Warmup Review Questions

- What is the frame rate you need on computers for an animation?
- What is rotoscoping?
- What are the 3 stages in 3D animation?

Computer Science 1033 – Week 10

VIDEO

Your goal is to count how many times the ball is passed by those wearing white shirts

"A good film is when the price of the dinner, the theatre admission and the babysitter were worth it." → Alfred Hitchcock

Today

- Intro to video, TVs, resolution
- Colour Sampling
- Compression
- Download vs Streaming
- Other things to consider

Make sure you get a copy of all your work!

- Your assignment 2 and 3 websites will only be posted for the next month (till about ONE month after our final exam) so make sure you take a copy of everything you want to save and put it on a memory stick or in the cloud.
- ONE MONTH AFTER THE COURSE ENDS YOU WILL **NOT** BE ABLE TO GET ANYTHING YOU POSTED ON cs1033.gaul.csd.uwo.ca BACK. KEEP COPIES!

Announcements

- Readings: Video

Announcements

- Feedback page is open:
  - Please fill in the Feedback form: https://feedback.uwo.ca

What is Video?

- A sequence of still images (photographs) that create the illusion of movement when played in succession.
- **Question**: What is each still image called?
- Frames Per Second (fps)
  - Movies on film → 24-30 fps
  - TV was originally 29.97 fps (59.94 fields per second)
  - Computer Displayed Video → AT LEAST 12-15 fps
    - Humans can distinguish as single images at less than 10 fps
  - https://frames-per-second.appspot.com/
    - Set Motion Blur to None and Frame Per Second to 5 fps
  - Digital Video → each frame is a bitmapped graphic, stored as 0s and 1s
- Does this sound familiar?

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Sampling and Quantizing of Motion

- Since each frame is just an image →
  - Each frame is sampled into a discrete samples and each sample becomes a pixel → **Sampling process**
    - Remember:
      - More samples means better quality (10 pixels by 10 pixels vs 200 pixels by 200 pixels)
      - More samples means bigger file sizes (10 pixels by 10 pixels vs 200 pixels by 200 pixels)
  - Each pixel gets assigned a colour, maybe just 2 colours(black and white→1bit colour) or maybe 16 million colour (24 bit colour) → **Quantization process**
- What else can we "**sample**" with MOTION?
  - Timing of the motion
  - Sampling = frames
  - Higher FPS = more accurate motion, but larger file size

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Quantizing →Colour Compression In The Video

- For still images RGB is commonly used
- For video the model is YUV (YIQ) or YCbCr (for MPEG compression)
- Y → **luminance** (brightness)
- UV →(CbCr) **chrominance** (color/hue)
- **Question**: Black and White TV only used the _____ signal (fill in the blank with Y, U, or V)
- **Question**: Which one will the human eye detect changes in more easily? How does this help us with compression? Where have we seen this used before?

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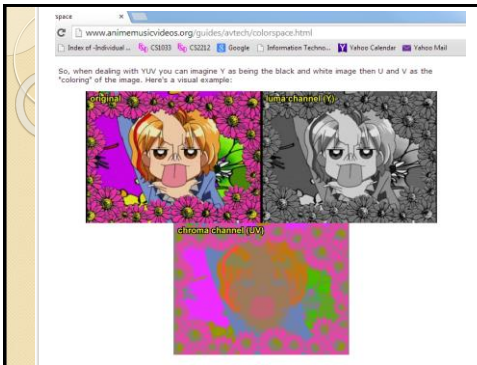

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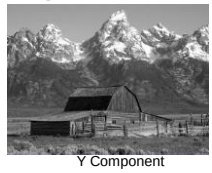
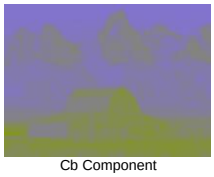
YUV / YCbCr Components


Original Picture


Y Component


Cb Component


Cr Component

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- You may see that the compression used 4:1:1 Color Sampling Method what does this mean?
- Assume we have 16 pixels that we are looking at in blocks of 4→


http://dvxuser.com/articles/colorspace/

Color Sampling Method	Amount of Y (luminance)	Amount of U (color or hue)	Amount of V (color or hue)	Amount of Compression	Used in
4:4:4	4 samples (i.e. 4 pixels)	4 samples	4 samples	None 12 samples for each group of 4 pixels	
4:2:2	4 samples	2 samples	2 samples	Reduced from 12 samples to 8, 33% reduction in storage	Digital Betacam format
4:2:0	4 samples	2 samples of either U or V, one scan line of U, then one scan line of V		12 to 6, 50% reduction in storage	HDV, MPEG-1, DVD, MPEG-2, PAL DV
4:1:1	4 samples	1 sample	1 sample	12 to 6, 50% reduction in storage	NTSC DV, miniDV digital camcorder

