6.837 Introduction to Computer Graphics

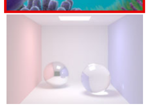
Luxo Jr.

- Pixar Animation Studios, 1986
- Director: John Lasseter

Plan

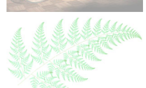
- Introduction

- Overview of the Semester



- Administrivia

- Iterated Function Systems (Fractals)



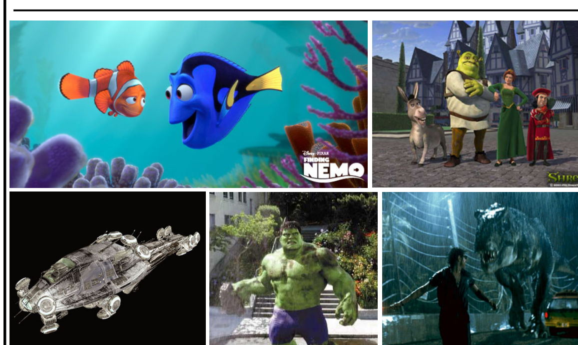
Team

- Lecturers
  - Frédo Durand
  - Barb Cutler
- TA
  - Rob Jagnow
- Course secretary
  - Bryt Bradley
- 6.837-staff@graphics.csail.mit.edu
- 6.837-ta@graphics.csail.mit.edu

Why Computer Graphics?

- Movies
- Games
- Simulation
- CAD-CAM
- Architecture
- Virtual Reality
- Visualization
- Medical Imaging

