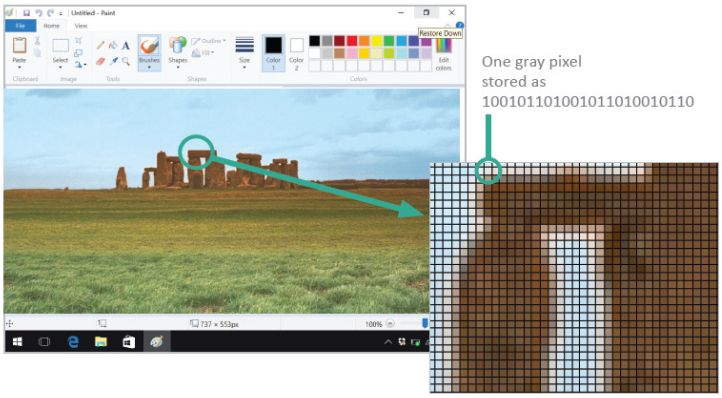
CSC 170 – Introduction to Computers and Their Applications

Lecture #3 – Digital Graphics and Video Basics

Bitmap Basics

- As digital devices gained the ability to display images, two types of computer graphics evolved: bitmap and vector
- A ***bitmap graphic*** is composed of a grid of tiny rectangular cells
- Each cell is a picture element, commonly called a ***pixel***
- Each pixel is assigned a color, which is stored as a binary number

Bitmap Basics



Bitmap Basics

- You can create a bitmap graphic from scratch using the tools provided by graphics software — specifically a category of graphics software referred to as paint software
- Examples of paint software are Adobe Photoshop, Apple Photos, and Microsoft Paint

Bitmap Basics

- You can use a ***scanner*** to convert a printed image into a bitmap graphic
- A scanner divides an image into a fine grid of cells and assigns a digital value for the color of each cell
- As a scan progresses, the values are transferred to a digital device and stored as a bitmap graphics file

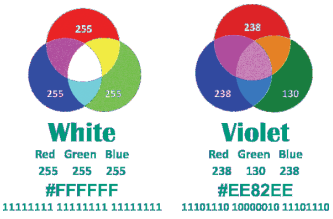
Bitmap Basics

Bitmap Basics

- In a digital camera, the lens focuses light from the image onto a small image sensor called a ***CCD*** (***c***harge-***c***oupled ***d***evice)
- A CCD contains a grid of tiny light-sensitive diodes called ***photosites***
- Photosites correspond to pixels; the more pixels used to capture an image, the higher its resolution
- Cameras, scanners, and graphics software offer a choice of bitmap formats, such as **`BMP`**, **`RAW`**, **`TIFF`**, **`JPEG`**, **`GIF`**, and **`PNG`**

Bitmap Data Representation

- Color and resolution are key elements in bitmap data representation.
- Today's color display devices represent color using the ***RGB color model***.
- Look at the center where the circles intersect to see the color that is generated. Color numbers are shown in decimal, hexadecimal, and binary.



Bitmap Data Representation

- ***Color values*** can be specified in decimal (base 10), hexadecimal (base 16), or binary (base 2).
- With 8 bits used to represent each color value, one pixel requires 24 bits.
- The number of colors available in a graphic is referred to as ***color depth***.

Bitmap Data Representation

- The dimensions of the grid that forms a bitmap graphic are referred to as ***image resolution***.
- ***High-resolution graphics*** contain more data than low-resolution graphics; more data makes it possible to display and print high-quality images that are sharper and clearer.

Bitmap Data Representation

- Graphics software, such as Adobe Photoshop, can help you gauge how large an image can be printed before the quality begins to deteriorate.

