Name(s)

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Project Number

J1508

Project Title

The Science of Music

Abstract

Objectives/Goals

The goal of my project was to determine why the same notes sound different when played on different instruments, and how these differences can be mathematically characterized.

Methods/Materials

The same notes were played on a piano, violin, viola, cello, flute, and voice, recorded, and then analyzed using Matlab and Goldwave software. For each of these six instruments, the envelope and the harmonic characteristics were examined from qualitative and quantitative points of view. This project involved learning methods of harmonic analysis (mathematics, signal processing, and Matlab Software).

Results

The envelope characteristics allow one to distinguish between (a) piano (percussion), (b) voice and string instruments, and (c) flute (woodwind).The harmonic analysis allows one to differentiate between all of the instruments except for the flute and piano.

Specifically, in the experiments, the attack time on the piano was consistently shorter than that of the voice and strings, while the attack time on the flute was consistently the longest. The flute was the only instrument whose envelope showed a periodic structure (vibrato). The harmonic characteristics of a piano and a flute were indistinguishable, and were the closest to a pure synthesized tone. All string instruments had many spectral frequencies present, because of the sympathetic vibration of the strings. In all tests, the cello was the only one with significant subharmonics, and, among these instruments, the viola was unique in having more power in its second harmonic than in the fundamental (first harmonic). The voice had the least power in its fundamental.

Conclusions/Discussion

The envelope and harmonic characteristics of the sound waves enable us to differentiate between the sounds produced by different instruments. This research suggests that an electronic device can be built that would train a beginning string instrument player to position his or her bow and fingers correctly on the instrument to produce notes correctly. Although this is not necessarily a great contribution to humanity, it could help to save young musicians and their parents from much frustration.

Summary Statement

I recorded the same pitches played on six different instruments, and analyzed them using a computer to discover why different instruments sound different.

Help Received

Dad acted as a mentor--wrote computer programs and showed me how to use Matlab and Goldwave software; musicians from the Music and Arts Conservatory of Santa Barbara played notes for me to record; parents edited report; Dr. Kuchera-Morin of UCSB gave an interview about computer music and