Computer Science 1033 – Week 2

INTRODUCTION TO GRAPHICS

How to design a poster

"Think honk if you're a telepath."→ *Unix Fortune*

Overview of This Week's Topics

- Representing/Encoding our World
- Binary System
- Converting Analog Data to Digital Data
- Sampling Images
- Quantizing Images
- Black and White, Colour Images

Textbook Readings

- Understanding Computers
    - Fundamentals of Computers
    - Binary, Hexadecimal, and Other Number Systems
    - Digital Language
- Graphics
    - Pixel Measurements and Resolution
    - Digitized Images

Before computers how did we encode data (i.e. store information about our world)?

- How did we represent the world around us before ~1880?
- How did we represent the world around us after 1900?
- How do we represent our thoughts?
- How do we represent our language?
- How did we SAVE representation of our thoughts before 1980ish?
- How about now?

How did we represent NUMBERS in history?

- How do humans represent cost and quantities?
- How did "the average person" calculate costs before home computers (Still used today)?
- How did we calculate costs before 1950s?
- How did we calculate costs before 1600s?
- Why is our number system base 10? OR how did we calculate costs before 2700BC?

Remember

- _ is a digit place holder
- 987 is a 3 digit number
- BUT it could also be a 8 digit number as follows:
  000000987

If you had to represent the numbers with digit holders, you pad the front with zeros 0:

0	0	0	0	0	9	8	7

How does a computer represent numbers and words and images and sound?

- How does a computer represent numbers?
- How does a computer represent words?
- How does a computer represent images?
- How does a computer represent sound?
- What is DNA and why is Laura mentioning it here? → http://en.wikipedia.org/wiki/Quaternary_numeral_system
- https://www.youtube.com/watch?v=dNtVWPaOzho

Important…

- Basically everything we talk about from now in this course is how a computer encodes/represents stuff!
- Remember computers only understand/speak "**Binary**" → 0 or 1
- Programmers have figured out how to convert our world to something a computer can understand, thus they convert:
  - Words to binary
  - Images to binary
  - Sound to binary
  - Movies to binary
- Something from a former student

Let's try an experiment:

- How could we possibly represent anything with just 0's and 1's? Seems impossible but everyone in this class can do it (if we start small)!
- THE ALIENS ARE COMING, they only speak binary!!! OH NO…Using binary let's represent:

Let's trying using Binary to represent our world!

- Use only 1's and 0's to represent:
  - Over 6 feet tall.
  - People who went to high school the longest in:
    - London
    - Ontario (but not London)
    - Canada (but not Ontario)
    - Outside of Canada
  - People who were born on a Su, M, Tu, W, Th, F, Sa
  - People who were born in Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec
  - People who were born in 1913, 1914, 1915, … 2013
  - Bonus Question:
    - What are the alien's names on The Simpsons ☺ ?

How many items can we represent with Binary Bits? (how many patterns can we make)

- If we have 1 bit →

0
1

Could represent:
-Black and White OR
-True and False

- If we have 2 bits →

00
01
10
11

Could represent:
-Black, Light Gray, Dark Gray, White OR
-DNA Bases OR
-Red, Blue, Yellow and Black

- If we have 3 bits →

000
001
010
011
100
101
110
111

Could represent:
-days of the week but not the months of the year, WHY?
-8 shades of GRAY

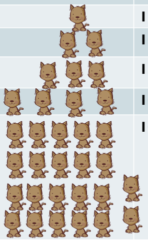
Representing Decimal Numbers in Binary

Decimal	Number of Digits	Binary	Number of Bits
0	1	0	1
1	1	1	1
2	1	10	2
3	1	11	2
4	1	100	3
5	1	101	3
6	1	110	3
7	1	111	3
8	1	1000	4
9	1	1001	4
10	2	1010	4
11	2	1011	4

What do you notice every time we need to increase the number of bits?

