

# Computer Graphics

CS475 / 675, Fall 2016

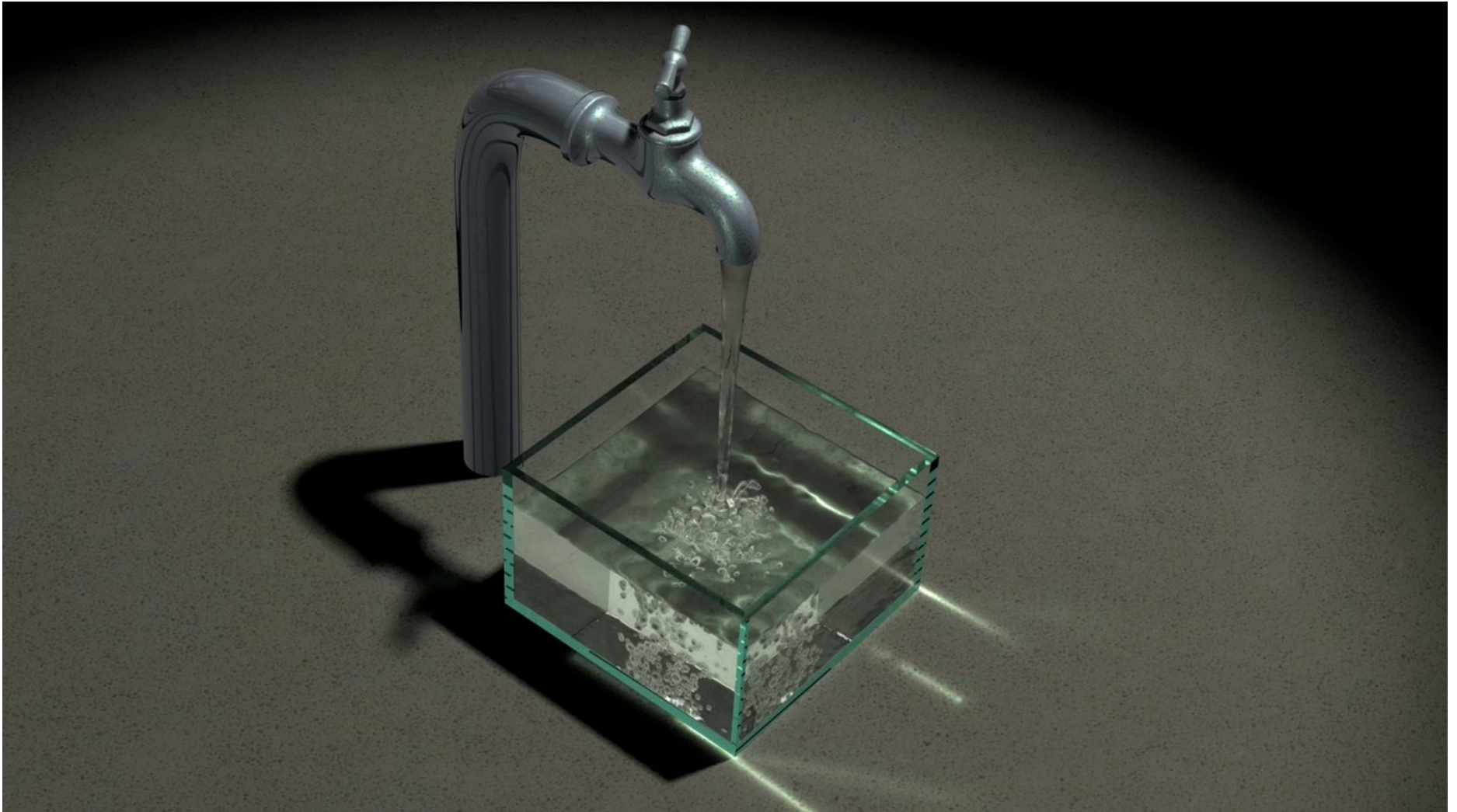
IIT Bombay

Instructor: Siddhartha Chaudhuri

# What is Computer Graphics?

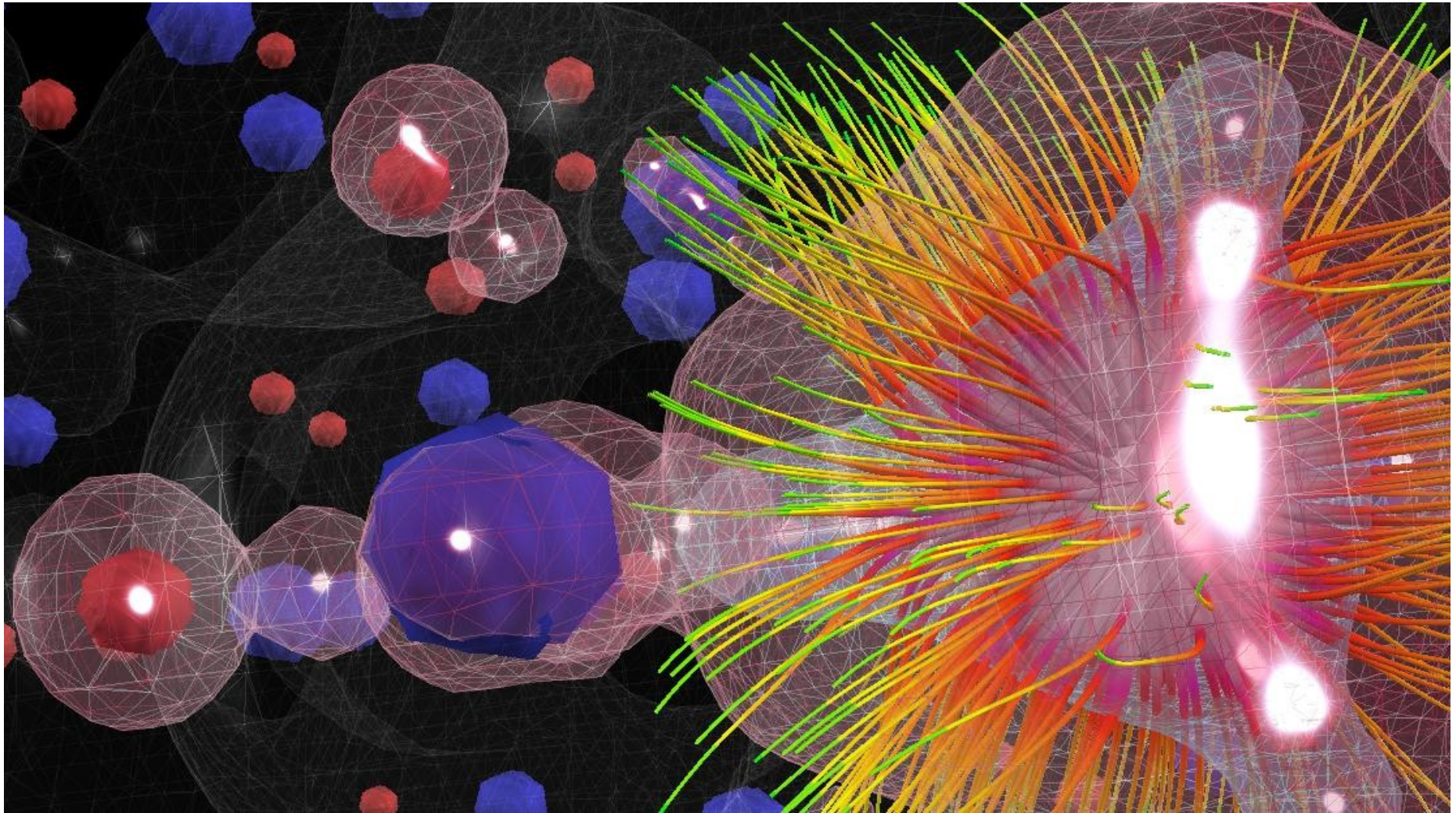
Study of: digital synthesis and  
manipulation of visual content, and  
interaction with it

