CS-184: Computer Graphics

Lecture #1: Introduction, Overview,
and Image Basics

Prof. James O'Brien
University of California, Berkeley

V2013-S-01-1.0

Today

- Introduction and Course Overview

- ~~Assignments #1 and #2~~
  - Will post on Monday

- Digital Images

The Subject: Computer Graphics

- Computer Graphics:
  - Using computers to generate and display images

- Issues that arise:
  - Modeling
  - Rendering
  - Animation
  - Perception
  - Lots of details...

Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
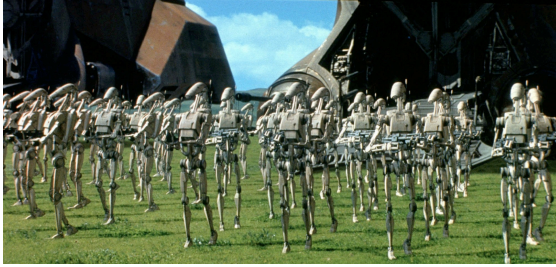 - Simulation
  - Analysis
  - Design
  - Others...

Computer Graphics

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  - Movies
  - Video Games
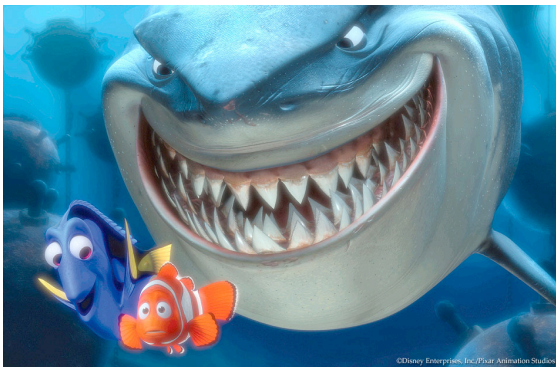 - Simulation
  - Analysis
  - Design
  - Others...

From *Star Wars Episode 1*, Lucasfilm Ltd.

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Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
  - Simulation
  - Analysis
  - Design
  - Others...

©Disney Enterprises, Inc./Pixar Animation Studios

From *Finding Nemo*, Pixar Animation Studios

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Computer Graphics

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  - Movies
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  - Simulation
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  - Others...

From Halo 4, 343 Industries

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Computer Graphics

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  - Video Games
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  - Analysis
  - Design
  - Others...

Game footage recorded from Xbox 360 version of
Star Wars: The Force Unleashed

Game footage copyright 2008 LucasArts, Inc.
Used with permission.

From *Star Wars: The Force Unleashed* by Lucas Arts

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Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
  - Simulation
  - Analysis
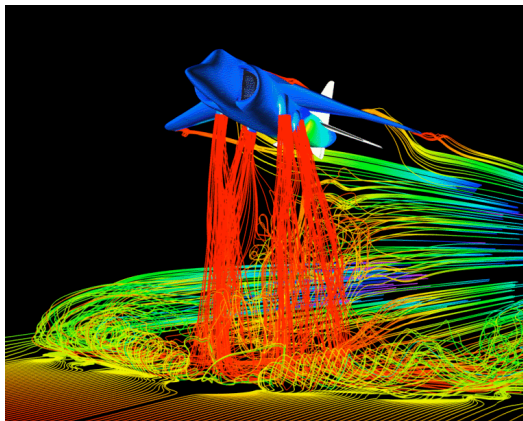 - Design
  - Others...

From America's Army

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Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
  - Simulation
  - Analysis
  - Design
  - Others...

Image from CAE Inc.

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Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
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  - Analysis
  - Design
  - Others...

Carlo Sequin

Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
  - Simulation
  - Analysis
  - Design
  - Others...

Fluid simulation w/ NASA FAST

Computer Graphics

- Applications (in other words, why we care)
  - Movies
  - Video Games
  - Simulation
  - Analysis
  - Design
  - Others...

