

# A Hybrid System for Automatic Infant Cry Recognition I

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## INTRODUCTION

Crying in babies is a primary communication function, governed directly by the brain; any alteration on the normal functioning of the babies' body is reflected in the cry (Wasz-Höckert, *et al*, 1968). Based on the information contained in the cry's wave, the infant's physical state can be determined; and even pathologies in very early stages of life detected (Wasz-Höckert, *et al*, 1970).

To perform this detection, a Fuzzy Relational Neural Network (FRNN) is applied. The input features are represented by fuzzy membership functions and the links between nodes, instead of weights, are represented by fuzzy relations (Reyes, 1994). This paper, as the first of a two parts document, describes the Infant Cry Recognition System's architecture as well as the FRNN model. Implementation and testing are reported in the complementary paper.

## BACKGROUND

The pioneer works on infant cry were initiated by Wasz-Höckert since the beginnings of the 60's. In one of those works his research group showed that the four basic types of cry can be identified by listening: pain, hunger, pleasure and birth. Further studies led to the development of conceptual models that describe the anatomical and physiologic basis of the production and neurological control of crying (Bosma, Truby & Antolop, 1965). Later on, Wasz-Höckert (1970) applied

spectral analysis to identify several types of crying. Other works showed that there exist significant differences among the several types of crying, like healthy infant's cry, pain cry and pathological infant's cry. In one study, Petroni used Neural Networks (Petroni, Malowany, Johnston, and Stevens, 1995) to differentiate between pain and no-pain crying. Cano 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 where he demonstrates the utility of the Kohonen's Self-Organizing Maps in the classification of Infant Cry Units (Cano-Ortiz, Escobedo-Becerro, 1999) (Cano, Escobedo and Coello, 1999). More recently, in (Orozco, & Reyes, 2003) we reported the classification of cry samples from deaf and normal babies with feed-forward neural networks. In 2004 Cano and his group, in (Cano, Escobedo, Ekkel, 2004) reported a radial basis network (RBN) to find out relevant aspects concerned with the presence of Central Nervous System (CNS) diseases. In (Suaste, Reyes, Diaz, and Reyes, 2004) we showed the implementation of a Fuzzy Relational Neural Network (FRNN) for Detecting Pathologies by Infant Cry Recognition.

The study of connectionist models also known as Artificial Neural Networks (ANN) has enjoyed a resurgence of interest after its demise in the 60's. Research was focused on evaluating new neural networks for pattern classification, training algorithms using real speech data, and on determining whether parallel neural network architectures can be designed to perform efficiently the work required by complex

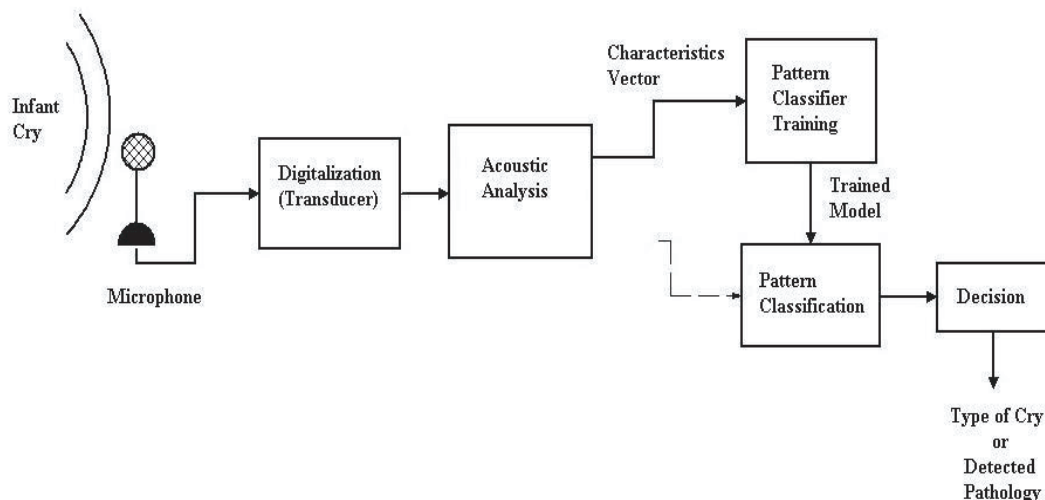
speech recognition algorithms (Lippmann, 1990). In the connectionist approach, pattern classification is done with a multi-layer neural network. A weight is assigned to every link between neurons in contiguous layers. In the input layer each neuron receives one of the features present in the input pattern vectors. Each neuron in the output layer corresponds to each speech unit class (word or sub-word). The neural network associates input patterns to output classes by modeling the relationship between the two pattern sets. The pattern is estimated or learned by the network with a representative sample of input and output patterns (Morgan, and Scofield, 1991) (Pedrycz, 1991).. In order to stabilize the perceptron's behavior, many researchers had been trying to incorporate fuzzy set theory into neural networks. The theory of fuzzy sets, developed by Zadeh in 1965 (Zadeh, 1965), has since been used to generalize existing techniques and to develop new algorithms in pattern recognition. Pal (Pal, 1992a) suggested that to enable systems to handle real-life situations, fuzzy sets should be incorporated into neural networks, and, that the increase in the amount of computation required with its incorporation, is offset by the potential for parallel computation with high flexibility that fuzzy neural networks have. Pal proposes how to do data fuzzification, the general

system architecture of a fuzzy neural network and the use of 3n-dimensional vectors to represent the fuzzy membership values of the input features to the primary linguistic properties *low*, *medium*, and *high* (Pal, 1992a) and (Pal, and Mandal, 1992b). On the other side, the idea of using a relational neural network as a pattern classifier was developed by Pedrycz and presented in (Pedrycz, 1991). As a result of the combination of the Pal's and Pedrycz's proposed methodologies in 1994 C. A. Reyes (1994) developed the hybrid model known as fuzzy relational neural network (FRNN).

## THE AUTOMATIC INFANT CRY RECOGNITION PROCESS

The infant cry automatic classification process is, in general, a pattern recognition problem, similar to Automatic Speech Recognition (ASR) (Huang, Acero, Hon, 2001). The goal is to take the wave from the infant's cry as the input pattern, and at the end obtain the kind of cry or pathology detected on the baby (Cano, Escobedo and Coello, 1999) (Ekkel, 2002). Generally, the process of Automatic Infant Cry Recognition is done in two steps. The first step is known as signal processing, or feature extraction, whereas the second is known as

Figure 1. Automatic infant cry recognition process



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