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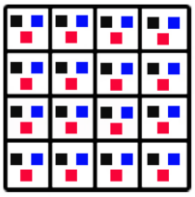
- If we look at a grid of 4x4 pixels, the ratio tells us how many values from the YCbCr or YUV layers are showing.



- In this example there are 4 of each layer (Y, U, and V) so this is a **4:4:4** image.
- Watch this starting at 2:45

http://blogs.adobe.com/VideoRoad/2010/06/color_subsampling_or_what_is_4.html

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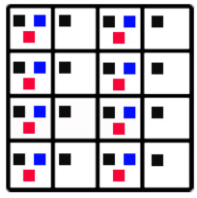
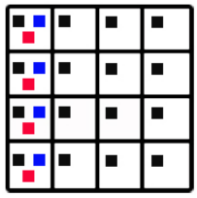
- Here we have Y in every pixel but the U and V are only in every 2nd column.
- This is **4:2:2**.



- The U and V only appear once in four columns.
- This is **4:1:1**.



http://blogs.adobe.com/VideoRoad/2010/06/color_subsampling_or_what_is_4.html

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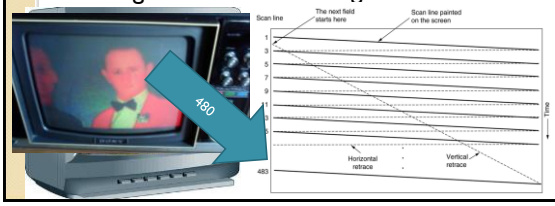
How did the original TV display work?

- Our eyes see phosphor dots on the screen.
- An electron beam (gun) activates the dots. The gun scans through the dots horizontally
- A complete scan is when the gun starts at the top left and scans several times horizontally till it gets to the bottom right



- The scan only draws every OTHER line (1,3, 5, …479) then starts back at the top and draws the even lines (2,4,…480).
  - Thus two passes
  - Each pass is called a ***field***
  - The process is called ***interlaced display***
- This way it can cheat the eye, while the phosphor dots are disappearing, it is drawing the line underneath.
- Interlacing should be avoided now, instead use progressive (interlacing is for old TVs) for video that will be displayed on the web.

http://www.crutchfield.com/Learn/learningcenter/home/understanding-resolution.html

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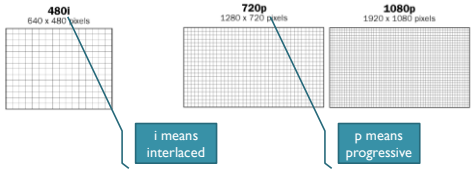
The image on the left simulates the picture resolution of an old-fashioned TV, while the image on the right simulates high-definition TV. Notice the soft edges and jagged lines in the non-HD image.



2000's TVs

- **Question**: On a HD TV, what does the circled area mean?

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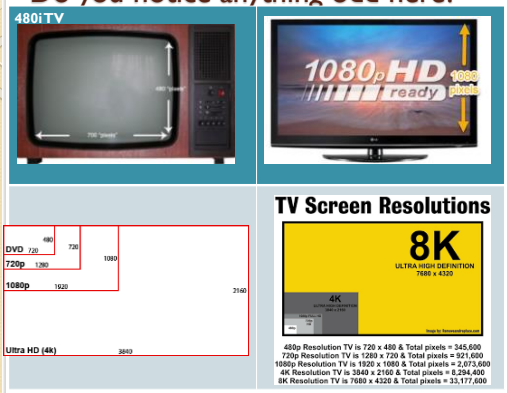
Do you notice anything odd here?



What do TV specs mean?

