Computers and Media: Digital Media Technologies – Compression, Images, Video & Communication

CSCI 1200

JAREK SZLICHTA

Comparing the Errors

Analog

- Resonance
- Reflection
- Noise

Digital

- Encoding
- Compression

Goals

Today we will continue our review of the digital media technologies with an overview of:

- Compression
  - Lossless
  - Lossy
- Images
  - Resolution
  - Sampling
  - Colour
  - Compression

Compression

MEDIA TECHNOLOGIES

CD Digital Audio

44,100 samples per second

x 2 bytes per sample

x 2 channels (L & R)

= 176,400 bytes/s

x 70 min x 60 s/min =

740,880,000 bytes, or ~ 700 MB per CD

- but the same music as MP3s might be 50 MB!

CD speeds

Ever see “1x”, “4x” or even “24x” on CD burners?

1x = 176,400 bytes/sec – the CD audio data rate

So, a 25x CD burner can transfer information to a disc at 25 x 176,400 bytes/sec = 4,410,000 bytes/sec

Uncompressed Media

When all the samples are stored without any special algorithms applied, this is called *uncompressed media*.

Uncompressed media files are big! A 4 minute uncompressed song on a CD is 42.4 MB!

Higher sampling rates make these files even larger!

File Size Issues

Restricts the number of songs that we can store on portable music players

Music files become too large to download, take too long and use bandwidth which may be charged per MB (especially mobile)

Compression reduces the amount of space required to store a file

Compression

There are two types of compression:

- Lossless: no information is lost when the file is compressed, get back the exact same information when the file is uncompressed
- Lossy: some of the information is lost when the file is compressed, do not get the same information when the file is uncompressed

In general, lossy compression will reduce file size much more than lossless compression

Lossy compression: approximation and "rounding"

Lossless Compression

Used for text files, other files where the exact contents of the file is important

On average, reduces the size of the file by as much as one third, but may make no difference

Based on discovering patterns in the file and using a shorthand for each pattern

Task

Download text file: http://norvig.com/big.txt

Compress it with zip

Compare the size of original and compressed file

Run-Length Encoding: Lossless

Take repeated sequences and summarize them:

- Uncompressed: “aaaaaaaaaaaa” -> 12 *bytes*
- Compressed: “12a” -> 2 *bytes*

- Pixels are stored as (**r**ed, **g**reen, **b**lue) where each colour is a 1 byte number (0-255)

- Uncompressed: (0, 0, 255), (0, 0, 255), …, = 30 bytes
- Compressed: 10 (0, 0, 255) = 4 bytes

Lossless Compression Table

The stegosaurus went up the hill to meet the other stegosaurus.

- Compression table:

  The = 1
  stegosaurus = 2

- 1 2 went up 1 hill to meet 1 other 2

Lossless Compression

A small number of very common patterns results in better compression

- Small compression table, much repetition

Basically a statistical approach that usually helps, but not always

- Files with no common patterns cannot be compressed

ZIP files are a good example of lossless compression

- Zip and unzip – contents are unchanged

Lossy Compression

Lossy compression mainly used for media files, sound, images, and video, *not used for text*

Can reduce a file to 10% or less of its original size

Does this by throwing away information

- hopefully information that is not very important..

Lossy Compression

But how do we know what to throw away?

Want to keep the important information, get rid of the stuff that is not as important

Example: MP3

Standard lossy compression technique for music is MP3, which is part of the MPEG family of standards

- the MPEG video standard has several sound compression schemes
- MP3 is really MPEG audio level 3

Gives the user control over compression vs quality

MP3

Compression works by reducing accuracy of certain parts of sound that are considered to be beyond the auditory resolution ability of most people

This method is commonly referred to as perceptual coding

Result in a file that is about 1/11 the size (but it depends on the settings)

