# It sure is smart but can it swing?

(Digital audio and computer music)

COS 116: 2/22/2011

Sanjeev Arora

(slides from Prof. Rebecca Fiebrink)

Today:

Concrete example of how different concepts studied so far apply in one domain: Music.

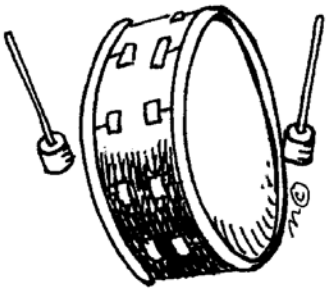
# Overview

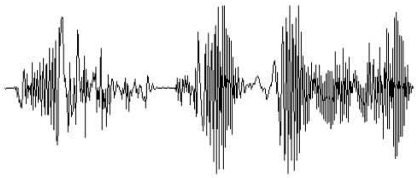
1. Sound and music in the physical world and in human experience
2. Representations of music
3. Analyzing music with computers
4. Creating music with computers

# 1. Sound and music

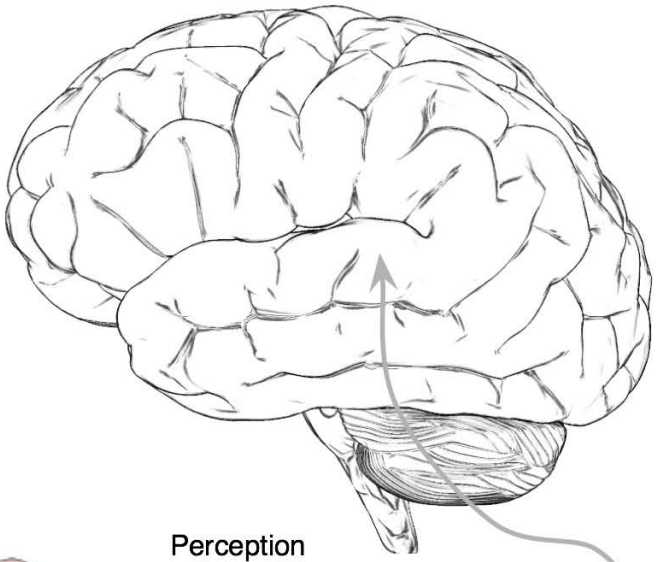
# Discussion Time

## What is sound?



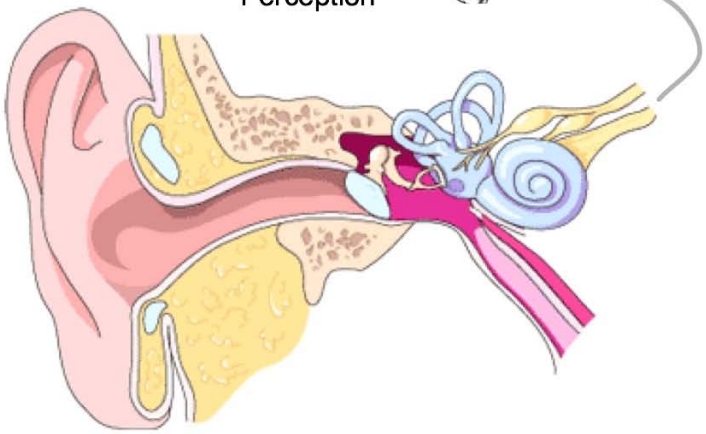


Sound



Perception

"Pressure wave"



# Discussion Time

## What is music?

"Organized sound"

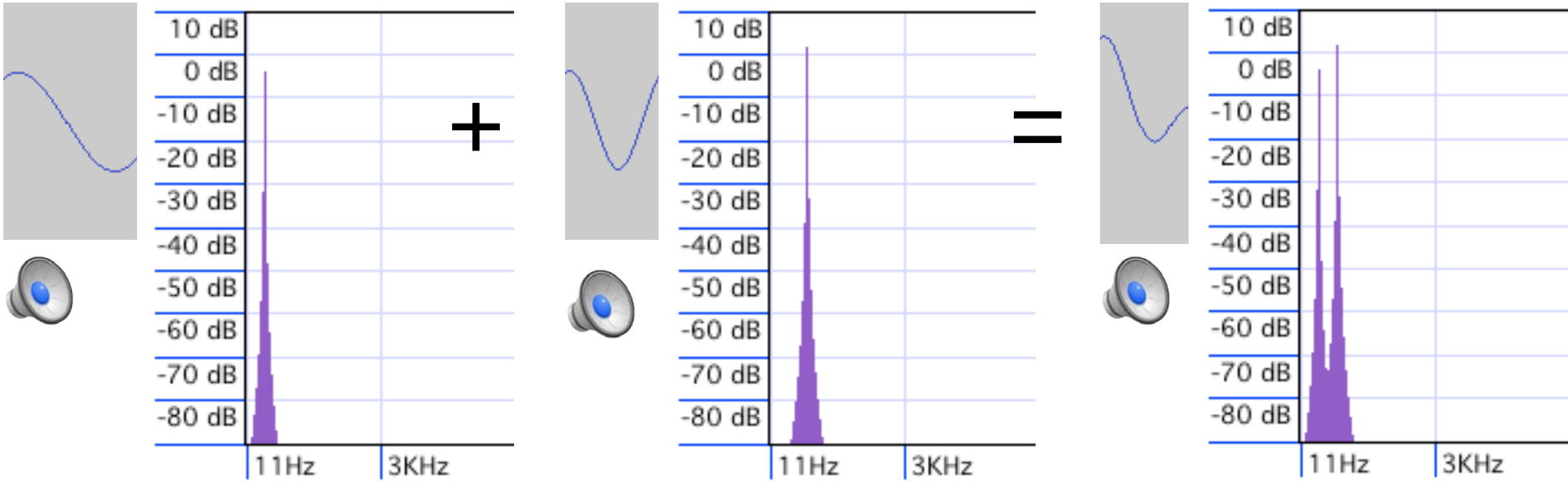
- Psychoacoustics play an important role
- Also dependence upon history, culture, experience
- Engages listeners' psychological mechanisms for expectation/reward