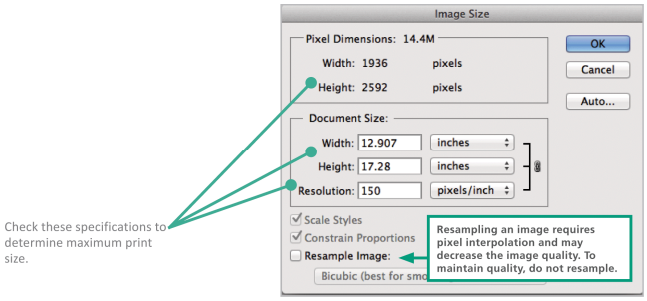


Image Compression

- ***Image compression*** refers to any technique that recodes the data in an image file so that it contains fewer bits.
- ***Run-length encoding*** (RLE) is a type of lossless compression that replaces a series of similarly colored pixels with a binary code that indicates the number of pixels and their colors.

Image Compression

- ***Lossy*** compression techniques discard some data from an image to shrink its file size.
- For many images, lossy compression results in only a minor reduction in the sharpness of the images.

Noncompressed JPEG image

JPEG image with 35% compression

Modifying Bitmap Images

- ***Photoshop*** software and a host of local and online apps make it easy to modify digital images.
- ***Photoediting*** software includes sophisticated tools based on graphics algorithms that produce amazing transformations of digital images.

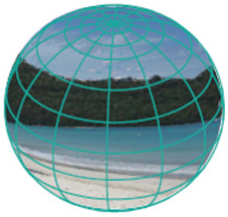
Modifying Bitmap Images

- Characteristics of bitmap that can be modified:
  - **Noise reduction** – "noise" refers to spots, dust, and scratches left on old photos after they are scanned
  - **Image enhancement** – improves brightness, color saturation, and focus
  - **Selective color change** – algorithms are used to colorize black and white photos
  - **Correcting image distortion** – reconstructing perspective with photoediting

Modifying Bitmap Images

- Characteristics of bitmap that can be modified:
  - **Cloning** – employs algorithms pulling pixels from one area and moving them to another
  - **Inpainting** – reconstructing lost or unwanted areas in a photo
  - **Digital compositing** – assembling more than one image into one by using clipping paths and alpha bending

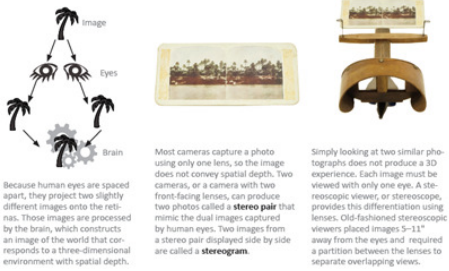
Panoramic and 360° Images



1. **Rectilinear projections** are viewed in a two-dimensional plane, typically as a long horizontal photo. These images can be produced using the panoramic feature of a digital camera.
2. **Cylindrical projections** produce a 360-degree image similar to the view from a merry-go-round. Images are captured from the front, back, and sides, and then stitched together.
3. **Spherical projections** include images from the 360-degree vertical view as well as the 360-degree horizontal panorama.

Stereoscopy

- **Stereoscopic imaging** (or stereoscopy) is a graphical technique used to produce an illusion of spatial depth from flat, two-dimensional images.



Stereoscopy

- Modern stereoscopic imaging uses digital images and viewers.
- A stereoscopic viewer, such as Google Cardboard, displays images generated by mobile devices.

Google Cardboard stereoscope

Digital stereogram

Stereoscopy

- An **anaglyph** is a graphic composed of two images, one that is tinted red and the other that is tinted blue.
- Viewing anaglyph images requires red-green or red-blue glasses.
- Usually, the red lens on the left filters out blue and green, while the blue- or green-colored lens on the right filters out red.

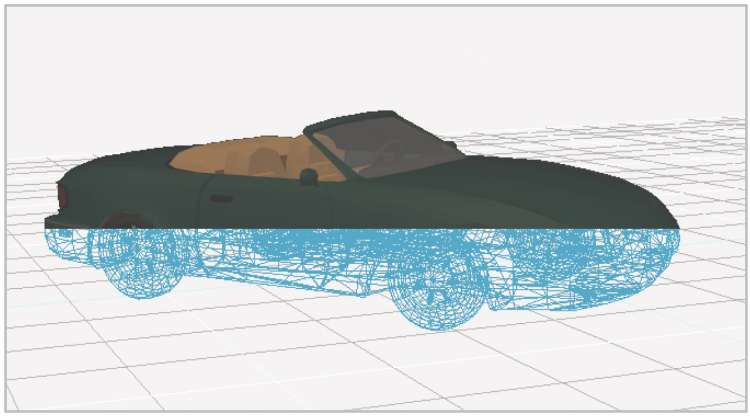
Vector Tools

- ***Vector graphics*** are created from scratch using drawing software such as:
  - Adobe Illustrator
  - LibreOffice Draw
  - Open source Inkscape
  - Various vector drawing apps

