EMG of Facial Muscles for Subvocal Speech Recognition

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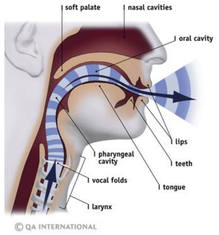
Geoffrey S. Meltzner[2], James T. Heaton[4], Yunbin Deng[3], Bhawna Shiwani[1], Gianluca De Luca[1], Serge H. Roy[1], Joshua C. Kline[1]

[1]Delsys, Inc and Altec Inc, Natick, USA, [2]VocaliD, Inc. Belmont, USA, [3]BAE Systems, Burlington, USA, [4]Massachusetts General Hospital Voice Center, Boston, USA

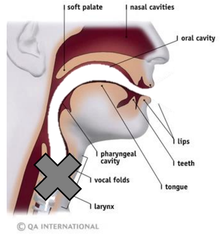
Background

Natural Speech Vocalization



- Air pressure from lungs
- Frequency (pitch) variation from larynx
- Auditory filtering from tongue, cheeks, lips, etc.

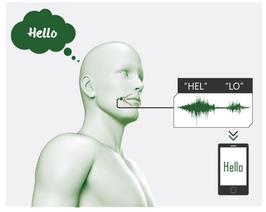
Impaired Speech Vocalization



- 60,000 cases of cancer in mouth, throat and larynx each year in US
- Most result in vocal impairment
- In such cases, speech musculature still remain intact and can provide an Alternative Speech source

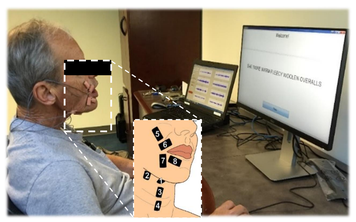
Objective

To provide sEMG-based Subvocal Speech Recognition platform that utilizes silently mouthed (subvocal) speech for Augmentative and Alternative Communication (AAC).



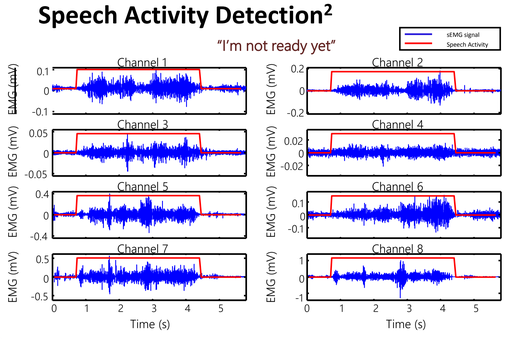
Methods

Experiment Setup[1]



Data Collection	
Subject Population	n = 7 Total Laryngectomy
Sensor Type	Trigno wireless sEMG (Delsys, Inc)
Sensor Location	
1,2	Neck – submental
3,4	Neck – ventromedial
5,6	Face - supralabial
7,8	Face - infralabial
Data Corpus	2500 words/ 980 continuous sentences

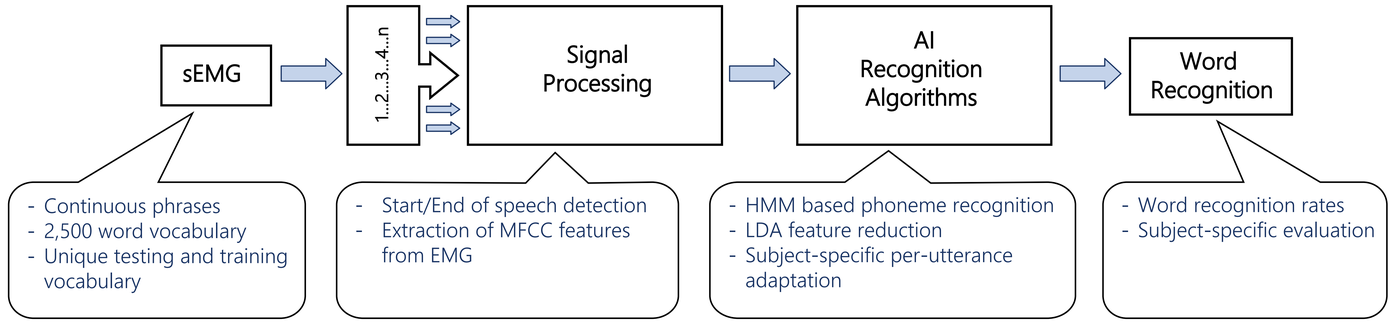
Speech Activity Detection[2]



- Unique EMG activation across muscles
- Separated speech from non-speech activity by identifying simultaneous multi-channel activation
- Robust against single channel noise

Subvocal Algorithm Architecture

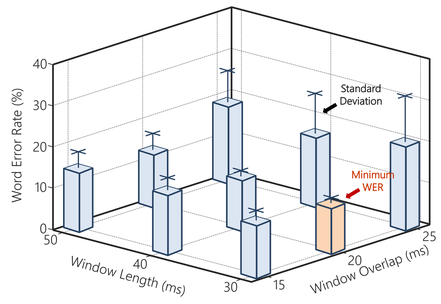
Front-end Signal Processing + Back-end Machine Learning



sEMG Speech Performance Findings

Key Finding 1

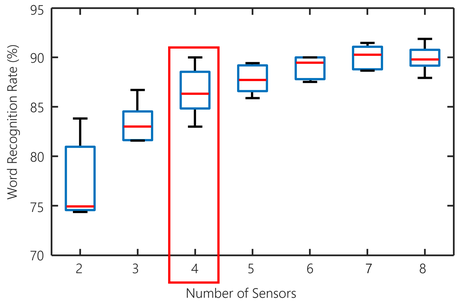
Average WER as a function of Window Length, Overlap (ms)



- Word Error Rate (WER) is highly influenced by window lengths and overlaps selected
- Most effective Window/Overlap pair: 30ms/20ms
- Mean WER at 30ms/20ms: 11.4%

Key Finding 2

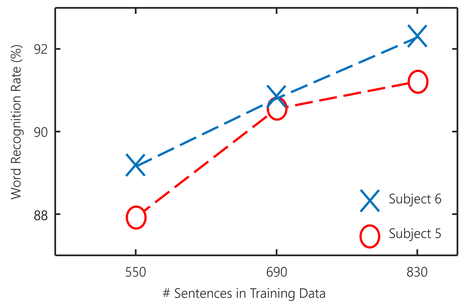
Word Recognition as a function of the Number Sensors



- Increase in number of sensors is exponentially related to increase in Word Recognition
- Optimal number of sensors for facially worn interface: 4

Key Finding 3

Word Recognition vs Training Data



- Word Recognition improves with increase in number of sentences used for training
- Training data expansion has potential to improve subvocal speech recognition

Conclusion

- Proof of concept of first sEMG –based subvocal speech recognition system that provides 85-90% WERs for continuous speech from 2500 word vocabulary
- Restores sense of embodiment & intuitive speech by augmenting natural voice musculature
- With larger data corpus and optimal parameters guided by key findings, this technology has the potential to provide AAC that approximates natural speech vocalization

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References

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2. Meltzner et. al. Annual International Conference of the IEEE EMBS, 2011