Sucker Punch **Copyright 2011 Warner Bros**
Visual effects by Moving Picture Company

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Course Topics

- Image representation and manipulation

- 2D and 3D drawing algorithms

- Object representations

- Rendering
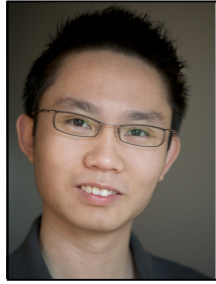
- Animation

- Interaction techniques

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People

James O'Brien   Jiamin Bai   Bandon Wang

Send class related email to
cs184@imail.eecs.berkeley.edu

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Contact Information

- Class web site:
  - http://inst.eecs.berkeley.edu/~cs184
  - Handouts assignments, *etc.* will be posted there
  - Lecture notes posted there (*hopefully*) before classes
- Discussion group:
  - Piazza discussion group
  - Email: cs184-f11@googlegroups.com
  - Not reading discussion group... bad idea
- Staff email addresses, office hours, etc on website

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Computing Resources

- Class accounts handed shortly

- Can also use CS Labs

  - Linux
  - Windows
  - Mac

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Text Book
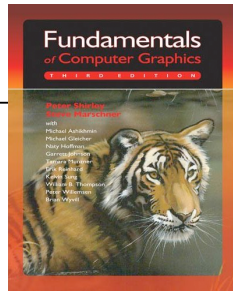
- *Fundamentals of Computer Graphics*
    by P. Shirley, S. Marschner, et al.

  * Get the current version

- Also handouts and other supplemental material will be provided

- See other books listed in course information handout

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Grading

- Assignments: 40%
  - Mix of written and programing
  - Average 1 or 2 weeks to do them
- Final Project: 25%
  - Presentation: Wednesday, May 1, 2013, 11:00am - 2:00pm
- Midterm: 15%
  - Monday, March 18, 2013, 10:30am-12:00pm
- Final: 20%
  - Tuesday, May 14, 2013, 3-6pm

- Check *now* for conflicts!

Prerequisites

- You must know how to program C or C++

  - Big final project, several programing assignments
  - No hand holding
- Data structures (CS61B)
- Math: linear algebra, calc, trig

Waitlist

- Might be able to add an extra section.
- Quite a few people will drop
- Hopefully everyone will fit...

Class Participation

- Reasons to participate
  - More fun for me and you
  - You learn more
  - I won't give stupid little annoying quizzes in class
- How to participate
  - Ask questions
  - Make comments
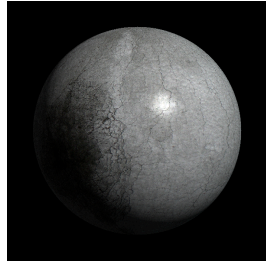- Stupid questions/comments
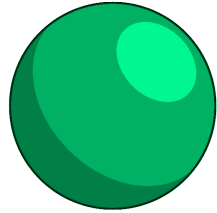 - That's okay

Assignment: Shading
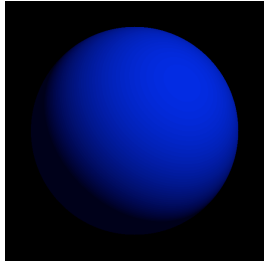
Diffuse Only
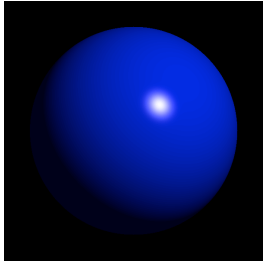
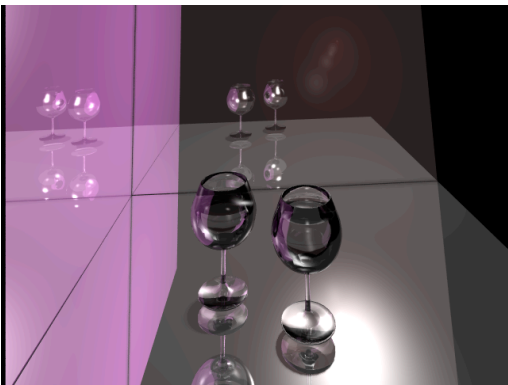Diffuse & Specular

