Digital audio and computer music

COS 116: 2/26/2008

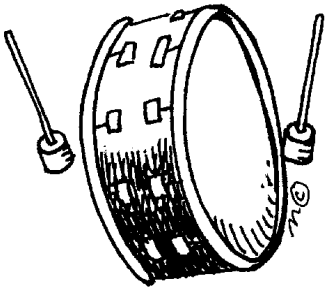
Overview

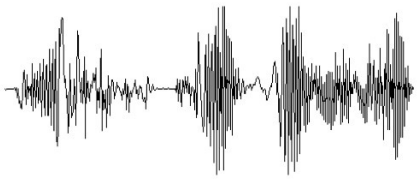
- Sound and music in the physical world and in human experience
- Representations of music
- Analyzing music with computers
- Creating music with computers

1. Sound and music

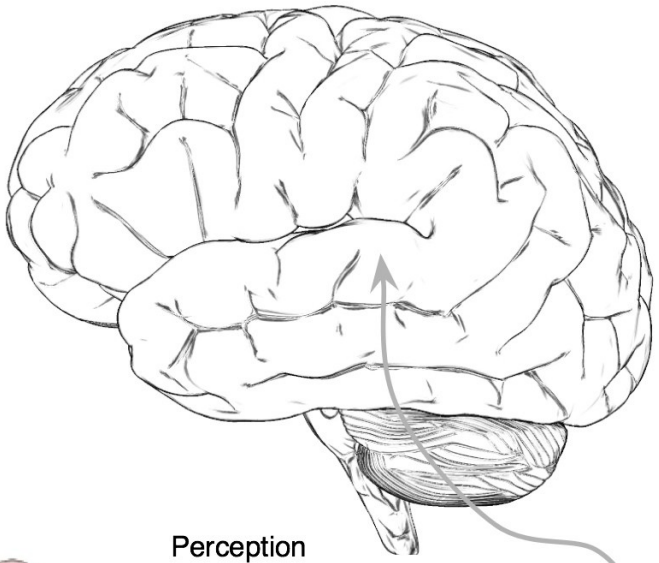
Discussion Time

What is sound?



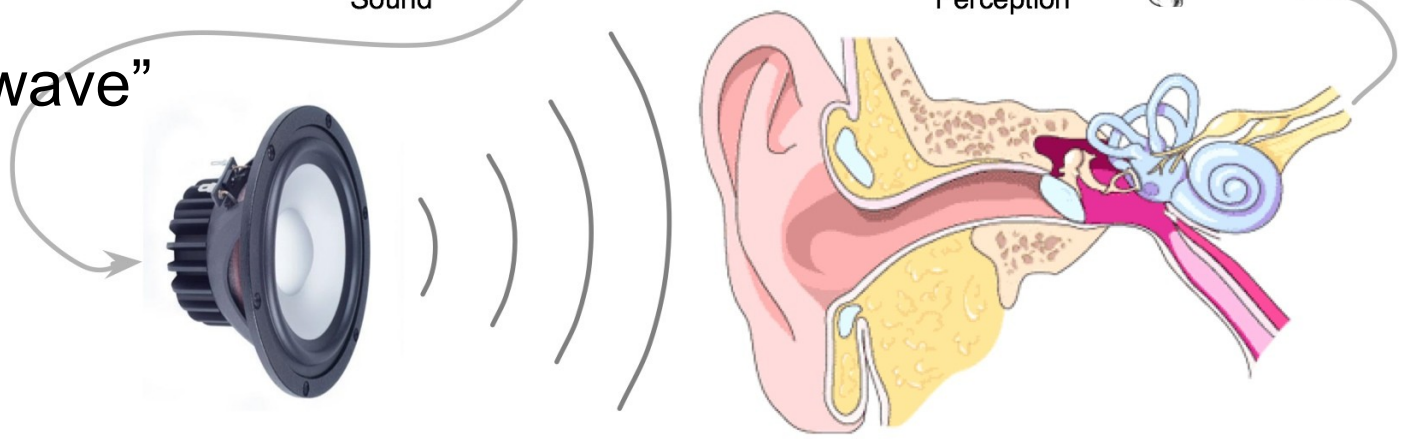


Sound



Perception

"Pressure wave"

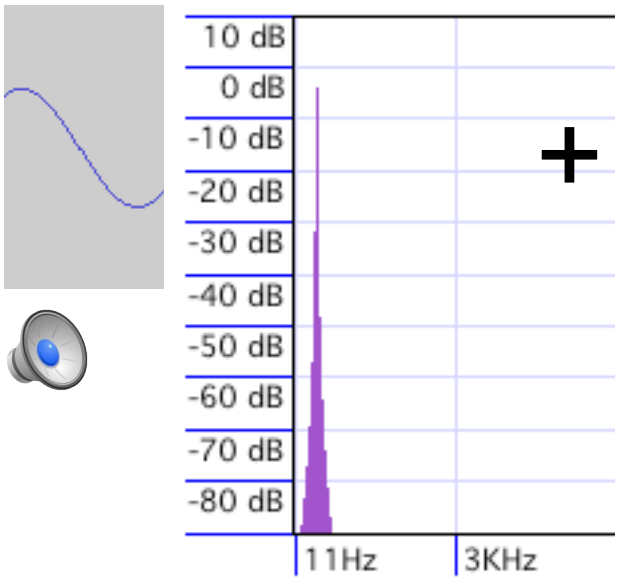


What do we hear?

