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

Computer hardware, network, operating system, database

Image, audio, speech processing

Human computer interaction

Multimedia computing

Computer graphics

Computer vision, pattern recognition, Machine learning
Books and References

- **Recommended Textbook**

- **Reference books**

- **Resource**
  - Home page

  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
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
- Much easier to edit
- Portability/mobility
- Film -> Polaroid -> Digital camera
- MP3 player, iPod, YouTube
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**: $X' \neq X$
  - 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

- **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
Coding Rate and Standards

[Diagram showing bitrates and standards]

Very low bitrate: Mobile videophone, Videophone over PSTN, ISDN videophone
Low bitrate: VCD, SD DTV
Medium bitrate: DVD
High bitrate: HDTV

- MPEG-4
- H.263
- H.261
- MPEG-1
- MPEG-2

H.264 / H.265 can do all of them!
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)
**Audio coding standards**

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

<table>
<thead>
<tr>
<th>Format</th>
<th>Bit Depth</th>
<th>Sampling Rate</th>
<th>Bit Rate (2 channels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD Audio</td>
<td>16 bits</td>
<td>44.1 kHz</td>
<td>1,411,200 bps</td>
</tr>
<tr>
<td>DVD Audio</td>
<td>24 bits</td>
<td>96 kHz</td>
<td>4,608,000 bps</td>
</tr>
</tbody>
</table>

- **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)