

# Analysis of Cry in New Born Infants

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**Abstract:** The acoustic analysis of infant cry is used to deduce information on the state of health of new-born babies as well as of children a few weeks old. Crying is the first tool of communication for an infant. These cries seem to be uniform, but there are a lot of differences between two infant's cries. Infant cry characteristics reflect the development and possibly the integrity of the central nervous system. The preterm infants and infants with neurological conditions have different cry characteristics like fundamental frequency, when compared to healthy full term infant. There are differences between full term and preterm infant in their neuro-physiological maturity and its impact on their speech development. Cry characteristics of New born infant, changes with increase in age. Acoustics analysis of infant cry signals can thus give an aid to clinical diagnosis and prevention of distress since it is easy to perform, cheap and completely non-invasive. Hence, this paper aims at pre-processing to eliminate silenced region of cry signal and estimating the fundamental frequency (pitch) using time domain and frequency domain analysis. Such parameters are of interest in exploring brain function at early stages of child development, for the timely diagnosis of neonatal disease and malformation.

**Keywords:** Fundamental frequency, Formants, Cry characteristics, Cry signal

## I. INTRODUCTION

Cry is not just an infant behavior, but rather it is a part of a behavioral system in the human species that assures survival of the helpless neonate by eliciting others to meet basic needs. The cry signal results from coordination among several brain regions that control respiration and vocal cord vibration from which the cry sounds are produced. There is a relationship between acoustic characteristics of the cry and diagnoses related to neurological damage, Sudden Infant Death Syndrome, prematurity and substance exposure during pregnancy. Assessment of infant cry provides a window into the neurological and medical status of the infant. Assessment of infant cry is brief and noninvasive and requires recording equipment and a standardized stimulus to elicit a pain cry. It involves 30 seconds of crying from a single application of the stimulus. The recorded cry is submitted to an automated computer analysis system that digitizes the cry and either presents a digital spectrogram of the cry or calculates measures of cry characteristics. The most common interpretation of cry measures is based on deviations from typical cry characteristics. Infants with abnormal cries should be referred for a full neurological evaluation. Crying is a biological siren, alerting the care giving environment about the needs and wants of the infant and motivating the listener to respond. There are two key aspects of cry (1) the cry itself, which is innervated by the cranial nerves modulating the autonomic nervous system and signals emergency status, and (2) the salience of the cry to any potential caretakers in the environment, producing a visceral reaction that compels action.

## II. METHODS

### A. "Cry": An Acoustic Signal

Infant crying comprises the rhythmic alteration of cry sounds (utterances) and inspirations. Crying is part of the

expiratory phase of respiration with sound or phonation produced by the larynx, which contains the vocal cords or folds and glottis (opening between vocal folds). The larynx has three functions: swallowing, breathing (glottis is fully open), and voice production (glottis is closed). When air is forced through adducted (closed) vocal cords, the increased air speed due to passage through a constricted tube, results in a drop in air pressure, causing the vocal cords to open and close rapidly (approx. 250 to 450 Hz or cycles per second in a normal healthy newborns). This vibration is the **fundamental frequency (f<sub>0</sub>)** and is heard as the pitch of the cry. In addition to f<sub>0</sub>, the lower vocal track produces sound characteristics such as loudness, and the rhythm of expiratory cry sounds and inspiration, which includes inhalation as well as breath holding. The upper vocal tract shapes the sound to produce resonant frequencies or formants (frequency bands above f<sub>0</sub>). The infant vocal tract is smaller than the adult vocal track.[2]

There are three identifiable cry modes of vocal fold vibration: basic cry or phonation or fundamental frequency (f<sub>0</sub>), high pitch cry or hyper-phonation (1000 to 2000 Hz), and noisy or turbulent cry (dysphonation). The brainstem controls the contour and cross-sectional airway of the supraglottal system, which shapes formant frequencies. Only the first two formants are usually measured: The first formant (F1) occurs at approximately 1100 Hz and the second formant (F2) at approximately 3300 Hz.

