Multiple Fundamental Frequency Estimation Based on Harmonicity and Non-negative Matrix Factorization

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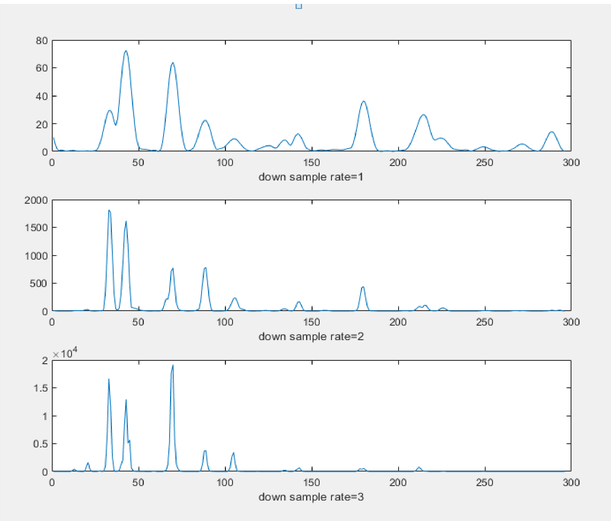
INTRODUCTION

- Fundamental frequency estimation is an important part in understanding sounds. In the music which has only single instrument, there are several computational method to get the fundamental frequency, for example, Yin algorithm, and non-negative matrix factorization. However, for the music with several instruments plays simultaneously, the task became difficult. We proposed a mixed method that using its harmonic structure and NMF to estimate pitches from music played by multiple instruments.

METHOD

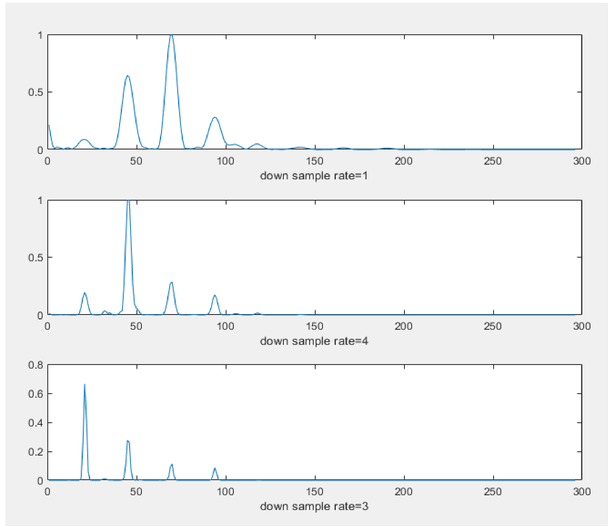
- Using harmonic structure to detect the first step result
  - Down-sample the original by different integer factors
  - Multiply them together
  - The remained peak are the pitches
- Using non-negative matrix(NMF) to get a more accurate result



Down-sample and multiplication result without filtering

HARMONIC STRUCTURE

- For instrument, its spectra has peak not only at fundamental frequency, but also at frequency that is integer times than fundamental frequency.
- By down-sample the original signal and multiply them together only the peak at fundamental frequency will remain.
- Since some instrument has the strongest peak at second harmonic, need to use filtering method to avoid detecting the second harmonic.

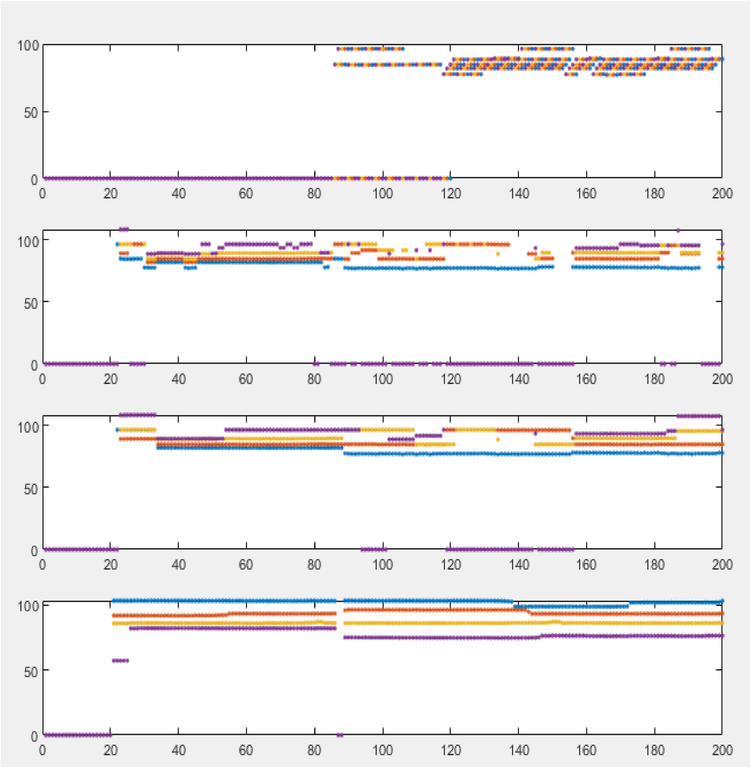


Down-sample and multiplication result with filtering

NMF

- Find continuity from the result of first step
  - If a pitch last only one frame than it must be a wrong detection
  - Every score in the music is longer than 70ms
- Decompose the spectrogram by segment detected from continuity
- Only pick the pitch that is similar to the result in first step

CONTINUITY DETECTION



The first figure shows the original result from step 1 without any filtering
The second figure shows the result by employing the first constrain
The third figure shows the result by employing the second constrain
The forth figure shows the ground truth pitch

CONCLUSION