2010's TVs

- **Most TVs sold now are 4K** → 4K resolution (4096 x 2160 → 4K refers to WIDTH now???) https://www.youtube.com/watch?v=RodCjVf-5AE
  - Initially they were very expensive and there was very little content available for them
  - Now the prices have come down a lot, and there are a lot more shows and movies shot in 4K now
  - Newer phones have 4K video cameras
  - 4K video games are being made for the PS4 Pro and Xbox One S and Xbox One X

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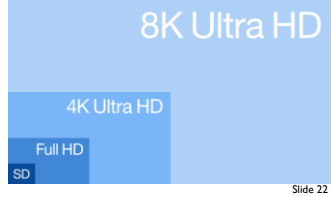
Comparison of Resolutions

- Standard Definition resolution was 480 or 576
- High Definition resolutions started at 720, then up to 1080, 1440, and then to 4K. Now companies are beginning to make 8K TVs but they are very expensive (and not much content)



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2010's Small Devices Matter Too!

- Apple suggests that small devices (iPads, etc) should be held at 10-12 inches away from your face, and that the screen resolution should be at least 300ppi to look crisp. Apple uses the term "high retina display" for this.
  - http://www.makeuseof.com/tag/how-does-the-retina-display-work/ (watch Steve Jobs video)
  - https://www.youtube.com/watch?v=Zl5cN8Z7LnM (just watch the first two minutes)

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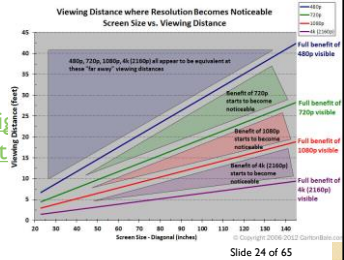
For Retina Display:

- **Retina Displays** – have a pixel density high enough so that your eyes cant detect pixels at a normal viewing distance. You need to consider:
  - Pixel density
  - Viewing distance
  - Display size
- https://www.desi… ources/is-this-ret…



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Editing of Video

- Before Digital Video:
  - Had to copy from one tape to another tape
  - Had to load up tapes on a machine to copy
  - Loss of quality after each copy made
- Now:
  - Can easily move clips around
  - No loss of quality
  - Slight compression occurs in the camcorder when the video is captured

https://www.youtube.com/watch?v=Wa_VZISu6fc

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A Little History of Camcorders

Before 1967 NOTHING was portable (had to use tripods)
1967 → Sony came up with first portable black and white camcorder (needed BIG shoulders)
1971 → first cassettes (didn't need to load reels)
1982 → combine video, sound recording and playback (**cam**era re**corder**)
2001→ Most camcorders record at 5fps
2019 → iPhoneX records 4K at 60fps

Things to think about before exporting video:

- Where will I be putting my video?
  - On the web:
    - Bandwidth is an issue, need good compress
    - Standard file format is now mp4
  - On CD-Rom (playback speed is an issue)
  - DVD video (must be in mpeg2 format)
- Who is my audience?
  - Will they be on different platforms
  - How old will their computer be, how old will their CD or DVD player be?
- Will I still need to edit it later on? Should I compress it at all?

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Why Compress? An Example

- Assume we have video that is:
  - 1440 X 1080 pixels → 1,555,200 pixels per frame
  - 24-bit colour
  - 30 fps
  - 1 second long
  - Audio is stereo so 2 channels
  - Audio is 48,000Hz and 16 bit = 48,000*1sec*16bits/sample*2=1,536,000bits
- **Video**
  - 1,555,200 X 24 bits per pixel (for color) = 37,324,800 bits per frame
  - 37,324,800 * 30 frames per second * 1 second= 1,119,744,000 bits/8 = 139,968,000 bytes =**133MB**
- **Audio**
  - 1,536,000bits/8 → **188 KB**
- **Total**
  - **133MB + 188KB =~ 133MB → LOTS OF STORAGE FOR JUST 1 SECOND**
  - **OR 1,067 Mb**
  - **OR 1.04 Gb**
  - **THUS a DVD could hold 35 seconds of uncompressed video… Not a very long movie ☹**
  - https://www.youtube.com/watch?v=r6Rp-uo6HmI

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Data Rate or Bit Rate

- Amount of video processed per second
- Average **bit rate = file size/length** in seconds of video
- Our example from previous slide → 133MB per second
- Consider a 48X Speed CD Rom
  - Average playback (bit/data rate) rate is 7MB/s
  - Our video would be VERY CHOPPY
- Consider a video that is 100MB and 10 Seconds long:
  - **Question**: what would its data rate be?
  - it would be choppy on our CD Player
- Consider a video that is 100MB and 33 second long, it would play back at 3MB per second and be fine on our CD Player
- NOTE: problems occur not just because of file size but also because of data rate!
- Bit rate is normally measured in bits NOT bytes (Mb is mega bits, MB is mega bytes)