MP3 at a Price

With MP3 we can save a lot of space, but at the cost of reduced sound quality

Cannot recover original sound

Repeated compression and decompression will eventually destroy sound

Lossy Compression Summary

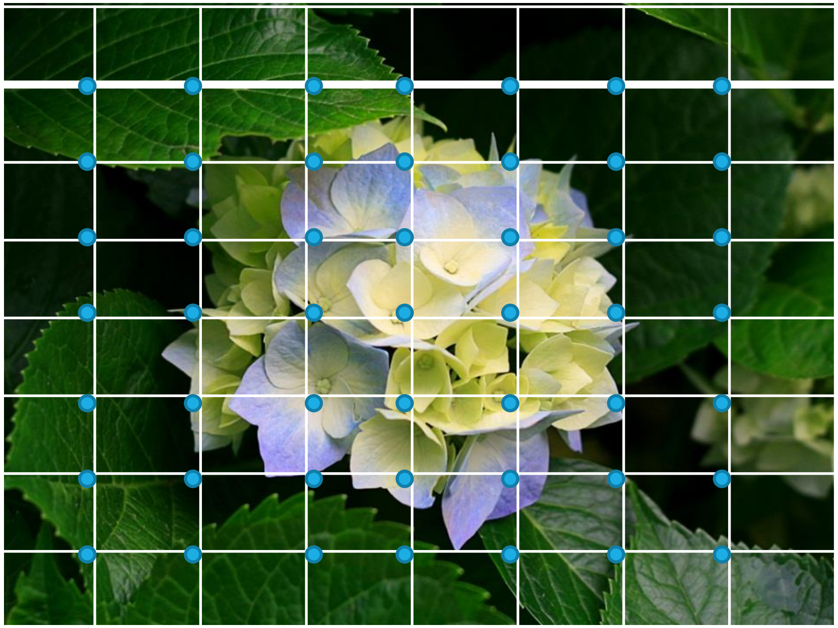
By selecting the settings of the compression scheme carefully, we can reduce loss of quality

There are other compression schemes for images, video, and audio, they work in basically the same way and have the same general properties..

Images

DIGITAL MEDIA

Sampling in 2D Space



Sampling Images

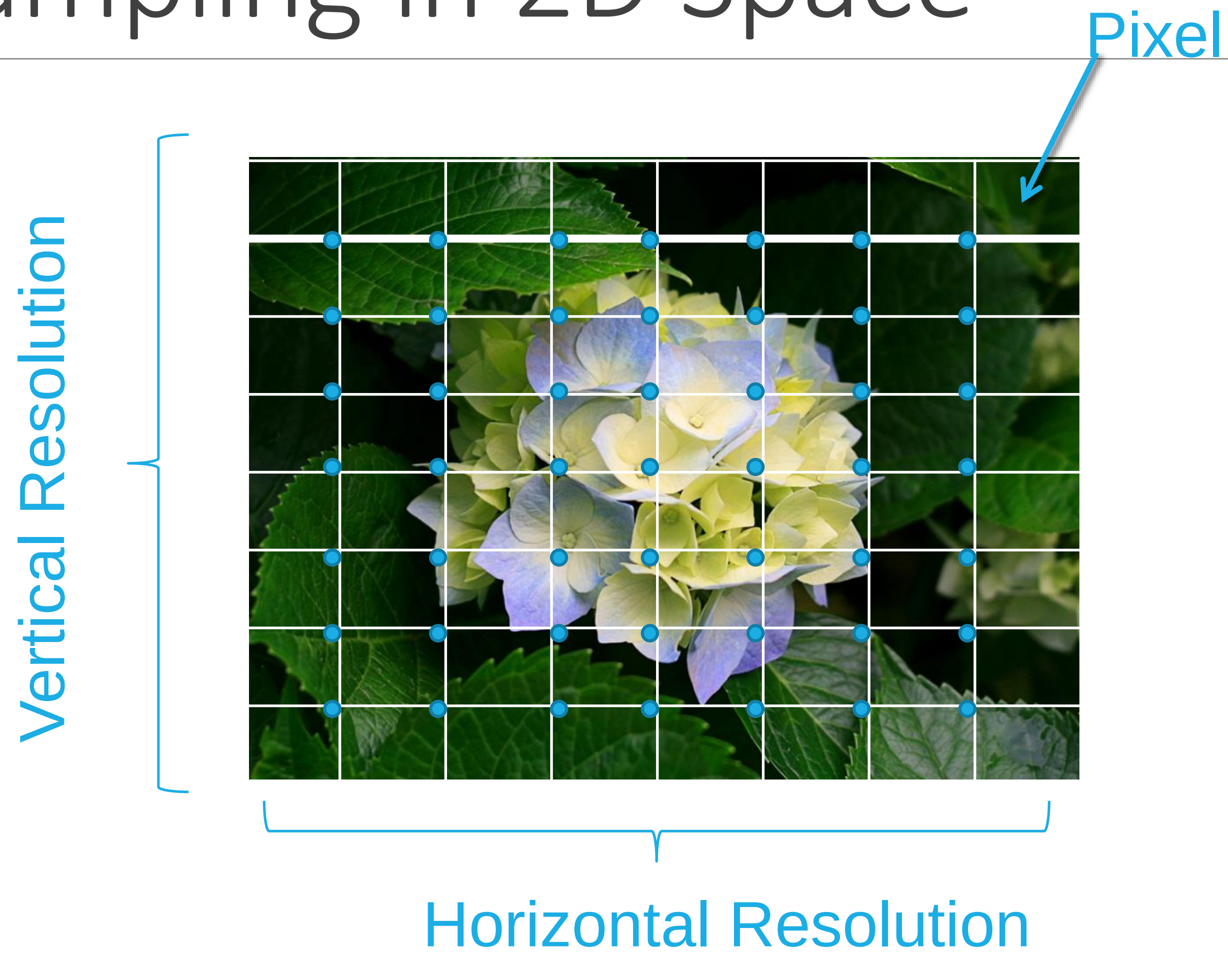
We can think of a picture as a 2D plane, a flat surface

