Word Accuracy and Dynamic Time Warping to Assess Intelligibility Deficits in Patients with Parkinson's Disease

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Outline

Introduction: Parkinson's Disease

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- Second most prevalent neurological disorder worldwide
- Affects about 2% of people older than 65 years
- Patients develop several motor and non-motor impairments
- Speech impairments are one of the earliest manifestations

Introduction: Parkinson's Speech

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- Reduced Loudness
- Monotonic
- Imprecise articulation
- Accelerated/slowed
- Repetitive phenomenon
- Hoarse voice

Hypokinetic dysarthria

Healthy Person

Parkinson's Patient

Introduction: Speech Features

Phonation | Articulation | Prosody | Intelligibility

Introduction: Phonation

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Phonation | Articulation | Prosody | Intelligibility

Capability of the speaker to make the vocal folds vibrate

- Jitter
- Shimmer
- Long term perturbation measures

Introduction: Articulation

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Phonation | **Articulation** | Prosody | Intelligibility

Modification of the position, stress, and shape of limbs to produce the speech

- Formant frequency
- Vowel Space Area
- Energy of Onset/Offset

Introduction: Prosody

Variation of loudness, pitch, and timing to produce natural speech

- Fundamental frequency
- Energy
- Speech rate

Introduction: Intelligibility

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Phonation | Articulation | Prosody | **Intelligibility**

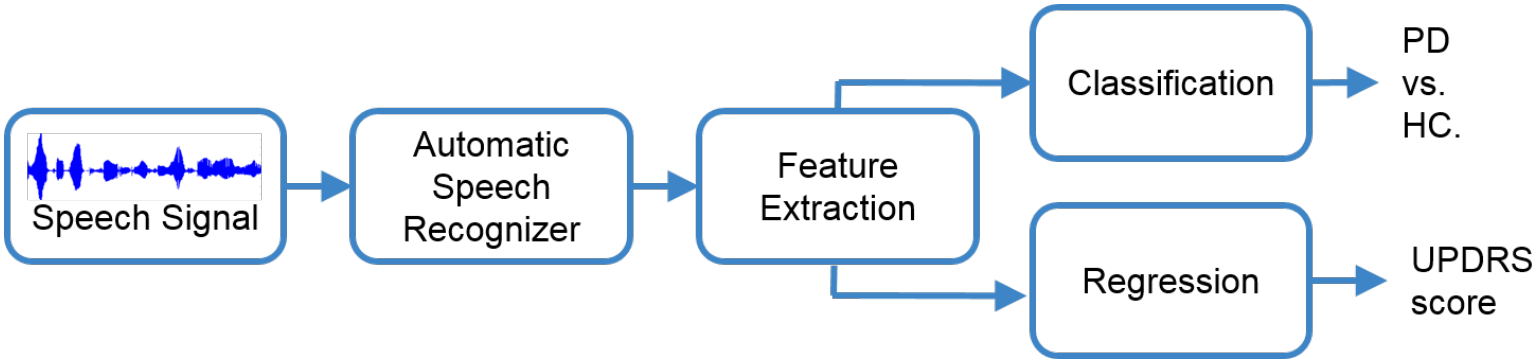
Capability of a person to be understood by other person or by a system.

