

Computers and Music

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What computers can do for music?

- ▶ record
- ▶ manipulate
- ▶ generate/compose

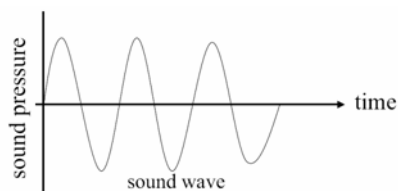
review: image representation

- ▶ Raster graphics
- ▶ Vector graphics

Music representation

- ▶ Audio (music as sound)
 - CD
 - WAV
 - MP3
- ▶ Time-stamped events
 - MIDI file
- ▶ Music Notation
 - Conventional Music Notation (CMN)
 - guitar tablature
 - GUIDO
- ▶ Even higher level representations:
 - structure: movements, repeats
 - algorithms

sound waves

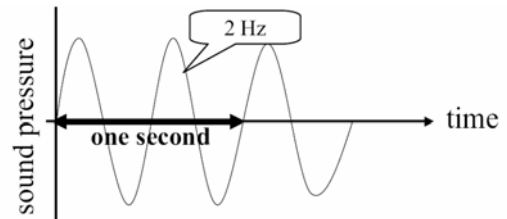


1. source of sound vibrates

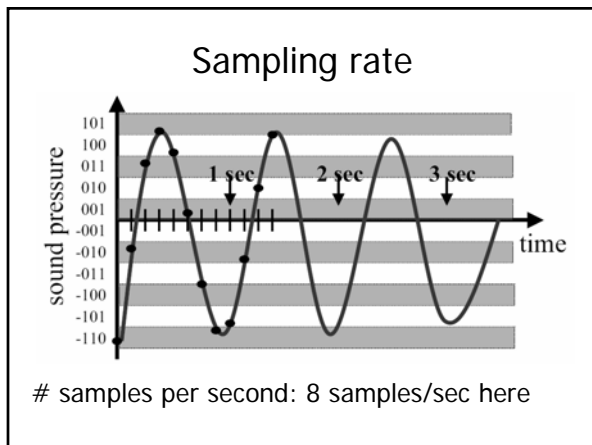
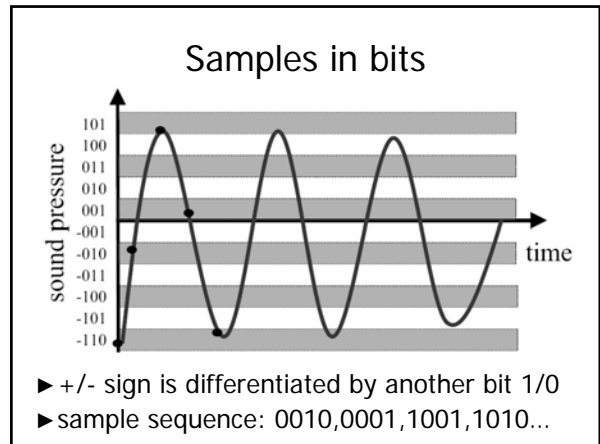
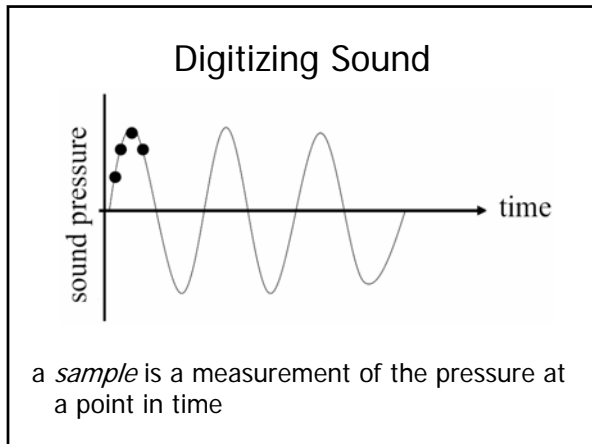
2. pressure waves (vibrations) emanate from the source

3. waves are sensed by nerves in ear

Properties of sound waves



- ▶ a *single* wave: continuous(analog) and periodic
- ▶ frequency: measured in Hertz(Hz), number of periods per second
- ▶ Audible waves: 20~20,000Hz



- ### Digitised sound quality
- ▶ quality factors:
 - Sampling rate
 - Number of bits per sample
 - ▶ guideline: Nyquist–Shannon sampling theorem
 - Exact reconstruction of a continuous-time baseband signal from its samples is possible if the signal is bandlimited and the sampling frequency is greater than twice the signal bandwidth.
 - Example: want to capture frequencies up to 20kHz
 ➔ need 40 k samples/sec

exercise

A sound wave that extends for 1 minute is sampled at 16 bits per sample and contains frequencies up to 20,000 Hz.

