

# Multimedia Technology Fundamentals

## A Comprehensive Guide

MMT Class

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# What is Multimedia?

- **Definition:** Integration of multiple forms of media
- Text, Audio, Video, Graphics, Animation
- Interactive and non-linear content delivery
- **Real Example:** Netflix combines video, audio, subtitles, interactive menus

## Key Characteristics

- Digital representation
- Computer-controlled
- Interactive user experience

## Entertainment:

- Gaming (PlayStation, Xbox)
- Streaming (YouTube, Spotify)
- Virtual Reality

## Professional:

- E-learning platforms
- Medical imaging
- Digital marketing

# Hypermedia Explained

- **Extension of hypertext** with multimedia elements
- Non-linear navigation through content
- Links connect text, images, audio, video
- **Example:** Wikipedia articles with embedded videos, images, and cross-references

## Hypermedia vs Multimedia

Hypermedia = Multimedia + Hyperlinks + Non-linear Navigation

# World Wide Web (WWW)

- Created by Tim Berners-Lee in 1989
- Information system on the Internet
- Documents connected via hyperlinks
- Accessed through web browsers

## WWW Components

- **HTTP/HTTPS:** Protocol for data transfer
- **URL:** Unique resource identifier
- **HTML:** Markup language for web pages

# Internet Architecture

- Global network of interconnected computers
- **Client-Server Model:** Request-response architecture
- **Protocols:** TCP/IP, HTTP, FTP, SMTP
- **Real Scenario:** When you access Amazon.com:
  - 1 DNS resolves domain to IP address
  - 2 TCP connection established
  - 3 HTTP request sent to server
  - 4 Server responds with web page data

# Internet vs WWW

<b>Internet</b>	<b>WWW</b>
Hardware infrastructure Network of networks Includes email, FTP, VoIP Exists since 1960s	Software service Information system Web pages and websites Created in 1989



# Multimedia Software Categories

- ① **Content Creation:** Adobe Creative Suite, Blender
- ② **Editing Tools:** Premiere Pro, Audacity, GIMP
- ③ **Authoring Tools:** Adobe Animate, Unity
- ④ **Playback Software:** VLC, Windows Media Player
- ⑤ **Compression Tools:** HandBrake, FFmpeg

# Editing Tools Overview

## Image Editing

**Adobe Photoshop:** Professional raster graphics editor

**GIMP:** Free alternative for image manipulation

**Use Case:** Photo retouching, color correction, compositing

## Video Editing

**Adobe Premiere Pro:** Industry-standard video editor

**DaVinci Resolve:** Professional color grading

**Use Case:** YouTube content creation, film production

# Audio Editing Tools

- **Audacity:** Free, open-source audio editor
- **Adobe Audition:** Professional audio workstation
- **Pro Tools:** Industry standard for music production

## Real Scenario: Podcast Production

- 1 Record audio with microphone
- 2 Import into Audacity
- 3 Remove background noise
- 4 Normalize audio levels
- 5 Export as MP3 for distribution

- Software for creating multimedia presentations
- Combine text, graphics, audio, video, animation
- **Examples:**
  - Adobe Animate (Flash successor)
  - Unity (Game development)
  - Articulate Storyline (E-learning)
  - H5P (Interactive HTML5 content)

# Authoring Paradigms

- ① **Card/Page-Based:** PowerPoint, Keynote
- ② **Timeline-Based:** Adobe Animate, After Effects
- ③ **Icon/Flow-Based:** Authorware (legacy)
- ④ **Programming-Based:** Unity, Unreal Engine

## Choosing the Right Tool

Consider: Project complexity, interactivity needs, target platform, budget

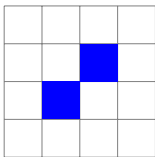
## Raster Graphics:

- Pixel-based images
- Resolution-dependent
- Photos, digital paintings
- Examples: JPEG, PNG, BMP

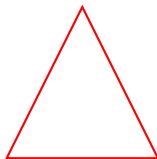
## Vector Graphics:

- Mathematical equations
- Resolution-independent
- Logos, illustrations
- Examples: SVG, AI, EPS

# Raster vs Vector: Visual Comparison



Raster (Pixels)



Vector (Paths)

**Key Difference:** Raster loses quality when scaled; Vector maintains quality

# Image Resolution and Quality

- **Resolution:** Number of pixels (width  $\times$  height)
- **DPI/PPI:** Dots/Pixels per inch
- **Common Resolutions:**
  - HD:  $1920 \times 1080$  (2.1 MP)
  - 4K:  $3840 \times 2160$  (8.3 MP)
  - 8K:  $7680 \times 4320$  (33.2 MP)

## Real Example

iPhone 14 Pro:  $2556 \times 1179$  pixels, 460 PPI



# Popular Image File Formats

Format	Type	Compression	Use Case
JPEG	Raster	Lossy	Photos
PNG	Raster	Lossless	Web graphics
GIF	Raster	Lossless	Animations
BMP	Raster	None	Raw images
SVG	Vector	N/A	Logos, icons
TIFF	Raster	Both	Professional

