CMPT 820 Multimedia Systems

Introduction

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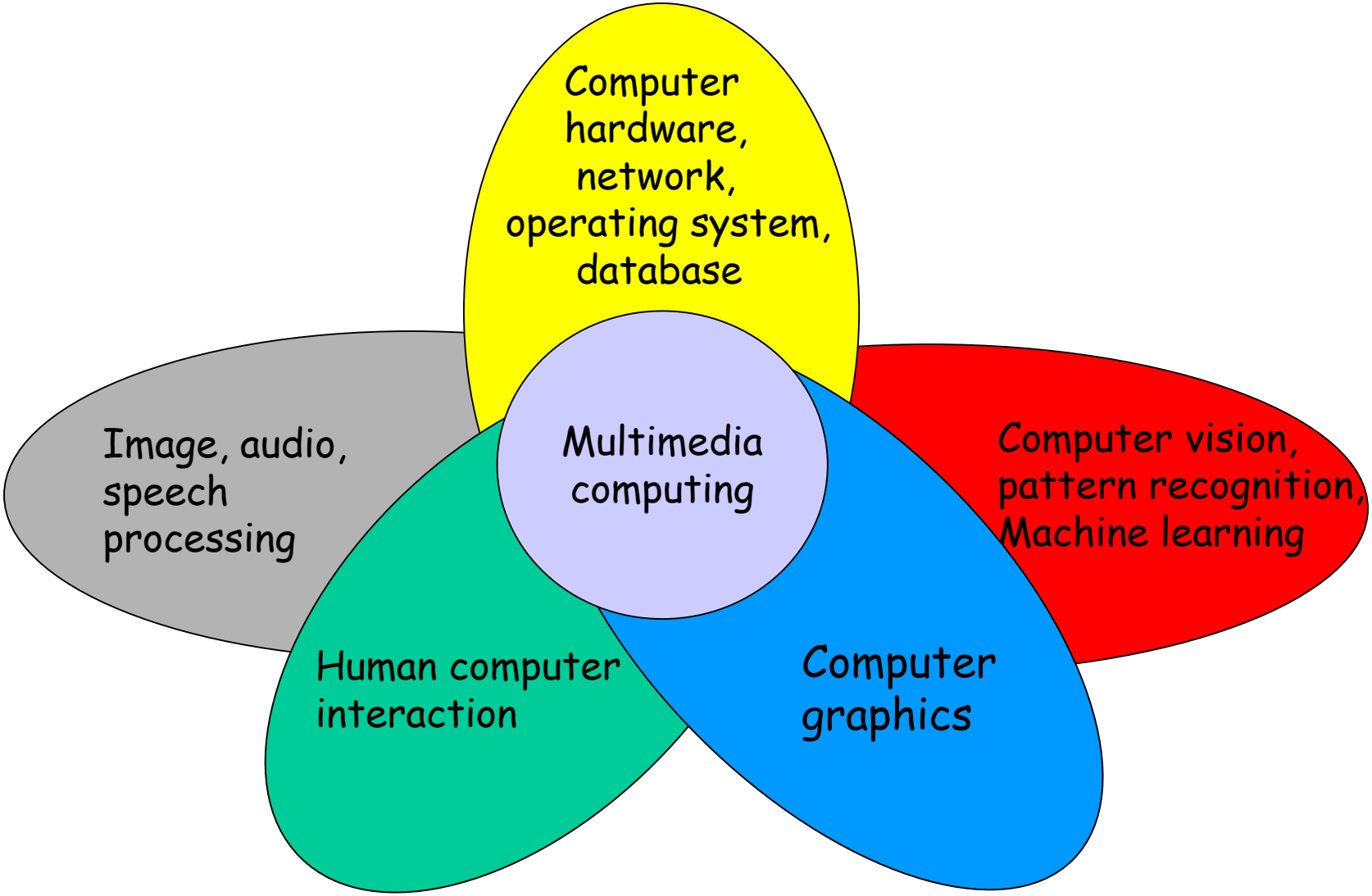
Why this course?