(Video: Zhang and James, Harmonic Fluids)





# (Video: The AlloSphere)



# (Video: The Hubble Ultra Deep Field in 3D)





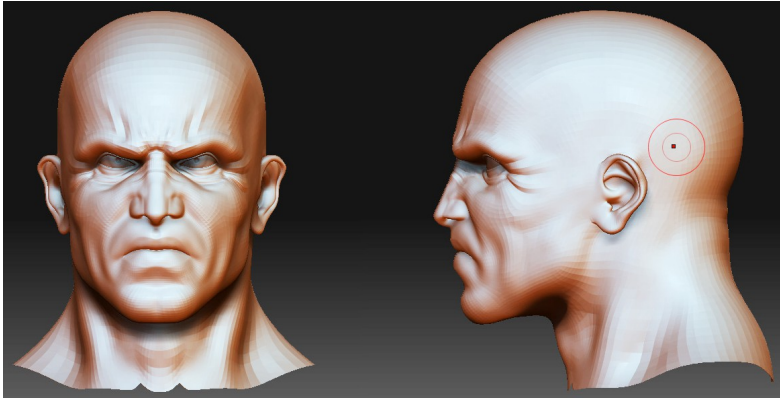
# Graphics is...

## *Rendering*



Rendered in POV-Ray by Gilles Tran

# Graphics is... *Modeling*



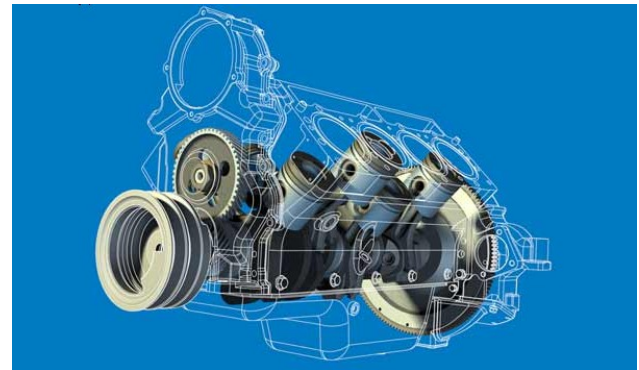
Human head modeled in ZBrush (Shon Mitchell)



Trees generated with L-systems (Talton et al., 2010)



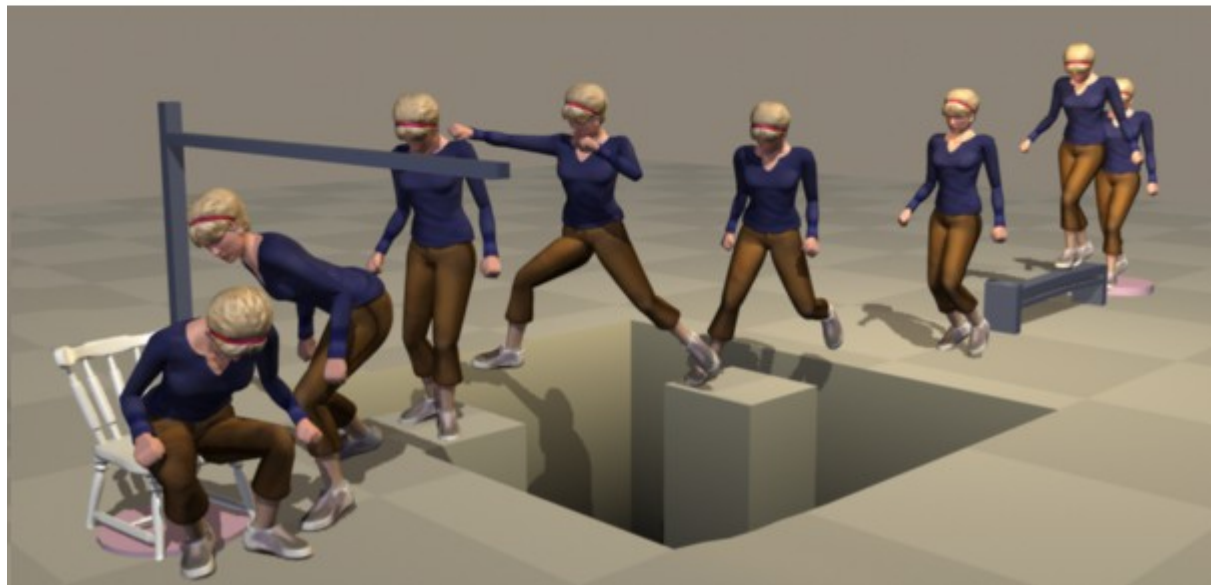
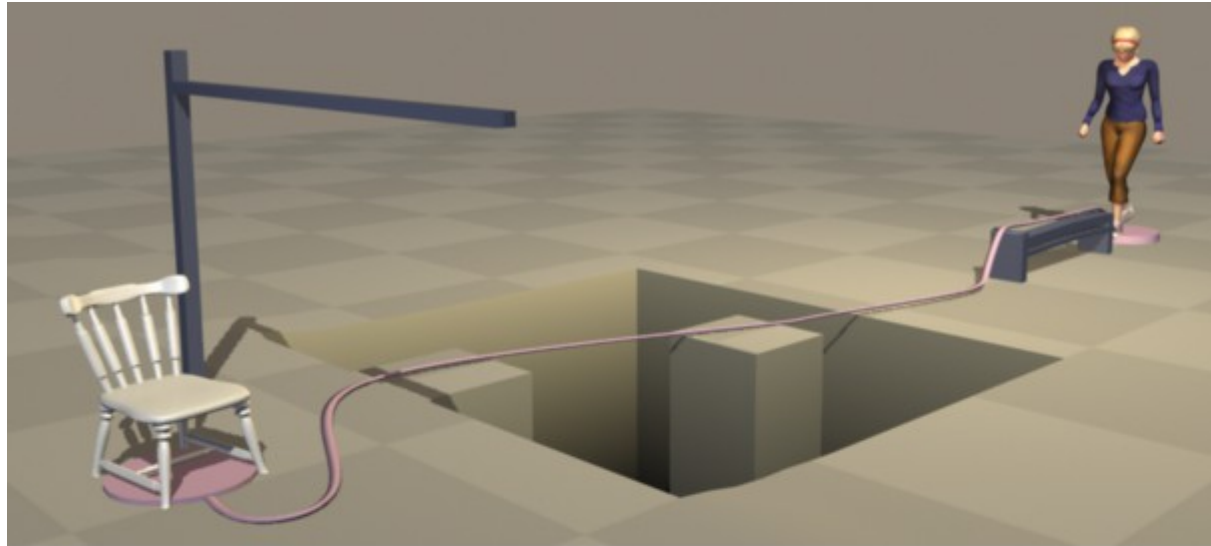
Procedurally generated model of Zurich  
(Parish and Müller, 2004)