# What do we hear?

- Frequency
- Pitch
- Loudness
- Timbre
- …

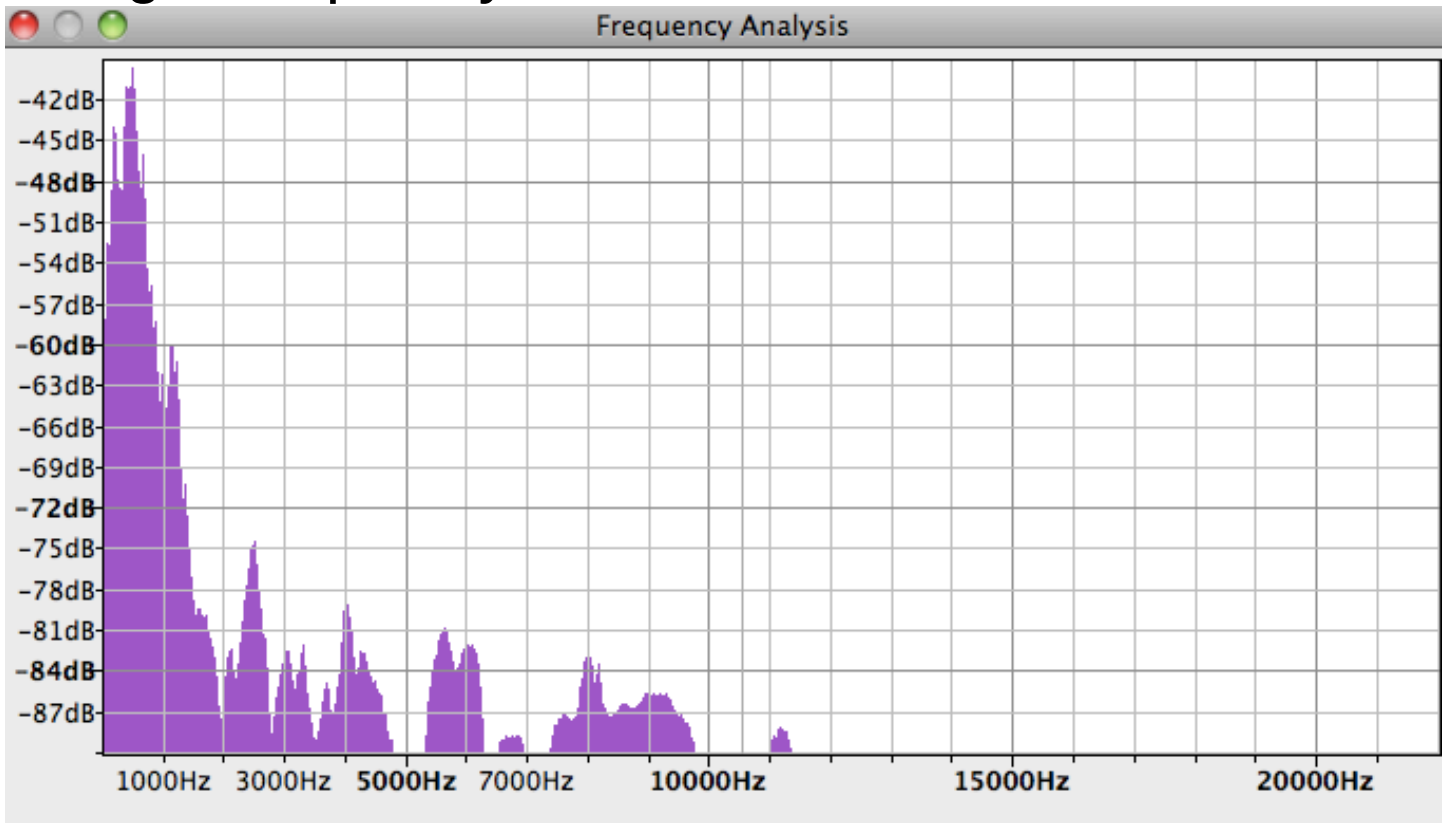
# Psychoacoustics

- Relationships between **physical phenomenon** of sound and our **perception**
- Frequency <-> pitch
  - 20-20,000Hz
- Amplitude <-> loudness
- Identities and strengths of frequencies present : timbre



# Spectral representation

- Every wave (sounds included) can be decomposed into “pure sine waves”, each of a single frequency.

