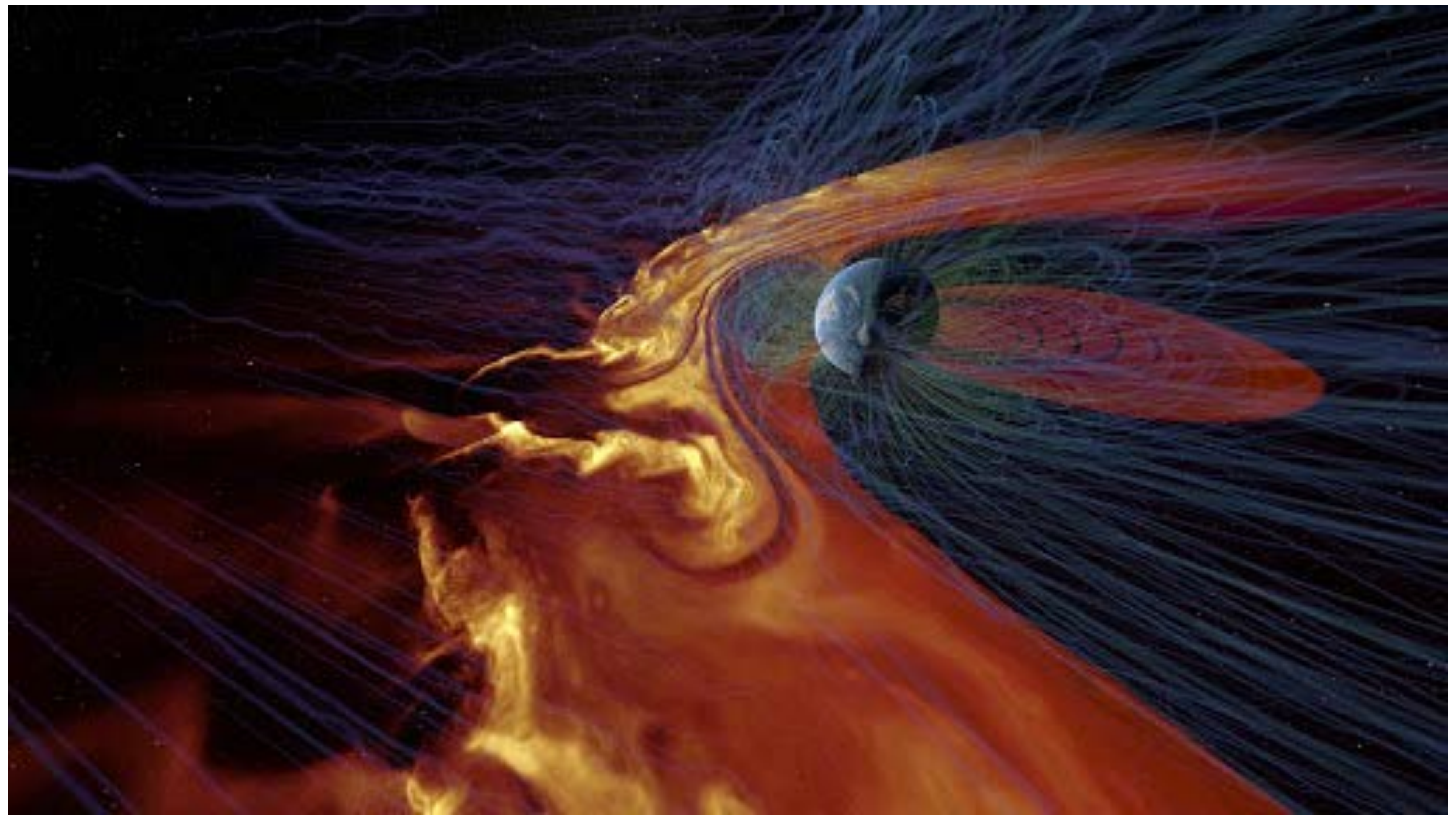
Beyond controlling pixels

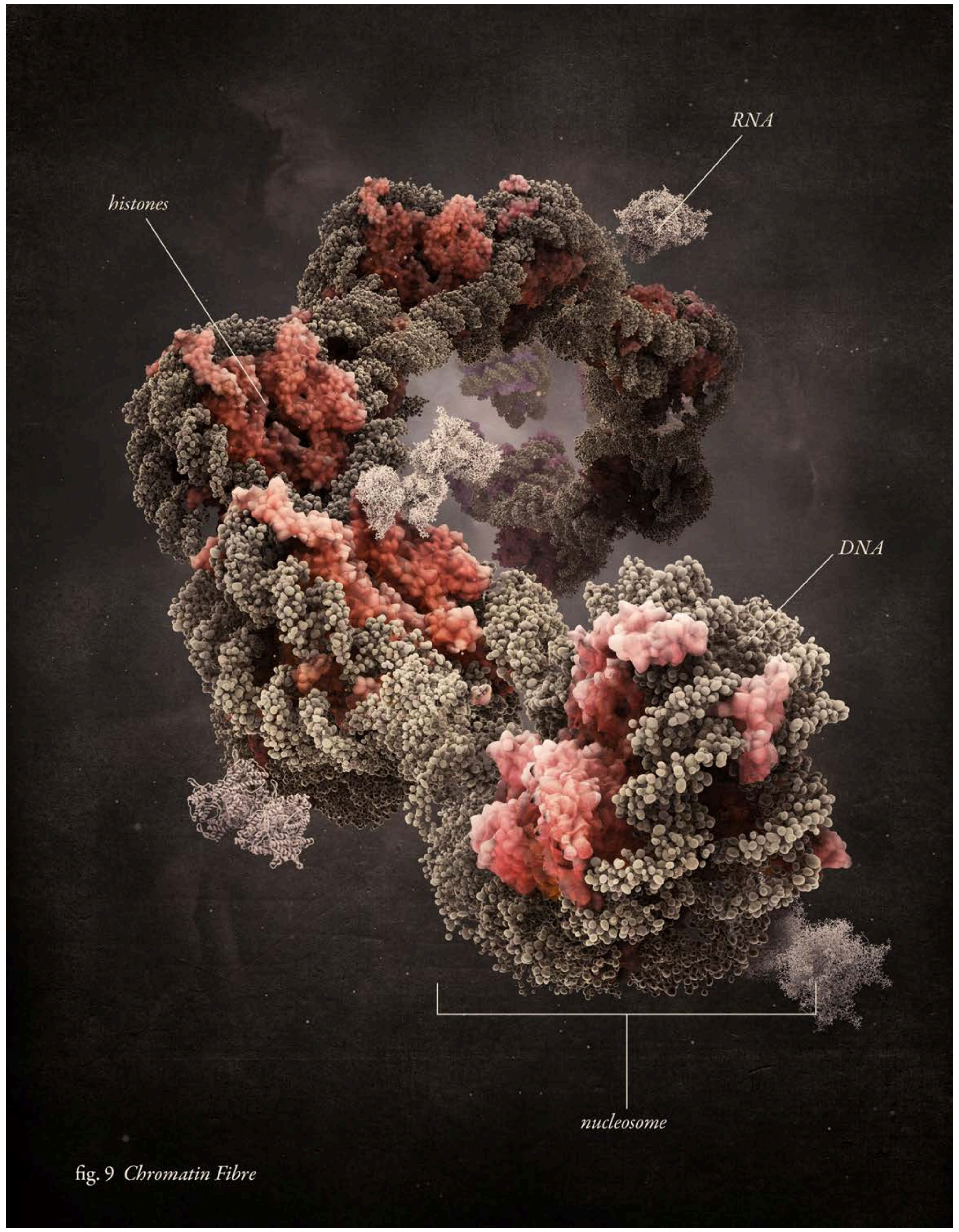
Physical simulations in entertainment