- Multimedia is cool
  - Media -> Multimedia
  - Everywhere
  - Requires broad knowledge in mathematics, signal processing, communications, networking, software, hardware, ...
- Job opportunities
  - Multimedia is a booming industry
    - in the metro Vancouver area
  - Tons of opportunities created by next-generation standards and emerging applications:
    - JPEG/JPEG 2000
    - MPEG-1/2/4 H.264/265/HEVC 4K/8K TV 3D/freeview
    - 3G/4G/5G mobile communications
    - Multimedia-enabled smartphone, tablets
    - Social media, Cloud media, Crowd media
    - Online gaming

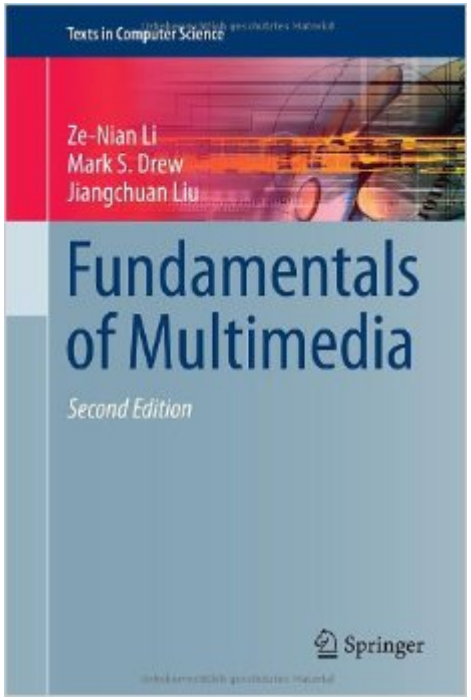
Multimedia is Multidisciplinary



Books and References

- Recommended Textbook
  - *Fundamentals of Multimedia, 2nd Edition, by Z.N. Li, M.S. Drew, and J. Liu, Springer, 2014.*
- Reference books
  - *Video Processing and Communications, Y. Wang, J. Ostermann, Y-Q Zhang, Prentice Hall, 2002.*
- Resource
  - Home page
    - www.cs.sfu.ca/CC/820/li/

  Please check it regularly



Grading Scheme

Two programming assignments	2x10%
Presentation and class participation	40%
Term project	40%

It is a Graduate ***seminar*** course !

Topics

- Introduction to Image and Video Compression
- Wavelets and JPEG-2000
- H.264/MPEG-4 AVC, H.265, and MPEG-7
- Image and Video Quality Assessment
- Content Based Image and Video Retrieval
- Visual Content Analysis
- Digital Audio Compression

Questions?

What is Multimedia?

Multimedia means that information can be represented through audio, images, graphics and animation, video, in addition to traditional media (i.e., text and graphics drawings).

- text
- graphics
- images

} Discrete media: time independent

- animation
- audio
- video

} Continuous media: time dependent

Multimedia Applications

- Using computers to present and process multimedia information, in an integrated manner
- Examples of Multimedia Applications:
  - World Wide Web
  - Video conferencing
  - Video-on-demand
  - Interactive TV
  - Games
  - Virtual reality
  - Digital video editing and production systems
  - Multimedia Database systems

Multimedia Applications (cont'd)

- Fields where multimedia are useful.
  - Business
  - Education
  - Entertainment
  - Home
  - Medical Applications
  - Museums
  - News
  - Science
  - etc.

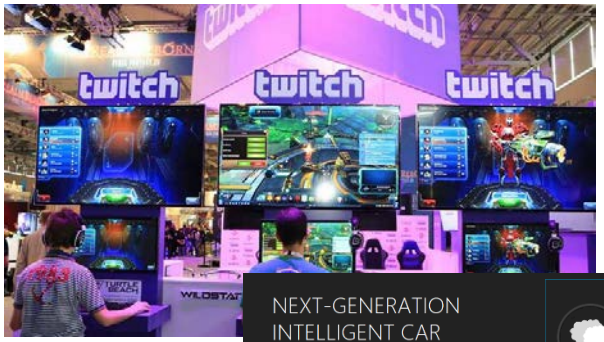
Killer Internet Applications

- Web2.0/Media streaming (Internet TV)
  - YouTube, Netflix, Google TV, Apple TV
  - HD/UHD video ?
  - 3D video, Free View Video ?
- E-commerce
  - Ebay, Amazon, Craigslist, Groupon
- Online games
  - PS3, XBOX 360, Wii
- Social networking (2004-)
  - Facebook, Twitter, Google+,WhatsApp, …
- Mobile Internet
  - iPads, tablets …