We want to sample this plane, measure the picture colour at points on the plane

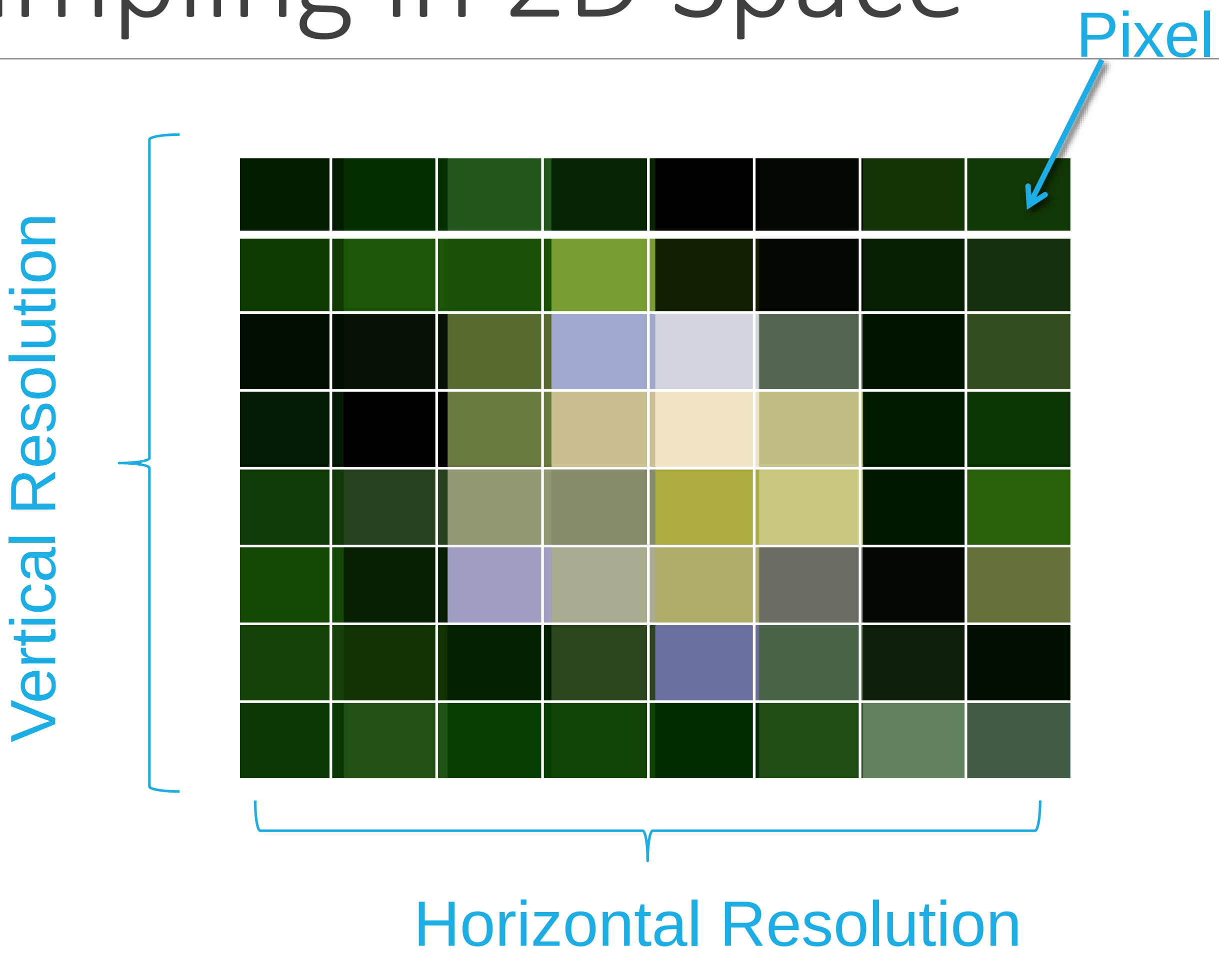
The easiest way to do this is to use a grid, we evenly space our sample points in the x and y directions

