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# Cause Estimation of Neonatal Cry Using Raspberry Pi

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## Abstract

The analysis of newborns' cry has been an issue of increasing interest. Babies cry for various reasons like hunger, sleepiness, pain and discomfort. It is often difficult to understand why baby is crying since they cannot express their feelings in definite words. The aim of this system is to find the reason behind the neonatal cry with feature extraction technique using raspberry pi. This paper features detection of baby's cry and classification of cry in classes like hunger, pain, fever.

**Keywords:** Cry signal, voice detection, feature extraction, cry analysis

## INTRODUCTION

The emotions of babies are not easily understood. Parents and doctors have always been interested to know why the baby is crying. Basically the crying waves are generated in the central nervous system. Neonatal cry is primary communication function, governed directly by the brain, thus alternation in normal functioning is reflected through cry. The baby has only cry to communicate in the first few months of life before they use the signs and the words. As there is only way to communicate by neonatal is crying, it's really important to understand the language or logic behind their cry. Through crying, baby shows her or his physical and psychological states. Decoding baby's cry supports the mother's built-in intuition about knowing and responding to their baby's needs, and physician to treat infant early [1-3].

## METHODOLOGY

System block diagram is shown in figure 1. The mic is used to collect raw cry signal and then fed to filter to remove noise end then amplified using amplifier. The amplified signal is fed to microcontroller through sound card. Raspberry pi is used for signal processing. The detection of cry signal is done using the voice activity detection algorithm developed using python. Further noise is reduced by using filters.

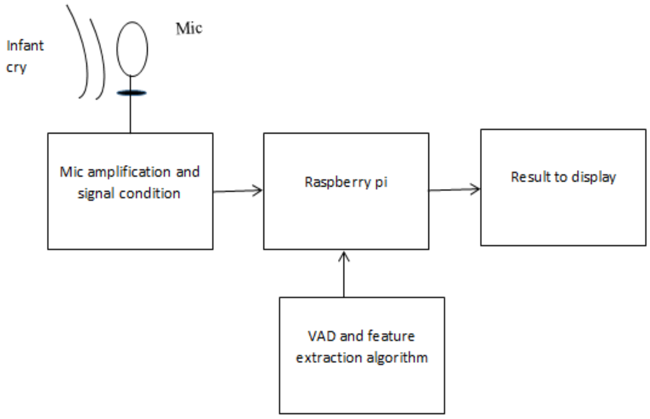


**Figure 1.** Block diagram of system

Then collected database of cry signal are analyzed using feature extraction and compared with feedback taken from doctors and parents about cry. After analyzing cry waveform, a signal is classified to its definite type. A GUI is developed and the results are displayed on a display unit.

## HARDWARE AND SOFTWARE IMPLEMENTATION

### A. Hardware Implementation

Figure 2 and 3 show signal conditioning circuit and its hardware implementation respectively. The amplitude of the cry signal is very low, thus it is amplified using LM 358. Sound card is used to measure and analyze cry signals. A sound card with 10 bit inbuilt ADC is interfaced to microcontroller shown in figure 4.

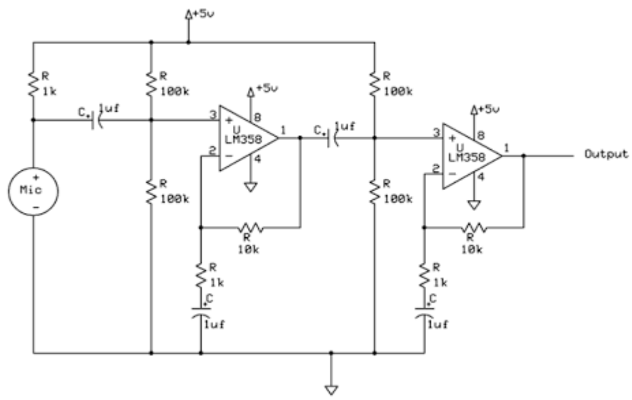


**Figure 2.** Cry signal conditioning circuit.

**Figure 3.** Hardware implementation

**Figure 4.** Sound card interfacing with raspberry Pi

### B. Software Implementation

The graphical user interface (GUI) and all the controlling and processing part of signal is programmed through the python. After the mic amplification, the cry signal is processed on raspberry pi for analysis using python. As soon as the cry is detected, the signal is recorded and the signal graph is generated in 5 seconds. The algorithm for the system is:

1. Start the module.
2. Initiate GUI and USB serial port.
3. Record the voice signal through the mic system connected to the raspberry pi board.
4. Sample the data frame by frame.
5. Plot FFT.
6. Analyze the signal and calculate the signal features value.
7. Classify the cry signal as per thresh holding values set for each type of cry.
8. Display results in GUI.
9. End.

### C Voice activity detection (VAD)

Voice activity detection is used as a pre-processing algorithm for speech coding, speech recognition, and speech enhancement. VAD shown in figure 5 detects whether a sound signal contains speech or not. In VAD, some property of the signal which would give an indication of whether the signal is speech or non-speech is measured. Cry detection is simply the voice detection activity to find whether the cry is present or not. The performance is then often described as in table 1 by looking at how often are frames which do contain speech labeled as speech/non-speech, and how often is non-speech labeled as speech or non-speech. Figure 6 represent the signal waveforms with frame wise energy in the signal and voice activity decision at the end.

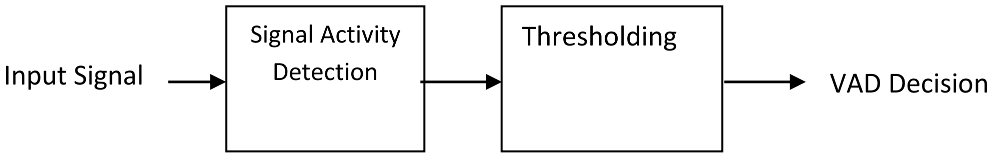


**Figure 5.** VAD algorithm

**Table 1.** Identification of voice signal

| Input | Identification Result | |
|---|---|---|
| Speech | Non-speech | |
| Speech | True Positive | False negative |
| Non-speech | False Positive | True negative |