How many things can we represent with Binary Digits (Bits)

- **QUESTION : if I have a one bit number, how many items can I represent?**
- **QUESTION : How about 2 bit number?**
- **QUESTION : How about 3 bit number?**
- **QUESTION: How about an 8 bit number (8 bits is called a *BYTE*)**

Stuff (number of dogs let's say)	Binary Representation of Stuff	Decimal Representation of Stuff
	**0** or 00000000	**0** or 00000000
	1 or 00000001	**1** or 00000001
	10 or 00000010	**2** or 00000002
	11 or 00000011	**3** or 00000003
	100 or 00000100	**4** or 00000004
	10110 or 00010110	**22** or 00000022

http://www.youtube.com/watch?v=b6vHZ95XDwU&feature=related

Representing Characters in Binary

- Use 1 byte for each letter →
- Called the ASCII code
- Thus DOG would be encoded as:

01000100	01001111	01000111
D	O	G

- With 8 bits, (or 1 byte), we can encode 2^8 → 256 different characters

@	0100 0000
A	0100 0001
B	0100 0010
C	0100 0011
D	0100 0100
E	0100 0101
F	0100 0110
G	0100 0111
H	0100 1000
I	0100 1001
J	0100 1010
K	0100 1011
L	0100 1100
M	0100 1101
N	0100 1110
O	0100 1111
P	0101 0000
Q	0101 0001
R	0101 0010
S	0101 0011
T	0101 0100
U	0101 0101
V	0101 0110
W	0101 0111
X	0101 1000
Y	0101 1001
Z	0101 1010

How many numbering systems are there?

- Infinite! Some of the common ones are:
- **Binary** → (2 **B**inary Dig**its**/ **BITS**) **0,1,10,11,100,101, 110, 111,1000, 1001, …**
- **Octal** → (8 Digits) 0,1,2,3,4,5,6,7,10,11, 12,13,14,15,16,17,20
- **Decimal** → (10 Digits) 0,1,2,3,4,5,6,7,8,9,10,11,12,13, 14,15,16,17,18,19,20, … , 99, 100, 101, 102… 999
- **Hexadecimal**→ (16 Digits) 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F,10,11,12, 13,14,15,16,17,18,19,1A,1B,1C,1D,1E,1F,20… FA, FB, FC, FD, FE, FF, 100, 101, 102,…. FFE, FFF, 1000, 1001, 1002
- *NOTE: as soon as you run out of patterns, you need an extra place holder (just like you learned in grade 2, that in decimal, when you have the numbers from 000 to 999, you only need 3 place holders but after 999, you will need another (4) place holder → 1000)*
- Select: Start>Programs>Accessories>Calculator>View>Programmer or use this online one: http://calc.50x.eu/

Decimal Representation	Binary Representation
0	0 0 0
1	0 0 1
2	0 1 0
3	0 1 1
4	1 0 0
5	1 0 1
6	1 1 0
7	1 1 1

Binary to Decimal Conversion

- Each digit must be converted individually and then the digits are added together
- How is a digit converted?
  - If the digit is a 0, ignore it!
  - If the digit is a 1, get the place value of the digit and calculate 2 to the power of that place value
  - Note that the place values always begin with the **right-most** digit at place 0

Binary to Decimal Conversion

- Suppose we want to convert 1001 to decimal
- The small, red numbers below represent each digit's place value $\underset{3}{1}\ \underset{2}{0}\ \underset{1}{0}\ \underset{0}{1}$
- Now we raise 2 to the power of the place value for each of the 1's
- The first 1 has place value 3, so take $2^3 = 8$
- The next 1 has place value 0, so take $2^0 = 1$
- Now add them together. 8+1 = 9

Binary to Decimal Conversion

- Another example: Convert 0111 to decimal
  $\underset{3}{0}\ \underset{2}{1}\ \underset{1}{1}\ \underset{0}{1}$
- The three 1s are at place values 2, 1, and 0
  - $2^2 = 4$
  - $2^1 = 2$
  - $2^0 = 1$
- Add them together. 4+2+1 = 7

Binary to Decimal Conversion

- Another example: Convert 100 to decimal
  $\underset{2}{1}\ \underset{1}{0}\ \underset{0}{0}$
- The only 1 is at place value 2
  - $2^2 = 4$
- The solution is 4.
- The formula is the same for any number of digits. In this course you only need to do conversions on up to 4 bits (4 digits)

Binary example:

- Think of lights in your home. If a light is on, it has a value of 1, if it's off then it's 0.

