# GROUP DELAY BASED AUDIO ONSET DETECTION

**P A Manoj Kumar, Jilt Sebastian, Hema A. Murthy**
Indian Institue of Technology Madras

## ABSTRACT

This extended abstract describes an audio onset detection algorithm based on minimum phase group delay processing and amplitude frequency demodulation

## 1. INTRODUCTION

The work was inspired by the need for very accurate onset detection in the case of Carnatic (south Indian classical) percussion instruments. Group delay functions have been employed earlier for segmentation tasks in speech signal processing, and have been extended to onset detection task in this work. The audio signal is treated as an amplitude and frequency modulated waveform. Demodulation is carried out to extract the necessary information and onset locations are emphasized using group delay functions. The algorithm has been tested extensively on Carnatic percussion instruments and is introduced to other types of onsets through this submission.

## 2. THEORY

### 2.1 AM-FM Demodulation

In the context of communication theory, any message signal $m(t)$ is modulated with a high frequency carrier signal $c(t)$ before transmission. Various modulation techniques exist based on the effect of $m(t)$ on $c(t)$. Expression for a typical signal which is modulated with amplitude and frequency is given by,

$$s(t) = m(t)cos(w_c t + k_f \int m'(t)dt) \tag{1}$$

where, $cos(w_c t)$ is the carrier and $m(t)$ and $m'(t)$ are the modulating signals. This on taking derivative with respect to time, gives instantaneous change in frequency as a part of it's amplitude. Hence, an envelope detector is necessary to extract information about the message signals.

Any real time signal $S(t)$ with Fourier transform $S(w)$ can be represented by its analytical version [1] and is given by

$$S_a(t) = 2\int_0^\infty S(w)exp(j2\pi wt)dw \tag{2}$$

Hence, it is the inverse Fourier transform of positive frequency part alone. In terms of input signal $S(t)$,

$$S_a(t) = S(t) + iS_H(t) \tag{3}$$

where, $S_H(t)$ is the Hilbert Transform of $S(t)$. Real part of an analytical signal represents the actual signal and imaginary part is it's Hilbert Transform. The real and imaginary parts of analytical signal, when added in quadrature, result in a straight line along the top of the peaks. Thus magnitude of analytical signal gives the envelope of the input signal. This property is used in AM Demodulation Scheme [2].

$$|S_a(t)| = \sqrt{S(t)^2 + S_H(t)^2} \tag{4}$$

where, $S(t)$ and $S_H(t)$ are input signal and it's Hilbert transform respectively.

Carnatic percussion strokes are observed to resemble AM-FM modulated signals. Hence, the derivative of the music signal is computed which emphasizes the frequency component in the amplitude. An envelope detector based on Hilbert transform is applied.

### 2.2 Group delay processing

Although the phase spectrum of a signal contains similar or complementary information compared to that of the magnitude spectrum of the signal, it is seldom used owing to the phenomenon of wrapping (only principal values of the phase are available $[-\pi, +\pi]$). On the other hand, the group delay function which is defined as the negative derivative of the phase spectrum has been used in a number of applications in speech signal processing, in particular, for segmentation of speech signals at the syllable level in [4]. In this work, the envelope of music signal, being positive, is treated as magnitude spectrum of some signal. The causal portion of it's inverse Fourier transform is minimum phase [3] and group delay is computed.

## 3. RESULTS

Results will be added after evaluation.

## 4. CONCLUSION

A simple onset detection algorithm employing group delay functions is presented. Being developed for percussion instruments, it's performance is evaluated for other genres in this submission.

## 5. REFERENCES


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