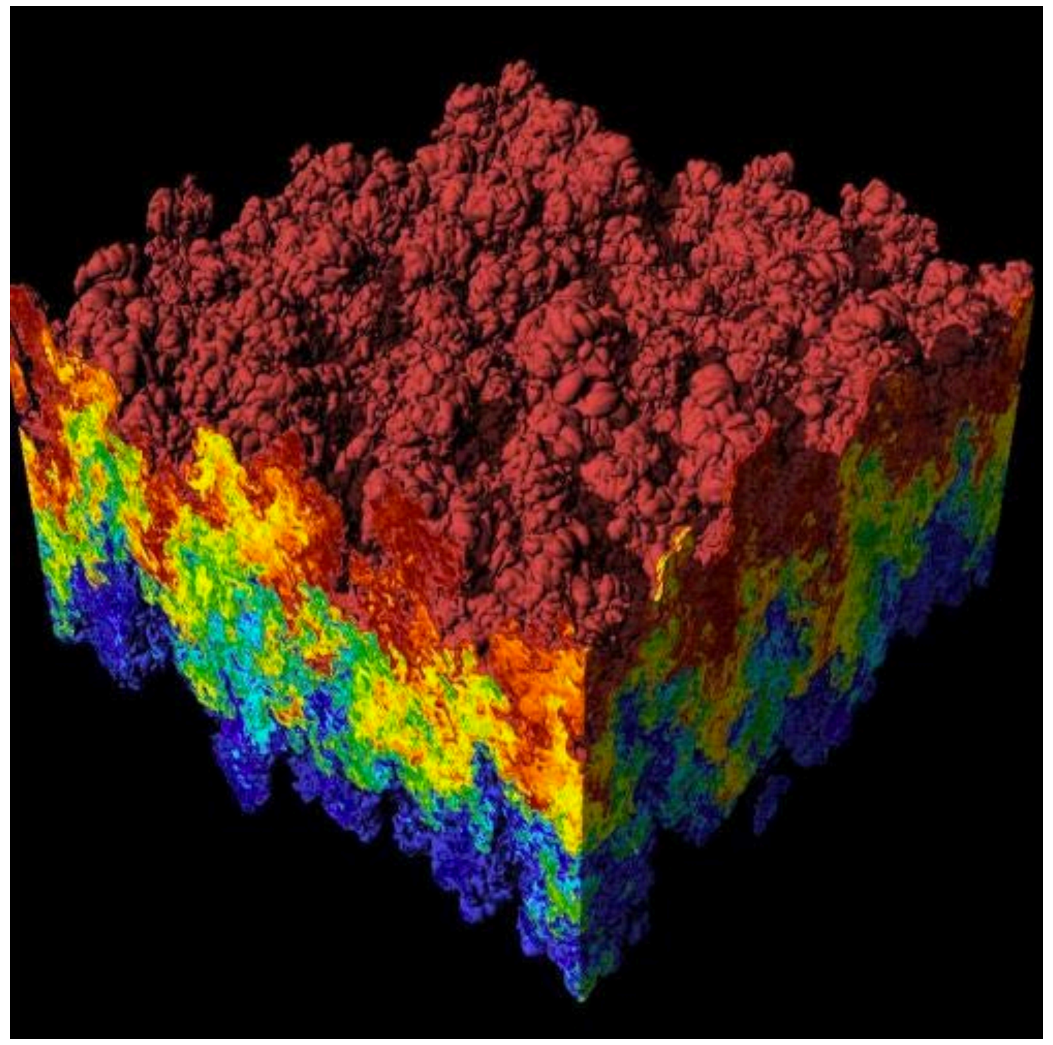
Beyond controlling pixels

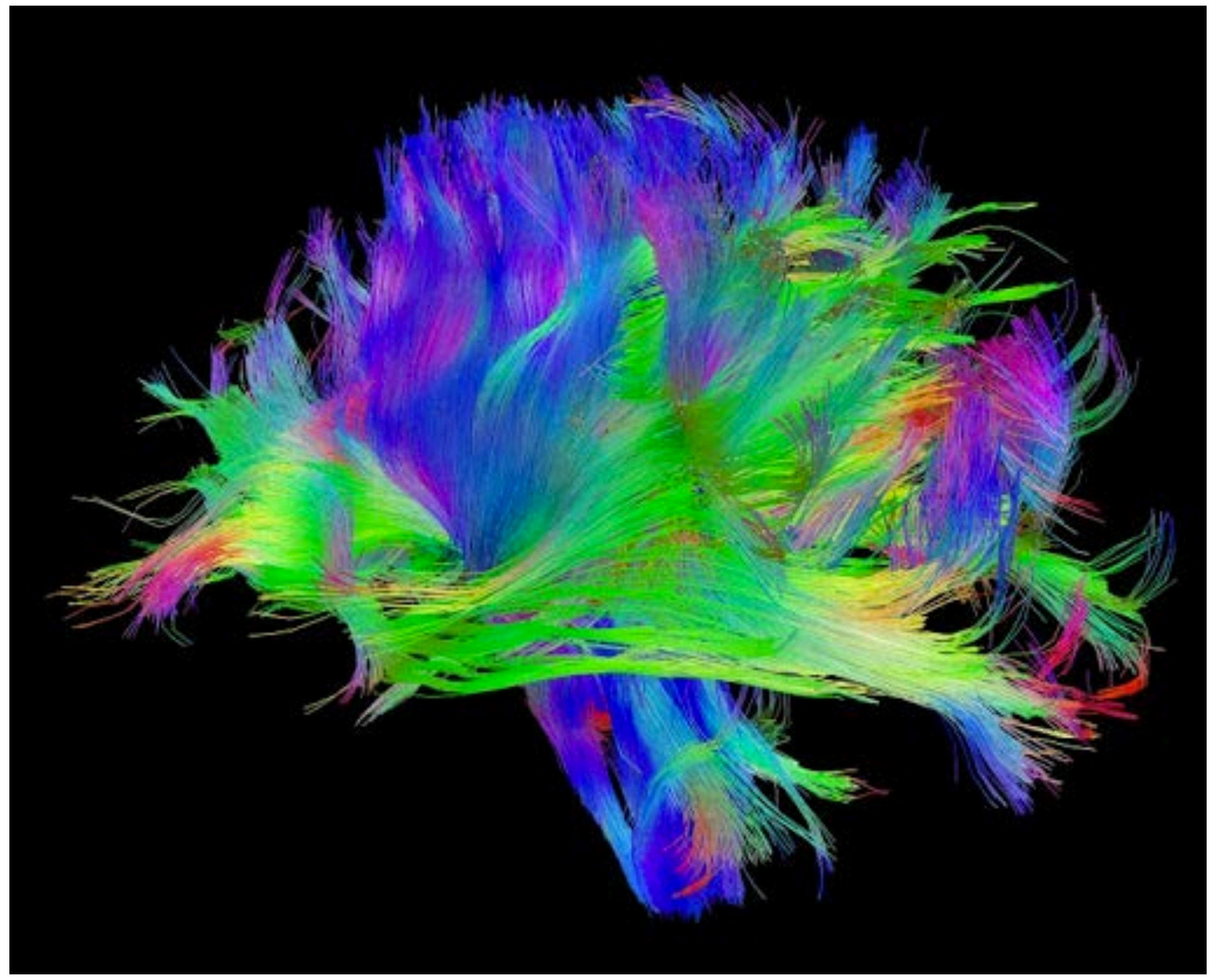
Mathematical and Scientific Visualizations