What is the total number of bits you recommend to represent that sound wave digitally faithfully?

- ### Advantages of digitised sound
- ▶ can be copied without loss of quality
 - ▶ can be edited in complex ways, e.g.,
 - Remove coughing from live recording
 - Speed up or slow down the speed of the music without changes in pitch
 - ▶ can be compressed by removing non-audible aspects of sound (basis for MP3 coding)

GUIDO

- ▶ a general purpose musical notation format
- ▶ applications include
 - notation software
 - compositional and analytical systems and tools
 - performance systems
 - large musical databases
- ▶ powerful, flexible, easily portable, and human readable.

GUIDO

- ▶ essential concepts designed by UBC CS faculty member Holger H. Hoos (<http://www.cs.ubc.ca/~hoos/>)
- ▶ Project: <http://www.salieri.org/guido>

Elements of music notation

- ▶ pitch (related to frequency)
 - Pitch class(note name):
c-sharp d-sharp f-sharp g-sharp a-sharp b
c d e f g a b
=d-flat =e-flat =g-flat =a-flat =b-flat
GUIDO: c c#/d& d d#/e& e f f#/g& g g#/a& a a#/b& b
 - register (octave number)
-2, -1, 0, 1, 2, 3, 4...
Pitch classes repeat in each register:
c1 d1 e1 f1 g1 a1 b1 c2 d2....
GUIDO pitch: <pitch class> <register>
c1 a2 f#-1

Elements of music notation

- ▶ Note values (related to duration):
 - Specified as fractions: 1/1, 1/2, 1/4, 1/8, 1/16
GUIDO duration: /1, /2, /4, /8
rests: _/2, _/4, _/8
- ▶ Additional parameters:
 - tempo(speed)
 - intensity(loudness)
 - timbre(instrument/style of playing)

GUIDO sequences and segments

- ▶ Sequences: notes played sequentially
[c1/4 d1/4 e1/4 f1/4 g1/2]
- ▶ Segments: sequences played concurrently
{[c1/4 d1/4 e1/2],
[e1/4 f1/4 g1/2]}

GUIDO Example

- ▶ http://en.wikipedia.org/wiki/GUIDO_Music_Notation

```
[ \clef<"treble"> \key<"D"> \meter<"4/4">  
a1*1/2 b a/4. g/8 f#/4 g a/2 b a/4. g/8 f#/4 g  
a/2 a b c#2/4 d c#/2 b1 a/1 ]
```



Music Programming

- ▶ Build/specify music in the same way as algorithms/software
- ▶ Process music algorithmically (like numerical or image data)
- ▶ Build/specify interactive music systems (instruments, installations,...)

Examples

- ▶ Music (or sound) programming languages
 - Extensions of existing programming languages (C, LISP)
 - New, dedicated programming languages (Csound, SALIERI, Elody,...)
- ▶ Interactive music systems:
 - Reactive, graphical environments (MAX, Pure Data, Open Music,...)
 - Event-based programming environments (Realtime SALIERI, Realtime Csound...)

SALIERI

- ▶ Interactive software environment for creating, manipulating, and analysing musical material
- ▶ Based on a music programming language with native music data types based on GUIDO music notation
- ▶ Facilitates exploring algorithmic and mathematical concepts in music
- ▶ <http://www.salieri.org/>

SALIERI Example

```
% create and play a scale (c-major):
cm := [c1/4 d1/4 e1/4 f1/4 g1/4];
play(cm);

% set rhythm to all 16th notes and play:
cmf := comb(cm,[_/16]);
end := [c1/4];
play(cmf+end);

% play twice (plus end note):
Play(cmf+cmf+end);

% play scale over two octaves
% (=scale+version transposed by 12 semitones = 1 octave):
play(cmf+transp(cmf,+12)+end);
```

Music and Artificial Intelligence

- ▶ David Cope's "Experiments in Musical Intelligence" (Emmy)
<http://arts.ucsc.edu/faculty/cope/experiments.htm>
 - Automated system that composes in the style of certain composers based on database of pieces using randomised recombination
 - Emmy+limited amount of human tuning and selection passes "Musical Turing Test"

Algorithmic recombinatorial music

- ▶ a long heritage: Music Dice Game (18th century, many composers including Mozart)
- ▶ two dices are used to determine which measures of the composition would be played
- ▶ easily implementable into computer software
<http://jmusic.ci.qut.edu.au/jmtutorial/MozartDiceGame.html>

Dilemma?

- ▶ Compose by yourself or compose with software?
- ▶ Go to a concert performed by humans or by algorithms?