

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: Online for Spring 2021

**Office Hours: After class Mondays*,
And by email appointment**

Teaching Assistants:

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Office Hours:

Wed – 2:00pm – 4:00pm

Fri – 2:00pm – 4:00pm

Location : Online, a webex/zoom link will be created

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(408) 334-6580

Tue – 2:00pm – 4:00pm

Thu – 2:00pm – 4:00pm

COURSE DETAILS

PREREQUISITES

Good Programming Skills

Basic Math Skills

Helpful – Signal Processing, Graphics, Networks...

COURSE GRADE DECISION

One Term Exam – 35 % (Mon April 5th)

Assignments, Project 65%

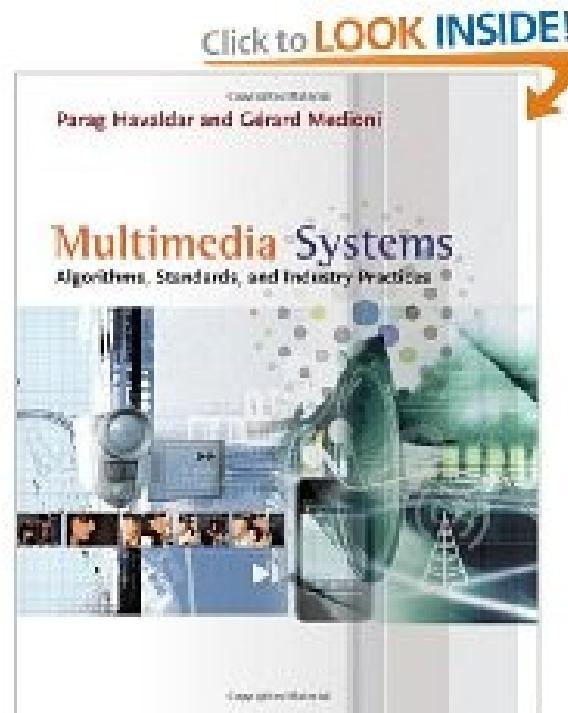
- 2 to 4 Theory/Programming Assignments (35%)**
- Project, done in a group of 2-3 students (30%)**

BOOKS

List of Recommended Books:

- Ze Nian Li , Mark S. Drew, *Fundamentals 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 Haveldar and Gerard Medioni

INTRODUCTION



EXAMPLES AND !EXAMPLES

Reading a newspaper YES/NO

Describing a Picture to your friend NO\YES

Video Game Playing and Multiplayer Games YES

Riding a bicycle NO

Video Conferencing YES

Visiting your doctor NO/YES

Watching Television YES

Assembling a car in a garage NO

Listening to Radio YES/NO

Having a phone conversation 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

Age	Time and Era	Type of Information	Storage medium	Mode of Distribution
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 –

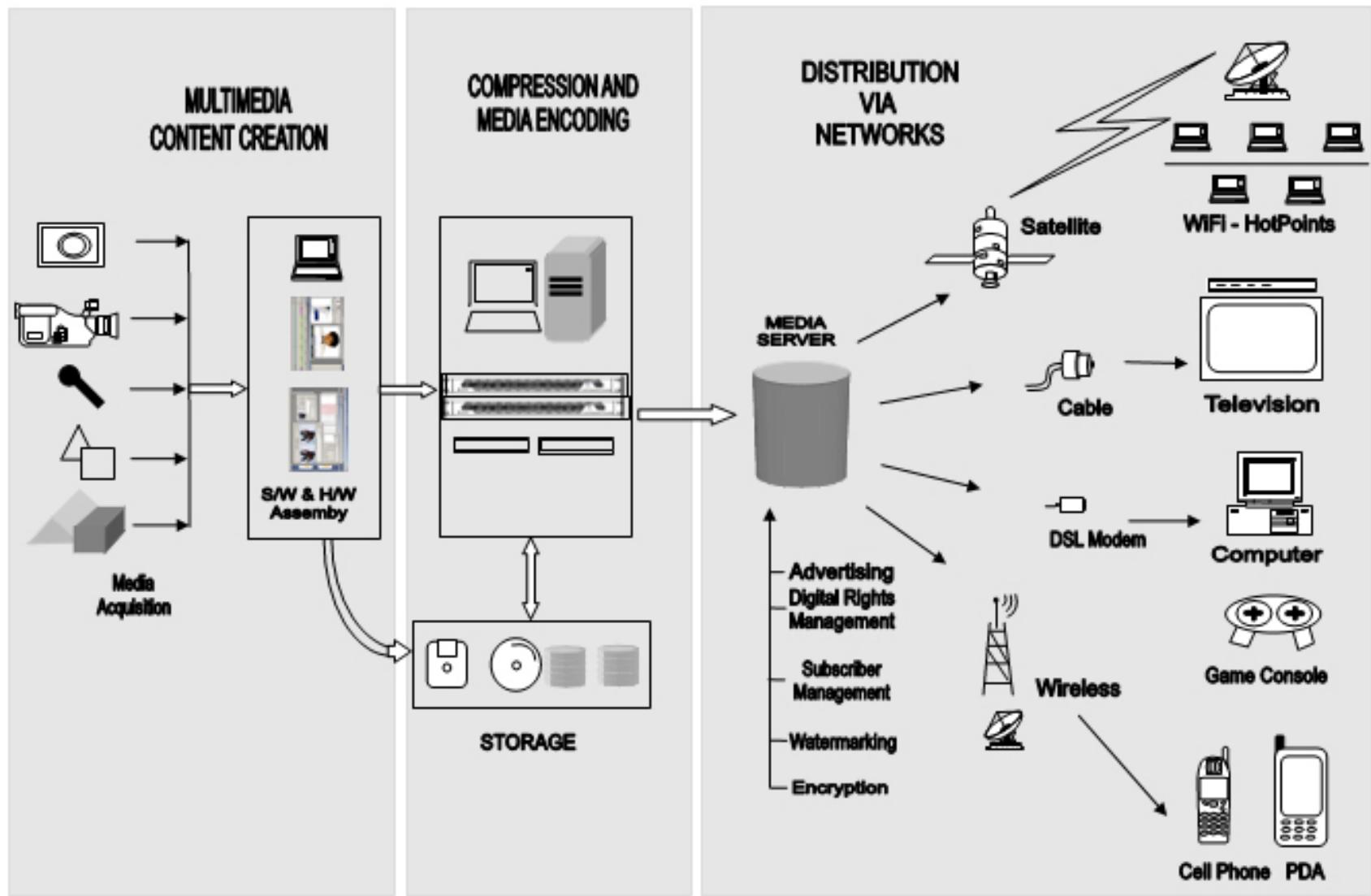
Ethernet (10-100 Mbs), ATM, Fiber Optics, Wireless

