

Forecasting of change in speech function using remote assessment of acoustics

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Introduction

Amyotrophic lateral sclerosis (ALS) is a debilitating neurodegenerative disease that presently has no cure. Bulbar symptoms cause accelerated disease progression, and they affect over 90% of patients over the disease course [1]. Speech is the most well-established indicator of bulbar disease in ALS, and so there has been a considerable recent push to develop automated speech assessments to capture the early signs of bulbar disease onset, its severity and progression [2,3]. A critical next step is to identify predictors of bulbar decline as well as evaluate the use of methods to reduce acoustic predictor dimensionality, all of which will be invaluable for developing tools to stratify patients for clinical trials and for optimizing clinical management.

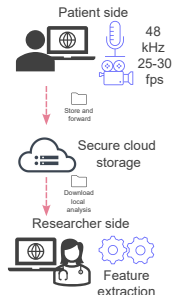
Hypotheses

- (1) Acoustic features of speech will be able to predict bulbar deterioration in ALS patients.
- (2) Feature grouping and aggregation approaches will be able to improve prediction performance.

Methods

1 Data collection

Recordings (Bamboo passage) were recorded using a custom remote assessment tool. Patient-reported ALS functional rating scale-revised (ALSFRS-R) was collected. Total FRS score was (/48) and the bulbar score was (/12). SFT speaking rate (words per minute) and intelligibility (%) were collected.



	N (num. F)	24 (7)
Disease duration (mo.)	44.2 (35.2)	
ALSFRS-R total delta	-3.7 (3.9)	
ALSFRS-R bulbar delta	-0.5 (1.5)	
Days between Ax.	193.4 (42.2)	
Baseline speaking rate	147.4 (37.1)	
Baseline intelligibility	94.9 (3.4)	

All except N(%)F are shown as median (IQR).

2 Feature extraction

Acoustic speech features were calculated from recordings. A total of 24 articulatory and timing features were considered for analysis.

Formants 1 and 2 (F1 and F2): 5th percentile, median, 95th percentile, 5th-95th percentile range.

Formant 1 and 2 (F1 and F2) speeds: 5th percentile, median, 95th percentile, 5th-95th percentile range.

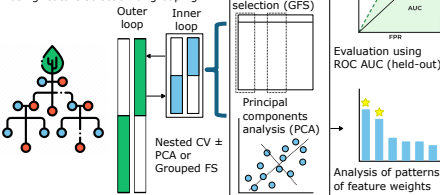
Formant 1 and 2 (F1 and F2) accels: 5th percentile, median, 95th percentile, 5th-95th percentile range.

Timing: average pause duration and speech rate

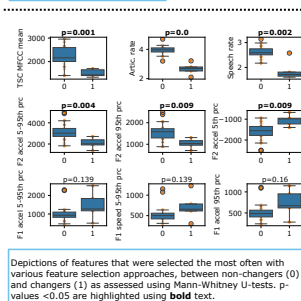
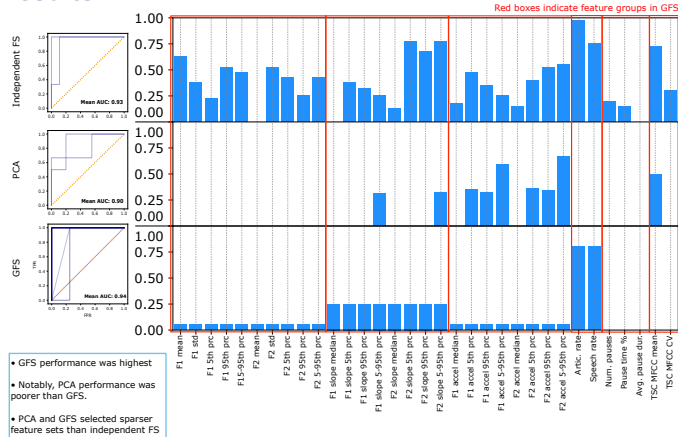
Mel-frequency cepstral coefficients (MFCCs): Total squared change (TSC) mean and coefficient of variation

3 Modeling

Random forest models were fitted using 2-fold nested cross-validation, using feature selection or grouping.



Results



Conclusions

We demonstrated that bulbar decline in ALS could be predicted using a combination of automatically-extracted acoustic features in our pilot analysis. Feature selection and aggregation approaches identified overlapping, reduced subsets of features that led to improved predictive performance. Knowledge-based feature grouping provided high performance and enforced interpretable solutions, which may inform subsequent clinical management and trial practices, and mitigate false positive feature identification.

References

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