Digital audio and computer music

COS 116, Spring 2010

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Slides and demo thanks to Rebecca Fiebrink

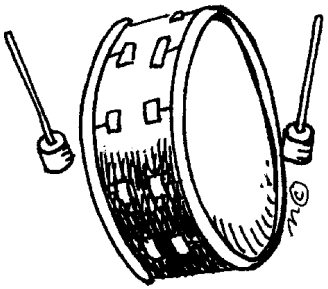
Overview

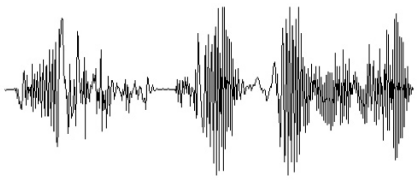
1. Sound and music in physical world / human experience
2. Representations of music
3. Analyzing music with computers
4. Creating music with computers

1. Sound and music

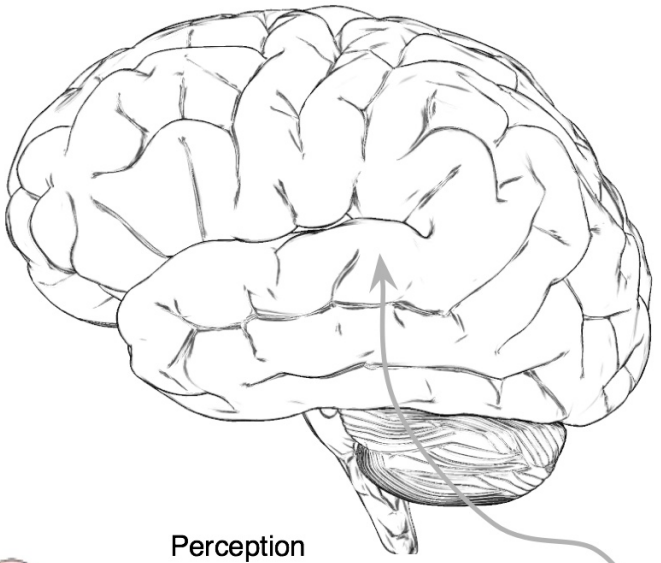
Discussion Time

What is sound?



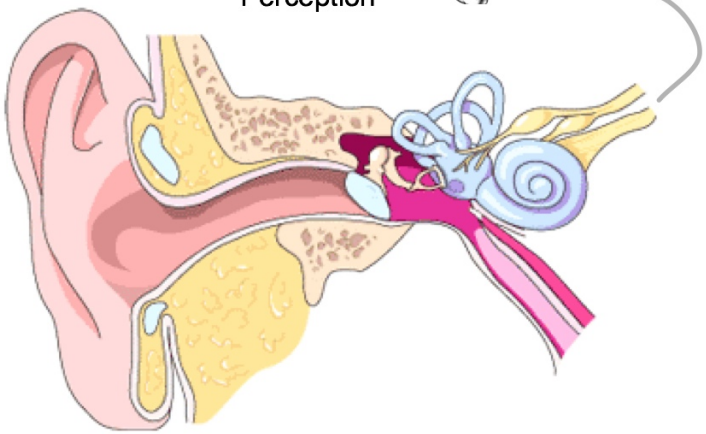


Sound



Perception

"Pressure wave"