Introduction: Proposed features

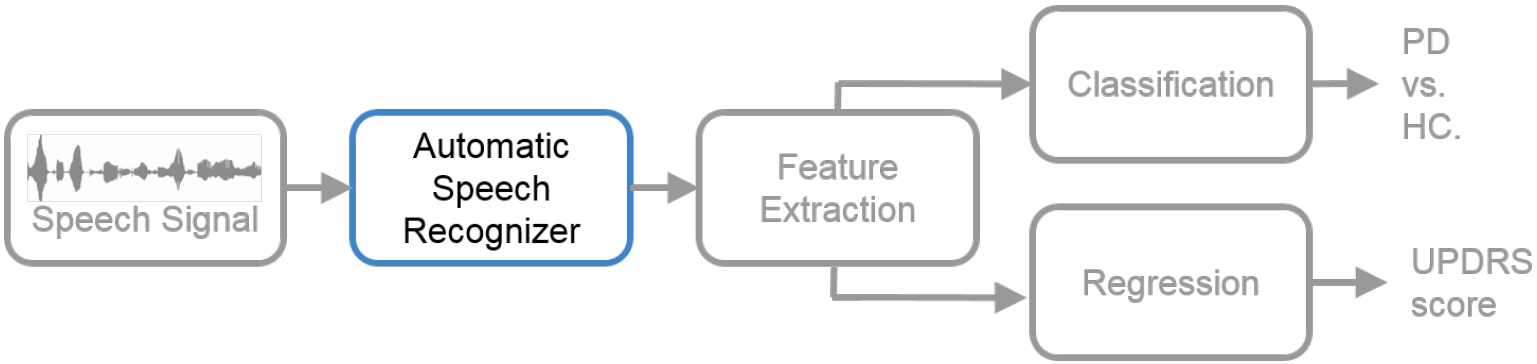
Two novel features are proposed to analyze the intelligibility deficits of patients with PD.

- Word Accuracy
- Similitude Dynamic Time Warping

Methodology



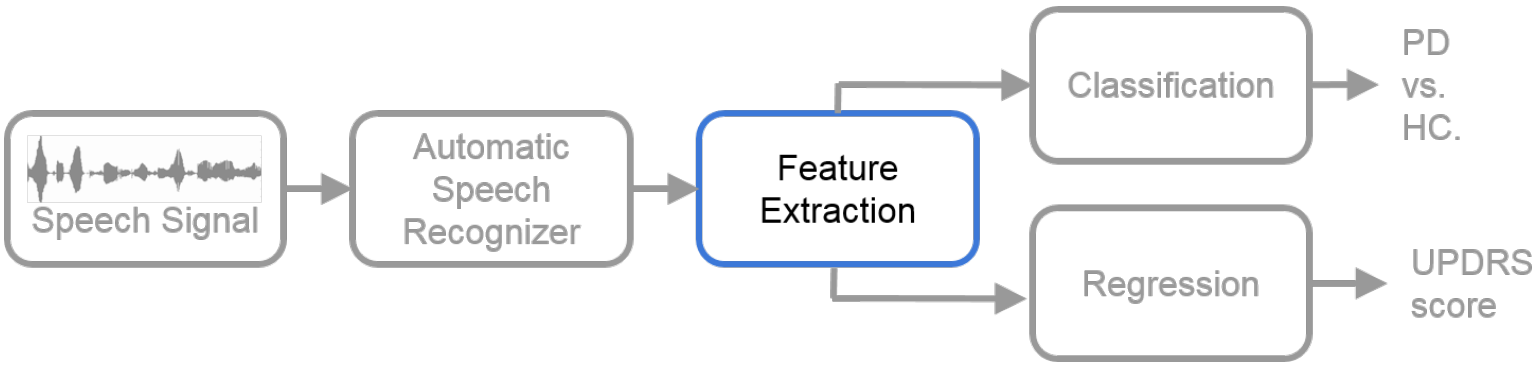
Methodology: Automatic Speech Recognition[1]



- Google API for ASR
- Spanish from Colombia

[1] www.google.com/intl/es/chrome/demos/speech.html

Methodology: Feature Extraction[2]