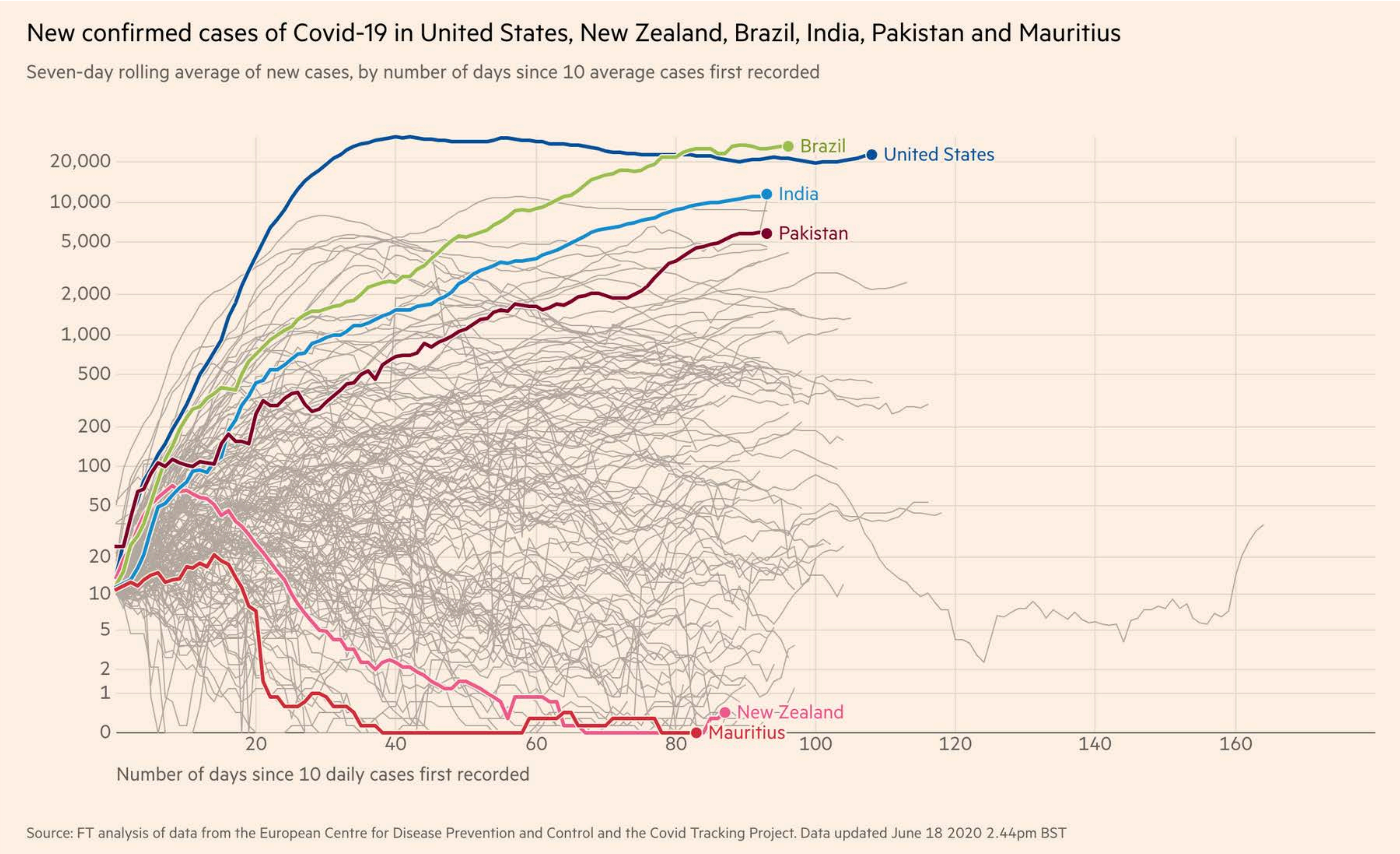


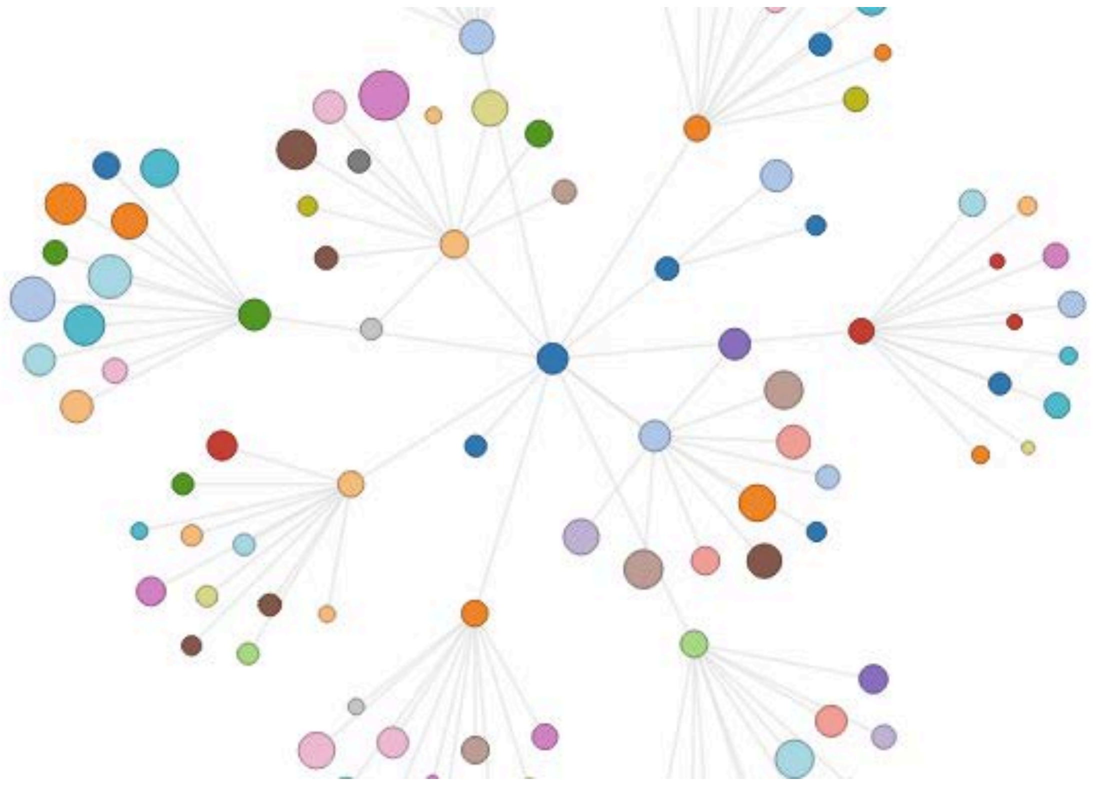




Beyond controlling pixels

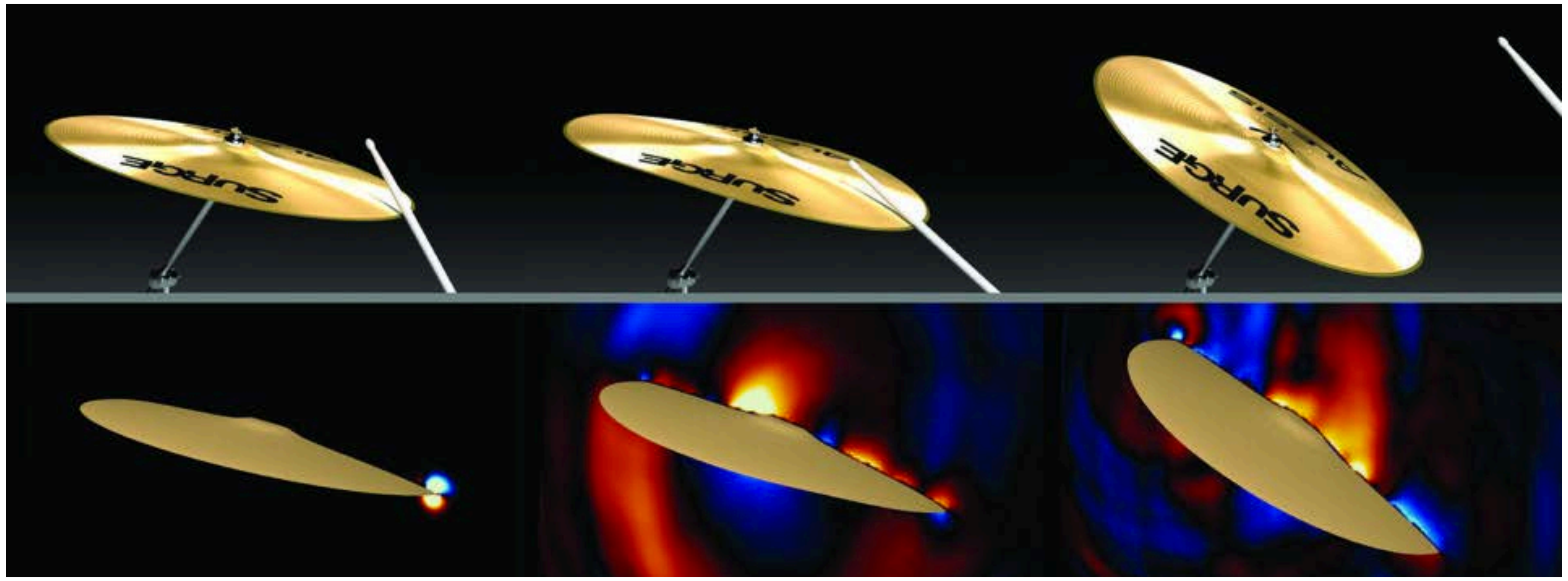
Data visualizations





Beyond controlling pixels

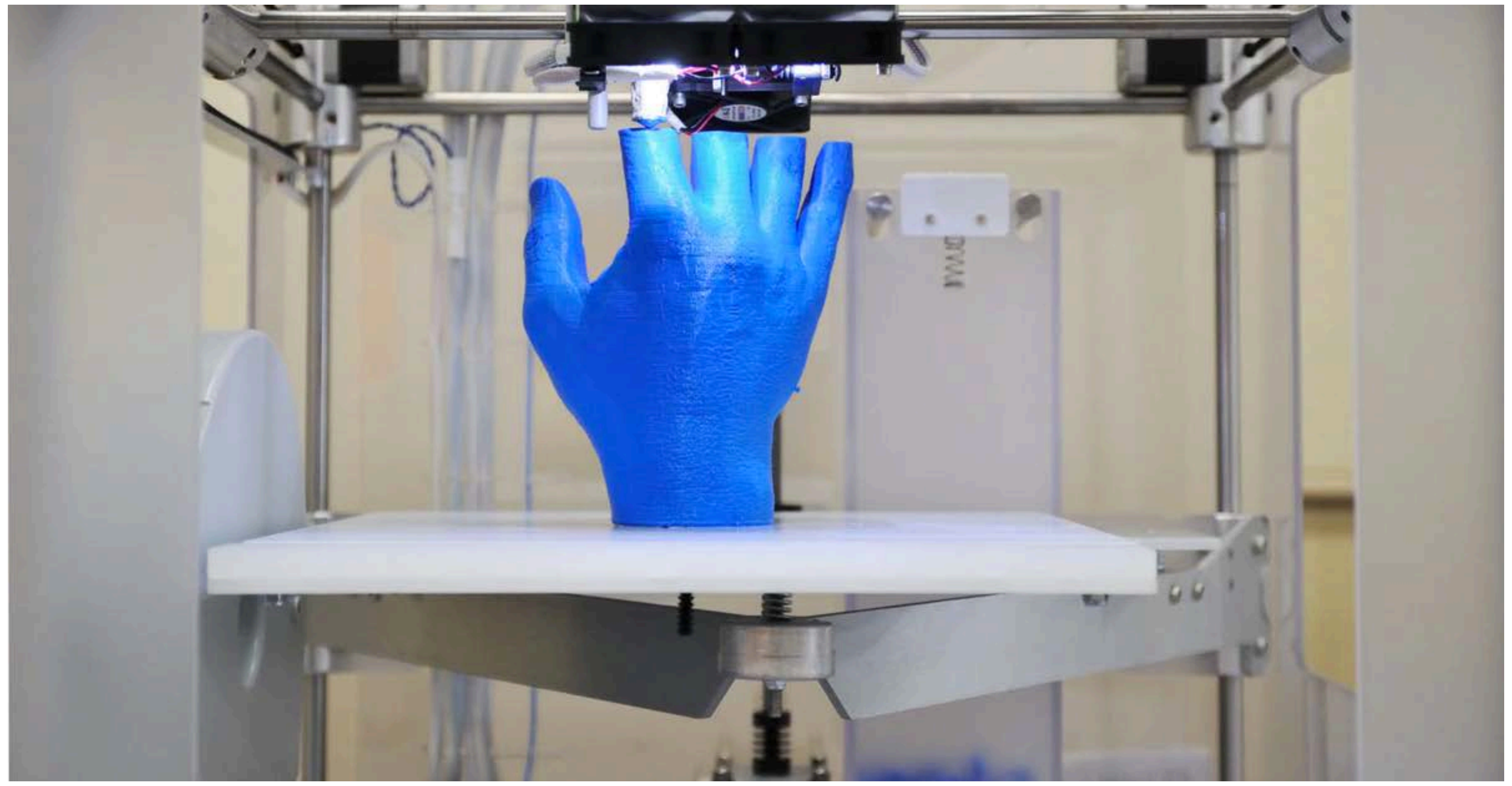
Synthesize sound (not only visual information)



