

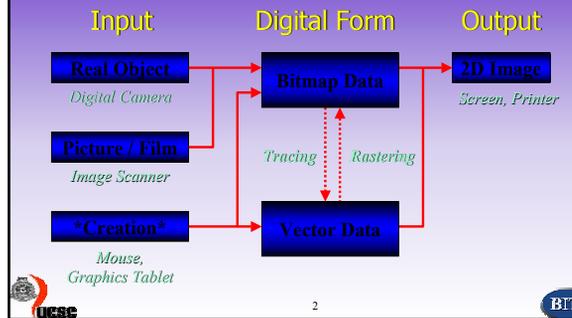
## Graphics - 2D Graphics



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## 2D Graphics - Digital Form



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## 2D Graphics - Digital Form

- Usually graphics software creates, manipulates, and stores graphics as one of two types:

- Bitmaps
- Vectors

For bitmapped graphics, the computer stores information about the screen location and colour value of each dot.

A vector image is composed of a large number of lines and Circles, each reflecting a mathematical relationship.



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## Bitmaps



## Vectors



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## Bitmaps

- Bitmap graphics are comprised of dots, called pixels, arranged in a grid. Your computer screen is a large grid of pixels.
- In a bitmap version of the leaf, the image would be determined by the location and color value of each pixel in the grid.
- Each dot is assigned a color. When viewed at the correct resolution, the dots fit together like tiles in a mosaic to form the image.



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## Vectors

- Vector graphics describe images using lines and curves, called vectors, that include color and position information.
- For example, the image of a leaf may be described by a series of points, the result of which is the leaf's outline.
- The leaf color is determined by the color of the outline, or stroke, and the color of the area enclosed by the outline, or the fill.



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## Bitmap Image

- Pixel based
  - Group of colored dots
- Best for real-world image
  - Photography, Painted picture
- Large data size
  - Needs **compression** for transfer
- Resolution Dependent
  - Not suitable for resizing/zooming



Full Color Windows BMP / 44KB

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## Bitmap Image - Compression

- Multimedia productions usually include numerous image and sound files.
- Storage space required can be quite extensive.
- Slow storage devices, narrow bandwidth of networks affect bit map images.
  - Difficult to present the multimedia in real time.
- Solution – **Compress** the files

Using algorithms that reduce the number of bytes needed to encode the data

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## Bitmap Image - Compression

- Two types : **Loss-less** , **Lossy**
- **Loss-less** Compression
  - Every pixel in the image is preserved during compression.
  - Can reproduce original image without loss
  - Not high compression ratio (~2.0)
  - Algorithms: RLE, LZW, etc.

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## Bitmap Image - Compression

- **Lossy** Compression
  - Reduce non-sensitive information to human eyes (not mathematical, but physiological method)
    - Cannot reproduce original image
    - Can specify the amount of information loss
  - High compression ratio (~100)
  - Algorithms: DCT, Wavelet , etc.

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## Compression Algorithms

	Algorithm	Basic Concept	Comp. Ratio	File Format
Loss-Less	RLE (Run-Length Encoding)	Compress repetitive data	~1.2	BMP
	LZW (Lempel-Ziv-Welch)	Build treed dictionary	~2.0	TIFF, GIF
Lossy	DCT (Discrete Cosine Transformation)	Transform to series of Cosine functions	~100	JPEG, MPEG1/2
	Colour Space Compression	Cut non-sensitive color information	~2	JPEG, (TV)
	Wavelet	Transform to series of Wavelet functions	~100	JPEG2000, MPEG4

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## Run Length Encoding (RLE)

- Many files, particularly image files, contains sequences of identical symbols.
  - Eg. In an image, a section of many adjacent pixels may all be the same colour .
  - Be encoded with the same bit pattern.
- RLE replaces sequence of identical bit patterns with
  - one instance of the pattern
  - Plus a number specifying how many times the pattern is to be repeated.
- Uses with BMP

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## Lempel-Ziv-Welch (LZW)

- Dictionary based coding algorithm
- Another Loss-Less compression algorithm.
- It was not designed specifically for graphics
- Data Dictionary is used to represent linear sequences of data in a uncompressed input stream. Then uses an algorithm similar to RLE.
- It does not work well with black and white or true colour images.
- Uses with GIF



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## Colour Space Compression

- Uses human eye characteristics
  - Less sensitive to color than lightness
  - Less sensitive to **Red** than **Green**
- YUV colour space
  - Originally developed for colour TV signal
  - Convert colour to Luminance(Y) and Chrominance (U,V) values



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## Mathematical Transformation