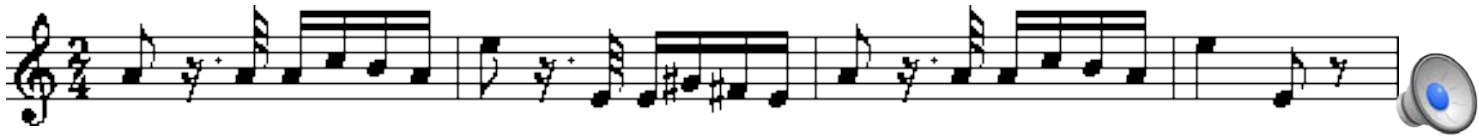


# 2. Representations of sound and music

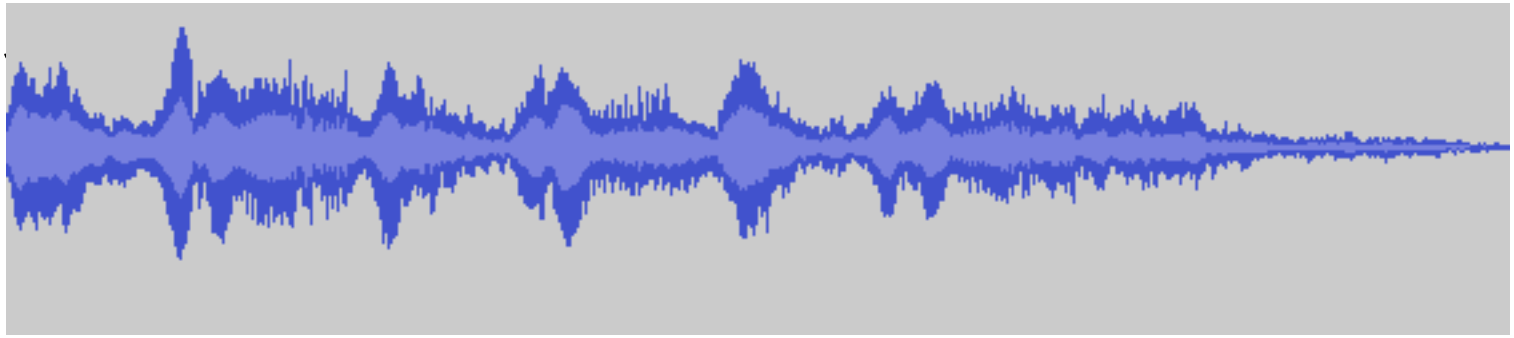
# Discussion Time

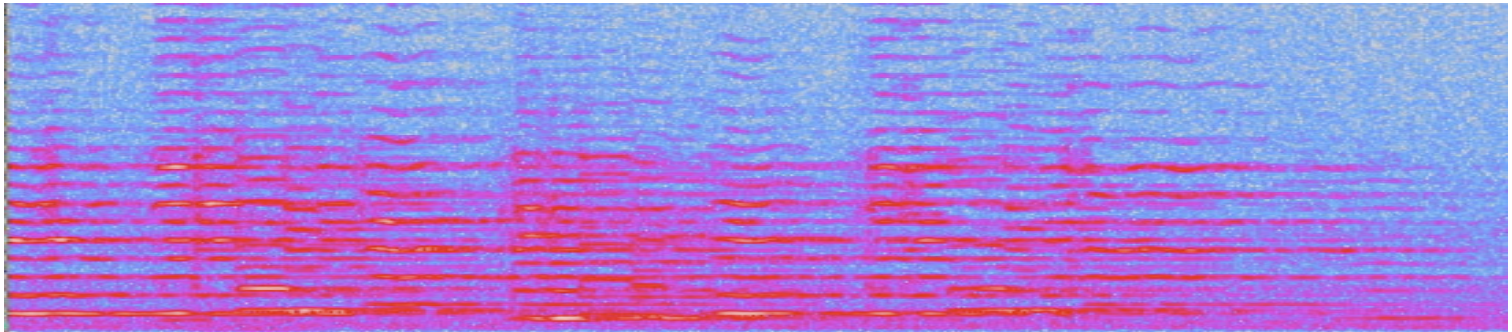
How do you represent music?

- Score:

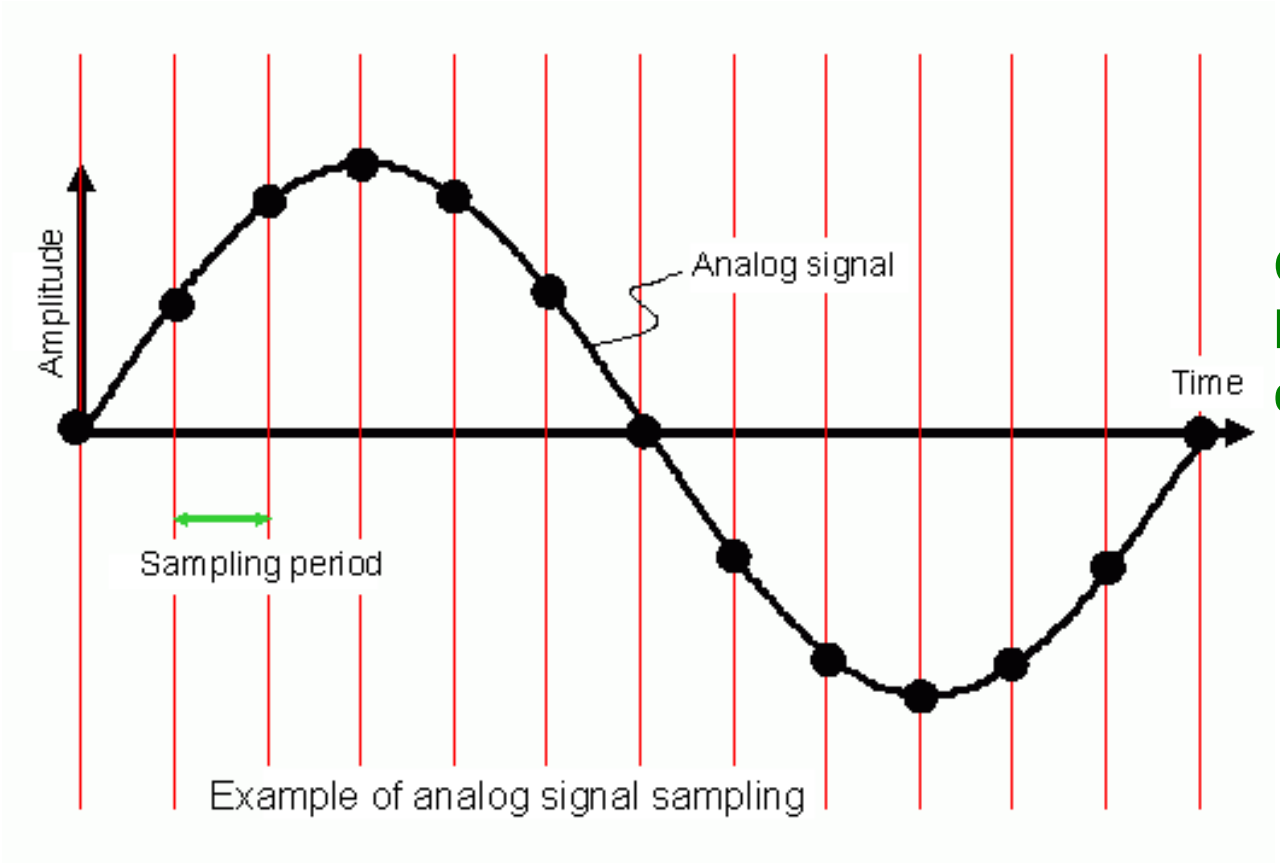


- Audio samples
-





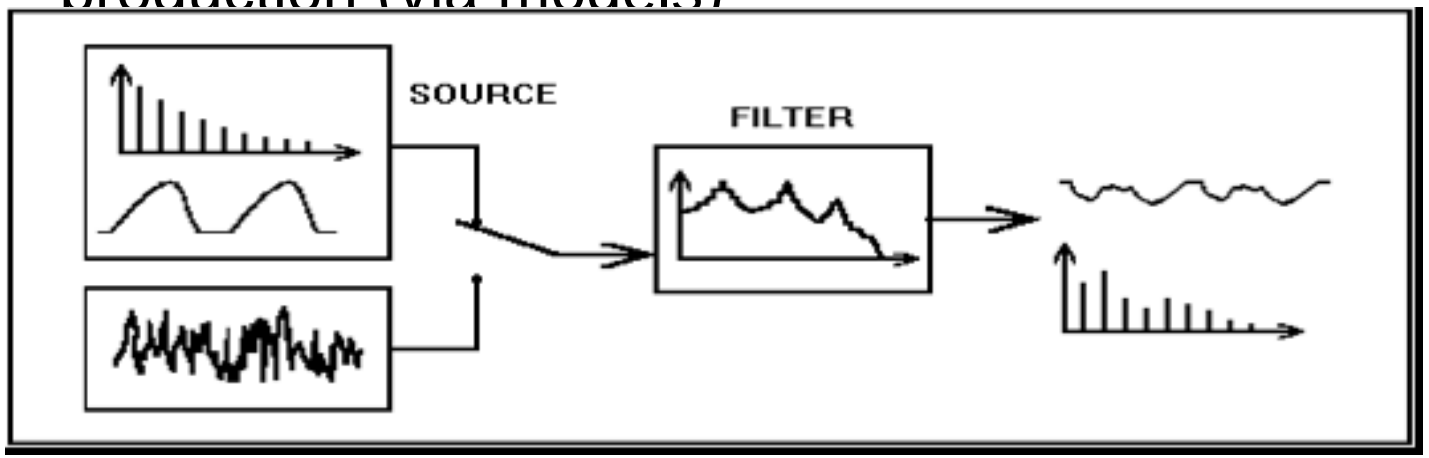
# Digital representation of music




Qs: How can computer halve the frequency of this signal?