➔ 0000

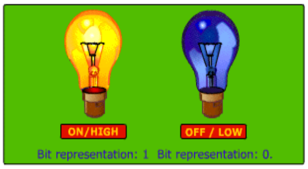
➔ 1111

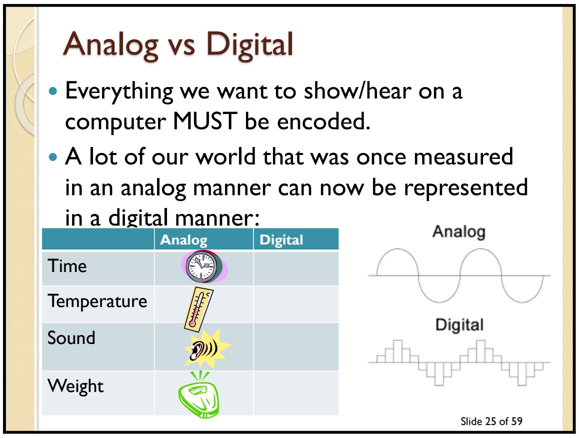
➔ 1000

➔ 0101

Why do Computers like Binary?

- A computer uses electricity and can distinguish between getting a high volt or a low volt. A high volt is a 1, a low volt is a 0





Analog vs Digital

- Everything we want to show/hear on a computer MUST be encoded.
- A lot of our world that was once measured in an analog manner can now be represented in a digital manner:

	Analog	Digital
Time		
Temperature		
Sound		
Weight		

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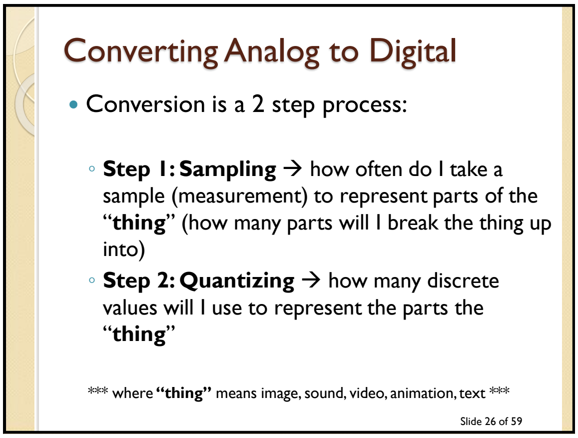

Converting Analog to Digital

- Conversion is a 2 step process:
  - **Step 1: Sampling** → how often do I take a sample (measurement) to represent parts of the "**thing**" (how many parts will I break the thing up into)
  - **Step 2: Quantizing** → how many discrete values will I use to represent the parts the "**thing**"

*** where **"thing"** means image, sound, video, animation, text ***

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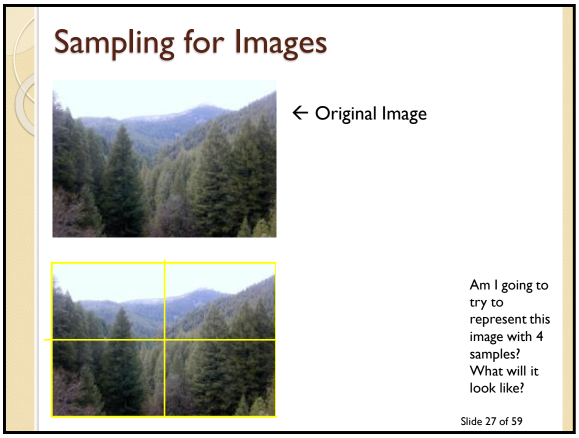

Sampling for Images

← Original Image

Am I going to try to represent this image with 4 samples? What will it look like?

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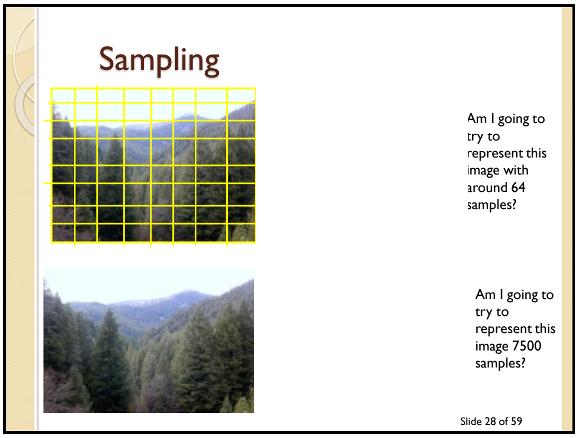

Sampling

Am I going to try to represent this image with around 64 samples?

