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On the implementation of a method for automatic detection of infant cry units

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Abstract

In Infant Cry Analysis, the cry units are the most important parts of the cry wave to be analyzed. The cry units are segments of cry in the recorded samples the separation of these segments from the rest of the recording is known as cry units detection. Currently, the detection of cry units is done by expert doctors, who perform the detection based on their visual and auditory perception, which is done by inspecting spectrograms and listening the recorded samples. Here, a method based on the energy of the signal measure is presented, which allows to automatically detect, in an effective way the cry units from a recording, even under noise conditions. In this paper we describe the implemented method as well as some encouraging results.

Keywords: , automatic cry detection, cry analysis, cry pattern recognition, cry units, spectrograms inspection.

1. Introduction

Unit Cries are the most important parts of Infant Cry Analysis these units contain the information which is used to analyze the Infant Cry.

Nowadays the detection of Unit Cries in Infant Cry Analysis is made manually [1] [2]. For instance, in 1982 Hirscberg and Szende or in 1992 Michelsson used an espectrographic analysis of Infant Cry, they selected manually the cry sounds by analysing the espectrogram of the cries. Expert physicians in this area, based in their visual and hearing perception carry out the detection of Unit Cries. First, the spectrogram of the signal is obtained and then, the part where the Unit Cries is visualized is selected, then it is verified that this part contains a Crying Sound by listening to it this second step of the selection and verification is repeated until the end of the record is reached.

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The Unit Cries Detection is carried out in order to use them in a posteriori analysis, as in [3] [4], where the average duration of Unit Cries are analyzed, the Unit Cries fundamental frequency average, as well as their melody type.

Some useless sounds are found in wave records, these sounds are not used in Infant Cry Analysis, such is the case of the sounds produced by the ambience and the inspiratory sounds produced by the infants before they emit a Unit Cry, this is due to before the infant emits a sound, he takes a breath to fill his lungs and this creates a small sound, physicians call this sound as inspiration and in most of the cases is useless for further analysis, therefore these sounds must not be considered. Another important point that must be considered is the variety of ambience and devices where the wave records are acquired, as well as the intensity and the infant cry kind, in the wave records cries there are highpitched cries, lowpitched cries, reedy cries, woody cries, etc, and the variation of the intensity, this is because the infant can reduce or increase the intensity of his cry in the same wave record.

In this way, cry detection is defined as a procedure by which the cry sounds are selected and separated from the wave record, cry detection has been made manually in several works, as in [1] [5] . Also, in order to facilitate this arduous procedure, speech detection software has been used to carry out the Unit Cries Detection, however the results have been poor, and this is because the cry signals and the audio signals are different.

In the present work, a method which aloud the automatic detection of Unit Cries in several kinds of wave records is presented, this detection is made by the definition of a threshold applied to the energy of the signal and the definition of a threshold which is applied to the duration of the Unit Cries detected, this threshold is used in order to eliminate the inspiratory sounds, as well as other useless sounds.

2. State of the Art

As in speech detection, where the initial and final points in each word are chosen, the objective in Cry Detection is to find the initial and final points of a Unit Cry, as well as with the words, the cry segments have a higher energy than the unvoiced segments, the cry segments have 4 times more energy than the unvoiced segments [6], due to this information we have made an analysis of the content of signal energy by applying the Short-Time energy Function.

2.1. Short-Time Energy Function

The ShortTime Energy (STE) function of an audio signal is defined as:

$$E_n = \frac{1}{N}\sum_m [x(m)\cdot w(n-m)]^2 \tag{1}$$

where $x(m)$ is the discrete time audio signal, n is the time index of the short-time energy, and $w(m)$ is a rectangle window,i.e.

$$w(n) = \begin{cases} 1 & , 0 \le n \le N-1 \\ 0 & , otherwise \end{cases} \tag{2}$$

In this way the values for the unvoiced segments, are generally smaller than the cry segments.

3. Problem

Along the past years, multiple and different efforts have made generations of researches and studious who want to establish the general laws that describe the process of generation and perception of Infant Cry, not only as an acousticlinguistic, but also as an indicator of the neurophysiologic status of the infant.

The detection of Unit Cries is a fundamental procedure necessary to achieve this objective this is because the quality of the obtained results in posterior analysis relies on the quality of the units obtained in this step.

