World Telecommunication

&

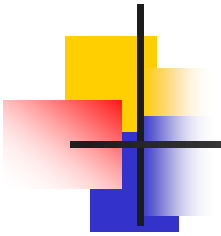
Information Society Day:

17 May 2024

Digital Innovation for Sustainable Development in the field of **multimedia** over **wireless**

M. Salim Beg

IE(I) Aligarh Centre



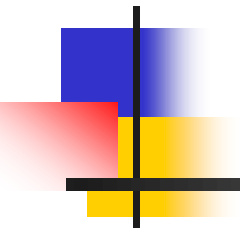
Overview

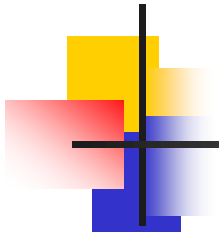
- World Telecommunication Day: Background
- History of Telecommunications
- Early developments in Multimedia
- Basic concepts of Multimedia
  - Definition, Advantages, Enabling technologies for multimedia
- Latest & futuristic Innovations
  - Virtual telepresence, displays, compression
- What is 5G and why do we need it!

World Telecommunication Day

Background

History of Telecommunications

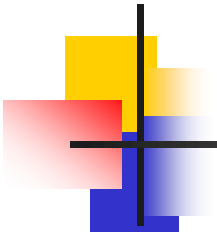




Historical Background

Text

- Designed **electronic systems for text**:
  - transmission
  - processing
  - storage
  - display
- Telegraphy, **1838**
  - Services stopped in India during Autumn **2013**.



Historical Background

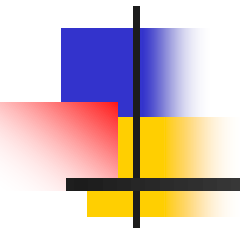
Sound/Audio

- Telephony: speech, **1875**
  - **Initial** systems were all **analog**
  - **PSTN** continued to grow & evolve with **new value added services**
  - Gradually many parts of PSTN became **digital**
- Design & development of **electronic systems** capable of handling **sounds**
  - spoken language (**speech**) processing
  - **Music** / **Audio**

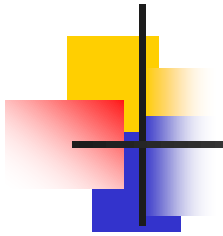
Historical Background

Video/TV

- First TV demonstration, Baird, **1938**
- Initial systems were **B&W** (i.e. **grey scale** picture which is also called **monochrome**) and were based on **analog communication**.
- Colour TV transmission started in **1960s** but it was still **analog** transmission at that time.



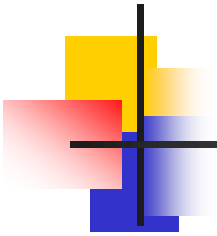
Early Developments in Multimedia



Early Developments in Multimedia

Sound/Audio

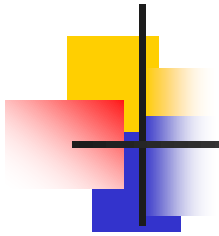
- sound card for PCs in **early 1990s**
- need for compression of audio
- **audio** compressions standards developed
  - MPEG-1, **1991**
  - MPEG-2, **1995**
  - MPEG-4, **1999**



Early Developments in Multimedia

Graphics / Images

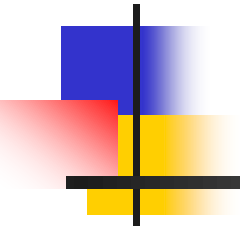
- PCs began to deal with graphics, late **1980s**
  - monitors in **1980s** were mainly **monochrome**
- **colour monitors** emerged, early **1990s**
- Development of **colour graphics**, **1990s**
- Use of **colour images** in PC began with development of image **compression** of colour images, **early 1990s**
  - GIF
  - JPEG, **1991-92**

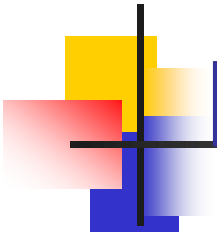


Multimedia PCs

- Term "Multimedia PC" emerged, **early 1990s**
- First set of Multimedia PCs (early 1990s) could not handle video

Basic concepts of Multimedia





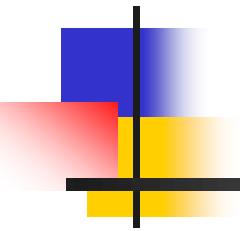
Formal definition of Multimedia

Digital multimedia deals with the computer-controlled **integration** of

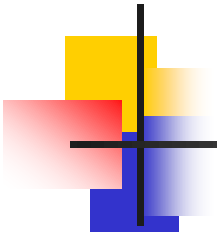
- **text,**
- **graphics,**
- **still images,**
- **animations,**
- **audio and/or video**

where every type of information can be **represented, stored, transmitted and processed digitally**.

Ref: Francois Fluckiger, "Understanding Networked Multimedia" Prentice Hall, 1995.



Advantages of Multimedia

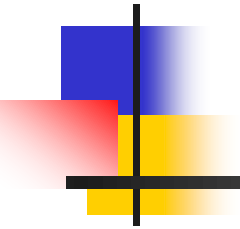


Advantages of Multimedia

Advantages of Multimedia:

- Ease of use
- Intuitive interface
- Immersive experience
- Self-paced interaction and better retention
- Better understanding of the concept
- Cost effectiveness
- More fun and greater efficiency
- Dashboard philosophy

Reference: Stephen McLoughlin, Multimedia Concepts & Practice, Prentice-Hall, 2001.

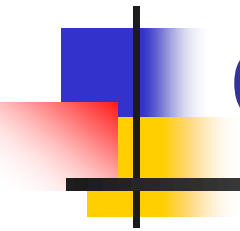


Enabling Technologies For Multimedia Revolution

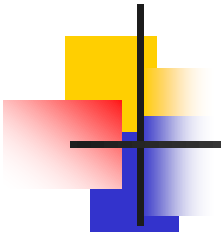
Enabling technologies for multimedia

Reasons multimedia revolution in early 1990s lies in dramatic concurrent advances in some enabling technologies.

- **Higher Processing Power Per Chip**
- **Higher Capacity Semiconductor Memory Chips**
- **Storage Technologies**
- **Compression Technologies**
- **Input/Output Device Technologies**
- **Carrier & Transmission Technologies**
- **Network Switching Services Technologies**
- **Protocol Technologies**
- **Database Technologies**
- **Software Technologies**



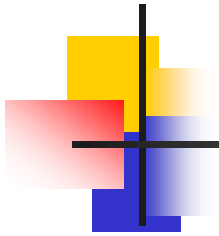
Latest & futuristic developments in multimedia



Background so far!

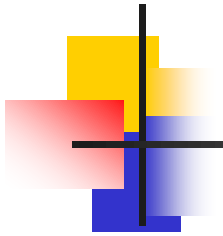
- **text**, **graphics**, **images**, **video**, and **animation** serve the user's **eyes** only.

- **speech** & **audio** serve user's **eyes** & **ears** only.



Latest & futuristic developments

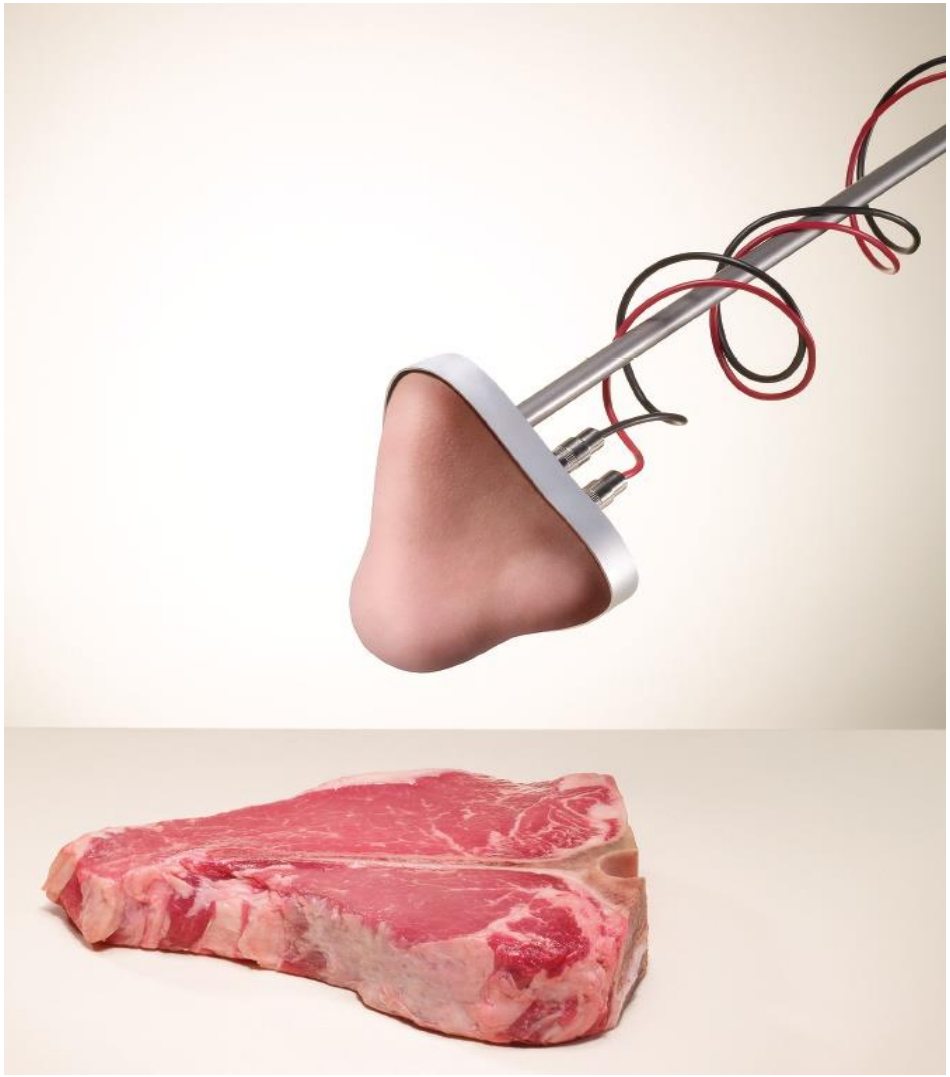
- Researchers are **developing new systems** that invoke the other human sense organs too:
  - **Nose**
  - **Skin**
  - **Tongue**



Latest & futuristic developments

- Formal definition of multimedia (discussed earlier) **is likely to change** in future with incorporation of new media elements that can cater to
  - smell
  - touch
  - taste

Electronic-Nose

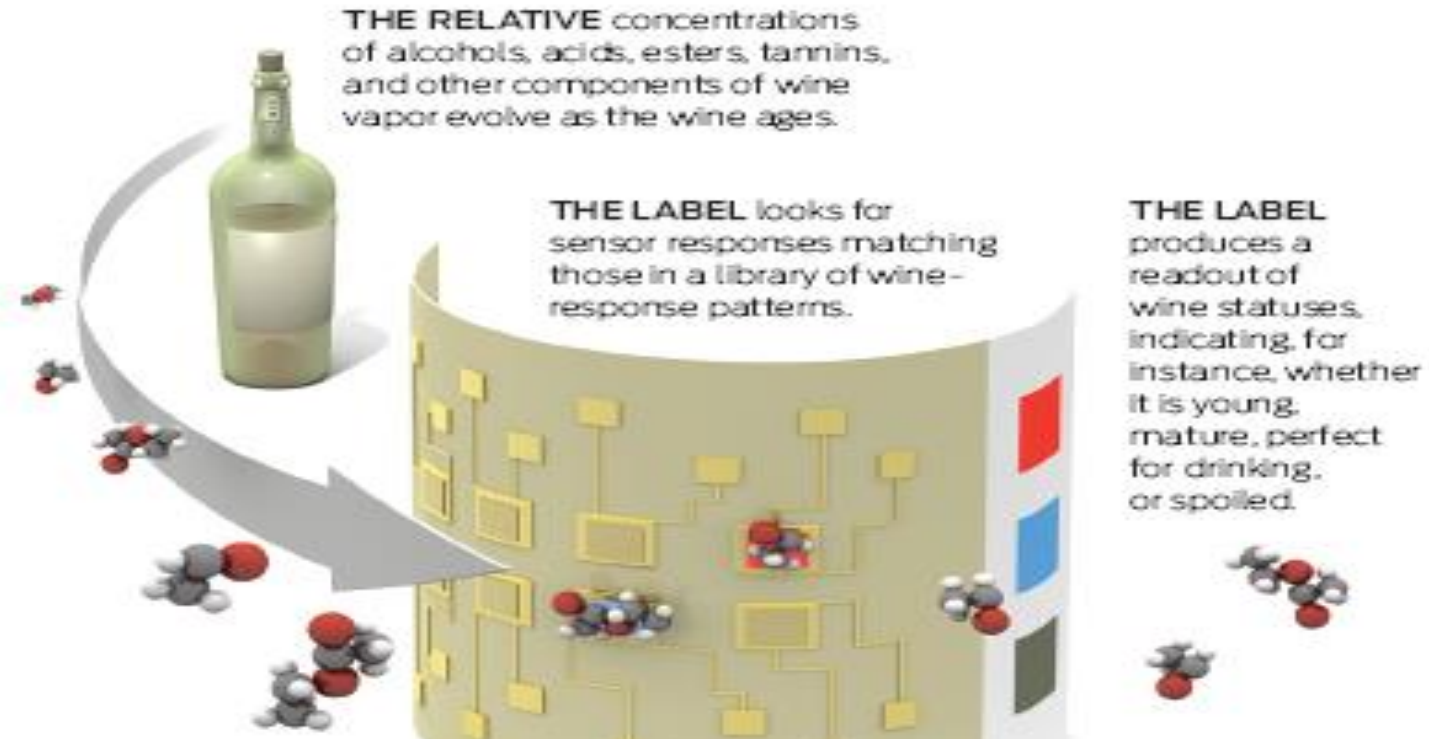


Electronic-Nose

Electronic-Nose

USING ELECTRONIC-NOSE technology, a label of the future sniffs a fine wine, monitoring the evolution of its contents as it ages. The device, manufactured by printing conducting polymers on a flexible substrate, will use a sensor array and pattern-recognition algorithms to differentiate between young wines, mature wines, and spoiled wines. Developers will generate a reference library of patterns by exposing the nose to a vast variety of wines at each of the different stages and having it look for distinctions among the stages.

