

# **MULTIMEDIA SYSTEMS DESIGN – CS576**

**DR. PARAG HAVALDAR**

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# YOUR INSTRUCTOR!



## **COURSE WEB PAGE ON DEN**

**TIMES – Mon 6:40 pm – 10:10 pm**

**Class Location:** SGM 124

**Office Location:** TBD

**Office Hours:** before/after class Mondays\*

## **Teaching Assistant/Course Producer:**

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Wednesday 9:30am – 11:30am

Location : PHE 108

Email : [sterbent@usc.edu](mailto:sterbent@usc.edu)

Phone: **208-346-1921**

Office Hours: Monday - 11:00am – 1:00pm

Thursday 11:00am – 1:00pm

Location : SAL 100 lobby

# **COURSE DETAILS**

## **PREREQUISITES**

**Good Programming Skills**

**Basic Math Skills**

**Helpful – Signal Processing, Graphics, Networks...**

## **COURSE GRADE DECISION**

**One Term Exam - 40% (Mon April 1 2019 *tentative*)**

**Assignments, Project 50%**

- 2 to 4 Theory/Programming Assignments (20%)**
- Project, done in a groups (30%)**

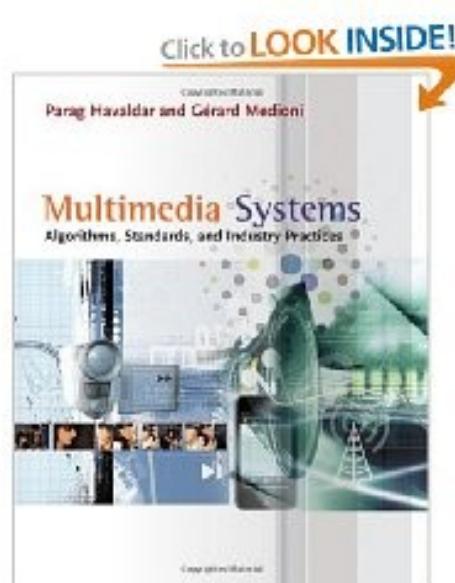
**Participation and ICT Lectures - 10%**

# BOOKS

## List of Recommended Books:

- Ze Nian Li , Mark S. Drew, *Fudamentals of Multimedia*, Prentice Hall, 2004
- S.V. Raghavan, S.K. Tripathi, *Networked Multimedia Systems: Concepts, Architecture, and Design*. Prentice Hall, 1998
- F. Kuo, W. Effelsberg, J.J. Garcia-Luna-Aceves, *Multimedia Communications: Protocols and Applications*. Prentice Hall PTR, 1998
- David S Taubman, Micheal W. Marcellin, *JPEG 2000 – Image Compression, Fundamentals, Standards and Practice*, Kluwer Academic Publishers 2002
- Mohammed Ghanbari, *Video Coding – An Introduction to Standard Codecs*. The Institution of Electrical Engineers (IEE), London, UK, 1999.
- A. Puri, T. Chen (eds.), *Multimedia Systems, Standards, and Networks*. Marcel Dekker, 2000
- Ming-Ting Sun, Amy R. Reibman (eds.), *Compressed Video over Networks*. Marcel Dekker, 2000
- Marin Bosi and Riach E. Goldberg, *Introduction to Digital Audio Coding and Standards*, Kluwer Academic Publishers 2003
- Foley, Van Dam, Feiner, Hughes, *Computer Graphics – Principles and Practice*, Second Edition. Addison-Wesley – 1990.