Am I going to try to represent this image 7500 samples?

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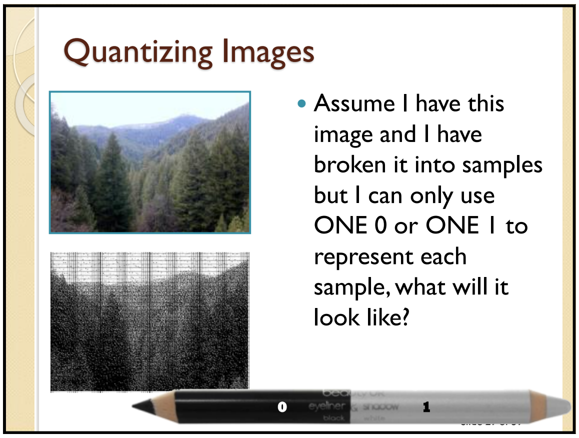
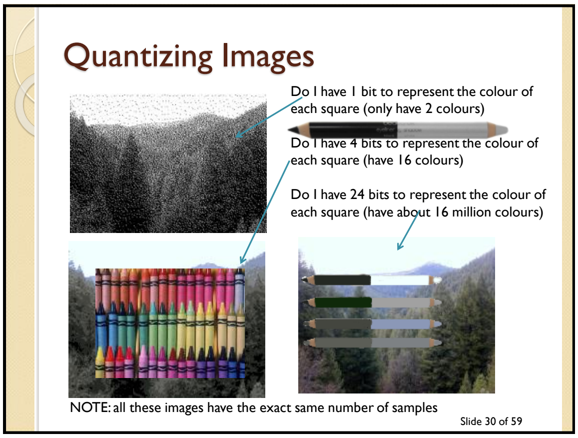


Quantizing Images

- Assume I have this image and I have broken it into samples but I can only use ONE 0 or ONE 1 to represent each sample, what will it look like?



Quantizing Images

Do I have 1 bit to represent the colour of each square (only have 2 colours)

Do I have 4 bits to represent the colour of each square (have 16 colours)

Do I have 24 bits to represent the colour of each square (have about 16 million colours)

NOTE: all these images have the exact same number of samples

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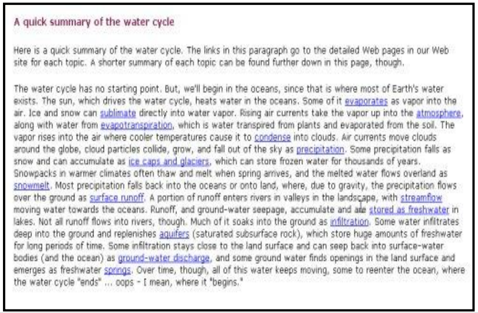
Sampling and Quantizing

- We will learn how to sample and quantize sound and video as well
- Right now let's figure out how to sample and quantize a picture

Introduction to Graphics

- What can you learn from this:

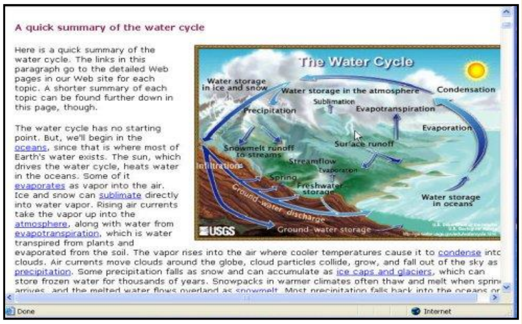


A quick summary of the water cycle

Here is a quick summary of the water cycle. The links in this paragraph go to the detailed Web pages in our Web site for each topic. A shorter summary of each topic can be found further down in this page, though.

The water cycle has no starting point. But, we'll begin in the oceans, since that is where most of Earth's water exists. The sun, which drives the water cycle, heats water in the oceans. Some of it evaporates as vapor into the air. Ice and snow can sublimate directly into water vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds. Air currents move clouds around the globe, cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snowpacks in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and ground-water seepage, accumulate and are stored as freshwater in lakes. Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some water infiltrates deep into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as ground-water discharge, and some ground water finds openings in the land surface and emerges as freshwater springs. Over time, though, all of this water keeps moving, some to reenter the ocean, where the water cycle "ends" ... oops - I mean, where it "begins."

How about this?