- **Convert images to mathematical functions**
    - Discrete Cosine Transformation (DCT)  
Use series of cosine functions to approximate image.  
Use with JPEG, MPEG 1/2
    - Wavelet Transformation  
Use wavelet function to approximate image.  
Use with JPEG2000, MPEG 4
- Both are **Lossy** Compression Algorithms



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## Bitmap Image – File Formats

- Industry standard
  - TIFF (Tagged Image File Format) - **Adobe/Silicon Graphics**
- Platform Standard
  - BMP - **Windows**
  - PICT - **Macintosh**
  - GIF (Graphics Interchange Format) - **CompuServe**
- International Standard
  - JPEG (Joint Photographic Experts Group) - **ISO 10918**
  - JPEG2000 – **ISO 15444**
  - PNG (Portable Network Graphic) - **MIT/W3C**

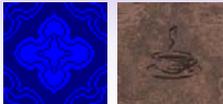


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## BMP

- The Microsoft Windows graphic file format
- Common file format used to display bitmap images.
- BMPs are used primarily on the Windows operating system.
- Many applications can import BMP images.



Two .bmp file come with windows O/S



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## TIFF (Tagged Image File Format)

- Highly flexible
  - Ability to handle various kinds of specialized image formats by using internal Tag
    - over-24bit images (**32, 36, 48, etc.**)
    - Alpha-channel (**Transparency**)
    - Multiple Layers
- For Professionals
  - Used in professional imaging industry
    - Medical, Publishing, Photographers



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## GIF (Graphics Interchange Format)

- Developed by Compuserve in 1987
- Designed to store multiple bitmap images into a single file for easy exchange over computer networks.
- Oldest graphic file format on the Web. Widely used in WWW
- If you want to be absolutely sure every one will see your graphics, make it GIF
- There are technically two types of Gif file: GIF87a, GIF89a



A Microsoft GIF image

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## GIF (Graphics Interchange Format) cont..

- Many useful features
  - Transparency (1 bit only)
  - Interlace (for fast perception over net) -GIF display in a series of four passes, 12.5%,25%, 50%,100% (not from top to bottom)
  - Animation (Cell Animation)
- Suitable for small pictures / icons
  - Flexible choice of bit-per-pixel (1~8)
  - Indexed colour only (no full color support) max of 256 colours (8 bits)
- Uses LZW compression (loss less)

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## GIF (Graphics Interchange Format) cont..

- **When to use GIFs**
  - Well Suited for any image with areas of flat colour such as *logos, line art, icons, cartoon-like illustrations.*
  - If you want a portion of the image to be transparent.
  - Good option for adding simple animation to your page.
  - Not good for Photographic images. true colour information is lost (8 bit limit), JPEG better

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## GIF (Graphics Interchange Format) cont..

- GIFs can be created with a wide variety of graphics programs and utilities.
  - Image editing software
  - Web graphics tool
  - Vector drawing programs
  - Third party plug-ins
  - Shareware Utilities

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- **Image editing software** : Industry standard – Adobe photoshop,([www.adobe.com](http://www.adobe.com)) PaintShop Pro ([www.jasc.com](http://www.jasc.com))
- **Web graphics tool** : Adobe Image-ready(comes with photoshop 6.0 up), Macromedia fireworks ([macromedia.com](http://macromedia.com)) fine tune controls over bit depth, dithering, and palette selection.
- **Vector drawing** : Macromedia Freehand (v7 higher), Adobe illustrator (v7 higher) – Not as effective at optimizing file sizes as Web graphics tools

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- **Third part plug- ins software** – PhotoGIF ([boxstopsoft.com](http://boxstopsoft.com)), HVS ColourGIF ([digfrontiers.com](http://digfrontiers.com)) Exceeds Photosops built-in features for fine tuning GIFs
- **Shareware** – GifConverter, Ulead GifSmartSaver see [shareware.com](http://shareware.com)

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## Portable Network Graphic (PNG)

- Designed to be the alternative of GIF
- Developed (1995) when Unisys threatened to enforce its patent on LZW compression, and collect license fees from developers of GIF supporting programs
  - No patent problem - free loss-less compression (zip)
- Many features
  - Up to 48bpp color depth
  - 16 bit Alpha channel
  - 2 dimensional interlace (Progressive image) ie. Horizontal and vertical filling
  - Gamma correction
- W3C recom.. //www.w3.org/Graphics/PNG/



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## PNG cont...