## REQUIRED BOOK



***Multimedia Systems – Algorithms, Standards and Industry Practices.***  
***-Parag Havaldar and Gerard Medioni***

# INTRODUCTION



## **EXAMPLES AND !EXAMPLES**

**Reading a newspaper YES/NO?**

**Describing a Picture to your friend YES/NO**

**Video Game Playing and Multiplayer Game YES**

**Riding a bicycle NO**

**Video Conferencing YES**

**Visiting your doctor NO**

**Watching Television YES**

**Assembling a car in a garage NO**

**Listening to Radio YES/NO**

**Having a phone conversation YES/NO**

# **INTRODUCTION**

## **Historical Perspective**

**When was the word multimedia created?**

**Timeline of information creation and distribution**

## **Multimedia Data and Information**

**Contains a mixture different types of media – text, images, video, audio, graphics**

**Definition and media types have been changing**

## **Multimedia Systems**

- Generation**
- Processing**
- Storage**
- Distribution**
- Rendering**

## HISTORICAL PERSPECTIVE OF MEDIA

<b>Age</b>	<b>Time and Era</b>	<b>Type of Information</b>	<b>Storage medium</b>	<b>Mode of Distribution</b>
Prehistoric	15000BC	Sounds, Gestures Painting	Rocks, cave walls	-
Ancient	500 BC	Alphabets, Drawing	Invention of paper	People delivering messages, Horse back
Middle Ages	400-1000 AD	Letters, Writing	Books	Beginning of a postal system
Renaissance	1300-1800 AD	News, paintings, magazine	Books, Libraries	Printing press, steam engines, automobiles
Modern World	1900 AD	Morse Code, radio, Photographs, Movies	Film, Magnetic Tapes, Phonograph	Telegram service, wireless radio waves
Electronic	1950-1980	Telephone, Television, Fax, Computers	Electronic memory, cassette tapes. LP records	Radio and TV Broadcasting, Satellite Communication
Digital	1980 to present day	Computers, Digital Video, Surround Sound	Hard Disks, CDROMs, DVDs, IPTV, Facebook,	Ethernet, Wireless Networks, Optical networks, Cell phone networks

## **COMPONENTS OF A MULTIMEDIA SYSTEM**

**Capture devices –**

**Video camera, audio microphone, keyboard etc.**

**S/W Processing Elements –**

**S/W for content creation, compression, encryption etc.**

**Storage devices – CDROMS, Hard disks, Memories**

**Distribution network –**

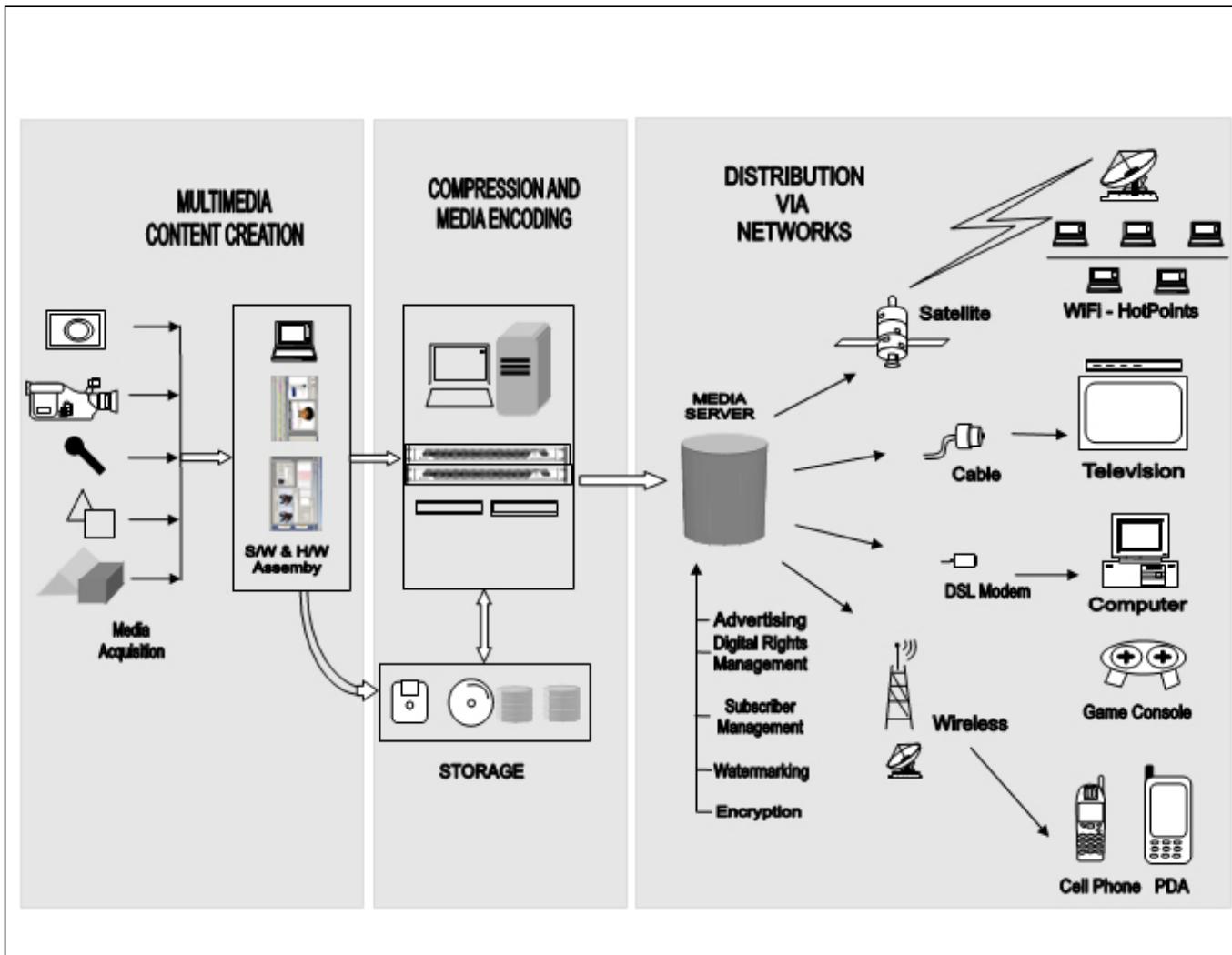
**Ethernet (10-100 Mbs), ATM, Fiber Optics, Wireless**

