Computer Graphics

What Powers Instagram?
Announcement

- Quiz 3 Today!
- Please go to TA’s office hours!
- The best way to learn is to practice, to get hands-on experience!
- And Ask questions!
Computer Graphics

A small detour...
What is your favorite graphics applications?
What is Computer Graphics?

- Different from graphic design: illustration, etc.
- Creation, manipulation, viewing of models
- Physical simulation, human–computer interfaces
- Building art tools
- Games
- Animation
William Fetter of Boeing coins the term **computer graphics** from his human factors cockpit drawings (1960)
Entertainment

https://www.youtube.com/watch?v=CG2T7upUVAk
How far we have come
Graphics Applications: Everyday Use
Airflow around a Harrier Jet: NASA
Graphics Applications: Scientific Visualization

3D Vector Fields Visualization

Graphics Applications: Computer Aided Design (CAD)
Design effective Step by Step Assembly Instructions (Maneesh Agrawala et. al.)
This is NOT a new Endeavor: Making Models
This is NOT a new Endeavor: Viewing Models

Rendering, turning a model into an image that can be viewed
Enabling Modern Computer Graphics

- Moore’s Law: every 12–18 months, computer power improves by factor of 2
- Significant advances in graphics chips every 6 months, outrunning CPU chip advance
- Graphics subsystems (GPUs)
  - Offloads graphics processing from CPU to chip designed for doing graphics operations fast
  - NVidia GeForce, ATI Radeon
  - GPUs are being ganged together to make supercomputers
Graphics Basics

- Color: our perception of the various frequencies of light
- Perception is quite subtle: optical illusions
- Our retinas have 3 types of cone cells
  - Respond to red, green and blue
  - How do we see other colors?
- In a computer, color is represented as an RGB value
  - 3 numbers indicating the relative contribution of each
  - Given a scale of 0–255, (255,0,0) represents red
    - full contribution from R
    - No contribution from G or B
Graphics Basics

A. Relative absorption

- B: 420 nm
- G: 530 nm
- R: 560 nm

Wavelength (nm)

B. Color spectrum
Graphics Basics

- Color depth: the amount of data used to represent a color, usually expressed in terms of # of bits
  - HiColor (16-bits)
    - 5 bits used for each number in RGB
    - extra bit sometimes used to represent transparency
  - TrueColor (24-bit)
    - 8 bits used for each number in RGB, giving a range of 0–255
    - More than 16.7 million unique colors
Representing Images

- Pixel: a picture element
- Each pixel is composed of a single color
- Arrange pixels in a 2D array to make an image
- Resolution: # of pixels used in an image
Image Manipulation

- Have you ever edited an image?
- Is this the same as manipulating an image?
- Kerry Fonda 2004 election photo controversy: Composition of 2 different images one of Kerry taken on June 13, 1971, one of Jane Fonda taken in August, 1972
Uses of image manipulation

Image and video retargeting: recomposing the image to fit on different screens, like a cell phone (Bruce Gooch, U of U alum)
What Powers Instagram?
Linear Filters
**Image as a function**

- Treat each image as a function on the plane \( f: \mathbb{R}^2 \rightarrow \mathbb{R} \)
- At a location \((x,y)\), \(f(x,y)\) is the intensity of the position \((x,y)\)
- A color image is three functions paste together, think about it as a vector-valued function
Image as Functions

Credit:
Credit:
Seitz and Szeliski Slides
We work with digital image: points on a grid, every function value is an integer.

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How do you filter away noise in the image?

How do we smooth away noise in an image?
What happens if we reshuffle all pixels in an image?
No change to the histograms: pointwise operations are not affected
Filters reflect spatial information

**Image Filtering**

*Modify* the pixels in an image with a function of local neighborhood of a pixel

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**Linear Filters**

Replace each pixel with an linear combination of its neighbors

*Convolution kernel*: prescription for the linear combination

Why Filter The Image?

- Noise Reduction
- Image Enhancement
- Feature Extraction

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- Noise Reduction
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Mean Filter

Mean Filter: common weights

Median Filter

Replace each pixel value with Median value of its neighbors...

\[ \text{Median}[1,2,3,4,5,6,7] \]
\[ \text{Median}[23, 45, 78, 100, 122] \]
\[ \text{Median}[2,3,4,6] = (3+4)/2 = 3.5 \]
Median Filter

Next: how to create your own image filter?
Next: How did Instagram succeed?
THANKS!

Any questions?

You can find me at 
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http://www.sci.utah.edu/~beiwang/teaching/cs1060.html
Credits

Special thanks to all the people who made and released these awesome resources for free:

- Presentation template by SlidesCarnival
- Photographs by Unsplash