# Compression

- Why? Saves bandwidth, memory etc.
- How?
  - Trivial but very lossy: sample less often
  - Cleverer: use psychoacoustic principles
    - MP3: Masking
  - Even cleverer: use physical principles of sound production (via models)

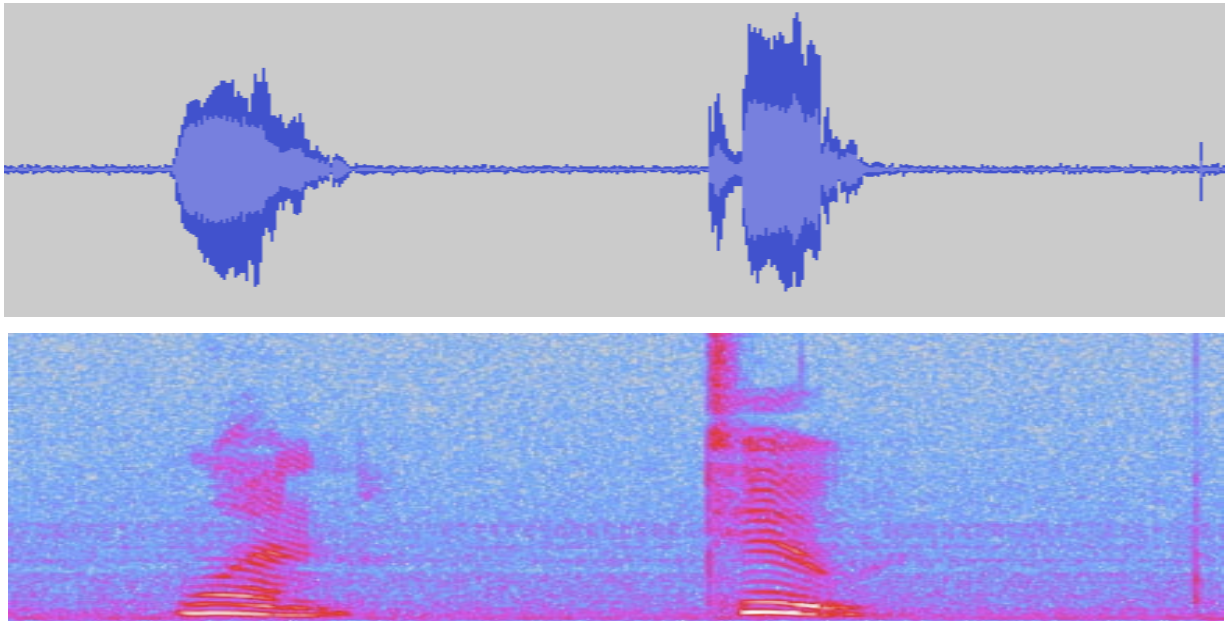


# Choosing a representation

- Representations are compromises
- Standard representations are somewhat arbitrary (e.g. MIDI)
- Best representation is task-dependent

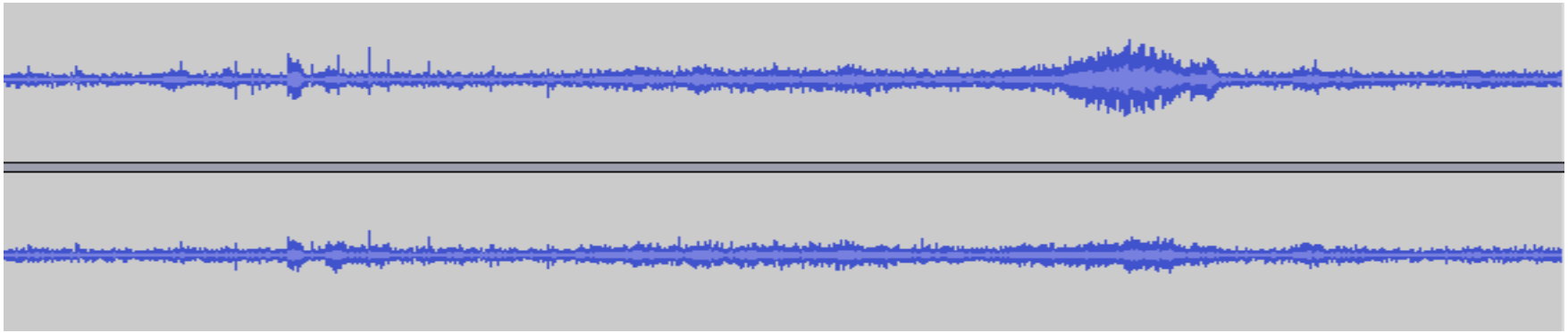
# 3. Using technology to analyze sound and music

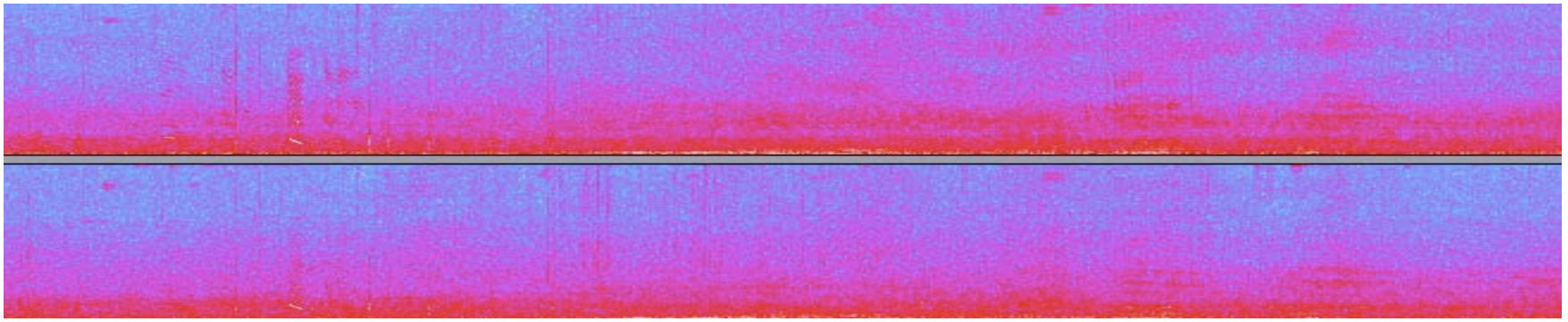
# Analyzing speech



- Real-life apps:
  - Customer service phone routing
  - Voice recognition software