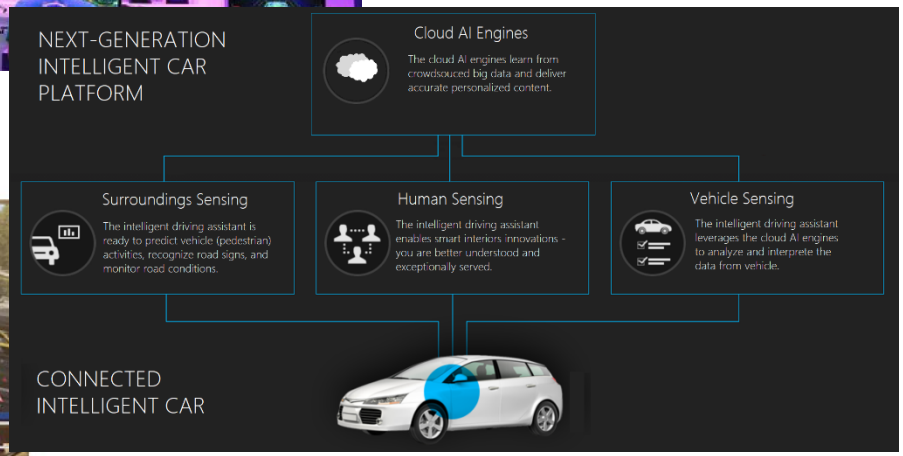
Past Five Years

- **Skype/YouTube/Netflix**
  - Replacing phone, movie theatre, TV !
- **AR/VR immersive media**
  - Pokemon Go !, MS Hololens …

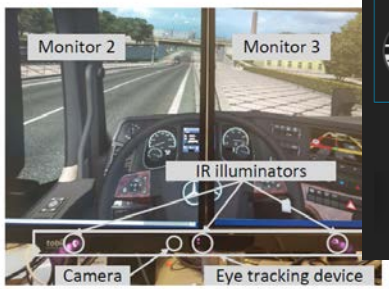
- **Cloud gaming**
  - Onlive, Gaikai, Sony …



- **Livecast**
  - Twitch.tv …
  - eSports broadcast …



- **Drone/car**



- **Deep learning**

Digital Media

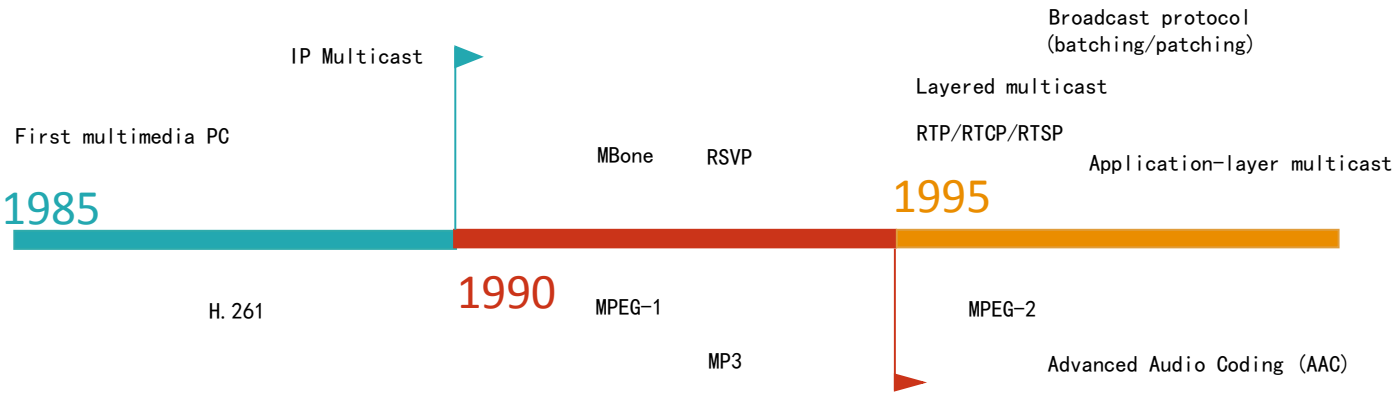
- What do you mean by **digitization** ?
  - Audio/visual signals from the natural world is Analog
    - Continuous in time and space
    - Conventional storage/playback: LP (audio record), tape, CRT TV (old TV), film
    - Can't be handled by digital computer
  - A/D conversion
    - to 1/0 discrete signals

