Exploring Vocalization Differences for Automatic Autism Identification: A Detailed Look at the LENA Autism Screen

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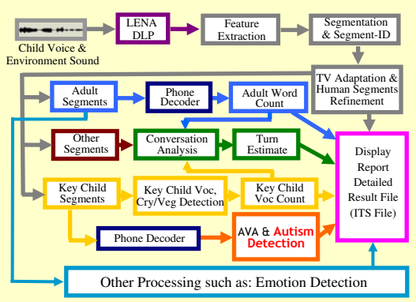
Abstract:

Vocalization differences between children with autism spectrum disorders (ASD) and other children have been noted by human observers and reported in the literature. However, there is a lack of fully automatic computational modeling of these differences. This presentation will show how daylong recordings and computational methods can be utilized to explore different patterns in vocal outputs. Details of the methods, the vocalization features and the cross-validation results for the most up-to-date data set will be presented. Our current data set includes 106 typically developing (TD) children (802 recordings), 49 language-delayed (LD) children without ASD (333 recordings), and 77 children with ASD (351 recordings). Various cross-validations are used to estimate the performance of the screen method. The sensitivity and specificity at the equal-error-rate (EER) point ranges from 85% to 90%.

What is LENA -- System Overview

- Monitoring of Child Natural Language Environment
- Monitoring of Child Development Status
- Important Feedback to Parents, Caregivers or Teachers
- Tool for the Intervention of Children with Disorder
- General Data Collection and Analysis Tool for Clinical Practice and Psychological and Behavior Research

How LENA Works -- System Diagram

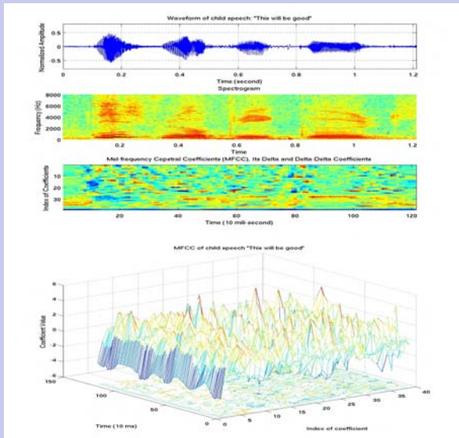


Examples of LENA Segmentation Results

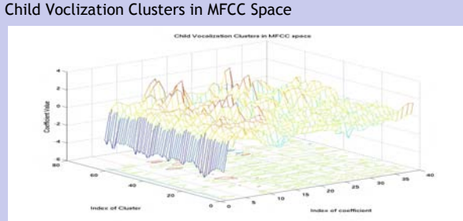
More Child Voc Examples: IP1_051(32), 156(32), IP6_013(33), 061(33), IP9_017(32), 059(31)

Child Vocalization Processing

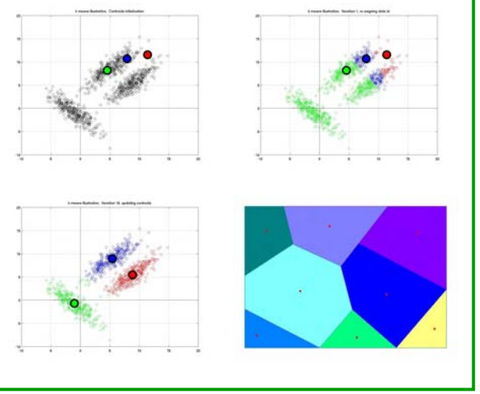
Acoustic Feature: Mel-Frequency Cepstral Coefficients (MFCC)



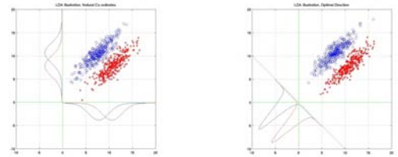
Child Voclization Clusters in MFCC Space