Diff. & Spec. & Texture

Diff. & Spec. & Texture

Toon Shading
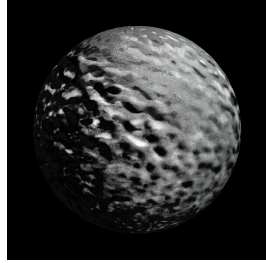
Bump Mapping

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Assignment: Ray Tracing
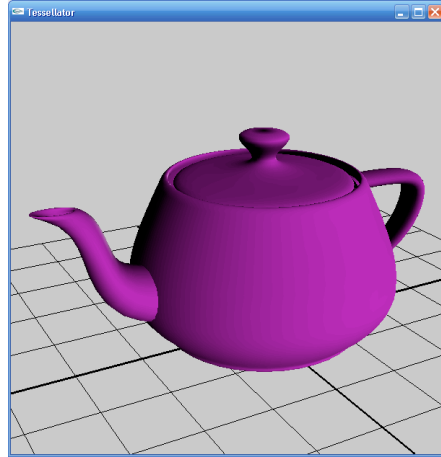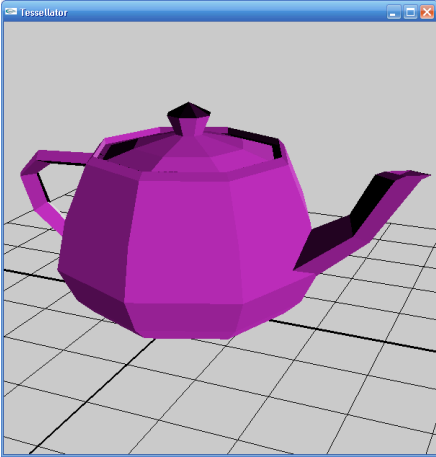
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Assignment: Parametric Surfaces

[Ritchie & Cho, F08]

Final Project: Open Ended

Your image/animation/game here!

Academic Honesty

- If you use an external resource cite it clearly!

- Don't do things that would be considered dishonest... if in doubt ask.

- Cheating earns you:
  - An 'F' in the class and
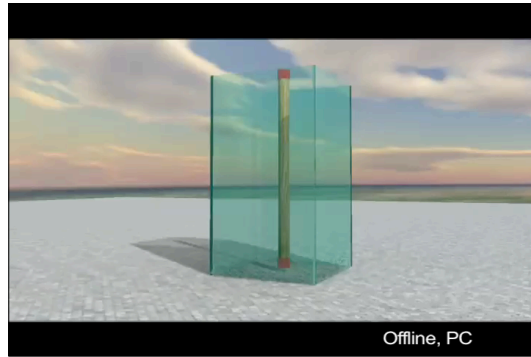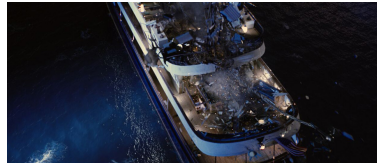 - Getting reported to the University
  - No exceptions.

Questions?