and touch senses

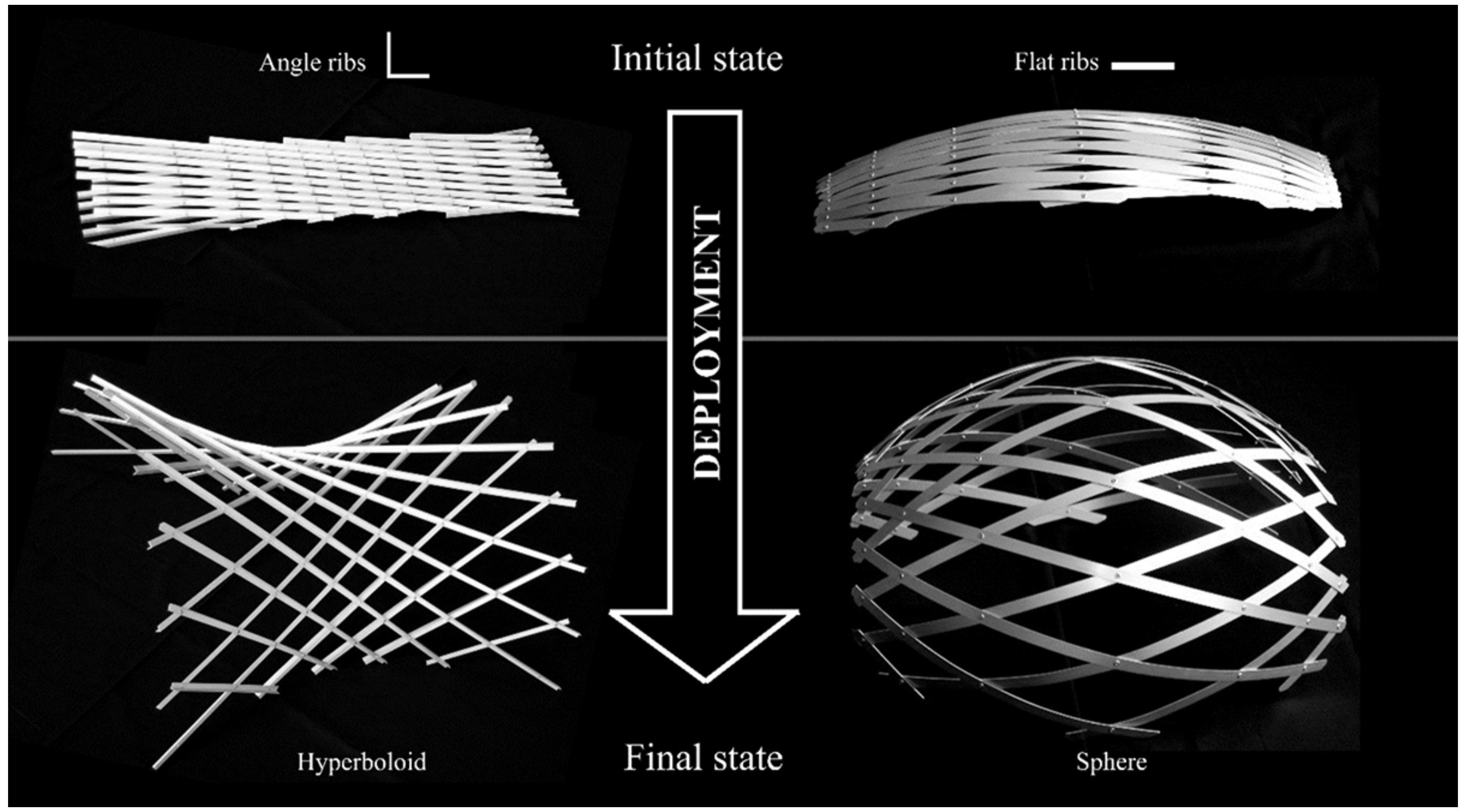
Beyond controlling pixels

3D printing



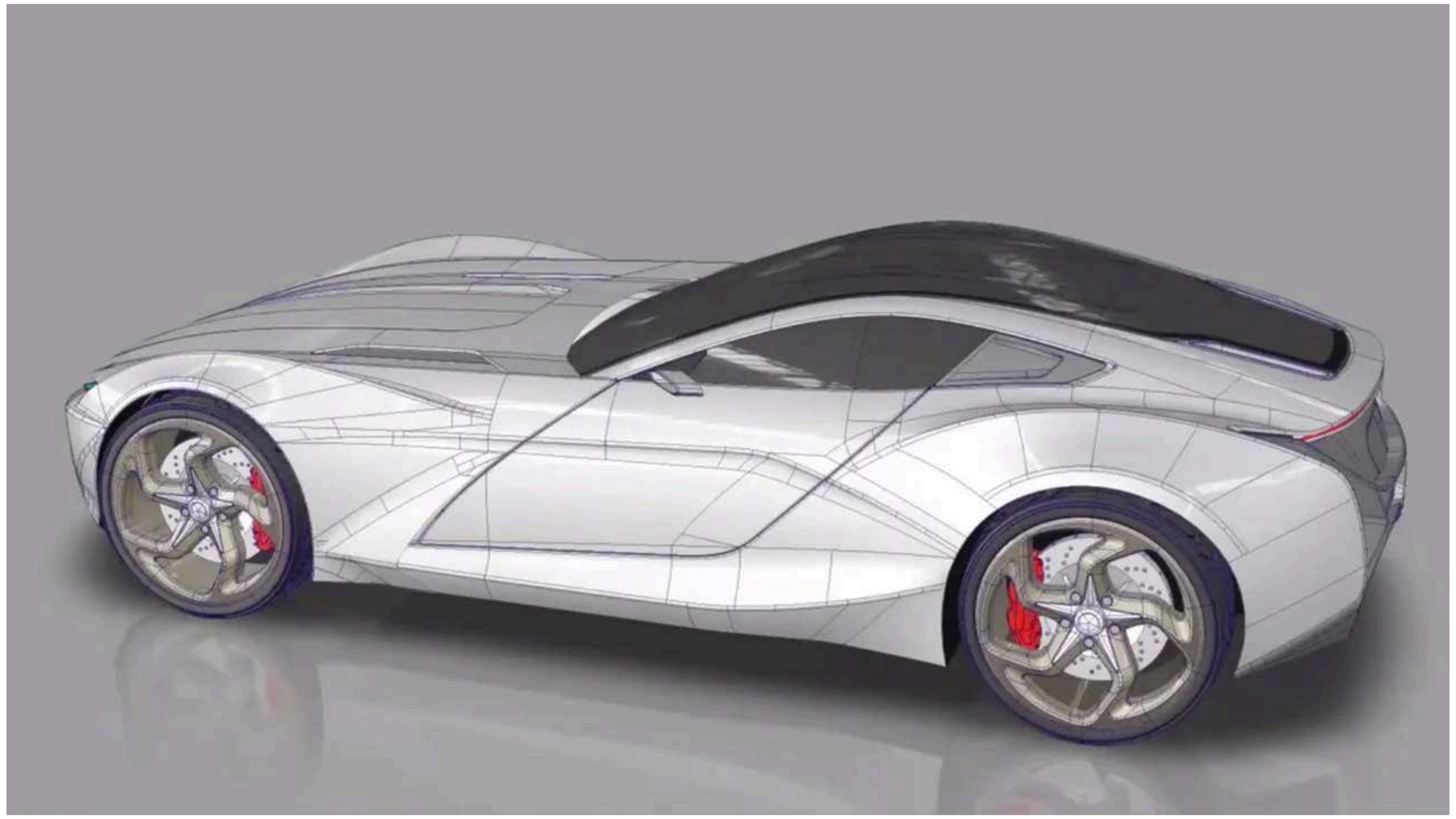
Constrained deformable geometry

architecture



Beyond controlling pixels

Industrial computer aided design



Fonts on your screen and on newspapers

Frontier of Computer Graphics

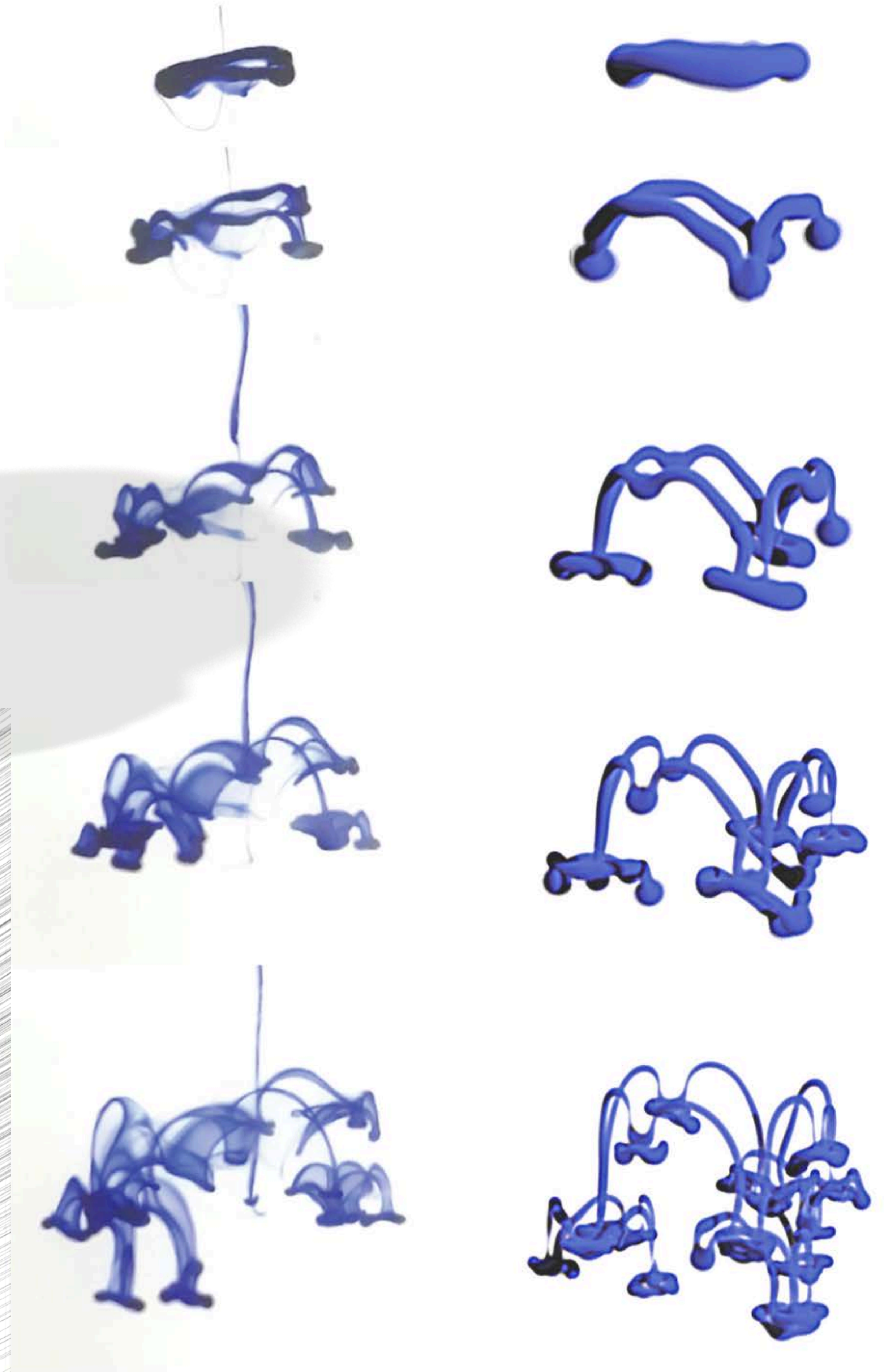