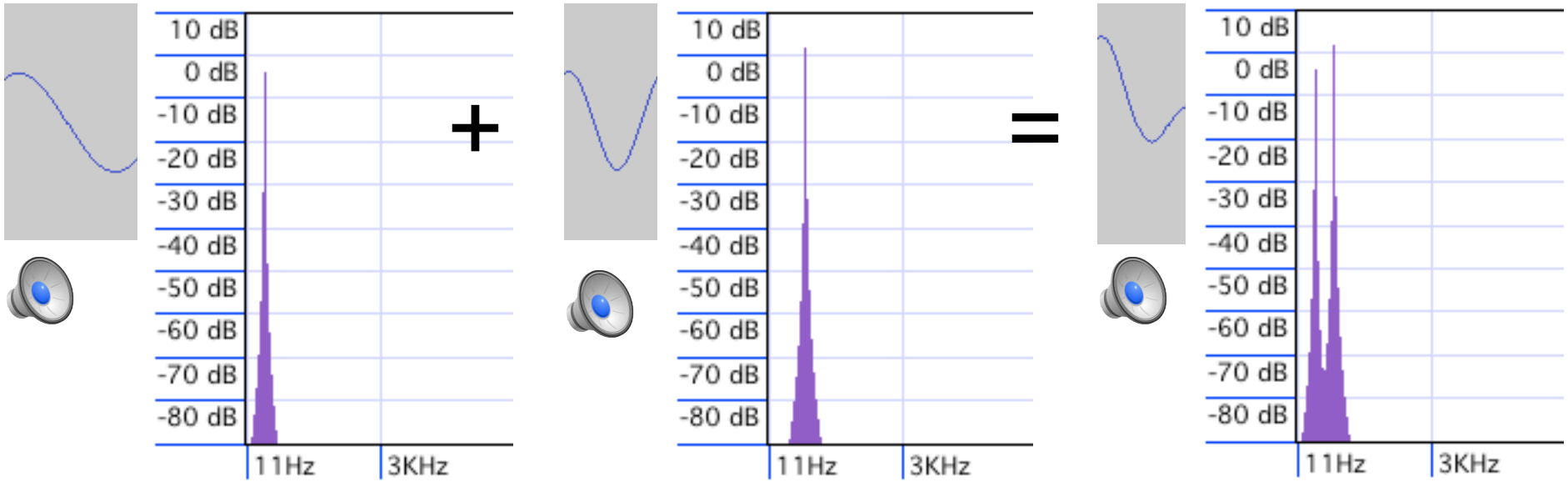


What do we hear?

- Video: http://www.youtube.com/watch?v=SsV2O4fCgjk
- Frequency
- Pitch
- Loudness
- Timbre
- etc...

Psychoacoustics

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



Discussion Time

What is music?

"Organized sound"

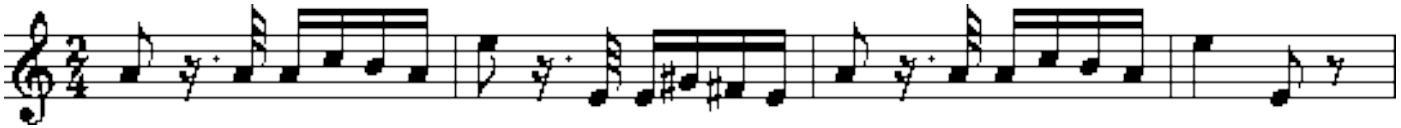
- Psychoacoustics play an important role
- Also dependence upon history, culture, experience
- Engages listeners' psychological mechanisms for expectation/reward

2. Representations of sound and music

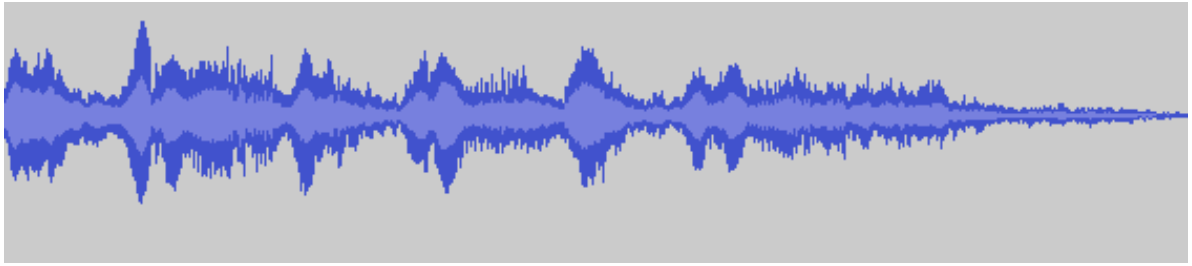
Discussion Time

How do you represent music?