# Computational Auditory Scene Analysis



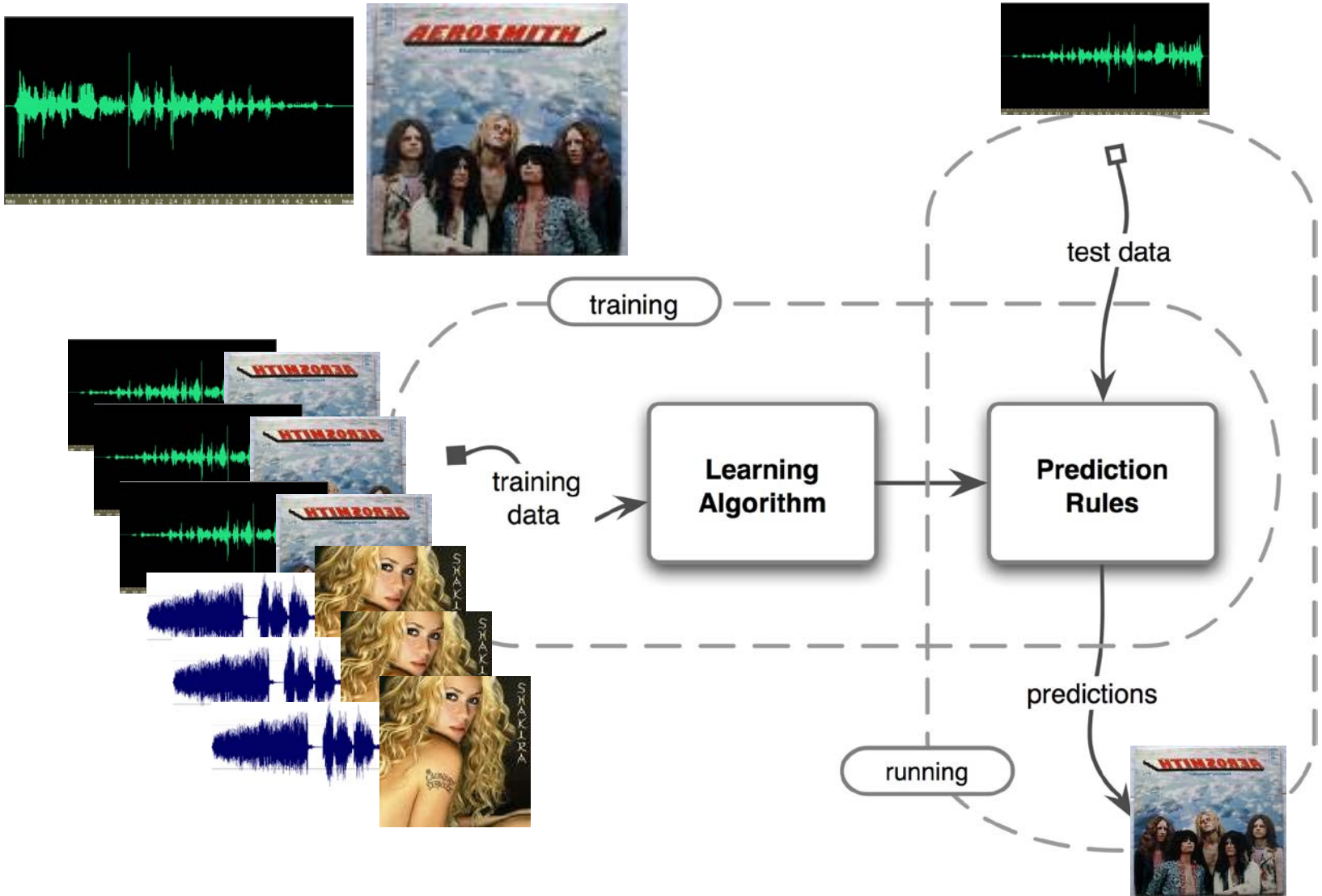


- Applications: Archival and retrieval, forensics, AI

# Music information retrieval

- Analyzing musical data
- Query, recommend, visualize, transcribe, detect plagiarism, follow along with a score
- Sites you can try
  - midomi.com
  - Themefinder.com
  - Pandora.com (human-driven), last.fm

# Machine learning for analysis



(1) What does this pseudocode do?

Variable i;

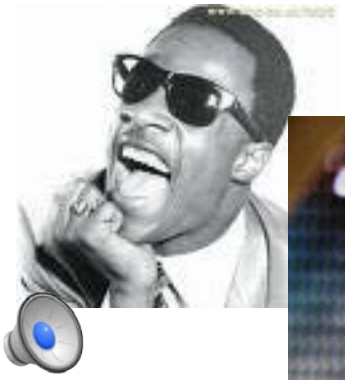
```
for i=1 to 4 do
 { if (i < 3) then
          print( i*i)
   else
          print (i);}
```


(2) Write 33 in binary.