**Processing devices**

**CPUs, Set Top boxes, workstations, DSP hardware**

**Display / Rendering devices -**

**HiRes Monitors, Speakers, HDTV, Projectors, Printers**



# **MEDIA TYPES – AN “IN”COMPLETE TAXONOMY**

## **Current Media Types**

- Text – Hypertext
- Images – Static & Dynamic
- Audio – Speech, Music
- Video – Movies, Documentaries
- 2D Graphics – Vector Graphics, 2D Sprites
- 3D Graphics – Games

## **Future Media Types**

**TEXT**

This is a line of text to explain that text does convey information!

[Hypertext](#)

## IMAGES – GRAY & COLOR



# IMAGES – FAX

Medium	QoS Parameter	Range	Quality Characterization
Video		64 Kbps–2 Mbps	H.261 encoded videoconferencing
		1.2 Mbps	MPEG-1 VCR Quality
		2–4 Mbps	MPEG-2 broadcast quality TV
		3–6 Mbps	MPEG-2 compressed studio-quality TV
		140–166 Mbps	Uncompressed TV, PCM coding
		25–34 Mbps	HDTV lossy MPEG-2 compression
		around 500 Mbps	HDTV lossless compression
		$\geq 1$ Gbps	HDTV uncompressed quality
	Bit-error rate	$\leq 10^{-6}$	Long-term bit-error rate
	Packet loss rate	$\leq 10^{-2}$	Uncompressed video
Bit-error rate		$\leq 10^{-11}$	Compressed video
	End-to-end delay	250 msec	Video telephony
		200 msec	JPEG video transmission
Delay jitter		10 msec	Video telephony
		5 msec	JPEG video transmission
	Frame rate	30 frames/sec	NTSC format
Frame width		$\leq 720$ pixels	Video signal MPEG coded
	Frame height	$\leq 576$ pixels	Vertical size
	Color resolution	8 bit/pixel	Grayscale resolution of 256 colors
Compression ratio	2:1		Lossless compression of HDTV
	50:1		Lossy compression of HDTV
Decoded buffer		$\leq 376,832$ bits	MPEG related parameters

## IMAGES - STITCHED TOGETHER



[Mosaic example](#)

[Panorama example](#)

## IMAGES – STEREO



# VIDEO

**How do you describe video ?**



creamedgeates.mpa

# AUDIO

**Audio Media is of various kinds**

**CD Quality (uncompressed)**

**Mp3 compressed audio**



sound3-brubeck\_takefive.mp3

**Speech –** (.wav)

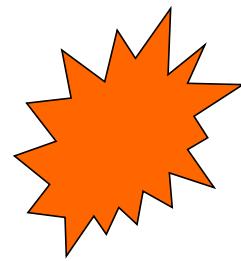
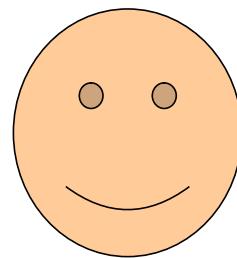


