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Classifying infant cry patterns by the Genetic Selection of a Fuzzy Model

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ABSTRACT

Infant crying analysis is an important tool for identifying different pathologies at a very early stage of the life of a baby. Being able to perform this task with high accuracy is therefore important and required as a medical support system to assess a baby's health. In this research we propose an automatic classification model for infant crying for early disease detection. Our model mainly consists of two phases: (a) an acoustic features acquisition from the Mel Frequency Cepstral Coefficient and the Linear Predictive Coding from signal processing and (b) the selection/creation of an optimized fuzzy model through the Genetic Selection of a Fuzzy Model (GSFM) algorithm. GSFM searches for the best model by choosing a combination of a feature selection method, a type of fuzzy processing, a learning algorithm together with its associated parameters that best fit the input data. Our approach improves the predictive accuracy on the identification of the cause of crying and clearly helps to differentiate between normal and pathological cry. Experimental results show a significant accuracy improvement when using our optimized genetic selection method for most of the cases.

1. Introduction

Infant crying is at birth the only communication means of babies, which, while very restricted, takes the roll of adults' speech. Through crying, the baby shows his/her physical and psychological state. Several studies have been performed in order to distinguish between different kinds of cries. The crying wave carries useful information, as to detect possible physical pathologies from very early stages of life. Those studies bring the opportunity of helping babies by understanding their needs or by detecting specific diseases, in which case the appropriate treatment can be provided and future complications prevented. For example, world-wide statistics indicate that from one thousand new born, 1 or 2 present deep hearing loss or severe hearing loss. Nevertheless not all of them receive diagnosis and timely treatment. This fact generates a very serious problem, because the beginning of an opportune treatment is delayed. The earlier the deafness diagnosis the better guaranteed the possibilities of rehabilitation and acquisition of language. In cases like those the application of non-invasive tools, like infant cry analysis, to produce early diagnosis could help to provide the needed treatment.

The first works with infant cry were initiated by Wasz–Hockert since the beginnings of the 60s [56]. In 1964 the research group of Wasz–Hockert showed that the four basic types of cry can be identified by listening: pain, hunger, pleasure and birth [56]. In a recent study Sheinkopf et al. examined differences in acoustic characteristics of infant cries in a sample of babies at risk for autism and a low-risk comparison group [49]. Besides, many other studies related to this line of research and to that of automatizing the recognition of cries have been reported.

Sergio D. Cano carried out and directed several works devoted to the extraction and automatic classification of acoustic characteristics of infant cry. In one of those studies, in 1999 Cano presented a work in which he demonstrates the utility of Kohonen's Self-Organizing Maps in the classification of Infant Cry Units [14]. In [12] a radial basis function (RBF) network is implemented for infant cry classification in order to find out relevant aspects concerned with the presence of Central Nervous System (CNS) diseases. First, an intelligent searching algorithm combined with a fast non-linear classification procedure is implemented, establishing the cry