3.1. Guidelines for Automatic Infant Cry Detection

The method to carry out automatic cry detection must consider the next consideration:

- The distance between the inspiratory sounds and the segments of the record is usually less than 100ms, therefore it is recommended to do a windowing with a maximum of 50 ms.
- The energy of the voiced and inspiratory segments is clearly higher than the unvoiced segments.
- Cry records come from different sources, for this reason it is necessary to determine a threshold for each record.

4. Proposed Method

4.1. Automatic Infant Cry Detection

Automatic Infant Cry Detection was implemented in MATLAB. Based in experimental tests, it was determined that the Unit Cries less than 200ms are sound of a very short duration, and these sounds do not contribute to the posterior analysis due to short duration of the units it is impossible to determine characteristics as the melodic type, these characteristics are of a great importance for the physicians. By eliminating these segments it is reached the elimination of inspiratory sounds. Now we have to define the energy threshold applied to the signals, based on [6] and in our experiments this threshold has been defined in the next way:

$$Energy\_threshold = \frac{E_n(R)}{4} \tag{3}$$

where E_n is the short-time energy function and R is the analized recording.

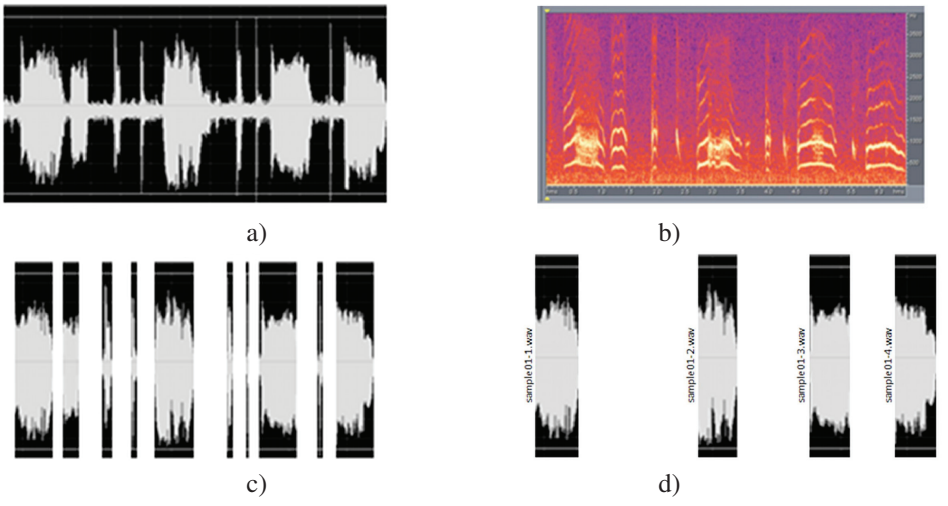

Fig. 1. Main steps in the automatic cry units detection. a) Recorded signal. b) The spectrogram of the cry signal. c) Cry units resulting from the application of the short-time energy function threshold. d) Cry units obtained eliminating sound segments of less than 200ms.

In the figure 1 it is shown the steps of the proposed method. In figure 1a) a cry signal is shown, in figure 1b) the spectrogram of the cry signal is shown, in figure 1c) the Unit Cries detected using the energy threshold is shown, and finally in figure 1d) the Unit Cries detected by eliminating the segments less than 200ms are shown. Once we have the Unit Cries detected, these units are separated from the record and some attributes like, the start of the Unit Cry, the end of the Unit Cry, duration, number of Unit Cries in the record, are obtained, these attributes are useful for the expert physicians in order to make posterior analysis.

Table 1. Results of the manual and automatic infant cry units detection experiments for the Mexican set.