ILLUSTRATION: BRYAN CHRISTIE DESIGN

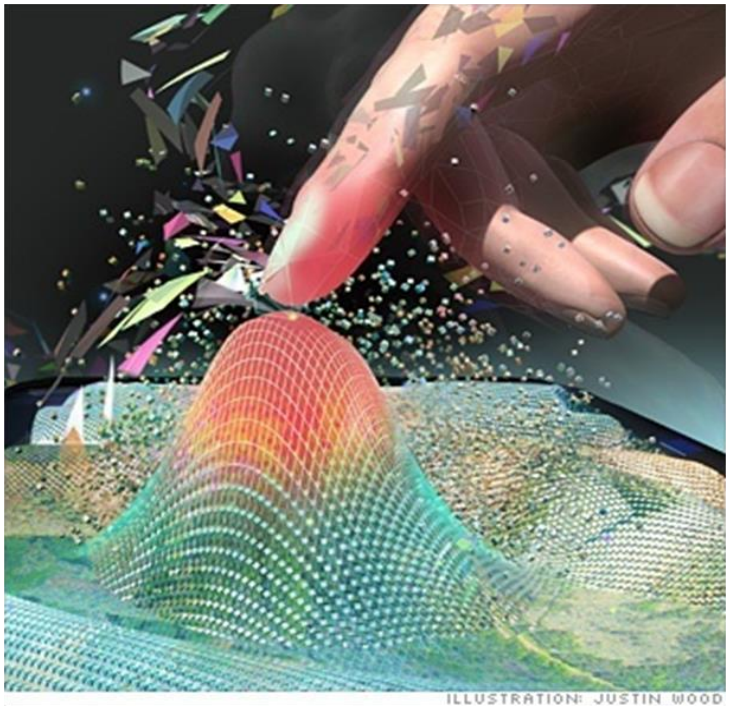


NTT Develops a **Smell-o-Phone**

Developing **Smelling screens**

What is haptic multimedia?

- **Haptics** is capability to sense a natural or synthetic mechanical environment through **touch**.



Haptic multimedia

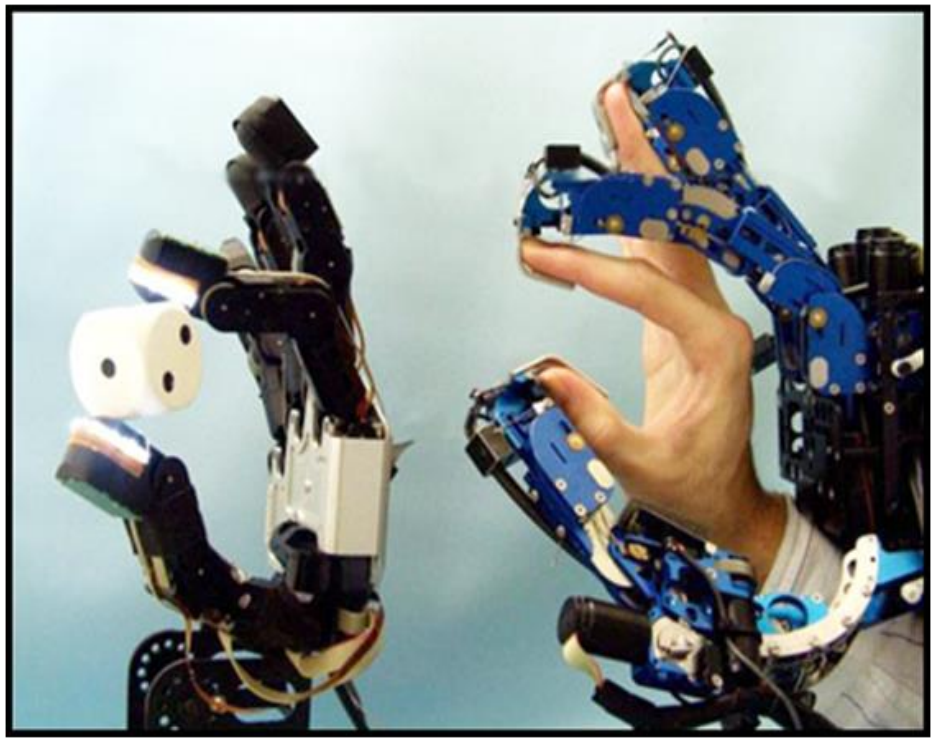
Haptic multimedia deals with human - computer interaction which compulsorily involves the sense of touch.

Why is haptics important?

- Providing a sense of "touch" betters our perception and understanding of a object.
- Haptics provides information about surfaces, textures, temperature etc. of an object.

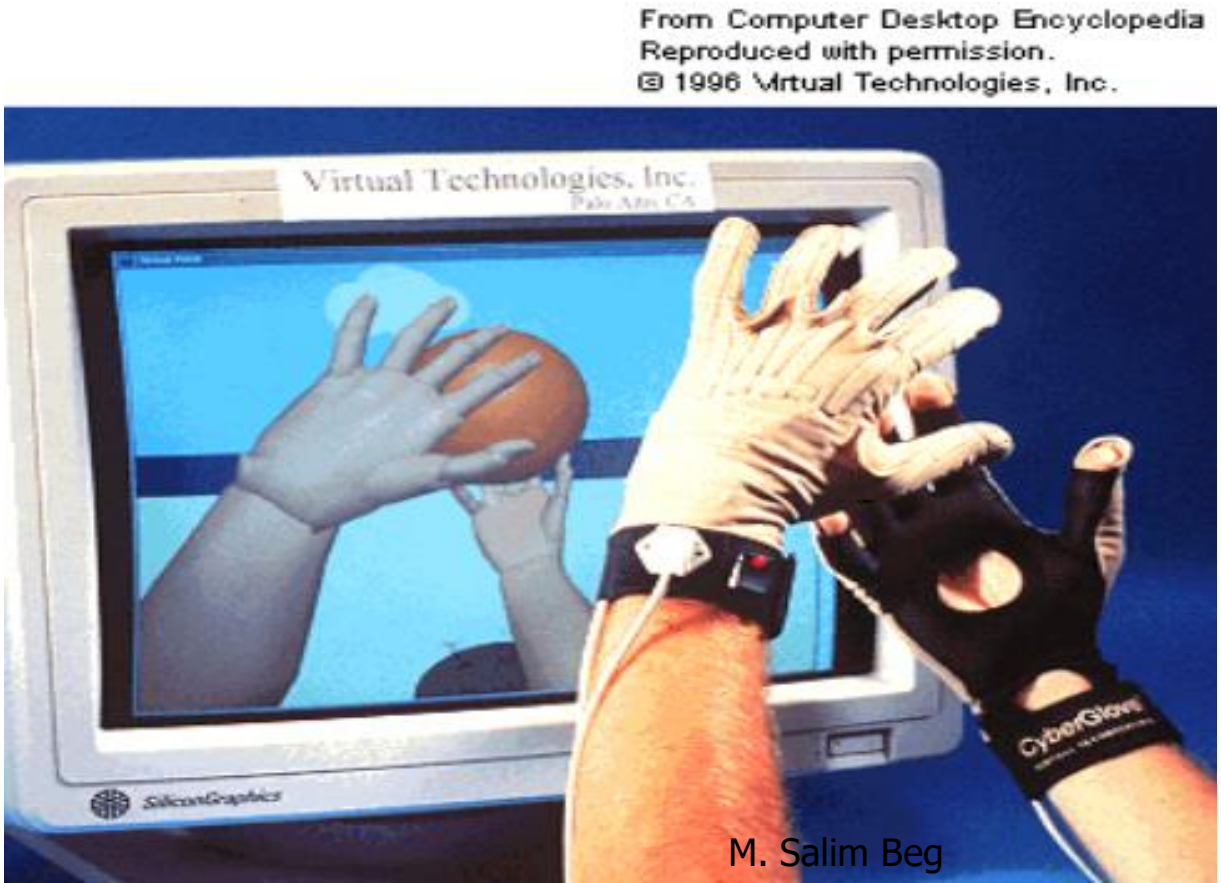
Components of Haptic interface (device)

- One or several electromechanical transducers (sensors and actuators) in contact with a user.
- computational system driving the transducers.



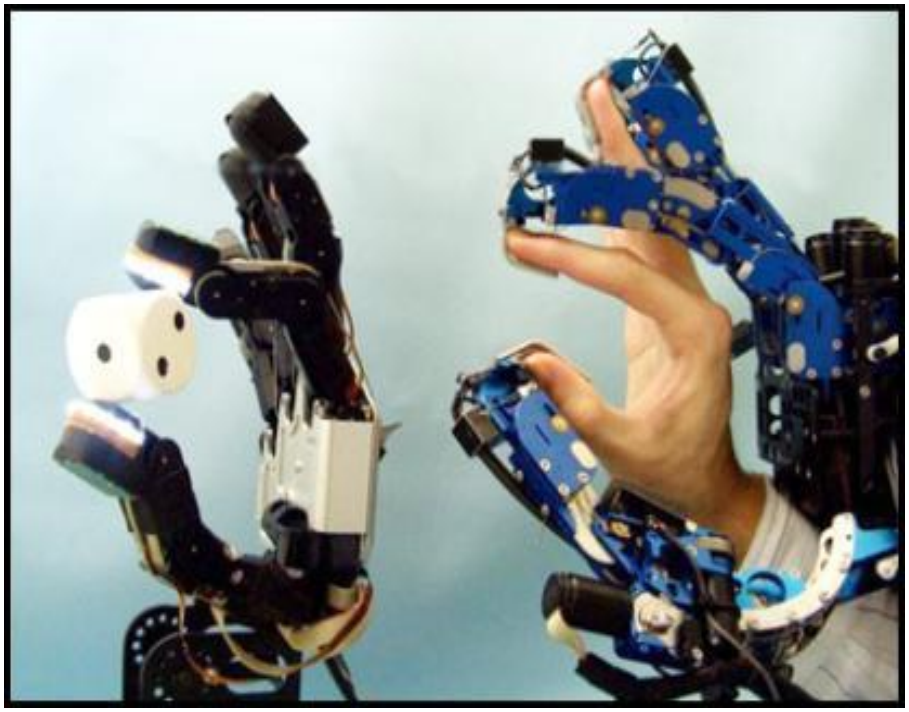
Haptic devices

- It allows users to touch, feel and manipulate 3-D objects in virtual environments.



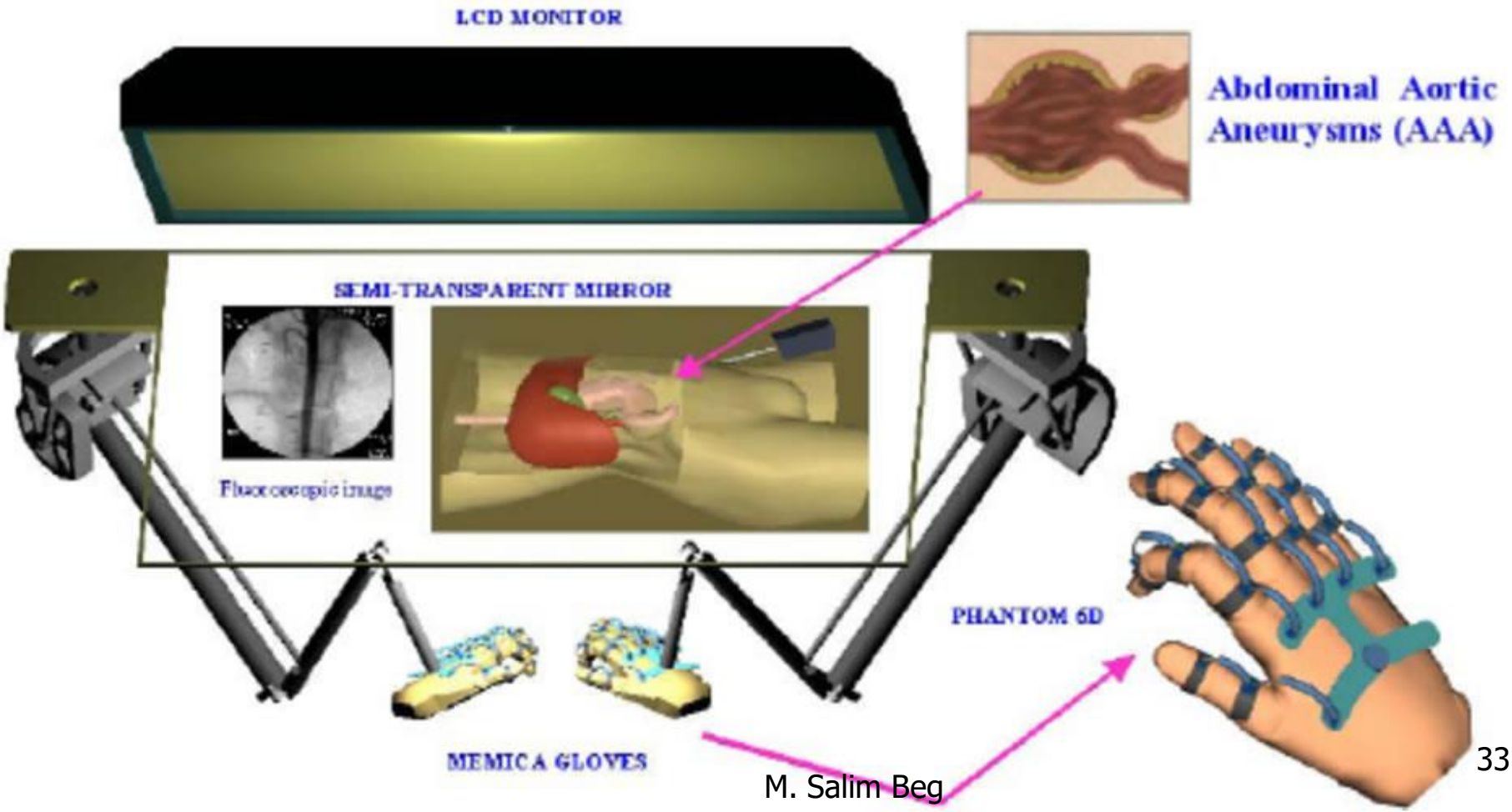
Cyber grasp

- This device produced by Immersion Corporation fits over the user's entire hand like an exoskeleton and adds resistive force feedback to each finger.



Applications for haptics

- **Surgery**



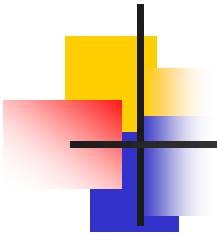
Applications for haptics

- Great future for **online computing** and **E-commerce**.
  - **enhances shopper experience** and help **online shopper** to feel the merchandise without leaving their home.
- It has huge applications in **training**.
- Potential applications in **critical fields** as well as for **leisurely pleasures**.
- Haptic devices must be smaller so that they are **lighter**, **simpler** and **easier to use**.

Future for haptics

- Haptics will serve in future to improve **Human Computer Interaction** (**HCI**).
- In near future, haptic technology can potentially revolutionize our everyday interaction with computing devices and multimedia as well as our perception within **Virtual Reality** (**VR**) applications.