Engine CAD drawing (SolidWorks Corp.)

# Graphics is...

## *Animation*

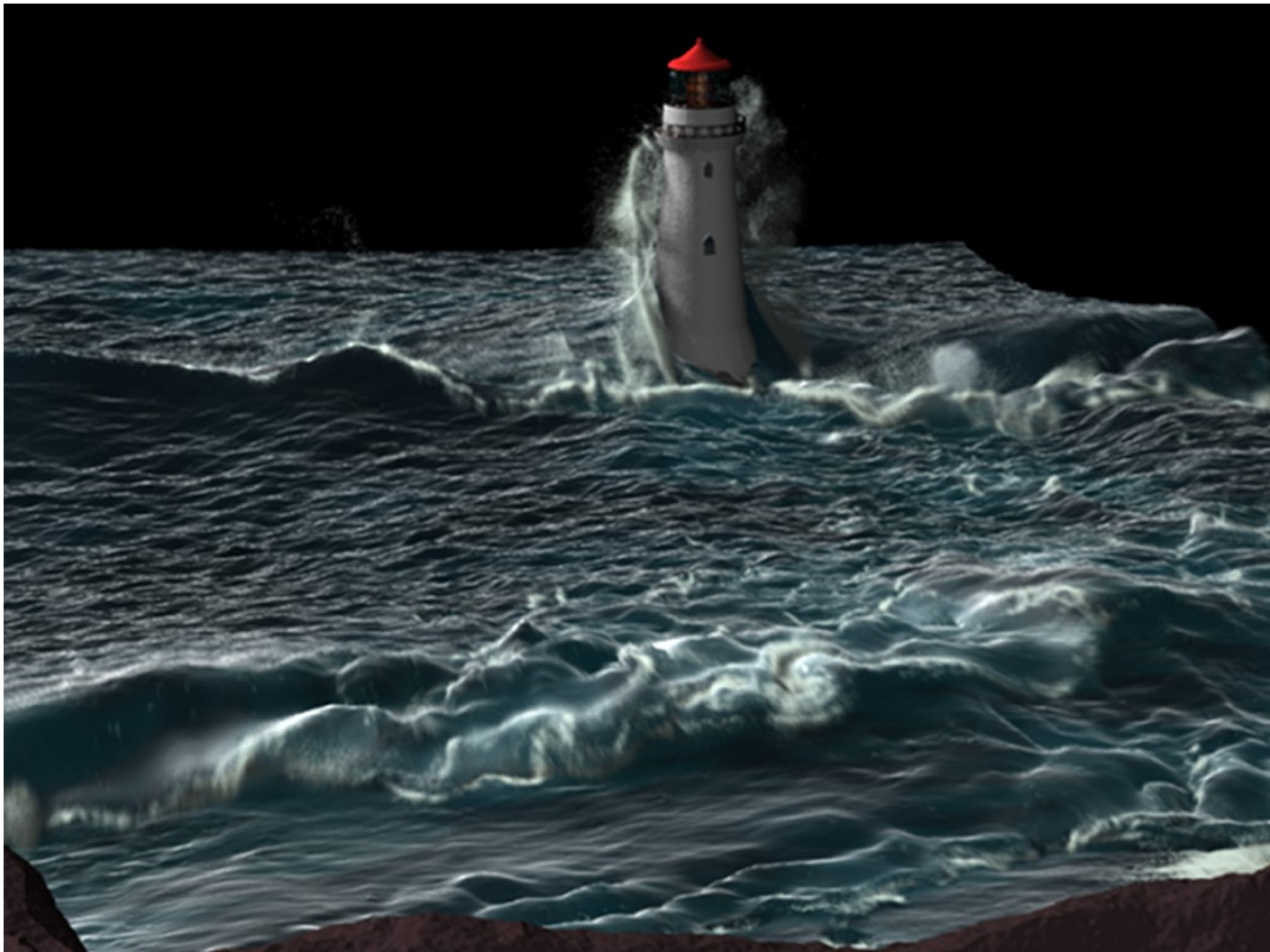


Safonova and Hodgins, 2007



# Graphics is...

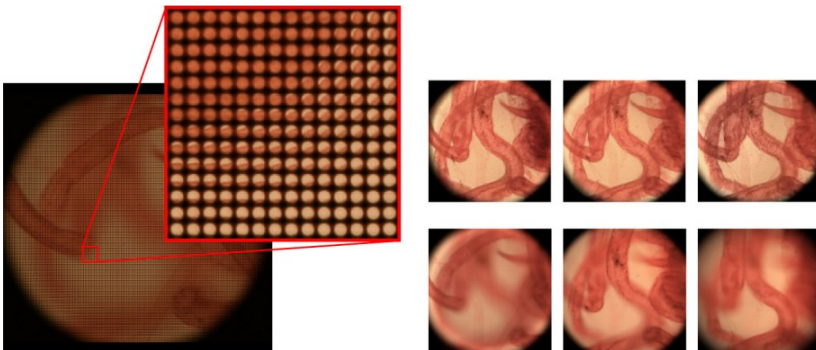
## *Physical Simulation*



Losasso et al., 2008

# Graphics is...

## *Digital Capture*



Light Field Microscopy (Levoy et al., 2006, 2007)



Digital Michelangelo Project (Levoy et al., 2000)

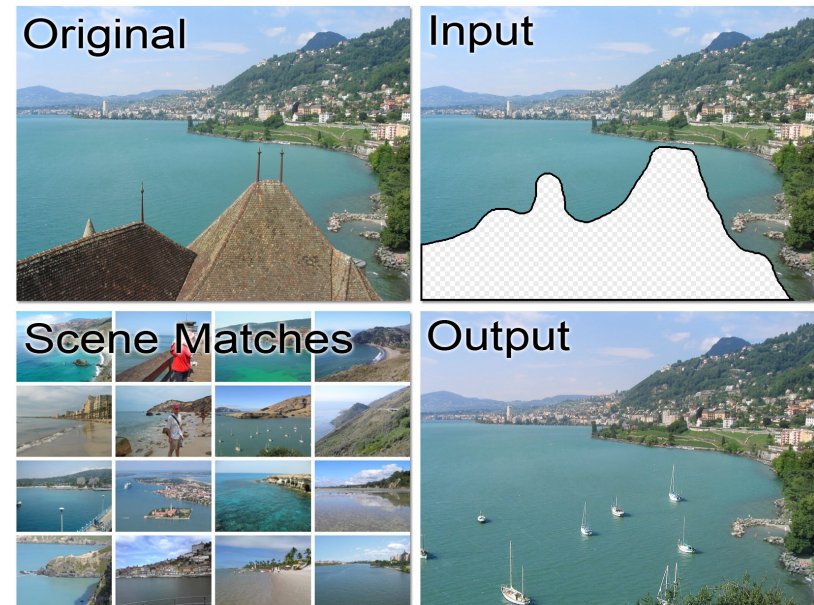


# Graphics is...

## *Image Processing*



Image Analogies (Hertzmann et al., 2001)

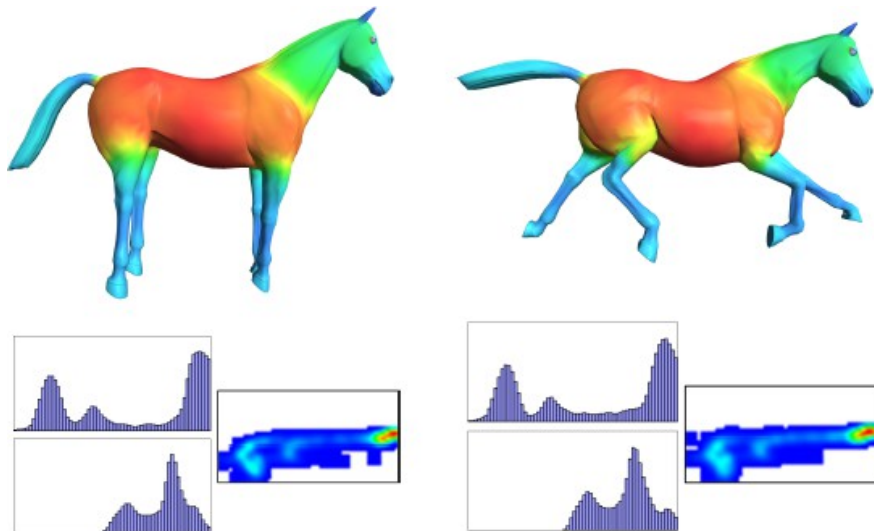


Scene Completion with Millions of Photographs  