SIGGRAPH: Annual conference since 1974 with ~20k attendees per year.

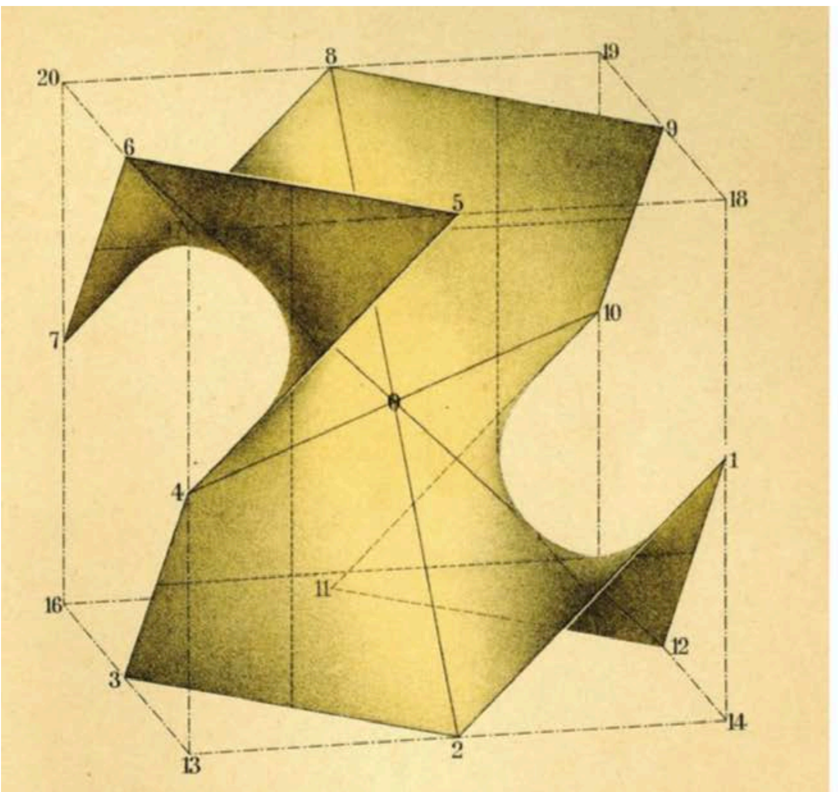
Youtube search “**SIGGRAPH technical paper trailer**”

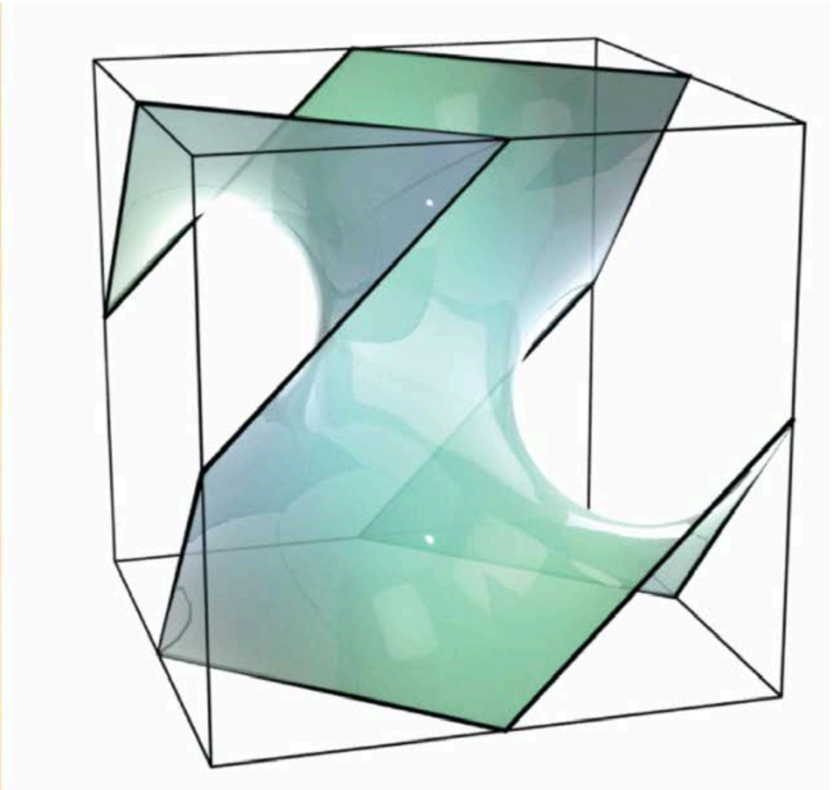
Our research

Geometry processing & physical simulation

- Find underlying geometric structures to make simulations easier







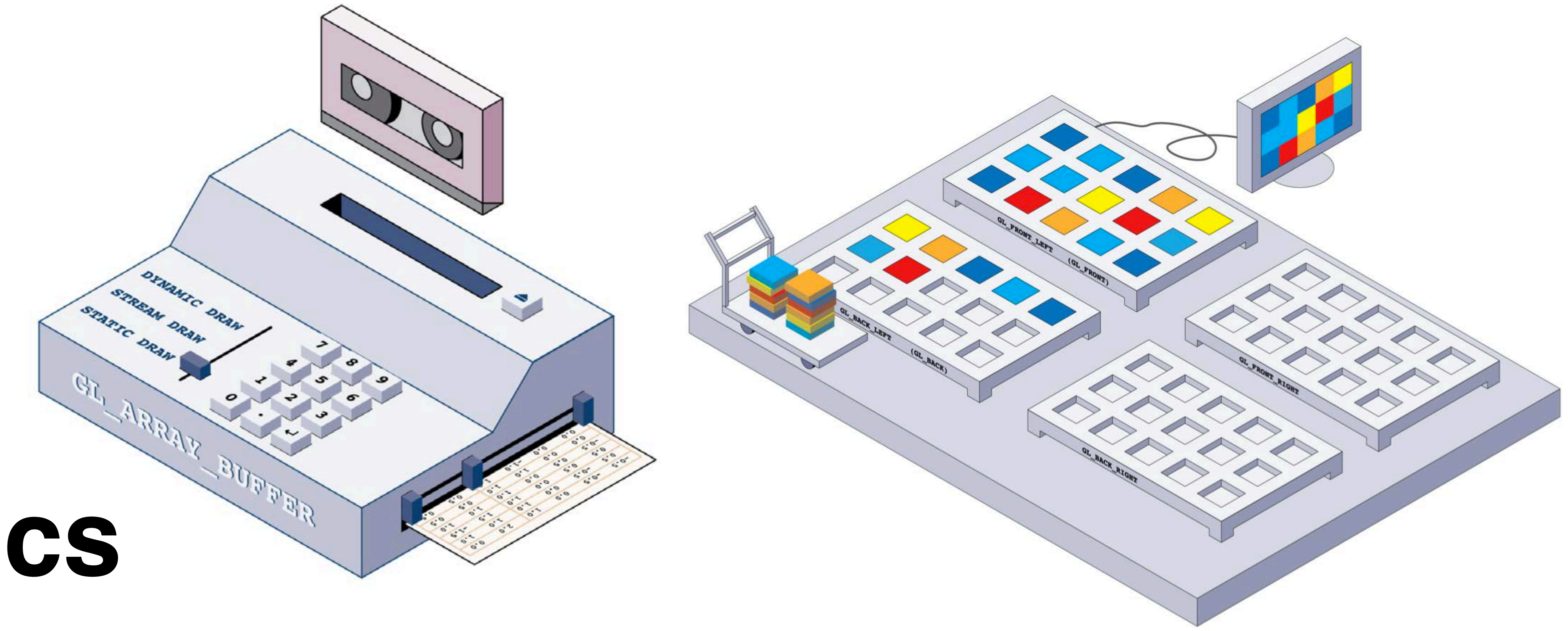
Nabizadeh, Wang, Ramamoorthi, C.
Covector Fluids
2022