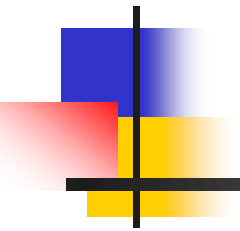
Ref: Susanne Boll, Nadia Magnetat-Thalman, Ugo Bonanni, "Haptics in Virtual Reality and Multimedia", IEEE Multimedia, Vol. 13, No. 3, July-Sept. 2006, pp. 6-11 In special issue on Haptic User Interfaces for Multimedia Systems).



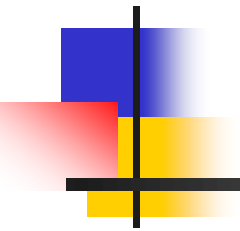
Conclusions

- Field of Multimedia continues to grow at a rapid pace in the form of:
  - New revolutionary ideas
  - New products
  - New services

- Perhaps one can say that we are gradually moving towards "**flawless telepresence**" systems of future.



Electronic Displays

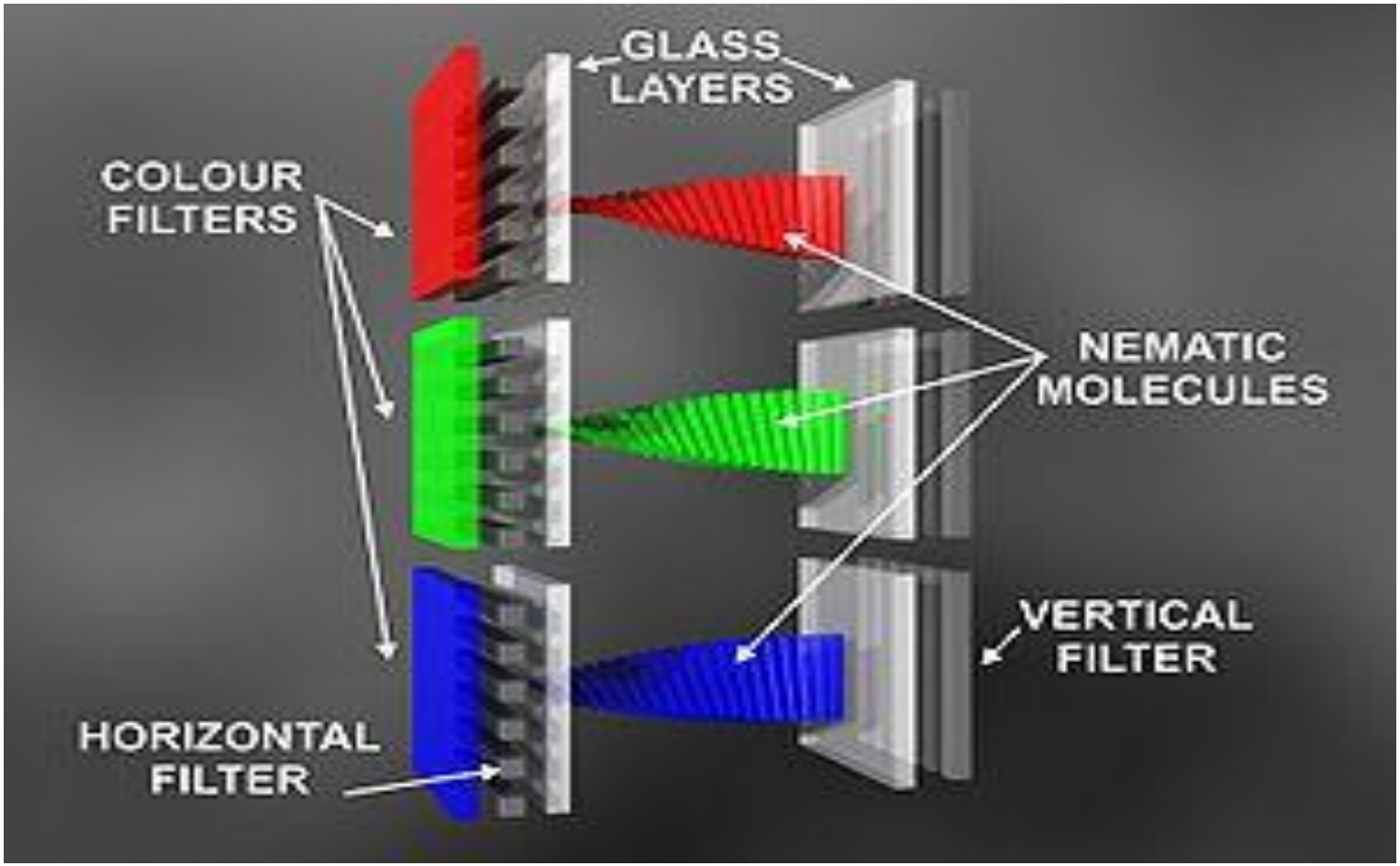


Flat Panel Displays (FPDs)

Background of Flat Panel Displays

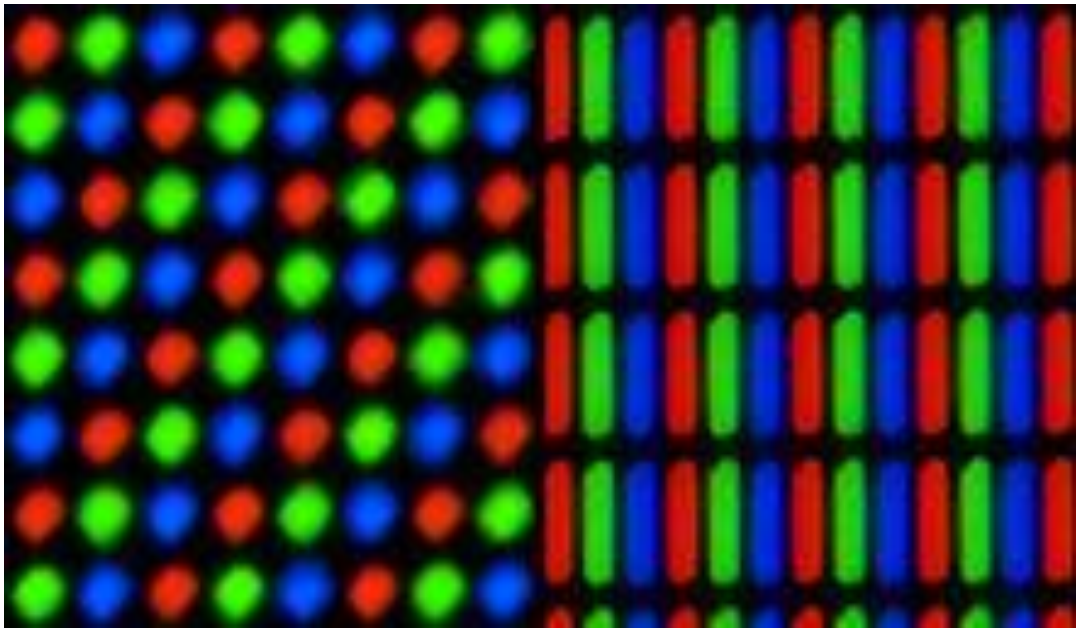
- FPDs are thin, flat electronic devices (usually less than 10 cm thick) used for displaying alphanumeric information, graphics, and image.
- The most advanced FPDs now are capable of displaying full-colour, high-definition images at full video rates.
- The major FPD technologies are:
  - Liquid Crystal Displays
  - Plasma Displays
  - Organic LED (OLED) Displays
  - LED Displays
  - Electroluminescence Displays
  - Field Emission Displays

Sub-pixels of a colour LCD



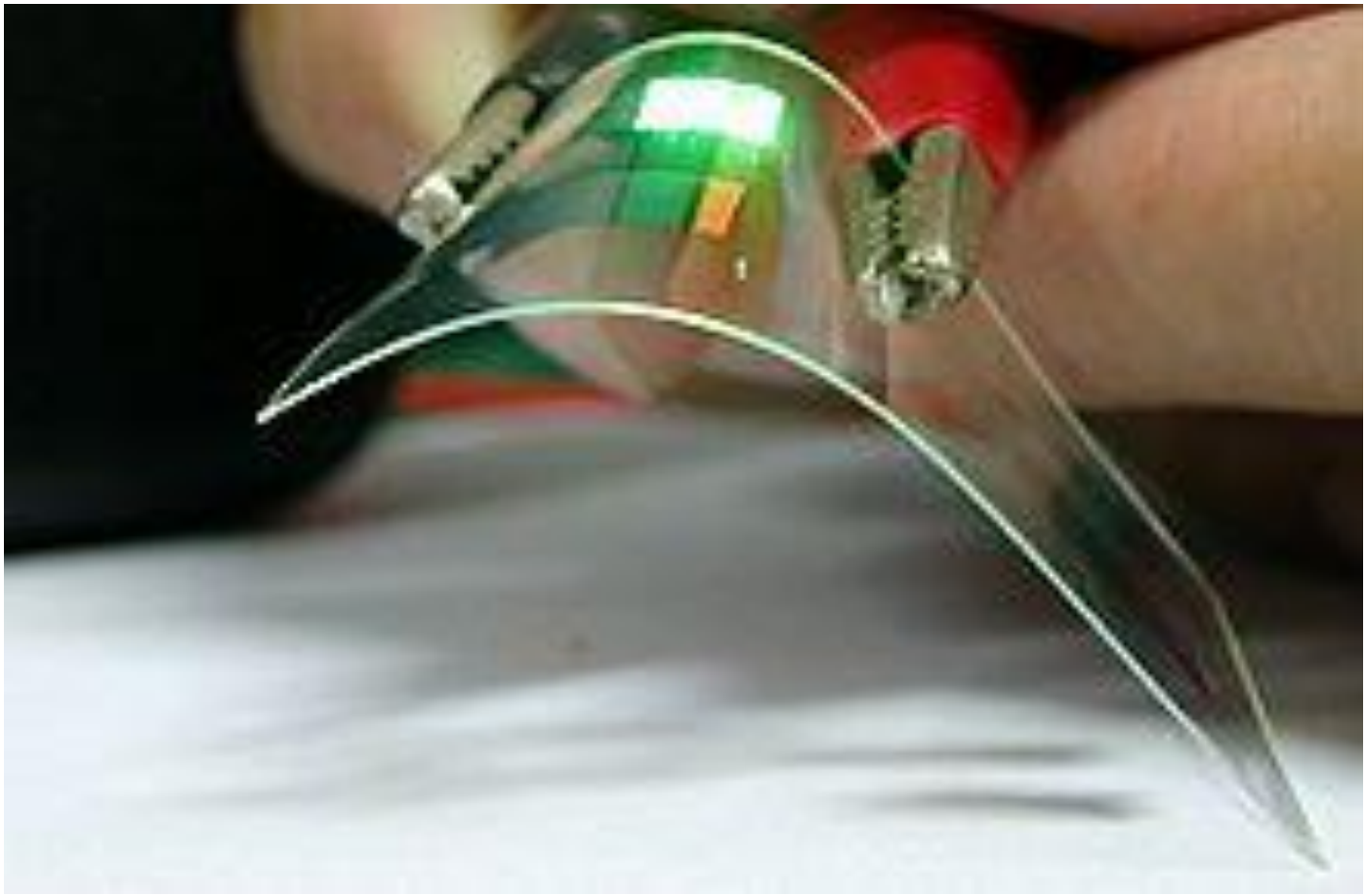
Ref: http://en.wikipedia.org/wiki/Liquid_crystal-display

Comparison of the OLPC XO-1 display (left) with a typical colour LCD



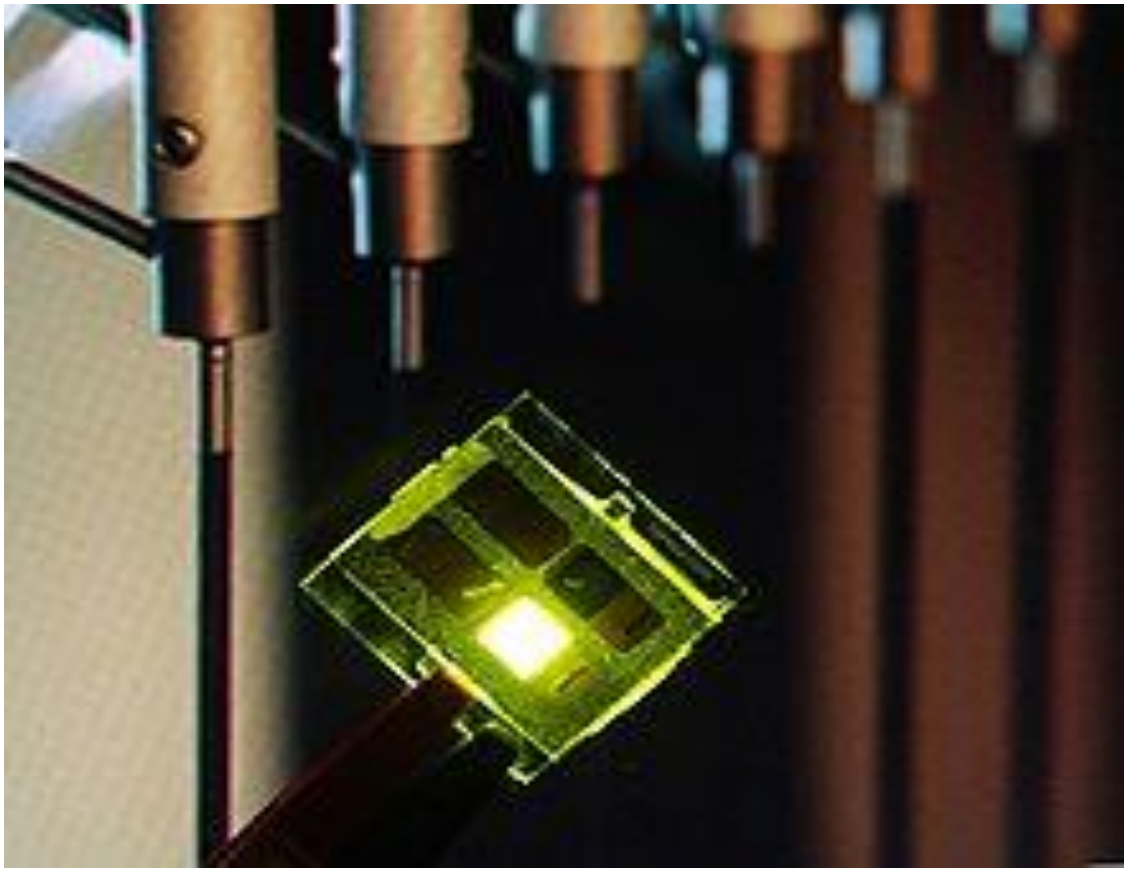
Comparison of the OLPC XO-1 display (left) with a typical colour LCD. The images show 1×1 mm of each screen. A typical LCD addresses groups of 3 locations as pixels. The XO-1 display addresses each location as a separate pixel.