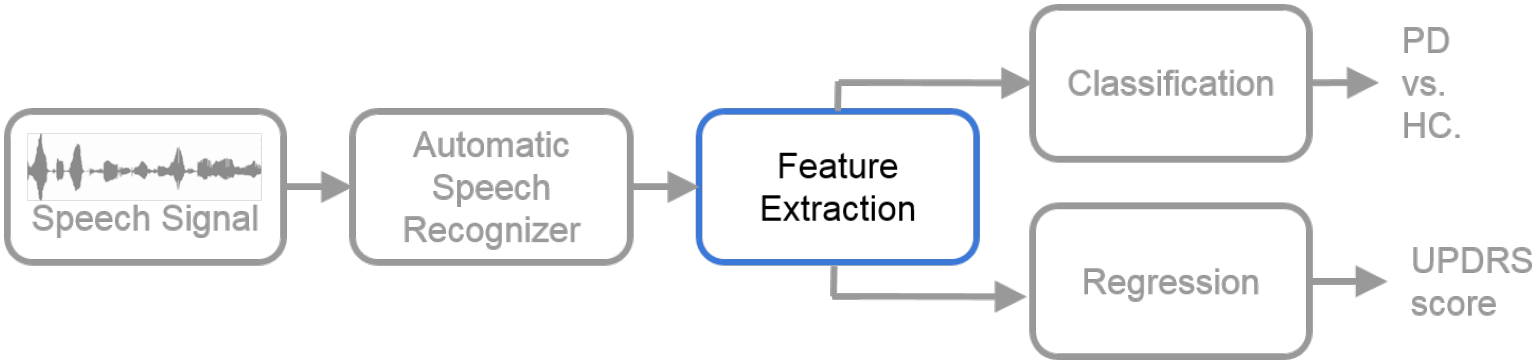


Word Accuracy (WA)

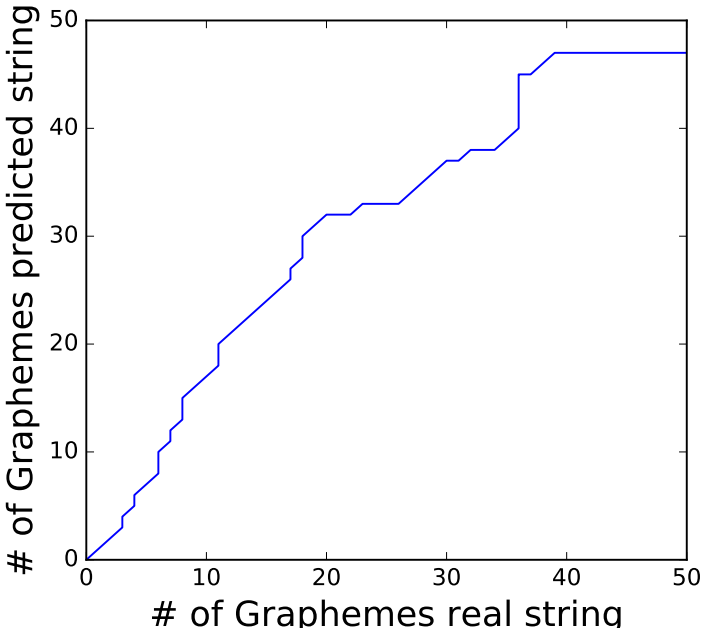
$$WA = \frac{\#words\ correctly\ recognized}{\#\ of\ total\ words} \quad (1)$$

[2] https://github.com/jcvasquezc/intelligibility

Methodology: Feature Extraction[3]