Again, if we do this correctly..we can exactly reproduce the image from the sample points

Sampling in 2D Space



Sampling in 2D Space



Pixels & Resolution

Array or grid of pixels

- Each pixel has a constant colour

Number of pixels along the x axis is called the horizontal resolution

Number of pixels along the y axis is called the vertical resolution

Sometimes these numbers are multiplied and the result is called the resolution, this is common with digital cameras

Image / Camera Resolution

Digital cameras usually specify the total number of pixels in the image

Example: a 6 MPixel camera represents an image as a grid with 6 million pixels

This may seem like a lot of pixels, but this is not good enough for professional work..

A professional camera will typically have 10 – 12 MPixel resolution

Resolution Limitations

Why do we care about resolution?

The next slide shows a picture taken with an iPhone, it was taken from a glass elevator in Los Angeles

This is a 1200 x 1600 image, or a little bit less than 2 Mpixel

It looks pretty good on the slide (in fact its been reduced in resolution for the slide)

Image

Lets Enhance!

Now lets take the orange sculpture in the middle of the slide and blow it up 4x

The next slide shows the original cropped image, extracted from the picture and the 4x image

Note that we can see the pixels in the blown up image, and the software that I used tried to cover up this problem

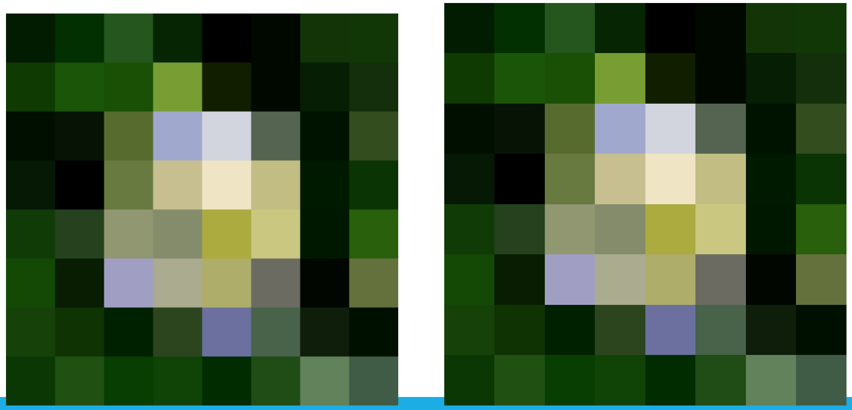
The following slide shows the top of the sculpture blown up 4x more

Resolution

The resolution cannot be increased, only decreased through downsampling (resampling at a lower rate)

Pictures look best at the native resolution

Software will apply blurring techniques to mask the problem:



Output: Printers

Printers are the simplest display device

In the case of printers resolution is measured in dots per inch (DPI), this is the number of pixels along each inch of paper

Printers

Laser printers have resolutions of 600 DPI or 1800 DPI

Our original example image was 1200 x 1600 pixels

Printed it would end up being 2 inches by 2.67 inches

If we tried to print this as a larger image we would get the pixel artefacts that we saw earlier

A good consumer camera can do a 8” x 10” print, but it cannot do a poster

Computer Monitors

A typical computer monitor is around 96 DPI, this depends upon the video card and the monitor resolution

- Much lower than a printer!
- MacBook Pro Retina: 144 dpi

Things are improving

- iPhone 4/5 screen has 326dpi!

Representing Colour

The current approach is to use 3 bytes per pixel, one byte for red, one byte for green and one byte for blue

So a colour is represented by its RGB components, with one byte each

This is adequate for most purposes, for professional editing more bits per pixel are used

What's the consequence of more bits per pixel?

