Web-based Sound and Music Games with Activities for STEM Education

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Motivation

- Video game platforms provide unique possibilities for simulating, exploring and visualizing difficult scientific concepts.

- In education, video games can potentially:
  - Create a greater interest in the material
  - Improve the skills practiced, (Shaffer2006)

- Flash provides the ability to rapidly develop rich game interfaces:
  - Not easy to install software on school computers
  - Only requires a browser with internet access
• In previous work, we developed prototype games that use sound and acoustics to explore concepts.

• Through our current work we have developed:
  ‣ Tools for developing prototype activities for science, technology, engineering and mathematics (STEM) in Flash
  ‣ Including dynamic audio processing tools for Flash
    • ALF - Audio processing Library for Flash
    • DATF - DSP Audio Toolkit for Flash
• **Summer Music Technology Program**
  ‣ A week-long program for 24 rising 10th and 11th grade students (ages 15-17)
MET-lab Outreach

- National Science Foundation GK-12 Program
  - School year program for 6th-8th grade teachers and students (ages 11-14)
• National Science Foundation Discovery K-12
  ‣ School year program for 9th-12th grade students (ages 14-18)
MET-lab Outreach

• National Science Foundation Discovery K-12
  ‣ School year program for 9th-12th grade students (ages 14-18)

• Several local high schools
  ‣ Girard Academic Music Program
  ‣ Creative and Performing Arts High School
  ‣ Martha Washington Elementary
Previous Work

• Initially we developed games for collaborative psychoacoustic data collection
  ‣ Hide & Speak
  ‣ Tone Bender

• Involvement in outreach led to desire to integrate educational goals into our activities

• Initial prototypes revealed development issues
  ‣ Inability to use native software (i.e., MATLAB)
  ‣ Audio latency / processing problems
  ‣ Interface problems

• Based on these events, we developed our current platform
Qualitative Feedback

• Our initial activities were used through our outreach programs

• Activities appealed to some students and not others
  ‣ Interested students were highly motivated to continue playing and explore game logic

• Students provided suggestions as to how they would address the confusing aspects of the games

• Feedback led to several iterations of re-design of the prototype web games
Hide & Speak Versions
Hide & Speak Versions

- Structure: Java Applet Only
Hide & Speak Versions

• Structure: Java Applet and Flash Hybrid
Hide & Speak Versions

- Structure: Java Applet and Flash Hybrid
Hide & Speak Versions

- Structure: Flash Only

Flash Application

**ActionScript**
- GUI
- Audio

**Alchemy C Library**
- FFT
- Convolution
- Overlap-Add
Hide & Speak

• Simulates an acoustic room environment
  ‣ Demonstrates the “cocktail party” phenomenon
    • Ability to isolate a voice of interest from other sounds, essentially filtering out background sounds
  ‣ Presents real-time audio processing

• The game explores the relationship between sound and acoustics and the physical environment
  ‣ Moveable sound sources and listener
  ‣ Modifiable room characteristics
  ‣ Sound representative of the actual configuration
Hide & Speak

Hide the Spy

Room 1
Score: 0

5 People in Room
3 Echo Strength

Playback Controls
Submit Room

Audio Analysis
Leaderboard
Legend

Drexel University
Hide & Speak

Find the Spy
Score: 0

Determine if the sample voice belongs to any of the people in the room!
Sample voice: Play
Take a peek in the room:
Room audio: Play

Do you hear the sample voice in the room?
Yes
No

Audio Analysis

Trust Level
Good

Leaderboard

Sample voice: Play
Room audio: Play

Legend
Users attempt to modify the timbre of various musical instruments while retaining identifiability

- Instruments with modified timbre are evaluated to determine salient factors in perception
- Utilizes dynamic audio processing from ALF/DATF

Educational objectives

- Demonstrate how changes in the distribution of acoustic energy over time and frequency affect timbre
- Correlate the changes in the visual spectrum to the perception of the sound
Tone Bender

Graph showing amplitude and time (sec) relationship.
Tone Bender
Tone Bender

Listen to the Instrument

What instrument do you hear?
- bass

Submit Choice

Listening Skill

Score 0
Wave Propagation Activity

• Activity explores:
  ‣ How waves propagate through a medium
  ‣ The time required for a wave to travel from one point to another

• Educational objectives:
  ‣ Calculate wave travel time and the speed of sound
  ‣ Measuring distances using a virtual tape measure while performing necessary conversions
  ‣ Provide a qualitative explanation of how sound waves travel from one location to another
Example Assessment

• Students will:
  ‣ Explain how waves travel from one location to another by drawing a diagram of the waves
    • Diagram should represent the circular (spherical) wave propagation pattern
  ‣ Create multiple configurations that meet a specified time measurement
    • Distance must be calculated
    • Many solutions exist, which enforces the wave propagation concept
Future Work

• Present the newly developed activities in the classroom to obtain feedback from students
  ‣ Will most likely lead to re-designing of lessons
• Provide more customizations for teachers and instructors to monitor students’ performance
• Expand the package of lessons to include more topics from the K-12 curriculum
• Provide a tutorial aimed at educators for creating new applications
References


Questions?