CS101 Lecture 19: Digital Audio Compression

CD Audio Encoding
MP3 Compression

Aaron Stevens (azs@bu.edu)
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Addendum to last time....

<table>
<thead>
<tr>
<th>Continuous dB</th>
<th>Permissible Exposure Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>85 dB</td>
<td>8 Hours</td>
</tr>
<tr>
<td>88 dB</td>
<td>4 hours</td>
</tr>
<tr>
<td>91 dB</td>
<td>2 hours</td>
</tr>
<tr>
<td>94 dB</td>
<td>1 hour</td>
</tr>
<tr>
<td>97 dB</td>
<td>30 minutes</td>
</tr>
<tr>
<td>100 dB</td>
<td>15 minutes</td>
</tr>
<tr>
<td>103 dB</td>
<td>7.5 minutes</td>
</tr>
<tr>
<td>106 dB</td>
<td>3.75 minutes (&lt; 4 min)</td>
</tr>
<tr>
<td>109 dB</td>
<td>1.875 minutes (&lt; 2 min)</td>
</tr>
<tr>
<td>112 dB</td>
<td>.9375 min (~ 1 min)</td>
</tr>
<tr>
<td>115 dB</td>
<td>.46875 min (~ 30 sec)</td>
</tr>
</tbody>
</table>
# What You’ll Learn Today

- How does compact disc audio work?
- What we can and can’t hear
- What is mp3, and how does it work?

## Digital Audio Information

**History of Sony’s music technology:**

[http://www.youtube.com/watch?v=VSJ41PdAK0Y](http://www.youtube.com/watch?v=VSJ41PdAK0Y) (6 minutes)

- part 1: walkman, headphones invented
- part 2: digital audio: compact disc replaces vinyl and magnetic tape
CD Audio

A CD player reading binary information

http://static.howstuffworks.com/flash/cd-read.swf
http://electronics.howstuffworks.com/cd.htm
A CD player reading binary information

CD-Quality Audio

Compact Disc audio is encoded by sampling:

- 44,100 samples per second
- 16 bits per sample per channel (2 channels)
- thus: 44,100 * 16 * 2 = 1,411,200 bps
- Or about 10,600,000 bytes per minute

CD Audio uses about 10 megabytes per minute of audio. A CD holds about 70 minutes of music.

You would get about 800 minutes of audio on an 8GM iPod nano.
Sampling, Bitrate, Quality

<table>
<thead>
<tr>
<th>Quality</th>
<th>Bytes per second</th>
<th>Bytes per minute</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD</td>
<td>88,200</td>
<td>5.2 million</td>
<td>16 bit @ 44 kHz</td>
</tr>
<tr>
<td>Video Game</td>
<td>44,100</td>
<td>2.6 million</td>
<td>8 bit @ 44 kHz</td>
</tr>
<tr>
<td>Phonograph</td>
<td>44,100</td>
<td>2.6 million</td>
<td>16 bit @ 22 kHz</td>
</tr>
<tr>
<td>FM Radio</td>
<td>22,050</td>
<td>1.3 million</td>
<td>16 bit @ 11 kHz</td>
</tr>
<tr>
<td>Radio</td>
<td>22,050</td>
<td>1.3 million</td>
<td>8 bit @ 22 kHz</td>
</tr>
<tr>
<td>Phone</td>
<td>11,025</td>
<td>661,500</td>
<td>8 bit @ 11 kHz</td>
</tr>
<tr>
<td>Old Radio</td>
<td>8,000</td>
<td>480,000</td>
<td>8 bit @ 8 kHz</td>
</tr>
</tbody>
</table>

Digital Audio Formats

Audio Formats
- CDA, WAV, AU, AIFF, VQF, and MP3

MP3 (MPEG-2, audio layer 3 file) is most popular
- Based on psychoacoustics
- Bit stream is compressed using Huffman Encoding
Psychoacoustics

Perceived Human Hearing

Auditory Masking

Auditory Masking
MP3 Encoding Principles

- Break file into small “frames” with a couple of hundred samples in each;
- Analyze each frame in terms of frequencies present;
- Eliminate frequencies which would be masked anyway;
- Recalculate the samples; and
- Perform Huffman encoding on final file

Representing Audio Information

- MP3 compression rates are based on how much bandwidth the final file will use to play music in real time:
  - 128kbps ~ 128,000 bits per second
  - Or about 960,000 bytes per minute
  *Compare to CD Audio – 10,600,000 bytes per minute!*

A CD holds about 700 MB (700,000,000 bytes)
- About 70 minutes of CD audio format
- Or about 700 minutes of MP3 audio format
Audio Formats

What You Learned Today

- CD Audio
- Auditory Masking
- MP3 - compression
Announcements and To Do

Readings:
- Wong ch 4, pp 102-117 (today)
- YouTube: History of Sony music technology
  - [http://www.youtube.com/watch?v=V5l41PdAK0Y](http://www.youtube.com/watch?v=V5l41PdAK0Y)
  (6 minutes)

HW 7 due Tuesday 10/23

For next week:
- Read Alice chapter 1
- install Alice on your laptop ([www.alice.org](http://www.alice.org))

Sound quality blind test

On paper, Sky’s streaming audio quality -- at 48Kbps AAC+ -- is just a third as good as Spotify’s free service -- at 160Kbps OGG Vorbis -- and just one sixth as good as Spotify’s paid-for service, at 320Kbps OGG Vorbis. So the results, theoretically at least, should be cut and dried: Spotify sounds better.

But what was unusual was the reasoning a couple of people gave for picking Sky Songs. They thought Sky’s version produced better bass, and therefore was encoded at a higher bit rate. Both versions of the song were taken from the same CD, and therefore was not affected by better bass via remastering.

The results
Of the 16 people tested, six people -- over a third -- thought Sky Songs (version B') was the higher-quality audio. Conversely, ten people identified Spotify (version A) as being the higher-quality track.

- [http://crave.cnet.co.uk/digitalmusic/0,39029432,49303980,00.htm](http://crave.cnet.co.uk/digitalmusic/0,39029432,49303980,00.htm)