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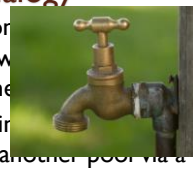
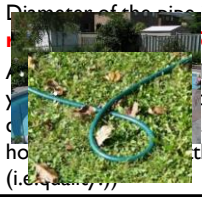
Analogy

- Dor… …e f… …so how… …ve …n time…
- Thir… …r fr… …ol to another pool via a pipe.
  - Amount of water in the pool is the **file size**
  - D… …is the **b…** **(you can't r… …or you…**
  - A… …low you… …(if y… …much c… …he pres… …ur ho… …tle leaks… …ter (i.e. quality))





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Compression

- **Question**: What things do you think we should think about optimizing to decrease video file size?
  - One thing to think about: what we did to an image to make it smaller
  - Another idea: think about what you could do with the frames on Ellen Degeneres doing an interview vs. a tennis match

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General Compression Strategies

- **Lower the frame size of the video**
  - If it was 640 by 480, change it to 320 by 240, less pixels!
- **Lower the frame rate of the video**
  - Changing the frame rate by ½ (say 20 fps to 10fps) will generally ½ the file size (remove ½ of the frames). Common fps are 24, 30, 60
  - **Question**: What type of video would you NOT want to do this on?
- **Pick a codec that does higher compression**
  - **Question**: What is a codec?

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Codec

- A **codec** is a piece of code that **co**mpresses video or audio as it is created (exported from the editing software) and then when displaying it to the user **dec**ompresses the video or audio (also stands for **co**der/**dec**oder)
- There are LOTS of codecs. You have to use the same one to decompress that was used to compress a video.
  https://www.youtube.com/watch?v=GhWki9a7s18
- Most common codecs are:
  - H.264 – the one YouTube uses
  - DivX
- Can sometimes get a piece of video on your machine and then not be able to play it, this is because you are missing the appropriate codec! (just watch till 2:30)

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Codec Continued

- For example …if you take your friend's camera and plug it into your computer and the jpgs will display but the videos won't play then likely: **You are missing the codec!**
- Codecs sometimes depend on the file format.
- What are the file formats available for video?

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Video File Formats

File Type	Also known as:	Originally created by	More Info	Platforms
.mov	QuickTime movie	Apple	•Also for audio •Supports MIDI •Streaming with QuickTime Streaming Server •Can watch video as it is downloaded •Codecs→ Animation, Sorenson Video, H.264, PlanarRGB, Cinepak	Apple QuickTime player available for Mac and Windows
.avi	Audio Video Interleave	Intel	•Codecs→ Microsoft RLE, Intel Indeo Video, Cinepak	Mostly Windows but Apple QuickTime player can play avi files
.rm	Real Video		ed on connection speed Server compromises quality	Cross platform Need Real Player
.wmv	Windows Media			Used with Windows Media Player
.mpg .mpeg .mp4 (container)	MPEG	Motion Picture Experts Group	•mpeg-1→ VCD, V	Cross Platform
.flv	Flash Video, f4v	Adobe		Cross Platform Need Flash Player to play a SWF file that holds the flv file

.mp4 is by far the most common now. Used by YouTube

Flash video is becoming obsolete

have transparent video), H.264

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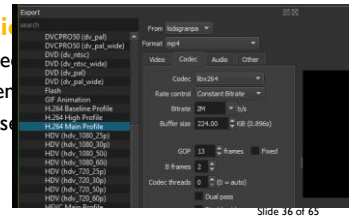
Compression Strategies Continued

- **Pick a codec that does higher compression**
  - QuickTime and AVI use different codecs so you can pick one that gives better compression.
  - Watch this.
- **Lower the pi**
  - Sorenson code
  - H.264 is curren
  - Some let you s



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Compression Strategies Continued

- **Lower the color depth**
  - Not popular because video looks best at 24bit color (unless it is a cartoon)
  - Some compressors won't compress color
- **Play with the audio**
  - Unfortunately the audio is usually not the problem so compressing it more won't usually help much!