Demonstration of a flexible OLED device



Ref: http://en.wikipedia.org/wiki/Organic_light-emitting_diode

A green emitting OLED device



Ref: http://en.wikipedia.org/wiki/Organic_light-emitting_diode

Sony XEL-1, the world's first OLED TV

Ref: http://en.wikipedia.org/wiki/Organic_light-emitting_diode

Advantages of OLEDs

- **Flexibility**: The substrate used can be flexible. Thus flexible OLED displays may be produced inexpensively.

  Use of flexible substrates could open the door to new applications such as roll-up displays and displays embedded in fabrics or clothing.

Demonstration of a 4.1" prototype flexible display from Sony

LED Displays

The 1,500-foot (460 m) long LED display on the Fremont Street Experience is currently the largest in the world.

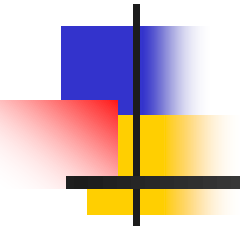
LED Displays

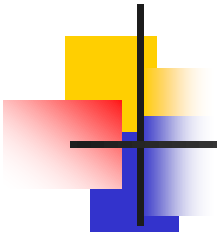
The 40m large LED display at the Armin Only event on 19/20 apr 2008 in the Jaarbeurs Utrecht.

LED Displays

The LED Display at the Taipei Arena displays commercials and movie trailers.

Compression
of
Natural
grey scale and colour images





Basic Concepts

- Compression ratio
- Quality needed
- Application

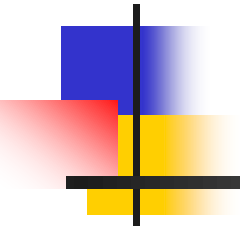
JPEG Example: Lena Image

65536 Bytes
8 bpp

4839 Bytes
0.59 bpp
CR=13.6

3037 Bytes
0.37 bpp
CR=21.6

1818 Bytes
0.22 bpp
CR=36.4



Lossy Compression of grey scale and colour images

JPEG2000

Region of Interest (ROI) coding

- Selected region (head and scarf) are coded at higher quality compared with the rest picture (background).

JPEG2000 compression results

Original Carol Image (512 x 512 Pixels, 24-Bit RGB, Size 786K)

JPEG2000 compression results

300:1, 2.6 Kbyte

Comparison of JPEG and JPEG 2000

Lenna, 256x256 RGB
Baseline JPEG: 4572 bytes

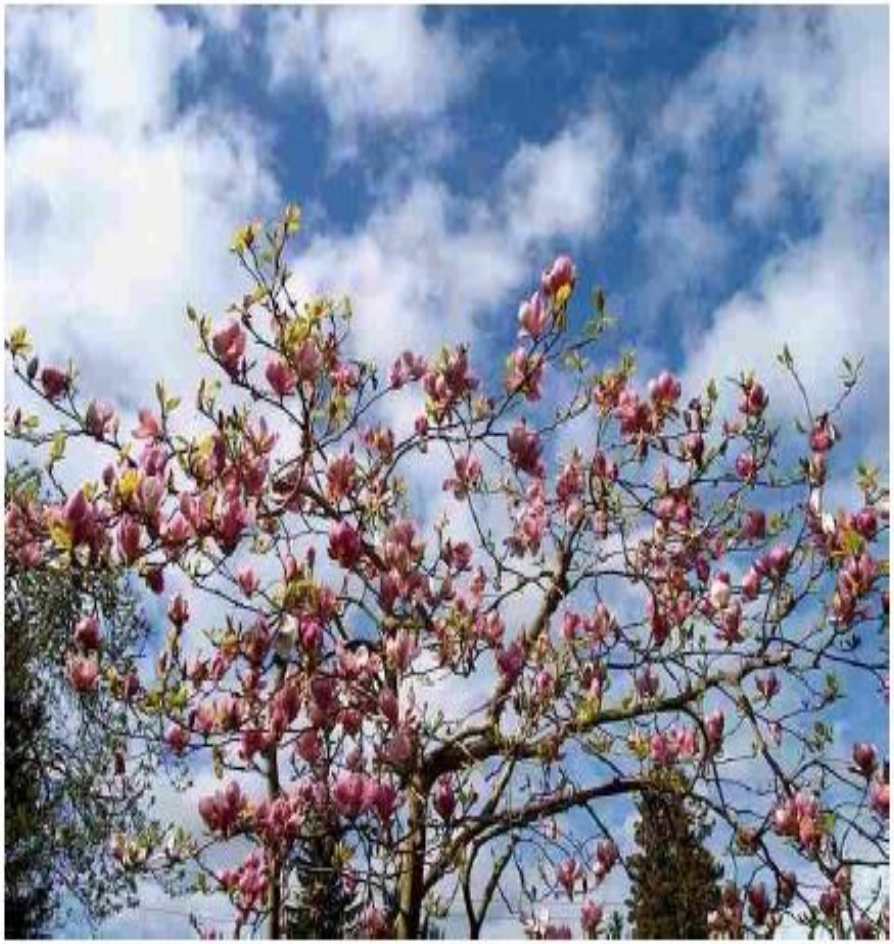
Lenna, 256x256 RGB
JPEG-2000: 4572 bytes

Source: Prof. Bernd Girod, Image and Video Compression Lecture Slides, Stanford University

Comparison of JPEG and JPEG 2000

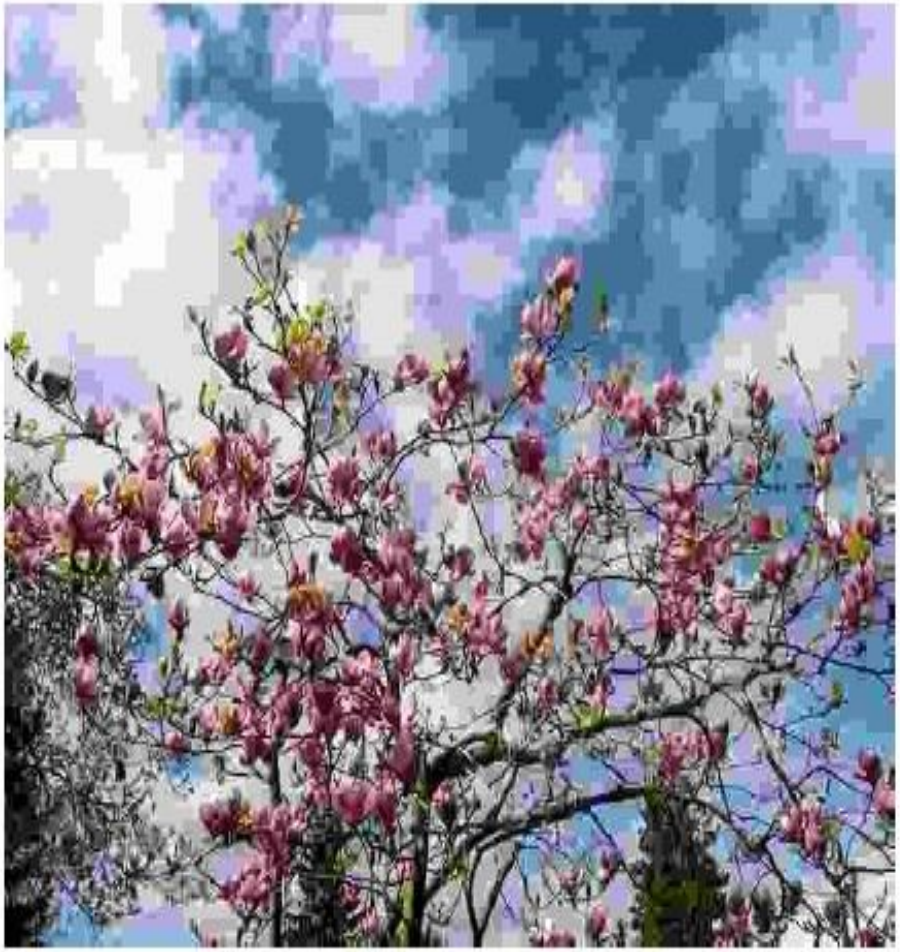
Original image

Comparison of JPEG and JPEG 2000



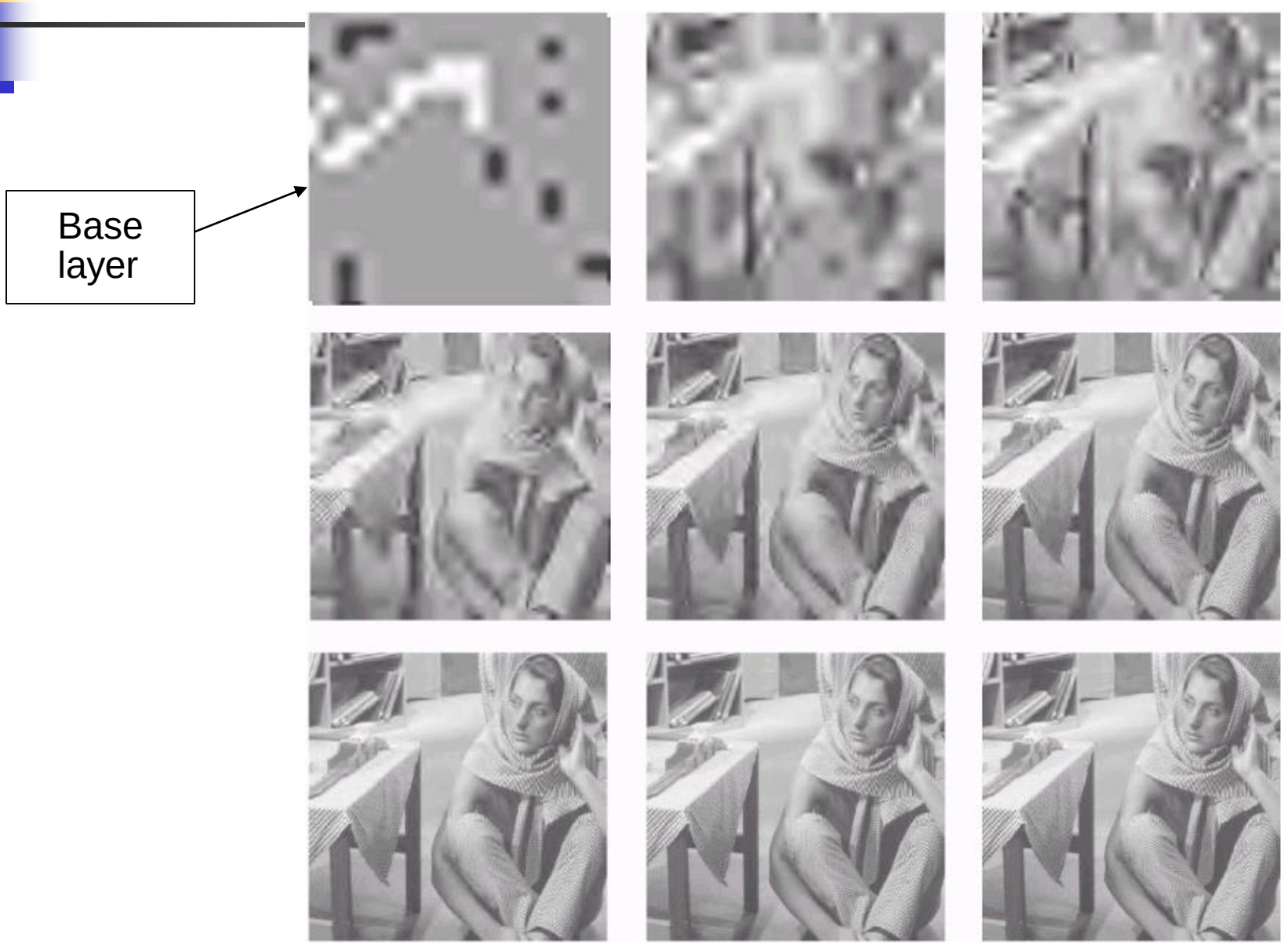
JPEG (left) and JPEG 2000 (right) images compressed at 0.75 bpp

Comparison of JPEG and JPEG 2000

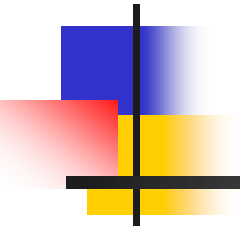


JPEG (left) and JPEG 2000 (right) images compressed at 0.25 bpp

SNR Scalability



Spatial Scalability

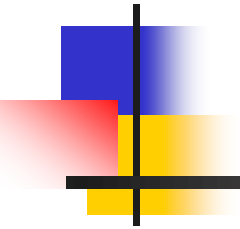


DIGITAL VIDEO

Basics of Digital Video

Typical Video Image Resolutions at a glance

Image resolution	Number of sampling points	Application / Quality
352 x 288	101 376	VHS video & VCD
704 x 576	405 504	Broadcast TV & Standard Definition TV
1440 x 1152	1 313 280	HDTV



DIGITAL VIDEO

Characteristic Parameters of Digital Video

Digital Video: Characteristics & Data Size

Characteristic Parameters of Digital Video:

- **Frame Rate**
- **Frame Size**:
  - 640x480 for full screen VGA;
  - 320x240 for quarter of a VGA display;
  - 160x120 for sixteenth of a VGA display
- **Colour depth or resolution**

Data Size of Digital Video:

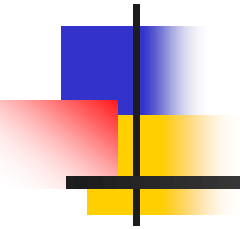
The size of the digital video data stream is F*R*C*T, where

F = Frame Size

R = Frame Rate

C = Colour Depth (in bits/pixel)