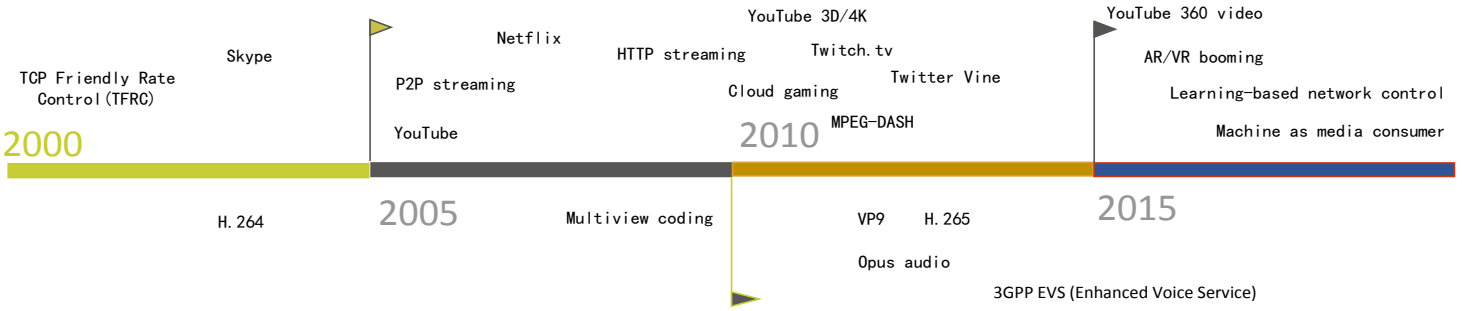
Why Digital Media?

- Mass storage (space, cost, lifetime)
- Better quality (esp. for reproduction, and transmission)
- Better compression
- Better security (encryption)
- Much easier to edit
- Portability/mobility

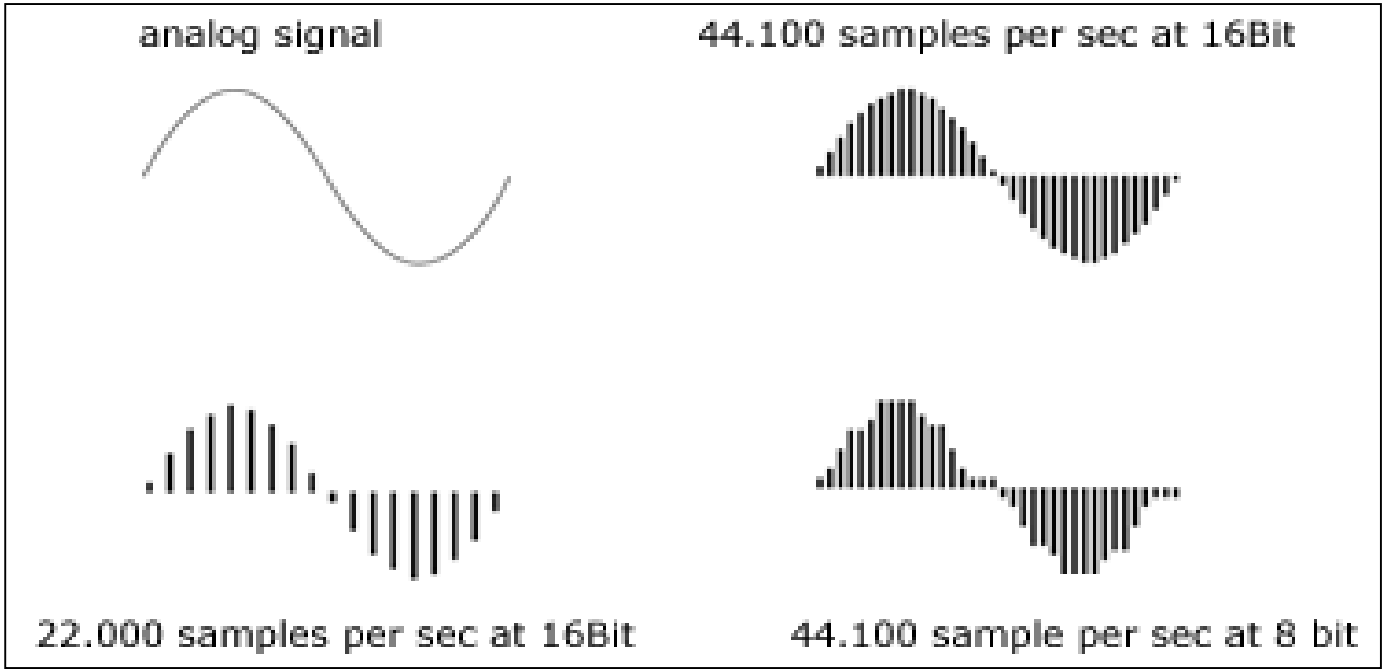
- Film -> Polaroid -> Digital camera
- MP3 player, iPod, YouTube