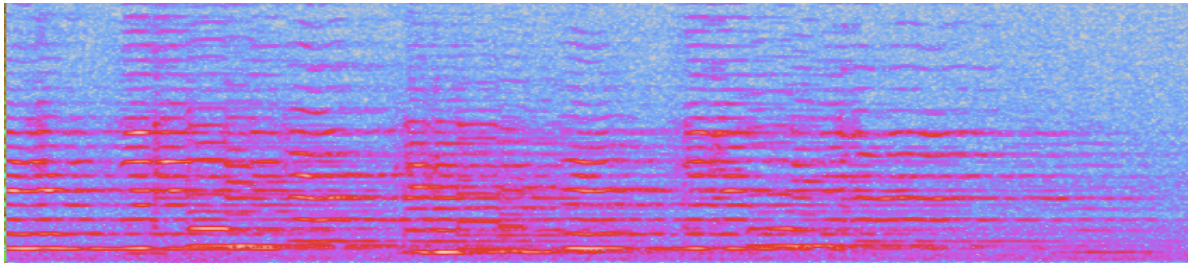
- Score:



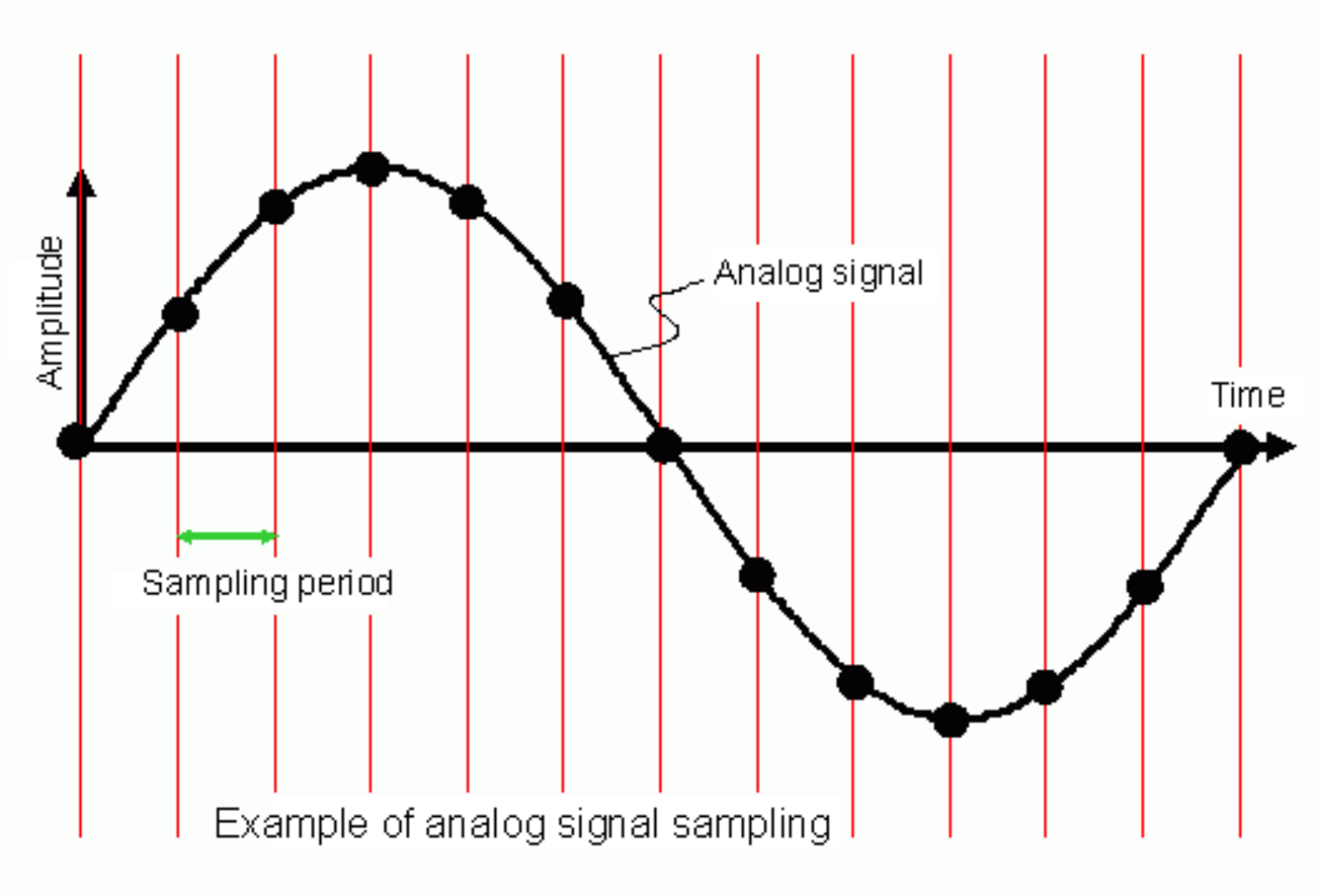
- Audio samples



- Spectrogram



Digital representation of music



Compression

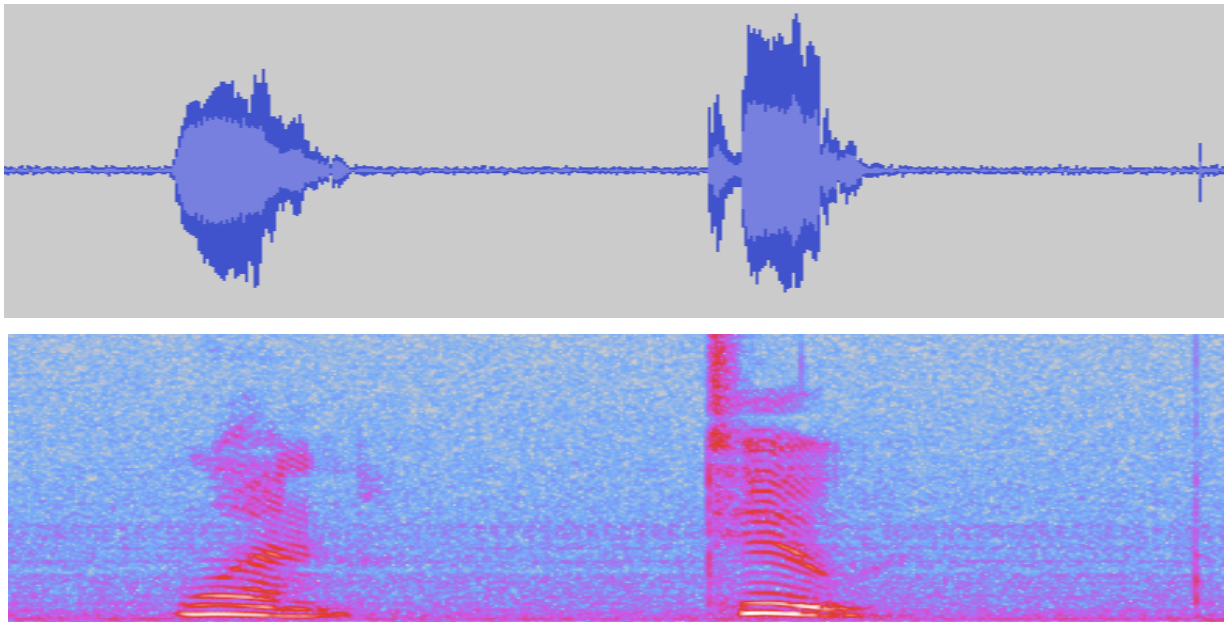
- A “better” representation with fewer bits
- Why? Security, transmission, storage
- How?
  - Psychoacoustic principles
    - MP3: Masking
  - Physical principles of sound production (uses models of sound source)

Choosing a representation

- Representations make compromises
- Standard representations are arbitrary
- Appropriate choice is task-dependent