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	Bit-error rate	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
		$\geq 1 \text{ Gbps}$	HDTV uncompressed quality
	Packet loss rate	$\leq 10^{-6}$	Long-term bit-error rate
		$\leq 10^{-2}$	Uncompressed video
Bit-error rate	End-to-end delay	$\leq 10^{-11}$	Compressed video
		250 msec	Video telephony
		200 msec	JPEG video transmission
Packet loss rate	Delay jitter	10 msec	Video telephony
		5 msec	JPEG video transmission
End-to-end delay	Frame rate	30 frames/sec	NTSC format
	Frame width	≤ 720 pixels	Video signal MPEG coded
	Frame height	≤ 576 pixels	Vertical size
	Color resolution	8 bit/pixel	Grayscale resolution of 256 colors
Delay jitter	Compression ratio	2:1	Lossless compression of HDTV
		50:1	Lossy compression of HDTV
Frame rate	Decoded buffer	$\leq 376, 832$ bits	MPEG related parameters

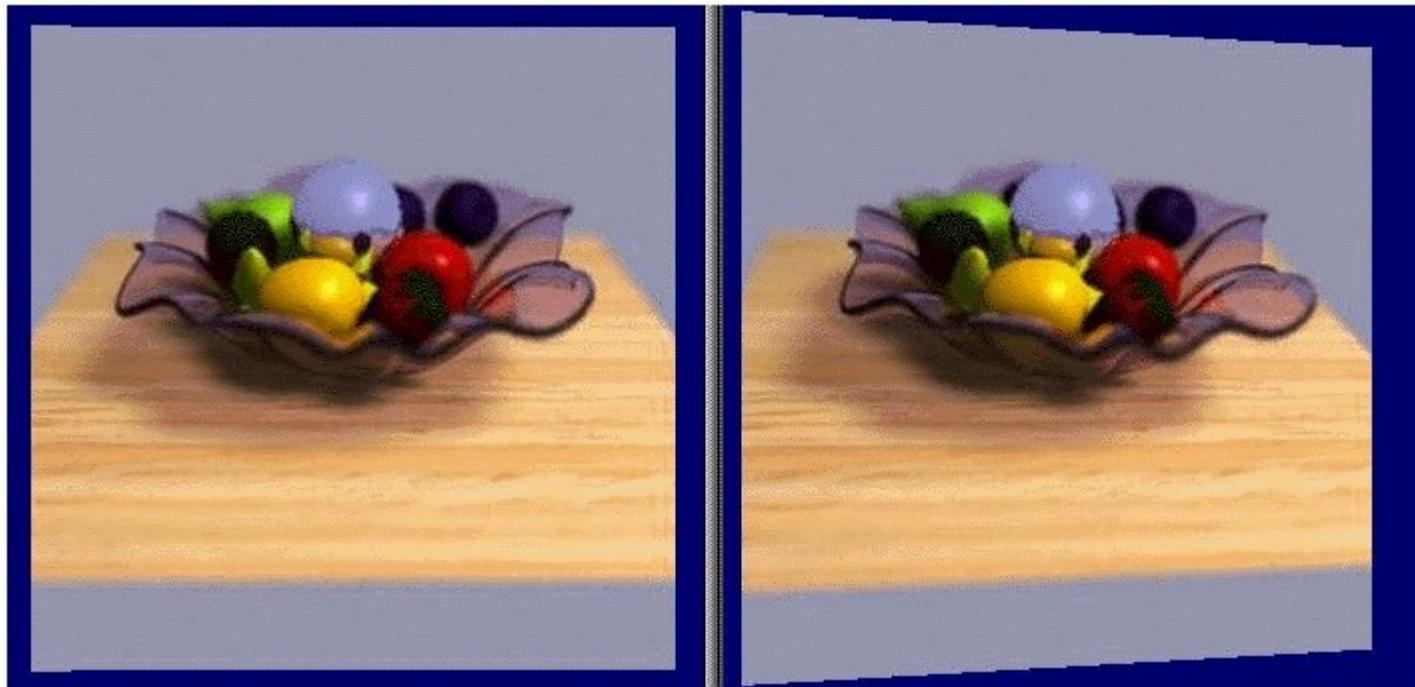
IMAGES - STITCHED TOGETHER



Mosaic example

Panorama example

IMAGES – STEREO



VIDEO

How do you describe video ?

[creamedgates.mpa](#)

AUDIO

Audio Media is of various kinds

CD Quality (uncompressed)

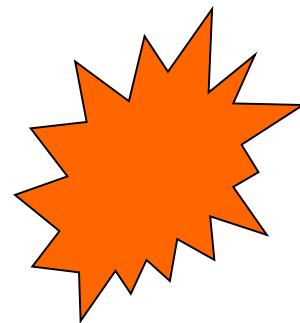
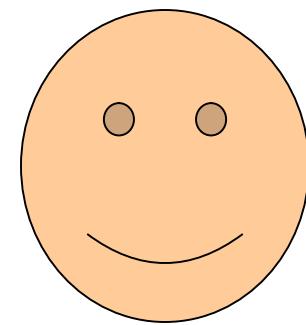
Mp3 compressed audio [takefive.mp3](#)

Speech – [JFKCELP8kHz.wav](#)

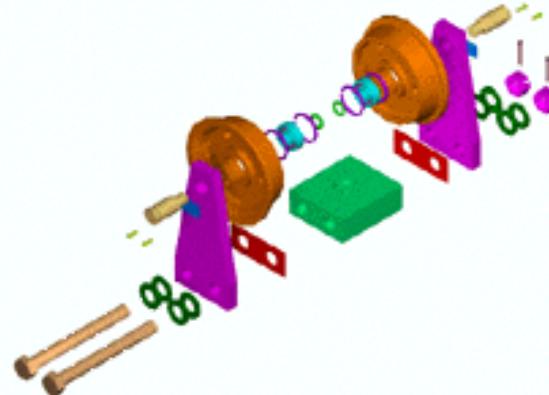
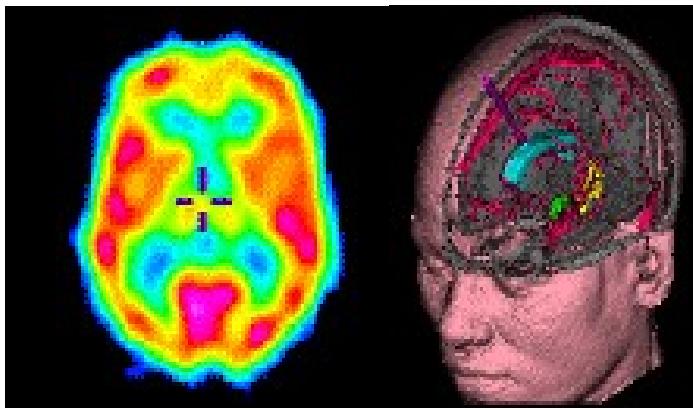
MIDI example – [furelise.mid](#)

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

STRECH YOUR LEGS

EXAMPLES IN MULTIMEDIA

ImmersiveMedia – Interactive Video

Augmented/Virtual Reality

Industry Example, Oculus VR, Holoportation

**Deep Learning with media – Real time Face Replace,
Synthesizing Obama, GAUGAN**

Movies, Animation & VFX Pipeline

Performance capture technologies

Display Technologies- Auto stereoscopic Displays

InFORM – Make the digital physical

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, Monitors and Calibration – 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, Compressive Sensing

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 – Deep Learning in Media, Basics and Recent Trends

- Overview of Machine Learning/Deep Learning**
- Deep Learning Networks with Media**
- Traditional Networks architectures used – CNN, R-CNN, RNN, AutoEncoders, GANs**
- Examples of recent progress in media and animation**
- Programming setup and project**

LECTURE 10 - 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 – Monday April 5th

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

Game Pipelines and In Game workflows

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 Databases

Multimedia Frameworks and Industry wide Multimedia Deployments

Current Trends – MPEG DASH, HEVC, DCI

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