My research

- Simulation

Offline, PC

With Eric Parker

My research

- Simulation

Cloth Draping

With Huamin Wang
and Ravi Ramamoorthi

My research

- Simulation

With Rahul Narain and
Armin Samii

Adaptive Anisotropic Remeshing for Cloth Simulation

Rahul Narain, Armin Samii, James F. O'Brien
University of California, Berkeley

SIGGRAPH Asia 2012

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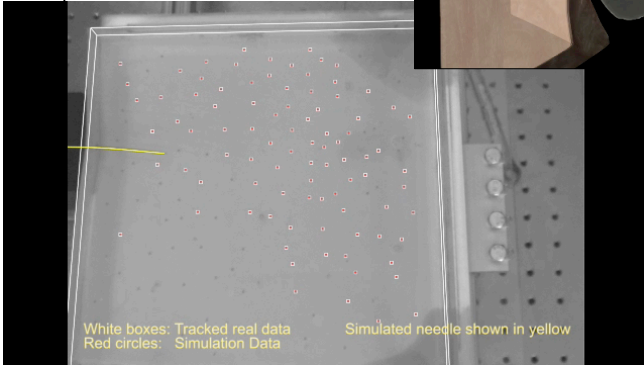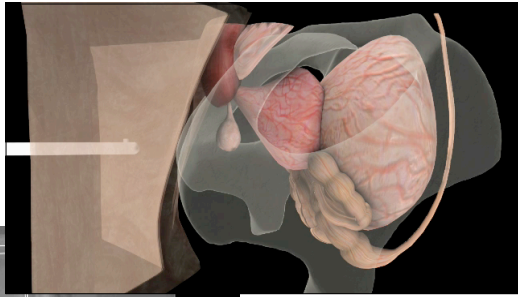# My research

- Simulation

With Rahul Narain and
Tobias Pfaff

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My research

- Simulation

With Nuttapong Chentanez,
Ron Alterovitz, Daniel Ritchie,
Lita Cho, Kris K. Hauser,
Ken Goldberg, and
Jonathan R. Shewchuk

White boxes: Tracked real data   Simulated needle shown in yellow
Red circles: Simulation Data

My research

- Simulation   With Adam Kirk
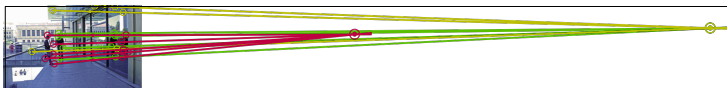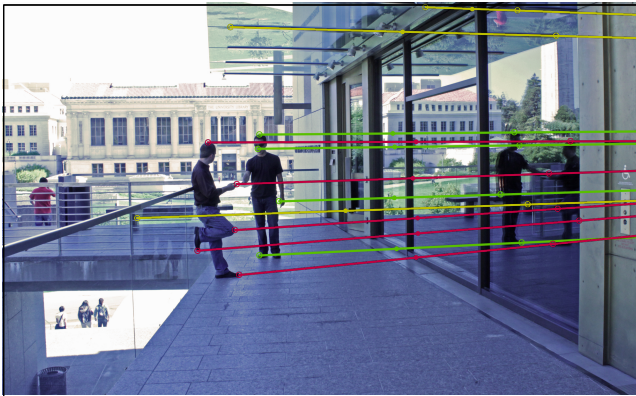
My research

- Forensics

With Hany Farid
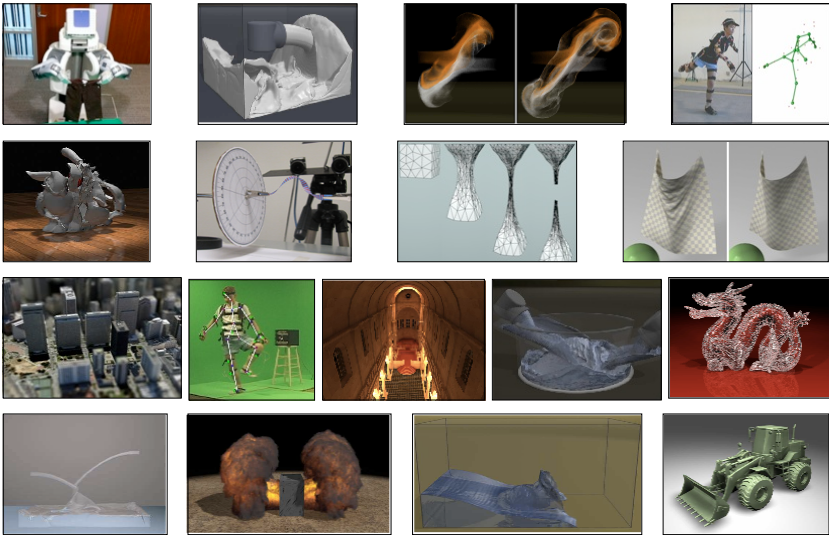
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My research

- Forensics

With Hany Farid

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My research

See my webpage for more information and other projects...