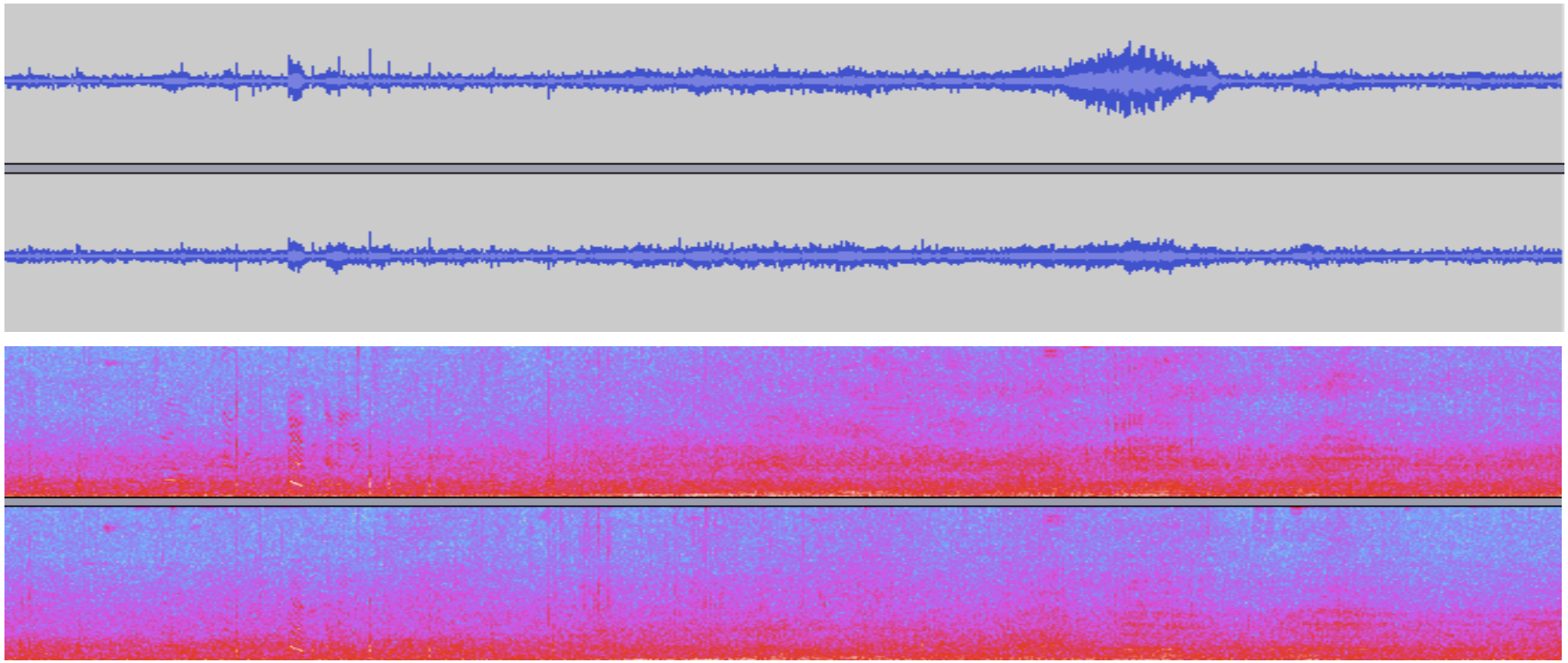
3. Using technology to analyze sound and music