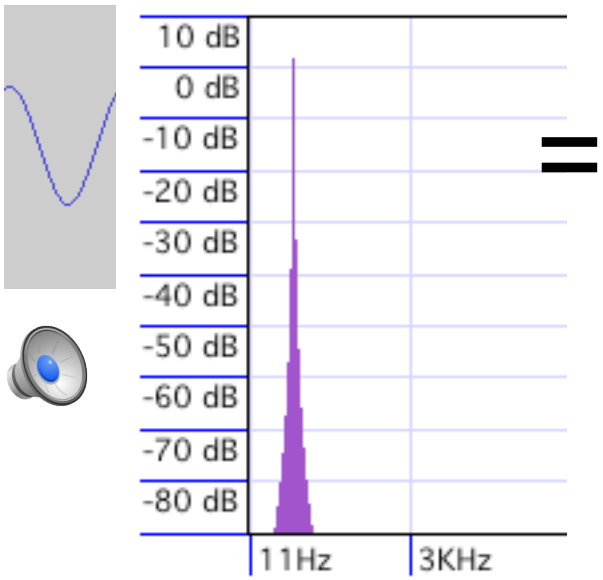
- Video: http://www.youtube.com/watch?v=0svoQcMQNY
- Frequency
- Pitch
- Loudness
- Timbre
- …

Psychoacoustics

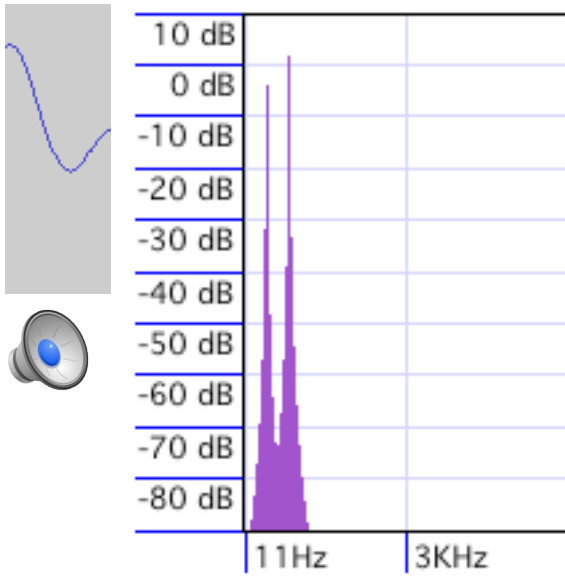
- Relationships between **physical phenomenon** of sound and our **perception**
- Frequency : pitch
  - 20-20,000Hz
- Amplitude : loudness
- Identities and strengths of frequencies present : timbre



+



=



Discussion Time

What is music?

"Organized sound"

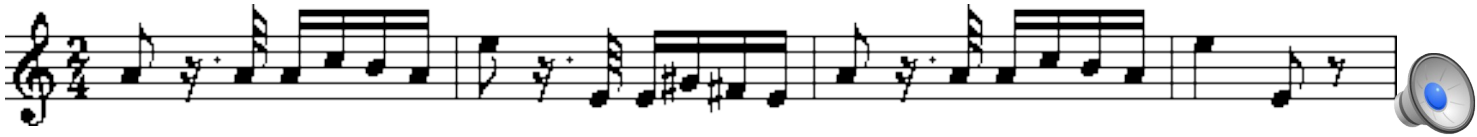
- Psychoacoustics play an important role
- Also dependence upon history, culture, experience
- Engages listeners' psychological mechanisms for expectation/reward