24 bit Colour

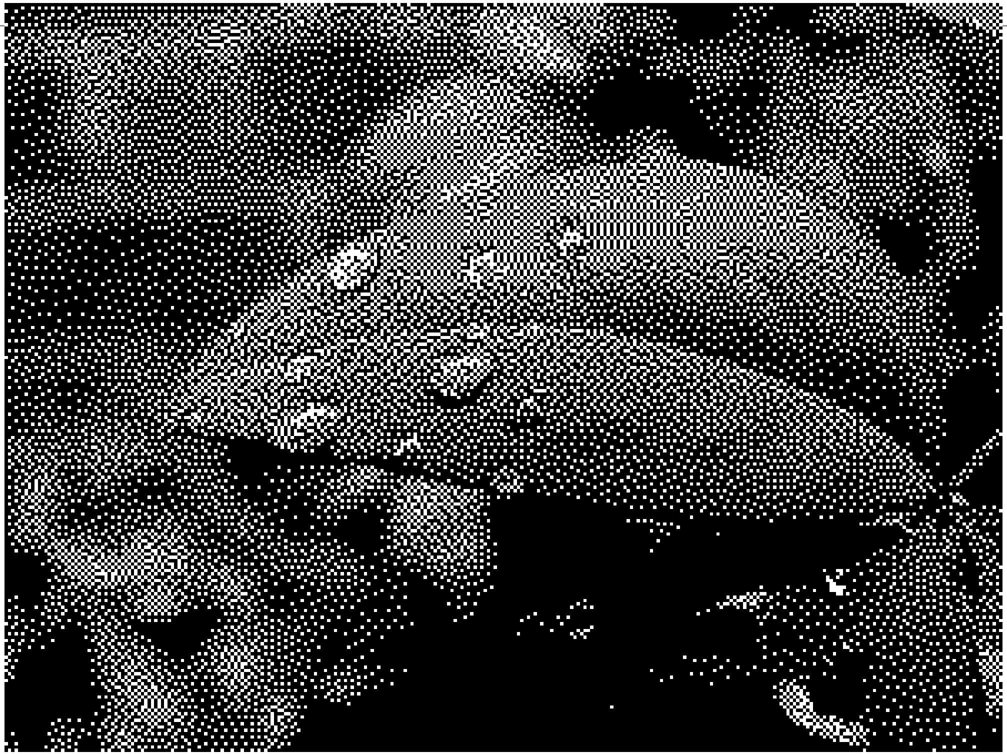
RGB with 1 byte each:

- R from 0-255
- G from 0-255
- B from 0-255

  = 16,777,216 possible hues

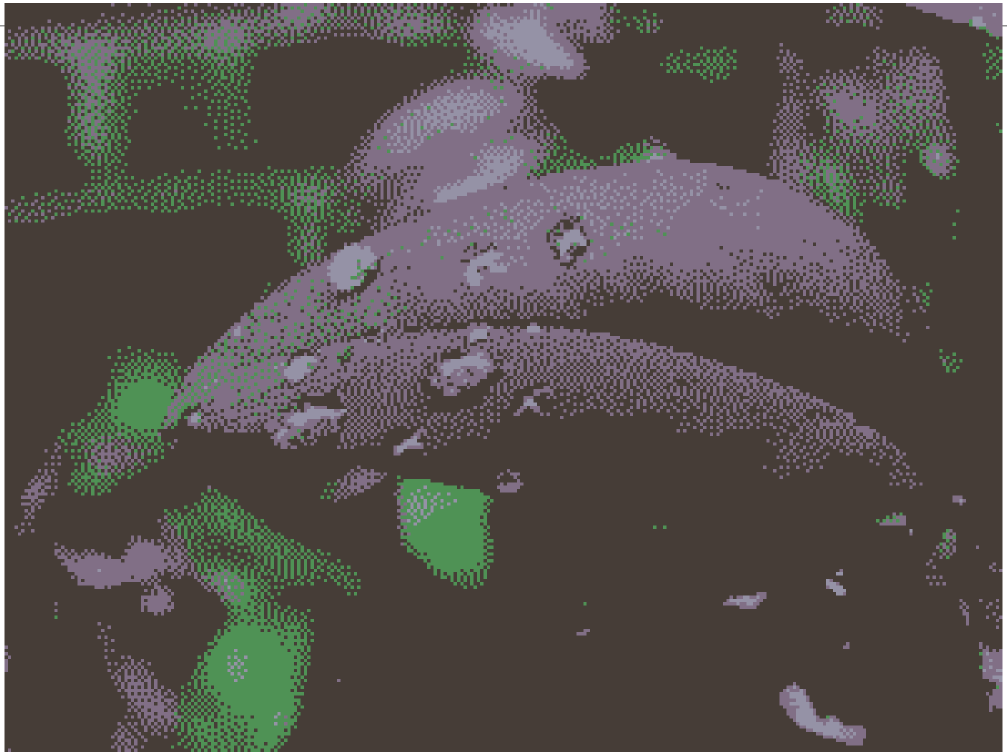
More bits = finer colour variations can be represented

1 bit colour



Source: Wikipedia

2 bit colour



Source: Wikipedia

8 bit colour

Source: Wikipedia

24 bit colour

Source: Wikipedia

Image Compression

If we have a 5 MPixel image and 3 bytes per pixel we need 15 Mbytes to store the image, this is not very practical..

