DIGITAL IMAGES

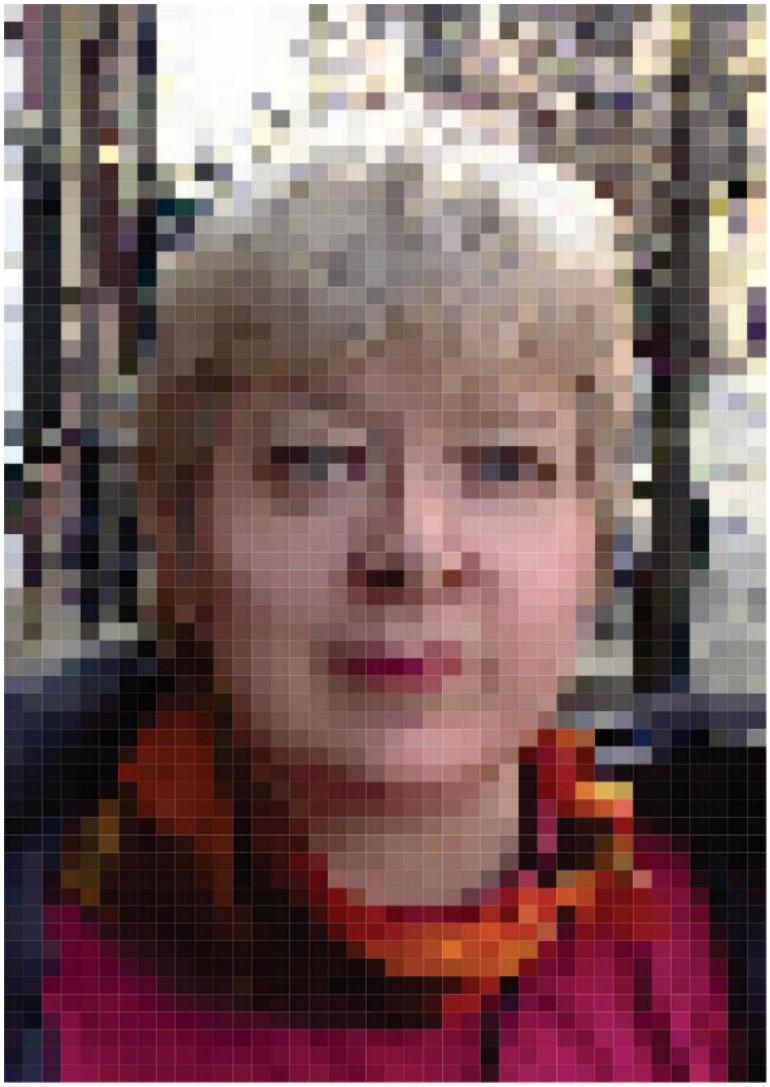
Presentation by Sherry Lynn Felix March 31, 1999 rev. April 19, 2018

Outline

1. **Raster and Vector:**
    a. Digital images are either Raster or Vector.
    b. Vector to raster OK, but to make vector from raster RtV software is needed.
2. **File Types:** Computer graphics come in a variety of files types:
    a. Raster File types: *.BMP, *.tiff, *.GIF, and *.JPEG to name a few.
    b. Vector file types: i.e., *.dxf, *.cdr, *.emf, *.svg and more
3. **Resolution:** Resolution effects output and file size and is measured in dpi, ppi and lpi.
    a. Computer monitors have their resolution and color settings (color depth).
        i. 1366x768 screen resolution with 24-bit color depth is now common.
        ii. The output may be very different from the image seen on the computer.
    b. Scaling and resampling interpolation all effect images.
        i. 35 mm photo resolution is 200 dpi
4. **Color:** Color models include HSB, RGB and CMYK
    a. Color matching (for color depth see above).
    b. How different devices "see" color.
5. **Scanning** and its effect on images.
    a. How a scanner scans.
    b. Interpolation.
    c. Histogram for B & W points, brightness and contrast.
    d. Moiré effect when scanning magazines (gaussian blur and unsharp mask).
6. **Printing:** The quality of an image is affected by all the above.
    a. Types of Black and white are: laser, inkjet, and dot matrix.
    b. Inkjet or desk jet are color or grayscale.
    c. Dye sublimation prints are photorealistic and
    d. Printing Press highest quality.