# 4. Using technology to create music and sound

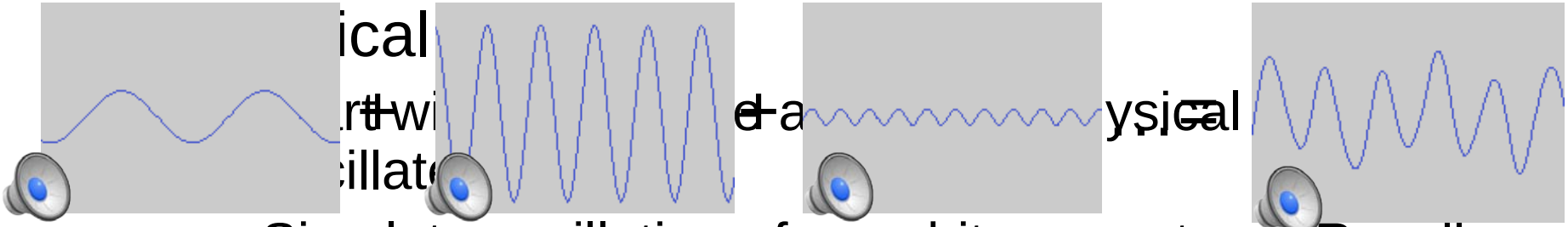
A whirlwind tour of the 20th century, with a focus on computer technology

# Creating music: Synthesis



# Three approaches to synthesis

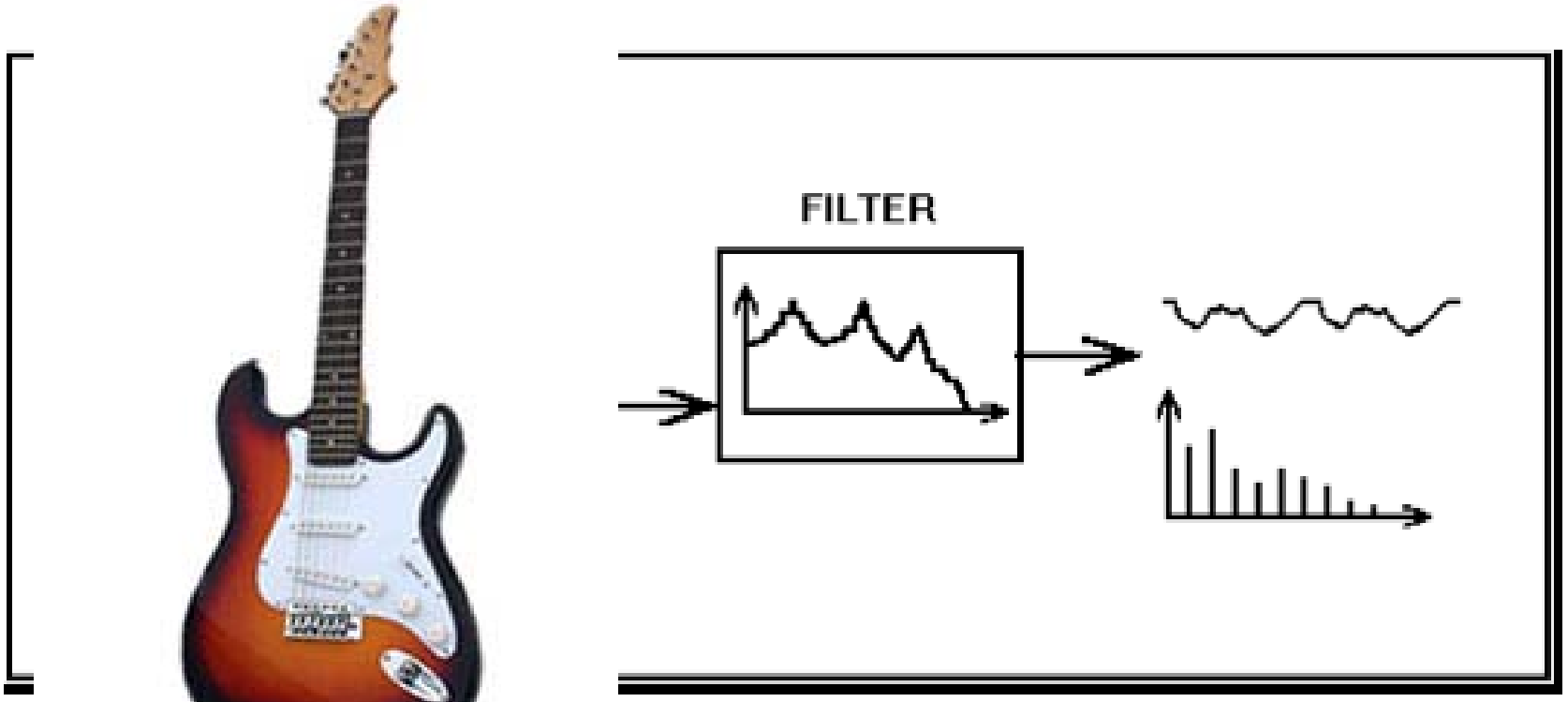
- Additive synthesis
  1. Figure out which frequencies are present, and in what proportions
  2. Synthesize a sine wave at each frequency, and superpose them.