Lossless compression images in the RAW format are available on professional grade cameras

Image Compression

Compression is more important for images than it is for sound, so a lot of effort has been put into this

One of the first compression schemes for images was GIF, which is a lossless compression scheme

GIF Compression

GIF was used extensively in the early years of the Internet, by far the most popular image standard

The format supports up to 8 bits per pixel for each image

The main problem with GIF is that each image is restricted to 256 unique colours

This is okay for line drawings and illustrations, but does not work very well for photographs..

JPEG Compression

Most common image compression scheme

JPEG is based on dividing the image up into 8x8 pixel blocks, each block is compressed independently

The basic idea is that a block of adjacent pixels are likely to be similar, so we only need to represent the common information once

JPEG Compression

First determine the frequencies in each block

An algorithm analyzes and ranks the information within the 8x8 pixel block for its importance to visual perception; the less important information can then be discarded.

JPEG is throwing away the details (approximiation method) with the hope that they won’t be missed

- a lossy technique

Controlling JPEG Compression

One of the nice features of JPEG is the person doing the compression has control over the image quality

Higher quality results in larger files, so there is a trade off between file size and image quality

Compression Effects

Compression Effects

Difference between original and JPEG image

http://en.wikipedia.org/wiki/Compression_artifact

Video

DIGITAL MEDIA

In a video, nothing is moving..

Video = Lots of Images

Nothing moving: it is really a sequence of still images shown very quickly to trick our eyes into thinking that the objects are moving

Moving images: films, animation, TV, etc.

Analog Sampling in Time

We have always used sampling in movies and animations, but with the analog version this sampling was only done in time

How frequently do we need to sample in time?

This is a difficult question, it depends upon

- how dark the room is and
- how bright the images are,
- if we are viewing the movie or video

Analog Sampling in Time

Standard movie film has 24 unique images per second, each image is shown twice, so its really 48 images per second

This works okay in a dark theatre, but in regular room lighting we would see it flicker and it would be unacceptable

Analog TV

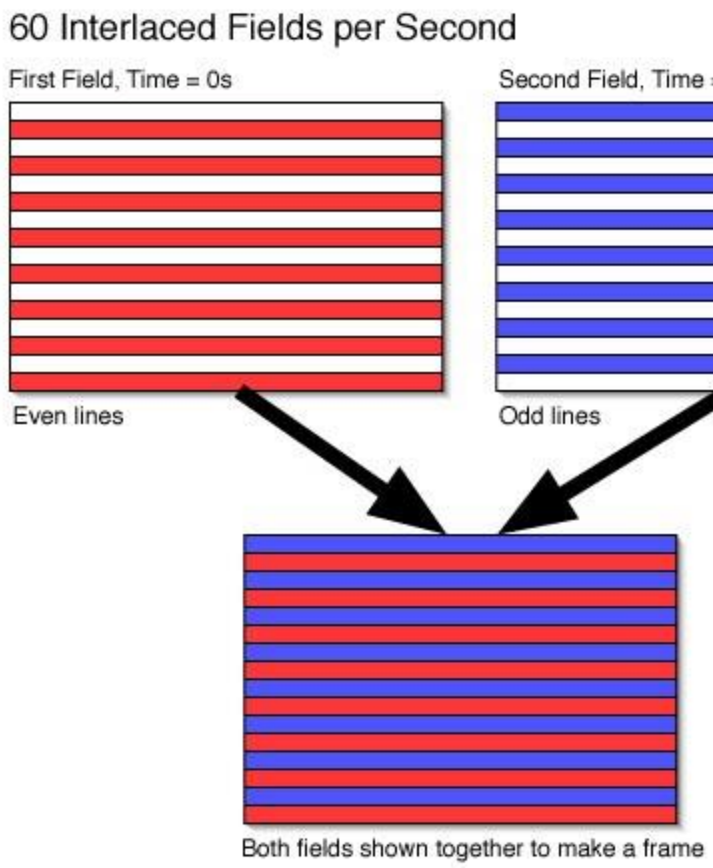
In North America analog TV is 60 fields per second, where a field is half an image

Recall: an image is a row of pixels, even analog TV divides the screen up into rows

The first field shows all of the even lines and the second field shows all of the odd lines

Thus, we need two fields to show the entire image which is called a frame, this is called interlacing

http://en.wikipedia.org/wiki/Interlacing



http://www.kenstone.net/fcp_homepage/24p_in_FCP_nattress.html

Interlaced Video

Interlacing reduced flicker in early TV sets, the North American version of TV was developed in the 1930s, and electronics was pretty primitive then

The North American standard is called NTSC, there are other standards in other parts of the world, PAL and SECAM, they were developed after NTSC and have better picture quality

Movies and TV Incompatible

Note that movies and TV have different sample rates, this made it difficult to show movies on early TV stations

The production process now takes this into account and separate versions are prepared for theatre and TV

The two versions will merge again when all the movie theatres are converted to digital cinema

Ideas about video compression?