Raster and Vector

Raster is a grid of small squares known as pixels or dots which are arrayed in a grid. Resolution in a raster file is the number of cells in a grid pattern. Raster is used for photos. Adobe PhotoShop and Corel PhotoPaint are two examples of applications that manipulate raster images.



Me as Raster Sherry—I am very pixilated!

An increase in size stretches the squares.

An increase in resolution adds more pixels. Software must interpolate the values of the new pixels between each color area. This leads to a loss in clarity. Some of this can be compensated for using filters like unsharp mask.

Vector images are mathematically described lines and arcs made of points stored by the computer. Vector is good for solid fills, technical drawings, pen and ink drawings, and logos.

Me as Vicky Vector.
I used Corel's OCR-Trace tool on a photo of myself.

Advantages:

1. Vector is compact. Color is stored as mathematical equations just as lines are.
2. Vector is infinitely scalable and prints at the maximum resolution of the printer.
3. And vector is precise. Scale and image elements retain the same relative positions.

Disadvantage: Computer made. Will not convert a picture into a vector image unless it is traced using a mouse, drawing tablet or digitizer.

Scanning line art turns it into raster; therefore, it's better to scan at the highest resolution of the printer and at the size desired. Do not resize after scanning or it'll get pixilated.

- Corel Draw, Adobe Illustrator, and AutoCAD produce vector images.
- Word, PowerPoint, and InDesign applications can import both raster and vector images.

R-t-V (raster to vector) software like Corel Trace and Adobe Image Trace can turn a raster image into vector. This requires interpolation and the results may not be ideal.

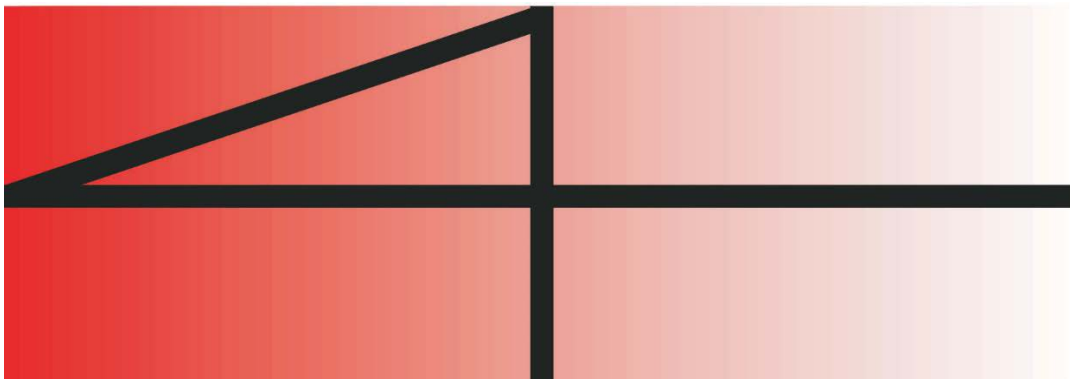
FILE TYPES

TIFF (Tagged Image File Format, extension: *.tiff *.tif) is the most widely used file format. It's good for storing bitmaps in different resolutions, color models and compression types. Originally made for fax data the TIFF file has a header describing the contents of the file, its compression, file size, and other information. Just about any kind of image data can be stored as TIFF file. Use the TIFF format whenever possible.

