Spatialized Anonymous Audio for Browsing Sensor Networks via Virtual Worlds

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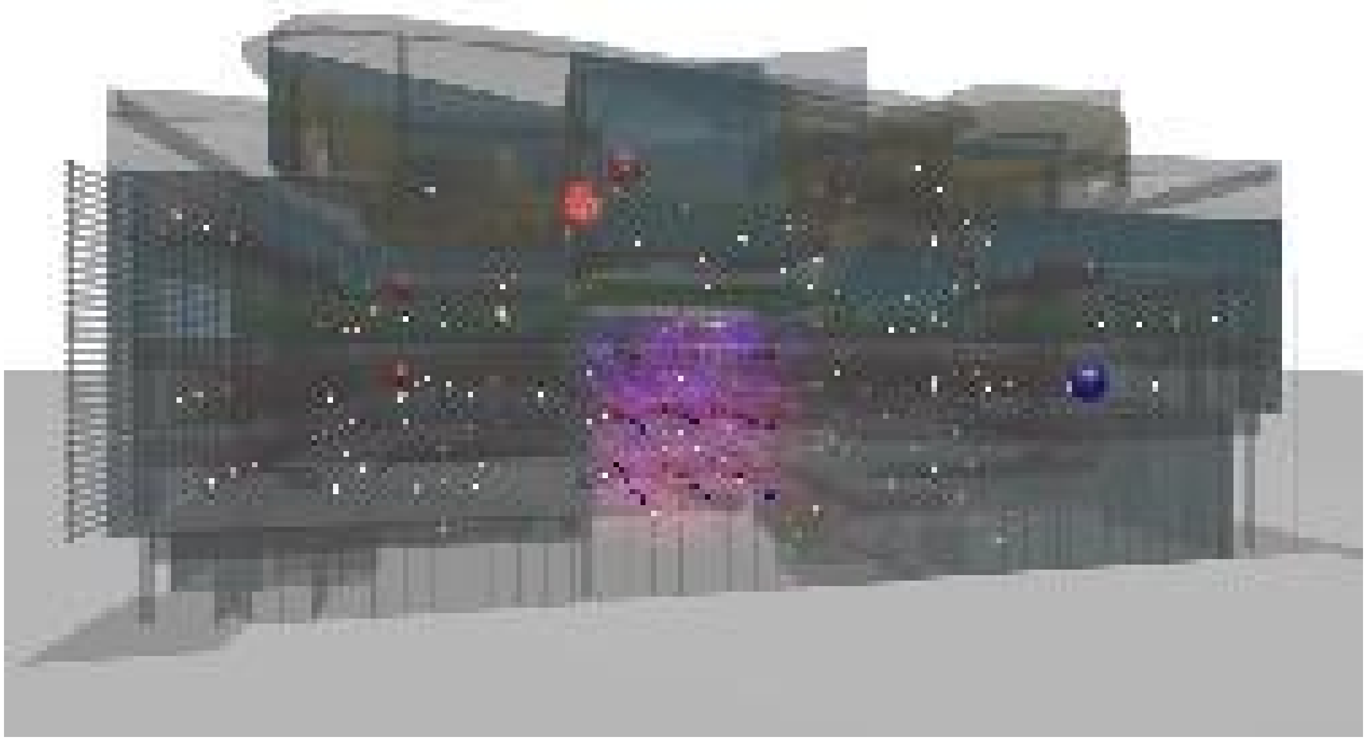
Existing work: DoppelLab

- 3D virtual environment for browsing sensor data
- Temperature, humidity, sound level, movement, opt-in ID recognition, etc.
- Explore trends over larger time scales



Spatialized Anonymous Audio Overview

- Use recorded audio to show activity, immerse user
- Multiple recording locations, spatialized playback
- Privacy; obfuscation
- Realtime and Historical operation
- Time compression, linear and variable-rate