Topics of this course

This course

Modern OpenGL

- Command the graphics card

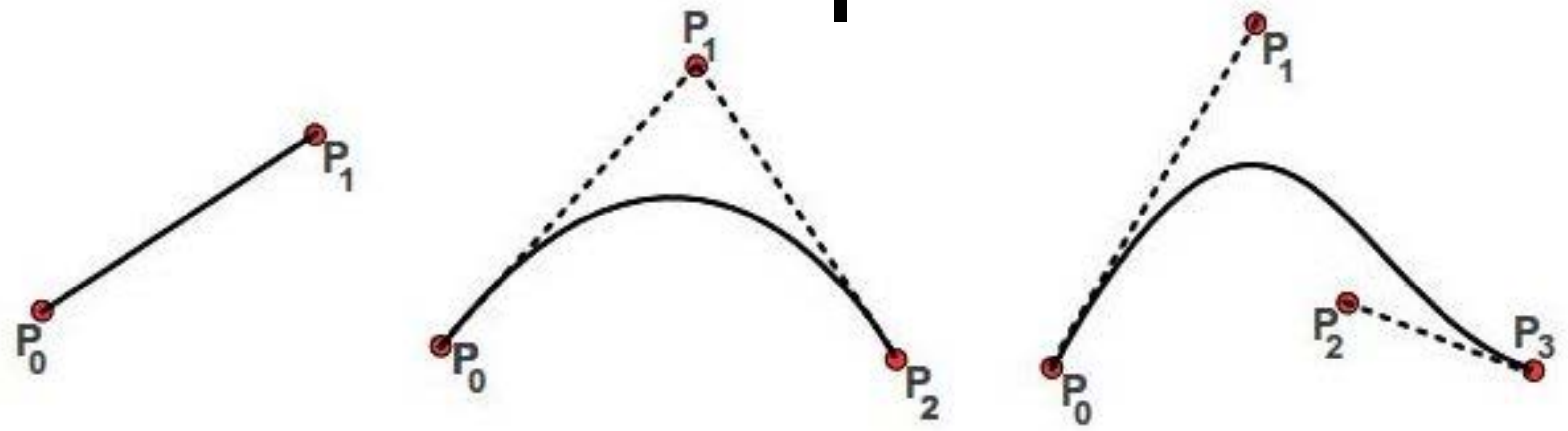


Foundation of 3D Computer Graphics

- Convert geometries in a 3D scene into pixel colors in a 2D screen.

Foundation of Vector Graphics

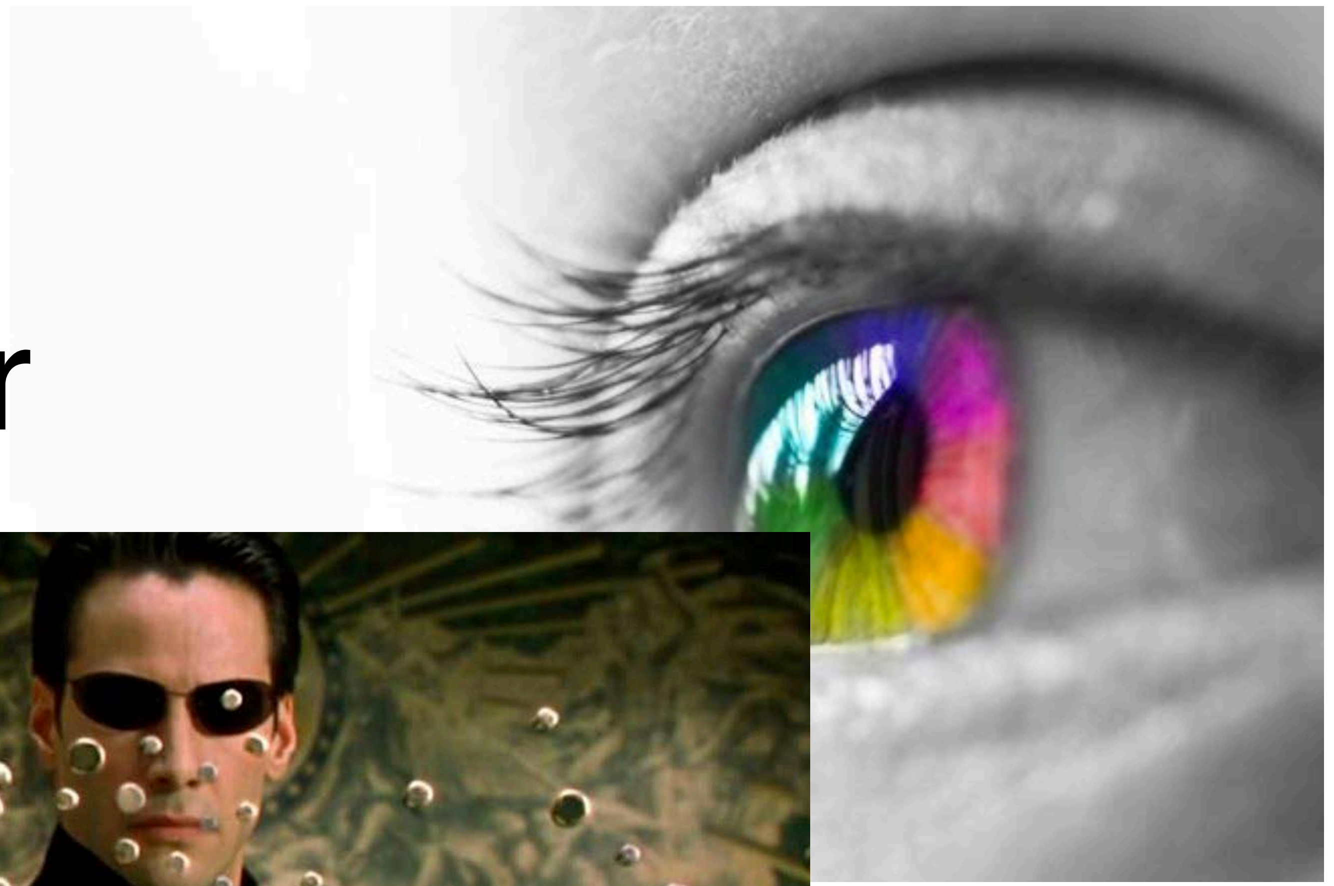
- Build smooth geometries from only a few control points