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Images are great for

- Information
- Explanation
- Entertainment

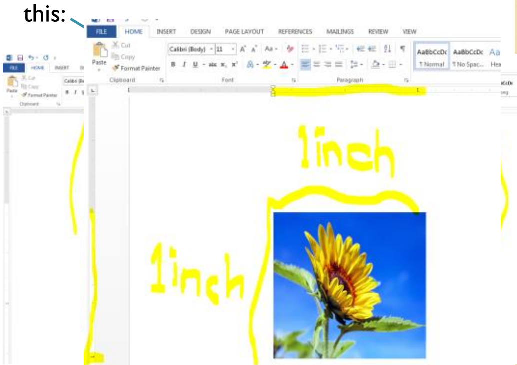
Where do we get our images to use on our computer?

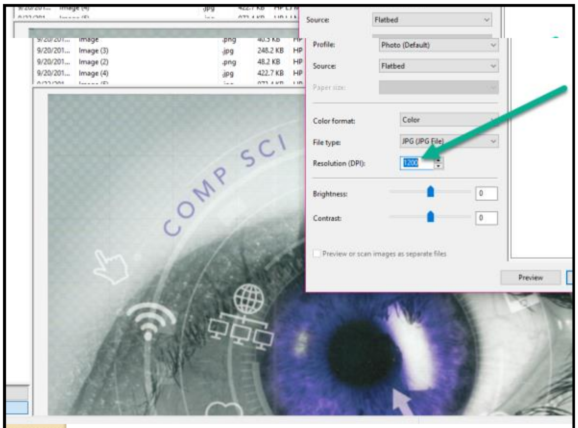
- By scanning existing images (a drawing or an old photograph or a painting)
- By era
- By S Paint or am

Some Terminology: Dots Per Inch (dpi)

- When scanning or getting an image from our digital camera, the scanner or the camera can determine how many samples to take (how finely to break down the images)
- The more samples that are taken, the higher the resolution will be.
- Samples on scanners/printers are measured as dots per inch (DPI)
- Samples on a monitor are measured as pixels per inch (PPI)

- Here is an image in MS Word that is 1 inch by 1 inch, if I scan it in at 4DPI, it will look like this:





Source: Flatbed

Profile: Photo (Default)

Source: Flatbed

Paper size:

Color format: Color

File type: JPG (JPG File)

Resolution (DPI): 1200

Brightness: 0

Contrast: 0

☐ Preview or scan images as separate files

Example

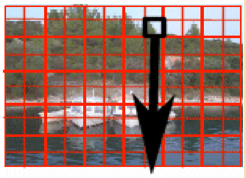
- If we scan an 8 inch by 10 inch image at 100dpi, the image will be (8*100) * (10*100) = 800*1000 = 800,000 samples (almost 1 million samples).
- **QUESTION: What do we call a sample in an image?**
- Thus the above image would have 800,000 ***pixels***.

Pixel

- An image is represented by a grid (array, matrix) of squared **Pic**ture **el**ements called **pixels**
- A pixel is the smallest image component and thus shows the smallest detail
- Arranged in column and rows

Pixels

- Each pixel is given a numerical value that represents the corresponding colour:
  - Green might be 1000
  - Gray might be 1010
  - Blue might be 1110



green	green	blu	blu	blu	blu
green	green	gray	blu	blu	blu
green	green	green	gray	blu	blu
green	green	green	green	gray	blu
green	green	blu	blu	blu	blu

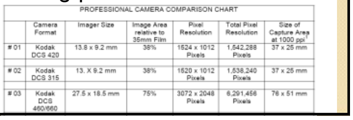
Now that we understand that …

- An *image* is broken into samples (called *pixels* → sampling the image) and each pixel is assigned a colour (represented by 0s and 1s → quantizing the image)
- Next question is … **HOW DO WE PUT THE IMAGE ON A PIECE OF PAPER OR ON TO A MONITOR?**

- If we scan that same 8 inch by 10 inch picture in and we set the resolution to 300dpi, after scanning, we will get (8 * 300) * (10 * 300) = 7,200,000 pixels (about 7 million pixels)
- NOTE: when printing an image, you should print with a dpi of at least 300.