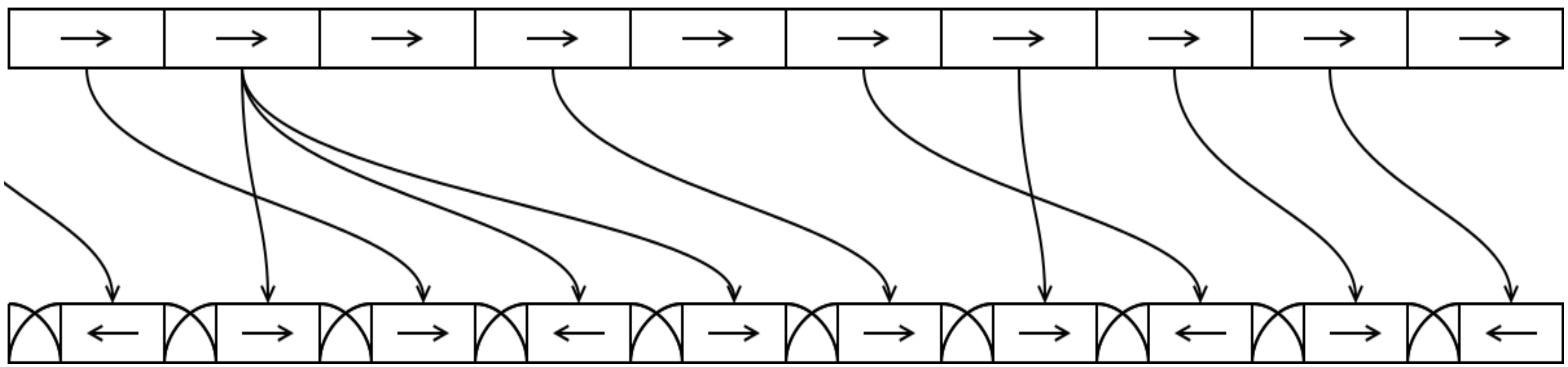
[demo: quick DoppelLab run-through]

Obfuscation I

- Objective:
  - hard to understand speech
  - preserve timbre (can we hear what's happening? how many people are there?)
  - hard to computationally unscramble
- Prior art:
  - Schmandt:
    - Shuffle recent buffers
    - Doesn't address reversibility
  - Lee, Ellis:
    - for certain parameters "virtually impossible" to reverse

Obfuscation II

- Shuffling, crossfading, reversing



- Algorithm runs at audio recording sites, so we don't transmit clear audio
- Computationally lightweight

[demo: obfuscation]

Time Compression

- Goal:
  - Speed up audio fast enough to hear on other time scales
  - Preserving speech is not an issue
  - Preserve timbre, and moments of interest

