PROJECT TITLE: A Simple Timbre Detector

Project Members

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Problem Statement

Timbre is the quality of sound that distinguishes a particular musical sound from another, even when they have the same pitch and loudness. The American Standards Association definition 12.9 of timbre describes it as, "...attribute of sensation in terms of which a listener can judge that two sounds having the same loudness and pitch are dissimilar," and adds "...Timbre depends primarily upon the spectrum of the stimulus, but it also depends upon the waveform, the sound pressure, the frequency location of the spectrum, and the temporal characteristics of the stimulus." (American Standards Association 1960, 45).
Most of the time, timbre is referred to as a subjective quality rather than something that can be measured without human help, unlike pitch and amplitude. The motivation of this project is to automatically detect musical timbre features from various simple sound samples (e. g. monophonic, short, of limited instrument types), and to map them to musical instrument classes as best as we can.

Introduction

To detect objective features of timbre from audio, J. F. Schoutien suggested five acoustic parameters to be related to timbre:

- The range between tonal and noise-like character
- The spectral envelope
- The time envelope in terms of rise, duration, and decay (ADSR-attack, decay, sustain, release)
- The changes both of spectral envelope (formant-glide) and fundamental frequency (micro-intonation)
- The prefix, or onset of a sound, quite dissimilar to the ensuing lasting vibration

We have found several research papers regarding timbre detection. Various acoustical features are analysed to find a viable method to extract timbre information in [1]. MPEG7 descriptors are the most popular and they are based on latest research [1].
In [2], a machine learning approach is presented to extract a musical instrument from a complex music using timbre classification. Influenced by these and considering our limited time to work on at this project, we decided to restrict our feature set so that we only include spectrogram features of the audio.

Methodology

We are planning to extract timbre-related properties of musical sound by using the FFT and low level MPEG7 descriptions such as spectrum centroid, spectrum spread, log attack time. After extracting the features, we aim classifying a sound as one of the four main families of instruments which share these features to most extent: strings, woodwinds, brass and percussive instruments.

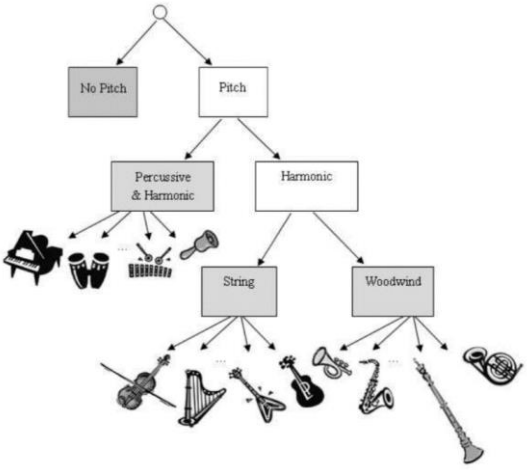

Figure 1: A possible method of classifying instruments with timbre

The two key determinants of the timbre of musical instruments that can be derived easily from spectrogram are as follows:

- energy distribution over the fundamental frequency and harmonics,
- the nature of attack -which describes how fast the energy is dissipated.

We believe using these two fundamental aspects of spectrogram will provide substantial information and enable us to detect the instrument class with a respectively low error rate.

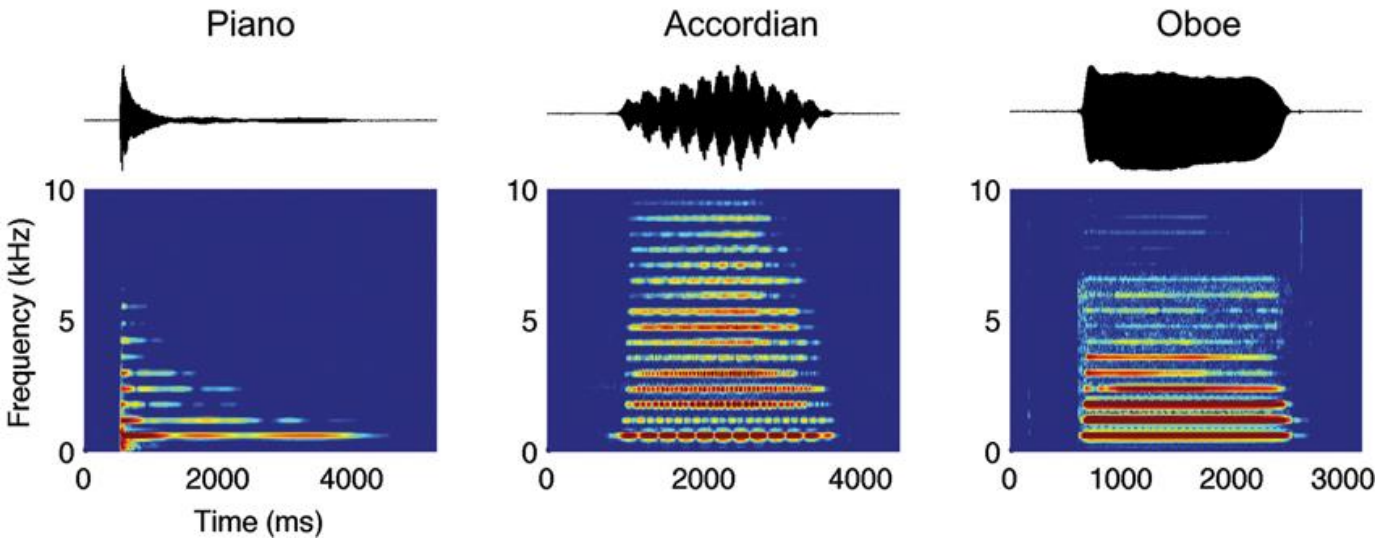

Figure 2: Spectrogram characteristics of three instruments. Note that both nature of attack and the distribution of energy in harmonics differ to the most extent.

Time Schedule

We plan to start working with analysing spectrum of audio and detecting harmonic features for different instruments. We are aware that we picked up a topic that may not possible to finish in the eight weeks we propose. Depending on how long it takes us to achieve building a harmonic features detector, we may end the project with only one feature (harmonics) for classification, rather than using exhaustive algorithms. At the first stage, we aim to finish harmonic features extractor within first 4 weeks, and then build an algorithm to classify samples using one feature space.

References

[1] *Zhang, Xin, and W. Ras Zbigniew. "Analysis of sound features for music timbre recognition." 2007 International Conference on Multimedia and Ubiquitous Engineering (MUE'07). IEEE, 2007.*

[2] *Park, Sang Hyun. "Musical Instrument Extraction through Timbre Classification." NVIDIA Corporation Santa Clara, CA 95050.*

[3] *Zhang, Cynthia Xin, and Zbigniew W. Ras. "Differentiated harmonic feature analysis on music information retrieval for instrument recognition." GrC. 2006.*

[4] *Town, Stephen M., and Jennifer K. Bizley. "Neural and behavioral investigations into timbre perception." Frontiers in systems neuroscience 7 (2013).*