A machine learning algorithm to identify neuromuscular speech disorders from acoustic profiles

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Background: Progressive neuromuscular brain disorders often cause to changes to speech. Acoustic measures of speech can be used as objective markers of pathology. Most investigations of pathological speech have compared controls with one specific condition and exclude comorbidities.

Objective: We aim to broaden the utility of speech biometrics by examining how acoustic features of speech differ between diseases and how composite features may strengthen these measures. We present novel machine learning methods that can discriminate between healthy speech and pathological speech, and further identify the underlying neurological disorder.

Methods: We applied machine learning algorithms to identify speech features that can discriminate between different neurodegenerative diseases including multiple sclerosis (N=144), Huntington's disease (N=164), and Friedrich's ataxia (N=80) as well as healthy controls (N=507). Participants performed a diadochokinetic task where they repeated the alternating syllables /PA/, /TA/, and /KA/. Signal processing techniques were used to extract a wide range of spectral and temporal prosodic features from the speech recordings. Summary statistics of these acoustic features were subjected to machine learning.

Results: Preliminary results suggest that multiple groups of acoustic features can be used to distinguish neurodegenerative diseases including speech rate, pause and speech rate variability, spectral energy, spectral entropy, spectral crest, f0 duration, and spectral spread. Machine learning techniques produced high discrimination accuracy (M = 85%; see Figure 1) by simultaneously considering combinations of these acoustic features. Huntington's disease showed the lowest accuracy (67%) and was often misclassified as speech from healthy controls. Friedrich's ataxia (82%) and multiple sclerosis (91%) were both identified with high accuracy and sensitivity.

Conclusion: We demonstrated that speech biometrics can identify neuromuscular brain disorders and distinguish healthy speech from and pathological speech with high accuracy. We emphasize the importance examining multiple acoustic features when assessing key

indicators of neurodegenerative disease, particularly for populations that may have speech-altering comorbidities. Applications for identifying other neurological diseases and affective disorders are discussed.

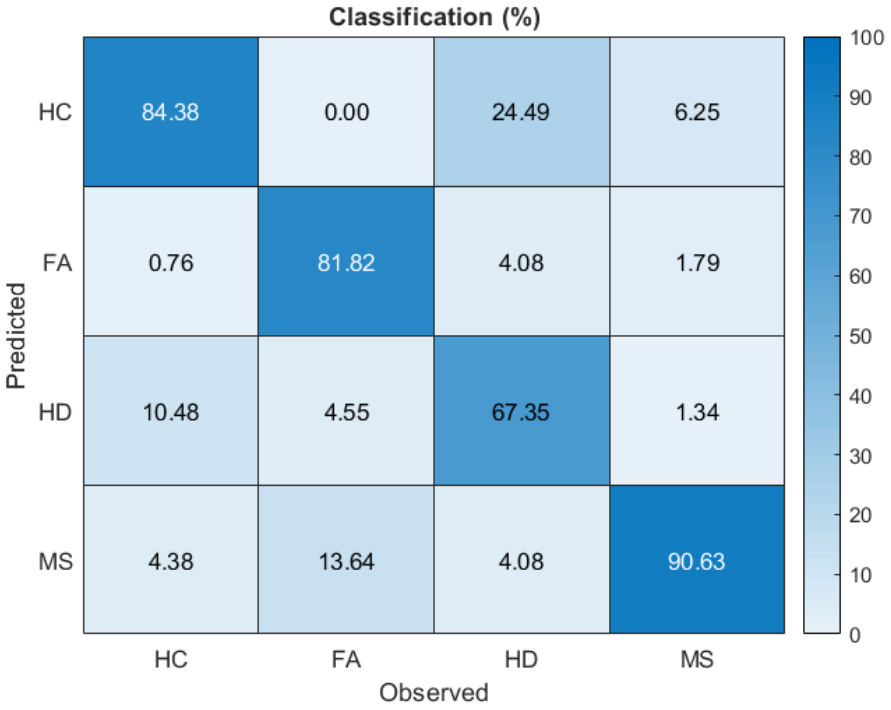

Figure 1. Percentage classified compared to the number of observed cases for healthy controls (HC), Friedrich's Ataxia (FA), Huntington's disease (HD), and Multiple Sclerosis (MS). The diagonal (top left to bottom right) shows the classification accuracy. Other cells in each column show the percentage of misattributions.