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Compression Concepts

- **Temporal Compression vs. Spatial Compression:**
  - **Spatial**
    - Compress each frame individually
    - Uses the same techniques as JPG compression
    - Codecs that do spatial compression are: Animation, PlanarRGB
  - **Temporal**
    - Just save info on selected frames (called keyframes)
    - All other frames just save the differences from the previous keyframe
    - Good when the difference between current frame and keyframe is small
    - Codecs using temporal compression are: Sorenson Video, H.264
  - **Question**: What kinds of video would not do well with temporal compression?
  - Watch this starting at 3:50 (just till 5min)

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Compression Concepts

- **Lossy vs. Lossless** Compression
  - Depends on the codec
  - **Lossless**
    - looks for large blocks of pixels that are the same to do RLE (run length encoding)
    - QuickTime Animation and PlanarRGB are lossless
  - **Lossy**
    - Lowers video quality but get better file size and better data rate (bit rate).
- How this relates to bit rate (just watch first 2 minutes and 40 seconds)

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HTML5

- A new standard (well not that new…first beta released in 2008) for the html in webpages. It includes a way to watch video on a website that does NOT require the browser to have a plug in (all new browsers can display the video using HTML5)

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Before HTML5, to insert video, the code looked like this ☹:

```
<object classid="clsid:D27CDB6E-AE6D-11cf-96B8-444553540000" width="475" height="269" id="FLVPlayer">
 <param name="movie" value="FLVPlayer_Progressive.swf" />
 <param name="quality" value="high" /> <param name="wmode" value="opaque" />
<param name="scale" value="noscale" /> <param name="salign" value="lt" />
 <param name="FlashVars"
value="&amp;MM_ComponentVersion=1&amp;skinName=Clear_Skin_1&amp;streamName=pictures_1&amp;autoPlay=fals
e&amp;autoRewind=false" />
 <param name="swfversion" value="8,0,0,0" />
<!-- This param tag prompts users with Flash Player 6.0 r65 and higher to download the latest version of Flash Player.
Delete it if you don't want users to see the prompt. -->
<param name="expressinstall" value="Scripts/expressInstall.swf" /> <!-- Next object tag is for non-IE browsers. So hide it
from IE using IECC. --> <!--[if !IE]>-->
<object type="application/x-shockwave-flash" data="FLVPlayer_Progressive.swf" width="475" height="269">
<!--<![endif]--> <param name="quality" value="high" /> <param name="wmode" value="opaque" />
<param name="scale" value="noscale" /> <param name="salign" value="lt" />
<param name="FlashVars"
value="&amp;MM_ComponentVersion=1&amp;skinName=Clear_Skin_1&amp;streamName=pictures_1&amp;autoPlay=fals
e&amp;autoRewind=false" />
 <param name="swfversion" value="8,0,0,0" /> <param name="expressinstall" value="Scripts/expressInstall.swf" />
<!-- The browser displays the following alternative content for users with Flash Player 6.0 and older. --> <div>
<h4>Content on this page requires a newer version of Adobe Flash Player.</h4> <p><a
href="http://www.adobe.com/go/getflashplayer">
<img src="http://www.adobe.com/images/shared/download_buttons/get_flash_player.gif" alt="Get Adobe Flash player"
/></a>
</p> </div> <!--[if !IE]>--> </object> <!--<![endif]--> </object>
```

Now it looks like this: **<video src="myvideos/movie.mp4" controls>**
if this text shows instead, your browser is really old!
</video>

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Inserting Video into your webpage using…HTML5

- Currently HTML5 supports 3 video formats:
  - MP4
  - WebM
  - Ogg
- Have to worry about what browser your viewer is going to use:

Browser	MP4	WebM	Ogg
Internet Explorer	YES	NO	NO
Chrome	YES	YES	YES
Firefox	YES	YES	YES
Safari	YES	NO	NO
Opera	YES (from Opera 25)	YES	YES

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HTML5 Video Formats

- Apple is trying to get away from Flash so it won't support .flv,
- HTML5 does NOT support .flv
- HTML5 Standards group wanted:
  - Good compression, good image quality
  - Royalty free
  - Should handle hardware issues as well as software issues
- Works on handheld devices too ☺

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HTML5 supports →ogg, webm and mp4