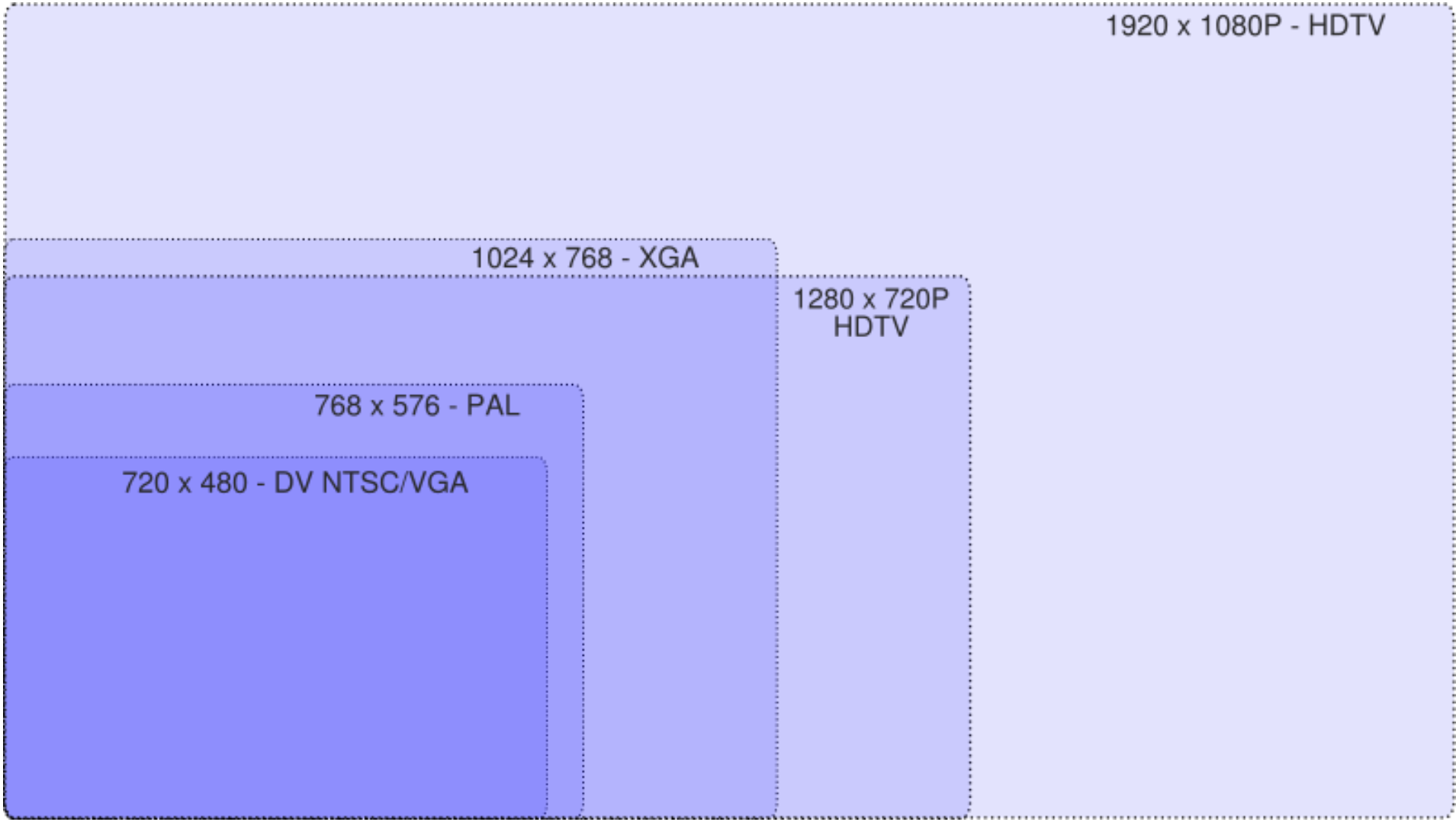
T = time in seconds



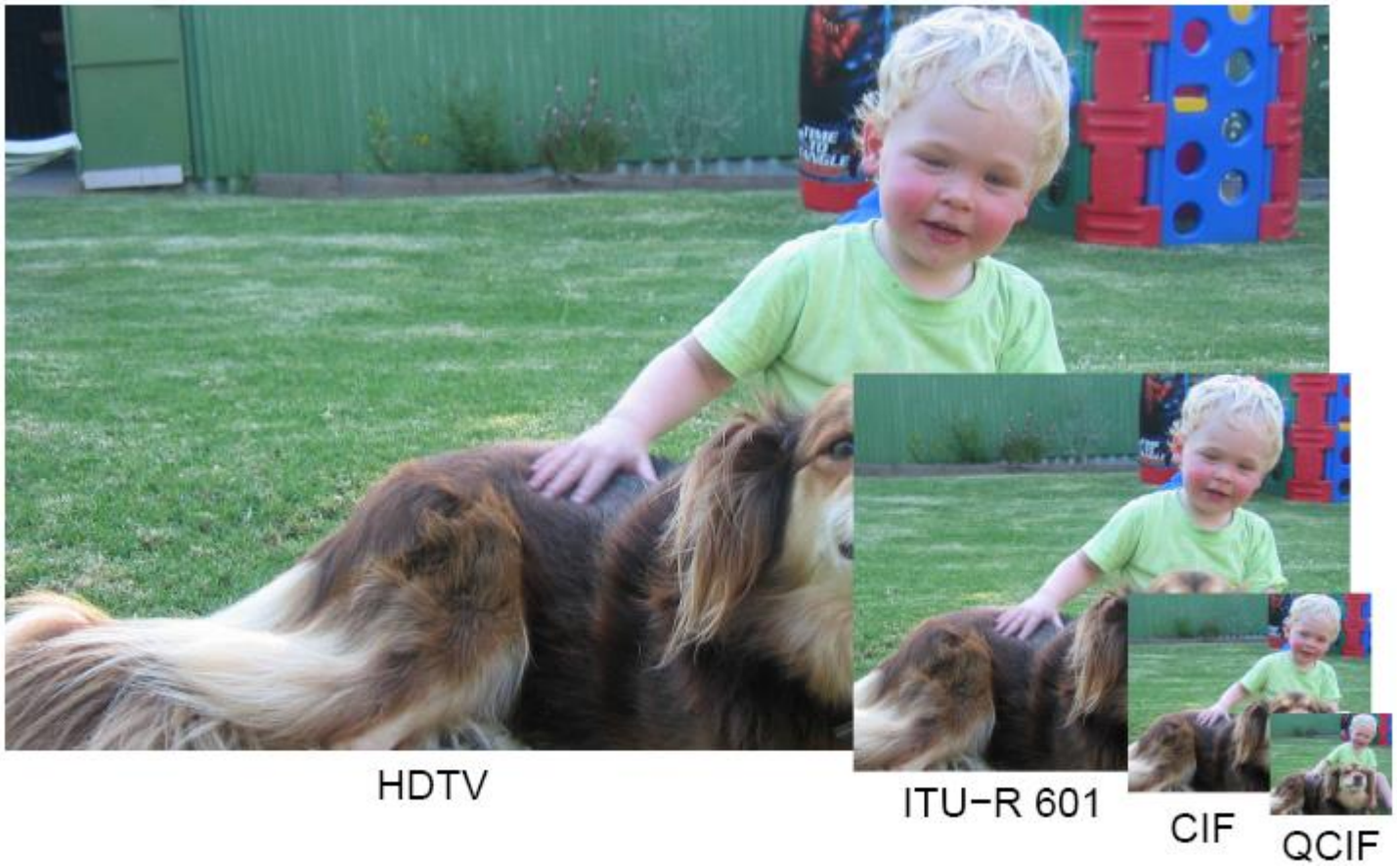
DIGITAL VIDEO

High Definition TV
(HDTV)

Different Resolutions

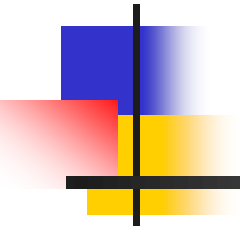


Digital Video Formats: Summary



Situation Before UHDTV: Summary

- SDTV (i.e. Standard Definition TV)
  - 0.3 Mpixels
- HD ready
  - 0.9 Mpixels
- HDTV
  - 2.1 Mpixels (1920 x 1080) (also called **2k**)

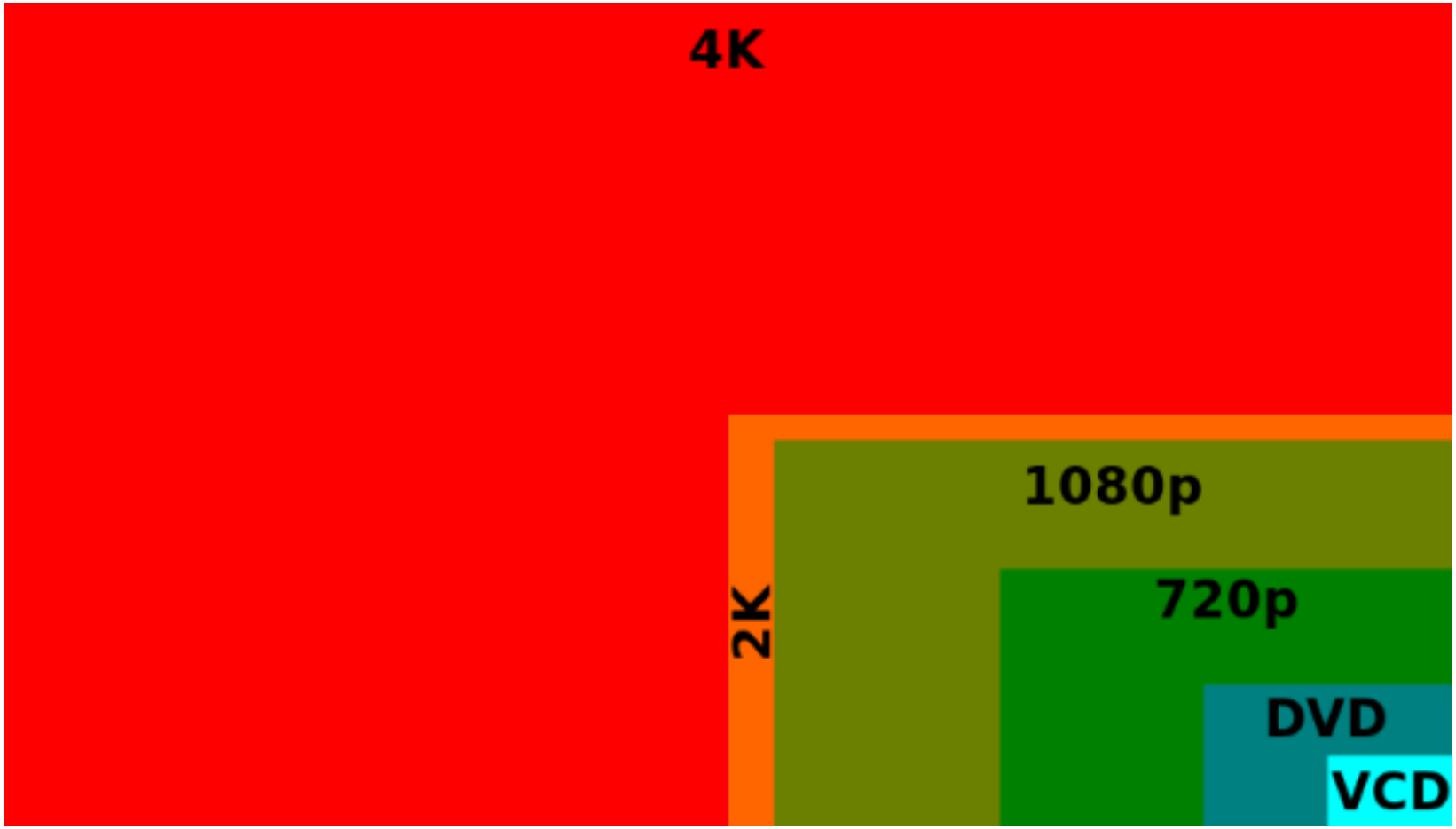


DIGITAL VIDEO

Ultra High Definition TV (UHDTV)

UHDTV

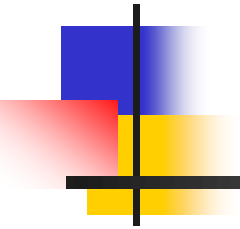
- Ultra-high-definition television is also known as
  - Ultra HD television,
  - UltraHD,
  - UHDTV, or
  - UHD,
  - Super Hi-Vision,
- It includes **4K UHD** (2160p) and **8K UHD** (4320p), which are two digital video formats proposed by NHK Science & Technology Research Laboratories and defined and approved by ITU.
- The Consumer Electronics Association announced in 2012, that "Ultra High Definition", or "Ultra HD", would be used for displays that have an aspect ratio of **16:9** and at least one digital input capable of carrying and presenting native video at a **minimum resolution of 3840×2160** pixels.



4K packs in four times the number of pixels as Full HD / 1080p.

UHDTV

- Most of UHDTV transmissions/trials have used a bandwidth of 6 or 8 MHz.
- Parameters of some trials/transmissions of **UHDTV** in some countries include:
  - **8k UHD**, 7680 x 4320p, 59.94 f/s, 4096 QAM, 91 Mbps, MPEG-4 AVC/H.264
  - **8k UHD**, 256 QAM, 50 Mbps, HEVC
  - **4k UHD**, 3840x2160p, 60 f/s, 256 QAM, 25-34 Mbps, HEVC
  - **4k UHD**, 3840x2160p, 50 f/s, 256 QAM, 40 Mbps, HEVC

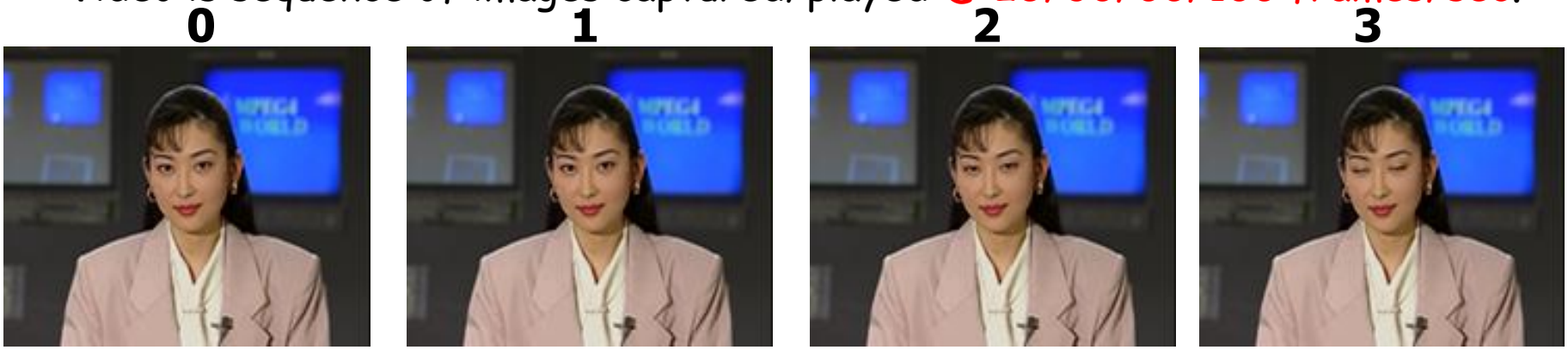


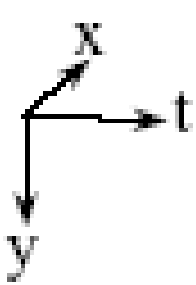
VIDEO COMPRESSION

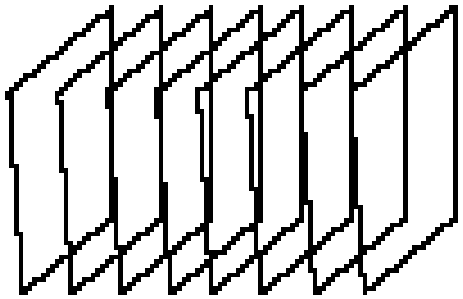
Basics

Video= Motion Picture

- Frame by frame => image sequence
- An image sequence (or video) is a series of 2-D images that are sequentially ordered in time. (3-D digital signal)
- Video is sequence of images captured/played @ 25/30/60/100 frames/sec.