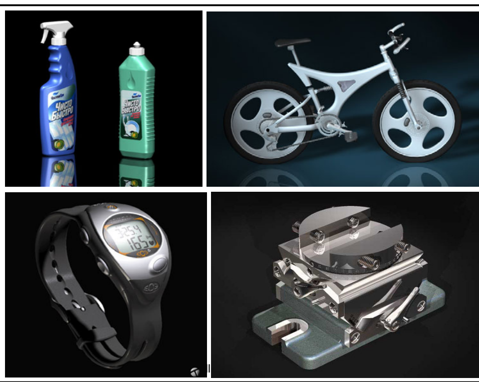
Movies



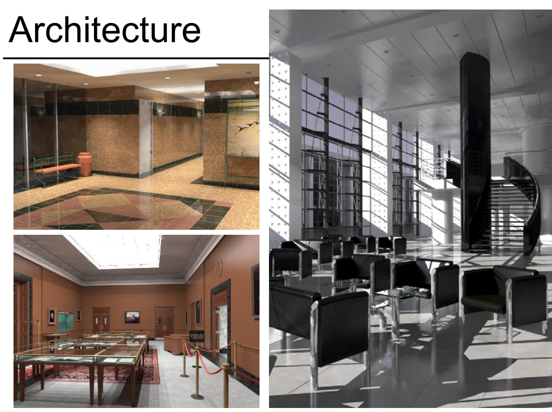
Games

Simulation

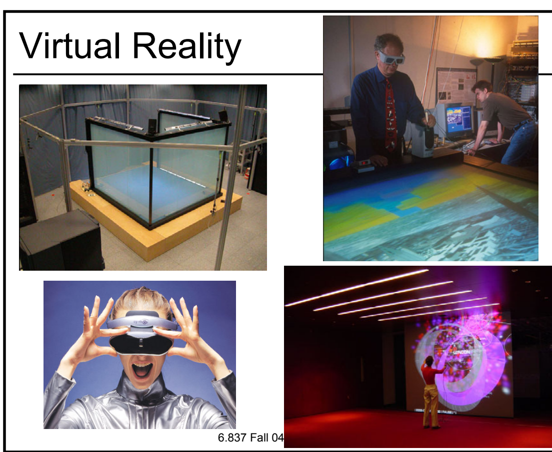
CAD-CAM & Design



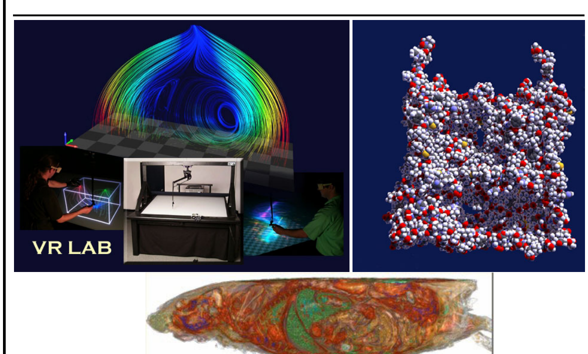
Architecture



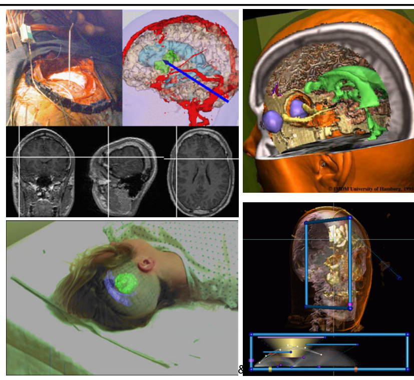
Virtual Reality



Visualization



Medical Imaging



What you will learn in 6.837

- Fundamentals of computer graphics algorithms
- How to implement most of the applications just shown
- How graphics APIs and the graphics hardware work

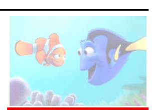
What you will NOT learn in 6.837

- Software packages
  - CAD-CAM
  - Photoshop and other painting tools
- Artistic skills
- Game design
- Graphics API
  - Although you will be exposed to OpenGL

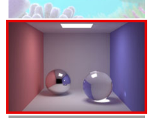
Questions?

Plan

- Introduction



- Overview of the Semester



- Administrivia

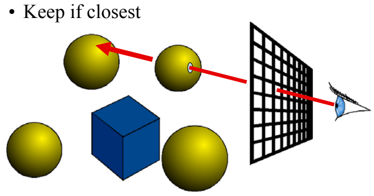
- Iterated Function Systems (Fractals)

Overview of the Semester

- Ray Casting / Ray Tracing
- The Graphics Pipeline
- Textures, Shadows
- Sampling, Global Illumination
- Modeling, Animation, Color
- Advanced Topics

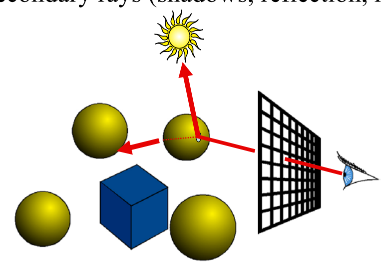
Ray Casting

- For every pixel
  construct a ray from the eye
  - For every object in the scene
    - Find intersection with the ray
    - Keep if closest



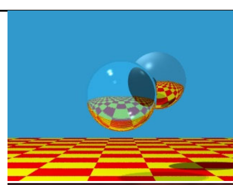
Ray Tracing

- Shade (interaction of light and material)
- Secondary rays (shadows, reflection, refraction



Ray Tracing

- Original Ray-traced image by Whitted



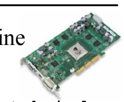
- Image computed using the Dali ray tracer by Henrik Wann Jensen
- Environment map by Paul Debevec

The Graphics Pipeline

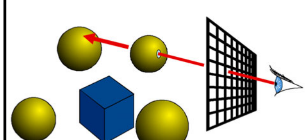
Ray Casting

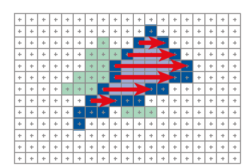
```
For each pixel
    For each object
      Send pixels to scene
```

Rendering Pipeline



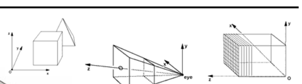
```
For each triangle
    For each projected pixel
      Project scene to pixels
```

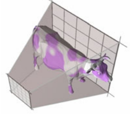


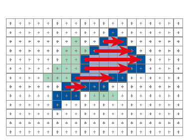


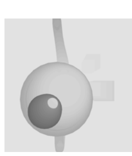
The Graphics Pipeline

- Transformations
- Clipping
- Rasterization
- Visibility

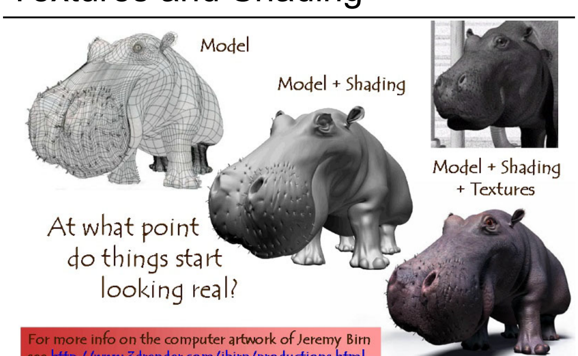








Textures and Shading



For more info on the computer artwork of Jeremy Birn
see http://www.3drender.com/jbirn/productions.html

