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!

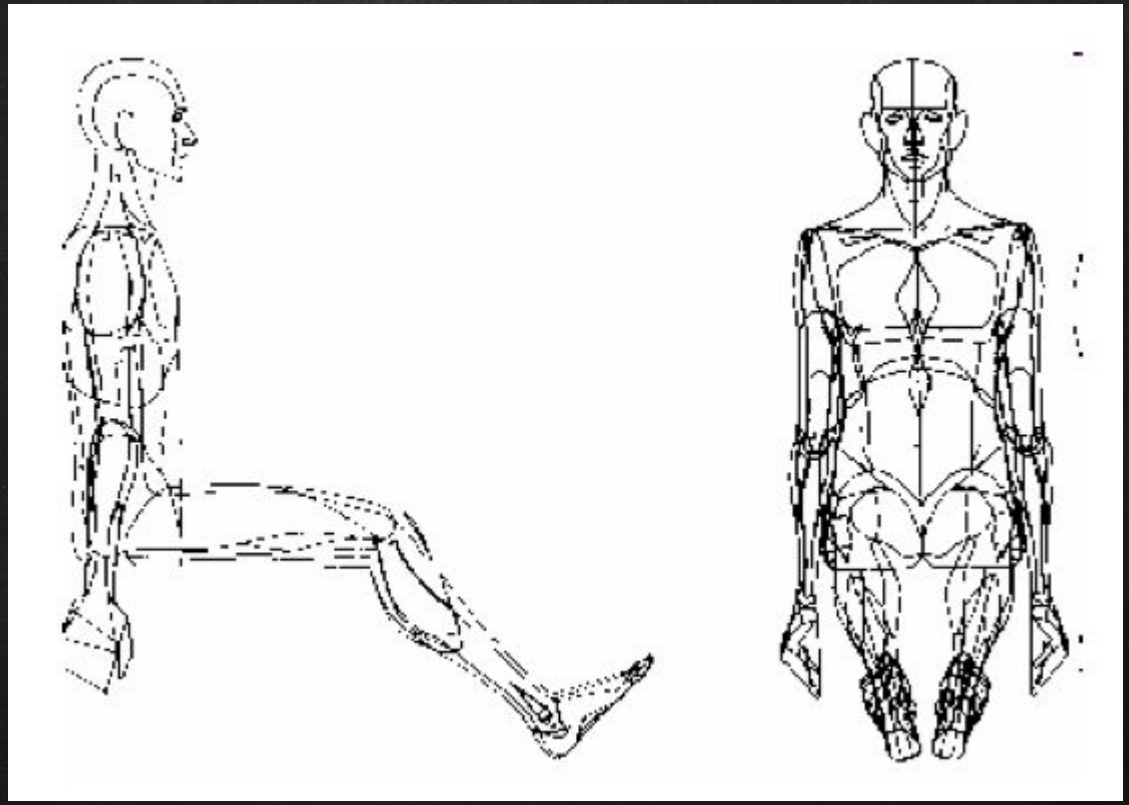
Computer Graphics

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

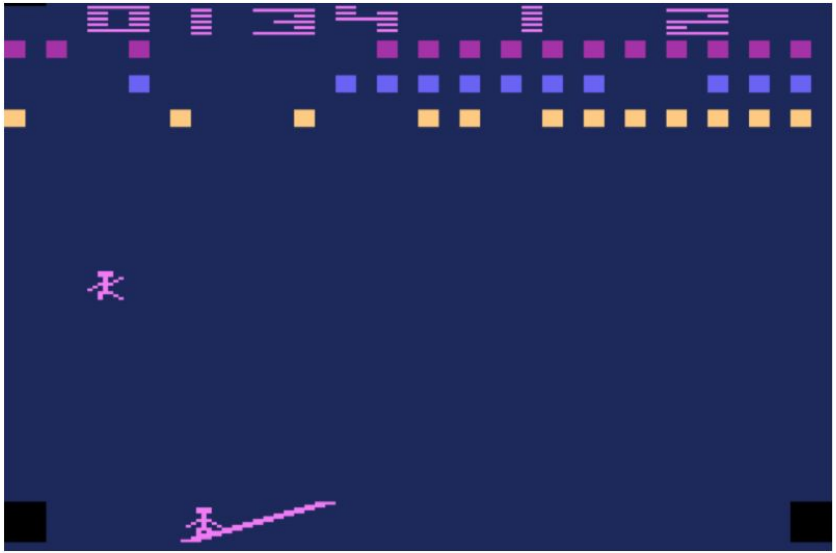


William Fetter of Boeing coins the term computer graphics from his human factors cockpit drawings (1960)