(Hays and Efros, 2007)



# Graphics is...

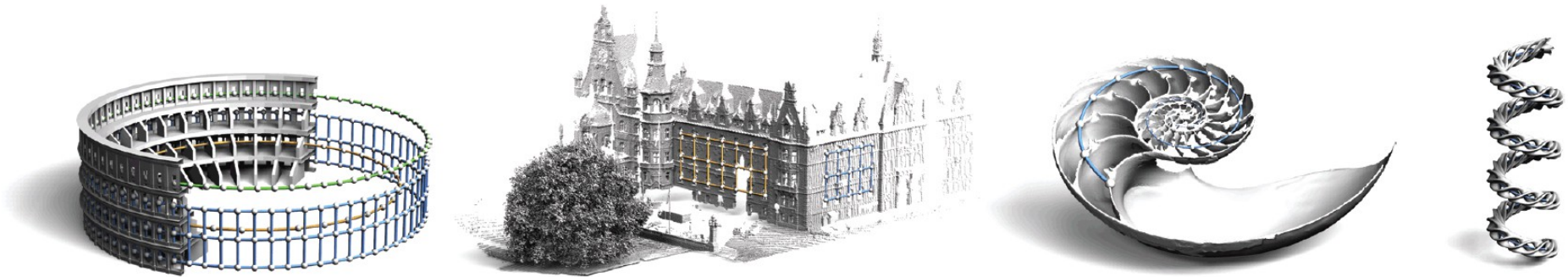
## *Geometric Computing*



Pose Oblivious Shape Signature (Gal et al., 2007)



Shadow Art (Mitra and Pauly, 2009)



Discovering Structural Regularity in 3D Geometry (Pauly et al., 2008)

# Graphics is...

## *Entertainment and Interaction*



Jurassic Park (Universal Pictures, 1993)



World of Warcraft (Blizzard, 2004)



Toy Story, the first full length film produced entirely on computers (Pixar/Disney, 1995)



Crysis (Crytek/EA, 2007)



# Graphics is...

## *Virtual Environments*



Second Life (Linden Research, Inc.)