Shadows

Figure 12. Frame from *Luxo Jr.*

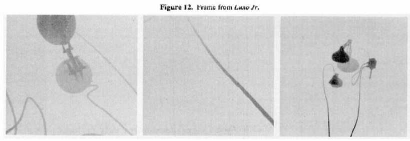
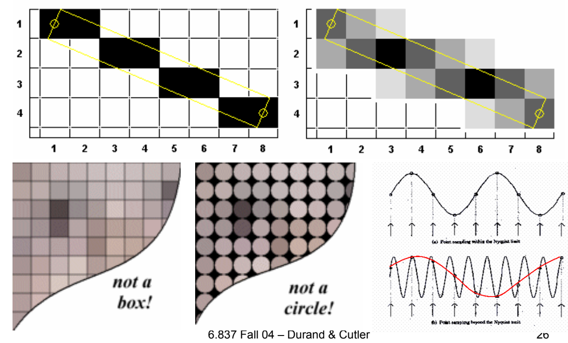
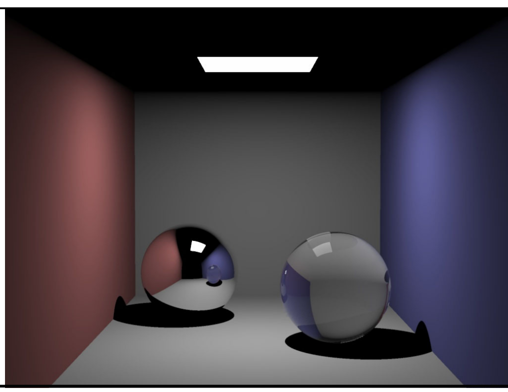