Dynamic Time Warping



$$sDTW = \frac{1}{1 + DTW\_distance} \quad (2)$$

[3] https://github.com/jcvasquezc/intelligibility

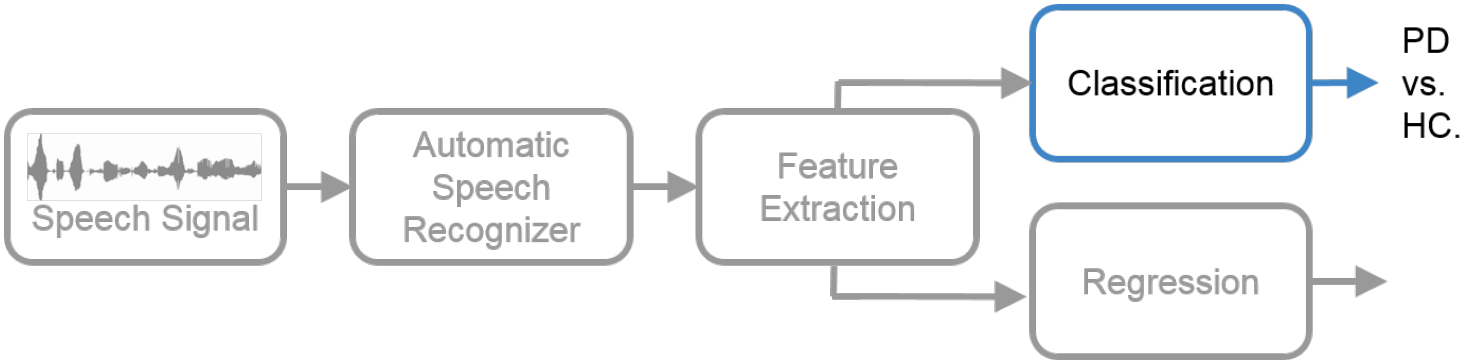
Methodology: Feature Extraction[4]

Table: Example of the intelligibility features for four sentences

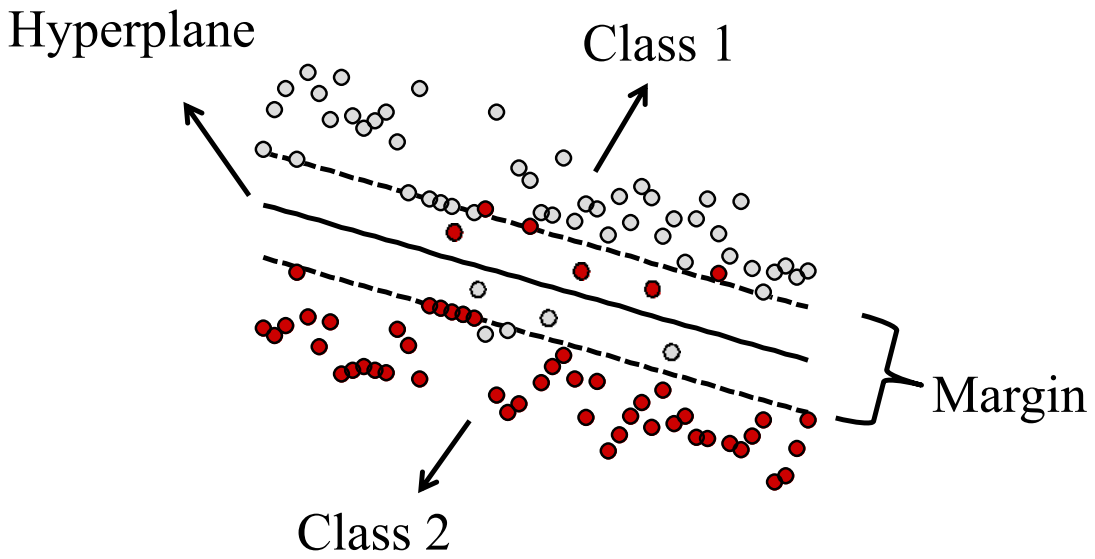
Original String	**Predicted String**	**WA**	**sDTW**
Mi casa tiene tres cuartos	Ricardo tiene tres cuartos	0.60	0.70
Omar, que vive cerca, trajo miel	Omar vive cerca dragón bien	0.50	0.38
Rosita Niño que pinta bien donó sus cuadros ayer	Recital Niño que pinta bien todos los juegos ayer	0.44	0.39
Luisa Rey compra el colchón duro que tanto le gusta	Luisa Rey comprar un colchón duro que tanto la lluvia	0.60	0.57

