On the use of elements of piano notes to improve the identification of polyphonic piano sounds

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Abstract: An original algorithm for identifying polyphonic piano sound signals, based only on the use of frequential positions of note partials, has been developed by the authors (1). This paper presents a study of the evolution of the amplitude of piano notes' partials and their energy, carried out to see if these elements can be used to improve the identification of notes in cases like short notes, long notes, repeated notes and polyphonic sounds. In the case of monophonic sounds, Doval (2) has shown that the evolution of the amplitude of piano notes' partials along with their frequency variations can be used to identify the fundamental frequency of signals. The case of polyphonic piano sounds (several notes played simultaneously on the same piano) is more difficult, but if a particular behavior of partials belonging to a given note could be detected, for example synchronous variations or typical amplitude evolution, the sorting of partials would be more reliable, the identification of notes more efficient, and the detection of notes' onsets more precise.

INTRODUCTION

The aim of this paper is to determine if elements like the temporal evolution of the amplitude of piano notes' partials can be used to identify piano notes in different cases such as isolated notes, repeated notes or polyphonic sounds. The complex spectrum of the sound analyzed is first computed via a 32768 point FFT. The relevant part of the spectrum containing the partial to study is next band pass filtered with a ±5 Hz gaussian filter, and an inverse FFT is performed to obtain the temporal evolution of the desired partial. The amplitude of the partial is then obtained with the help of the analytical signal associated with the partial.

REPEATED NOTES

A study of repeated notes was carried out in order to find out if the temporal evolution of the amplitude of the partials could be used in a note identification method by obtaining, for example, a model of evolution. For these experiments, a given note was played twice with the same intensity and with a variable delay between the note onsets, and the temporal evolution of the amplitude of a given partial obtained when the note was played once was compared with the evolution obtained when the note was repeated. The examples shown (two in Figure 1) are those of partial #1 of notes C1 and C4.

![Figure 1: Temporal evolution of the amplitude of partial #1 of notes C1 and C4 played twice.](image-url)
After the second onset, there is not a systematic increase in the temporal evolution of the amplitude of the partials. An increase or a decrease can be observed in the evolution of the amplitude of the partials depending on the delay between the first and the second onset and the perturbation is such that evolution of the amplitude is completely different from the one obtained when the note is isolated. These various behaviors are due to phase differences between the already existing partial and the new excitation and do not allow the elaboration of a model of the evolution of amplitude.

**POLYPHONIC SOUNDS**

In the case of polyphonic sounds, the interaction of partials pertaining to different notes can occur even if they do not have exactly the same frequential position. Figure 2 shows the perturbation which occurs in the temporal evolution of the amplitude of partial #10 of note C1 when note A1 is played after C1 with a variable delay between the note onsets. The "closest" partial of note A1 is situated 2 Hz from the observed partial.

![Figure 2: Temporal evolution of the amplitude of partial #10 of note C1 when note C1 and A1 are played successively with a variable delay between the note onsets.](image)

For each delay, the perturbation is significant and different from the others and does not allow the elaboration of a model of the evolution of the amplitude. The phenomenon which occurs in this case is the same as in the case of repeated notes and according to our tests the interaction between two partials pertaining to different notes is not negligible even for a difference gap of 20 Hz between the frequential positions of the partials. It is thus difficult to use the temporal evolution of the amplitude of a partial to attribute it to a given note. Another point must be underlined: the use of the value of the amplitude of a partial at a given instant is difficult because this value can include the influence of partials pertaining to other notes.

**CONCLUSION**

In the case of polyphonic sound signals or even in the simple case of repeated monophonic sounds, the amplitude of partials is disturbed by the many interactions which can occur when a note is played twice or more, or when partials pertaining to different notes are close in frequency domain. The amplitude of the partials is thus not a dependable parameter and cannot be used alone in an identification procedure.

**REFERENCES**