- Originally only wanted to use codec: Theora or Vorbis (.ogg containers) because they were open source but Apple wasn't sure if they were open source
- WebM another file format, royalty free, open source, backed by Google
  - YouTube uses WebM
- Apple and Microsoft only support the codec: H.264 which creates .mp4 files
  - Used in blu-ray discs, vimeo, YouTube and iTunes
  - H.264 is lossy but can do lossless

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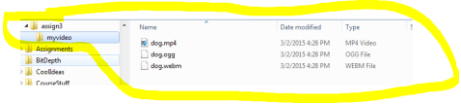
How to add video in HTML5

- Make sure you encode your video as a mp4, ogg or WebM file using Adobe Encoder
- Put your video somewhere inside the folder containing your website (perhaps a subfolder). E.g. if you folder is assign3, maybe put video in *assign3/myvideo* folder:



- Make sure the first line of your webpage is:
  - <!DOCTYPE html> (this indicates it is html5)

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HTML5 <video> tag

- Edit the html code in the assign3 folder (e.g. the index.html file) and put the following <video> tag where you want the video as follows:

```
<video width="320" height="240">
  <source src="myvideo/dog.mp4" type="video/mp4">
</video>
```

- Might need this →

```
<video width="320" height="240">
  <source src="myvideo/dog.mp4" type="video/mp4">
  <source src="myvideo/dog.ogg" type="video/ogg">
  <source src="myvideo/dog.webm" type="video/webm">
  Your browser does not support the video tag.
</video>
```

- QUESTION: What do you think each of these parameters do?

```
<video width="320" height="240" controls autoplay loop muted poster="doggy.jpg">
  <source src="myvideo/dog.mp4" type="video/mp4">
</video>
```

- QUESTION: What do you think this does:

```
...
  <source src="myvideo/dog.mp4#t=10,22" type="video/mp4">
```

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Other Terms You Need To Know

- ***Container File Format***
  - A file format that stores both the data (the frames) AND how to play the data (which codec to use)
  - Some common containers are:
    - **.avi** → sometimes has uncompressed video, just depends, no streaming
    - **.flv** (doesn't allow subtitle)
    - **.ogg** (free open source container format)
    - **.mp4**
- Newer container formats support subtitles, chapters, etc…
- **Question**: Why can your computer sometimes play one .avi file but then not play another .avi file?

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Something else cool you can do with HTML5 and container file formats:

- Pick a subtitle or closed captioning file

```
<video controls width="640" height="360">
    <source src="devstories.mp4" type='video/mp4>
    <track src="devstories-en.vtt"
label="English subtitles" kind="subtitles"
srclang="en" default></track>
</video>
```

http://www.html5rocks.com/en/tutorials/video/basics/

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Subtitles

- Subtitles help the viewer understand dialogue
  - Especially important for hearing impaired
- Two main types: hard and soft
  - Hard (hardsubs): embedded into the video file so they can not be turned off or removed
  - Soft (softsubs): usually stored in a separate file telling what text to appear at what time in the video. These can be turned off/on as needed.
  - Both types have pros and cons, but we will just work with softsubs here.

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Subtitles

- You must specify the **start time**, **end time**, and the **text** to be displayed for each subtitle panel on the video
- This format is also often used if you want to set up Karaoke.
- For videos embedded in a website, the format has to be a .vtt (Web Video Text Tracks) file.

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Subtitles

- In the webpage, add the following HTML:

```
<video width="1280" height="720" controls>
<source src="cat.mp4" type="video/mp4">
<track label="English" kind="subtitles" srclang="en"
src="cat.vtt" default>
Your browser does not support the video tag.
</video>
```

- The width, height, video source file, and subtitles file may need to be updated.

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Subtitles

- Here is a SOFT subtitled video demo: http://www.csd.uwo.ca/~bsarlo/cs1033a/samples/video.html
- Here is a HARD subtitle video demo:
  - http://www.csd.uwo.ca/~lreid/cs033/moviedemo/RachelB%20project_final.wmv
- Have a look at the WebVTT subtitle file here: http://www.csd.uwo.ca/~bsarlo/cs1033a/samples/cat.vtt

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Vote Now:

- Which video would YOU rather have (no right or wrong answer)
  - This one:

    http://www.csd.uwo.ca/~lreid/cs1033/ExamplesForLectures/videoslag/144example.mp4

    OR
  - This one:

    http://www.csd.uwo.ca/~lreid/cs1033/ExamplesForLectures/videoslag/8kexample.mp4

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Video on the Web

- Getting video/audio (media) from a website to your computer so you can view it:
  - **Downloading**
    - **Make a copy of the file/video on your machine**
  - **Streaming**
    - **Like listening to the radio – you can listen but can't save it (without difficulties)**