Digital Cameras

- **Megapixel**→ how many millions of pixels you can capture in a photograph on your digital camera (how many "samples" it will break the image into)
- **Example**:
  - Kodak DCS 460/660 captures 3072 by 2048 pixels for one photograph → about 6 million pixels or about 6 megapixels
  - iPhone 8 Plus features a 12-megapixel wide-angle and telephoto lens and a 7-megapixel FaceTime camera.



PROFESSIONAL CAMERA COMPARISON CHART

	Camera Format	Imager Size	Image Area relative to 35mm Film	Pixel Resolution	Total Pixel Resolution	Size of Capture Area at 1000 ppi
# 01	Kodak DCS 420	13.8 x 9.2 mm	38%	1524 x 1012 Pixels	1,542,288 Pixels	37 x 25 mm
# 02	Kodak DCS 315	13. X 9.2 mm	38%	1520 x 1012 Pixels	1,538,240 Pixels	37 x 25 mm
# 03	Kodak DCS 460/660	27.5 x 18.5 mm	75%	3072 x 2048 Pixels	6,291,456 Pixels	76 x 51 mm

Digital Camera Stats

Megabytes	Size of image (pixels WxH)	Total # of Pixels	Printing at 300dpi, biggest suggested print
1 Megapixel	1280 X 960	1,228,800	4.2" by 3.2"
2 Megapixels	1600 X 1200	1,920,000	5.3" by 4"
3 Megapixels	2048 X 1536	3,145,728	6.8" by 5.1"
4 Megapixels	2272 X 1704	3,871,488	7.5 by 5.6"
5 Megapixels	2560 X 1920	4,915,200	8.5" by 6.4"

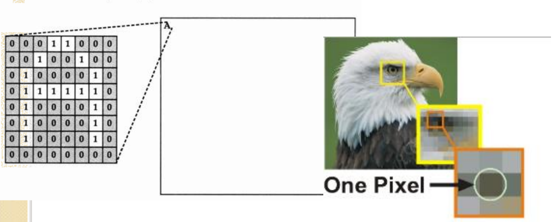
- Thus, a camera with more megapixels can print a larger image without the human eye detecting a loss of quality.
- If you just want to print 4" by 6" images, you don't need much more than 3 megapixels

Printing Images on Paper

- When printing an image, the image must be printed at a size that has a minimum of 300 pixels per inch.
- **QUESTION: Thus, if you had an image that was 3000 pixels by 1500 pixels, for the print quality to be good enough to the human eye, what size should you print it at?**
- **Answer**: 3000/300 → 10 inches by 1500/300 → 5 inches. DON'T PRINT IT ANY LARGER THAN 10" by 5"

Remember that we take an image and…

- Break it into samples (called pixels). But how does the pixel in the image go onto the screen (or paper)?

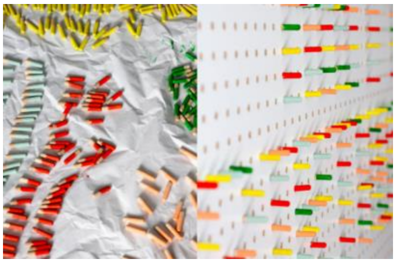


0	0	0	1	1	0	0	0
0	0	1	0	0	1	0	0
0	1	0	0	0	0	1	0
0	1	1	1	1	1	1	0
0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0
0	1	0	0	0	0	1	0
0	0	0	0	0	0	0	0

Displaying Images on the Screen

- Remember →The monitor/screen is made up of rows of screen pixels. Each screen pixel gets a colour. Thus we map the *image pixels* on to the *screen pixels* IN A ONE TO ONE MAPPING and see our image.
- The *Screen Resolution* is the number of pixels across by the number of pixels down that a screen is currently displaying
  - Common Screen Resolutions:
    - 640 by 480
    - 800 by 600
    - 1024 by 768
    - 1280 by 1024

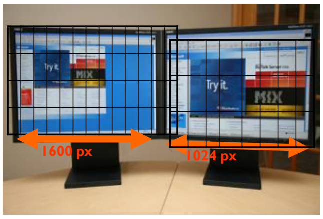
- Screen is like a peg board (holes are the monitor pixels)
- Image is like pegs (pegs are the image pixels)
- One to One mapping



Changing the Screen Resolution

- On a Windows machine:
  - Right click on the Desktop
  - Select Properties
  - Select Settings
  - Change the Screen resolution→

Resolution	% of Internet Users
Higher than 1024×768	57%
1024×768	36%
800×600	4%
Lower than 800×600	< 1%
Unknown	3%



	Size of fonts, icons, images	Amount of data you can fit on the screen at one time
640 by 480	Appear large, text larger, easier to read	Not as much
1280 by 1024	Appear smaller, text small, harder to read	A lot !