Video Compression

Brings together ideas from sound (time compression) and images (space compression)

One standard compression scheme for video is MPEG, of which there are many versions

MPEG compresses in both space and time

For space it uses a scheme similar to JPEG
- Colours that are close are averaged and stored as one

Codecs

A video compression algorithm is often called a “codec”.

A video player must know how to decode the compression to turn the data into images

- Must understand the codec

Standard codecs:

- WMV, MPG, H.264, DivX

Note, not AVI – this is a file format which can use any of a variety of different codecs

Compression in Video

Compression makes the observation that most things don't change from one frame to another

Usually the background stays relatively still and only a few objects move

Thus, we don't need to record every frame, only the differences between frames are required

The differences should require less space than an entire image

Visible Compression Effects

Depending on the bitrate (quality) of the encoding, the threshold for difference is set

With a low bitrate, smaller files are produced, but changes from one frame to the next have to be larger to be sent

- Effect is that backgrounds can appear unnaturally still because limit on difference is quite high "painting effect"

I-frames

To increase robustness and to make editing easier about every fourth or fifth frame is sent completely and the differences are sent for the frames in between

These are called i-frames ("intra-frames") (also, keyframes)

This what is currently done with digital cable and digital satellite

Broadcast TV switched to digital in 2009 in the US and in 2011 in Canada

Frame Rates in Games

Sometimes throttled at max 30fps

- Framerate cannot be maintained at a consistently high level (computational requirements vary from scene to scene)

FPS competition appears in gaming culture

Communications Technology

Communications

For distance there are basically two alternatives, LAN (Local Area Network) and WAN (Wide Area Network)

A LAN is basically anything within a single house or building, say less than a few hundred metres

A WAN is everything else, it is used for distances greater than a kilometre

WAN Technologies

There are basically two wired WAN technologies at the consumer level:

- DSL (Digital Subscriber Line)
- Cable

DSL is delivered over phone lines and requires special equipment at the phone company end, you have a single wire into the phone company

Cable is delivered over the cable TV network, theoretically the connection is shared between multiple subscribers on the same cable

Communications

The speeds of the two technologies are about the same:

- DSL is limited by wire length and tends to be slower than cable
- Cable is shared, but the cable company brings a lot more bandwidth so this usually isn't a problem

Cable and DSL are a good example of convergence, a popular term in the communications industry

Early 1990s

The phone company provided phones

The cable company provided TV

No one provided internet..

Mid 1990s – Communication Competition

Early consumer Internet was dialup, you called the internet service provider (ISP) over the phone line, and it was slow, very slow

As the Internet grew both the phone and cable companies wanted to get a part of the business, and they could provide much higher speeds, 100x faster

For the first time the phone and cable companies were in competition with each other, providing the same service..

Fierce Competition!

Phone companies started offering TV

- They had to do this through satellite since the phone wires aren’t fast enough for TV

The cable companies started providing phone service

- Through voice-over-IP (internet-based phone; VOIP)

They both offer cell phones

15 years ago Bell and Rogers didn’t compete, they had totally separate markets

Now you can get the same services from both Bell and Rogers..

Convergence

We call this convergence, since two separate markets have now become one

Two separate industries have merged into one industry

We are now seeing cell phones

- In the past cell phones were viewed as a secondary phone, nice to have when you are on the move
- Now they are the primary phone for a growing number of people, they don't have a wired phone

Who has only a mobile phone?

Cell Phone Technology

Now a form of WAN carrying the internet

Cell phone technology in North America is significantly behind the rest of the world, by about 3 to 5 years..

Cell phone technology is usually talked about in terms of generations

1G used analog technology, this is no longer available in North America and most parts of the developed world

2G

2G was the first digital generation,

There are two different 2G technologies, CDMA and GSM

CDMA is mainly used in North America, it is not popular elsewhere in the world

There are few GSM carriers in North America (Rogers is the only one in Canada), but it is widely used in the rest of the world

… 3G

If you want to use a cell phone outside of North America make sure it is GSM, and that it covers all 4 bands

2.5G is the addition of data services to 2G, they are not particularly fast and tend to be expensive (being phased out in urban in Canada)

3G is more current technology, it has been available in Europe and Asia for about 10 years now, several years ago it became available in North America, largely thanks to Apple..