Digital Media Timeline





Audio Digitization (PCM)

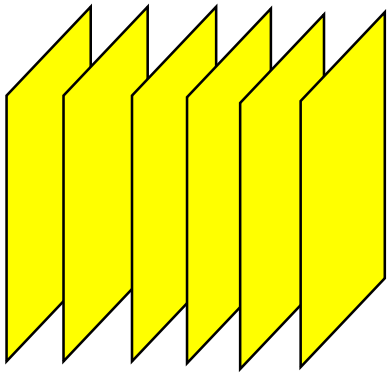


Data Representation ➔ for *digital* computers

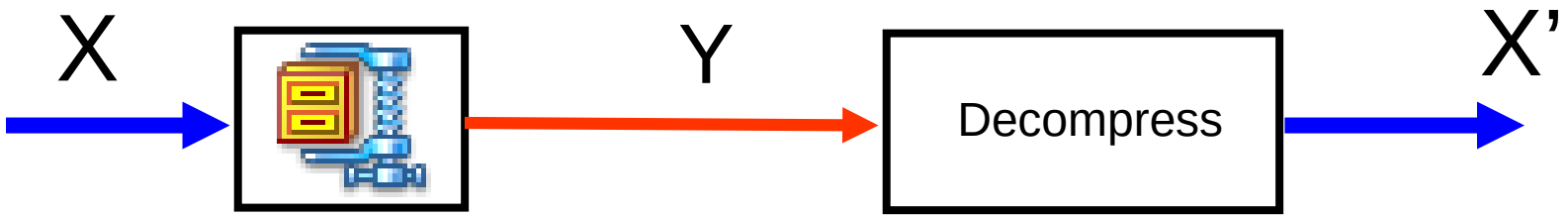
Image/Video Digitization

- Digital image is a 2-D array of pixels
- Each pixel represented by *color*
  - R:G:B

  - Y:U:V
    - Y = 0.299R + 0.587G + 0.114B (Luminance or Brightness)
      U = B - Y (Chrominance 1, color difference)
      V = R - Y (Chrominance 2, color difference)
- Video is sequence of images (frames) displayed at constant frame rate
  - e.g. 24 frames/sec in movies
  - 3D video (stereoscopic)



