# TOWARDS THE DETECTION OF PIANO PEDALLING TECHNIQUES FROM AUDIO SIGNAL

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## ABSTRACT

A particular direction in Automatic Music Transcription is to retrieve the playing techniques from music performances. This paper presents a framework for piano pedalling technique detection. We focus on instrument-specific analyses in order to make better use of knowledge about the physics and acoustics of pianos. A dataset has been created for training and testing purposes. We propose to train statistical models by integrating acoustic features, describing how signals are affected by various pedal effects, with a harmonic change value, revealing the likelihood of a pedal transition point according to musical grammars. The onset/offset time and the depth of a pedalling are expected to be derived from the trained models.

## 1. INTRODUCTION

Automatic detection of playing techniques from audio signal is challenging as it is comprised of subtle nuances of instrument timbres, for instance, in the particular case of the piano, the use of pedals. There have been many experiments in more explicit pedalling notations, but real standardisation for piano scores has not emerged yet. Even if pedal markings are given, pianists agree that pedalling in the same piano passage can be executed in many different ways [4]. Reliable detection of piano pedalling techniques can benefit many applications, including piano pedagogy, interactive performance and music information retrieval.

Modern pianos usually have three pedals which are commonly referred to as the una corda pedal, the sostenuto pedal, and the sustain pedal. The una corda pedal in grand piano is functioned by shifting the keyboard and hammers to the right so that one less string would be struck. This can decrease the loudness, but the more significant effect is the change in timbre. Unlike the grand piano, the una corda pedal of the upright piano makes the output sound softer through moving the action closer to the strings. The purpose of the sostenuto pedal can be varied with the instrument. In most modern grand pianos, the sostenuto pedal only sustains dampers that are lifted when the pedal is engaged so that the chosen notes can keep ringing. In some upright pianos, the tone is softened with a piece of felt which is lowered between the hammers and the strings, which makes the pedal act as a practice pedal. The sustain pedal is the most frequently used pedal. It lifts all dampers and sets all strings into vibration due to sympathetic coupling. There are three main techniques considering the timing of the sustain pedal with respect to the note onset: anticipatory, rhythmic and legato pedalling. Pianists also apply other pedalling techniques that change as a function of the depth of pedals. This part-pedalling enables pianists to subtly colour the resonance.

Our goal is to develop a detection method of the pedalling techniques mentioned above from audio signal. This is based on learning of empirical data that is previously collected with a non-intrusive sensing system. The learning consists of training of statistical models with a dataset of multi-modal data from piano performances. No sensors should be required once the detection system is trained. This method could also apply to the playing techniques detection on other instruments. In this paper we present the initial study on isolated notes as a starting point.

## 2. DATASET

Since there is no publicly available dataset for piano pedalling techniques detection across different tones and velocities, we build our own dataset of MIDI-annotated piano recordings. It is composed of isolated notes, repeated notes, trills, arpeggios and pieces of music played normally as well as using different pedalling techniques. Specifications with different pedalling conditions were encoded as standard MIDI files and then audio was generated using a reproducing piano. This provided fully-automatic and reliable annotation for our audio dataset. The recording was carried out at the Yamaha recording studio in Milton Keynes, United Kingdom, in March 2017. The instrument was a Yamaha Disklavier grand piano. The tones were recorded using the spaced-pair stereo microphone technique with a pair of Earthworks QTC40 omnidirectional condenser microphones positioned about 50 cm above the strings. The positions were kept constant during the recording. The signals were recorded with a sampling rate of 44.1 kHz and a resolution of 24 bits.

## 3. METHODS

Figure 1 illustrates the schematic overview of the proposed system. This has three main stages, where the last two are still work in progress. Firstly, pitch and duration information written in the score are detected by a piano-specific transcription system [1] based on non-negative matrix factorisation (NMF). For each detected note event, we perform harmonics plus residuals decomposition between its onset and offset, in which we initially find the frequencies of harmonic partials of each note, taking inharmonicity into account. We then obtain the residuals by subtracting the harmonic components from the original sound. After feature extraction, acoustic features are used through modelling variation in harmonics and residuals due to pedal use. Secondly, as pedalling is mainly changed with the harmony of of music, the performance of pedalling onset/offset detection should improve if this interrelationship is taken into consideration. Harmonic change value is devised to integrate chord transition and bass pitch estimation from NNLS chroma features [3]. This could indicate the likelihood of harmonic change. Finally, a trained statistical model utilise both the acoustic features and harmonic change value to detect the pedalling techniques from the audio signal recorded on the same piano which is previously used for training.

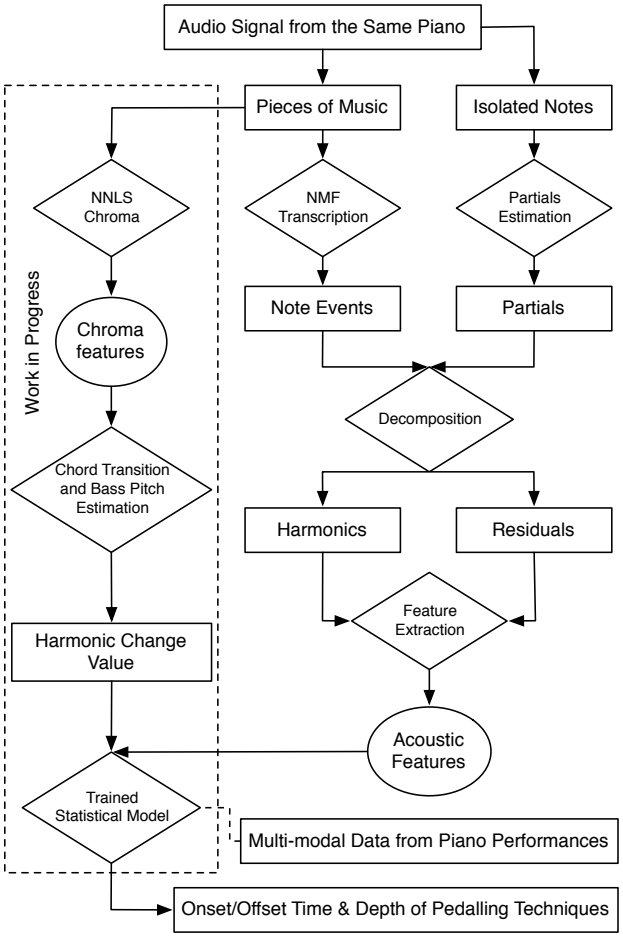


**Figure 1**. Schematic overview of the proposed piano pedalling techniques detection system.

## 4. EXPERIMENTS

We implemented the detection using isolated notes as a starting point [2]. By using the acoustic features extracted from harmonics and residuals, a model using decision-tree-based SVMs was trained to classify the notes into normal, anticipatory full, anticipatory half, legato full and legato half pedalling techniques. The effectiveness of our classifier was demonstrated using cross-validation. A mean F-measure score of 0.867 and 0.875 was obtained for classification of notes in mid-lower and mid-upper region separately. The results indicate that the current method is able to detect the pedalling techniques for single notes in the middle range of the piano.

## 5. CONCLUSIONS

We introduce a method for the detection of piano pedalling techniques from audio signal. A preliminary study on isolated notes exploited useful acoustic features. Further research will solve pedalling detection in the context of polyphonic piano music. This will take account of the interrelationship among musical elements in order to facilitate the development of our musically-motivated statistical model.

## 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

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