[4] https://github.com/jcvasquezc/intelligibility

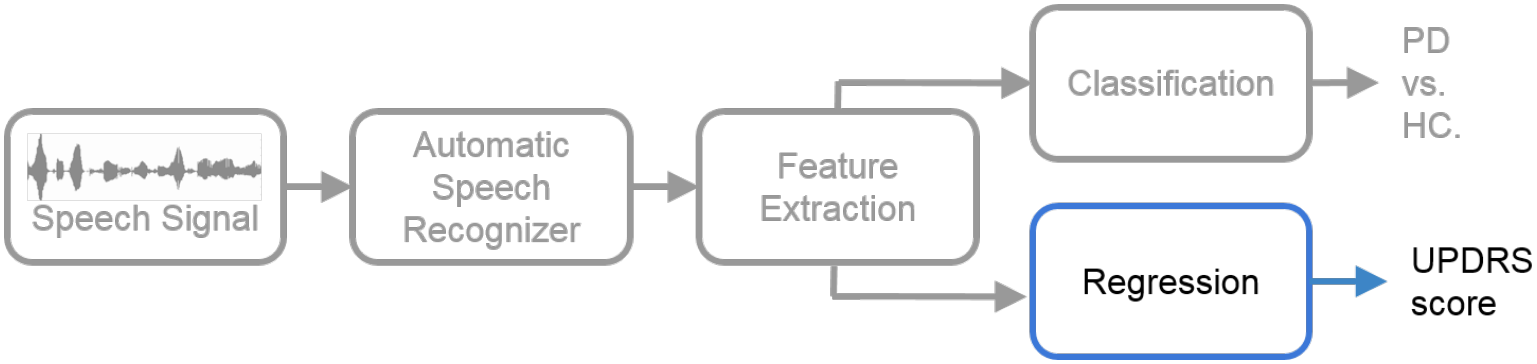
Methodology: Classification



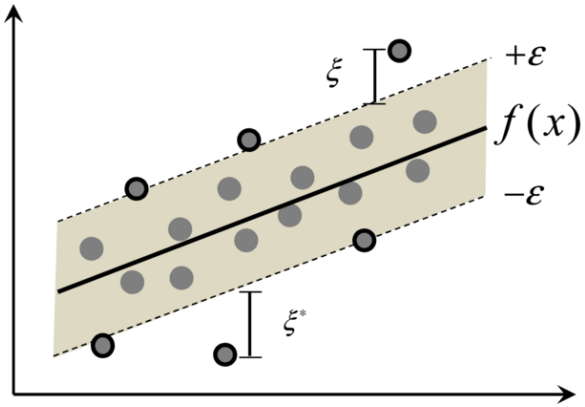
- Support vector machine (SVM)
- Gaussian kernel
- $C \in \{10^{-5}, 10^{-4}, \ldots 10^{4}\}$
- $\gamma \in \{10^{-6}, 10^{-5}, \ldots 10^{2}\}$
- Leave one subject out cross-validation

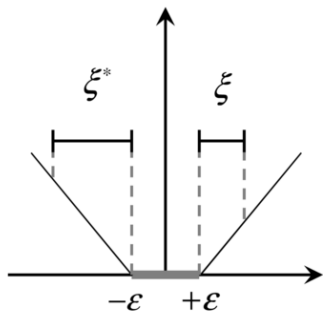


Methodology: Regression



- Support vector regressor (SVR)
- Linear kernel
- $C \in \{10^{-5}, 10^{-4}, \ldots 10^{4}\}$
- $\varepsilon \in \{10^{-4}, 10^{-3}, \ldots, 10, 20\}$
- Leave one subject out cross-validation





Experimental framework: Database[5]

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PC-GITA database

- 50 patients, 50 healthy controls
- balanced in age and gender
- recorded in a soundproof-booth
- six sentences and read text

[5] J. R. Orozco-Arroyave et al. "New spanish speech corpus database for the analysis of people suffering from Parkinson's disease." In: *9th Language Resources and Evaluation Conference, (LREC)*. 2014, pp. 342–347.