### B. Estimation of Fundamental Frequency

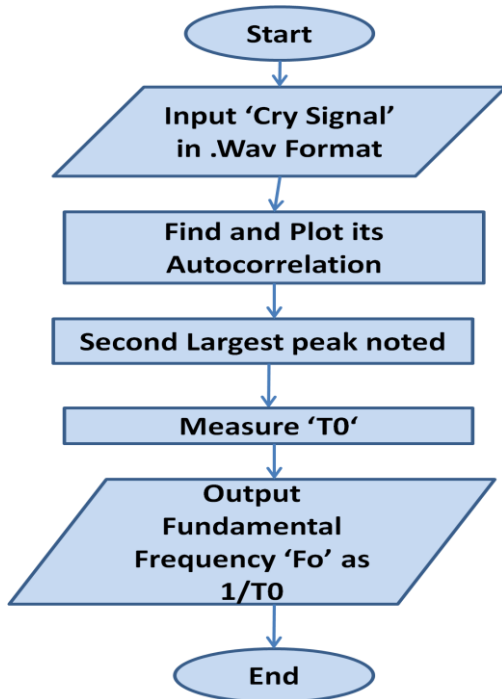
Speech signal can be classified into voiced, unvoiced and silence regions. The periodic vibration of vocal folds is excitation for the production of voiced speech. The random like excitation is present for unvoiced speech. There is no excitation during silence region. Unvoiced

sounds, or turbulences, are produced by forcing air through a constriction in the vocal tract, and voiced sounds are generated by forcing air through the glottis. The voiced regions look like a near periodic signal in the time domain representation.

The periodicity associated with such segments is defined is 'pitch period  $T_0$ ' in the time domain and 'Pitch frequency or Fundamental Frequency 'fo' in the frequency domain. Pitch is an important attribute of voiced speech. It contains speaker specific information.

**C. Method 1: Pitch estimation by Autocorrelation method (Time domain Analysis)**

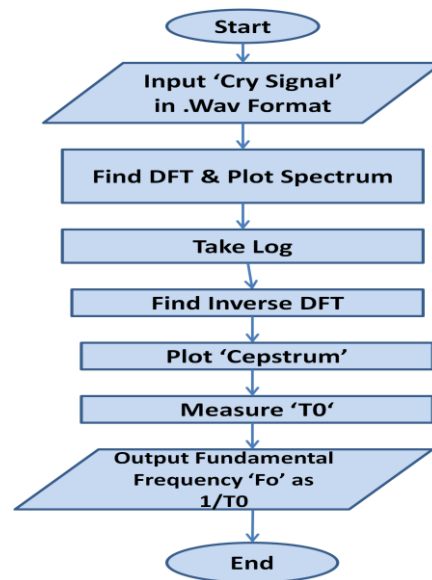
The information about pitch period ' $T_0$ ' is more pronounced in the autocorrelation sequence of voiced speech compared to the speech segment itself. The second largest peak is the autocorrelation sequence, represents ' $T_0$ ' and can be picked up easily by a simple peak picking algorithm. There is no prominent peak in the case of unvoiced speech. This is the fundamental distinction between voiced and unvoiced speech. Speech pitch is typically in the range 100-400 Hz and accordingly the pitch in the range 2.5-10 msec. Therefore for the estimation of pitch, the largest peak in the partial autocorrelation sequence starting from 2.5 msec lag is found out and its distance with respect to zero lag is measured as pitch peak ' $T_0$ '. Once  $T_0$  is known, then pitch can be computed as  $1/T_0$ . The flowchart is as shown.