Time Compression: Algorithm

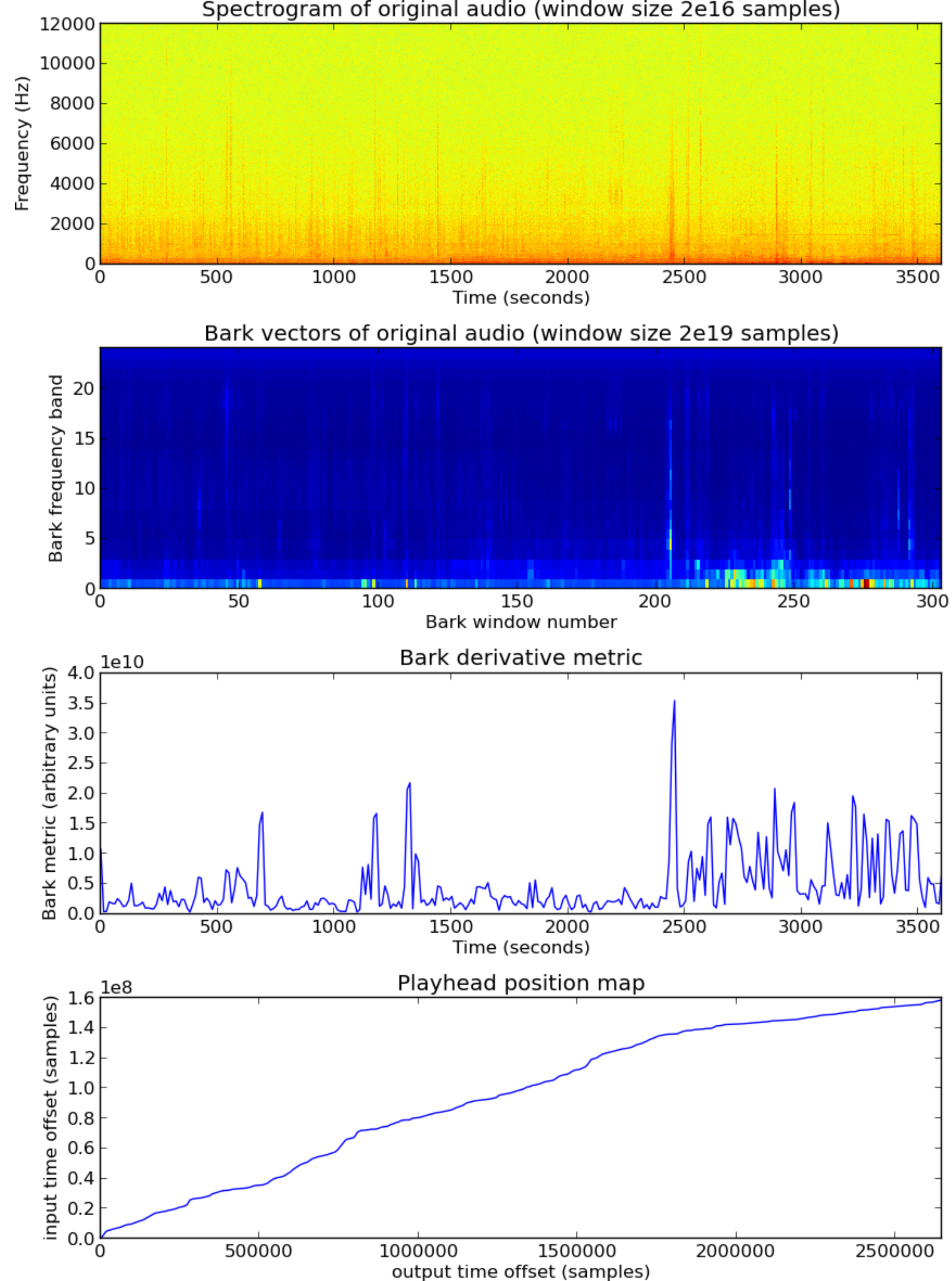
- Granular synthesis around a playhead
  - warp speed, preserve pitch
- Window grains, randomize size
- Move playhead faster than real-time
- Rendered offline, at ratios {60, 600, 3600}

