1. Introduction

- We investigate piano acoustics and compare the theoretical temporal decay of individual partials to recordings of real-world piano notes from the RWC Music Database.
- The energy of piano tones decreases over time, causing problems for piano analysis, such as offset detection. We would expect that modelling decay will help to improve performance of piano analysis applications.

2. Background

- Double decay and beats are well-known phenomena caused by the interaction between strings and soundboard.
- In a grand piano the string is set into a vertical motion after being struck. Due to the coupling of bridge and soundboard, the plane of vibration gradually rotates from vertical to horizontal motion which decays more slowly, referred to as a typical double decay of the piano.
- Detuning between strings causes a coupled oscillation. If the detuning is small, the coupled motion will result in a double decay. When the detuning is large, beats appear. In this case, the decay becomes a decaying periodic curve.

3. Partial Detection

- Given inharmonicity coefficient B, the partial frequencies are given by
  \[ f_n = n f_0 (1 + B n^2)^{1/2} \]
- Parameters B and f0 are estimated in a parametric non-negative matrix factorization framework.

4. Decay Modelling

- Linear regression
  - Multi-phase linear regression?
  - Non-linear curve fitting

5. Results

- We compare the average coefficient of determination, R², between the linear and mixed model (best among the three models). The mixed model has a better fit to the data by 15 percentage points.

6. Conclusions

- We model the decay of piano notes based on piano acoustics theory.
- The use of non-linear models provides a better fit to the data, especially for low-pitch notes.
- The decay response of the piano shows various decay rates along the frequency range.
- Dynamics have no significant effect on the decay rate.

Future work: use decay modelling for offset detection and other music analysis applications.

Acknowledgement

Tian Cheng is supported by a China Scholarship Council PhD Scholarship. Matthias Mauch is funded by a Royal Academy of Engineering Research Fellowship. This work is supported by an EPSRC Platform Grant EP/E045235/1.

References

1. https://code.soundsoftware.ac.uk/projects/inharmonicityestimation