# JPEG Format Deep Dive

- **Full Name:** Joint Photographic Experts Group
- **Compression:** Lossy (DCT-based)
- **Color Support:** 24-bit (16.7 million colors)
- **Advantages:** Small file size, universal support
- **Disadvantages:** Quality loss, no transparency

## Real Scenario

Digital camera captures 5MB RAW image → Converts to 500KB JPEG for sharing on social media

- **Full Name:** Portable Network Graphics
- **Compression:** Lossless (DEFLATE algorithm)
- **Features:**
  - Transparency support (alpha channel)
  - Better for text and line art
  - No quality loss on re-saving
- **Use Case:** Website logos, UI elements, screenshots

- **Full Name:** Graphics Interchange Format
- **Color Limit:** 256 colors (8-bit)
- **Features:** Animation support, transparency
- **Modern Alternative:** WebP, APNG

## Real Example

Twitter/X reaction GIFs, animated emojis, simple animations

- **Full Name:** Scalable Vector Graphics
- **Based on:** XML text format
- **Advantages:**
  - Infinite scalability
  - Small file size for simple graphics
  - Editable with text editors
  - CSS and JavaScript compatible
- **Use Case:** Responsive web design, icons, logos

# WebP and Modern Formats

- **WebP:** Google's modern image format
- Supports both lossy and lossless compression
- 25-35% smaller than JPEG/PNG
- Transparency and animation support
- **AVIF:** Next-gen format, even better compression

## Adoption

Used by Google, Facebook, Netflix for faster web performance

- **Light:** Electromagnetic radiation (380-750 nm)
- **Human Eye:** Three types of cone cells
  - S-cones: Short wavelength (blue)
  - M-cones: Medium wavelength (green)
  - L-cones: Long wavelength (red)
- **Color Perception:** Brain interprets signals from cones

# Additive vs Subtractive Color

## Additive (RGB):

- Light-based
- Red + Green + Blue
- Used in displays
- More light = brighter

## Subtractive (CMYK):

- Pigment-based
- Cyan + Magenta + Yellow + Black
- Used in printing
- More ink = darker



# RGB Color Model

- **Primary Colors:** Red, Green, Blue
- **Bit Depth:** Typically 8 bits per channel (24-bit total)
- **Color Range:** 0-255 per channel (16.7M colors)
- **Examples:**
  - Red: (255, 0, 0)
  - White: (255, 255, 255)
  - Black: (0, 0, 0)
  - Purple: (128, 0, 128)

## Real Application

Computer monitors, TVs, smartphones, digital cameras

# CMYK Color Model

- **Components:** Cyan, Magenta, Yellow, Key (Black)
- **Values:** 0-100% for each channel
- **Why K (Black)?:** Pure CMY mix creates muddy brown
- **Use Case:** Professional printing, magazines, brochures

## Important

Always convert RGB to CMYK before printing to avoid color shifts

# HSV/HSB Color Model

- **H:** Hue (0-360°) - Color type
- **S:** Saturation (0-100%) - Color intensity
- **V/B:** Value/Brightness (0-100%) - Lightness
- **Advantage:** More intuitive for humans
- **Use Case:** Color pickers in design software

# HSL Color Model

- **H:** Hue (0-360°)
- **S:** Saturation (0-100%)
- **L:** Lightness (0-100%)
- **Difference from HSV:** Lightness calculation
- **Use Case:** CSS color definitions in web development

## CSS Example

```
color: hsl(120, 100%, 50%); // Pure green
```

# YUV/YCbCr Color Model

- **Y:** Luma (brightness)
- **U/Cb:** Blue-difference chroma
- **V/Cr:** Red-difference chroma
- **Advantage:** Separates brightness from color
- **Use Case:** Video compression (JPEG, MPEG, H.264)

## Why YUV?

Human eye more sensitive to brightness than color → Can compress chroma more

# Color Depth and Bit Depth

- **1-bit:** 2 colors (black & white)
- **8-bit:** 256 colors (GIF)
- **24-bit:** 16.7M colors (True Color)
- **32-bit:** 24-bit + 8-bit alpha (transparency)
- **48-bit:** Professional photography (16-bit per channel)

## File Size Impact

1920×1080 image: 24-bit = 6.2MB, 8-bit = 2.1MB (uncompressed)

# Color Spaces and Gamut

- **Color Space:** Range of colors a device can represent
- **sRGB:** Standard for web and consumer devices
- **Adobe RGB:** Wider gamut for professional photography
- **DCI-P3:** Cinema and modern displays (iPhone, MacBook)
- **Rec. 2020:** Ultra HD TV standard

# Gamma Correction

- **Problem:** Display brightness not linear
- **Gamma:** Power-law relationship between input and output
- **Standard Gamma:** 2.2 for most displays
- **Purpose:** Perceptually uniform brightness

## Real Impact

Without gamma correction, images appear too dark or washed out



- **ICC Profiles:** Device color characteristics
- **Color Calibration:** Ensuring accurate color reproduction
- **Workflow:**
  - ① Calibrate monitor with colorimeter
  - ② Use color-managed software
  - ③ Embed ICC profiles in images
  - ④ Soft-proof before printing