Entertainment

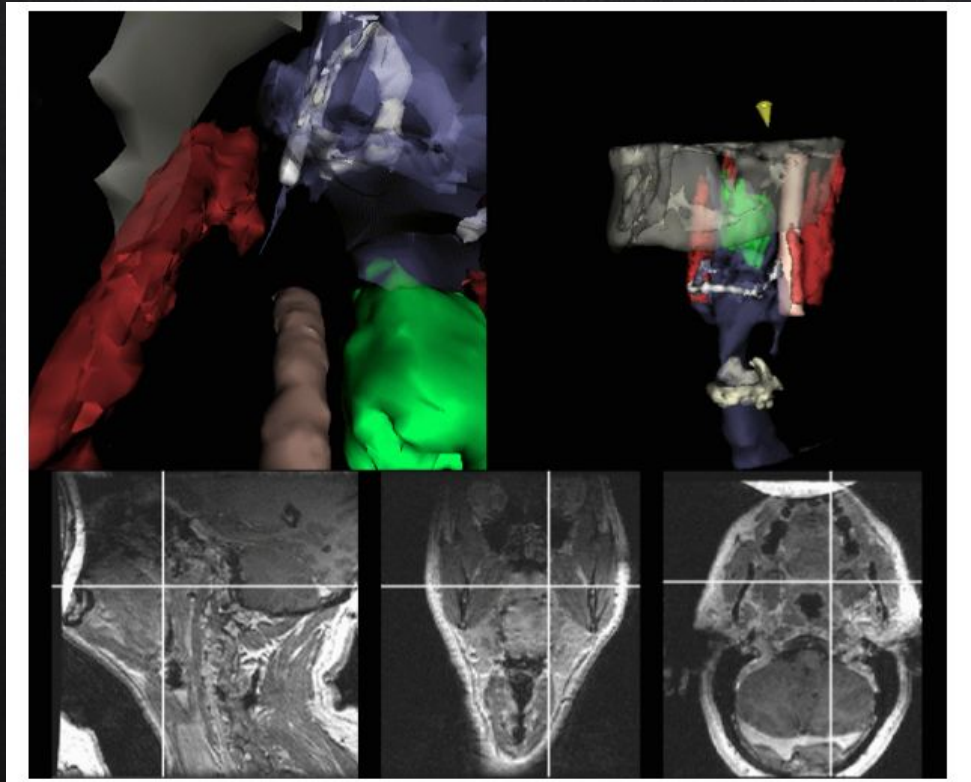
https://www.youtube.com/watch?v=CG2T7upUVAk