**MIDI example –** sound1-furelise.mid

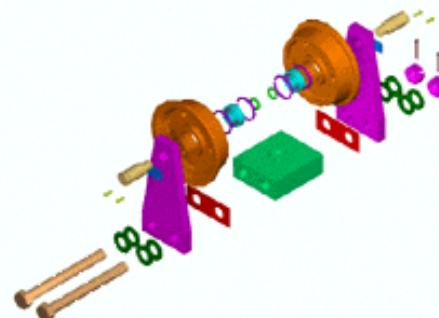
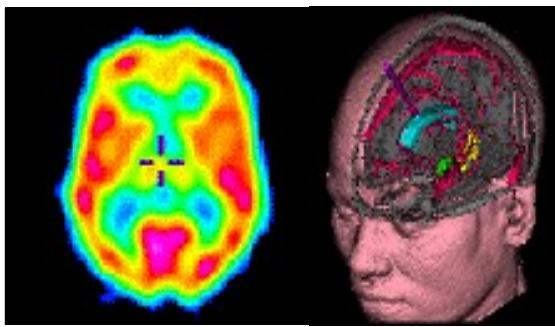


**How do you describe audio ?**

## 2D GRAPHICS



## 3D GRAPHICS



## **MEDIA TYPES – CONCLUSION**

**We have seen a lot of media types that are currently used; there may be others in future depending on**

- Need for information
- Capture device technologies
- Rendering devices and technologies

**Need for standards**

- Many media types, having many formats
- Information has to be easily interchanged and displayed

# BREAK



char.spiderman\_small.mov

## **EXAMPLES IN MULTIMEDIA**

**ImmersiveMedia – Interactive Video**

Commented [PH1]:

**Augmented/Virtual Reality**

**Industry Example, Oculus VR, Holoportation**

**Movies, Animation & VFX Pipeline**

**Performance capture technologies**

**Display Technologies- Auto stereoscopic Displays**

**Synthesizing Obama**

**Multiplayer Gaming**

**Research Progress – the Visual Microphone, Cocktail Party,**

## **INHERENT QUALITIES OF MULTIMEDIA**

**Digital Always**

**Mixture of different media types**

**Interactive**

**Multimedia Data is huge**

**Real Time Issues**

**Synchronization Issues**

- **Intra media Time dependencies**
- Inter media Time dependencies**

## **BACK TO EXAMPLES AGAIN**

**Reading a newspaper .**

**Describing a Picture to your friend .**

**Video Game Playing and Multiplayer Game .**

**Riding a bicycle .**

**Video Conferencing .**

**Visiting your doctor .**

**Watching Television .**

**Assembling a car in a garage .**

**Listening to Radio .**

**Having a phone conversation .**

# **MULTIMEDIA CLASSIFICATIONS**

**Static Vs Dynamic**

**Type - Real time Vs Orchestrated**

**Linear Vs Nonlinear**

**Person-to-Person Vs Person-to-Machine**

**Distribution**

- **Single user (CD ROM and Computer)**
- **Peer to Peer (Teleconferencing between two addresses)**
- **Peer to Multi Peer (Internet, Corporate Networks)**
- **Broadcast (Cable Network)**

## **FORCES DRIVING THE “MULTIMEDIA REVOLUTION”**

**Digitization of all information - text/audio/video documents, libraries, distributed nature of information**

**Evolution of data networks and communication standards with increasing availability of bandwidth on demand**

**Hardware - Faster processors, large capacity storage devices, smaller mobile computing devices.**

**Software - New algorithms, structures that deal with distributed queries**

**Better User Interfaces – hand held devices, sensors, displays**

**Digitization of virtually everything ....**

**Ubiquitous access of information**

# **TECHNOLOGICAL ASPECTS**

**Organizing, Storage and Retrieval, Distribution, Playback**

**Techniques for compression**

- Algorithms
- Standards

**Communications Aspects**

- Downloading and Streaming
- Synchronization
- Layering of Signals
- QoS – traffic, delays, packet loss, sync

**Access to multimedia signals**

- “natural” spoken language queries
- media conversion tools
- multimodal user interface
- distributed and collaborative access

# **COURSE MAP**

## **Lecture 1 (Chapter 1) – Introduction to Multimedia and Course Map**

## **Lecture 2 (Chapters 2 & 3) – Data Acquisition and Media Processing Basics**

Signal Processing Basics, time/spatial and frequency domain analysis,  
Sampling & quantization – aliasing effects. Bit rate  
Representational aspects of media – images, audio, video, graphics.