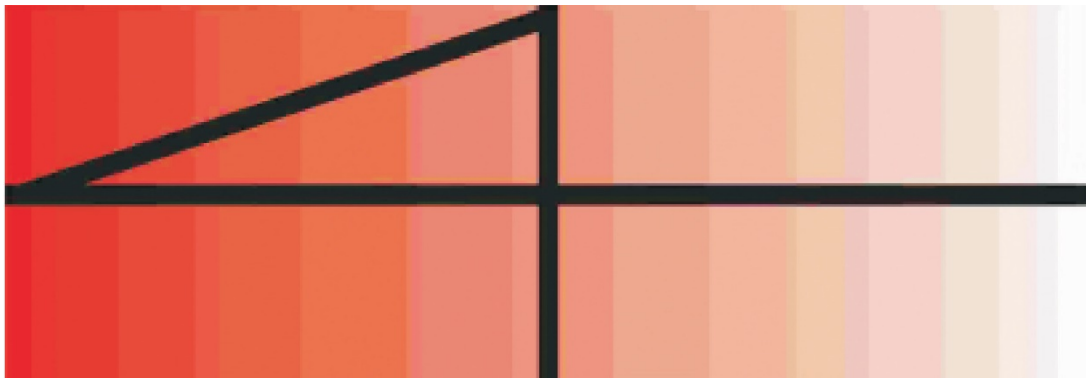
JPEG (extension: *.jpg , *.jpeg) files use a compression algorithm to store files; i.e., 20:1. JPEGs store pictures at a higher color resolution than GIF. JPEGs uses a "lossy" compression format which loses some of the information in the picture. This loss produces "artifacts" (where sharp edges become jagged and smooth textures start looking ragged). Increasing the compression quality reduces artifacts, but this increases the file size.

Use JPEG for compressing large TIFFs or BMPs. Don't use JPEG for compressing line drawings. Instead, use GIF or PNG.

Do **not** save a JPEG again as a JPEG. Re-saving a JPEG will degrade the image even further.



TIFF with no compression



Very "lossy" JPEG with "artifacts" from multiple savesBitmaps (extension: *.bmp) are a simple form of raster image. The files' header specifies height and width followed by a string of binary encoded numbers for each pixel. Bitmaps come in several color depths, from 2 colors to millions. Increasing the color depth makes the file bigger. Bitmaps resize poorly because of their strict pixel by pixel nature; consequently, they don't work well in elaborate drawing or painting packages. Small bitmaps are used for icons and images that need to be loaded quickly. Bitmaps load and display quickly because there is no decoding involved. They are "non-lossy" so bitmaps will preserve the quality of your images. They take up lots of room on your hard drive and are not net-friendly; however, they are convertible to formats that are.

GIF (Graphical Interchange Format, extension: *.gif) stores images with 256 colors or 256 shades of gray. GIF89a is the latest version of GIF and supports basic animation, transparency, and interlacing. GIF images are good for solid blocks of color -- like logos, icons, buttons, horizontal rules, simple line drawings, cartoons, or lettering. For photographs go with JPEG on the Internet or TIFF if you want a non-lossy format.

If you simultaneously displaying a bunch of GIFs with different palettes they can eat up all the colors on your screen, leaving you with strangely colored images.

	Photographic Images	**Graphics, Logos, Line Art and Screen Captures**
Properties	Continuous tones, 24-bit color or 8-bit Gray, no text, few lines and edges	Solid colors, up to 256 colors, with text or lines and sharp edges
Best Quality for Master Copy	TIF (or PNG)	PNG or GIF or TIF
Smallest File Size	JPG, 75% to 80% Quality factor is good. Normal useful range is 90% to 60% (not suitable for a master copy)	PNG or GIF, maybe TIF LZW Graphics. Logos usually use 2 to 16 colors for a smaller file
Maximum Compatibility (PC, Mac, Unix)	TIF without LZW compression (best for master file)	TIF without LZW
Poor Choice	256 color GIF is limited color, and is a larger file than 24 bit JPG	JPG compression adds artifacts, smears text and lines and edges

Vector file types: There is AutoCAD (CAD stands for computer aided design) which uses the file extensions *.dwg or *.dxf. *.ai extensions are for Adobe Illustrator, *.wmf is Windows Metafile, *.eps is encapsulated postscript file, and *.svg is a Scalable Vector Graphics file (for the web). Vector based applications often makes their own file types. There is usually an option to “save as” or export out into other more common file types.

RESOLUTION

An image with more dots is sharper and has better resolution than an image with fewer dots. Resolution is expressed in terms of **dpi** (dots per inch or pixels) or **ppi** (pixels per inch). Printers may use **lpi** (lines per inch). 150-300 dpi is sufficient for most documents.

Compression technology makes it possible to save at higher resolutions. An 8.5" x 11" image may (2550 dots times 3300 lines) takes a megabyte (one million fifty-one thousand eight hundred seventy-five bytes).