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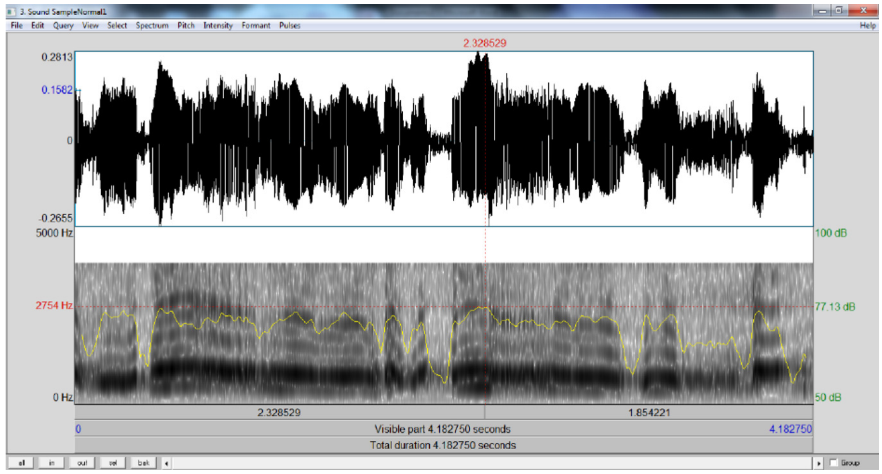
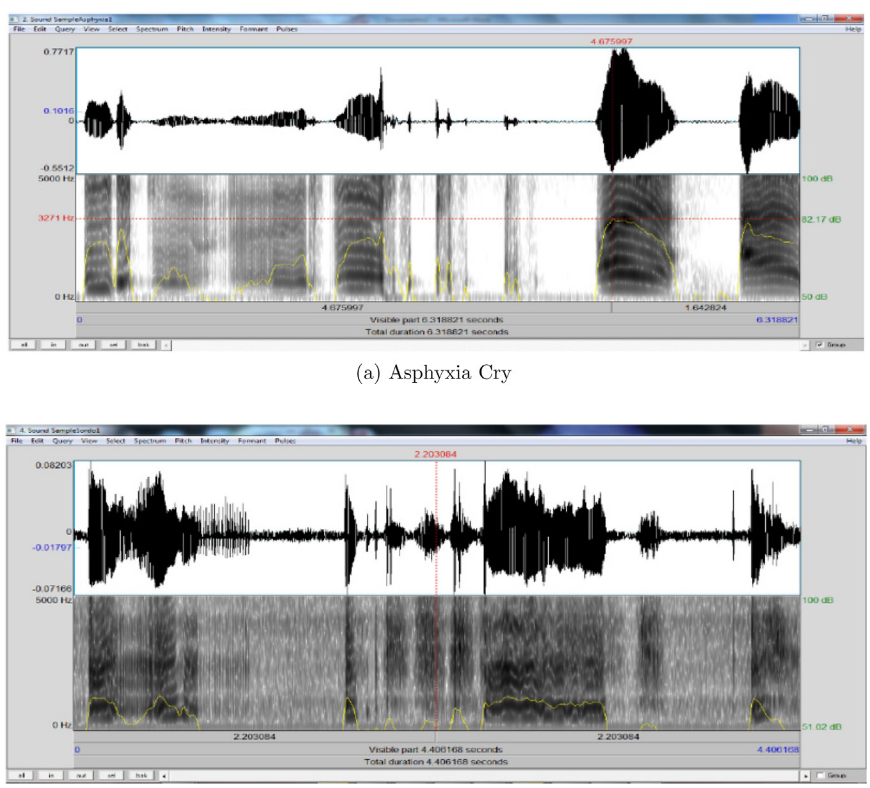


Fig. 1. Wave form and spectrogram of a normal cry.

parameters which better match the physiological status previously defined for the six control groups used as input data. Finally the optimal acoustic parameter set is chosen in order to implement a new non-linear classifier built on a RBF network, an ANN-based procedure which classifies the cry units into two categories, normal or abnormal class, as the ones shown in Figs. 1 and 2.

In 2004 a study is published in [55] which deals with classical and new methods of acoustic analysis of the infant cry, where the final goal is to detect hearing disorders according to the crying at the earliest possible moment. Manfredi et al. [38] developed, a new robust adaptive tool for new born infant cry analysis which is characterized by a high tracking capability, well suited for the signals under study. The tool performs F0 noise and resonance frequencies tracking, on signal frames of varying length. Moreover, voiced/unvoiced separation is implemented, allowing disregarding unvoiced parts of the signal where misleading results could be obtained. In a further study Manfredi et al. [37] presented a user-friendly software tool to deal with newborn infant cry signals, which allows robust tracking of main acoustic parameters on very short and time-varying signal frames.

In [31], LaGasse et al. state that the typical infant cry analysis protocol involves 30 s 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. Another study presented by Branco et al. [11] is focused in the extraction of the characteristics of pain vocal emission of newborns during venepuncture through acoustic analysis and relate them to the Neonatal Infant Pain Scale (NIPS) and some other variables of the newborns.



(a) Asphyxia Cry

(b) Deaf Cry

Fig. 2. Wave forms and spectrograms of abnormal cry. (a) Asphyxia cry and (b) deaf.