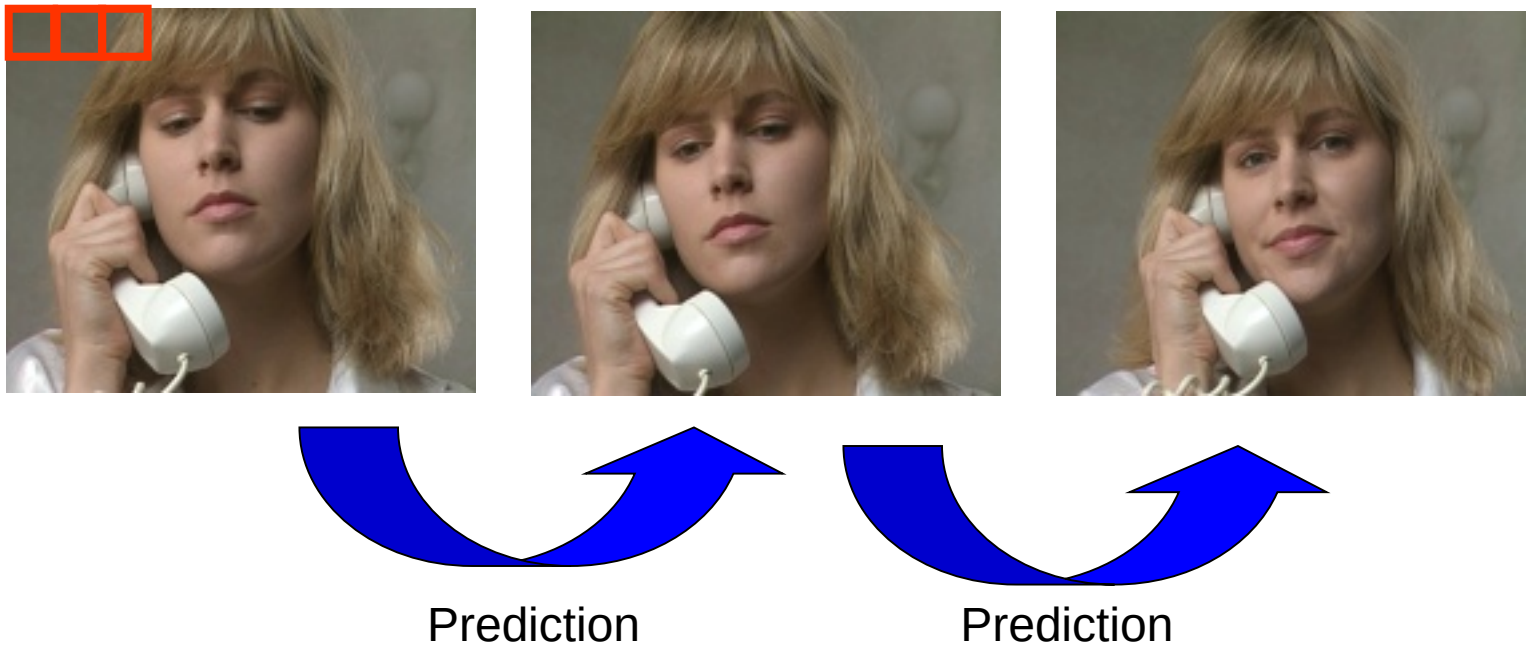
Data Compression



- Lossless Compression: X' = X
  - Example: Computer file compression
  - Low compression ratio
- Lossy Compression: X' ≠ X
  - Many applications do not require lossless compression
  - Our eyes and ears cannot identify some details
  - High compression ratio

Essentials of Compression

- Remove redundant information:
  - Spatial redundancy:
    - Neighboring samples have similar values
  - Temporal redundancy:
    - Neighboring frames in a video sequence are similar



