

Multimedia Technology Fundamentals

A Comprehensive Guide

MMT Class

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Table of Contents

- 1 Multimedia Basics
- 2 Graphics and Image Data Representation
- 3 Color in Image
- 4 Concepts in Digital Video

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

Multimedia Applications

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

- 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

Internet	WWW
Hardware infrastructure	Software service
Network of networks	Information system
Includes email, FTP, VoIP	Web pages and websites
Exists since 1960s	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

Authoring Tools

- 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

Graphics Data Types

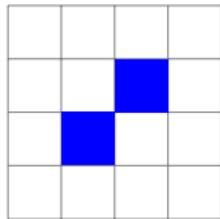
Raster Graphics:

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

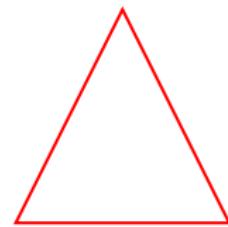
Vector Graphics:

- 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 × height)
- **DPI/PPI:** Dots/Pixels per inch
- **Common Resolutions:**
 - HD: 1920×1080 (2.1 MP)
 - 4K: 3840×2160 (8.3 MP)
 - 8K: 7680×4320 (33.2 MP)

Real Example

iPhone 14 Pro: 2556×1179 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

PNG Format

- **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

GIF Format

- **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

SVG Format

- **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

Color Science Fundamentals

- **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

Color Management

- **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
- $1080p = \text{full frame}$
- Modern standard
- Smoother motion

Video Compression Necessity

- **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

Video Codecs

- **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 ≠ 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)

Video Streaming Technologies

- **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

References & Further Learning

- **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?