- Not so popular
  - Lack of major breakthrough
- Not a JPEG substitute
  - Larger file size than JPEG
- Potential GIF substitute
  - Smaller file size than GIF
- W3C Recommendation in Oct. 1996
- PNG is the native file format for FireWorks
- See Libpng.org/pub/png, www.gimp.org



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## JPEG (Joint Photographic Expert Group)

- Designed for compressing either full-colour or gray-scale images of natural scenes.
- Compression (lossy) based on characteristics of human eyes
  - Less sensitive to color than lightness (YUV)
  - Good for photography or artistic image
  - Not Good for scientific image (uneven information loss)
- 24-Bit Colour , 16,777,216 colours
- Widely used in consumer market, WWW



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## JPEG Cont...

- Avoid using it for images
  - already forced into 256 colour palette or
  - for line drawings or
  - 1-bit black and white images.
- Block noise due to high compression



*Square noise in high compression*



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## JPEG Cont..

- Typical Compression Ratios
  - 10:1-20:1 , High quality, little or no loss
  - 30:1-50:1 , Moderate quality , best for Web
  - 60:1, 100:1 , Poor quality , suitable for thumbnails and previews
- Image loss (lossy compression)
  - Can never get it back
- Variable compression levels
- JPEG Decompression
  - Needed before they can be displayed
  - it takes browser longer to decode and assemble a Jpeg than a Gif of the same file size.



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## JPEG Cont..

- When to use JPEGs
  - Ideal for full colour images such as photographs, paintings, watercolour illustrations, and gray colour images.
  - Not good for images with areas of solid colour such as logos, line art, and cartoon-like illustrations.



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## JPEG Cont..

- JPEG is supported by all the popular graphics tools.
  - Adobe Photoshop/ImageReady, JASC Paint Shop Pro, and Macromedia Fireworks etc.
  - Allow you to set the quality/compression level, save images in progressive JPEG format
- Plug-in utilities supports JPEG creation.
  - ProJPEG
  - HVS JPEG



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## JPEG2000

- New international standard (2001)
  - Wavelet compression
  - ~20% better compression than JPEG
    - Less noise in high compression ratio
    - No block noise like in JPEG
- [www.jpeg2000-image-compression.com](http://www.jpeg2000-image-compression.com)



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## JPEG2000 cont..

- Many advanced features
  - True progressive image
  - Support for Loss-less compression
    - Much better than LZW
  - Support for video Codec
    - Motion JPEG2000
  - ROI (Region of Interest) support
    - Select which region to compress more



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## JPEG vs JPEG2000

- JPEG Limitations
  - Compression system is *lossy*. When compressed and decompressed it loses data.
  - Inability to handle sharp edges within the image. Stronger the compression rate, it is worse.
- JPEG2000 compression
  - uses complex mathematical formulas representing image data.
  - High rate of compression with small amount of data.



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## If you want to use JPEG200....

- Many applications are adding support...
  - Graphics applications (see below)
  - Web browser (already available as plug-in)
  - Digital camera(not yet...)
- Graphics applications
  - irfanView32 ver. 3.61 or later (free)  
<http://www.irfanview.com/>
  - Ulead PhotoImpact 7
  - LuraWave PhotoShop plug-in  
<http://www.luratech.com/>



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## WBMP (Wireless Bitmap)

- is a graphic format created for mobile computing devices such as cell phones and PDAs.
- This format is used on Wireless Application Protocol (WAP) pages.
- WBMP is a 1-bit format, so only two colors are visible: black and white.



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## Vector Image

- A **Vector** is a line that described by the location of its two end points.
- A simple rectangle, for example, might be defined as follows:  
**RECT 0,0,200,200**
- To draw the same square with a red boundary line and fill the square with colour blue:  
**RECT 0,0,200,200,RED,BLUE**



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## Vector Image cont..

**RECT 0,0,200,200,RED,BLUE**

- Above concise description of the vector-drawn coloured square contains less than 30 bytes of alphanumeric data.
- Same square as an uncompressed bitmap image,
  - in black and white (1 bit colour depth per pixel)
  - require 5000 bytes to describe (200x200/8)
- Same square image made in
  - 256 colours ( 8-bit colour depth per pixel)
  - Require 40K to describe (200x200/8\*8)



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## Vector Image cont...