2. Representations of sound and music

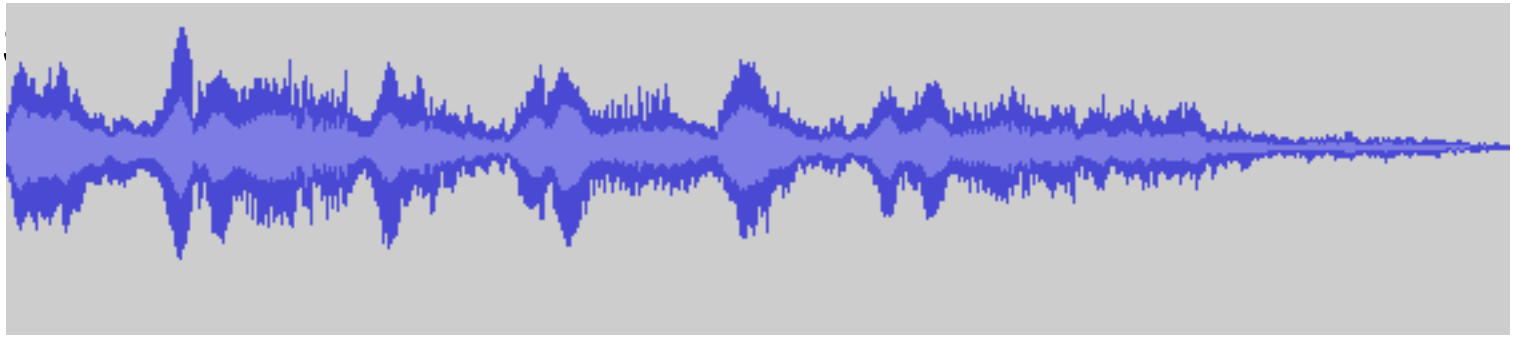
Discussion Time

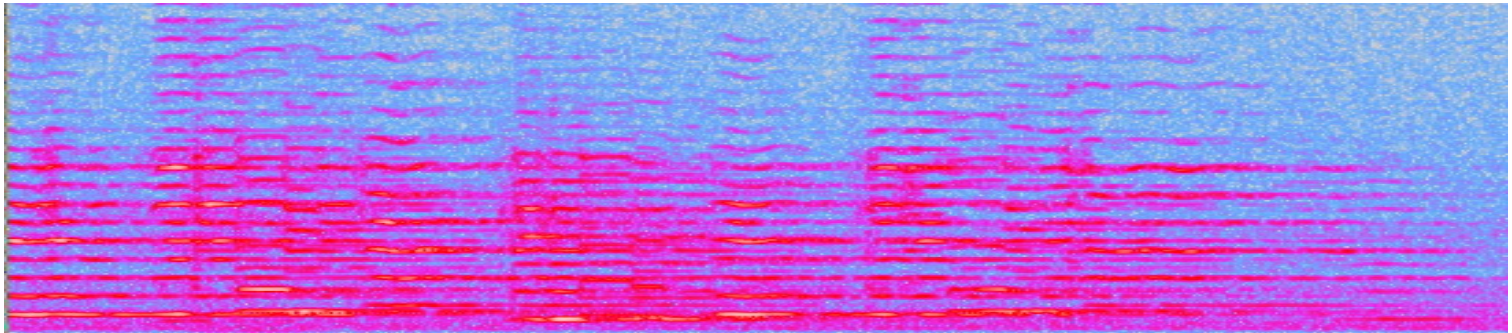
How do you represent music?

- Score:

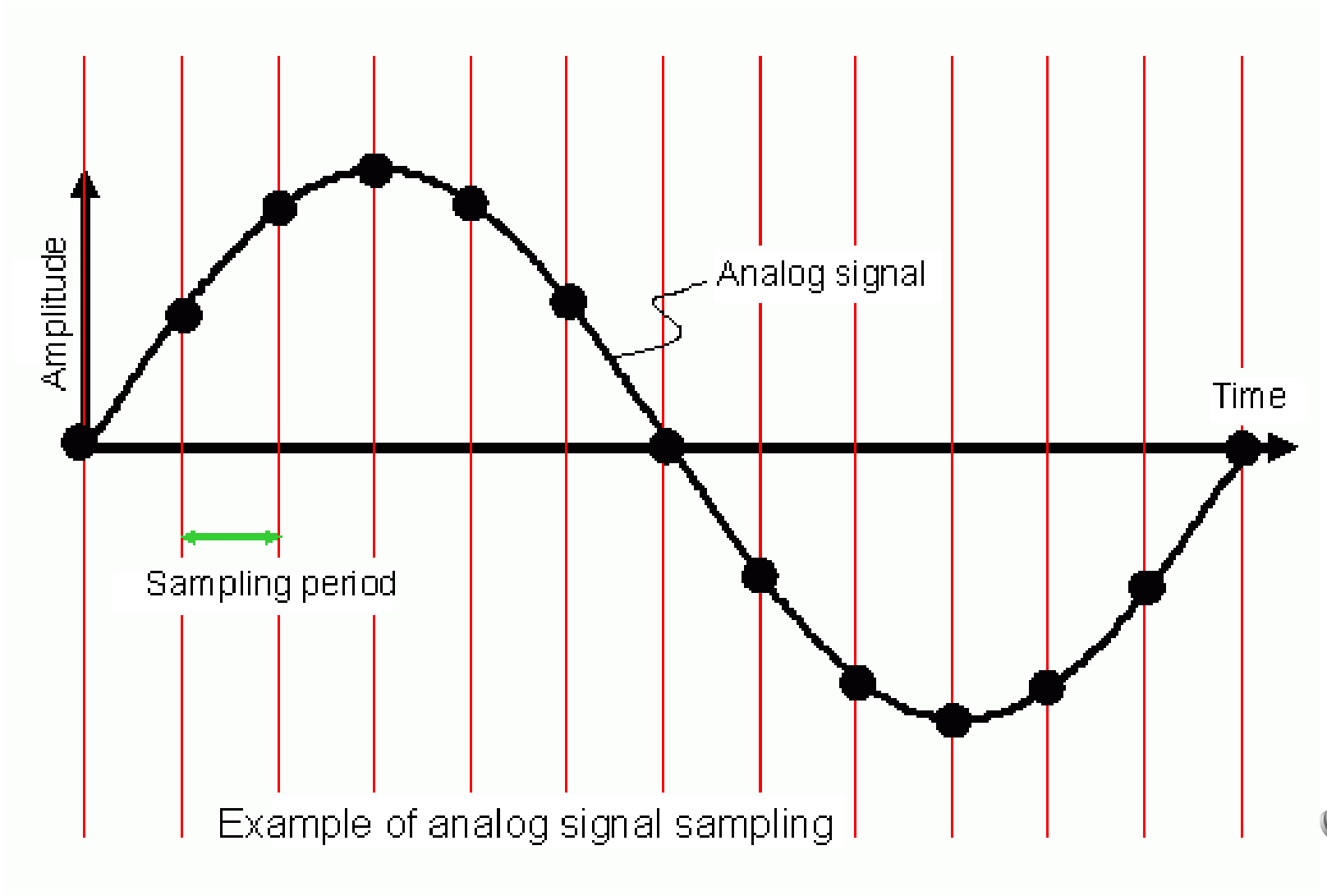


- Audio samples
-



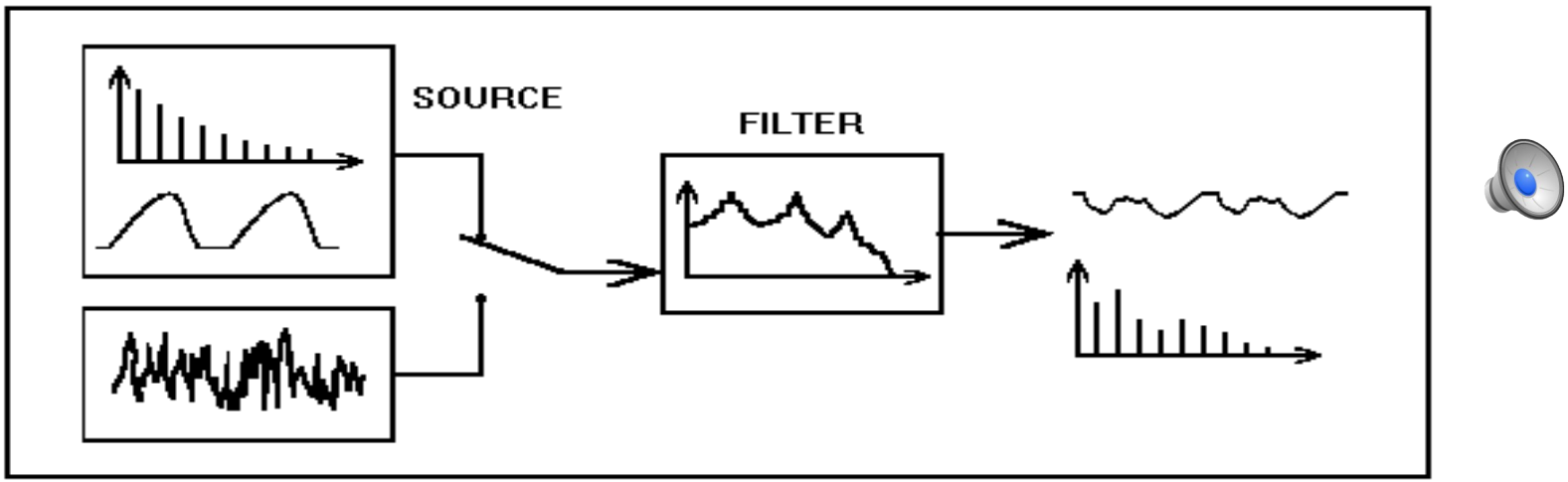


Digital representation of music



Compression

- A “better” representation with fewer bits
- Why? Security, transmission, storage
- How?
  - Psychoacoustic principles
    - MP3: Masking
  - Physical principles of sound production (uses models of sound source)