Images

- Something that represents a *pattern of light* that will be *perceived* by something

- Computer representations
  - Sampled (pixel based)
  - Object based
  - Functional

Images
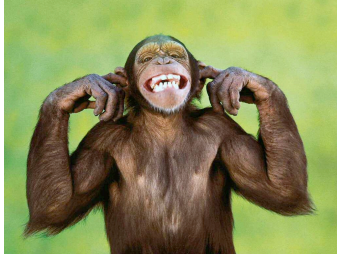
- Something that represents a *patten of light* that will be *perceived* by something

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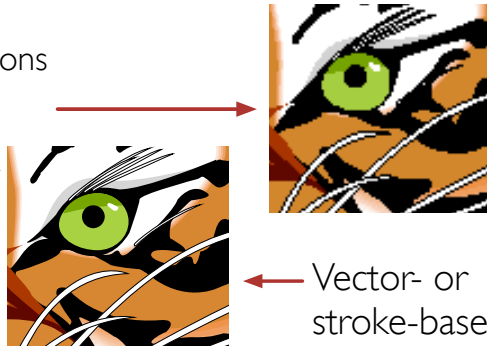 - Object based
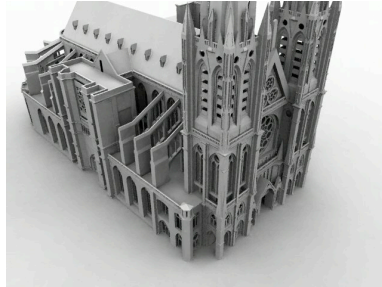 - Functional

PS Type 1 font ⟶ A

⟵ Vector- or stroke-based

Images

- Something that represents a *patten of light* that will be *perceived* by something

- Computer representations

  - Sampled (pixel based)
  - Object based
  - Functional

Well, this *used* to be in an object based representation…

Okan Arikan

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Images

- Something that represents a *patten of light* that will be *perceived* by something

- Computer representations

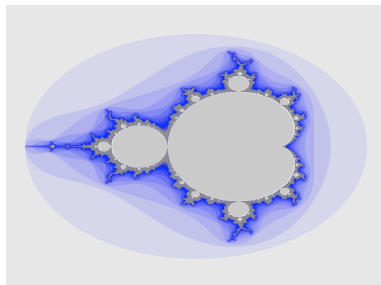 - Sampled (pixel based)
  - Object based
  - Functional

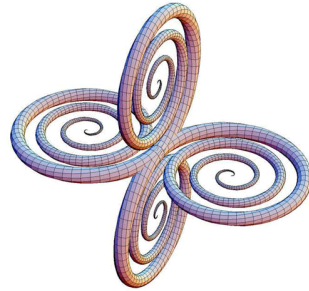Mandelbrot Fractal Plot by Vincent Stahl

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Images

- Something that represents a **patten of light** that will be **perceived** by something

- Computer representations

  - Sampled (pixel based)
  - Object based
  - Functional

  Function→**Polygons**→**Pixels**

  Think about making edits...

"Spiral Crossed" by Sandor Kabai
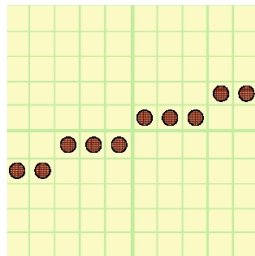
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Storing Images

- Object and Function representations basically arbitrary ...later...

- Raster Images
  - 2D array of memory
  - Pixels store different things
    - Intensity
    - RGB color
    - Depth
    - Others...
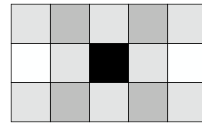 - May be mapped to special HW

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Storing Images

- Object and Function representations basically arbitrary ...later...