**D. Method 2: Cepstrum Pitch Determination method (Frequency domain Analysis)**

Main limitation of pitch estimation by the auto correlation of speech is that there may be peaks larger than the peak corresponding to the pitch period  $T_0$ . As a result there may

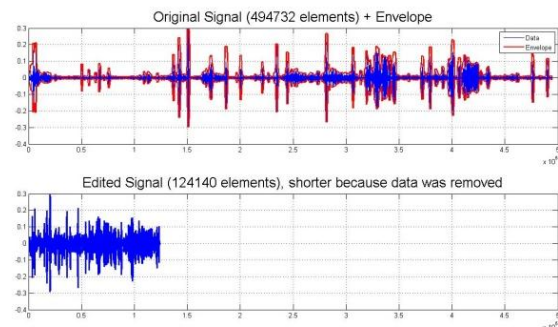
be picking of wrong peaks and hence wrong estimation of pitch. The approach to minimize such errors is to separate the vocal tract and excitation source related information in the speech signal and there use the source information for pitch estimation. The cepstral analysis of speech provides such an approach. The cepstrum of speech is defined as the inverse Fourier transform of the log magnitude spectrum. The cepstrum projects all the slowly varying components in log magnitude spectrum to the low frequency region and fast varying components to the high frequency regions. In the log magnitude spectrum, the slowly varying components represent the envelope corresponds to the vocal tract and the fast varying components to the excitation source. As a result the vocal tract and excitation source components get represented naturally in the spectrum of speech.



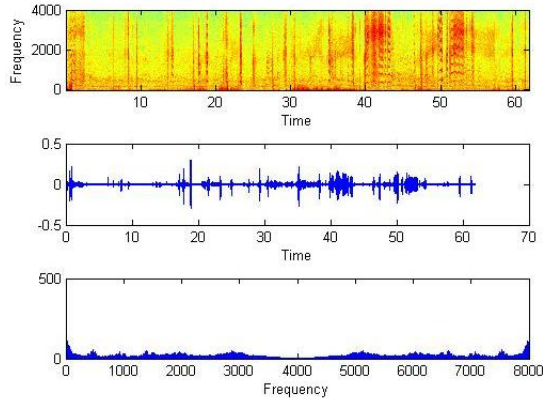
**III. RESULTS**

MATLAB 7.1 is used for coding. Codes are developed for representing cry signal in time & frequency domain and estimating fundamental frequency in time & Frequency domain. Also silenced region of cry signal has been removed for reducing the processing time. The results are as follows.

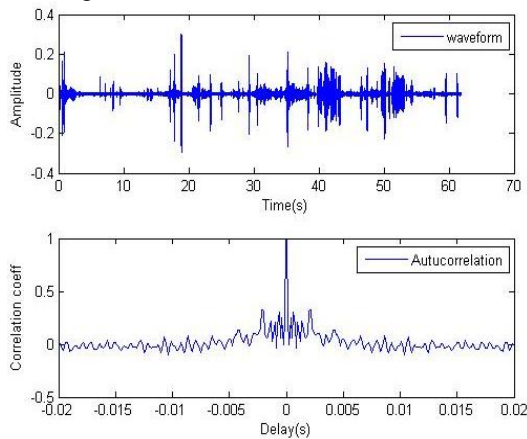
Removal of unvoiced (silenced region) segment from cry signal



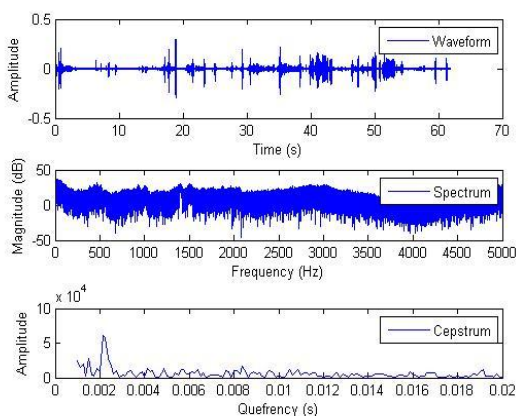
1) Representation of cry signal in time domain, frequency domain and its Spectrogram



2) Estimation of Fundamental Frequency in time domain (using Autocorrelation)



3) Estimation of Fundamental Frequency in frequency domain (Cepstrum analysis)



**IV. CONCLUSION**

The processing time of signal is reduced since silenced regions were removed. The Fundamental frequency found using two analyses are almost same and are in the range of normal infant.

$f_0 = 444.444\text{Hz}$  ( Using Autocorrelation method)

$f_0 = 470.588\text{Hz}$  ( Using Cepstrum Analysis)

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