How far we have come

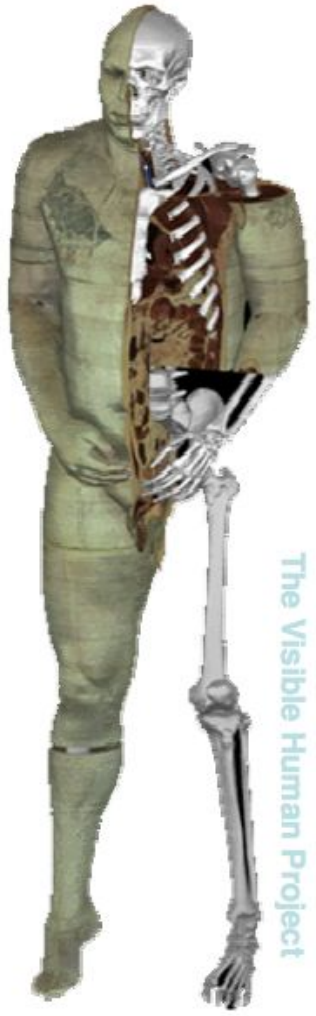


Circus Atari *(Atari)*

Graphics Applications: Medical Visualization

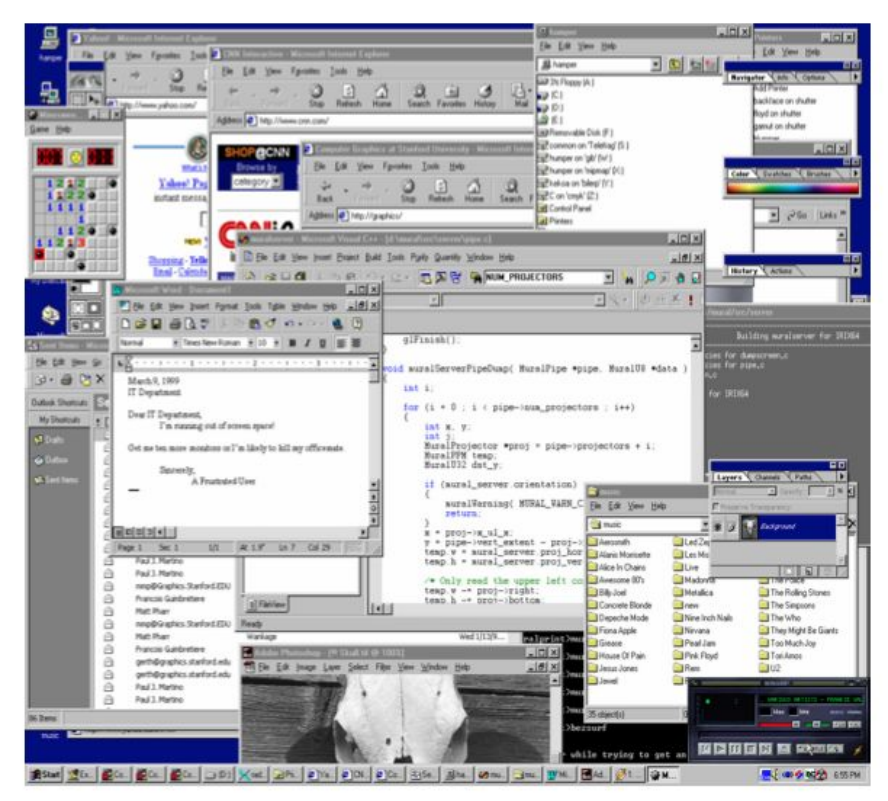


MIT: Image-Guided Surgery Project

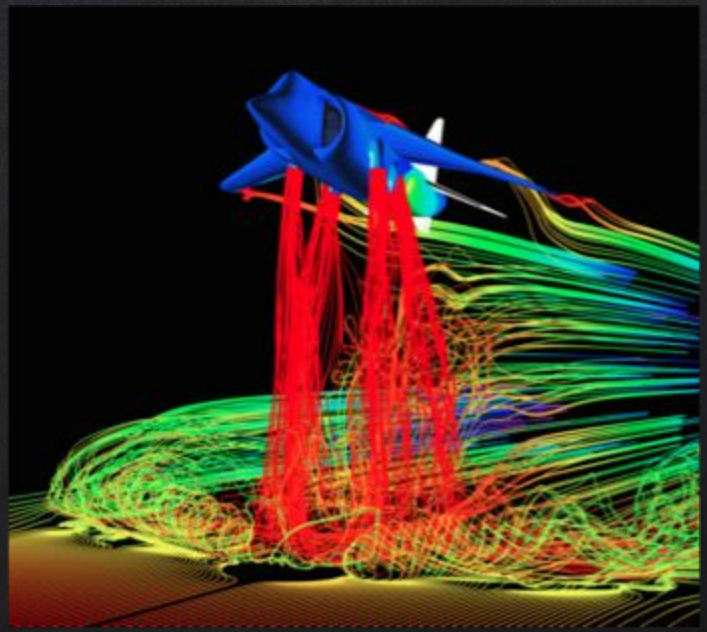


The Visible Human Project

Graphics Applications: Everyday Use

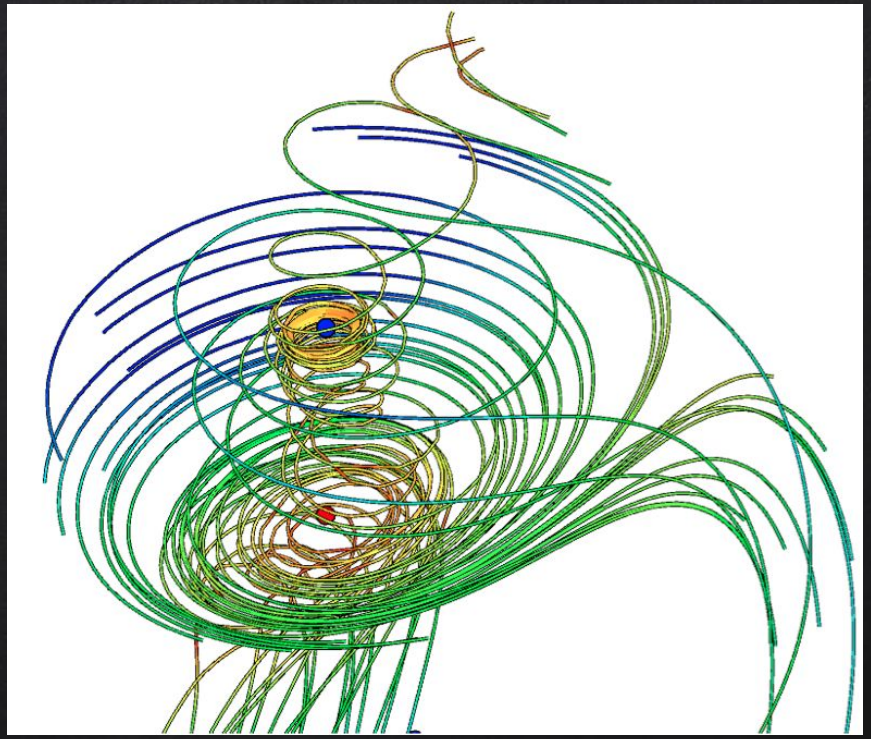


Graphics Applications: Scientific Visualization



Airflow around a Harrier Jet: NASA

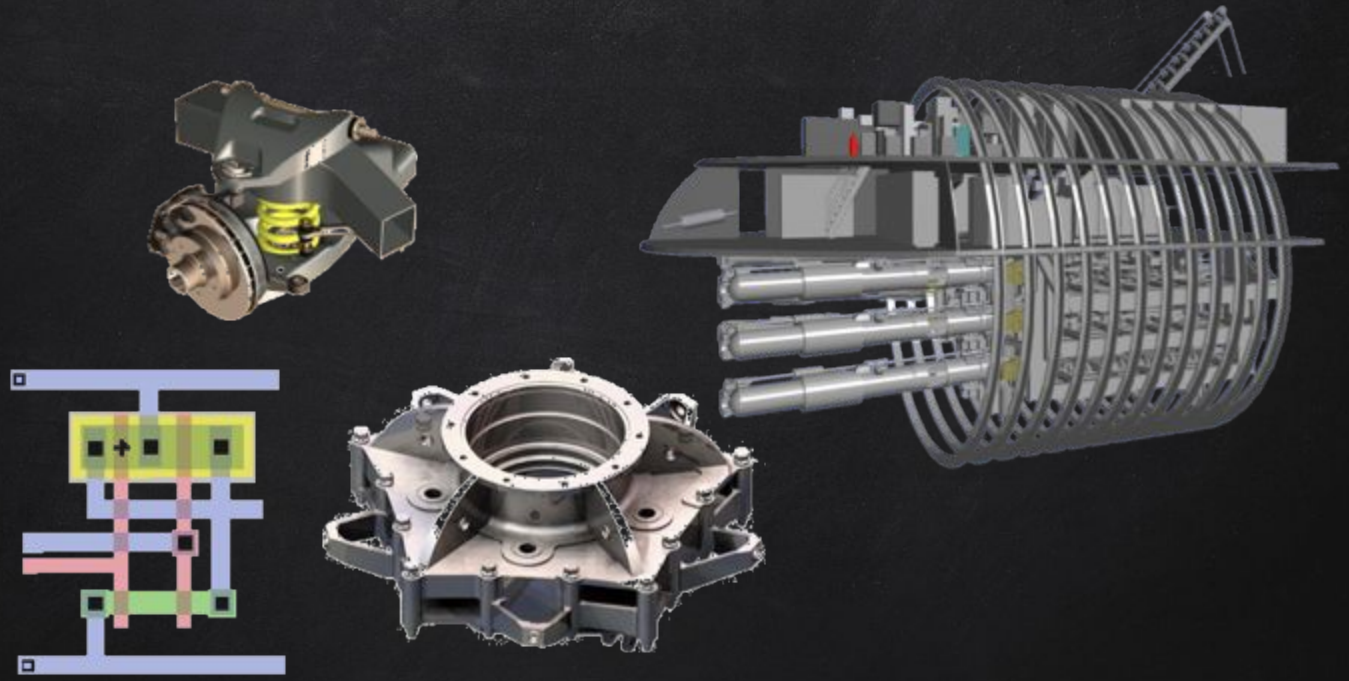
Graphics Applications: Scientific Visualization