- Raster Images
  - 2D array of memory
  - Pixels store different things
    - Intensity (scalar value, *e.g.* float, int)
    - RGB color (vector value)
    - Depth
    - Others...
  - May be mapped to special HW

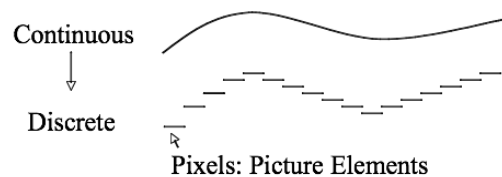| 0.25	0.5	0.25	0.5	0.25
1	0.25	0	0.25	1
0.25	0.5	0.25	0.5	0.25

Stephen Chenney

Discretization

- Real world and "object" representations are continuous.

- Raster images have discrete pixel *locations* and discrete pixel *values*

Continuous → Discrete

Pixels: Picture Elements

Stephen Chenney

- We will see problems from this soon...

Monitor Intensity and Gamma

Monitors convert **pixel value into intensity level**

- 0.0 maps to zero intensity = black (well not quite)
- 1.0 maps to full intensity = white

Monitors are not linear

- 0.5 does not map to "halfway" gray, (e.g. 0.5 might map to 0.217)
- Nonlinearity characterized by exponential function
$$I = a^\gamma$$
  where I = displayed intensity and a = pixel value (between 0 and 1)
- For many monitors γ is near 2 (often between 1.8 and 2.2)

Determining Gamma $I = a^\gamma$

Suppose I know displayed intensity of a patch $I = 0.5$
$$0.5 = a^\gamma$$

Let viewer adjust pixel value a of nearby patch until match
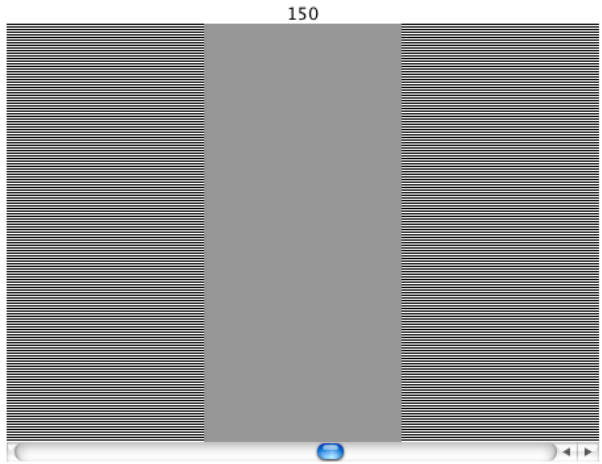$$\gamma = \frac{\ln 0.5}{\ln a}$$

Patch of known $I = 0.5$	Viewer adjusts pixel values a until this patch visually matches

How do we make a patch of known intensity?

Determining Gamma

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http://www.cs.cornell.edu/Courses/cs4620/2008fa/homeworks/gamma.htm
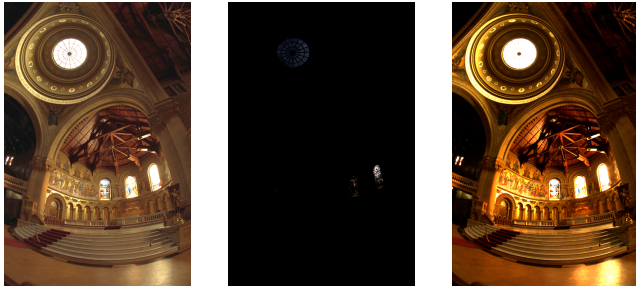
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High Dynamic Range Images

Jack Tumblin

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High Dynamic Range Images

- Dynamic range of the human eye >> range of standard monitors

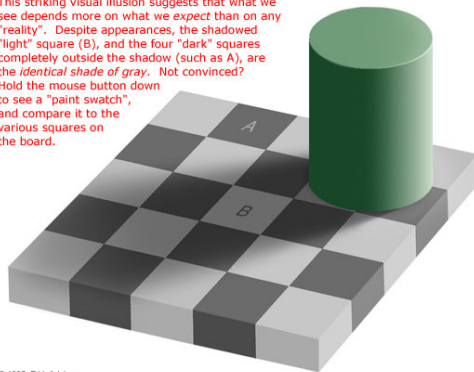- Eye adjusts as we look around

Paul Debevec and Jitenrda Malik

Perception

- The eye does not see intensity values...