Analyzing speech



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

Auditory Scene Analysis

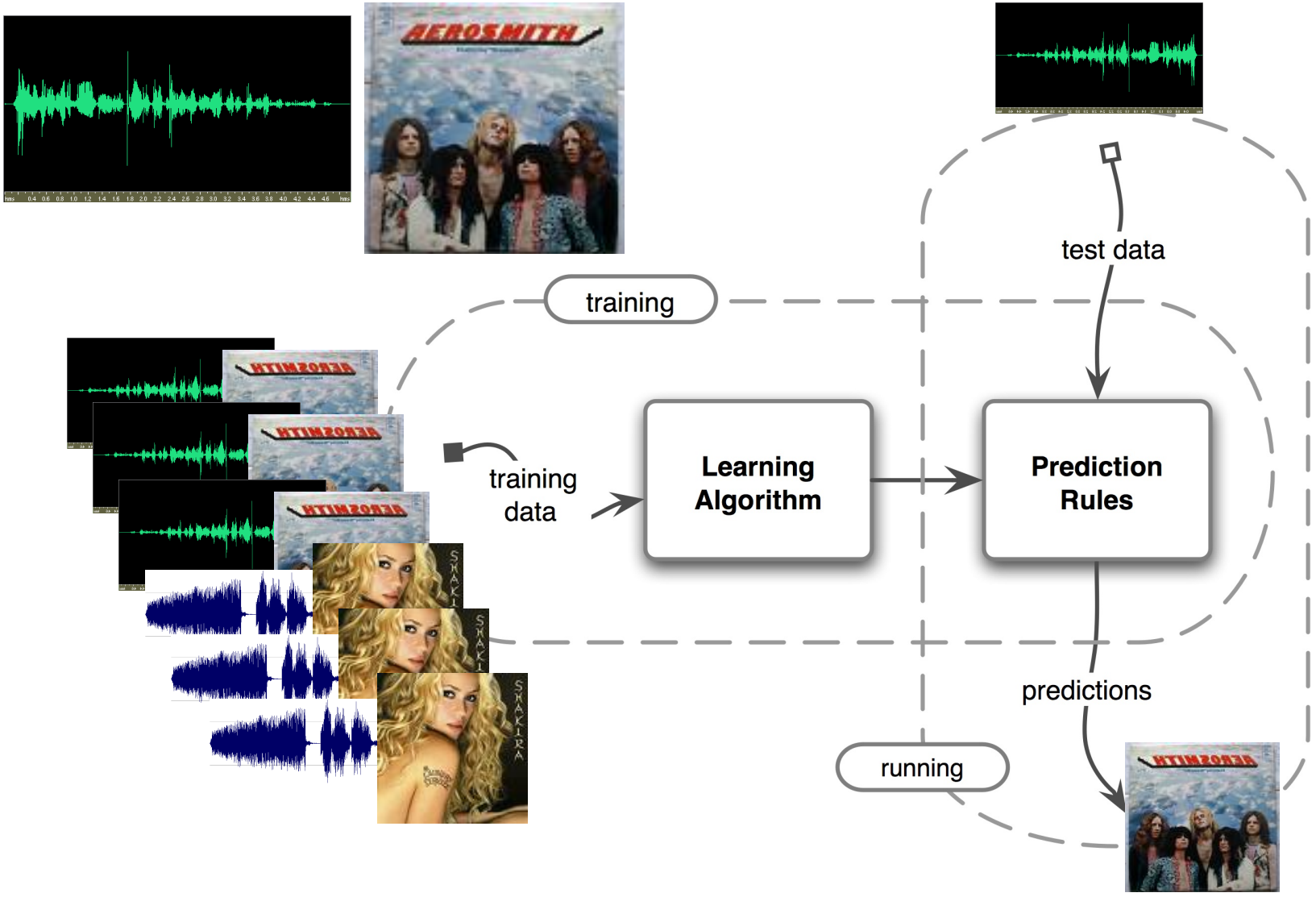


- Applications: Archival and retrieval, forensics, AI

Music information retrieval

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

Machine learning for analysis



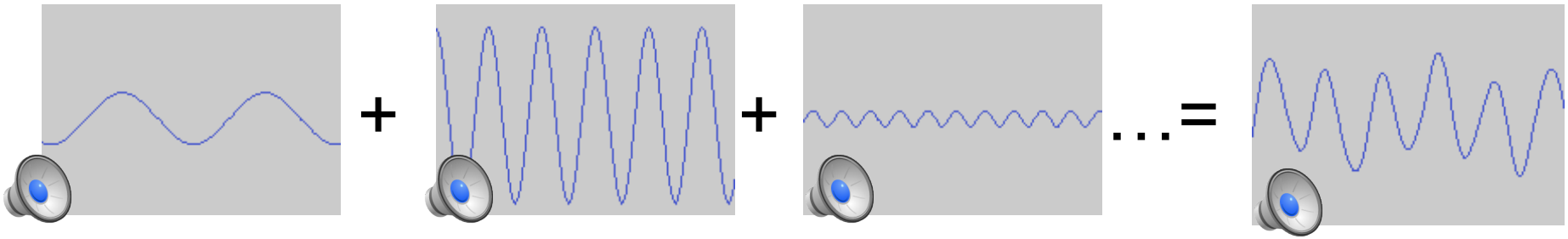
4. Using technology to create music and sound

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

Creating music: Synthesis

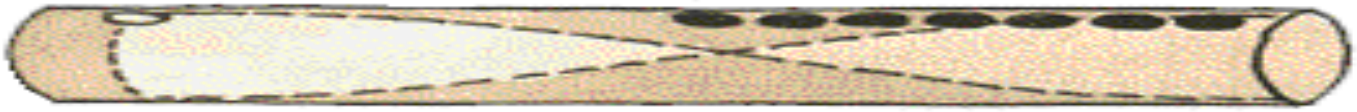
Three approaches to synthesis

- Additive synthesis
  1. Figure out proportions of various frequencies
  2. Synthesize waves and superimpose them