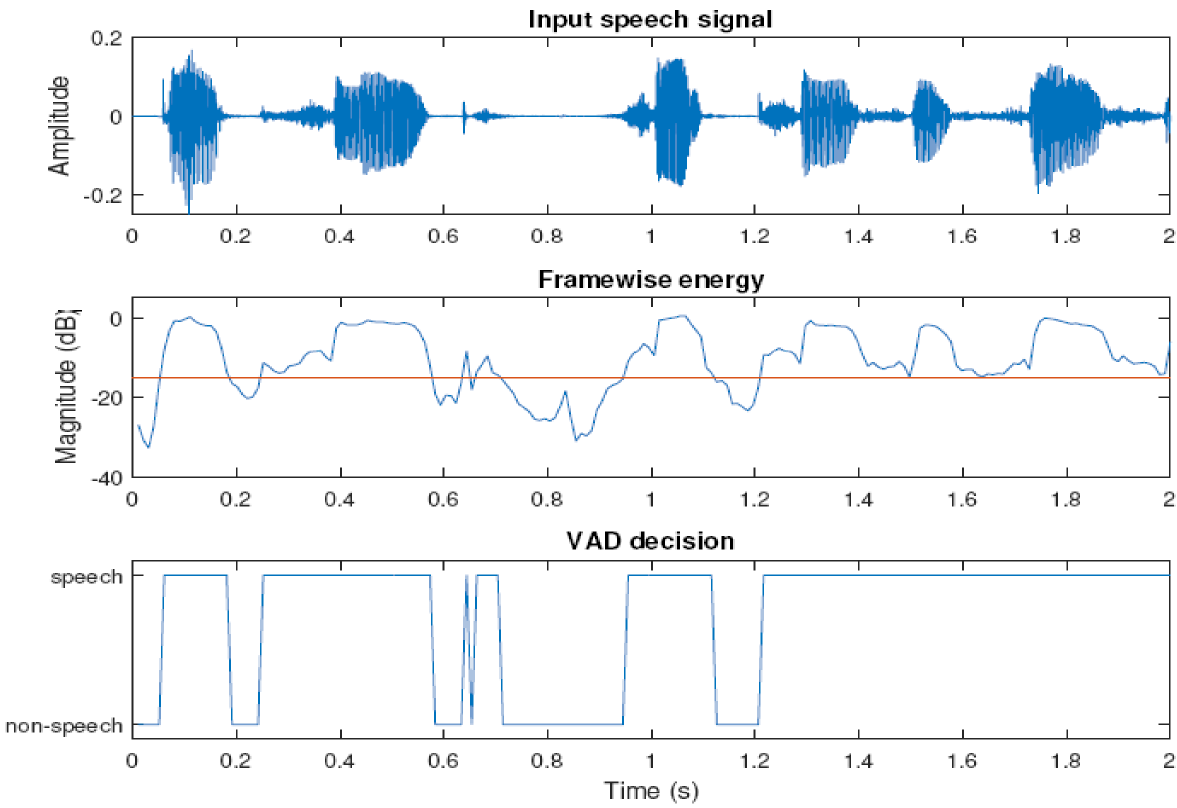


**Figure 6.** Voice Activity Detection waveforms

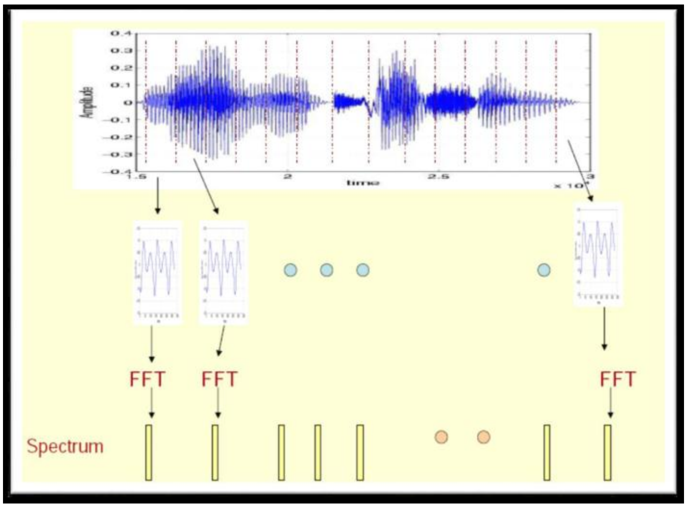


**Figure 7.** Convergence of signal waveform in FFT

**D. Feature extraction**

Figure 7 shows speech signal represented as the sequence of spectral vectors. The input waveform is transformed into a sequence of acoustic feature vectors, each vector representing the information in a small time window of the signal.

A signal is sampled by measuring its amplitude at the particular time. The speech extracted from each window is called frame, number of millisecond in a frame is called frame size and the number of milliseconds between the left edges of a successive window as the frame shift. The spectral information from windowed signal is extracted by calculating energy at different frequencies using DFT. This information is analyzed on the feature like peak amplitude, frequency, entropy, average entropy and average phase difference [4-6].