History of Video Coding Standards

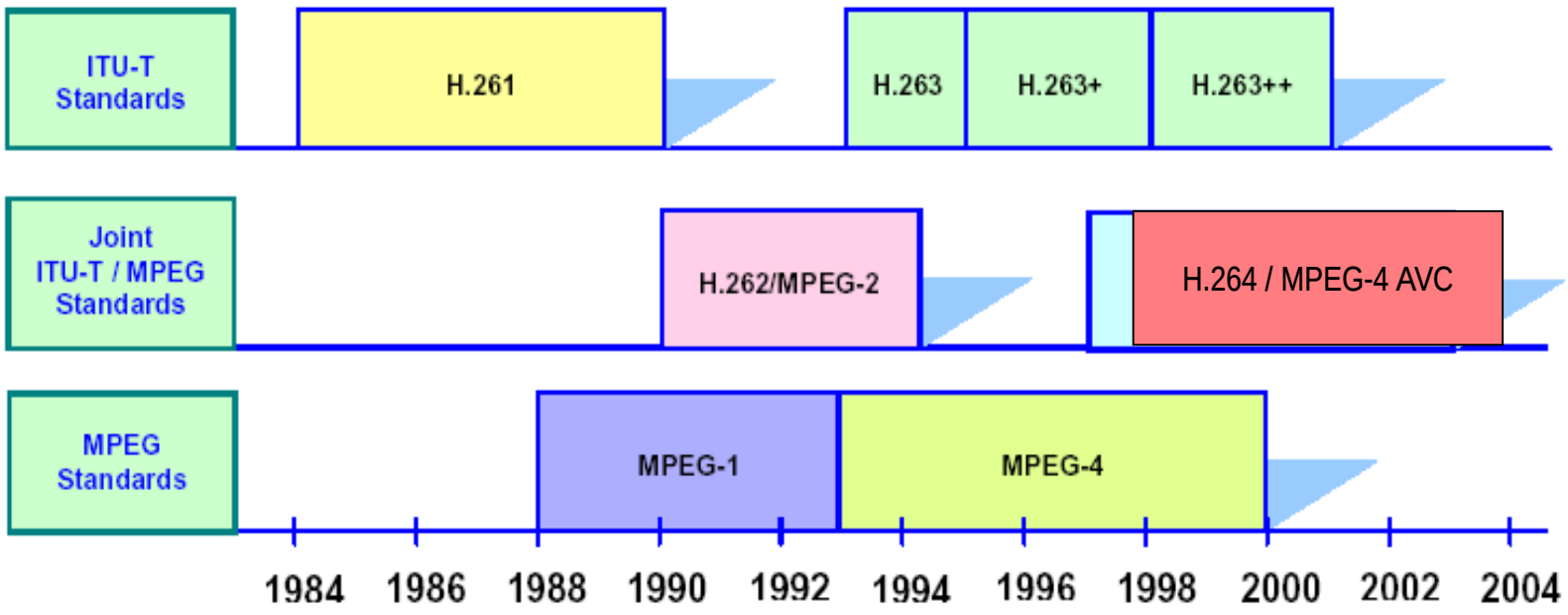
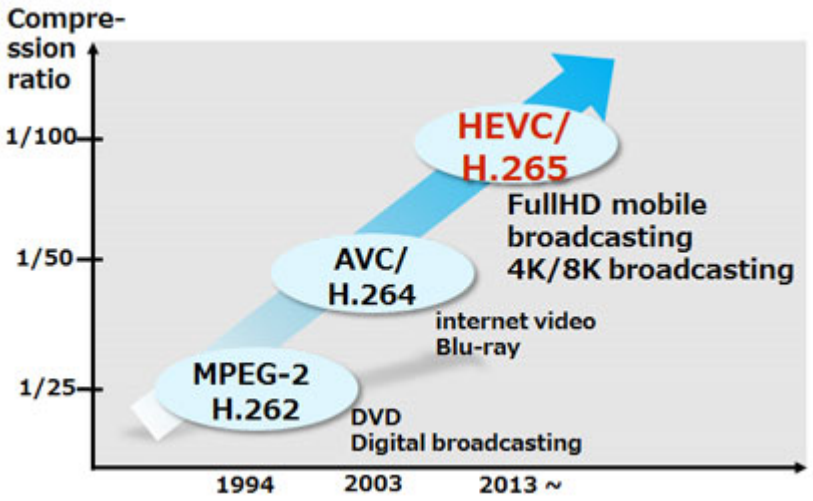


Figure 1. Progression of the ITU-T Recommendations and MPEG standards.

- H.264 / MPEG-4 AVC: ITU-T H.264 / MPEG-4 (Part 10) Advanced Video Coding (AVC) - finalized in 2004
- Scalable Video Coding (SVC) – in 2007
- Multiview Video Coding (MVC) – in 2009
- HEVC/H.265 (efficient & 50% bitrate reduction from H.264) – in 2013