Experimental framework: Experiments

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- Classification of 50 PD vs. 50 HC
- Regression to predict the neurological state of 50 PD patients
- Individual tasks
- Combination of tasks (Early fusion)

Results: Classification

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Task	Accuracy	AUC
sentence 1	78%	0.67
sentence 2	61%	0.64
sentence 3	63%	0.63
sentence 4	64%	0.67
sentence 5	82%	0.82
sentence 6	62%	0.65
read text	75%	0.79
all sentences	88%	0.96
all sentences + read text	92%	0.98

Results: Classification

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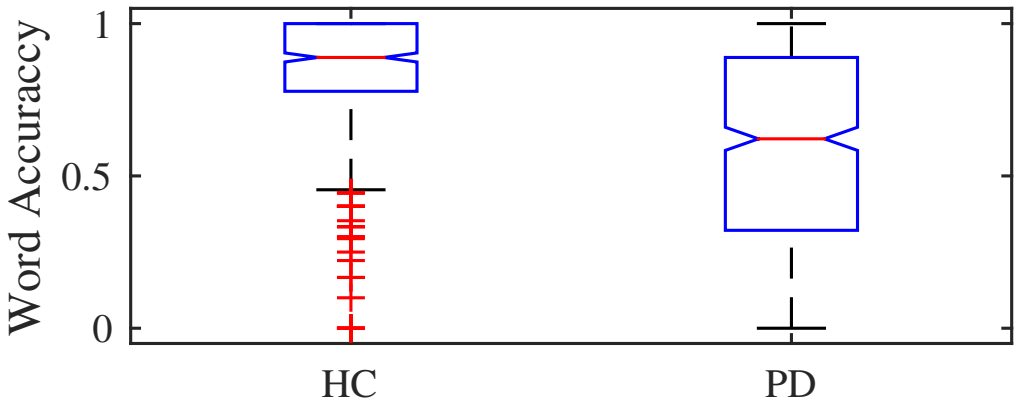

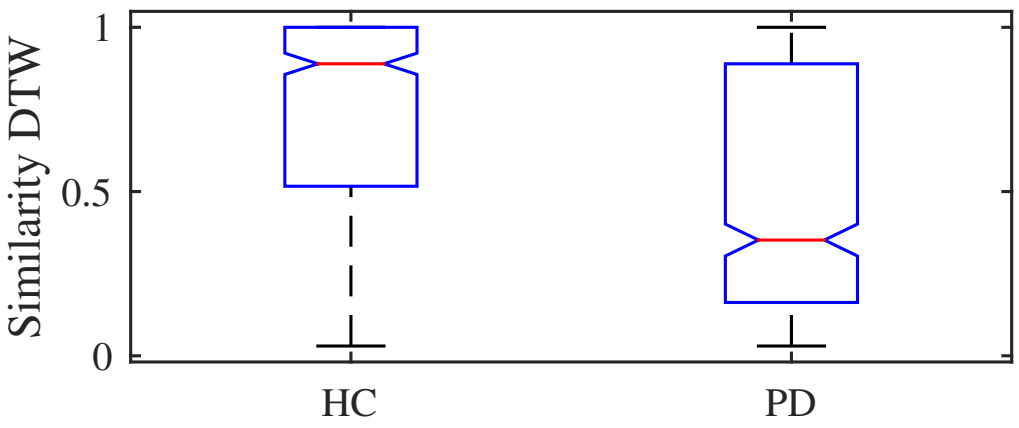

Wilcoxon rank sum test	
WA	p-val 8.3e-37
sDTW	p-val 7.5e-25

Results: Regression

Table: Spearman correlation coefficient (ρ) between the real and the predicted UPDRS

Task	ρ
sentence 1	0.20
sentence 2	0.02
sentence 3	0.16
sentence 4	-0.40
sentence 5	-0.07
sentence 6	0.23
read text	0.19
all sentences	-0.12
all sentences + read text	0.01

Results: Regression

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Conclusions

- Two novel features are proposed to evaluate the intelligibility deficits in PD patients.
- Classification and regression experiments are performed.
- The proposed features are highly accurate to classify PD patients from HC speakers.
- The proposed features are not able to predict the UPDRS score of the patients by themselves.
- Combination of the proposed features with other features that analyze other dimensions such as phonation, articulation, and prosody might be performed.

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