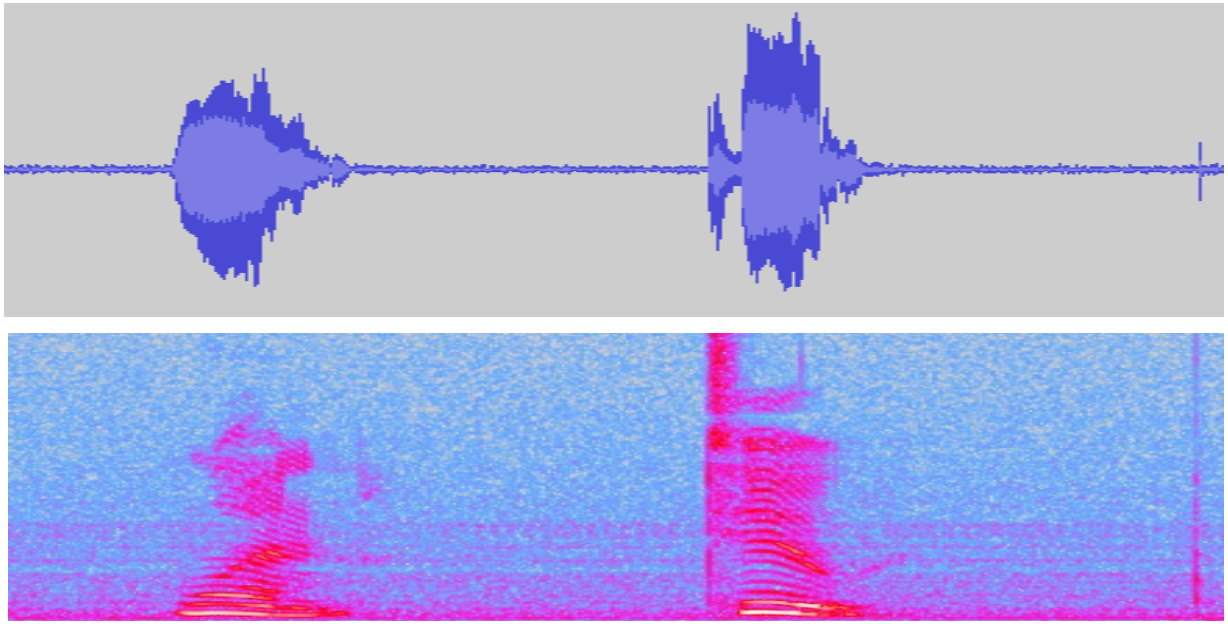


Choosing a representation

- Representations are compromises
- Standard representations are somewhat arbitrary
- Appropriate representation is task-dependent

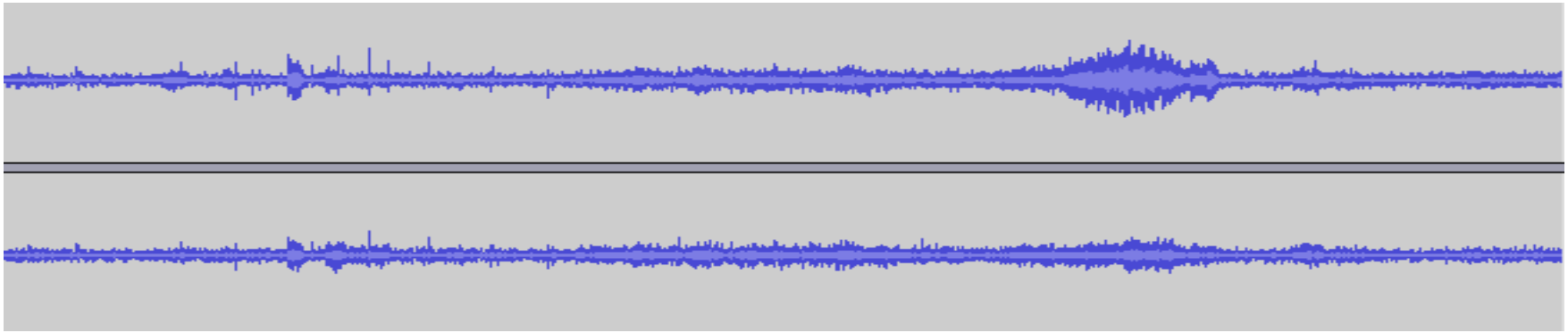
3. Using technology to analyze sound and music