Figure 13. Shadow maps from *Luxo Jr.*

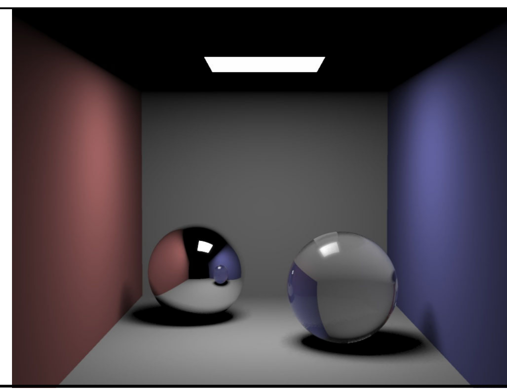
Sampling & Antialiasing



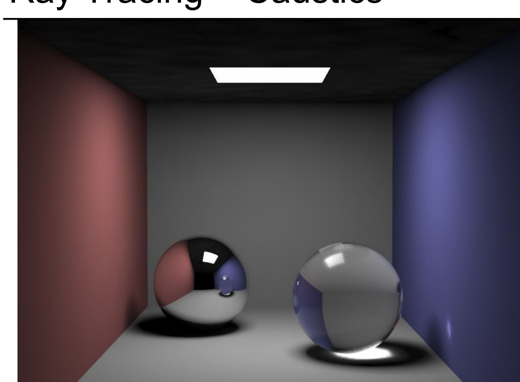
Traditional Ray Tracing



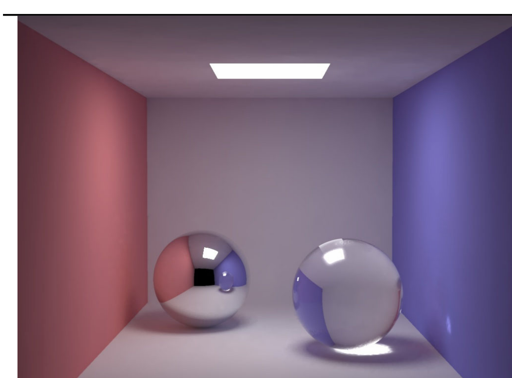
Ray Tracing + Soft Shadows



Ray Tracing + Caustics

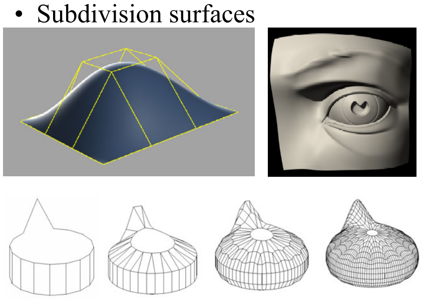


Global Illumination

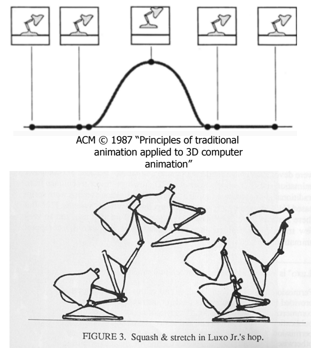


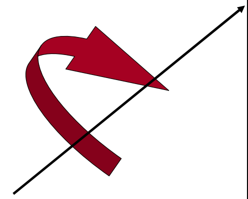
Modeling

- Curved surfaces
- Subdivision surfaces

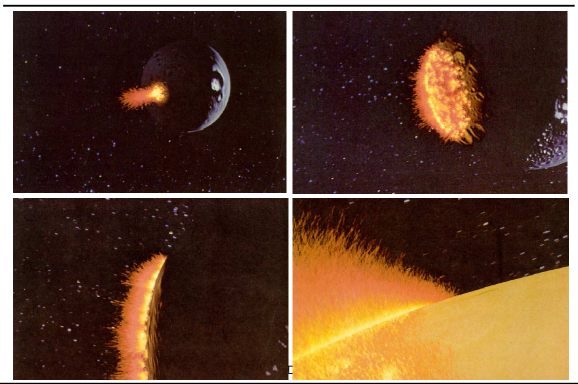



Animation: Keyframing



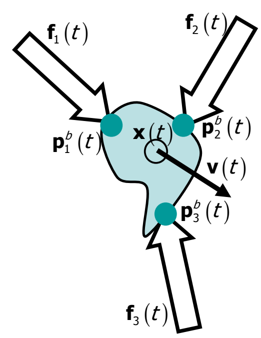


Particle system (PDE)



Rigid Body Dynamics

- Simulate all external forces and torques



Color

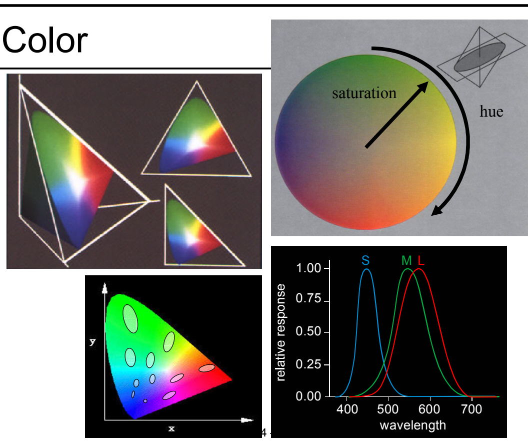


Image-Based Rendering

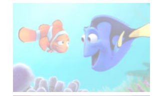
- Use images as inputs and representation
  - E.g. Image-based modeling and photo editing
    Oh, Chen, Dorsey and Durand 2001

Input image New viewpoint Relighting

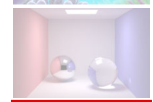
Questions?

Plan

- Introduction



- Overview of the Semester



- Administrivia

- Iterated Function Systems (Fractals)

Administrivia: Prerequisites

- Not enforced
- All assignments are in C++
  - *Optional review/introductory session Monday Sept 13, 7:30-9pm, 4-231*
- Linear Algebra (18.06)
  - vectors, matrices, basis, solving systems of equations
  - *Optional review/introductory session Monday Sept 20, 7:30-9pm, 2-105*
- Algorithms (6.046)
  - Orders of growth, bounds, sorting, trees

Administrivia: Grading Policy

- Assignments: 75%
  - Weekly programming assignments
  - Must be completed individually
  - *No final project this year*
- Quiz: 10%
  - Tuesday, Oct 26 (in class)
- Final Exam: 10%
  - TBA during finals week
- Participation: 5%

Administrivia: Assignments

- Turn in code and executable (Linux or Windows)
- Coding style important
  - Many assignments are cumulative
- Collaboration policy:
  - You can chat, but code on your own
  - Acknowledge your collaboration!
- Late policy:
  - Due Wednesday @ 11:59pm
  - Penalized 25% per day late
  - Extensions only considered if requested 1 week before due date