Characteristics of Video: Example

- Only the sun has changed position between these 2 frames

Previous Frame

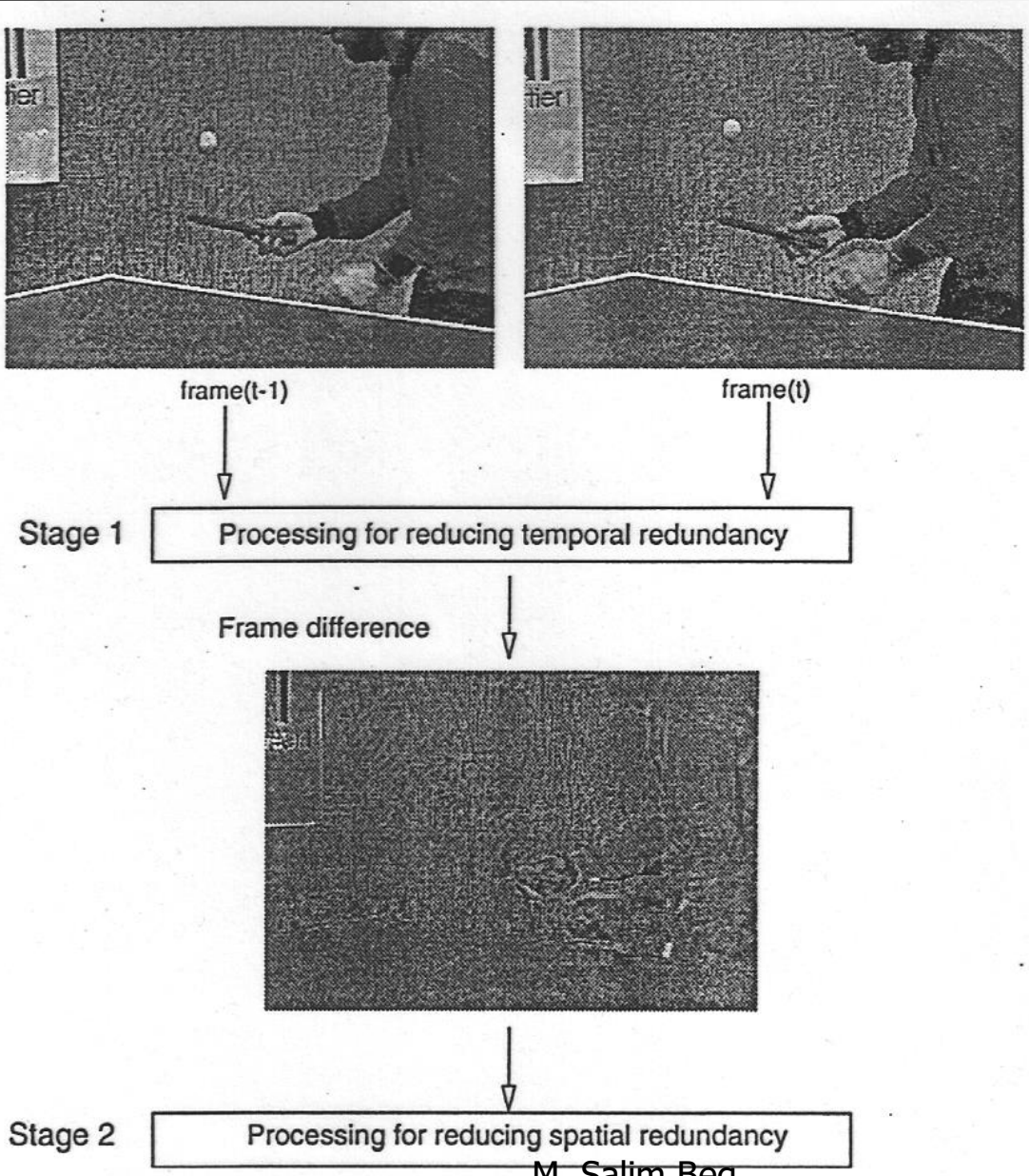
Current Frame

Presence of Temporal Redundancy

Miss America frame 21

Miss America frame 22

Video coding: Two-stage process



Motion Estimation
&
Motion Compensation

Motion Estimation & Compensation

Figure 3.10 Frame 1

Figure 3.11 Frame 2

Motion Estimation & Compensation

Figure 3.12 Residual (no motion compensation)

Figure 3.13 Residual (16 × 16 block size)

Figure 3.14 Residual (8 × 8 block size)

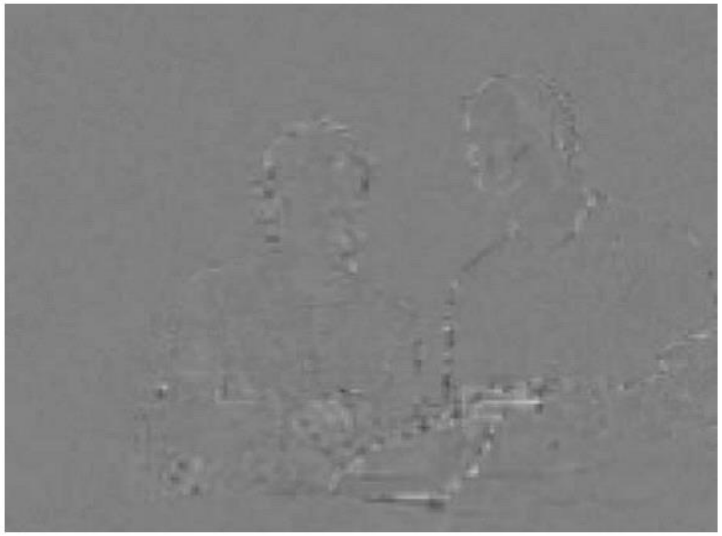
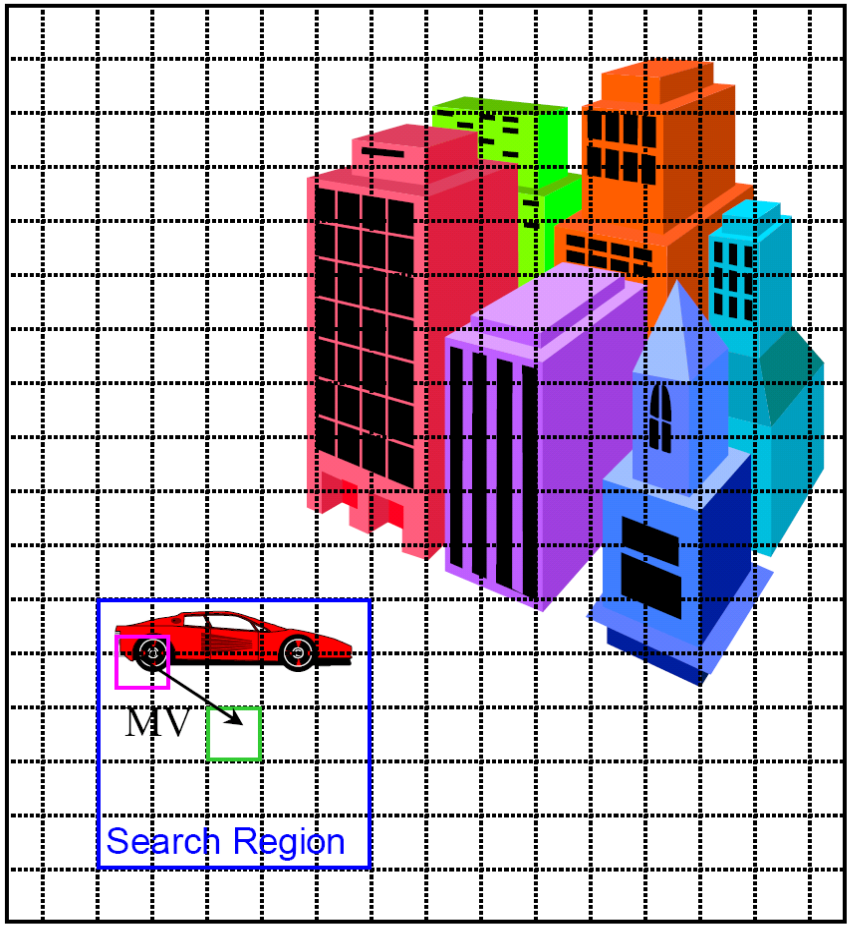
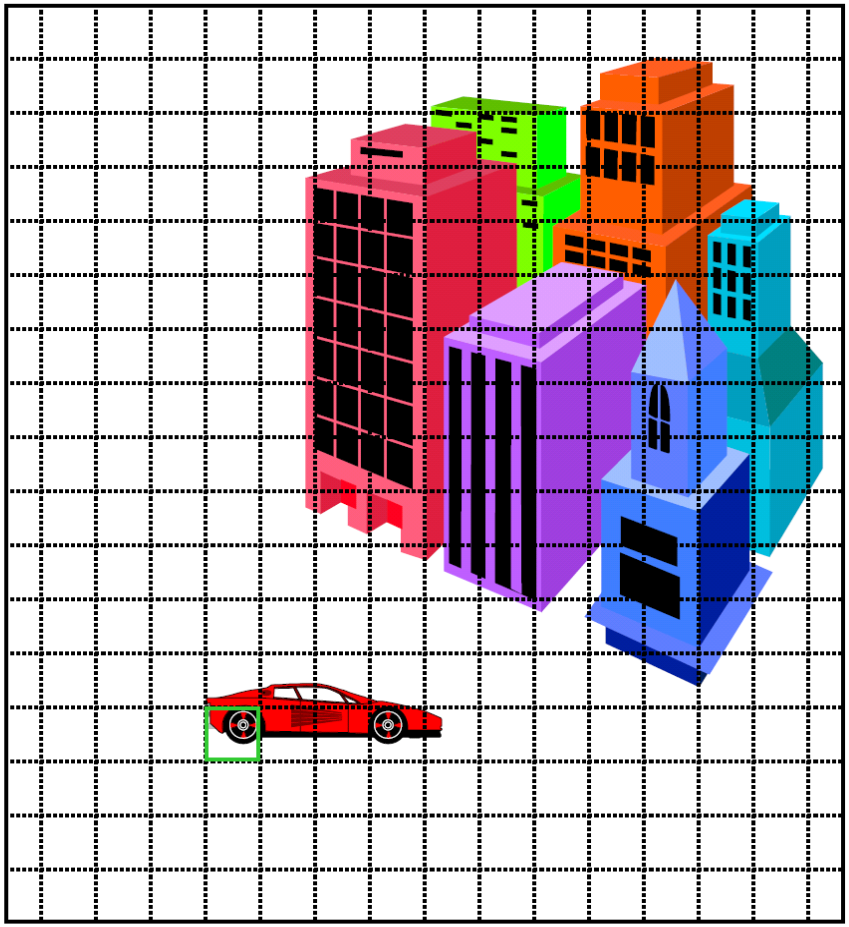


Figure 3.15 Residual (4 × 4 block size)

Motion Estimation & Compensation: Example 1



Frame *t-1*
(Reference Frame)



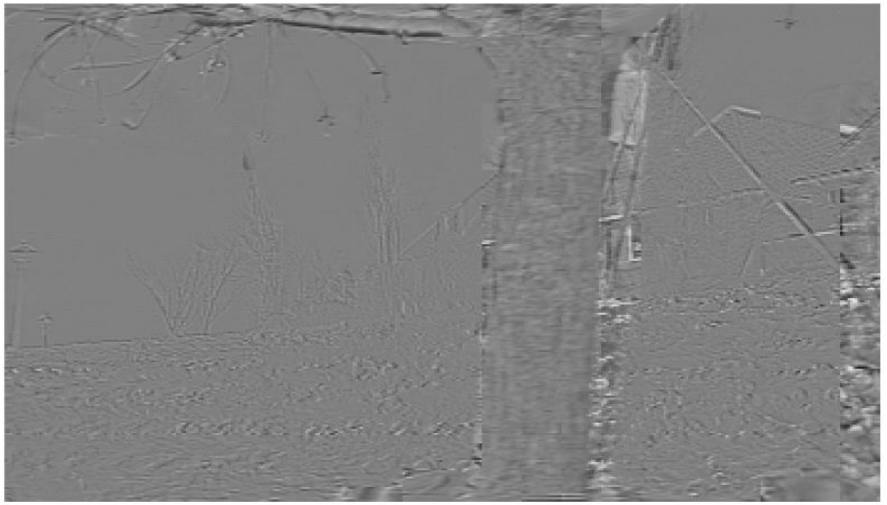
Frame *t*
(Predicted frame)

Motion Estimation & Compensation: Example 2

Previous frame

Current frame

Current frame with displacement vectors



Motion-compensated Prediction error

Standards
for
Video Compression

MPEG

- **MPEG** was set up in 1**988** by the ISO to formulate a set of standards relating to a range of multimedia applications involving **video with sound.**
- 1st standard for "coding of moving pictures and associated audio for digital **storage** media at 1.5 Mbps" was MPEG-1.
- MPEG standards are generic i.e. **Application dependent**.
- MPEG standards do not specify an encoding process.
- They **only specify the syntax** of the coded bit stream and the decoding process.
- Thus they provide **enough flexibility** in the specifications so that **different vendors** can include specific optimization elements.

Standards for Video Compression

MPEG-1

Summary of MPEG-1

- MPEG-1 video mainly for VCR-quality or **VCD-quality** audio/video sequences.
- MPEG-1 **doesn't** deliver **broadcast quality** video.
  - Towards that end, the MPEG-2 standard has been developed using many of the principles of MPEG-1.