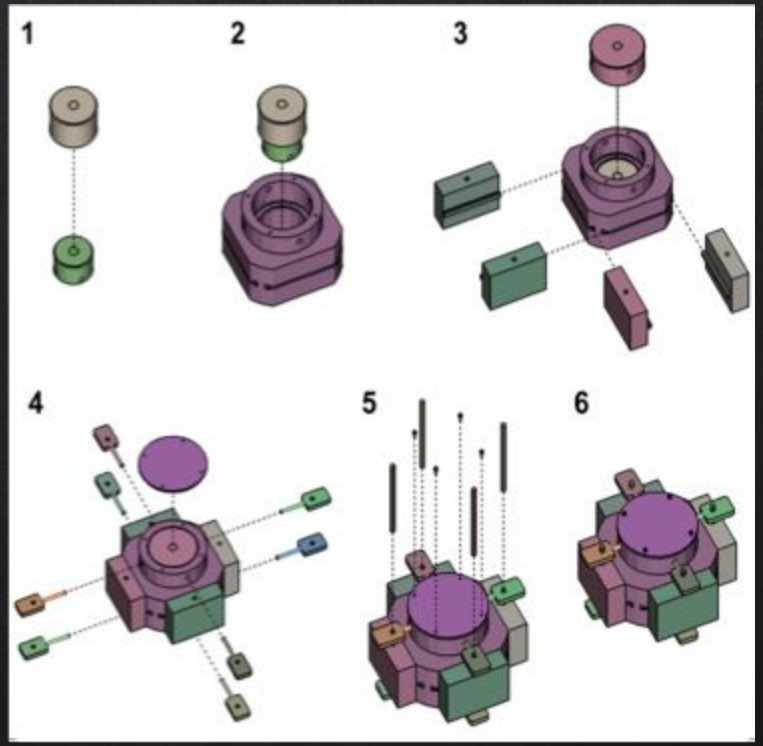
3D Vector Fields Visualization

(Primoz Skraba, Paul Rosen, Bei Wang, Guoning Chen, Harsh Bhatia and Valerio Pascucci 2015)

Graphics Applications: Computer Aided Design (CAD)

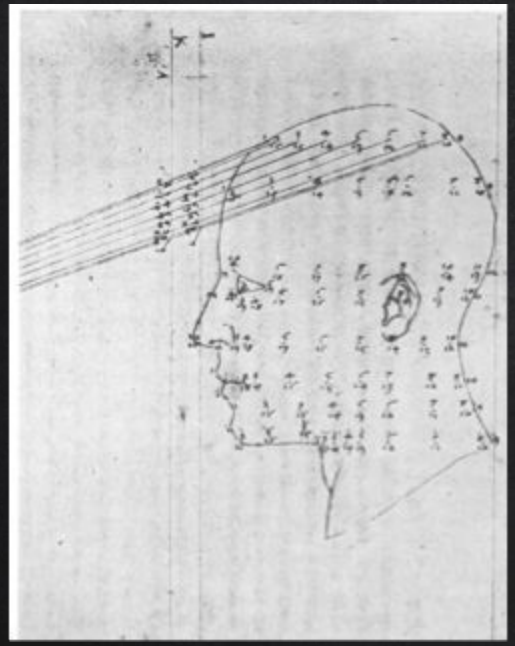


Graphics Applications: Training



Design effective Step by Step Assembly Instructions (Maneesh Agrawala et. al.)

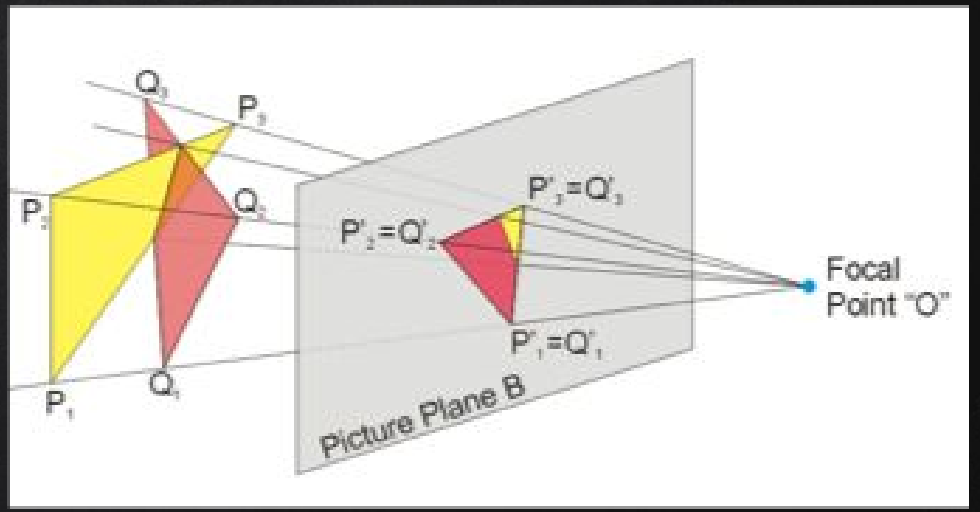
This is NOT a new Endeavor: Making Models



