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

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

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 + ∆ + ∆∆ = 39D vector
- Language model
- Tri-gram, we learn common errors from training set
- 60% for training, 40 % for testing

Syllable Recognition:

<table>
<thead>
<tr>
<th>Set</th>
<th>Conditions</th>
<th>SER [%]</th>
<th>Boundary Detection</th>
<th>PA</th>
<th>TA</th>
<th>KA</th>
<th>PATAKA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc.</td>
<td>Conceded</td>
<td>2.4</td>
<td>0.92 0.48 0.63</td>
<td>0.20 0.08 0.12 0.32</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Non-Conceded</td>
<td>3.5</td>
<td>0.91 0.48 0.63</td>
<td>0.27 0.20 0.24 0.73</td>
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<tr>
<td>PD</td>
<td>Conceded</td>
<td>7.9</td>
<td>0.82 0.46 0.59</td>
<td>0.75 0.50 0.38 0.75</td>
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<tr>
<td></td>
<td>Non-Conceded</td>
<td>6.2</td>
<td>0.85 0.46 0.60</td>
<td>0.25 0.38 0.25 0.63</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SER: syllable error rate

Data Collection
- We controlled SNR during recordings
- Recordings were manually transcribed

Reference:

Set | Total | Female | Male | mean | Age | max | min |
--- |-------|--------|------|------|-----|-----|-----|
Con. | 95    | 16     | 79   | 17.5 | 24  | 14  |
Non-Con. | 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 |

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

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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:

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

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

MAD = \sum_{i=1}^{n} |N_{meas} - N_{direction}| / L