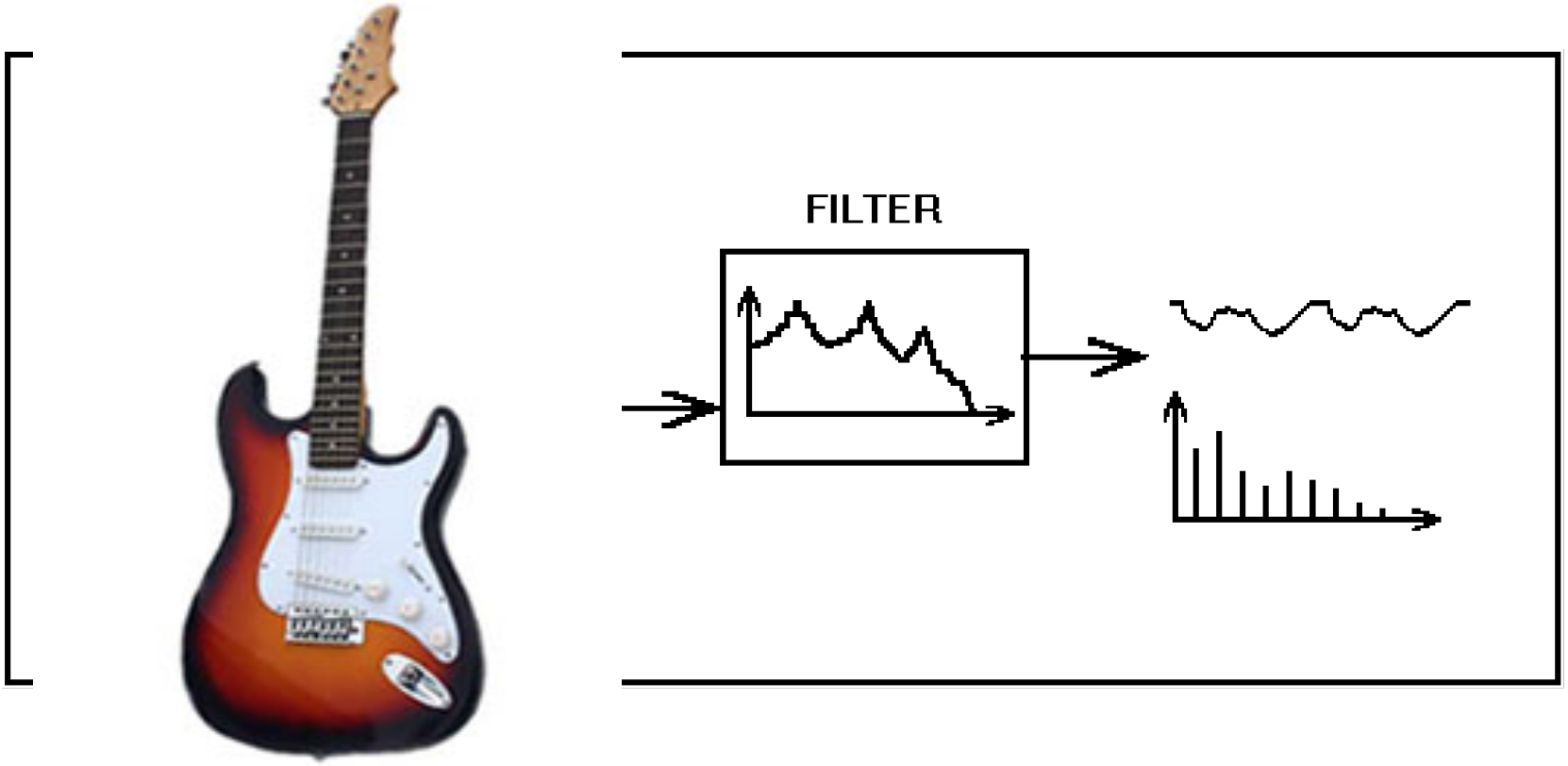
Three approaches to synthesis

- Additive synthesis
  1. Figure out proportions of various frequencies
  2. Synthesize waves and superimpose them
- Physical modeling
  1. Start with knowledge of physical systems
  2. Simulate oscillation (Recall Lecture 4)

