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INNOVATION HIGHLIGHT

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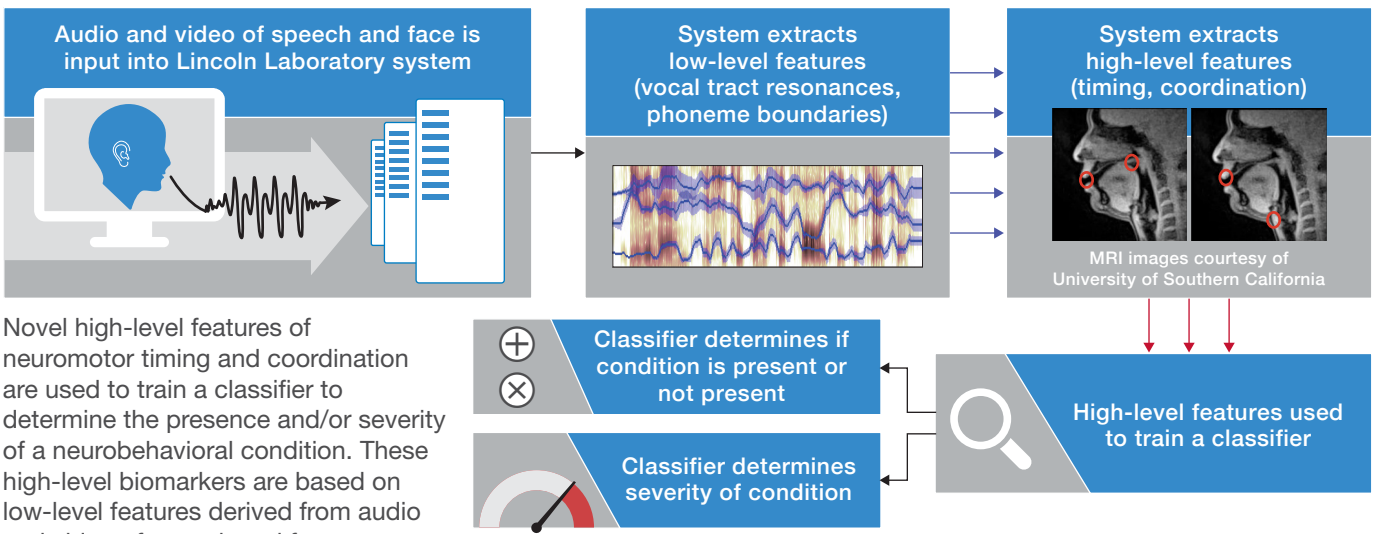
Speech Biomarkers for Early Diagnosis of Neurological Conditions

Overview of Lincoln Laboratory's Neurobehavioral Approach



Novel high-level features of neuromotor timing and coordination are used to train a classifier to determine the presence and/or severity of a neurobehavioral condition. These high-level biomarkers are based on low-level features derived from audio and video of speech and face.

Lincoln Laboratory's neurobehavioral approach to assessing a person's likelihood of diminished neurological function is based on an evaluation of features in speech production—phonetic timing, articulatory coordination, and facial-muscle synchronization. These vocal and facial features, i.e., biomarkers, can potentially screen for a range of conditions, including major depressive disorder, traumatic brain injury, post-traumatic stress, autism, and Parkinson's disease, and facilitate prompt medical and/or psychological interventions.

KEY FEATURES

- Enables detection and measurement of subtle biomarkers via signal processing of audio and video recordings of a speaker
- Classifies the severity of the neurological disorder
- Allows recurrent monitoring for gauging the effectiveness of treatments
- Applies vocal or facial analytics to assess neurological functioning by using nonobtrusive technology (e.g., audio) and conventional hardware (e.g., microphones) that can be deployed in common settings

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Speech Biomarkers for Early Diagnosis of Neurological Conditions

Motivation

The World Health Organization estimates that one in eight people worldwide will experience a mental or neurological disorder.[1] This estimate includes conditions that are psychological (e.g., major depressive disorder), neurotraumatic (e.g., traumatic brain injury), neurodegenerative (e.g., Parkinson's disease), and neurodevelopmental (e.g., autism spectrum disorder). The impact of these disorders is far-reaching as individuals struggle to function in their personal lives, jobs, and communities. Key to helping a person cope with a neurological condition is an early, accurate diagnosis that allows clinicians to judiciously prescribe timely interventions (e.g., counseling, behaviors, medication) to lessen the condition's impact. However, most determinations of disorders are subjective, made on the basis of self-assessments or observations by clinicians.

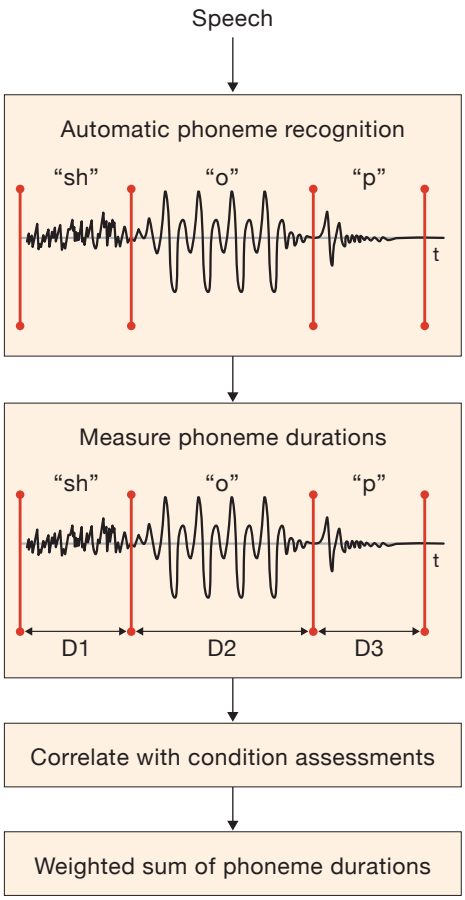
Speech Indicators of Neurological Dysfunction

A complex interplay of neurological and physiological behaviors is behind the production of speech. Lincoln Laboratory researchers have identified indicators, or biomarkers, of changes in timing and coordination within the neuromotor components of speech that reflect an alteration or decline in brain functioning. Our novel biomarkers detected disruptions in timing and motor control in audio and video recordings focused on various aspects of speech—cadence (or prosody), pitch, articulation, pronunciation (phonemes), and facial characteristics.

Our methodology employing speech/facial signal processing and automatic classification algorithms allows us to estimate the presence and severity level of a condition. Using audio and video speech samples in various demonstrations, our novel biomarkers have shown a capability in identifying

- Severity of major depressive disorder
- Severity of Parkinson's disease
- Post-traumatic stress disorder
- Cognitive state change from mild traumatic brain injury
- Evidence of COVID-19 infection
- Cognitive fatigue/overload

1 WHO fact sheet



Phoneme-dependent duration extraction first requires automatic phoneme recognition, followed by measuring the average duration (D) of each phoneme (there are 42 of these distinct sounds in the English language). Average duration measures are then correlated with the condition assessment (e.g., severity of depression) across subjects. The final feature is a weighted sum of phoneme durations, where weights are a function of the correlation value for each phoneme.

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INTERESTED IN WORKING WITH MIT LINCOLN LABORATORY?

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Contact the Technology Ventures Office
tvo@ll.mit.edu

U.S. PATENTS #9,763,617; 9,936,914; 10,127,929; 10,561,361

More Information

T.F. Quatieri et al., "Noninvasive Biomarkers of Neurobehavioral Performance," *Lincoln Laboratory Journal*, vol 24, no. 1, 2020.

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