# What is Digital Video?

- Sequence of digital images (frames) displayed rapidly
- Creates illusion of motion
- **Frame Rate:** Frames per second (fps)
  - 24 fps: Cinema standard
  - 30 fps: TV broadcast (NTSC)
  - 60 fps: Smooth motion (gaming, sports)
  - 120+ fps: High-speed capture

# Video Resolution Standards

Name	Resolution	Pixels
SD	720×480	0.3 MP
HD (720p)	1280×720	0.9 MP
Full HD (1080p)	1920×1080	2.1 MP
2K	2048×1080	2.2 MP
4K UHD	3840×2160	8.3 MP
8K UHD	7680×4320	33.2 MP

# Aspect Ratios

- **4:3:** Traditional TV (1.33:1)
- **16:9:** Widescreen HD standard (1.78:1)
- **21:9:** Ultra-wide cinema (2.35:1)
- **9:16:** Vertical video (TikTok, Instagram Stories)

## Real Scenario

YouTube automatically adapts to 16:9, adds black bars to other ratios

# Interlaced vs Progressive Scan

## Interlaced (i):

- Odd/even lines alternately
- 1080i = 540 lines per field
- Legacy broadcast TV
- Motion artifacts

## Progressive (p):

- All lines at once
- 1080p = full frame
- Modern standard
- Smoother motion

- **Uncompressed 1080p video:**
  - $1920 \times 1080 \text{ pixels} \times 3 \text{ bytes} \times 30 \text{ fps}$
  - = 186 MB/second
  - = 11 GB/minute
  - = 670 GB/hour
- **With H.264 compression:** 1-5 GB/hour
- **Compression Ratio:** 100:1 to 500:1

# Video Compression Types

## Spatial Compression

Compress individual frames (like JPEG for images)

## Temporal Compression

Store only changes between frames (motion compensation)

- **I-frames:** Complete image (Intra-coded)
- **P-frames:** Predicted from previous frames
- **B-frames:** Bi-directional prediction

- **H.264/AVC:** Most widely used, good compression
- **H.265/HEVC:** 50% better than H.264, 4K streaming
- **VP9:** Google's codec, YouTube default
- **AV1:** Royalty-free, next-gen (Netflix, YouTube)
- **ProRes:** Apple's professional codec

## Real Usage

Netflix uses H.265 for 4K, AV1 for newer content



# Video Container Formats

- **MP4:** Universal, web-friendly (.mp4)
- **MKV:** Matroska, supports multiple tracks (.mkv)
- **AVI:** Legacy Windows format (.avi)
- **MOV:** Apple QuickTime (.mov)
- **WebM:** Open format for web (.webm)

## Note

Container  $\neq$  Codec. MP4 can contain H.264, H.265, or other codecs

# Bitrate and Quality

- **Bitrate:** Data processed per second (Mbps)
- **Higher bitrate:** Better quality, larger file
- **Typical Bitrates:**
  - YouTube 1080p: 8 Mbps
  - Netflix 4K: 25 Mbps
  - Blu-ray: 40 Mbps
- **CBR:** Constant bitrate
- **VBR:** Variable bitrate (more efficient)

# Chroma Subsampling

- Reduces color information, keeps brightness
- **4:4:4**: No subsampling (full color)
- **4:2:2**: Half horizontal chroma (professional)
- **4:2:0**: Quarter chroma (most common, YouTube)

## Why It Works

Human eye more sensitive to brightness (luma) than color (chroma)

- **Adaptive Bitrate Streaming:** Adjusts quality to bandwidth
- **HLS:** HTTP Live Streaming (Apple)
- **DASH:** Dynamic Adaptive Streaming over HTTP
- **Real Example:** Netflix/YouTube buffer multiple quality versions

## User Experience

Slow connection → 480p, Fast connection → 4K, seamless switching

# Video Editing Workflow

- ① **Capture:** Record or import footage
- ② **Import:** Load into editing software
- ③ **Edit:** Cut, trim, arrange clips
- ④ **Effects:** Add transitions, color grading
- ⑤ **Audio:** Sync, mix, add music
- ⑥ **Export:** Render final video with codec/format

# Summary: Multimedia Basics

- Multimedia integrates text, audio, video, graphics
- Hypermedia adds non-linear navigation
- WWW is information system on Internet
- Editing tools: Photoshop, Premiere, Audacity
- Authoring tools: Unity, Adobe Animate

# Summary: Graphics & Color

- Raster (pixels) vs Vector (math)
- JPEG (lossy), PNG (lossless), SVG (scalable)
- RGB (screens), CMYK (print), HSV (intuitive)
- Color depth affects quality and file size
- Color management ensures accurate reproduction

# Summary: Digital Video

- Frame rate: 24-60+ fps
- Resolution: SD to 8K
- Compression essential: H.264, H.265, AV1
- Codecs compress, containers store
- Streaming uses adaptive bitrate



- **Books:**

- "Fundamentals of Multimedia" by Ze-Nian Li
- "Digital Video and HD" by Charles Poynton

- **Online Resources:**

- MDN Web Docs (color models)
- FFmpeg documentation (video processing)
- Adobe tutorials (editing tools)

# Thank You!

Questions?