Baby Cry Recognition (BRC) algorithm based on Fast Fourier Transform (FFT) for Baby Bracelet Monitor

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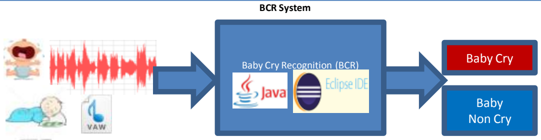
The monitoring of the health of a human baby, especially newborns, is very important both in hospitals and in homes. Baby Cry Recognition (BCR) is, among other parameters such as Heart Rate (HR) or Oxygen Saturation, of primary importance in the research and innovation of wearable devices. In this work I develop a BCR algorithm using Java programming language in the integrated development environment (IDE) Eclipse, the algorithm is a signal processing technique based on the calculation of the Fast Fourier Transform (FFT) of the normalized signal audio recording (baby's cry). Initially a set of 47 audio recordings (WAV format) were downloaded, from different websites, for signal processing. The audio recordings come from different babies aged from 0 to 1 year and a half approximately. The results, with a band pass filter between 1875-3875 Hz, showed that the threshold value was 2.45, the number of false positives (FP) was 2, the partial error or percentage of FP among Non-crying audios was 10% and the total error among Crying and Non-crying audios was 4.26%.

Introduction

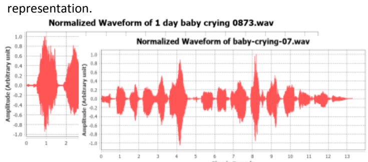
This work implements a computational technique called Baby Cry Recognition (BCR), it is based on the fast Fourier transform (FFT) algorithms, the FFT is really a class of algorithms for computing the discrete Fourier transform (DFT) efficiently and it is one of the most influential algorithms of the twentieth century (S. Allen Broughton and Kurt Bryan, 2018). Historically, the DFT appeared in D. Lewin's very first paper in 1959 (Emmanuel Amiot, 2017).
In this work, in the first stage of the signal processing.
The cry of a human baby is the main and first method of communication and involves the vibration of the vocal cords and the coordination of the larynx, pharynx and vocal tract. The most important parameters of a baby's crying are the fundamental frequency that reflects the regularity of the vibration of the vocal cords whose value goes from 200Hz to 1000Hz and the first three frequencies of formation of the vocal tract that go around 1000Hz, 3000Hz, and 5000Hz respectively (S. Orlandi et al, 2016). In this work I focus on the second frequency.

BCR System

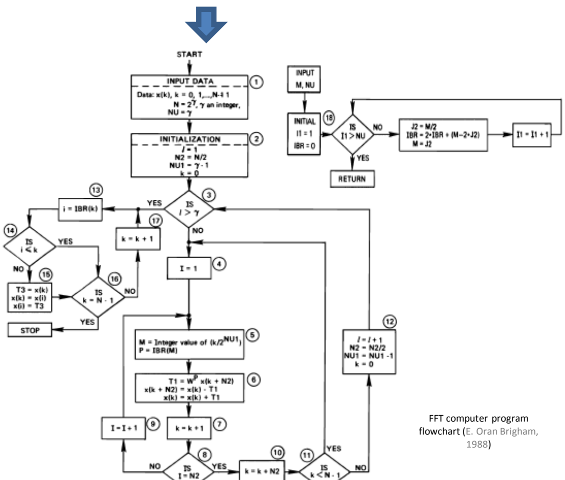


Method

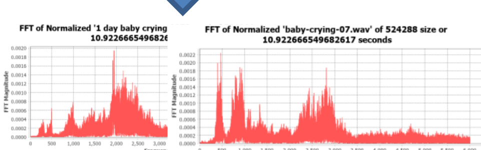
In the BCR, we use the FFT computer program for the analyses step of signal audio recording, which is first normalized to its maximum amplitude, to calculate the frequency domain representation.

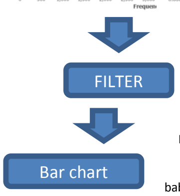


We took a group of 47 audio recorded signal of the baby's voice, the group consists of 27 audios of Crying baby and 20 of Non crying baby.