Additional topics

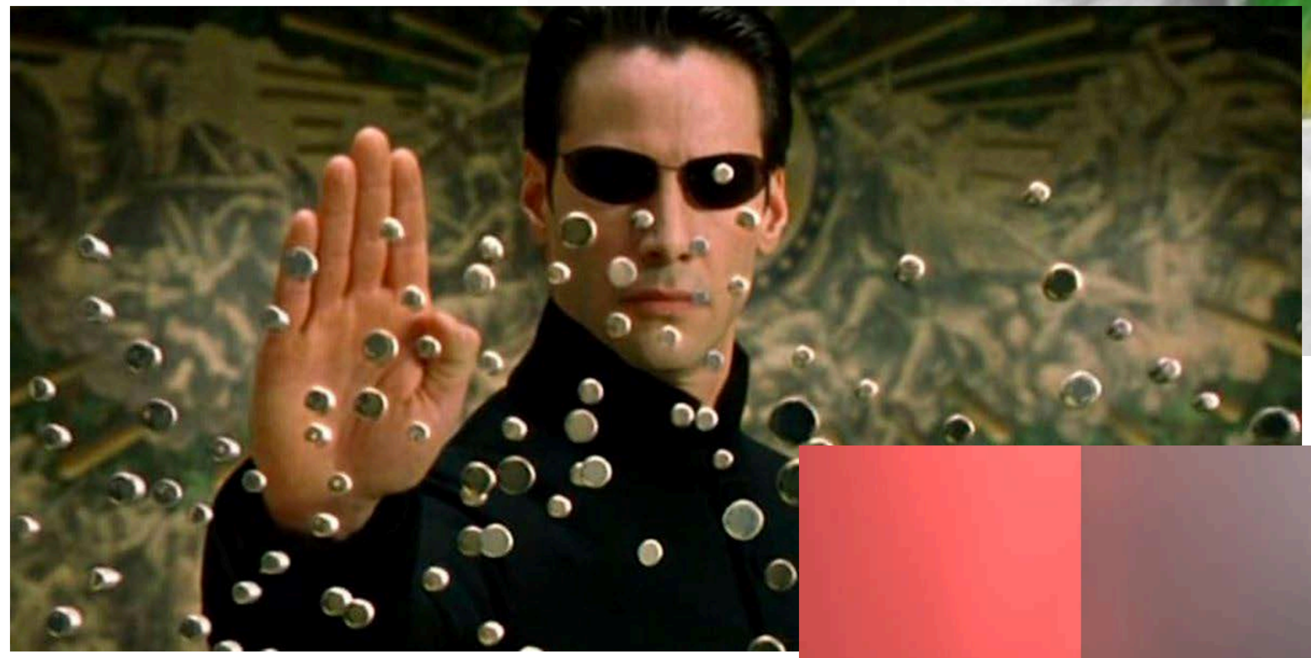
Perception of color

- Physical color, displayed color, perceived color



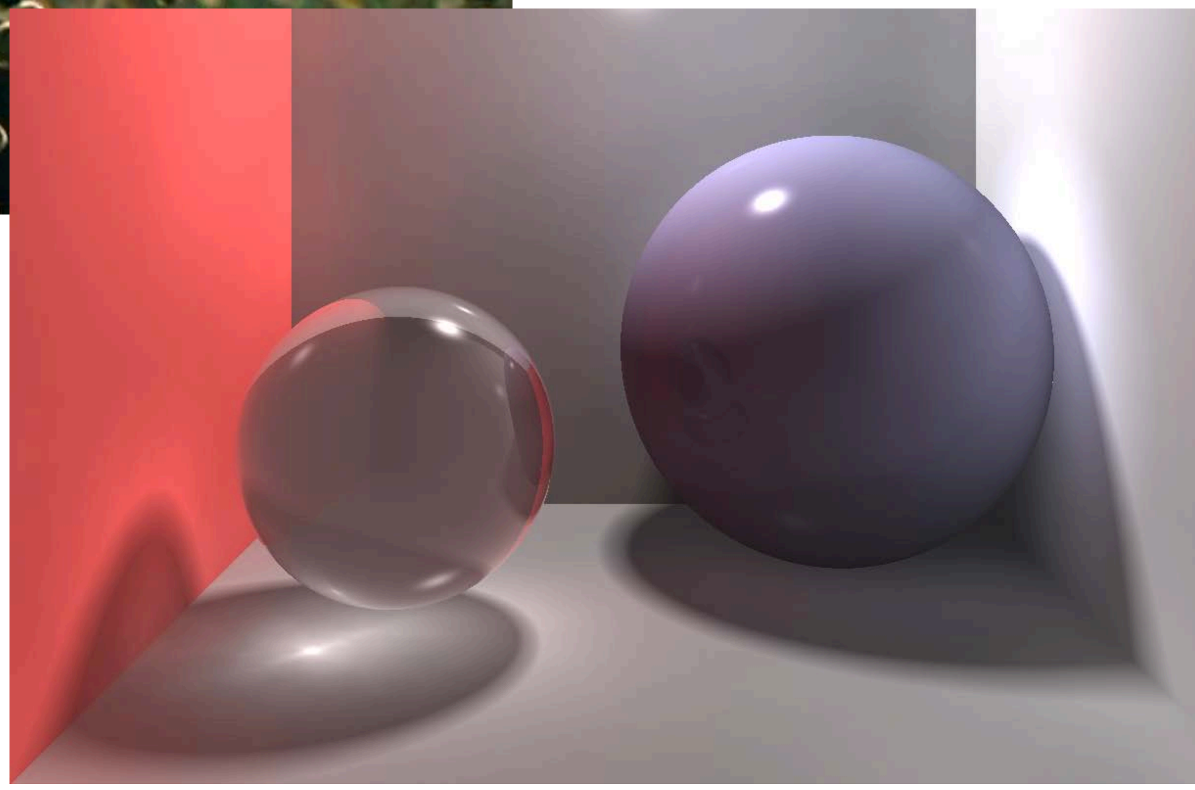
Physics-based animation

- Behind the scenes of special effects.



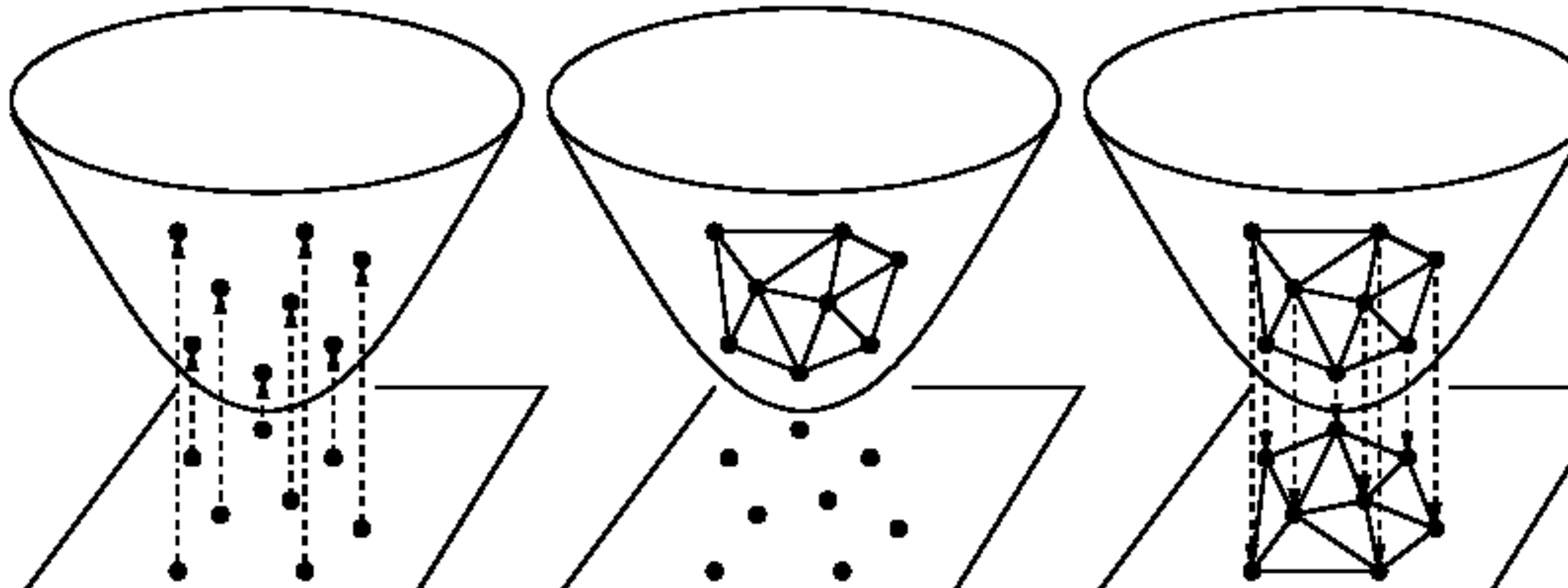
Optics

- Light transport equation



Geometry processing

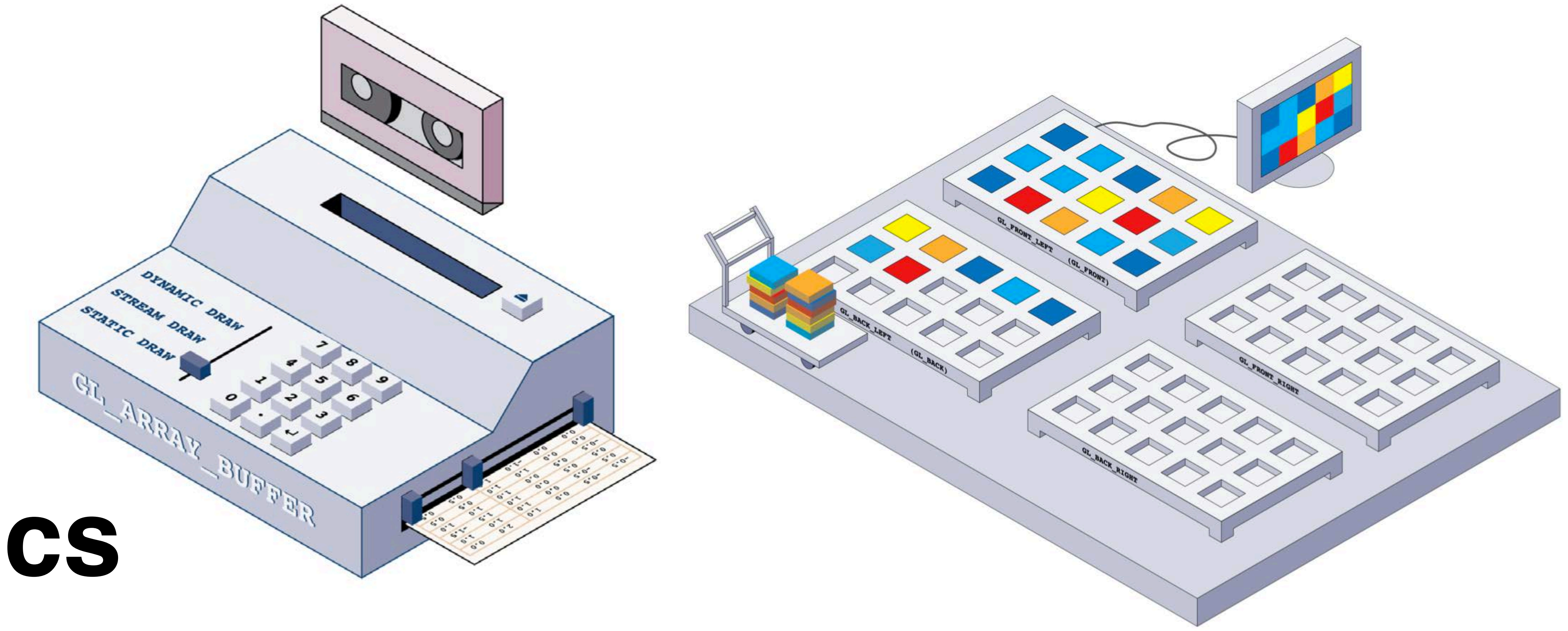
- Differential geometry of discrete meshes