This is NOT a new Endeavor: Viewing Models

Rendering, turning a model into an image that can be viewed

331. Two draughtsmen plotting points for the drawing of a lute in foreshortening, from Dürer's *Underweysung*, 1525.



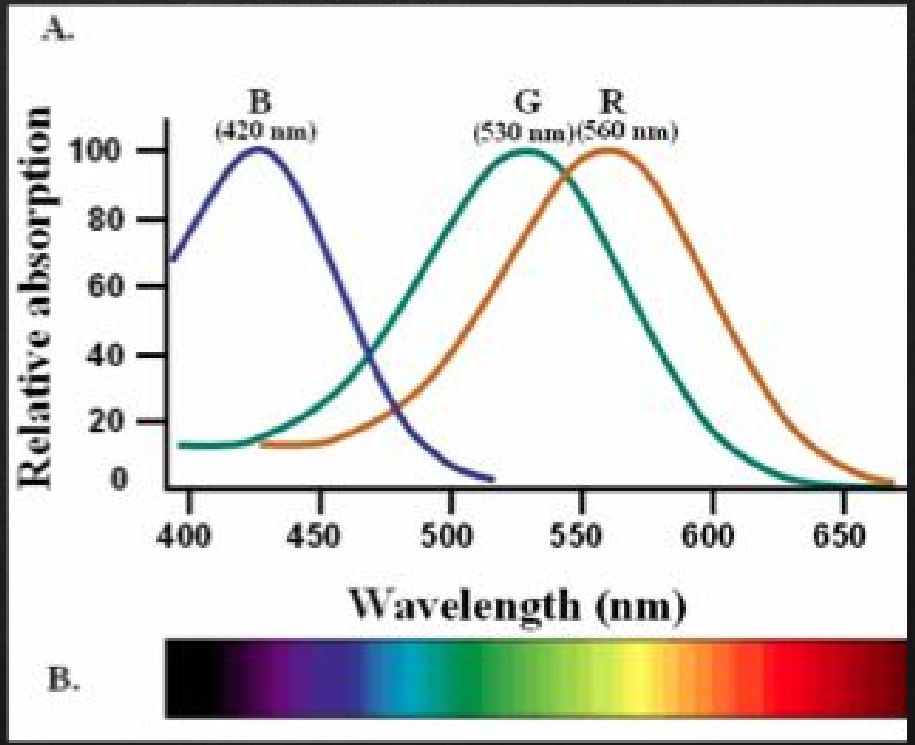
Enabling Modern Computer Graphics

- 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



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

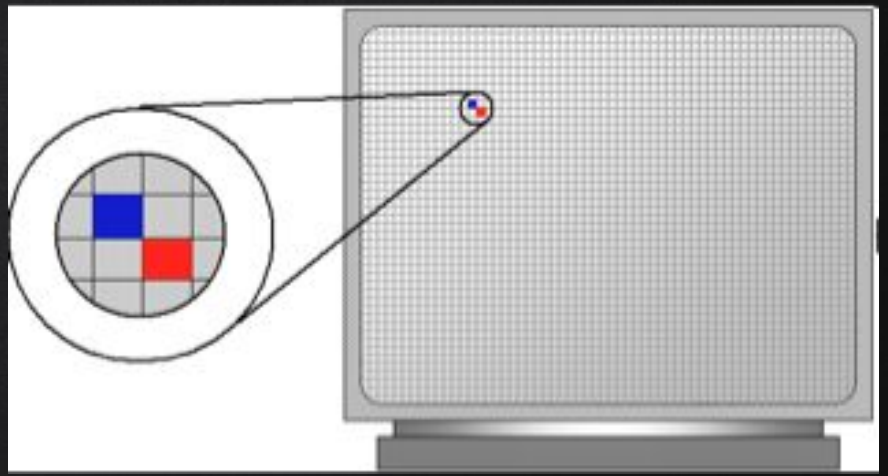


Image Manipulation

- 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

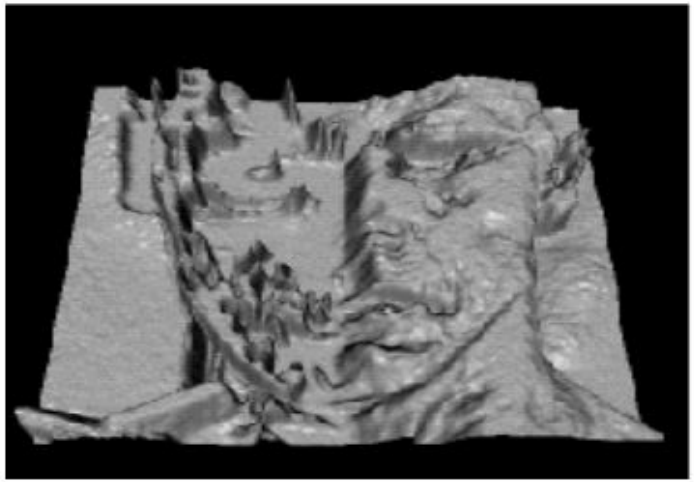
Image as a function

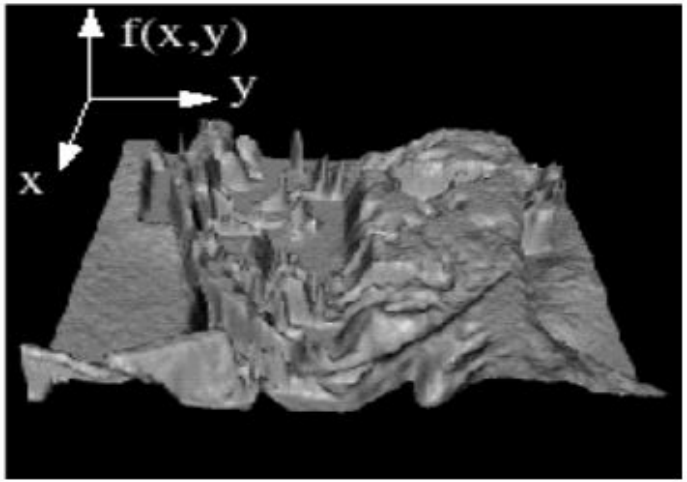
- Treat each image as a function on the plane f: R^2 -> R
- At a location (x,y), f(x,y) is the intensity of the position (x,y)
- A color image is three functions paste together, think about it as a vector-valued function

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

Image as functions

Credit:
http://web.eecs.umich.edu/~jjcorso/t/598F14/files/lecture_0924_filtering.pdf
Credit:
Seitz and Szeliski Slides





Digital Image

We work with digital image: points on a grid, every function value is an integer.