Variable-Rate Compression

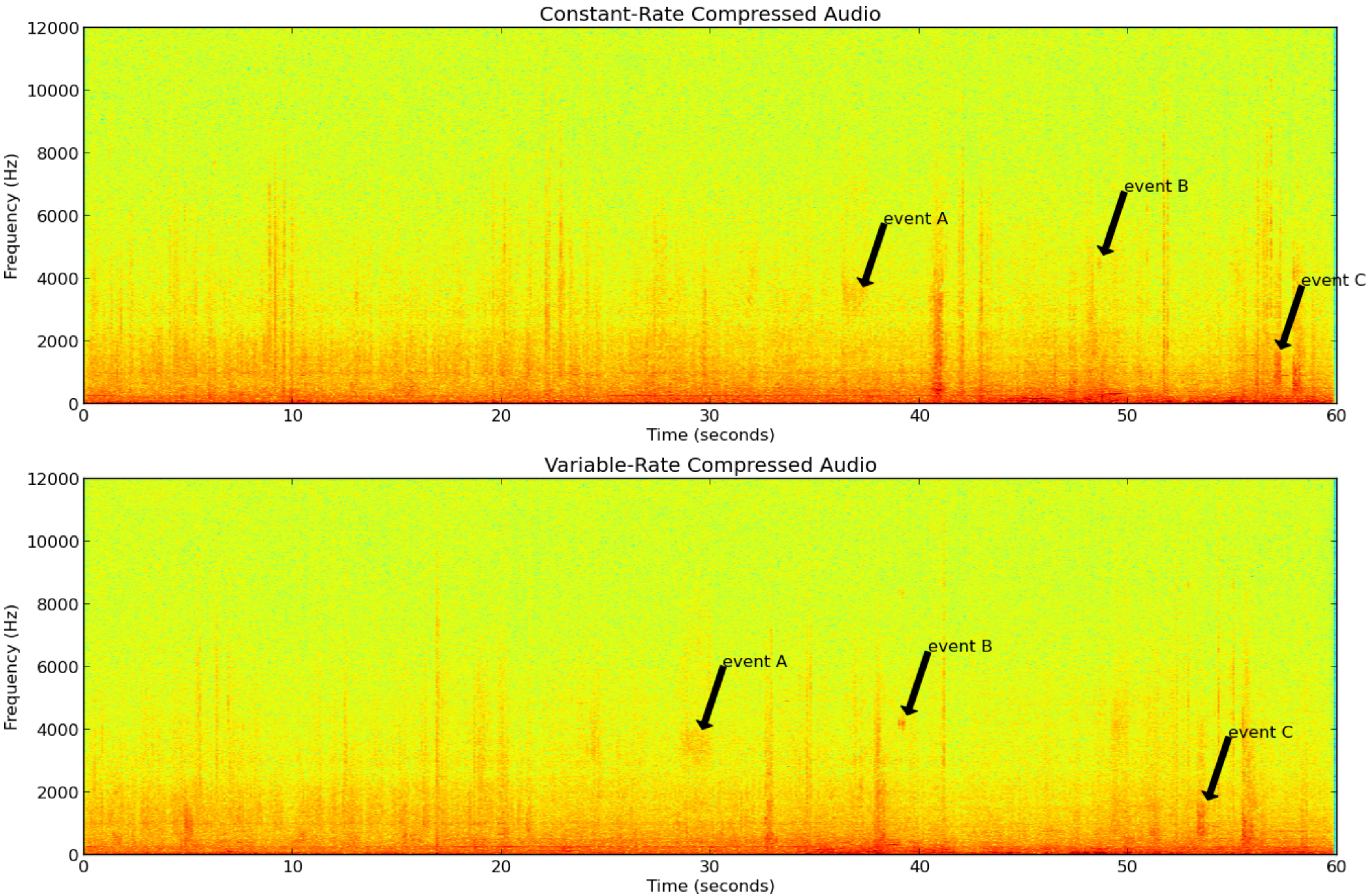
- Spend more time on moments of interest; compress monotonous audio more
- Bark metric bins frequencies according to critical bands of hearing
- Magnitude change in bark vector indicates activity in spectrum or amplitude
- Use that metric to control playhead speed

