A Portable Automatic *PA-TA-KA* Syllable Detection System to Derive Biomarkers for Neurological Disorders

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Motivation

Background:

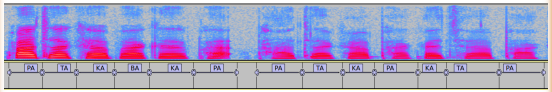
- Neurological disorders disrupt brain functions, affecting the life of many individuals.
- Conventional neurological disorder diagnosis methods require inconvenient and expensive devices

Goal:

- Stand-alone speech-based assessment tools for portable devices

PATAKA for ASR:

- Diadochokinetic test consisting of fast repetitions of "PA-TA-KA"
- It brings challenges for ASR
- Alter, replace, insert or skip syllables



Solution:

- Build an ASR-based application specific for "PA-TA-KA"

Task Design and Data Collection

Previous Effort At ND-SMC-UTD

- Derive reliable biomarkers of motor speech disorders using few minutes of speech recordings.
- Define 7 specific tasks for speech collection

ID	Task
1	Participate, Application, Education, Difficulty, Congratulations, Possibility, Mathematical, Opportunity
2	Put the book here
3	We saw several wild animals
4	PA
5	KA
6	PA-TA-KA
7	AAAHHH

Data Collection

- We controlled SNR during recordings
- Recordings were manually transcribed

Interface

Recording Speech

Set	Total	Female	Male	Age mean	Age max	Age min
Concussed	95	16	79	17.5	24	14
Non-Concussed	485	87	398	16.4	22	14
Total	580	103	477	16.6	24	14
PD	7	4	3	65.6	82	57
Non-PD	10	7	3	54.1	76	23
Total	17	11	6	58.5	82	23

mTBIs Dataset

- 580 youth athletes (boxing, football)
- 95 reported concussion symptoms
- Collect before season as baseline; repeat protocol after competition for comparison

Parkinson Disease (PD) Dataset (on going)

- Data collected from PD patients and their spouse (age matched control group)
- 17 participants collected; 10 of them were with Parkinson

Experimental Evaluation

Recognition Task Setting:

- Pocketsphinx is used for building an ASR on mobile device
- Acoustic model
  - Syllable model for PA, TA and KA
  - Filler model and background model
  - GMM-HMM trained with 3 states left-to-right structure
    - 13 MFCC + Δ + $\Delta\Delta$ = 39D vector
- Language model
  - Tri-gram, we learn common errors from training set
- 60% for training, 40 % for testing

Syllable Recognition:

Set	Conditions	SER [%]	Boundary Detection Pre	Rec	F
Con.	Concussed	2.4	0.92	0.48	0.63
	Non-Concussed	3.5	0.91	0.48	0.63
PD	PD	7.9	0.82	0.46	0.59
	Non-PD	6.2	0.85	0.46	0.60

SER: syllable error rate

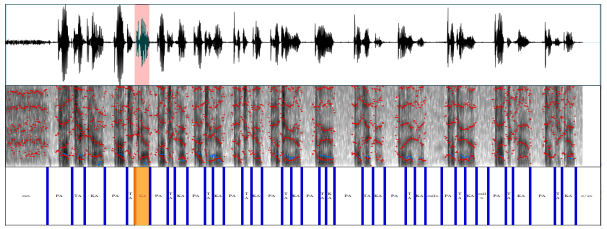
- **Target Speech Biomarkers:**
  - The number of repetitions of "PA-TA-KA"
  - The Diadochokinetic (DDK) rate
    - The number of syllables per second
  - The DDK period
  - The standard deviation of DDK rate
  - The degree of variation in DDK period
- Estimate the number of "PA","TA","KA" and "PATAKA", measured by MAD score

$$\mathbf{MAD} = \frac{\sum_{i=1}^{L} |N_{true} - N_{detection}|}{L}$$

Set	Conditions	PA	TA	KA	PATAKA
Con.	Concussed	0.20	0.08	0.12	0.32
	Non-Concussed	0.27	0.20	0.24	0.73
PD	PD	0.75	0.50	0.38	0.75
	Non-PD	0.25	0.38	0.25	0.63

MAD: mean absolute difference

Discussion



- We presented a task-specific ASR system for the popular test consisting of repetitions of syllables "PA-TA-KA".
- We are collecting more data from PD patients

Reference:

C. Poellabauer, N. Yadav, L. Daudet, S. Schneider, C. Busso, and P. Flynn, "Challenges in concussion detection using vocal acoustic biomarkers," IEEE Access, vol. 3, pp. 1143–1160, August 2015.

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