Sample	Manual detection	Automatic detection	Accuracy	False positive	False negative
026.wav	10	10	100%	0	0
028.wav	8	8	100%	0	0
067.wav	12	12	100%	0	0
079.wav	10	10	100%	0	0
083.wav	9	9	100%	0	0
084.wav	5	5	100%	0	0
087.wav	10	9	80%	0	1
088.wav	10	10	100%	0	0
090.wav	6	6	100%	0	0
091.wav	14	14	100%	0	0
094.wav	5	5	100%	0	0
096.wav	12	12	100%	0	0
097.wav	13	13	100%	0	0
098.wav	5	5	100%	0	0
099.wav	13	13	100%	0	0
100.wav	13	13	100%	0	0
101.wav	7	7	100%	0	0
103.wav	8	8	100%	0	0
105.wav	10	9	80%	0	1
113.wav	7	9	71%	2	0
Total	187	187	96.55%	2	2

5. Experimental Results

Our method was proved with two sets of samples, one of them obtained from the Chillanto data base from the Instituto Nacional de Astrofsica ptica y Electrnica, this data base, has Mexican infant cries, the other data base has cuban infant cries. The first set has 20 samples and the second set has 13 samples, both sets have healthy infant cries.

With our method we had detected 182 unit cries from the Mexican infants set, and 65 unit cries from the Cuban infants set.

These results where compared versus the results of the manual detection, these manual detections where carried out by expert physicians [7].

Tables 1 and 2 show the results obtained from the automatic and manual detections.

Records where obtained with different devices and in different ambiences, in figures 2 and 3 we show the signals and spectrograms of the records 88.wav and 103.wav in the first or them we can see that the record has few noise, while in the second one, the quantity of noise increases considerably, however, with the automatic unit cries detection we obtained very good results in both cases.

6. Conclusions

The duty of unit cries detection is a duty of vital importance in the infant cry analysis this is because posterior analysis relies on the results obtained in this step. The proposed method is able to detect unit cries even if the records show noise. The established thresholds used in this work allow eliminating silence, noises and inpiratory sounds from the records.

Table 2. Results of the manual and automatic infant cry units detection experiments for the Cuban set.

Sample	Manual detection	Automatic detection	Accuracy	False positive	False negative
C020812.wav	6	6	100%	0	0
C060812.wav	5	5	100%	0	0
C070812.wav	4	4	100%	0	0
C150812.wav	3	3	100%	0	0
C170812.wav	5	5	100%	0	0
C200812.wav	4	4	100%	0	0
C210812.wav	3	3	100%	0	0
C240812.wav	7	9	71%	2	0
C250812.wav	7	9	71%	2	0
C280812.wav	6	6	100%	0	0
C290812.wav	3	3	100%	0	0
C300812.wav	6	6	100%	0	0
C310812.wav	2	2	100%	0	0
Total	61	65	95.53%	4	0

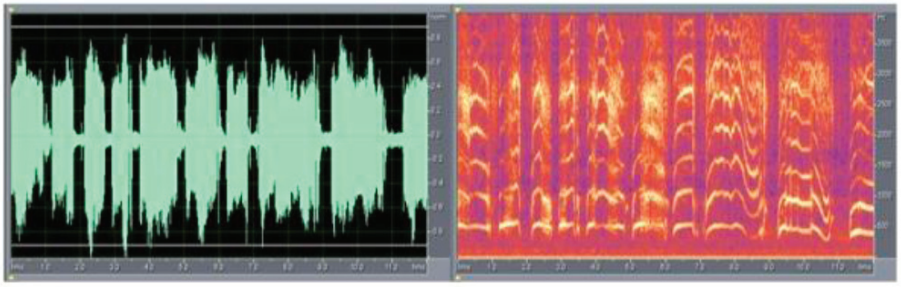

Fig. 2. Signal and spectrogram of the 88.wav record.

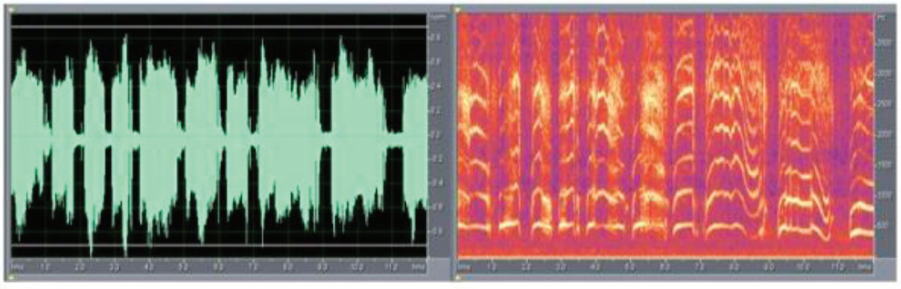

Fig. 3. Signal and spectrogram of the 103.wav record.

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