This course

Modern OpenGL

- Command the graphics card



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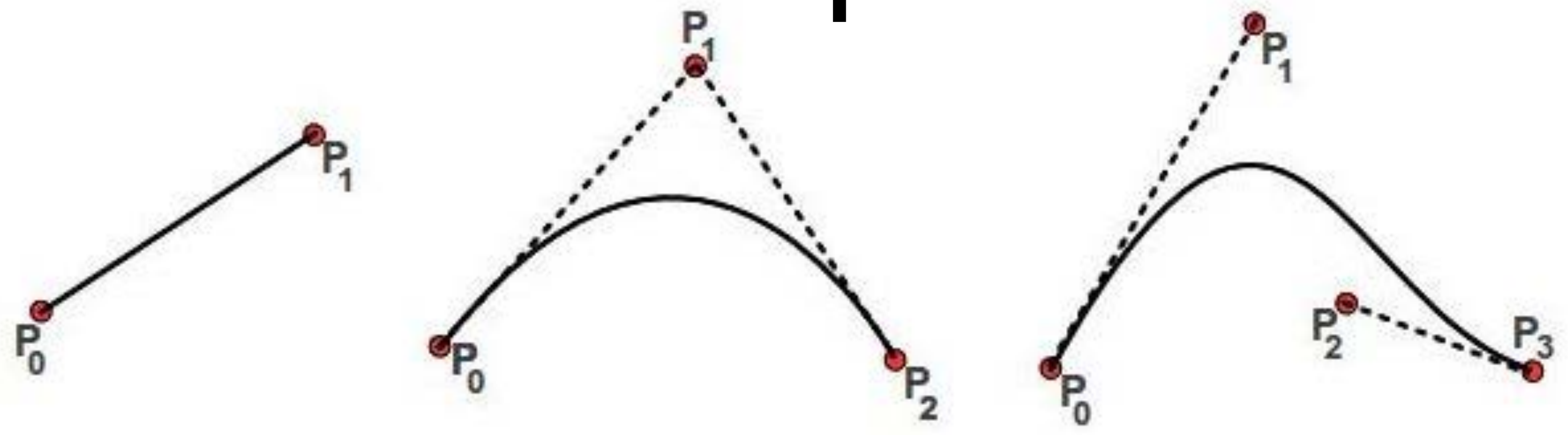
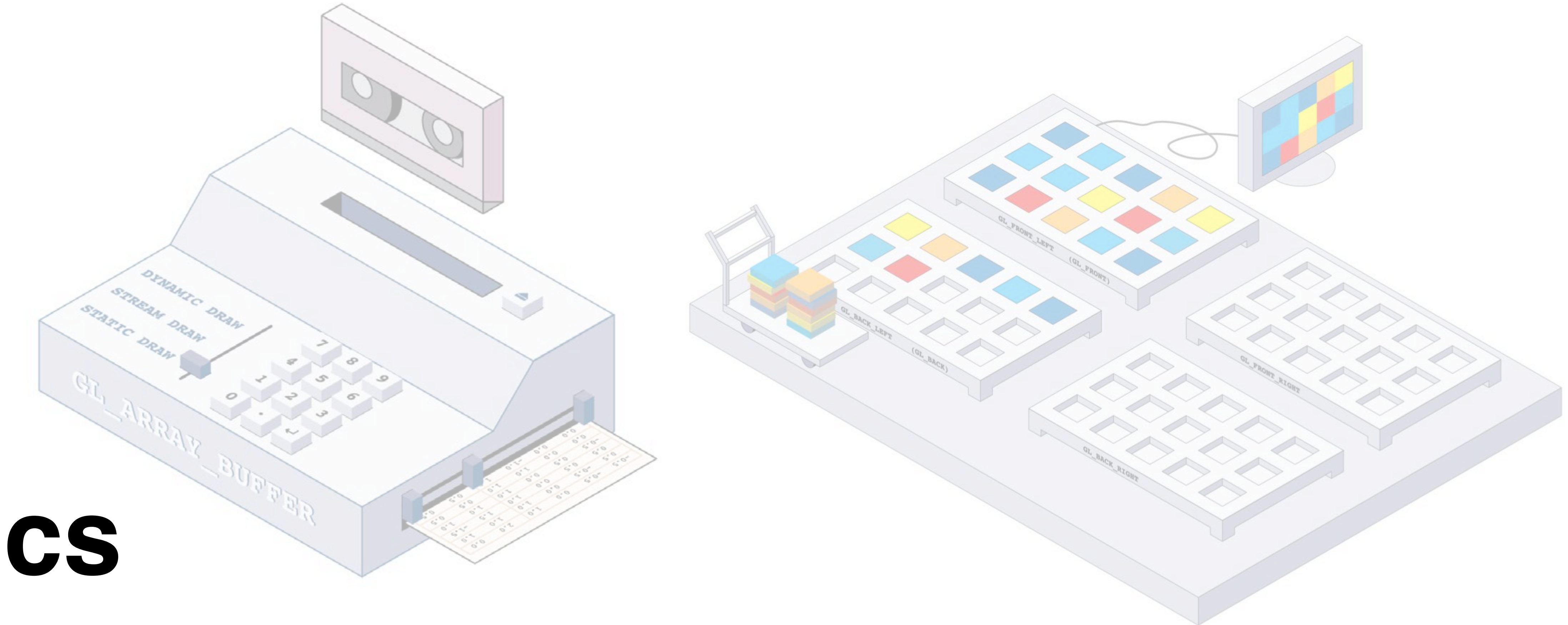


This course

Modern OpenGL

- Command the graphics card



Foundation of 3D Computer Graphics

- Convert geometries in a 3D scene into pixel colors in a 2D screen.

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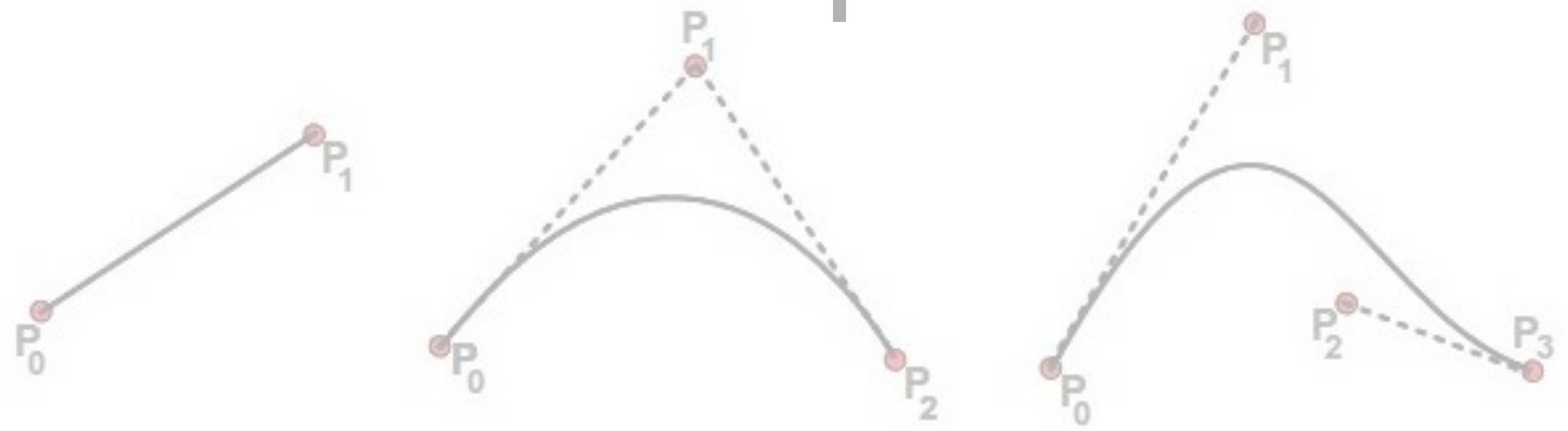

3D Computer Graphics

Foundation of 3D Computer Graphics

- Convert geometries in a 3D scene into pixel colors in a 2D screen.

- **How to draw pictures algorithmically?**
    - Rasterization v.s. Ray tracing
    - Graphics pipeline
    - Hardware: GPU