1	2	88	22	23	4
3	4	1	24	25	8
2	6	23	22	28	10
24	8	88	25	30	8
22	88	89	78	32	2
20	24	26	26	20	4

How do you filter away noise in the image?

How do we smooth away noise in an image?

1	2	88	22	23	4
3	4	1	24	25	8
2	6	23	22	28	10
24	8	88	25	30	8
22	88	89	78	32	2
20	24	26	26	20	4

Image Neighborhood

What happens if we reshuffle all pixels in an image?

No change to the histograms: pointwise operations are not affected

Filters reflect spatial information

Credit: http://www.cs.utexas.edu/~grauman/courses/378/slides/lecture4.pdf

Image Filtering

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

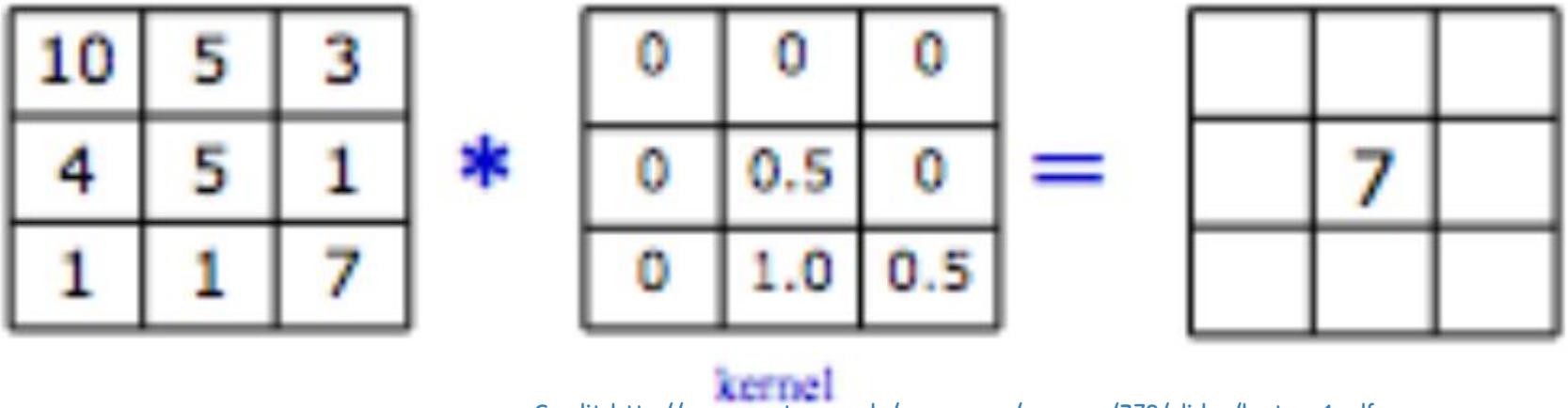
1	2	3
4	5	6
7	8	9

0	0	0
0	5	0
0	0	0

Linear Filters

Replace each pixel with an linear combination of its neighbors

Convolution kernel: prescription for the linear combination



Credit: http://www.cs.utexas.edu/~grauman/courses/378/slides/lecture4.pdf

Why Filter The Image?

- Noise Reduction
- Image Enhancement
- Feature Extraction

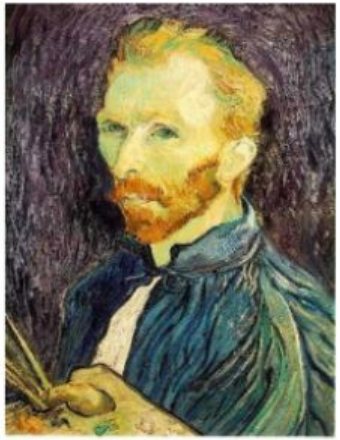
Credit: http://www.cs.utexas.edu/~grauman/courses/378/slides/lecture4.pdf

De-noising

Original

Salt and pepper noise

Super-resolution



In-painting

Image Inpainting, M. Bertalmio et al.
http://www.iua.upf.es/~mbertalmio//restoration.html