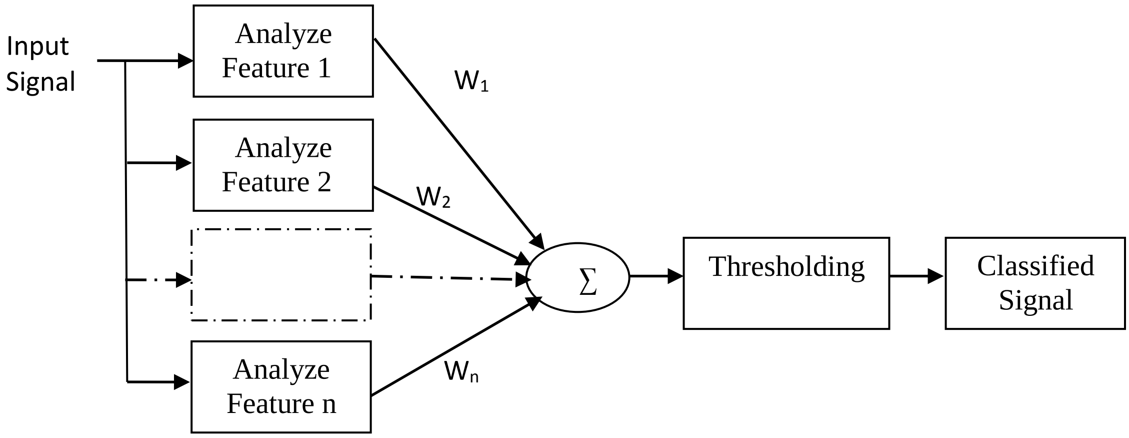


**Figure 8.** Voice Activity Detection waveforms

Figure 8 shows the classification of cry depending upon the feature extracted. The signal is classified as either fever or pain or hunger by observing extracted features like frequency, peak amplitude, entropy, average peak value, average entropy and adjacent phase difference.

## RESULTS

The cry signals before and after signal conditioning is shown in figure 9 and 10 respectively. The real time database for cry signal is collected from hospitals along with feedback from doctors and caretakers. The cry signals are interfaced with raspberry pi via mic and signal amplification and sound card. The features are extracted and tabulated in table 2.