K-means Clustering Algorithm & Space Partition

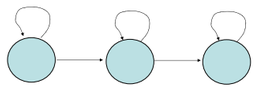


Linear Discriminant Analysis (LDA)



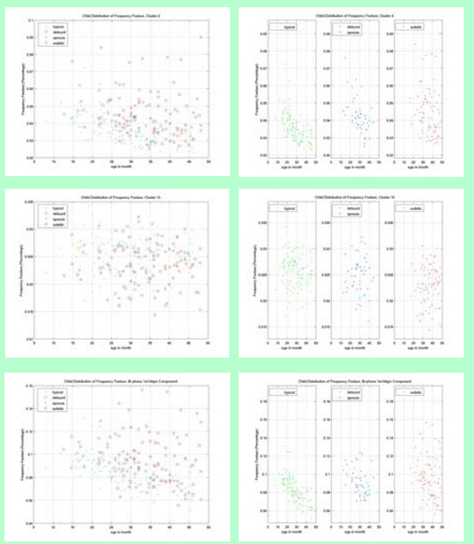
Phone Decoding with Adult-Phone-Model

Hidden Markov Model (HMM)

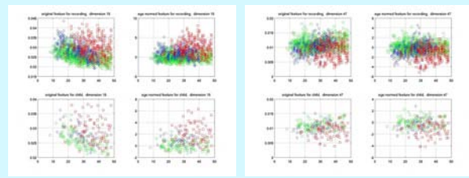


Principal Component Analysis (PCA) is used for Phone Sequence (Bi-phone) to cover larger time range

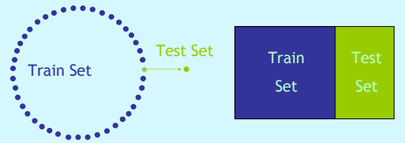
Examples of Child Vocalization Frequency Features



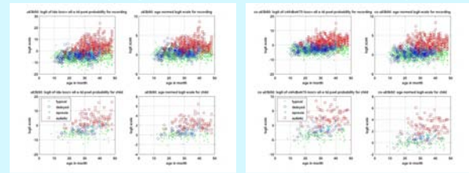
More Frequency Features & Age Normalization



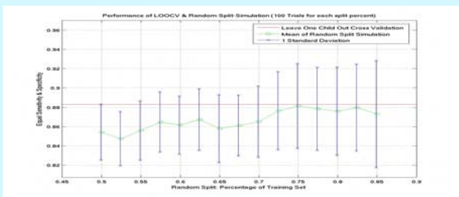
Cross-Validation: LOOCV and Random Split Simulation



LDA with Frequency Features: 113 Child Features and/or Overlap Features



Performance of Cross Validations



Comparison with other existing Human Assessed Autism Screen Tools

Screen name	N	Age	Administration	Time	Sensitivity	Specificity	PPV	NPV
LLAS – 1st Recording (24-48 mo. sample)	190 (75 ASD)	24-48	AUTOMATIC	-	.89	.89	.84	.93
CHAT (Checklist for Autism in Toddlers)	16,235 (12 ASD)	Avg.=19 mo.	Parent report 14 items; clinical observation	5-10 min.	.18	1.0 (100%)	.83	.99
M-CHAT (Modified Checklist for Autism in Toddlers)	1,293 (39 ASD)	18-30 mo.	Parent report 23 items	3 min.	.87	.99	.80	.99
ESAT (Early Screening for Autistic Traits)	31,724 (18 ASD)	13-23 mo.	Parent report 14 items	5 min	.90	.99	.25	unknown
ABC (Autism Behavior Checklist)	123 (38 ASD)	4 -11 years	Caregiver checklist of 57 behaviors	5-10 min	.92	.93	unknown	unknown
ASQ (Autism Screening Questionnaire) now called the SCQ	200 (160 ASD)	4-40 years	Clinician checklist of 40 questions	5-10 min	.85	.75	.93	.55

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Thank You for Your Attention!