"Create Your Own Assignment"

- Last assignment, ~ 1 week effort
- Extension of previous assignment *OR* Exploration of other topic discussed in class
- Suggestions throughout the semester
- We'll review your proposal to make sure the scope is appropriate

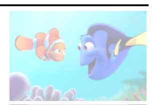
Administrivia: Lab & Office Hours

- http://graphics.csail.mit.edu/classes/6.837/F04/
- Fredo
  - Tuesday 6-7pm in W20-575
- Barb
  - Wednesdays 6-8pm in W20-575
- Rob
  - Wednesday 8-11pm in W20-575
- Send email to make an appointment for some other time

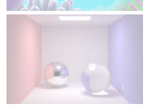
Questions

Plan

- Introduction



- Overview of the Semester



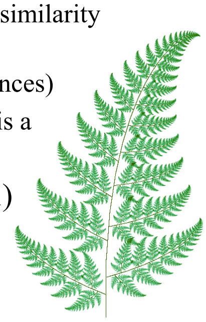
- Administrivia

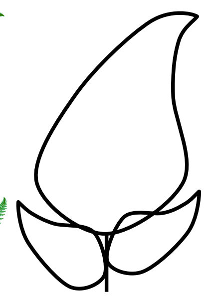
- Iterated Function Systems (Fractals)

Iterated Function Systems (IFS)

- Capture self-similarity
- Contraction (reduce distances)
- An attractor is a fixed point

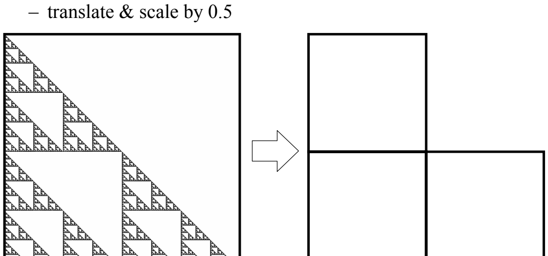
$$A = \bigcup f_i(A)$$





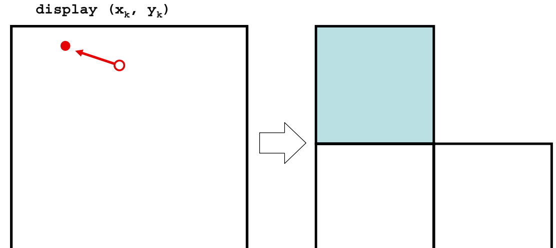
Example: Sierpinski Triangle

- Described by a set of n affine transformations
- In this case, $n = 3$
  - translate & scale by 0.5



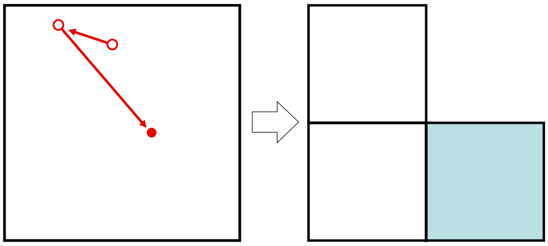
Example: Sierpinski Triangle

```
for "lots" of random input points (x_0, y_0)
   for j=0 to num_iters
      randomly pick transformation i
         (x_k+1, y_k+1) = f_i (x_k, y_k)
   display (x_k, y_k)
```



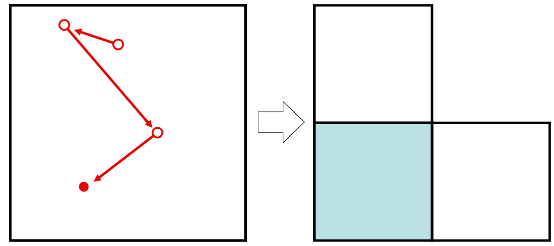
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



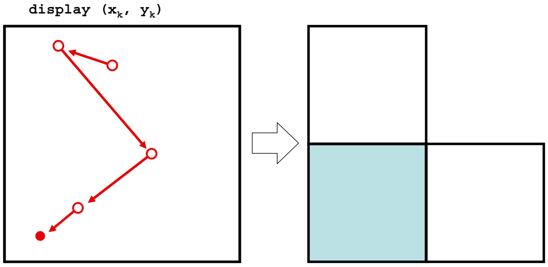
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



