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

- 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

• In a digital camera, the lens focuses light from the image onto a small image sensor called a **CCD** (charge-coupled device)
• 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 Size](image.png)

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.

![Norcompressed JPEG image](image1.png) ![JPEG image with 35% compression](image2.png)

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.

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**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.

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

- 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

- 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

- 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)