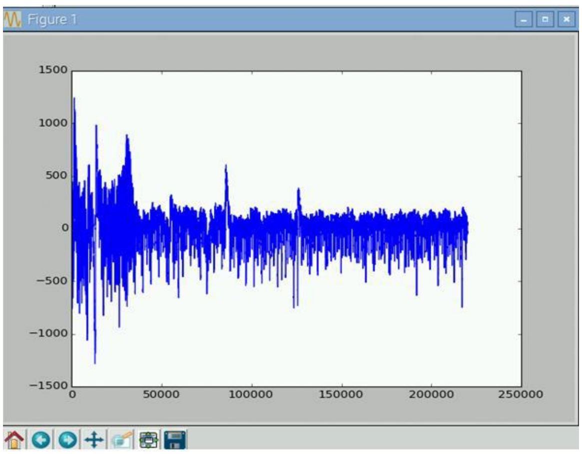


**Figure 9.** Raw cry signal before signal conditioning

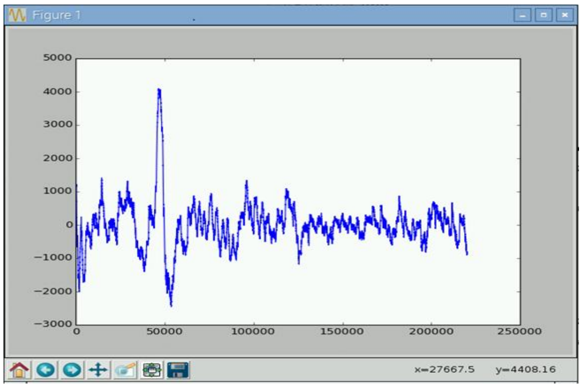


**Figure 10.** Cry signal after signal conditioning

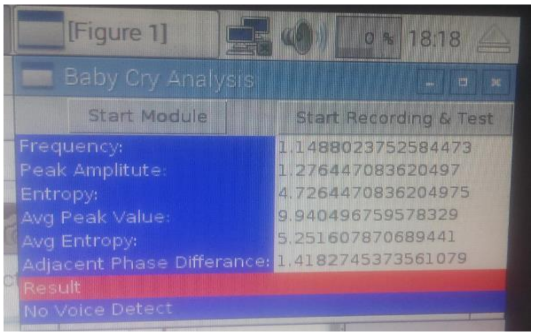


**Figure 11.** Raw cry obtained from signal conditioning

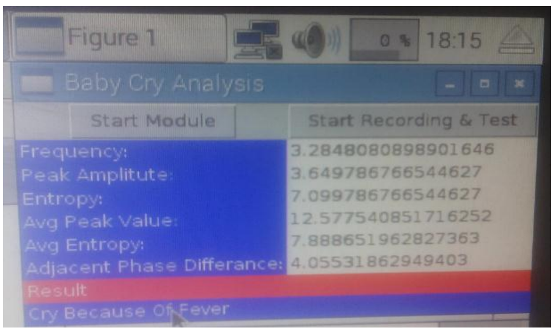


**Figure 12.** Cry signal parameters represented in GUI

**Table 2.** Features extracted from sample database

| Cause of Cry | Parameters of feature extraction | | | | | |
|---|---|---|---|---|---|---|
| | Sample no. | S1 | S2 | S3 | S4 | S5 |
| Cry due to Fever | Frequency | 1.35 | 1.79 | 2.03 | 1.01 | 1.40 |
| | Peak amplitude | 1.50 | 1.95 | 2.26 | 1.22 | 1.55 |
| | Entropy | 4.95 | 5.40 | 5.71 | 4.5 | 4.99 |
| | Avg. Peak Value | 10.19 | 10.69 | 11.03 | 9.77 | 10.30 |
| | Avg. Entropy | 5.50 | 6.00 | 6.34 | 5.08 | 5.55 |
| | Adjacent Phase Difference | 1.67 | 2.17 | 2.51 | 1.25 | 1.70 |
| Cry due to pain | Frequency | 0.92 | 0.96 | 1.08 | 0.79 | 0.76 |
| | Peak amplitude | 1.03 | 1.07 | 1.20 | 0.88 | 0.84 |
| | Entropy | 4.48 | 4.50 | 4.60 | 4.33 | 4.29 |
| | Avg. Peak Value | 9.6 | 9.7 | 9.8 | 9.5 | 9.46 |
| | Avg. Entropy | 4.9 | 5.0 | 5.1 | 4.81 | 4.77 |
| | Adjacent Phase Difference | 1.14 | 1.19 | 1.30 | 0.98 | 0.93 |
| Cry due to Hunger | Frequency | 1.95 | 2.34 | 1.99 | 2.01 | 2.17 |
| | Peak amplitude | 2.16 | 2.60 | 2.55 | 2.17 | 2.50 |
| | Entropy | 5.62 | 6.06 | 5.60 | 5.77 | 5.68 |
| | Avg. Peak Value | 10.9 | 11.41 | 10.9 | 10.98 | 11.20 |
| | Avg. Entropy | 6.24 | 6.73 | 6.28 | 6.30 | 6.5 |
| | Adjacent Phase Difference | 2.40 | 2.89 | 2.44 | 2.48 | 2.67 |

It is observed that the features extracted for each cry are different. Frequency, peak amplitude, entropy, average peak value, average entropy and adjacent phase difference are used for classification. Figure 11 and 12 shows GUI for no voice and GUI when baby is suffering from fever. Depending upon the range of values for various features extracted parameters, the cause of baby cry is estimated**.**

## CONCLUSION

This paper presents infant cry analysis and detection. The cry signal is signal conditioned and voice activity detector is used for preprocessing. The collected database of cry signal is analyzed using feature extraction to know the reason for baby's cry. Results are displayed on GUI. The extracted parameters are different for different causes for the same baby. Also it is observed that the most distinguishable features are frequency, peak amplitude and average entropy. This has potential application in baby care, pediatric hospitals etc.

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