3D Graphics

- ***3D graphics*** are based on ***vectors*** stored as a set of instructions describing the coordinates for lines and shapes in a three-dimensional space
- Vectors form a *wireframe* that works like the framework for a tent
- The process of covering the wireframe surface with color and texture is called *rendering*
- The technique for adding light and shadows to a 3D image is called *ray tracing*

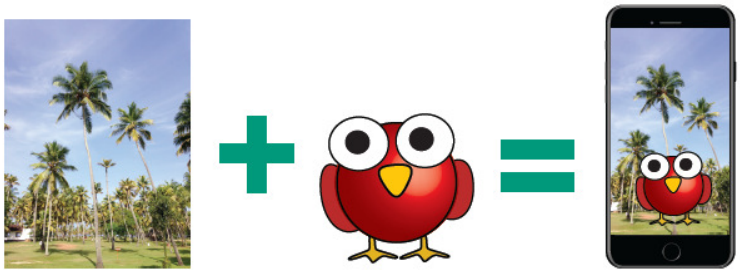
3D Graphics



3D Graphics

- A 3D vector image may have a three-dimensional appearance, but as a single image, it cannot convey ***visual depth***.
- A ***3D-rendered image*** can be modified to create a second rendering slightly offset from the original.
- A smartphone camera captures an image of the real world, and then a game character is rendered onto that image.
- The **composite image** is output to the smartphone screen.

3D Graphics



Vectors and Virtual Reality

- A ***vector animation*** is a type of motion graphic in which a series of vector images is displayed sequentially to convey the illusion of movement.
- Each image is called a ***frame***.

Vectors and Virtual Reality

- The process of rendering vector-based frames and packaging them into a digital movie file is called ***pre-rendering***.
- Pre-rendering is used to create special effect sequences for films, as well as full-length animated movies; these pre-rendered clips are referred to as ***CGI*** (computer-generated imagery).
- ***Real-time rendering*** fills in wireframe objects and generates a bitmap image as the action unfolds.

Vectors and Virtual Reality

- Most interactive virtual reality visuals are generated from 3D vector graphics and displayed on VR headsets, such as Google Cardboard and Oculus Rift.
- A **game engine** is graphics software that allows developers to create interactive videogames and educational modules.

Digital Video Basics

- Digital video uses bits to store color and brightness data for each video frame, a process similar to storing the data for a series of bitmap images in which the color of each pixel is represented by a binary number.
- Footage from Super 8 home movies, VHS tapes, and other older sources can be digitized using video capture equipment.

Digital Video Basics

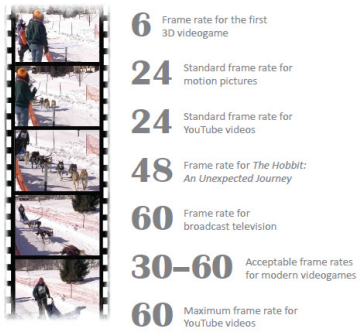
- You can shoot footage for digital video with:
  - A consumer-quality camcorder
  - A webcam
  - A smartphone camera

Digital Video Basics

- Digital cinematography is used in the motion picture industry; it captures moving images as bits, rather than on film.
- Digital video is a core technology for digital television, videoconferencing systems, and video messaging.

Digital Video Basics

- Digital video displays bitmap images in rapid succession.
- Each bitmap image is referred to as a frame.
- The number of frames that are displayed per second is the ***frame rate*** (fps).