FFT computer program flowchart (E. Oran Brigham, 1988)



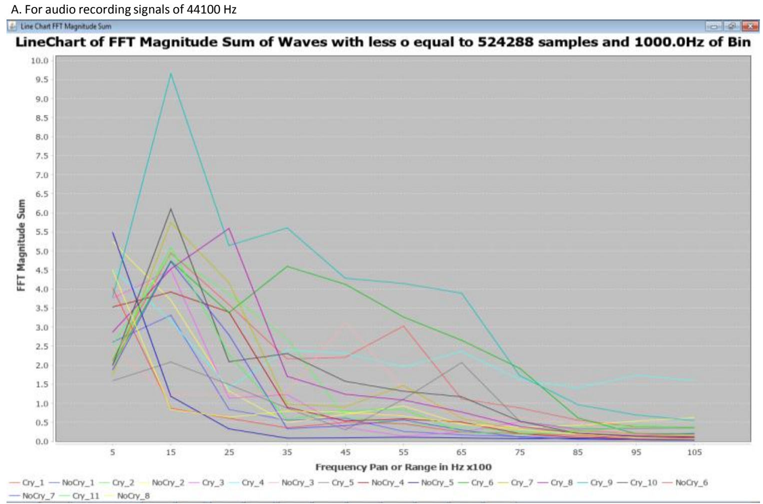


In the filtering step the BCR reduces or eliminates the lower and higher frequencies (band pass filter between 1875-3875 Hz).

Finally, in the bar chart step the BCR computes the filtered FFT magnitude sum of the different audios and compares them to determine the threshold value to determine if the baby audio recording corresponds to a baby who is crying or not.

Results

A. For audio recording signals of 44100 Hz



B. For audio recording signals of all three considered frequencies 44100, 48000 Hz, and 96000 Hz.

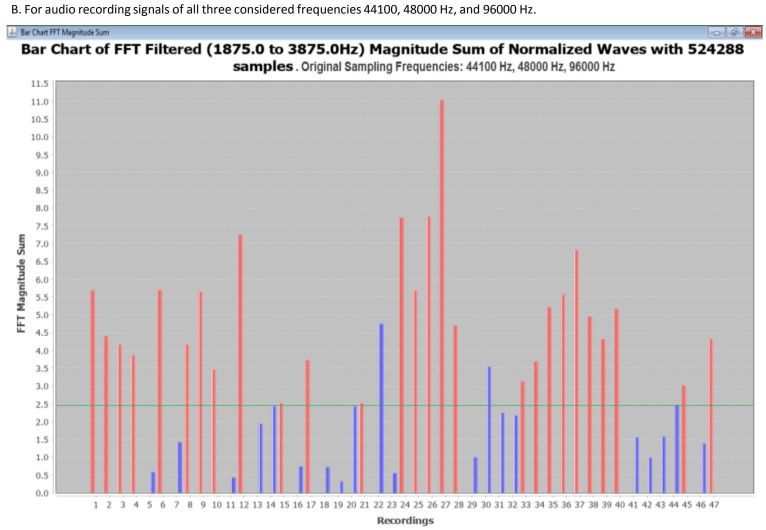


Table 1 Results of the processing of Baby audio recordings - Band pass filter: 1875Hz - 3875Hz

Original Sampling Frequency	44100 Hz	48000 Hz	96000 Hz	All three frequencies
Number of recordings	19	26	2	47
Crying recordings	11	16	0	27
No crying recordings	8	10	2	20
Threshold	2.43	2.43		2.45
Number of False positives	2	0	0	2
Partial error among Non crying audios(%)	25	0	0	10
Total error Crying and Non crying audios(%)	10.53	0	0	4.26

Conclusion

According to the results, this algorithm is a useful tool that can be implemented in wearable devices such as a Baby Monitor Bracelet (BMB) and it can be enhanced for instance with a machine or deep learning techniques.

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