Standards for Video Compression

MPEG-2

MPEG-2 Vs MPEG-1

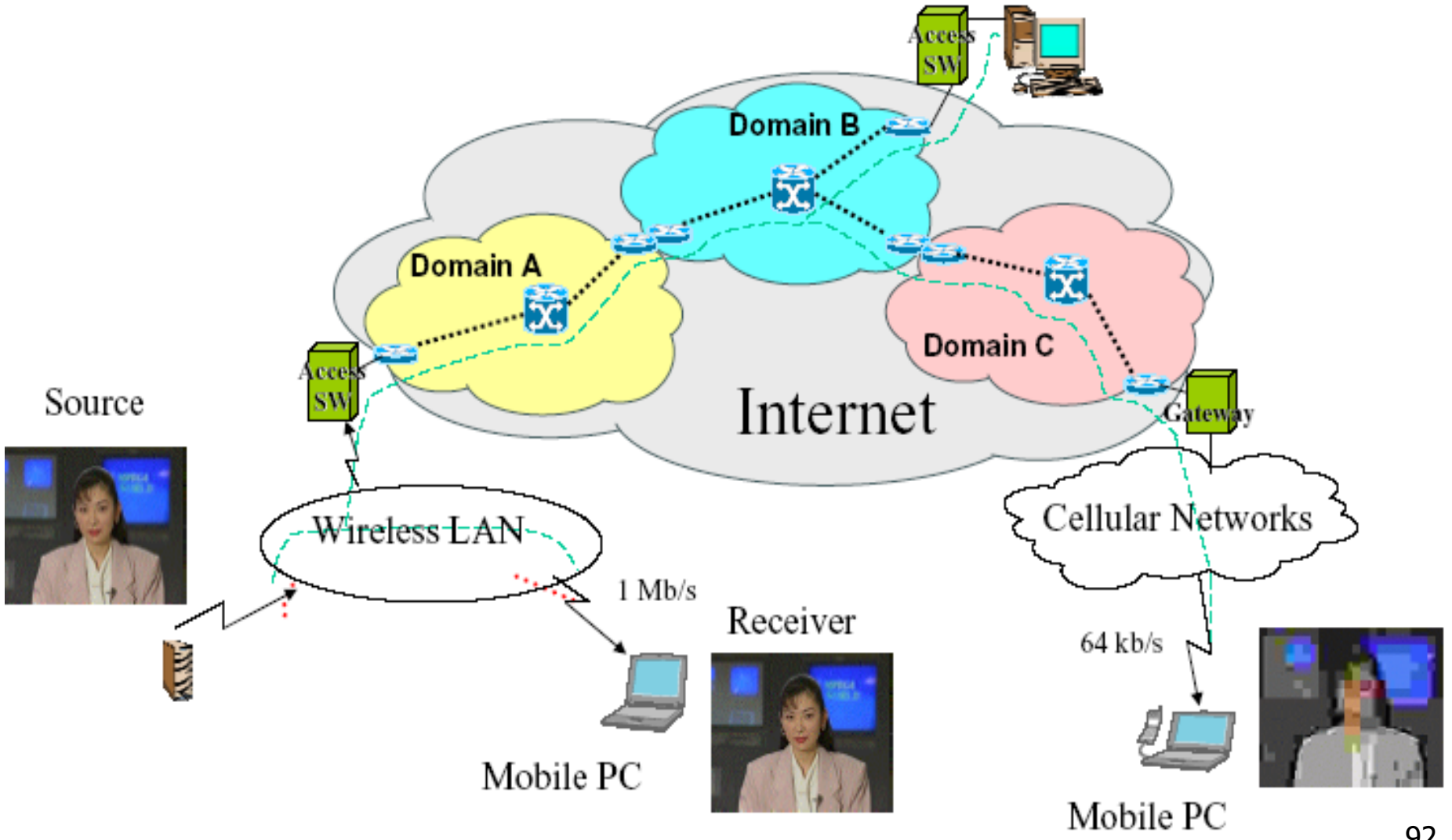
- MPEG-2 has various **profiles and levels**, each combination targeted for different application.

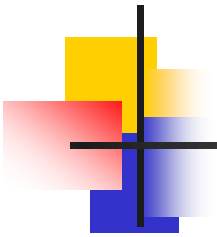
- MPEG-2 has various **scalability** modes.

Standards for Video Compression

Scalability in MPEG-2

Need for Scalability





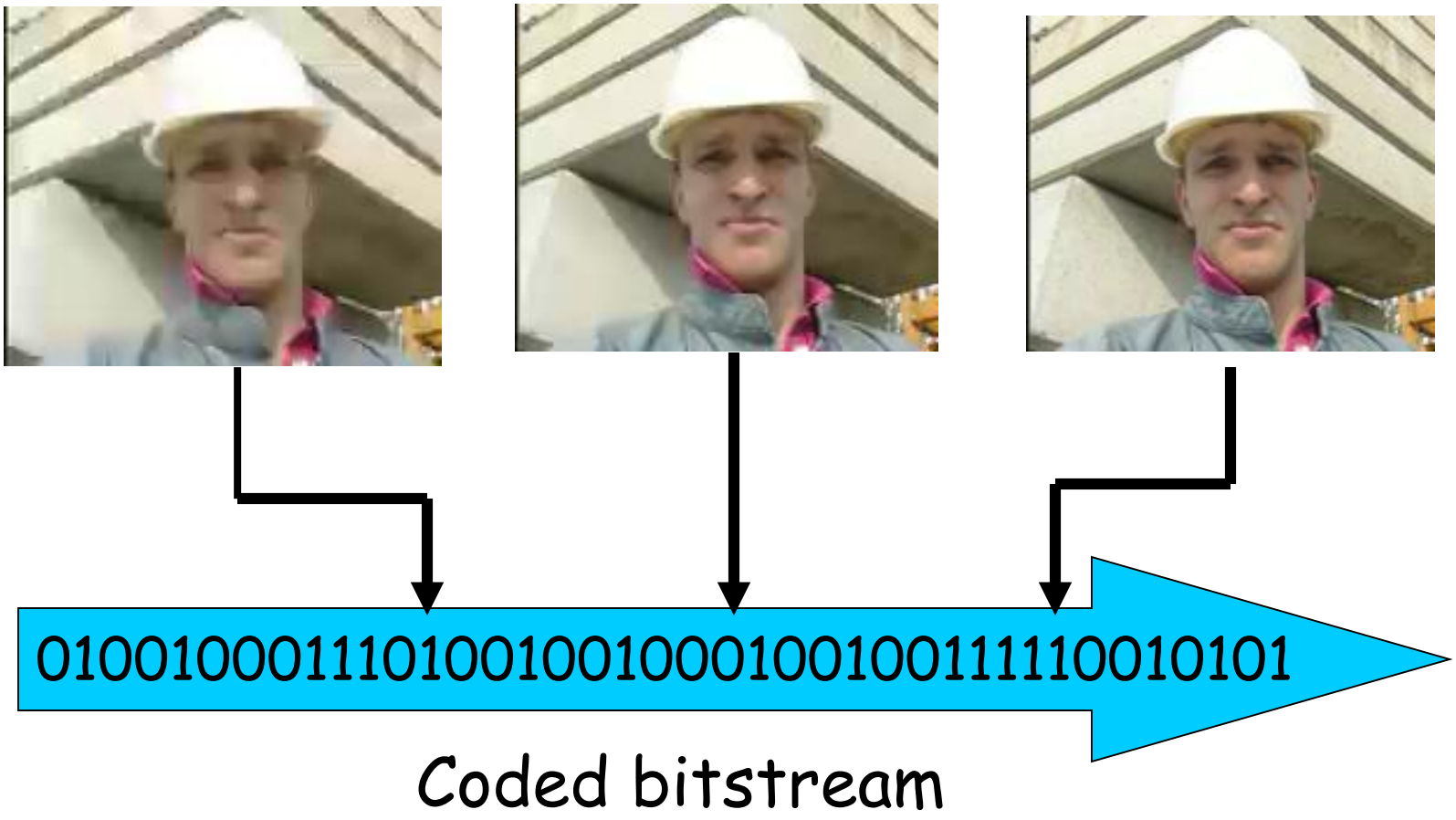
Types of Scalability in MPEG-2

- MPEG-2 allows for several forms of scalability:
  - **SNR scalability** (Quality scalability)
  - **Spatial scalability** (Resolution scalability)
  - **Temporal scalability** (Frame-rate scalability)
  - **Data partitioning** (Frequency scalability)

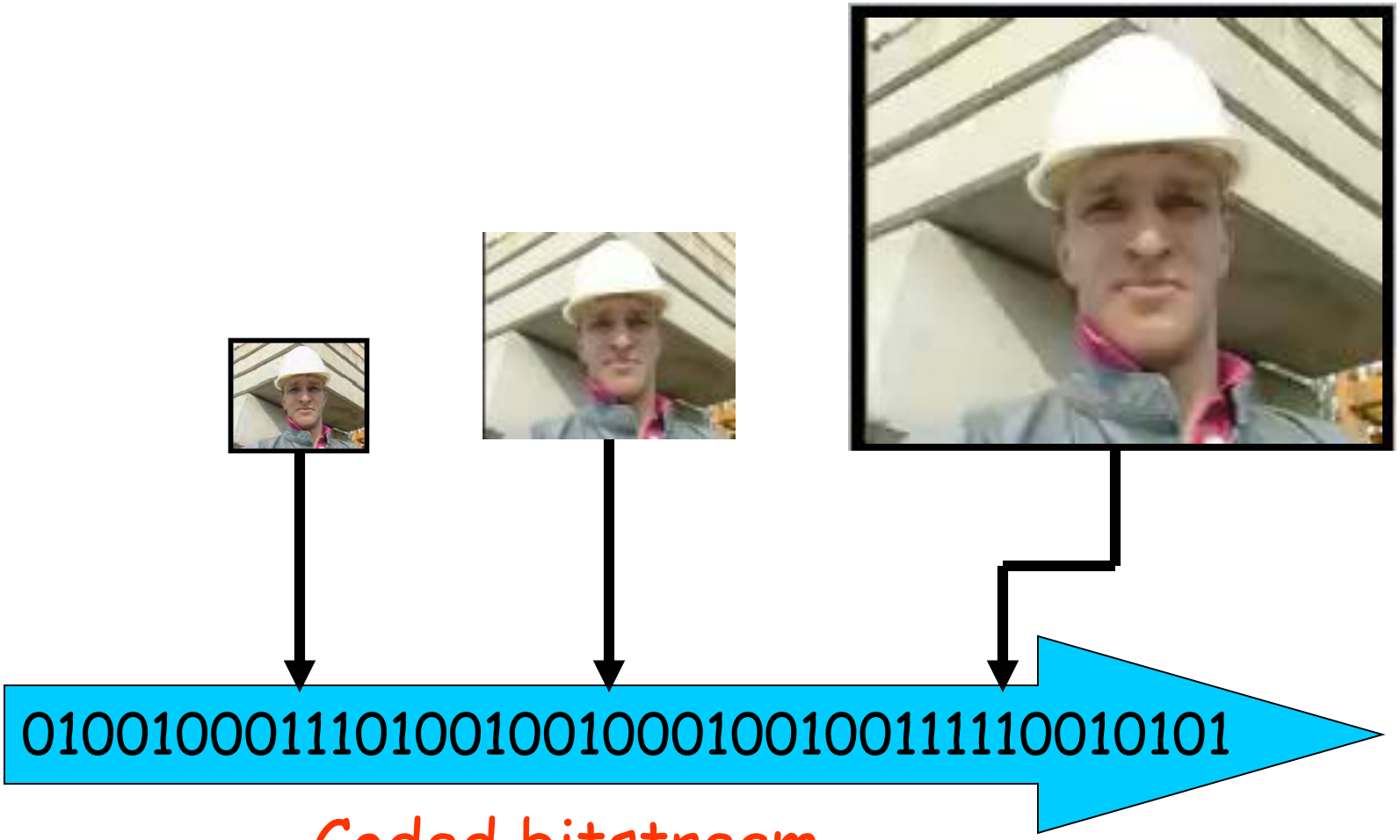
MPEG-2 Scalabilities

- **SNR scalability**. Enhancement layer provides higher SNR (higher picture quality).
- **Spatial scalability.** Enhancement layer provides higher spatial resolution.
- **Temporal scalability**. Enhancement layer facilitates higher frame rate.
- **Data partitioning**. Video stream divided into two partitions. Low-frequency DCT coefficients in base partition, high-frequency in enhancement partition

SNR Scalability



Spatial (Resolution) scalability



Standards for Video Compression

Applications of MPEG-2

MPEG-2 Application (DVD)

Video coding	MPEG-1, MPEG-2 (MP@ML)
Frame rate	29.97 or 25 Hz
TV system	525/60 or 625/50
Coded frame sizes	525/60: 720x480, 704x480, 352x480, 352x240 (NTSC) 625/50: 720x576, 704x576, 352x576, 352x288 (PAL) MPEG-1 allows only 352x240 or 352x288
Maximum bitrate	9.8 Mbit/s
Aspect Ratio	4:3 (all video resolutions) 16:9 (all video resolutions except 352 pixels/line)

MPEG-2 Application: DVB

- Application-specific restrictions on MPEG-2 video in the DVB standard are given below:
- Allowed resolutions for **SDTV**:
  - 720, 640, 544, 528, 480 or 352 × 480 pixel, 24/1.001, 24, 30/1.001 or 30 frame/s
  - 352 × 240 pixel, 24/1.001, 24, 30/1.001 or 30 frame/s
  - 720, 704, 544, 528, 480 or 352 × 576 pixel, 25 frame/s
  - 352 × 288 pixel, 25 frame/s
- For **HDTV**:
  - 720 x 576 x 50 frame/s progressive (576p50)
  - 1280 x 720 x 25 or 50 frame/s progressive (720p50)
  - 1440 or 1920 x 1080 x 25 frame/s progressive (1080p25 = film mode)
  - 1440 or 1920 x 1080 x 25 frame/s interlace (1080i50)

MPEG-2 summary

- MPEG-2 is widely used as the format of **digital television broadcast** by
  - terrestrial (over-the-air),
  - cable, and
  - direct broadcast satellite TV systems.
- It also specifies the format of movies and other programs that are distributed on **DVD** and similar discs.
- TV stations, TV receivers, DVD players, and other equipment are often designed to this standard.
- While MPEG-2 is the core of most digital television and DVD formats, it does not completely specify them. Regional institutions can adapt it to their needs by restricting and augmenting aspects of the standard.