Displaying images on a screen

- Amount of space the image takes up on the screen is dependent on:
  - Size of the image
  - The current resolution of the screen
  - **NOT THE DPI**
- Example:
  - Image that is 400 pixels by 300 pixels will take up ¼ of the screen on a monitor with resolution 800 by 600
  - Same image will take up about 1/16 on a screen that is set at 1600 by 1200
- All these images are 412 by 324 pixels but all are different DPI → http://www.csd.uwo.ca/~lreid/cs1033/resolution/

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800 by 600 Monitor Resolution

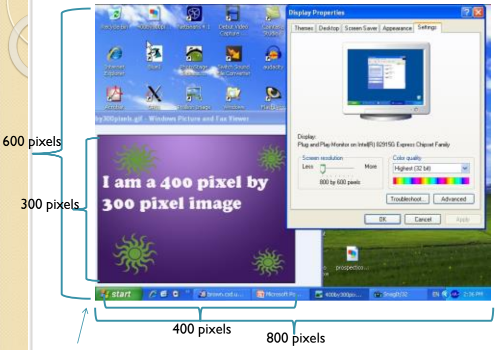
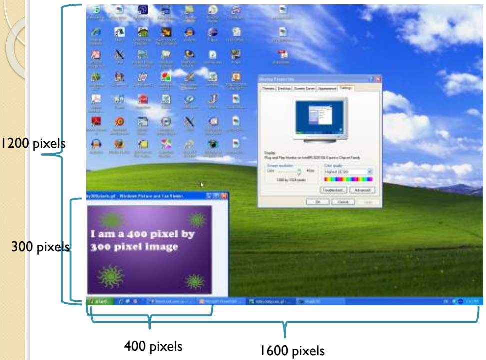
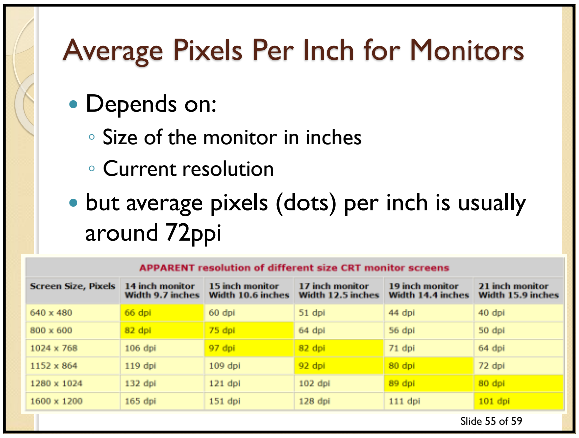


Image takes up ¼ of the screen

1600 by 1200 Monitor Resolution



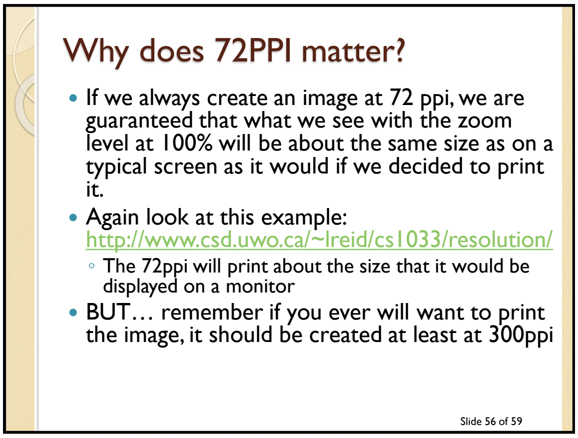


Average Pixels Per Inch for Monitors

- Depends on:
  - Size of the monitor in inches
  - Current resolution
- but average pixels (dots) per inch is usually around 72ppi