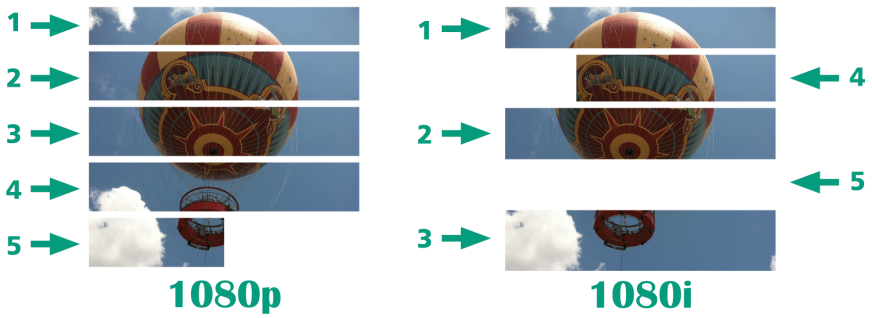
Digital Video Basics

- Video resolutions can be expressed as width x height, as the horizontal resolution, or as the vertical resolution.
- Cameras used for digital cinematography capture video with a resolution of 2048 x 1536.
- This resolution is referred to as 2K because the horizontal resolution is about 2,000 pixels.

Digital Video Basics

- Vertical resolutions are expressed with a "p" for ***progressive scan***, in which the frame is drawn line by line in sequence from top to bottom.
- An ***interlaced scan*** is a contrasting scanning technique that produces an image by drawing every other line, then going back and filling in the in-between lines.
- Digital video for computers typically uses progressive scanning; digital television uses interlaced scanning.

Digital Video Basics

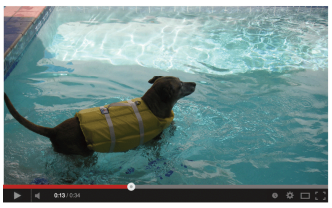


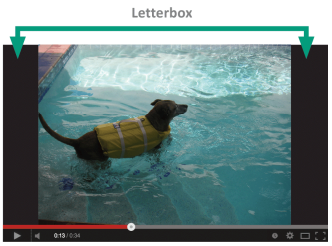
Digital Video Basics

- **Aspect ratio** is the proportional relation between the width and height of an image or video frame.
  - iPads use a 4:3 aspect ratio.
  - Widescreen devices, such as laptops and smartphones, use a 16:9 aspect ratio

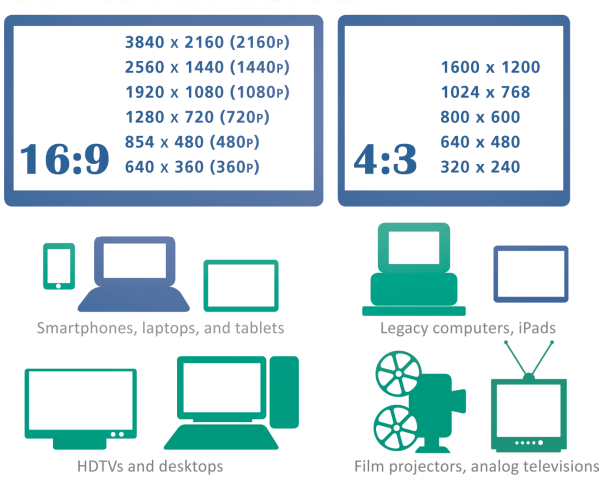
Digital Video Basics

- When 4:3 videos are displayed on a widescreen player, they are bordered by the black bars of a letterbox
- The video on the left has a 16:9 aspect ratio that fits into the YouTube player window. The video on the right has a 4:3 aspect ratio. A letterbox creates black bars to fill the playback window.





Digital Video Basics



Digital Video Basics

- 1,194,393,600 bits are needed for one second of digital video
- A feature-length video requires an astounding 8,599,633,920,000 bits! More than one trillion bytes!
- A bit rate is the number of bits that are processed during a specific unit of time, usually during one second
- Bit rate can be expressed as bits per second (b/sec or bps) and kilobits per second (Kbit/s or Kbps)