AN INTELLIGENT HARDWARE SYSTEM FOR REAL-TIME INFANT CRY DETECTION AND CLASSIFICATION

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Declaration

I declare that this dissertation does not incorporate, without any acknowledgment, any material previously submitted for a degree or a diploma in any university and to the best of my knowledge and belief, it does not contain any material previously published or written by any other person or myself except where due reference is made in the text. I also hereby give consent for my dissertation if accepted, to be made available for photocopying and for interlibrary loans, and for the title and summary to be available to outside organizations.

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The above candidate has carried out research for the Master's dissertation under my supervision.

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Abstract

Cry, the universal communication language of the infants encodes vital information about the physiological and psychological health of the infant. Experienced caregivers can understand the cause of cry based on the pitch, tone, intensity, and duration. Similarly, pediatricians can diagnose hearing impairments, brain damages, and asphyxia by analyzing the cry signals, providing a non-invasive mechanism for early diagnosis in the first few months. Hence, automated cry classification has gained great importance in the fields of medicine and baby-care. With the emergence of the concept of the Internet of Things coupled with Artificial Intelligence, baby monitors have recently gained huge popularity due to features like sleep analysis, cry detection, and motion analysis through multiple sensors. Since cry classification involves audio processing in real-time, most of the solutions have either complex and costly designs or distributed computing, which leads to privacy concerns of the users. This research presents a low-cost intelligent hardware system for real-time infant cry detection and classification. The proposed solution presents the selection of the hardware to suit the requirements of audio processing while adhering to financial constraints and the firmware design, which includes voice activity detection, cry detection, and classification. This proposes the use of the multi-agent system as a resource management concept while proving that AI concepts can also be extended to resource-limited hardware platforms as the novelty. Firmware and algorithm are designed to maintain the accuracy figures above 90% while processing the audio signal at a higher rate than its production to maintain stability. A voice activity detector was designed to filter human voice through temporal features while cry detection and classification were respectively based on Artificial Neural Network and K-Nearest Neighbor algorithm trained with a spectral-domain feature vector called Mel Frequency Cepstral Coefficients (MFCC). Evaluations under diverse conditions showed accuracy figures of 96.76% and 77.45% in cry detection and classification, respectively.

Keywords: Cry Detection, Cry Classification, Voice Activity Detection

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List of Abbreviations

ANFIS	Adaptive Neuro-Fuzzy Inference System
AI	Artificial Intelligence
ANN	Artificial Neural Network
BFCC	Bark Frequency Cepstral Coefficients
CIC	Cascaded Integrator Comb
CNN	Convolution Neural Network
CDHMM	Continuous Density Hidden Markov Model
FFT	Fast Fourier Transform
FN	False Negative
FP	False Positive
HMM	Hidden Markov Model
IoT	Internet of Things
MLP	Multi-Layer Perceptron
KNN	K-Nearest Neighbor
LPC	Linear Predictive Coding
LPCC	Linear Predictive Cepstral Coefficients
MFCC	Mel Frequency Cepstral Coefficients
PDM	Pulse Density Modulation
PHMM	Probabilistic Hidden Markov Model
PNN	Probabilistic Neural Network
PPG	Photoplethysmogram
PRU	Programmable Realtime Unit
RBNN	Radial Basis Neural Network
RDS	Respiratory Distress Syndrome
RNN	Recurrent Neural Network
SCP	Secure Copy Protocol
SIDS	Sudden Infant Death Syndrome
SoC	System on Chip
SSH	Secure Shell
STFT	Short-Time Fourier Transform
SVM	Support Vector Machine

TDNN	Time Delay Neural Network
TN	True Negative
TP	True Positive
WT	Wavelet Transform