AUTOMATIC DETECTION OF OBSTRUCTIVE SLEEP APNEA USING SPEECH SIGNAL ANALYSIS

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Outline

• Background – what is OSA?
• OSA and speech.
• Methods
• Results
• Conclusions
• Future work
**Background – what is OSA?**

**Definition:** Episodes of complete and/or partial cessation of breathing during sleep.

**AHI:** apnea hypopnea index
Background – what is OSA?

OSA consequences:

- Normal heart
- Hypertensive heart
- Thickening in walls of ventricles
- Car accident
- Brain with highlighted area

Automatic detection of obstructive sleep apnea using speech signal analysis
Background – Diagnosis

**OSA diagnosis today:**

The “gold standard” is PSG.

- Overnight stay at a sleep lab.
- Connected the numerous electrodes and medical devices.
- Expensive and time consuming.
- Uncomfortable.

Automatic detection of obstructive sleep apnea using speech signal analysis.
Goals

Develop a non-invasive, easy to use, available tool for initial screening of potential OSA patients using speech signals analysis.
Anatomical abnormalities associated with OSA:

- Narrowing of the upper airway.
- Softer soft tissues.
- Coupling of the oral and nasal cavities.

Automatic detection of obstructive sleep apnea using speech signal analysis.
Methods

Two stages computer based diagnosing system:
1. Automatic detection of vowels and nasal phonemes from fluent speech.
2. Classification system based on fusing 7 GMM classifiers.

All subjects are “potential” OSA patients.
All subjects diagnosed in sleep clinic.

Recording, Creating data base

Stage 1
Automatic phoneme recognition

Stage 2
OSA\non-OSA classification

Automatic detection of obstructive sleep apnea using speech signal analysis
Elongated utterance of vowels /a/, /i/, /u/, /e/, /o/.

Long sentences containing the mentioned vowels.

Short yes or no question ending with a vowel.

Individual words.

Short sentences containing nasal phonemes

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Automatic phoneme recognition

OSA\non-OSA classification

Data base

Vocal tract length normalization by $\alpha = 1.3$

Frequency [Hz]

Amplitude
Automatic detection of obstructive sleep apnea using speech signal analysis

**Methods – training stage 2**

(OSA \ non-OSA classification)

1. Framed speech signals
2. Feature extraction
3. Feature selection (SFFS)
4. Model Training
5. 7 OSA Models
6. 7 Non-OSA Models
7. Calculate the relative weight of each classifier
8. Weighted score

**Data base**

Automatic phoneme recognition

OSA\non-OSA classification
Methods - Validation

Automatic detection of obstructive sleep apnea using speech signal analysis
### Experimental setup

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of subjects</th>
<th>Age</th>
<th>AHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-OSA</td>
<td>17</td>
<td>46.23 ± 13.7</td>
<td>5.78 ± 2.5</td>
</tr>
<tr>
<td>OSA</td>
<td>70</td>
<td>56.87 ± 13.04</td>
<td>25.74 ± 14.9</td>
</tr>
</tbody>
</table>

Automatic detection of obstructive sleep apnea using speech signal analysis
## Results – stage 1

<table>
<thead>
<tr>
<th>True label</th>
<th>/a/</th>
<th>/e/</th>
<th>/i/</th>
<th>/o/</th>
<th>/u/</th>
<th>/m+/n/</th>
<th>Unvoiced and silence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/a/</td>
<td>70</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>/e/</td>
<td>7</td>
<td>73</td>
<td>15</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>/i/</td>
<td>1</td>
<td>8</td>
<td>67</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>/o/</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>72</td>
<td>13</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>/u/</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>61</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>/m+/n/</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>8</td>
<td>71</td>
<td>2</td>
</tr>
<tr>
<td>Unvoiced and silence</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>8</td>
<td>13</td>
<td>13</td>
<td>89</td>
</tr>
</tbody>
</table>
### Results – stage 2

<table>
<thead>
<tr>
<th></th>
<th>System A – manual segmentation</th>
<th>System B – automatic segmentation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>true label OSA</td>
<td>true label non-OSA</td>
</tr>
<tr>
<td>classified as OSA</td>
<td>91.66%</td>
<td>8.33%</td>
</tr>
<tr>
<td>classified as non-OSA</td>
<td>8.33%</td>
<td>91.66%</td>
</tr>
</tbody>
</table>
Conclusions

• We established that initial screening of potential OSA patients is possible by analyzing patients’ speech signals.

• The fusion of 7 independent classifiers into one system was proven efficient.

• Automatic segmentation reduces the system’s performances but is essential for making the system available for doctors.
Future work

• Increase data base.
• Examine other classifiers (GMM – UBM – SVM).
• Fit a SVR based regression model for estimation of OSA severity.
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Thank you for listening
Questions?

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