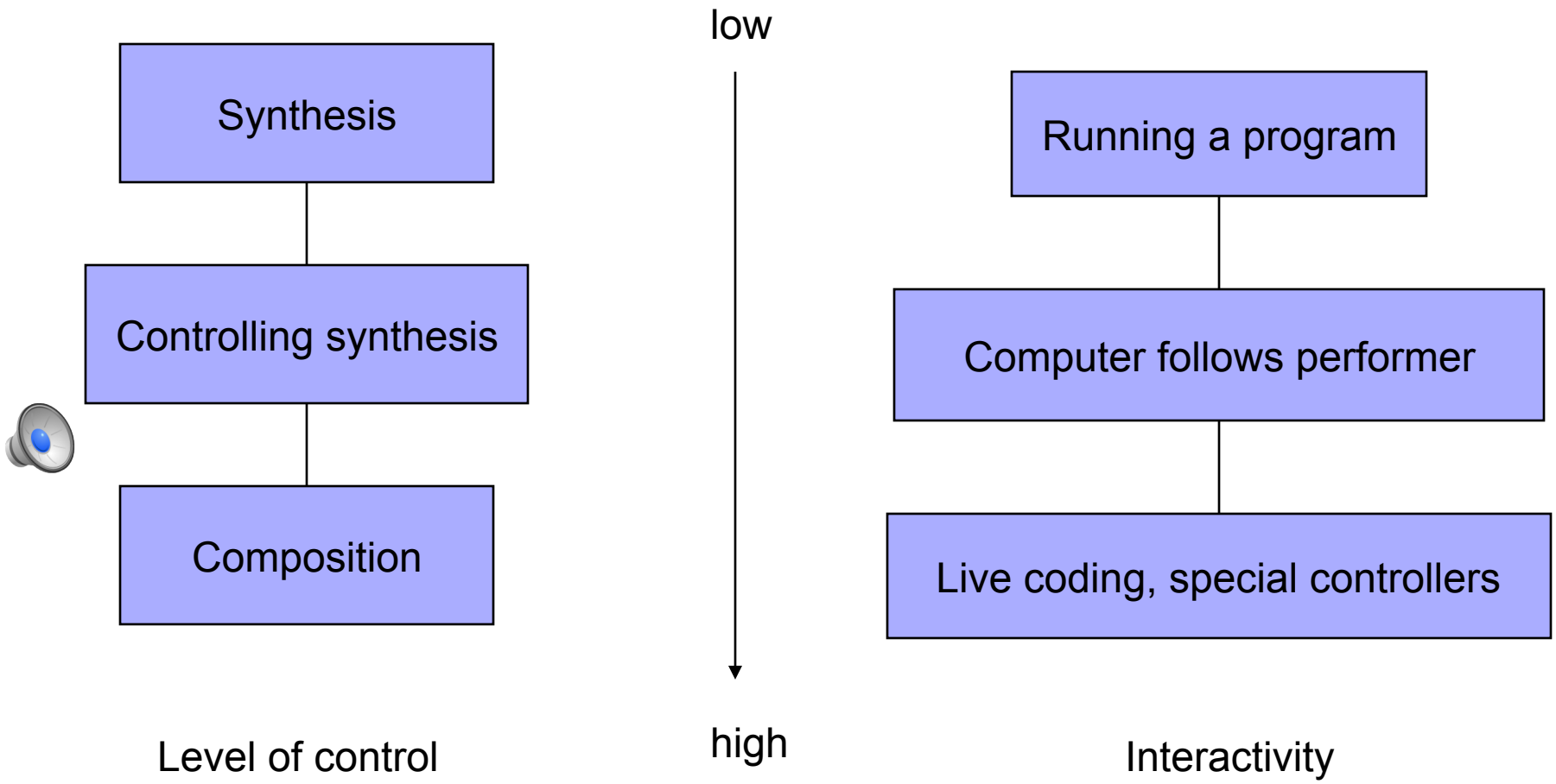


Three approaches to synthesis

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



Continuum of computer music



Performer-Computer Interaction

- Augmented instruments
- Software and hardware interfaces
  - Demo: PLOrk video, PBS
  - Demo: using a Wii-mote to control sound
  - 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/