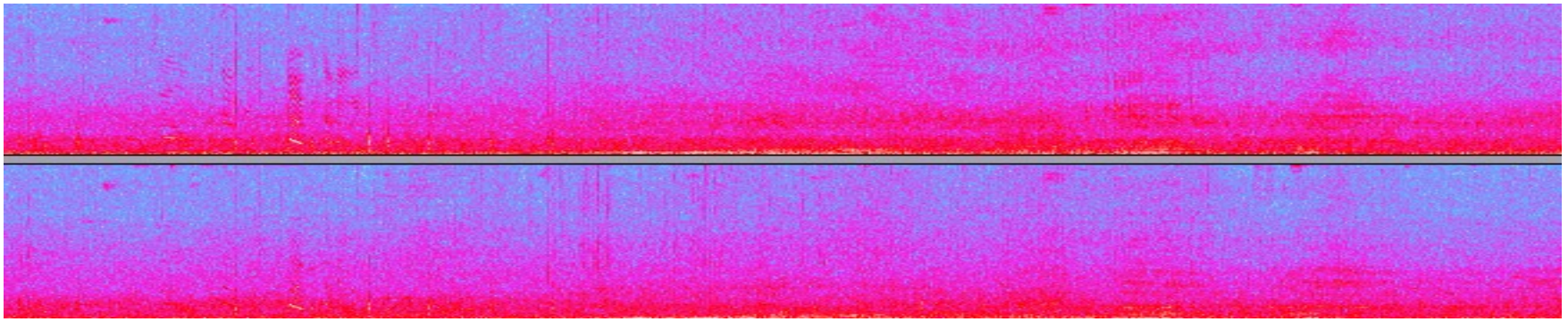
Analyzing speech



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

Computational Auditory Scene Analysis



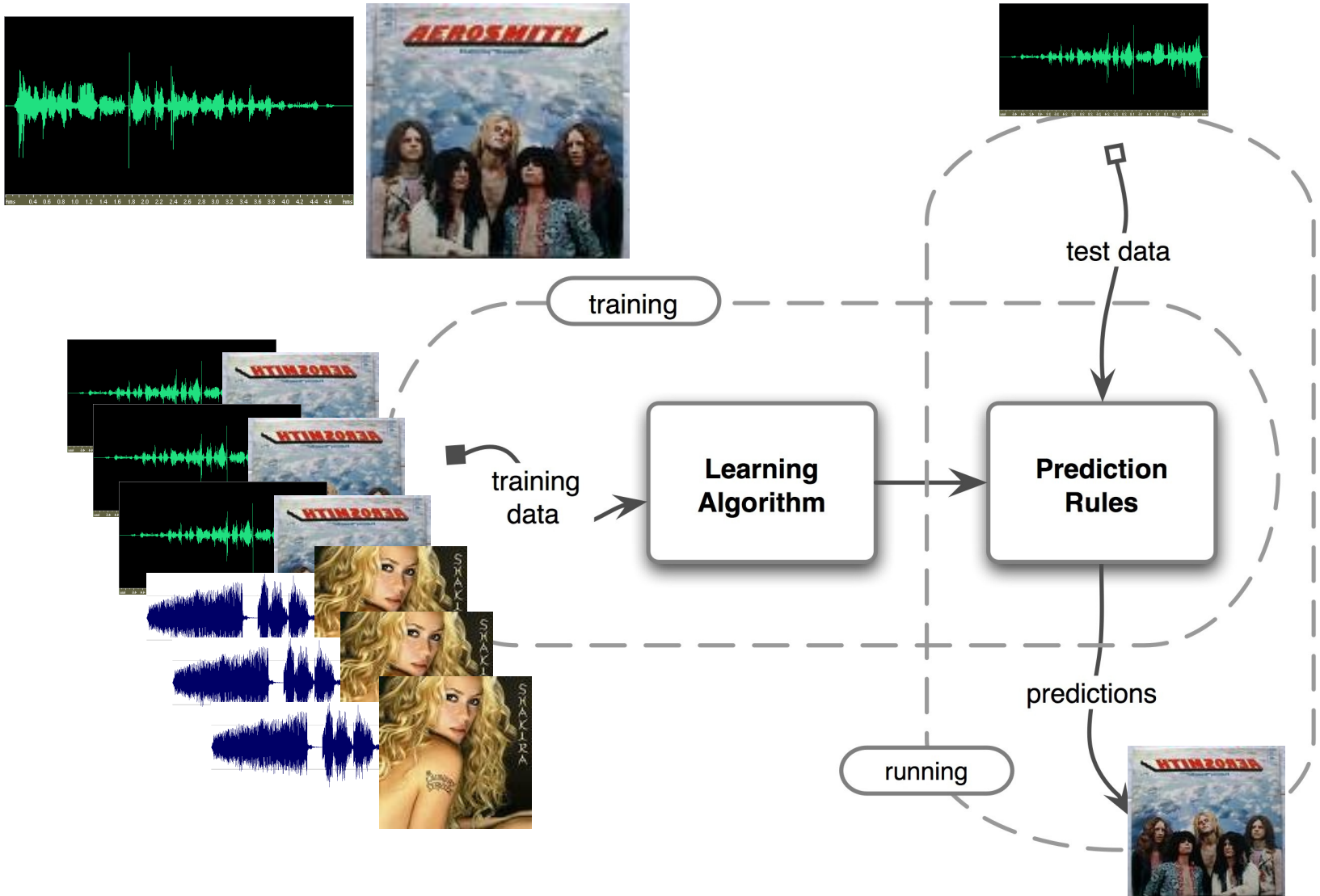


- Applications: Archival and retrieval, forensics, AI

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



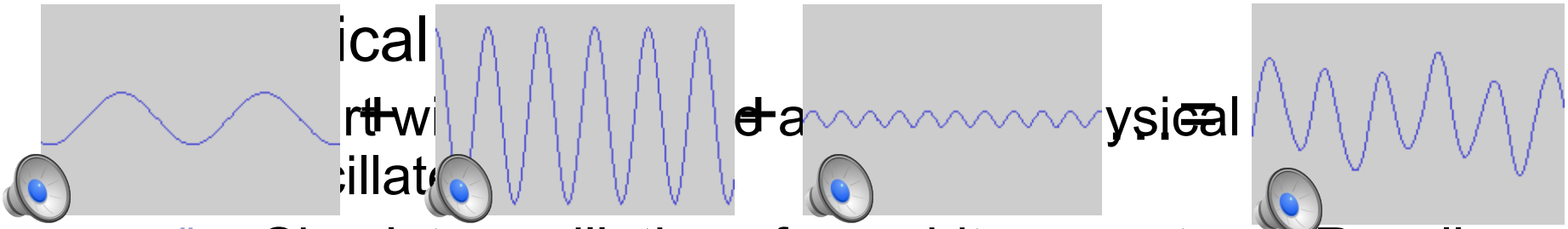