It is OK to reduce, but not to increase the image size. Resizing to be smaller discards excess pixels but resizing to be larger creates (fake) new interpolated pixels which were not in the original.

Screen resolution: A 6x4 inch photo portrait will fill your 800x600 screen vertically at 100 dpi (600 dots/6-inches = 100 dpi). The same image will look larger on a 640x480 screen than on an 800x600 screen, and smaller on a 1024x768 screen or the now common resolution of 1366x768.

A small image scanned at a low resolution will look a fuzzy on the monitor, because there aren't enough pixels to show detail. Using the **Unsharp Mask** to sharpen it helps, but it's still too small and low resolution.

Resolution doesn't determine image size on the printer as it does with video, and a scanned 6x4 inch photo will print as 6x4 inches. To print an image at a different size, it needs to be **scaled** in the printer software.

B&W printers use arrays of dots arranged in a grid **called halftones** to simulate grays. For dark gray, more grid dots are black. For light gray, more grid dots are white. (Color in magazines may use variable dot sizes instead of a ratio of light/dark dots). A laser printer might print 600 dpi, or 128 shades of gray, but it cannot do both at the same time. If a larger grid is used, more shades of gray are possible, but result in lower resolution.

Examples of some grid sizes for a 600-dpi printer:

Grid Size	Shades of Gray	Resolution/grid	lpi
1x1	2 (B&W line art)	600/2	300*
6x6	37	600/6	100
8x8	65	600/8	75

**is 600 dpi, but it is 300 lpi, because to draw a line, alternating black and white pixels are needed, else there is no line. Line Art cannot be over 300 lpi on a 600-dpi printer.*

Photographic Resolution: Color **prints** (35 mm) don't have more than a 200 dpi resolution. Negatives and slides have excellent resolution. Good **film** might resolve over 2000 dpi, but color prints on paper don't come close. Enlarging an image by a factor of 4 reduces resolution by a factor of 4. It's not so easy to get a sharp 8x10 inch photographic print from 35 mm film. To scan a photo and print it at 8x10 on an inkjet is not much better. **Slides** give the best detail and contrast.

COLOR

Color model systems use mathematical formulae to describe color. Some color models are geared towards 'on-screen' output, some 'printed' output, and some output independent.

RGB Color Model is used in computer monitors and TV's. Variable amounts of Red, Green or Blue light create color stored as numbers between 0 to 255, 0 being no light and 255 being the brightest light.

Examples of RGB colors:

	Red	Green	Blue
Black	0	0	0
White	55	255	255
Mid Grey	128	128	128
Blue	0	0	255
Orange	255	128	0
Yellow	255	255	0

HSB (Hue, Saturation and Brightness) represents color purely theoretically. With HSB each color has a value for each of the three variables. HSB is 'device independent' and not based on how printers and monitors function.

- **Hue** ranges from representing the color's position on a standard color wheel.
- **Saturation** is the amount of hue in the color.
- **Brightness** is the amount of white light in the color.
  Values for saturation and brightness may be stored as 0 to 255 or percentages.

Examples of HSB colors:

	Hue 0-360 degrees	Saturation %	Brightness %
Black	doesn't matter	doesn't matter	0
Bright Blue	200	100%	70%
Dark Blue	200	100%	30%
Pale or Gray Blue	200	30%	70%

The **CMYK** (Cyan, Magenta, Yellow, and Black) color model is used in printing and is commonly called CMYK. It's a 'four color printing process' using varying amounts of Cyan, Magenta, Yellow, and Black ink. Other color models mentioned use amounts of light. On an RGB monitor black is created by

using 0 red, 0 green, 0 blue, but on white paper, 0 red, 0 green, 0 blue would produce white; therefore, black (the 4th ink) is used. Colors in CMYK are represented in percentages.

Examples of CMYK colors:

	Cyan %	Magenta %	Yellow %	blacK %
Orange	0	50	100	0
Red	0	100	100	0
Blue	100	75	0	25
Green	80	0	80	0

The CMYK model is device dependent. Results depend on the kind of printing press used, and the type of paper. With porous paper the ink 'runs' more, and less ink is needed. High quality glossy paper can handle more ink.