This striking visual illusion suggests that what we see depends more on what we *expect* than on any "reality". Despite appearances, the shadowed "light" square (B), and the four "dark" squares completely outside the shadow (such as A), are the *identical shade of gray*. Not convinced? Hold the mouse button down to see a "paint swatch", and compare it to the various squares on the board.
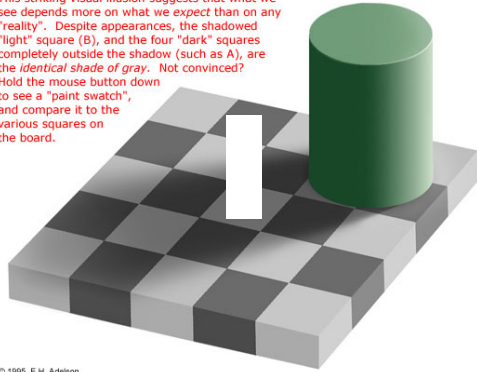

© 1995, E.H. Adelson

Perception

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© 1995, E.H. Adelson
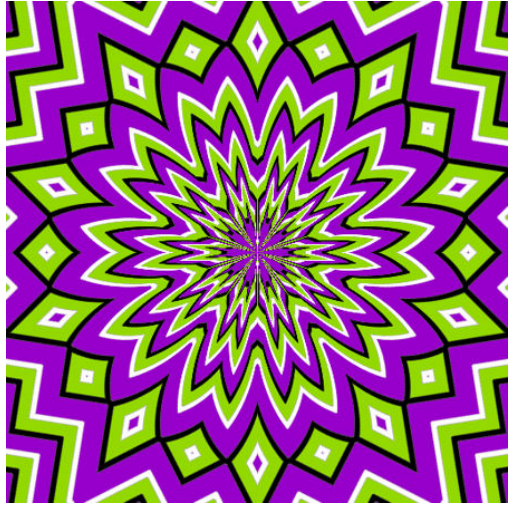
Perception

- The eye does not see intensity values...

Perception

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Perception

Keep your eyes on the cross
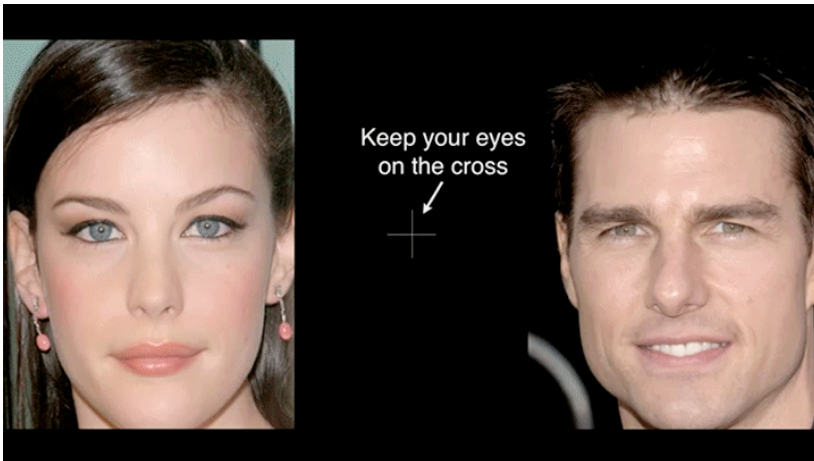
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Storing Images

- Digital file formats
  - TIFF, JPEG, PNG, GIF, BMP, PPM, *etc.* ...
  - Compression (lossless and lossy)
  - Interlaced (*e.g.* NTSC television)
  - Tend to be complex... use libraries
- Mapping to memory