3G < Wi-Fi

3G data rates are higher, but not at the level of Wi-Fi or similar technologies

A 3G phone can do video calls, streaming video, reasonable web surfing, etc

One of the main problems with 3G phones is battery life, a day of heavy use is the maximum, they can go for several days on standby

Batteries is one of the major problems with mobile devices

4G

4G equipment is in the development stage

Was introduced in Canada in 2011 (speeds around 5 times faster)

Has data rates that are competitive with Wi-Fi

The cell phone that was originally used for phone calls is now an Internet device (convergence)..

The Nokia N800/N810 does not have a phone component, voice calls are made over VOIP using Skype, basically a phone without a phone!

What’s up with NA?

Why does North America lag behind the rest of the world in cell phones?

On the business/technical side Canada’s land lines are superior to the rest of the world

Motivation to Invest

Since North American phone companies have invested heavily in wired technology its relatively cheap and easy to get

The North American life style is also different from the rest of the world

- North Americans tend to spend a larger portion of their time at home, and they use cars for commuting
- If you spend a lot of time at home you have little need for a cell phone

Lifestyle Affects Media Choices

People who use public transit have more time to interact with mobile devices

A person who is out of the home for 14 or more hours per day has little use for a land line, but can make good use of a cell phone

Its also likely that they would like to see other services on their phone, this is their main device for communicating

Cell Phone Proliferation

Outside of North America there are typically more cell phones than people

Advanced applications available before smart phones, e.g. SMS banking in Africa

http://www.flickr.com/photos/kristin_kee/1072492784/lightbox/

LAN

The main differences between LAN technologies are speed and whether they are wired or wireless

Many LAN technologies have been developed, the only one that is still in common use is Ethernet, which is a relatively simple but reliable technology

- In its wired version the common speeds are 100 Mbps and 1Gbps
- Network speed is measured in bits per second

Network Speeds

There is 10 Gbps Ethernet, but there is no consumer version of it yet

In general wired networks are faster than wireless ones

The standard wireless LAN technology is Wi-Fi, which has become a popular replacement for wired networks

There are multiple versions of Wi-Fi with the current popular ones being 54 Mbps and 108 Mbps

What media does network speed affect most?

Sharing the Road

One of the problems with wireless is its a shared medium, all the computers connected to a wireless network share the resource

This is okay for home where there is rarely more than 2 or 3 computers using the wireless network, but becomes a problem when there are a large number of users

If there are n users of the network the bandwidth is divided by n, so as the number of users increases the available bandwidth decreases

Security

Everyone on the network can potentially view your network traffic

This is why wireless network traffic is usually encrypted

This doesn’t guarantee security, it just makes it much harder for someone else to read your network traffic, basically not worth their while

New Technology: WiMax

Some people view this as a replacement for Wi-Fi, which might be the case in the future

WiMax is mainly a replacement for DSL and Cable

It has a range of several miles, so can be used as a replacement for the wires that come into your home

Communications

WiMax would basically piggyback on cell phone towers, so it could cover an entire neighbourhood without the need to lay cables

It has also been suggested that WiMax might be a competitor for cell phones

Equipment Grades

Media production equipment is often divided into four grades:

- Consumer
- Pro-sumer
- Broadcast quality
- High end

Consumer

Consumer grade equipment is designed for use at home, it produces lower quality results and is not as well made as the other grades

Designed to be quickly replaced

Pro-sumer & Broadcast

The pro-sumer grade is good enough for low end commercial use, for example wedding photographs

This equipment is slightly more expensive than consumer grade, so its also of interest to serious amateurs

Broadcast grade equipment is good enough for TV production, usually considerably more expensive than pro-sumer grade equipment

High End

High end grade produces the best quality results, such as movie production

This is the most expensive equipment grade

In the past there have been a considerable difference in price between the grades, with a high end video camera costing much more than a consumer camera

Equipment Grades

Over the past few years this difference has decreased quite dramatically

A pro-sumer grade HD video camera is good enough for broadcast TV, so the difference between pro-sumer and broadcast grade has largely disappeared

The cost of high end equipment has also come down by a factor of 10, and in some cases a lot more, for example high end video editing software

Your Action Items

Read chapter 3 and 4 of course text

Review slides!

Summary

Today we reviewed:

- Compression
- Images
- Video
- Communications
- Equipment Grades