## **Lecture 3 (Chapter 4) – Fundamentals of Color Theory & Displays**

Color and Color Perception  
Camera Color Calibration using CMFs  
Color Spaces – types, uses and applications  
Color Displays and Monitors – CRT, LCD, LED, OLED  
Color Quantization

## **Lecture 4 (Chapter 6) – Information Theory and Generic Compression Techniques**

**Coding Theory**

**Lossless techniques – Huffman, Arithmetic, Lempel Zev etc.**

**Lossy techniques – Predictive Coding, Transform Coding, Wavelets, Hybrid etc.**

**Introduction to perceptual analysis**

## **Lecture 5 (Chapter 7 and Research Papers) – Media Compression - Images**

**Representation Issues**

**Generic Image Compression algorithms – DCT, Wavelets, Fractals**

**Fourier Representation, DCT & Wavelet theory**

**Standards – JPEG, JPEG2000, GIF etc.**

**Image Dithering**

## **Lecture 6 (Chapter 8 and Research Papers) – Media Compression - Video**

**Issues in representation, spatial & temporal domain.**

**Generic compression algorithms and analysis (MPEG techniques)**

**MPEG standards - MPEG1, MPEG2, MPEG4: various video Profiles and AVC**

**ITU standards – H.261, H.263, H.264, H.265 (HEVC)**

## **Lecture 7 (Chapter 9 and Research Papers) – Audio Processing**

Representation and capture Issues  
Generic compression algorithms and analysis (MPEG techniques)  
MPEG (1, 2, 4) standards – mp3, AAC, CELP  
ITU standards – G.72x  
Dolby AC3, AC5  
Surround Sound, THX, Spatial Audio, Dolby Atmos

## **Lecture 8 (Chapter 10 and Research Papers) – 2D/3D Graphics Content Creation, 3D Compression & Recent Trends in 3D**

Representation issues  
Geometry Transformations in 2D and 3D  
Rendering Pipeline – modeling, lighting, transformations, scan line  
Animation techniques  
Special Effects & Gaming Technology discussions  
3D Compression  
Modern applications of computer graphics and computer vision – image based rendering, panoramic images and cameras  
3DTV, stereoscopic content

## **LECTURE 9 - Media Security & Digital Rights Management**

Watermarking – definition, generic schemes, specific to MPEG world

Encryption – requirements, common rules, encryption related to MPEG world

DVD Encryption rules

Watermarking/Encryption Architectures – digital movie distribution pipeline, session based architectures

### **Term Exam**

### **Lectures there after to be held at ICT**

Open House at ICT

Real Case studies from the Industry

Blending CG and Real Imagery – geometrically & photometrically

Digital Characters and Virtual Actors

Light Stage Data Acquisition

Advanced Technologies to create virtual actors

Natural Language Queries

Virtual and Augmented Reality

Multimodal Media Analysis

Multimedia Metadata, MPEG7 and Metadata Management

Standards of Metadata – MXF, TV-Anytime, Dublin Core,

Examples of multimedia databases

## ***Other Relevant Areas to be covered if we have time***

### **MPEG4 & Applications, MPEG 21 Frameworks**

- Introduction as a object oriented framework
- Representation Features – Audio Visual Objects, Scene Graphs
- Compositional, Synchronization & Delivery Features
- Compression features of each media object representation
- Applications around MPEG4, MPEG DASH
- MPEG 21 – distribution of content over a variety of networks

### **MPEG 21**

- MPEG 21 – distribution of content over a variety of networks
- Digital Items and Digital Item Transactions across different networks

### **Multimedia Frameworks and Industry wide Multimedia Deployments**

**Current Trends – MPEG DASH, HEVC, DCI**

**Industry Outlook & Job Scenarios, Discussions on the future of multimedia ...**