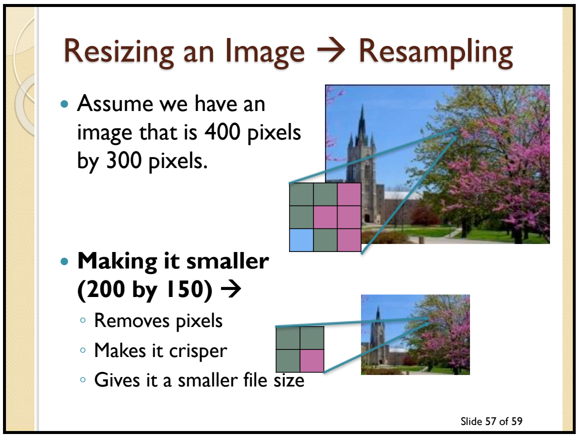
APPARENT resolution of different size CRT monitor screens

Screen Size, Pixels	14 inch monitor Width 9.7 inches	15 inch monitor Width 10.6 inches	17 inch monitor Width 12.5 inches	19 inch monitor Width 14.4 inches	21 inch monitor Width 15.9 inches
640 x 480	66 dpi	60 dpi	51 dpi	44 dpi	40 dpi
800 x 600	82 dpi	75 dpi	64 dpi	56 dpi	50 dpi
1024 x 768	106 dpi	97 dpi	82 dpi	71 dpi	64 dpi
1152 x 864	119 dpi	109 dpi	92 dpi	80 dpi	72 dpi
1280 x 1024	132 dpi	121 dpi	102 dpi	89 dpi	80 dpi
1600 x 1200	165 dpi	151 dpi	128 dpi	111 dpi	101 dpi



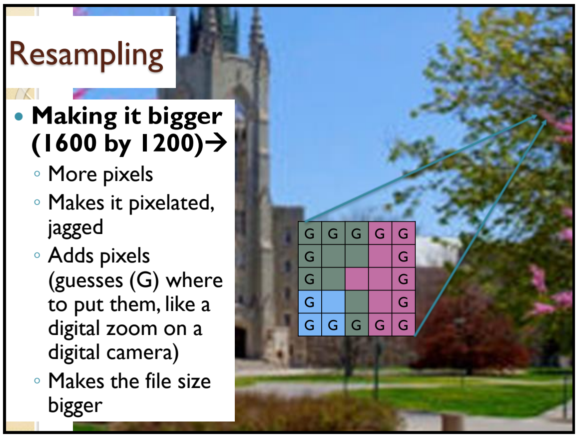
Why does 72PPI matter?

- If we always create an image at 72 ppi, we are guaranteed that what we see with the zoom level at 100% will be about the same size as on a typical screen as it would if we decided to print it.
- Again look at this example: http://www.csd.uwo.ca/~lreid/cs1033/resolution/
  - The 72ppi will print about the size that it would be displayed on a monitor
- BUT… remember if you ever will want to print the image, it should be created at least at 300ppi



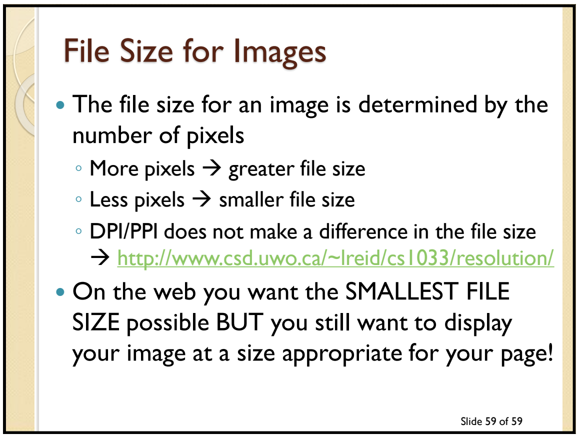
Resizing an Image → Resampling

- Assume we have an image that is 400 pixels by 300 pixels.
- **Making it smaller (200 by 150) →**
  - Removes pixels
  - Makes it crisper
  - Gives it a smaller file size



Resampling

- **Making it bigger (1600 by 1200)→**
  - More pixels
  - Makes it pixelated, jagged
  - Adds pixels (guesses (G) where to put them, like a digital zoom on a digital camera)
  - Makes the file size bigger



File Size for Images

- The file size for an image is determined by the number of pixels
  - More pixels → greater file size
  - Less pixels → smaller file size
  - DPI/PPI does not make a difference in the file size → http://www.csd.uwo.ca/~lreid/cs1033/resolution/
- On the web you want the SMALLEST FILE SIZE possible BUT you still want to display your image at a size appropriate for your page!