# Graphics is...

## *User Interfaces*



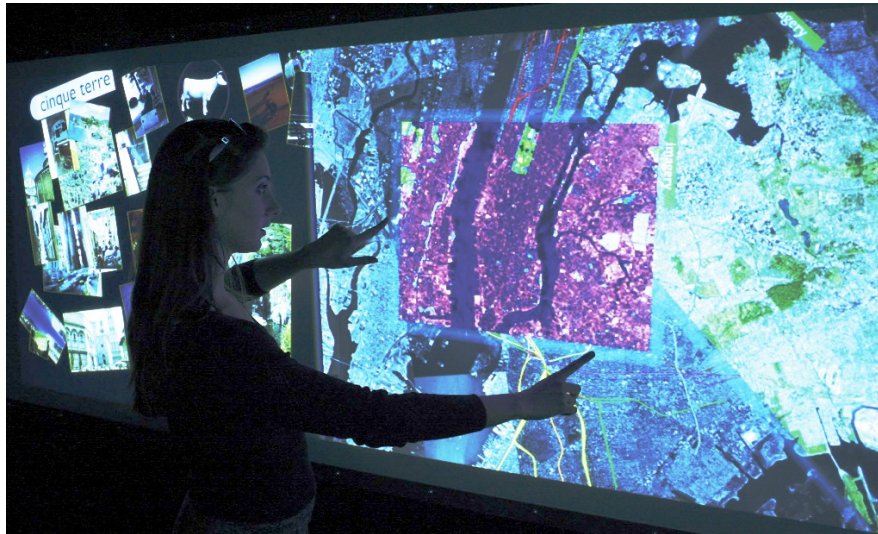
Xerox Star (Xerox, introduced 1981)



Windows 7 (Microsoft, 2009)



iPhone (Apple, introduced 2007)



Wall-mounted multitouch display  
(Perceptive Pixel, 2007)



Virtual car design in the CAVE  
(U. Mich./Prince, 1996)



# Graphics is...

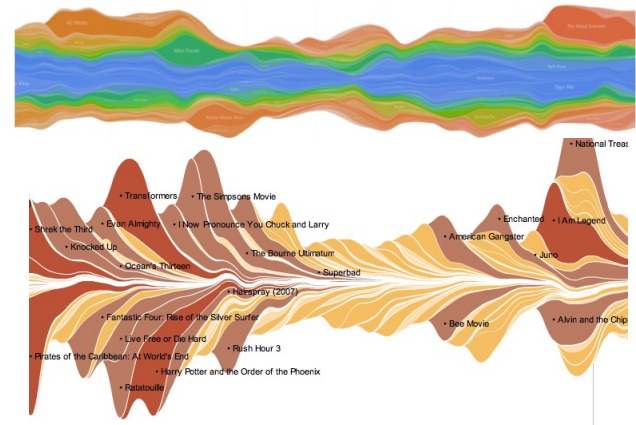
*Visualization*



Wordle (Feinberg, 2009)



Britain from Above (BBC, 2009)



Streamgraphs of listening history & movie sales  
(Byron/Wattenberg (t); New York Times, 2008 (b))



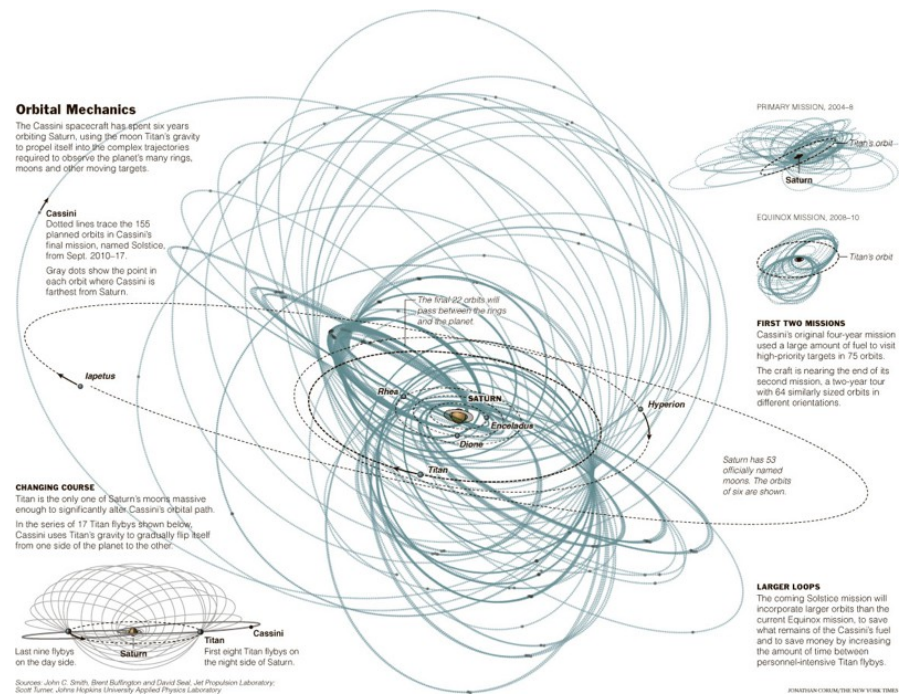
Visualization of traffic conditions (Google, 2009)

# Graphics is... *Design*



InDesign (Adobe, introduced 1999)