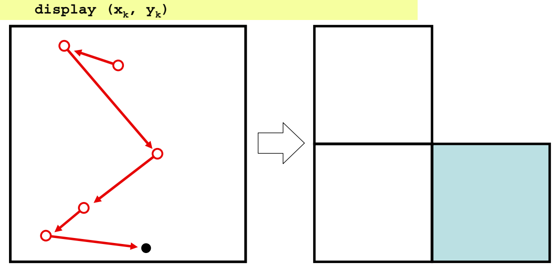
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



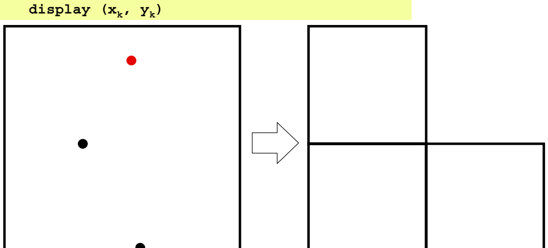
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



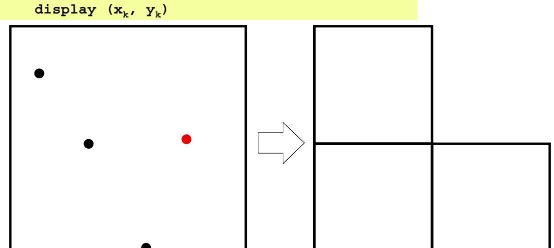
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



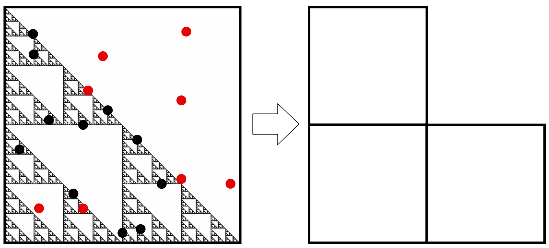
Example: Sierpinski Triangle

for "lots" of random input points (x_0, y_0)
  for j=0 to num_iters
    randomly pick transformation i
      $(x_{k+1}, y_{k+1}) = f_i(x_k, y_k)$
  display (x_k, y_k)



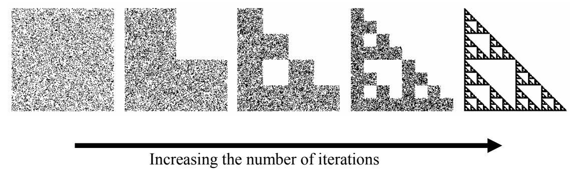
Example: Sierpinski Triangle

```
for "lots" of random input points (x_0, y_0)
    for j=0 to num_iters
        randomly pick transformation i
            (x_k+1, y_k+1) = f_i (x_k, y_k)
    display (x_k, y_k)
```

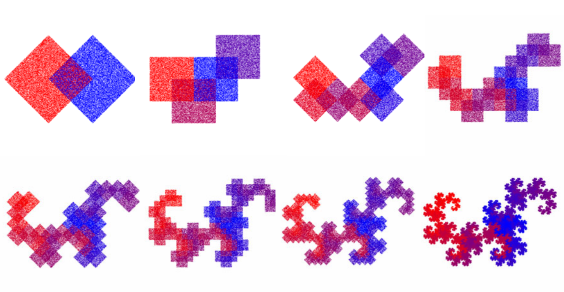


Example: Sierpinski Triangle

```
for "lots" of random input points (x_0, y_0)
    for j=0 to num_iters
        randomly pick transformation i
            (x_k+1, y_k+1) = f_i (x_k, y_k)
    display (x_k, y_k)
```

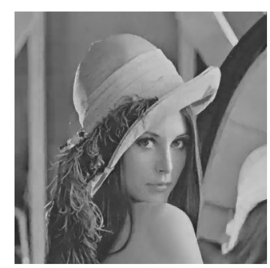


Another IFS: The Dragon



Application: Fractal Compression

- Exploit the self-similarity in an image



Compressed using Fractal Photo Lab

Assignment 0: IFS

- Get familiar with:
  - C++ environment
  - Vector, Matrix & Image classes
- Due Wednesday Sept 15 at 11:59pm
- Optional C++ review/introductory session Monday Sept 13, 7:30-9pm, 4-231
- http://graphics.lcs.mit.edu/classes/6.837/F03/

Questions?