Video Coding Standards



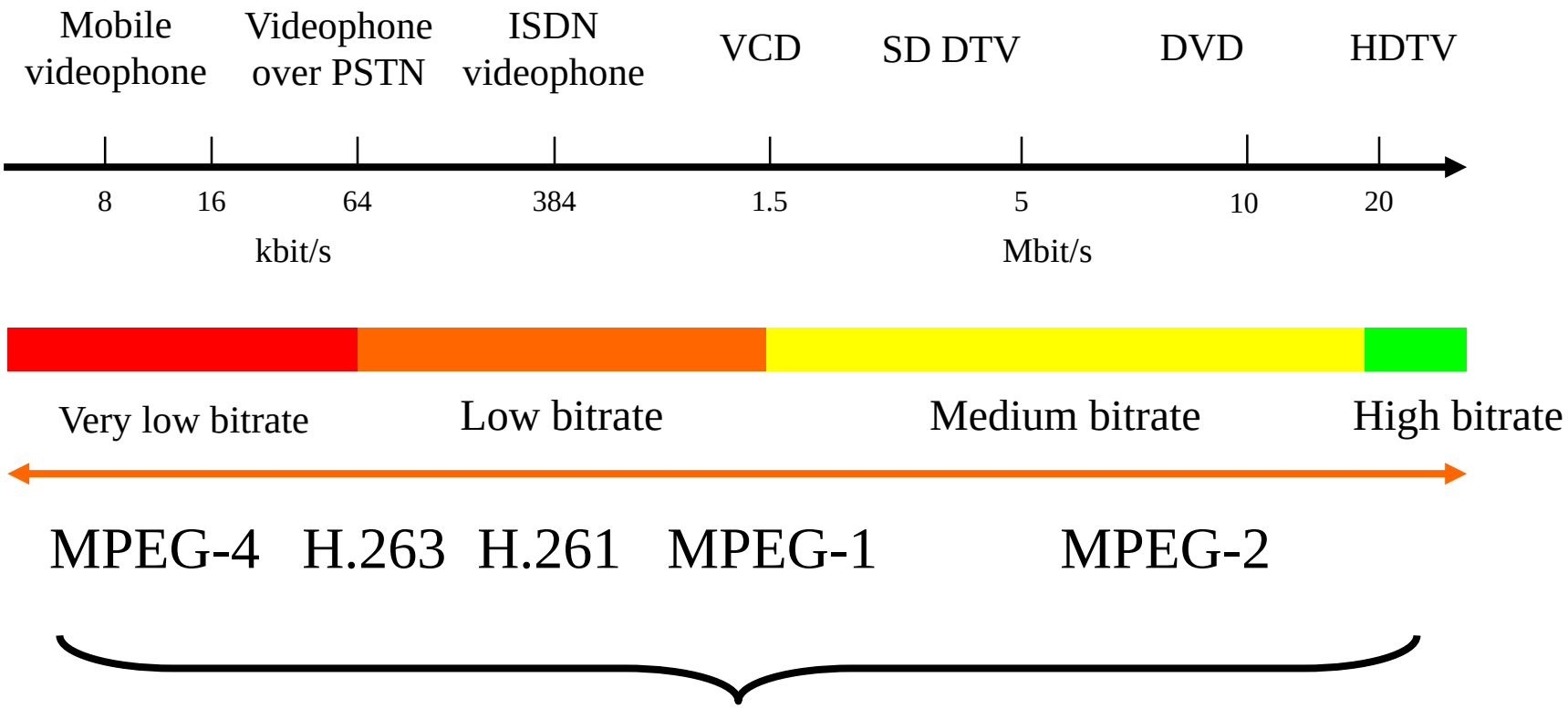
H.265/HEVC (High Efficiency)

- 50% goal (bitrate reduction)
- Start from 2010
- February 2012: Committee Draft (complete draft of standard)
- January 2013: Final Draft International Standard
- April 2013: Standard released

Google AV1 (open, royalty-free, succeed VP9, compete with H.265/HEVC)

H266 (Future Video Codec/FVC, expected by 2021)

Coding Rate and Standards



Audio coding standards

Range of human' hearing: 20Hz - 20kHz
➔ Minimal sampling rate: 40 kHz (Nyquist frequency)

Format	**Bit Depth**	**Sampling Rate**	**Bit Rate** (2 channels)
CD Audio	16 bits	44.1 kHz	1,411,200 bps
DVD Audio	24 bits	96 kHz	4,608,000 bps

- MPEG-1 or MPEG-2 audio layer 3 (MP3)
  - CD quality at 10:1 compression ratio, 128 kb/s.
- MPEG-2 AAC (advanced audio coding):
  - used by XM Radio (satellite radio in US)
- MPEG-4 AAC :
  - Up to 48 channels, 96KHz
- ATSC AC-3:
  - Dolby Digital (5.1 channel)
  - ATSC: Advanced Television Systems Committee
  - For DTV, DVD
- iTunes
  - AAC
  - AIFF (Audio Interchange File Format)