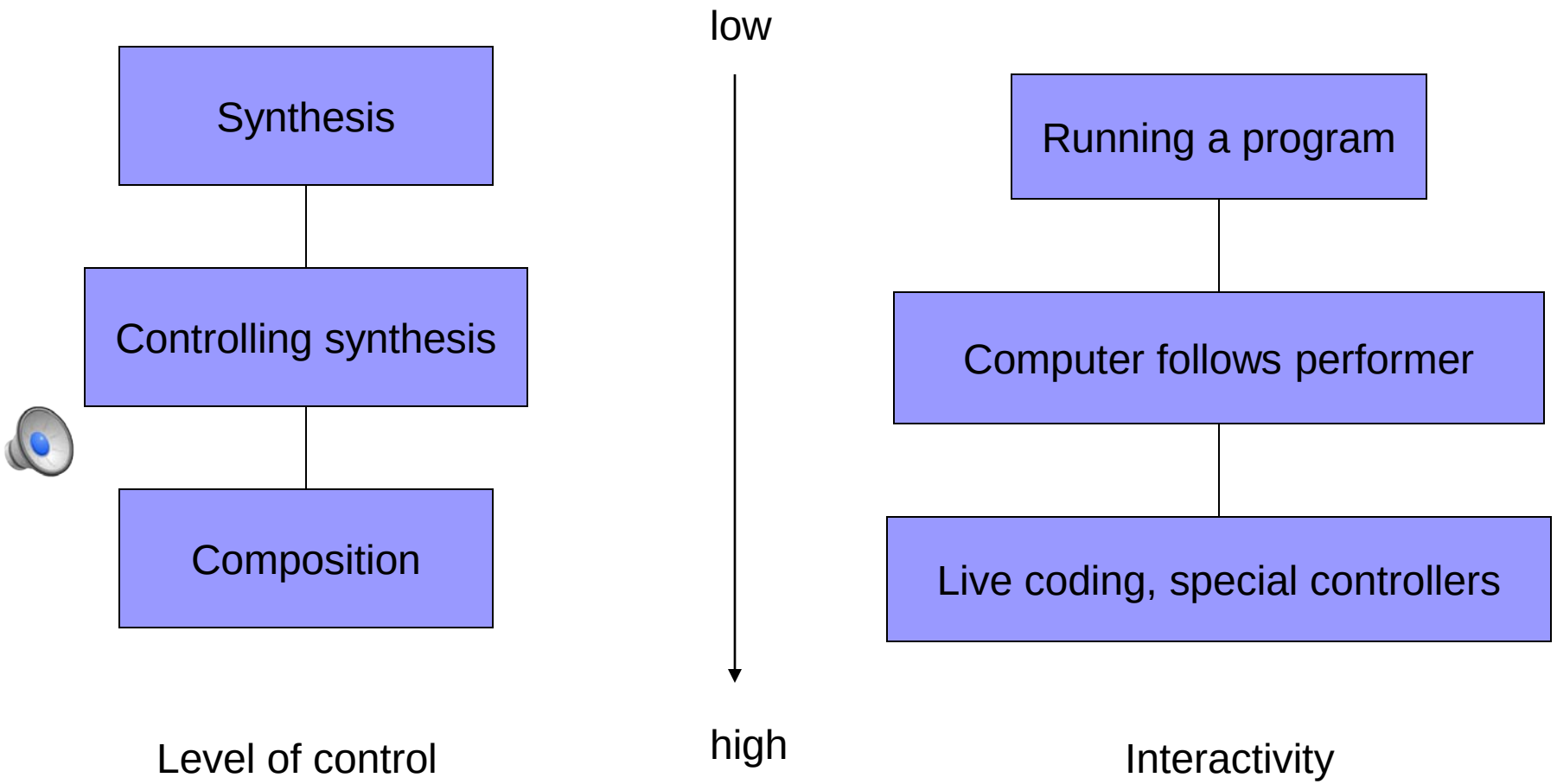
- ical
  - rt wi ed a ysical
  - illat
  2. Simulate oscillation of an arbitrary system. (Recall Lecture 4)

# Three approaches to synthesis

- Cross-synthesis (eg vocoder)
  - Choose filter for speech (vowel)
  - Choose source to be another sound



# Some continua of computer music creation



# Performer-Computer Interaction

- Augmented instruments
- Software and hardware interf
  - Demo: PLOrk video, PBS
  - Demo: using a Wii-mote to con
- New instruments
  - Perry's Mug.
- Live coding
  - Demo: Max's drum machine
  - Chuck/miniaudicle

# Questions: How can we….

- develop new ways to synthesize sound?
- give user control over synthesis parameters?
- make machines interactive in a musical way?
- augment human capabilities?
- design new instruments that are easy to play? allow expert musicality?
- create music that is emotionally and aesthetically compelling?

# Final remarks

- Distinctions in this presentation are superficial
  - Analysis, representation, and creation interact
  - Technology draws on and contributes to our understanding of the physics and psychophysics of sound
- Computer music is interdisciplinary
  - HCI, AI, programming languages, algorithms, systems building
  - Also psychology, music theory, acoustics, signal processing, engineering, physics, performance practice, library science, applied math & statistics, …
- Technology is constantly complicating and changing the landscape of our musical experiences as creators, participants, listeners, and consumers.

# http://soundlab.cs.princeton.edu/


Software to try:
Chuck,
Miniaudicle,