4. Using technology to create music and sound

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

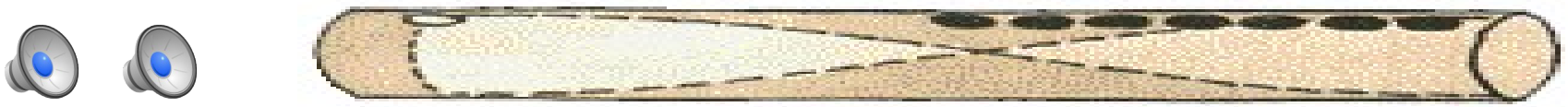
Creating music: Synthesis

Three approaches to synthesis

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

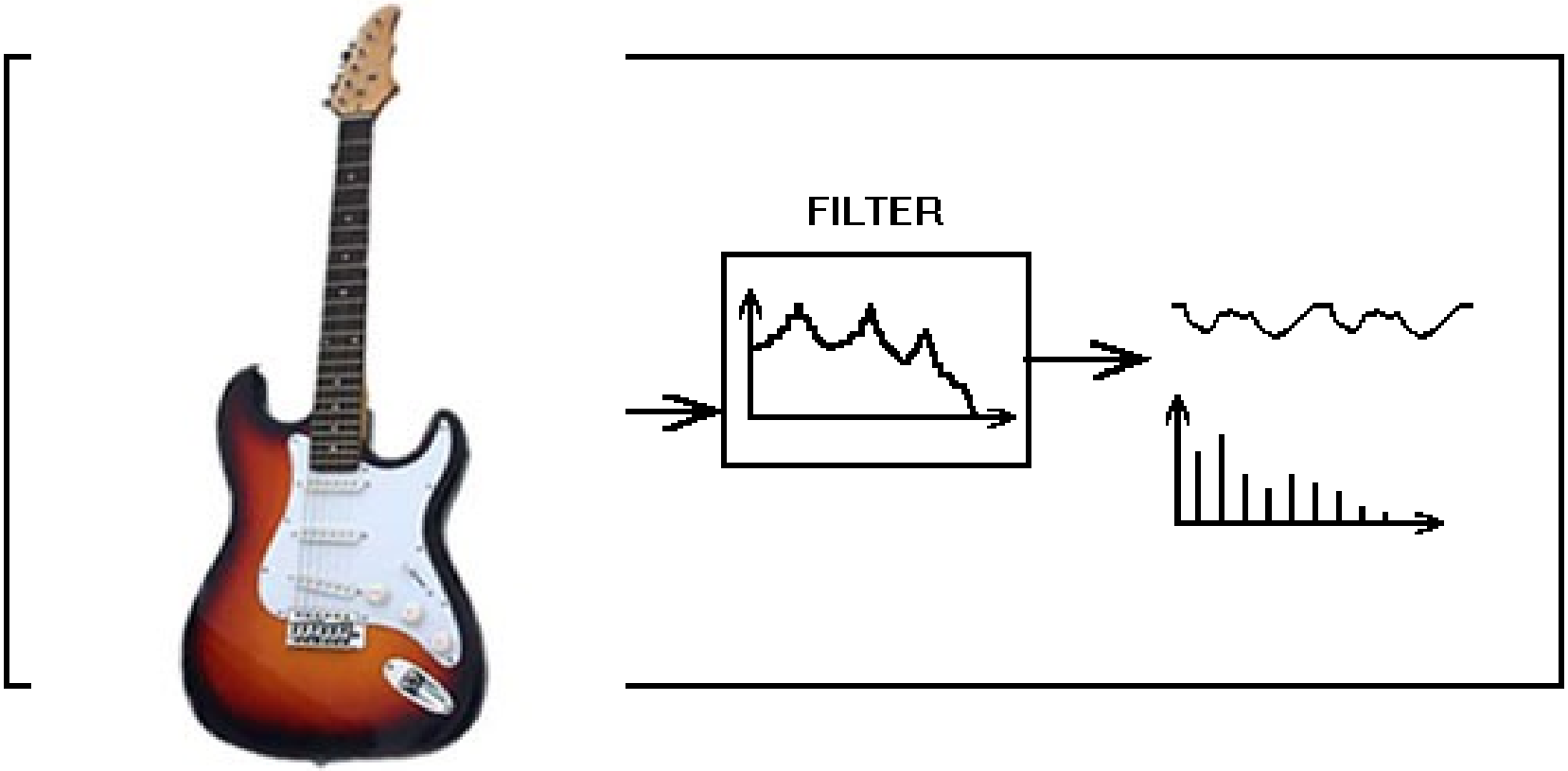


  - Simulate oscillation of an arbitrary system. (Recall Lecture 4)