A **color model system** is how color is represented and remembered. A '**color gamut**' is the range of colors that a color model can represent. The RGB model has many more colors in its gamut than are available in the CMYK model. Consequently, more RGB colors can be created and viewed on screen than can be printed using CMYK. The **color matching system** warns of 'unprintable' RGB colors and tries to match the colors to the CMYK model.

To fine tune color output, **color profiles** can be made using information about the scanner, monitor, software and printer. To set a profile for a desktop printer, you need a set of test colors, and a **densitometer**, to measure the actual printed density of ink. The printed ink densities are measured and compared to the documents 'true' values. The software can be instructed to compensate for the printer's variation in ink density. Every device (monitor, software package, printer, even paper type, etc.) used could have its own color compensation table. In addition, the color model of the video monitor matters. If the image is in 24-bit color it will look terrible if the video board is set to 256 color mode.

SCANNING

For example, a 300-dpi scanner (300 x 600) has an array of CCD optical cells spaced 1/300 inch apart horizontally. The scanner bed has 2500 cells is in a horizontal line (8.5" x 300 dpi = 2550). A stepping motor moves the CCD cells, which can move in 1/600-inch steps, down the length of the bed. Selecting to scan at 600 dpi means it'll step at 600 dpi vertically, and sample horizontally at 300 dpi. The vertical samples overlap each other by 50% because the CCD cells are roughly 1/300-inch diameter. The software must **interpolate** to create a 600 x 600 image.

Interpolation is a calculation or estimation of intermediate values occurring between two known values. For example, to create a new dot between adjacent dots of Red values 100 and 108, the new dot is assigned a Red value 104. The transitional value from 100 to 108 is 104. The same is done for Blue and Green. This provides a mix of real and 50% faked data, and can not be considered as an increas in resolution. Interpolated resolution does not work well for gray color modes either. Interpolation is a bigger problem than smoothing **jaggies** (stairlike lines that appear where there should be smooth straight lines or curves). Averaging the adjacent dots to create new pixels is likely make a blurry looking image. Applications use spophisticated algorithms to create more natural interpolations when attempting t increase resolution.

Line art becomes a raster image when scanned. If you have a 1200-dpi printer, you should scan Line Art at 1200 dpi. This will help eliminate jaggies.

Histograms can be used to adjust the perceived RGB black (0) and white points (255). Histograms are called "levels" in Photoshop and "level Equalization" in PhotoPaint. In addition to the **histogram** using the **gamma** control brings out details in low contrast images. **Brightness**/**Contrast** controls will act much the same as the histogram.

Moiré patterns appear when scanning images in magazines/books/newspapers. The scanned images will have a murky herringbone or crosshatched or dotted pattern. This interference is called a **moiré pattern** (pronounced more-ay). Moiré patterns are caused by interference between two sets of fine pattern grids, the scanner grid sampling pattern and the halftone screen in the original image. The interference of the two grids creates periodic patterns of variable light intensity. To fix a moiré pattern from a magazine image (originally a 1600x1200 camera image scaled by the magazine to 300 dpi for creating the 150 lpi screen and printed at about 5.6 x 4.1 inches in size), scan the image in at 300 dpi, and use a descreen filter. Then resample it to 33% size (effectively 100 dpi size). Lastly,

sharpen it with an Unsharp Mask filter.

With Moiré

Moiré is removed

Black and white printers (laser, ink jet, dot matrix) are suitable for producing text and line art, but they're not so good for printing grayscale images.

Inkjet and desk jet color printers produce color or grayscale images that are somtimes grainy as the pixels are converted into dots of color. These printers can print 256 shades of color or gray. More expensive color printers with more ink colors print the best.

Dye-sublimation color printers print images in photo-realistic color. Image-editing software can create the color separation files needed for printing on printing presses.

Video monitors and scanners make RGB color, but printers print in CMYK. This makes printing to CMYK a challenge as the colors have to be interpreted by software. Proofs and subsequnnt adjustments are necessary. Monitor calibration and printer proifiles are a must for good results.

SOURCES

1. Davidson, Andrew. URL: http://www.vom.com/svcg/Andypg.html 1997-1998. Email: Andrew.Davidson@onyx.octacon.co.uk
2. Fulton, Wayne. URL: http://www.scantips.com 1997 to 1999. Email: fulton@scantips.com