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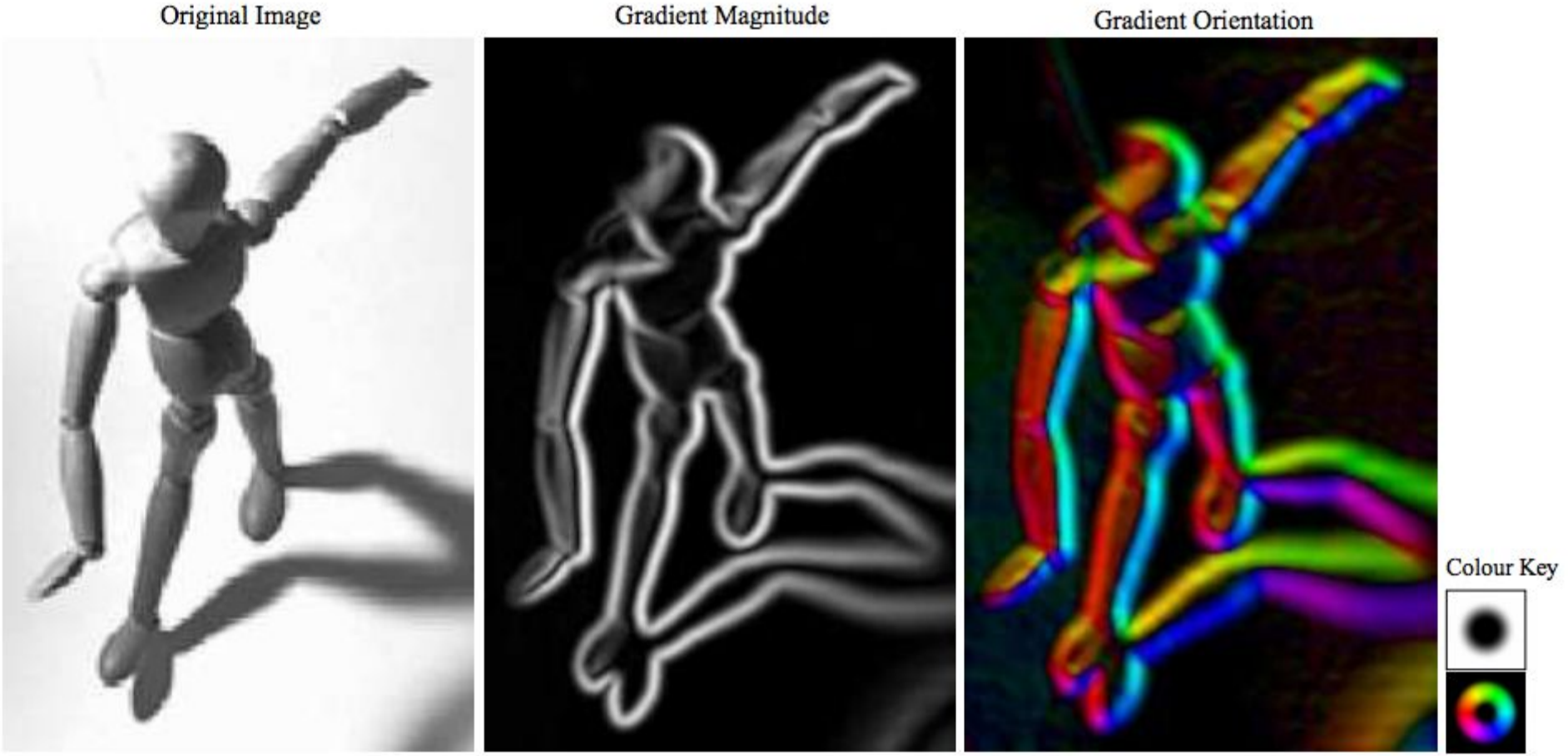
http://www.iua.upf.es/~mbertalmio//restoration.html

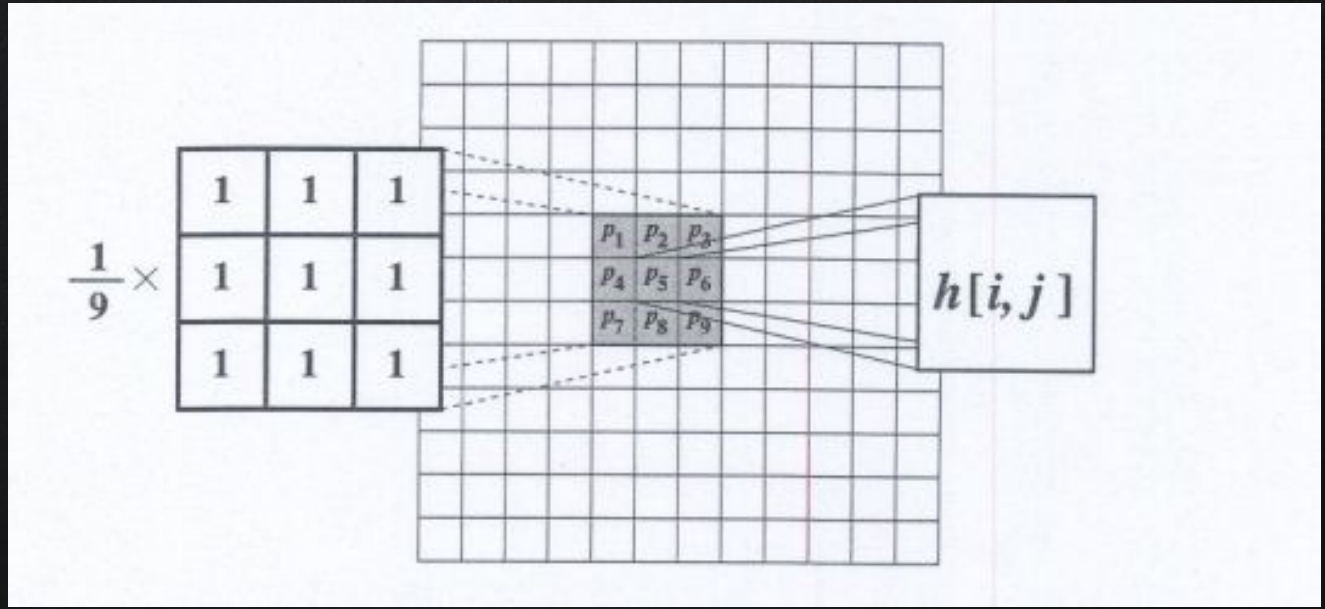
Source: Savarese Slides

Credit: http://web.eecs.umich.edu/~jjcorso/t/598F14/files/lecture_0924_filtering.pdf