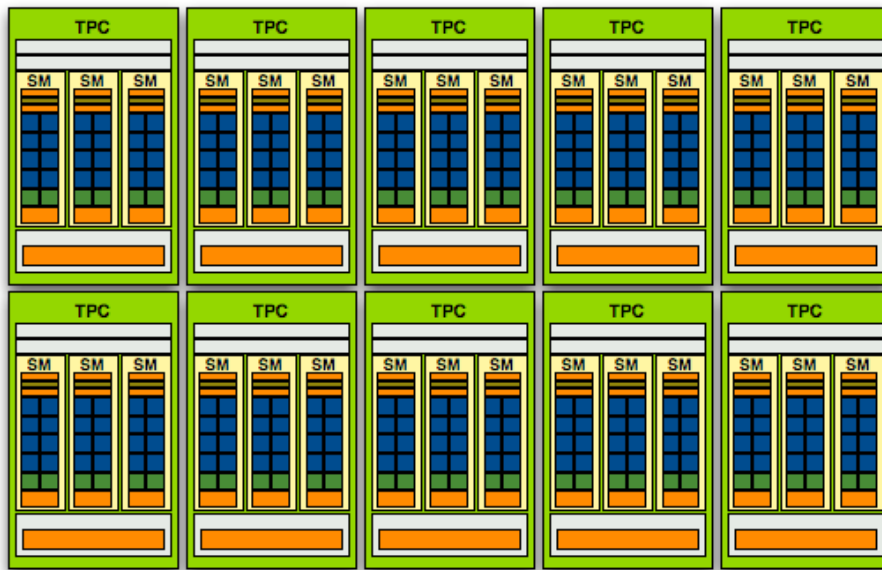
$$F = \frac{Gm_1m_2}{r^2}$$



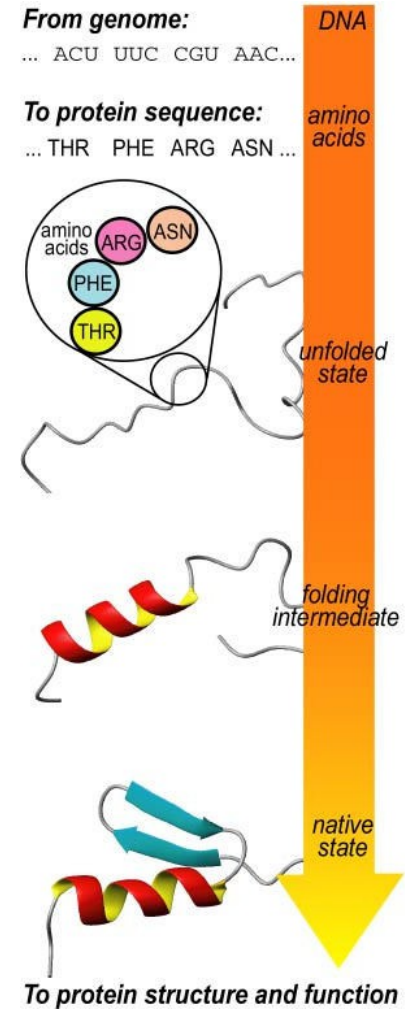
Planned orbits of Cassini spacecraft (New York Times, 2010)



# Graphics is... *Hardware*



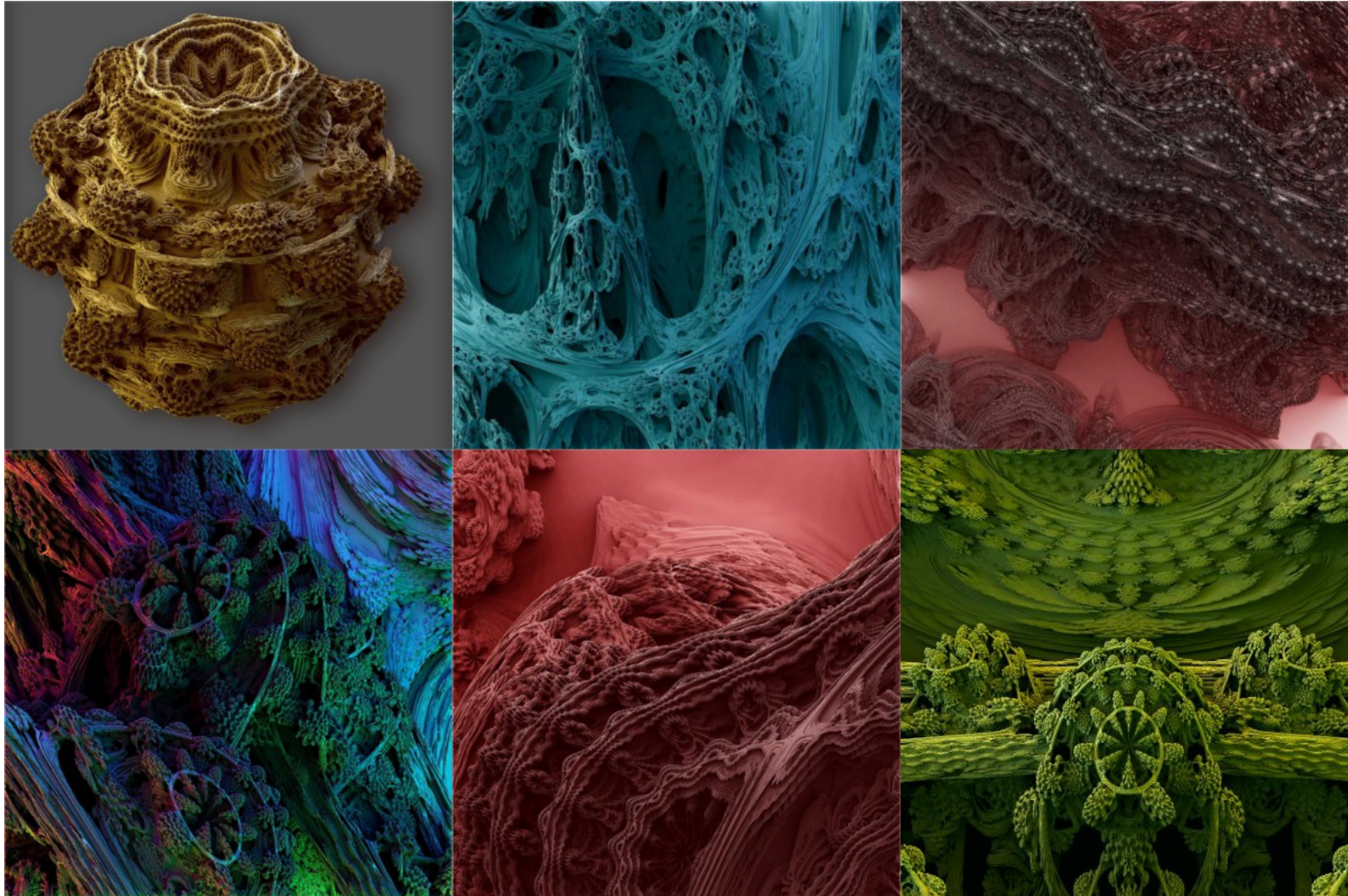
(GPU Images from anandtech.com)



Folding@Home (Pande et al.)