Standards for Video Compression

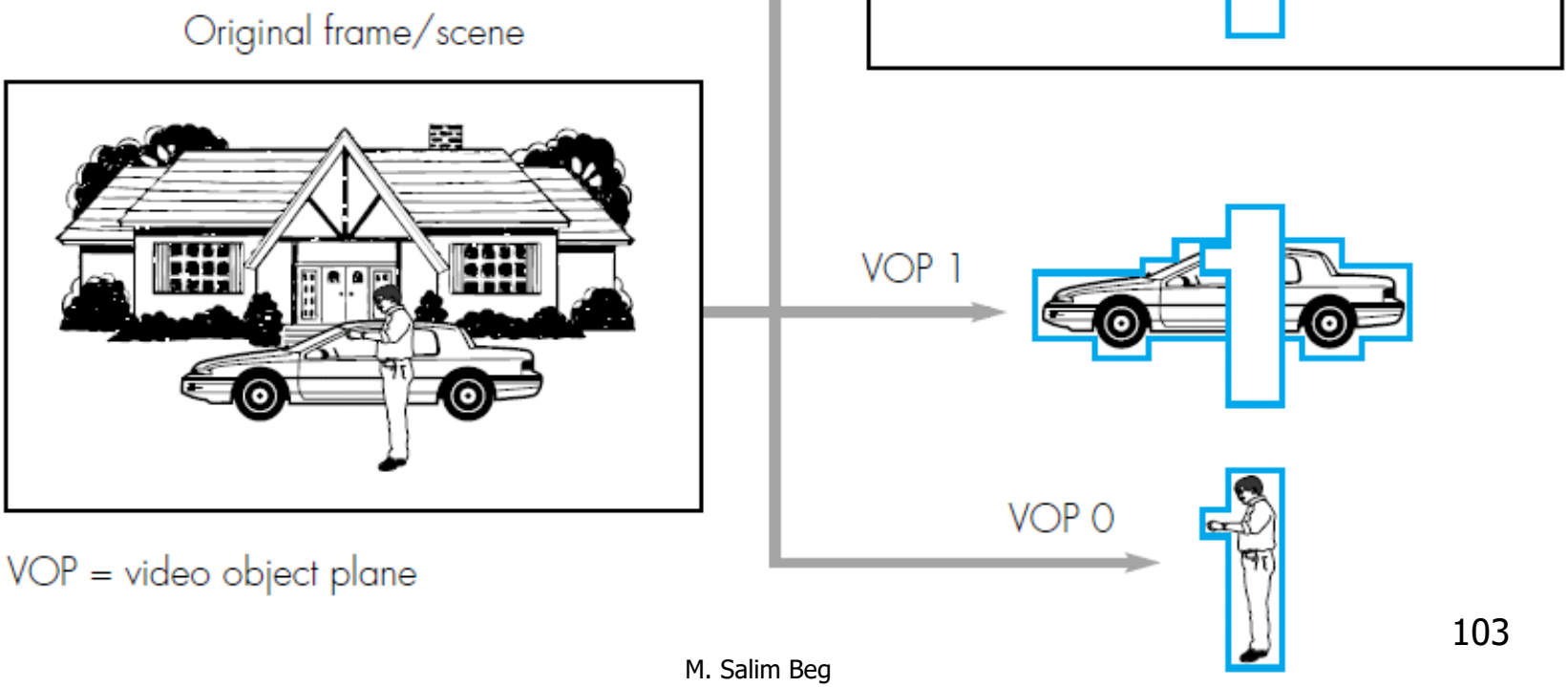
MPEG-4

Background Information

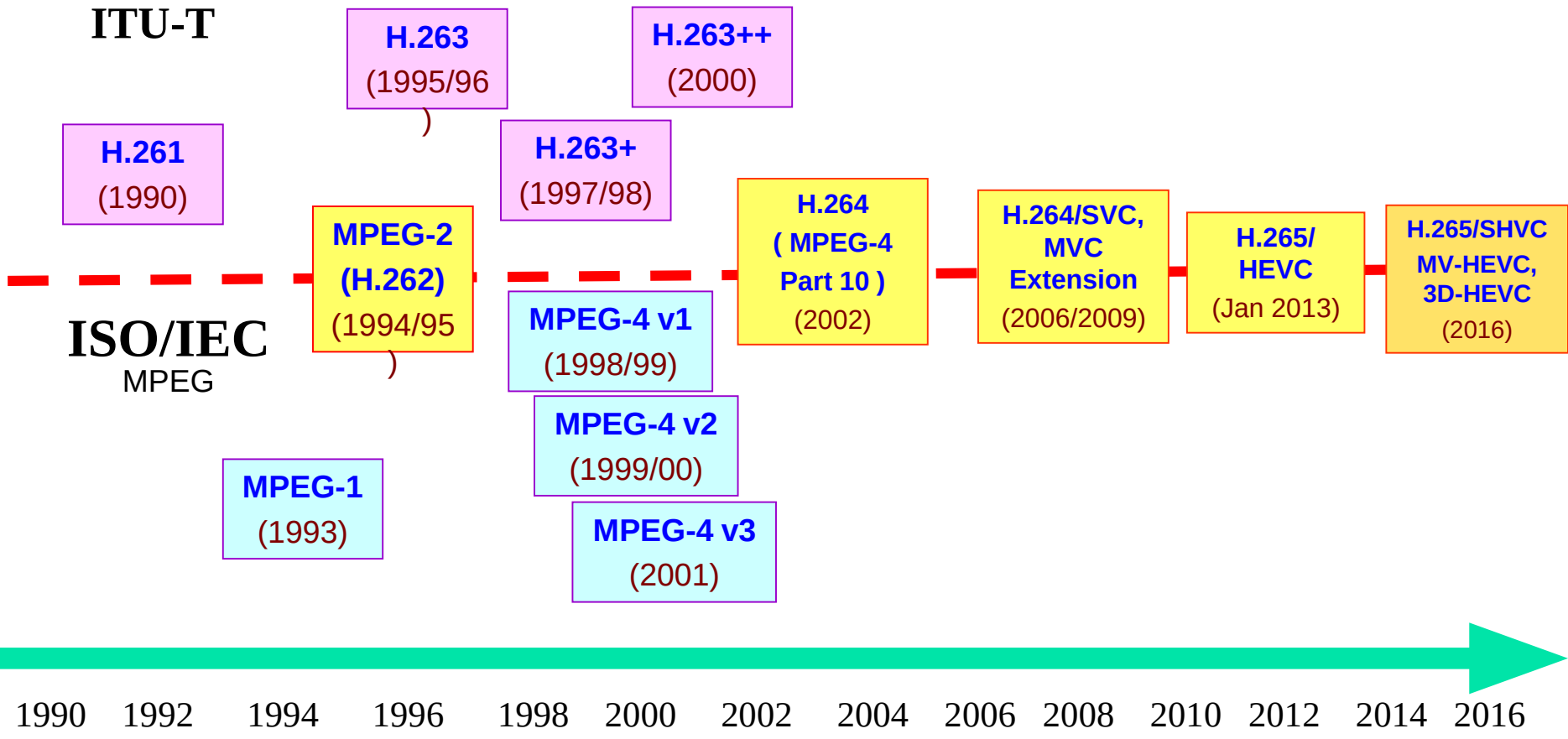
- Telephone
  - Telephone industry, PSTN, mobile phones
- Television
  - TV broadcast industry, TV broadcast channels
- Data Networks,
  - IT Industry, Internet

Content based coding

frame/scene is defined in the form of **multiple VOPs,** each corresponding to an **AVO**.
Each VOP **encoded separately**.
Decoder **can decode individual objects separately** and manipulate them at presentation time e.g. user can **reposition**, **delete** or **alter** the **movement of individual video object** within a scene.



Chronological of Video Coding Standards



What is 5G
and
Why do we need it

Four stages of Industrial revolution

1st (1760–1840)

2nd (1840–1914)

3rd (1950–2010s)

4th (2020–)

1st stage of Industrial revolution

Started in England with **power loom** and the **steam engine**; as a result of this the agrarian economy underwent rapid **transformation to an industrial one**.

2nd stage of Industrial revolution

Began with introduction of **steel processes** and culminated in early **factory electrification**, mass production and the **production line** e.g. Ford production model in the car industry.

3rd stage of Industrial revolution

This stage occurred thanks to **Electronics & IT** and in particular introduction of Programmable Logic Controllers (**PLCs**) which allowed further **automation of production processes** and increase in productivity.

4th stage of Industrial revolution

Era when a new generation of **wireless communications** enables pervasive connectivity between **machines and objects**, which itself enables another leap in industrial automation. **5G systems** will allow **all-connected world of humans & objects Industry 4.0**.

5G: From ICT to the whole economy

- **major objectives** of 5G is to
  - meet projected **mobile traffic demand**
  - and to holistically address the **communications needs** of most **sectors of the economy**, including **verticals** such as those represented by **industries**.

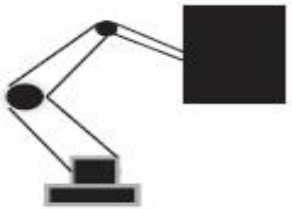
Economy sectors where 5G plays role

- **Economy sectors** (and some more additional industries) where 5G wireless communication shall play a major role are:
  - Agriculture
  - Automobile
  - Construction/Building
  - Energy/Utilities
  - Finance (including banking)
  - Health
  - Manufacturing
  - Media
  - Public Safety
  - Retail & Consumer
  - Transport (including Logistics)
  - Additional Industries such as Aerospace, Defence, etc.

use cases of 5G

(a) Autonomous vehicle control

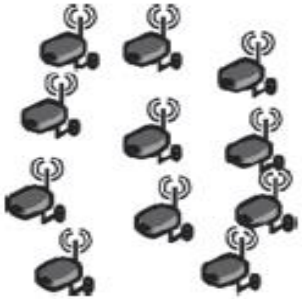
(b) Emergency communication



(c) Factory cell automation

(d) High-speed train

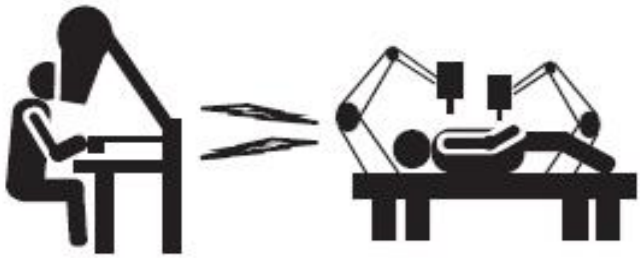
(e) Large outdoor event



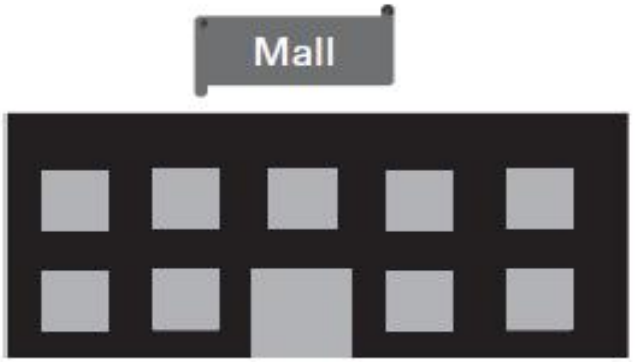
(f) Massive amount of geographically spread devices

(g) Media on demand

use cases of 5G



(h) Remote surgery and examination



(i) Shopping mall

(j) Smart city

(k) Stadium

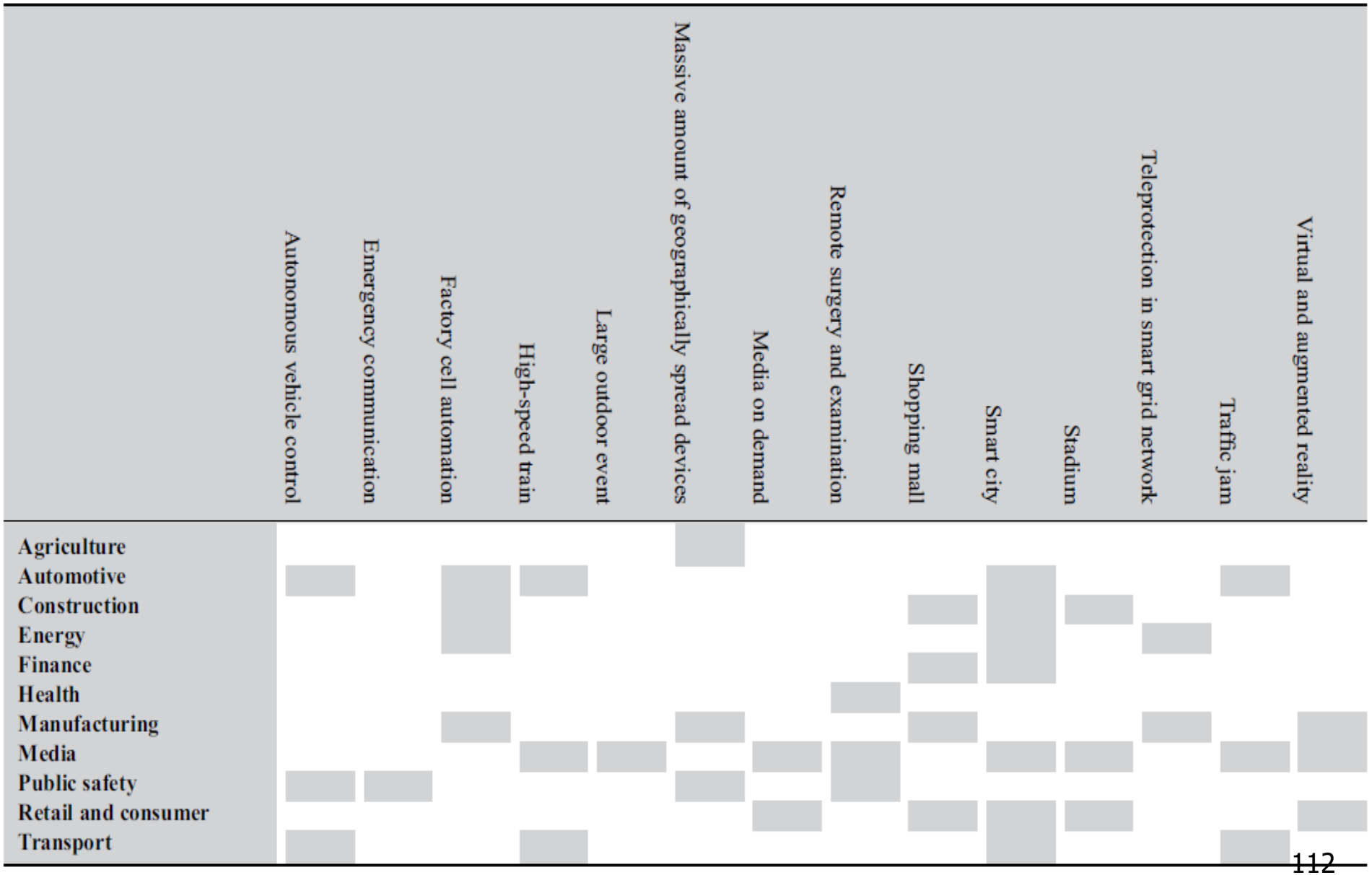
use cases of 5G

(l) Teleprotection in smart grid network

(m) Traffic jam

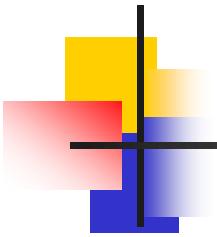
(n) Virtual and augmented reality

5G economic sectors vs use cases



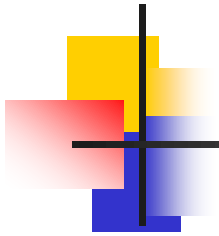
Automated vehicles

- Riding with Waymo One | During your ride (youtube.com)
- Sense, Solve, and Go: The Magic of the Waymo Driver - YouTube



Conlusions

- Field of multimedia over wireless would continue to grow and flourish!
- 5G may prove to be a game changer!



Thanks!