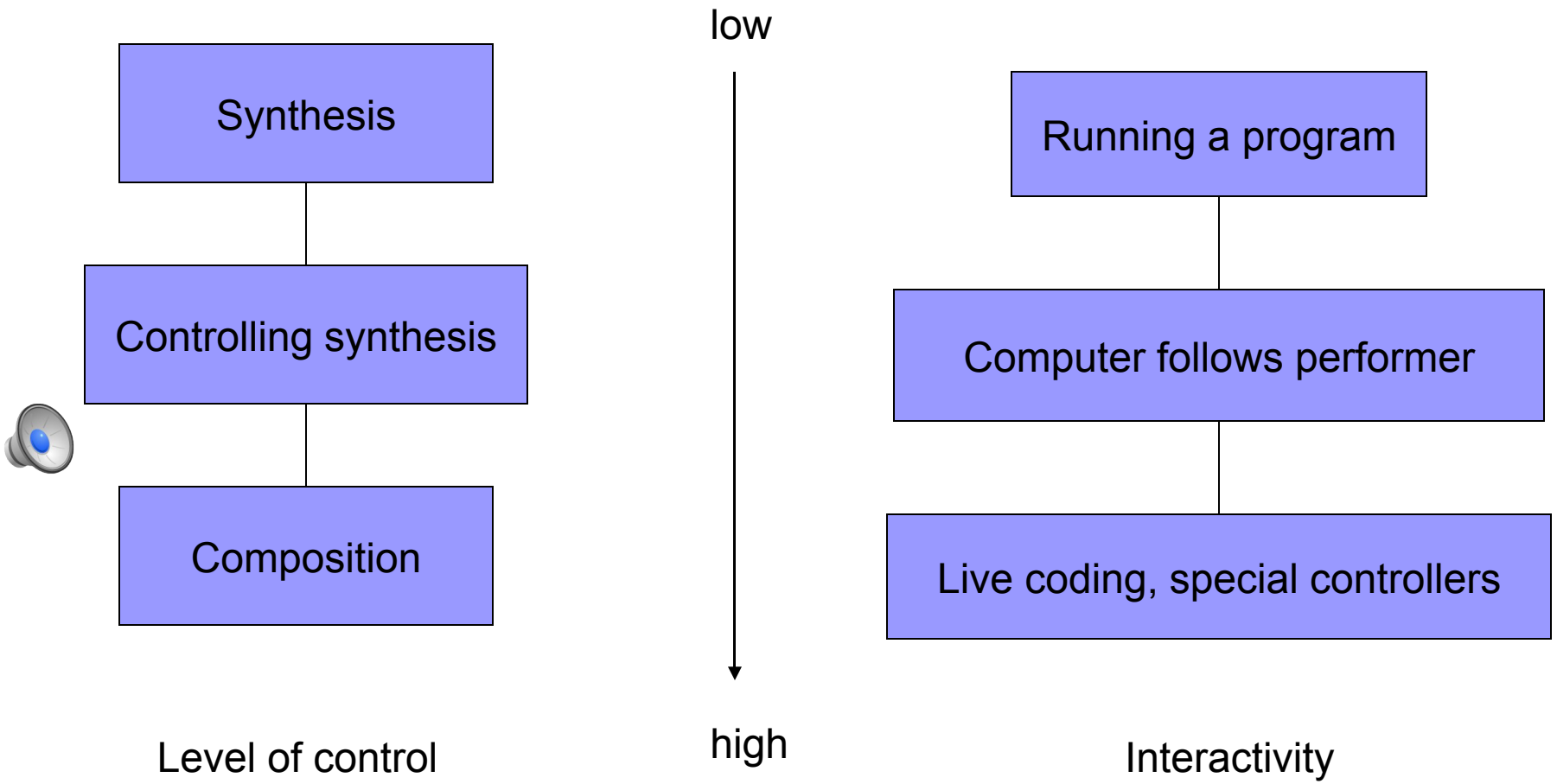


Three approaches to synthesis

- Cross-synthesis
  - 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 int
  - Demo: PLOrk video, PBS
  - Demo: using a Wii-mote to c
  - Demo: SMELT
- New instruments
  - Demo: Perry's Mug
- Live coding
  - Demo: Max's drum machine

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/