# Graphics is...

## *Art*



The Mandelbulb (Daniel White, 2009)

# Course Outline

- Introduction
- Light and Color
- Digital Cameras and Displays
- Image Processing and Compression
- Drawing and 2D Geometry
- 3D Geometry
- Rendering



# Course Outline

- Curves and Surfaces
- Animation and Simulation
- Interaction
- Visualization
- Programmable Graphics Hardware
- Typography and Layout
- Sampling, Aliasing and Special Topics

# You should know...

- Basic linear algebra
  - Vectors, matrices, simple coordinate systems (cartesian, polar, spherical, cylindrical)
- Basic calculus
  - Limits, derivatives, integrals, notation



# You should know...

- C/C++
  - Either is ok, but we provide more utility code for C++
  - Please write **standards-compliant, platform-neutral** code
    - Your code should compile with a C99/C++11 compiler, without changes, on **all** desktop platforms (Windows, Linux, OS X)
    - We will test your code on a Linux (or occasionally OS X) system...
      - ... but do **NOT** use platform-specific features

# Warning!

- I am a huge stickler for **well-written code**
- This includes proper...
  - Names, capitalization
  - Indentation
  - Documentation (functions, classes, code blocks...)
  - Modularization and re-use
  - Overall code structure and organization
- Yes, I will reserve 5-10% of each assignment for code quality



# Coding Tips

- Don't reinvent the wheel
- Look at the supplied code frameworks for models to follow
- Pick a coding standard (e.g. <https://google.github.io/styleguide/cppguide.html>) and stick with it
  - It's ok to disagree with a standard, especially on minor formatting conventions such as where to put an opening brace, but you should have a good reason for doing so, and be consistent in your own use
- <http://astyle.sourceforge.net> can help with formatting, though it's best to train yourself so it's virtually impossible for you to write badly constructed/formatted code
- Coding is a **design process**

# How to **pass** this course

- Attend the lectures
  - Yes, attendance is mandatory. I understand if you skip a lecture here or a lecture there, but wholesale bunking is a recipe for grade disaster.
- Understand the concepts
- Do the assignments
  - Try to get the bonus credits
- Do the exams



# How to **fail** this course

- Skip the lectures
- Ignore the concepts and only memorize formulæ
- Slack on the assignments
- Miss the exams
- Violate academic integrity  
<http://www1.iitb.ac.in/newacadhome/rules.jsp>
  - We will run your code through automatic code checkers. They are **remarkably good** (better than you are at covering up copying).

# Resources

- Course website: <http://www.cse.iitb.ac.in/~cs475>
  - Lecture slides, assignments, schedule, FAQ etc
- Textbooks
  - Shirley and Marschner, *Fundamentals of Computer Graphics*, 3<sup>rd</sup> ed. (in a pinch 2<sup>nd</sup> is ok)
  - **Optional:** Shreiner et al., *The OpenGL Programming Guide*, 6<sup>th</sup> or later ed.
    - Pretty much any decent OpenGL guide that covers programmable shaders (GLSL) is also ok

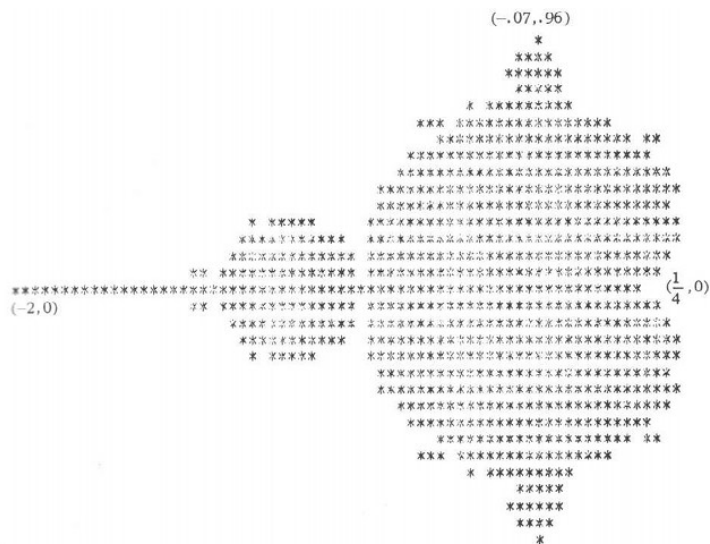


# Grading Policy

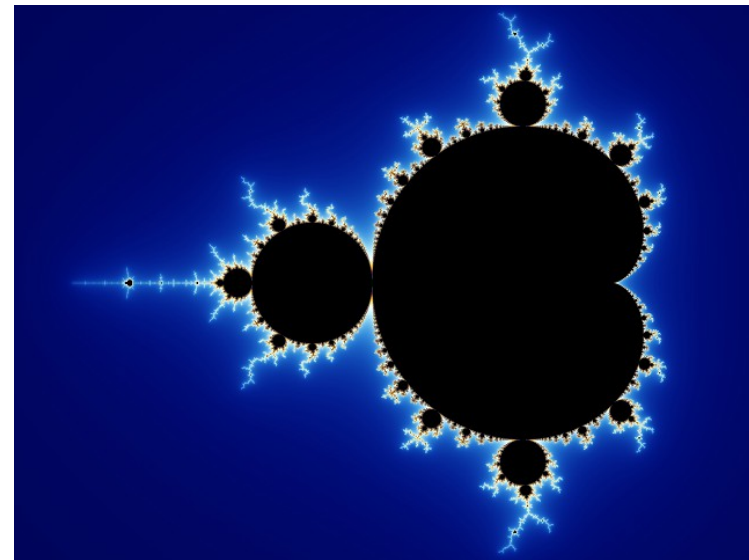
- Assignments: 55%
  1. Mandelbrot set (due Mon, Aug 1, 11:59pm)
  2. Image filtering
  3. Raytracing
  4. Interactive game (Quake)
  5. Visualization
- Midterm: 15%
- Final: 30%

# AS1: Mandelbrot Set (due Aug 1, 11:59pm)

- Fractal set embedded in 2D complex plane
- Studied by Brooks, Matelski, Mandelbrot etc.
- Set of complex  $c$  s.t.  $z \leftarrow z^2 + c$  does not diverge