Variable-Rate Compression

- Playhead speed inversely proportional to Bark magnitude derivative



Linear vs. Variable Compression

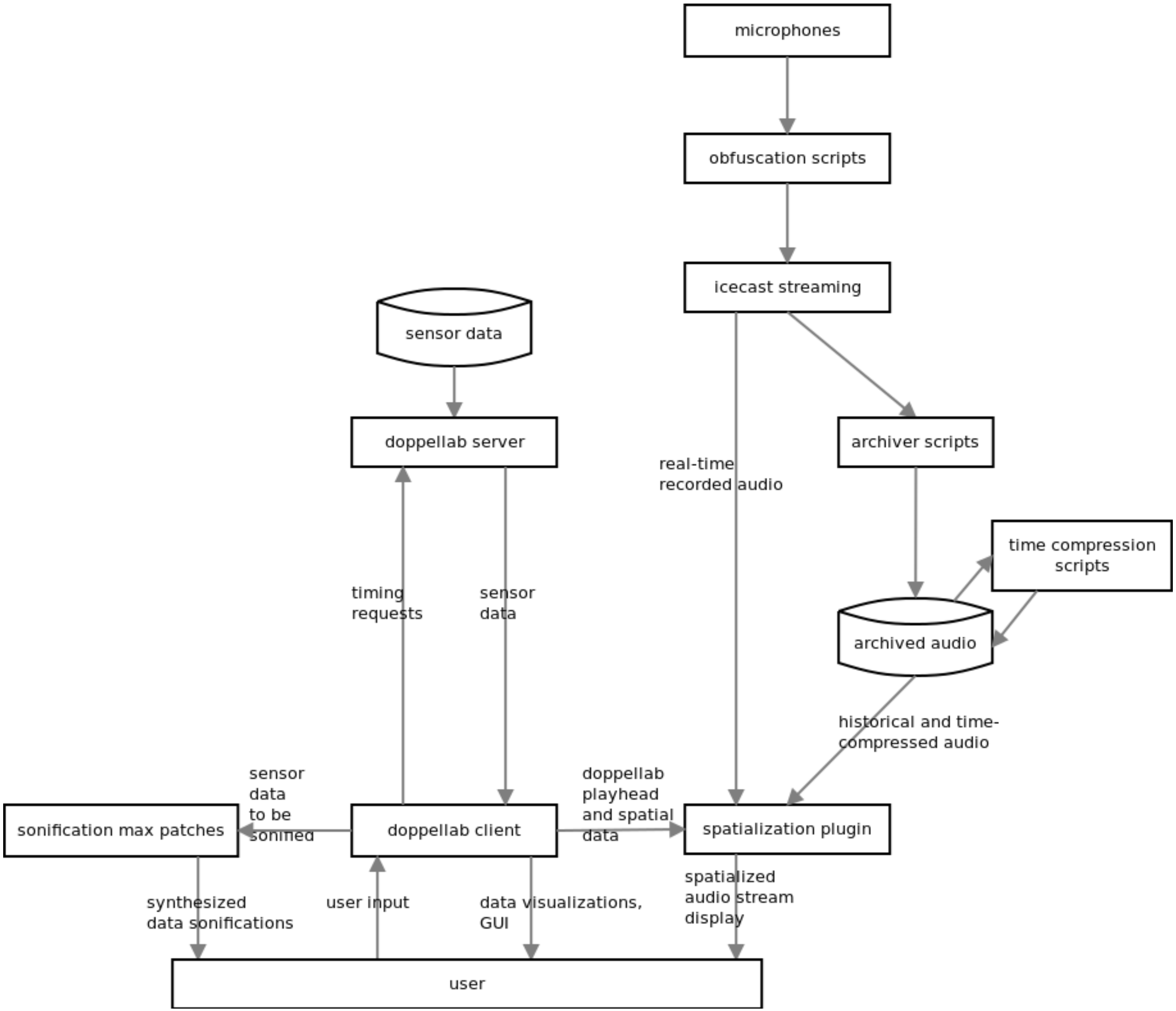


[audio: two compression methods]

Client / UI

- Download audio streams, spatialize relative to avatar
- Spatialization is done using OpenAL, using physical inverse square rolloff
- Stream real-time, historical, or time-compressed data, according to DoppelLab time travel GUI input

System / Implementation



System / Implementation

- Obfuscated ogg/vorbis audio streams to central streaming server
- Archiving scripts save streams in one-minute increments in directory tree
- Time compressed-audio is pre-computed at 4 speeds
- Client asynchronously fetches sequences of one-minute files
- server (archiving, dsp): python, gstreamer, numm.
- client: c, OpenAL

Ongoing & Future Work

- Ongoing: tidmarsh (http://tidmarsh.media.mit.edu) will use similar spatialization and time-compression, for changing outdoor ecosystem
- Audio visualization in GUI (with DoppelLab or standalone)
- Test different time compression parameters
- Spatialization: add some physics (e.g. floors attenuate more than empty space)
- More rigorous study of privacy
- Better audio quality (better mics, dynamic range compression on stream)

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papers, other media

http://resenv.media.mit.edu/sonification