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Download

- Used to be the ONLY option!
- When you visit a website containing video, the entire video must be downloaded to your computer before you can play it.
  - Progressive downloads allow you to start watching as soon as it has downloaded enough bits to stay ahead of the download
- For the web, usually stored on a HTTP protocol
- Data that is sent is **permanently** stored on the end machine.
- Disadvantages:
  - **Question**:What do you think is a disadvantage?
- Advantages:
  - **Question**:What do you think is an advantage?

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Streaming

- In true streaming the file is never permanently saved to the user's hard drive, media begins to play as soon as it gets enough packets to stay ahead of the viewer
- Disadvantages:
  - **Question**:What do you think is a disadvantage?
- Advantages:
  - **Question**:What do you think is an advantage?

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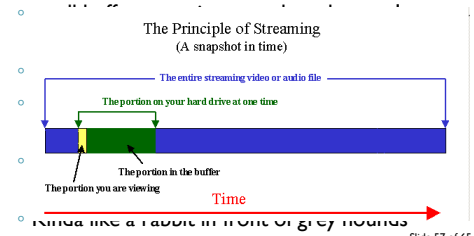
Streaming

- When streaming video (like on youtube), the video must be delivered fast enough so there appears to be no delay
- Uses buffering:



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Streaming…

- Sometime requires special streaming server (RTSP)
- Video starts almost immediately
- If the data rate (bit rate) of the encoded video file is bigger than the amount of bandwidth available, the video will frequently STOP PLAYING ☹
- Unicast vs. Multicast -http://www.bolermountain.com/
  - **Unicast** → each user gets his/her own stream of video, the server has to send out A LOT of data if several users are watching at once
  - **Multicast** → send the same stream to a bunch of users but then they lose the ability to pause, rewind, etc.

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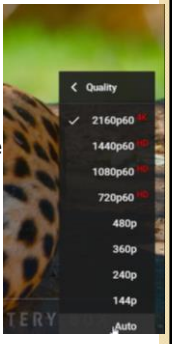
Adaptive Streaming

- YouTube is now (because of 4K content) doing *Adaptive Streaming*
- When you upload a 4K video, it makes several versions of it (1440 version, 1080 version, etc):

- When you upload your 4K video, give youtube a few hours to make the different versions THEN TEST THE QUALITY.
- Vimeo also does this.
- If the viewer picks *Auto*, it will serve up the BEST quality video it can to avoid buffering depending on the current bandwidth
- People find buffering MUCH more annoying than low quality, so youtube ADAPTS (adaptive streaming) depending on bandwidth



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YouTube

- YouTube accepts video in several formats including: .WMV, .AVI, .MOV, MPEG and .MP4
- Uses many codecs but the most common is H.264
- YouTube used to output everything in as either .flv or .f4v (Flash video) as every computer had Flash BUT NOW IT CONVERTS UPLOADED VIDEO TO .mp4
- YouTube ALWAYS re-encodes your video, so don't upload something that you have already highly compressed, it will get compressed again, instead upload high quality video
  - **QUESTION: what is the downside of uploading high quality uncompressed video?**

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Consider

- Going from 1080p HD video to 4K video will NOT always improve video quality on the internet because of compression
  - If you encode at the same bit rate and the bitrate is low, the 1080p video will be clearer than the 4K video because it had less compression done to it.
  - Comparison: which video looks better?
    - A
    - B
    - One of the videos is 4K and one is 1080p but both were given a bitrate of 1Mbps.

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Also consider:

- Over 75% of all videos are viewed on mobile devices now
- VERY Confusing:
  - How can a smart phone record 4K but not have 4K display?
  - Smartphones that are capable of recording 4K video do NOT necessary have a 4K display (they have at least an 8.8 Megapixel sensor for recording)

	OPERATING SYSTEM	PHYSICAL SIZE	PHYSICAL SIZE CM	WIDTH PX	HEIGHT
iPhone 7	iOS	4.7	11.5	750	1334
iPhone 7+	iOS	5.5	14.0	1080	1920
iPhone 6	iOS	4.7	11.9	750	1334

Check your connection right now!

- http://google.com