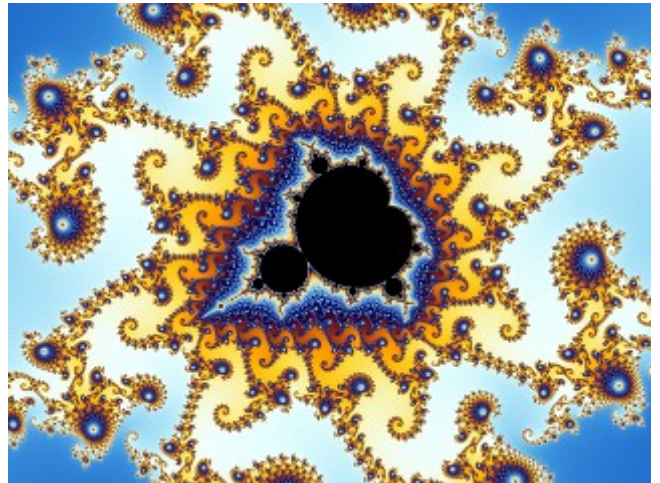
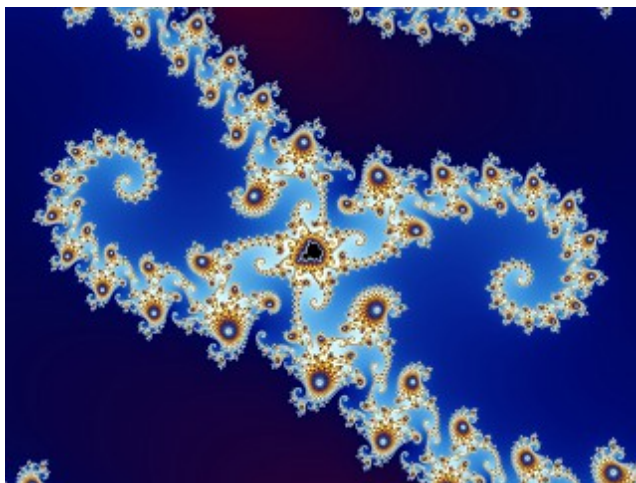
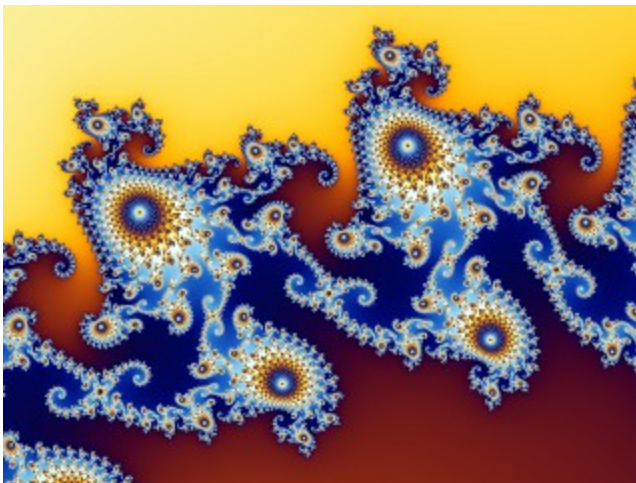
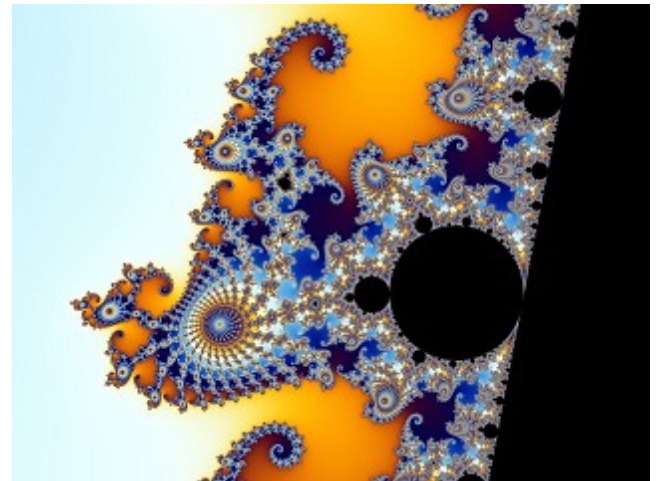
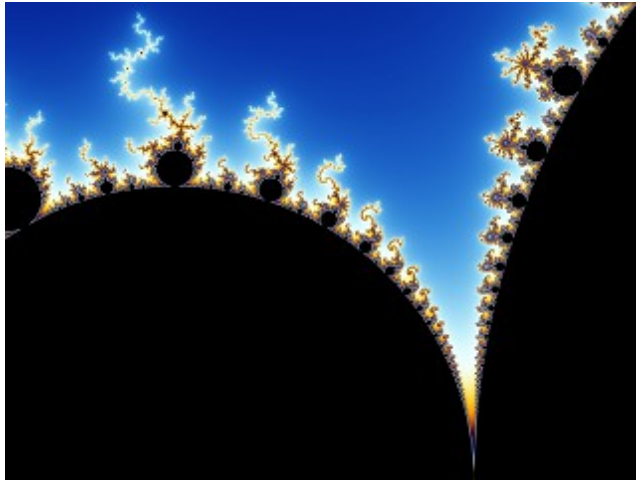
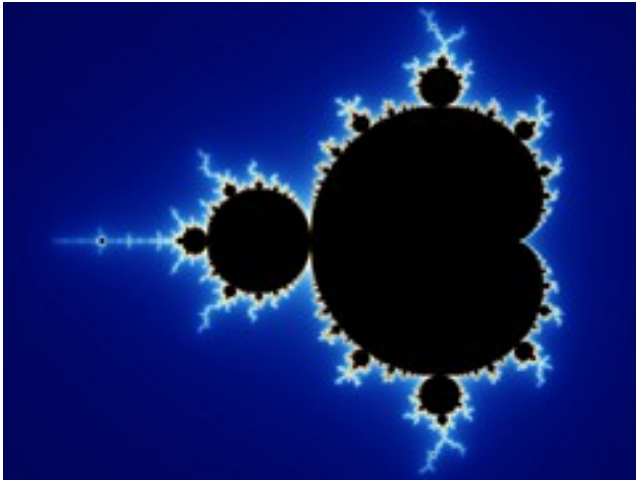


Brooks & Matelski, 1978



Beyer, 2006

# AS1: Mandelbrot Set (due Aug 1, 11:59pm)



Wolfgang Beyer, 2006