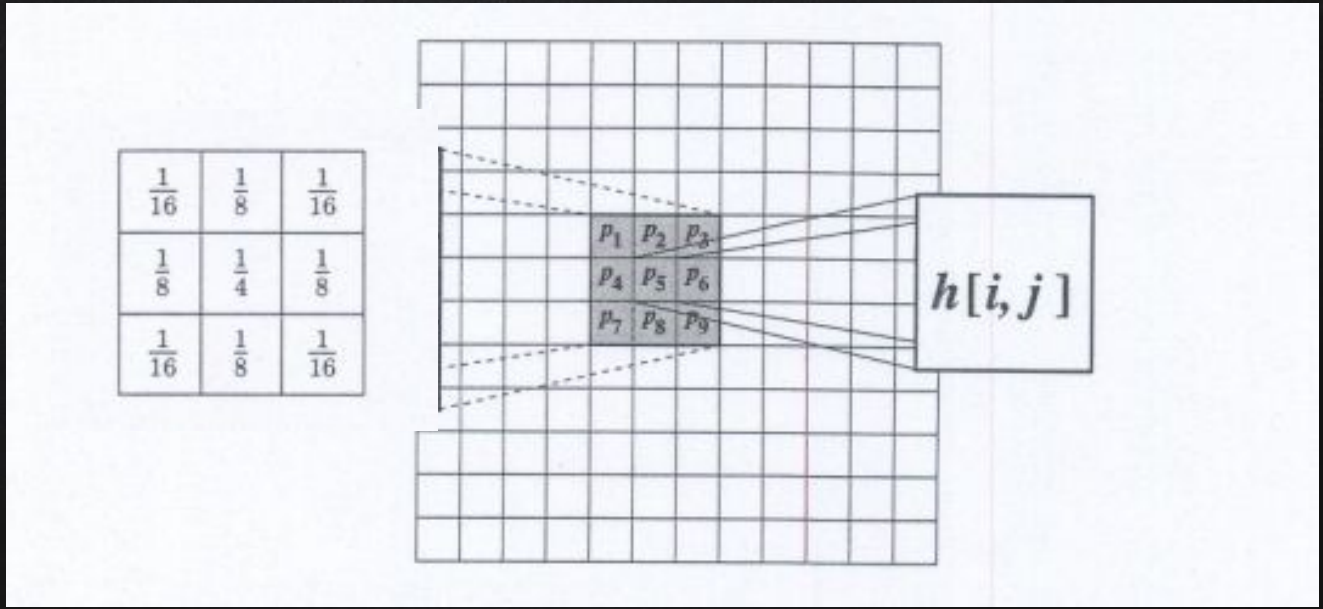
http://www.cs.toronto.edu/~jepson/csc420/notes/linearFiltering.pdf

Mean Filter



http://www.cse.usf.edu/~r1k/MachineVisionBook/MachineVision.files/MachineVision_Chapter4.pdf

Mean Filter: common weights



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Median Filter

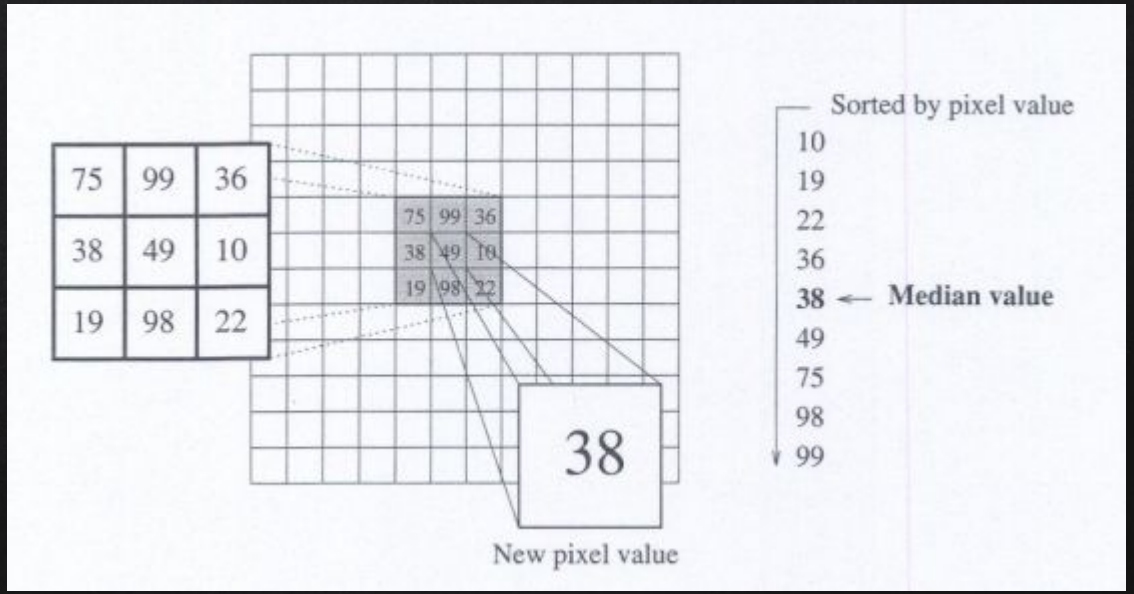
Replace each pixel value with Median value of its neighbors...

Median[1,2,3,4,5,6,7]

Median[23, 45, 78, 100, 122]

Median[2,3,4,6] = (3+4)/2 = 3.5

Median Filter



http://www.cse.usf.edu/~r1k/MachineVisionBook/MachineVision.files/MachineVision_Chapter4.pdf

Next: how to create your own image filter?

Next: How did Instagram succeed?

THANKS!

Any questions?

You can find me at
beiwang@sci.utah.edu

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