- Vector Based
  - Group of mathematical shape data
- Best for Illustration / Technical Drawing
  - Fully editable, structured data
- Small data size
  - ~1/100 of comparable bitmap image
  - Suitable for slow network (Internet)
- Resolution Independent
  - Suitable for resizing/zooming/printing

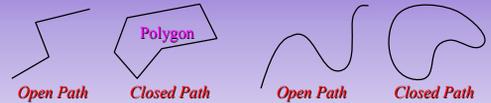


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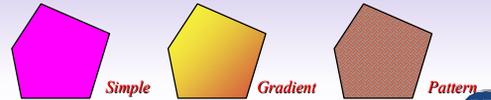


## Vector Image - Basic Elements

- Line
- Curve



- Fill - for closed path only

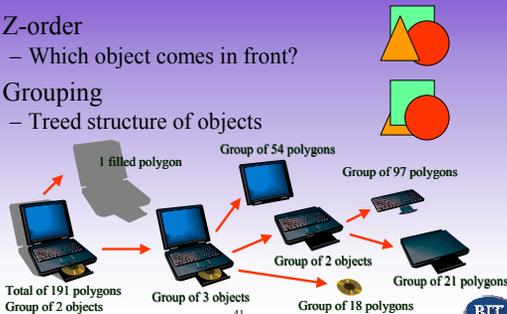


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## Vector Image - Z-order & Grouping

- Z-order
  - Which object comes in front?
- Grouping
  - Treed structure of objects

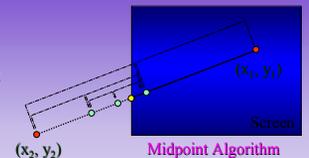


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## Vector Image - Drawing Algorithm

- Line
  - Many Algorithms
  - Clipping
- Curve
  - Parametric Curve
    - Draw curve as a function of independent parameter
    - B-Spline curve
    - Bézier curve



Midpoint Algorithm



$v = f(t); 0 \leq t \leq 1$

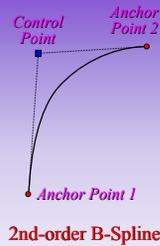


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## Vector Image - B-Spline Curve

- Simple or Complex
  - 2/3-order mathematical curve
  - 2nd-order is simple and fast (compared to Bézier curve)
  - Easy to modify curve locally
  - Needs many control points
- Not-so-widely used (in 2D)
  - TrueType Font
  - 3D Graphics → NURBS



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## Vector Image - Bézier Curve

- De-facto standard of 2D curve
  - Cubic mathematical curve
  - Easy to control the shape
- Widely used
  - Adobe PostScript, Type1 Font
  - Almost all vector based drawing programs
  - Used in *Premier, Illustrator, and Flash*



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## Vector Image - Format

- Industry Standard
  - EPS (Encapsulated Post Script) – **Adobe** → **artistic drawings**
  - DXF - **AutoDesk** → **2D/3D Graphics**
- Platform Standard
  - WMF ,EMF - **Windows**
- International Standard
  - CGM (Computer Graphics Metafile) - **ANSI/ISO**
  - SVG (Scalable Vector Graphic) – **(W3C recommendation)**



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## Vector Image - EPS

- PostScript based
  - PostScript - **Adobe**
    - Bézier-curve based page definition language
    - For printing complex page layout
  - Highly expressive for complex printing
    - Color separation, Layers, etc.
- For Professional Artist
  - Used in publishing / illustration industry
  - Not used in mechanical drawing → DXF
  - AI (Adobe illustrator) format is also popular



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## Vector Image - WMF,EMF

- WMF (Windows Meta File)
  - Line-based (**No curve!**)
    - Designed for Microsoft Windows 3.1
    - Limited feature, but widely used in office market
- EMF (Enhanced Meta File)
  - Bézier curve-based
    - Designed for Microsoft Windows 95
    - Used for exchange of vector data internally between Windows applications



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## Vector Image – SVG (Scalable Vector Graphics)

- New international standard (2001)
  - XML based
    - Designed for WWW
    - Entirely described in XML tag (text)
      - Editable by text editor
- Wealth of features
  - Bézier curve, transparency, filter effects, animation, interactivity, etc.
- But Not adopted widely yet...
  - Because Flash is already too popular



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## PPM (Portable PixMap)

- Graphics format for X windows System
- Supports 24-bit colour bitmaps
- Can be manipulated using many public domain graphics editors such as *xv*.
- Used in X windows system for storing icons, pixmaps etc.



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## Converting between Bitmaps and Drawn images

- Can convert a drawing with vector drawn objects into a bitmap when saving.
  - Most drawing programs offer
- Converting bitmaps to drawn objects is more difficult.
- Utilities available for *autotracing*.
  - Compute the bounds of a bitmapped image
  - Compute the shapes of colour
  - Derive the polygon object that describe the image.
- *Illustrator, FreeHand* supports *Autotracing*



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## References

- Ref1 –Tay Vaughan, “Multimedia :Making it work” 6th edition, Tata McGraw-Hill, 2004  
Page 264-272
- Ref1 – 5<sup>th</sup> edition Page 242-276
- Ref2 -71-79



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