Towards disease-specific speech markers for differential diagnosis in Parkinsonism

Biswajit Das[1] Khalid Daoudi[1] Jiri Klempir[2] Jan Rusz[3]

[1]INRIA Bordeaux Sud-Ouest (GeoStat team)
Talence, France

[2]Department of Neurology and Center of Clinical Neuroscience, First Faculty of Medicine
Charles University, Prague, Czech Republic

[3]Department of Circuit Theory. Faculty of Electrical Engineering
Czech Technical University in Prague, Czech Republic

16/05/2019

Outline

- Introduction
- Objective
- Speech database
- Methodology
- Results
- Conclusion and Discussion

Introduction

Parkinsonism is primarily a group of neurodegenerative disease.

- Disease groups:
  - Parkinson's Disease (**PD**): The clinical diagnosis requires the presence of bradykinesia, rigidity, resting tremor and postural instability.
  - Atypical Parkinsonian Disorder (APS)
    - Progressive Supranuclear Palsy (**PSP**): Spasticity is a major symptom for PSP patients. Symptom of parkinsonism is also prevalent for PSP.
    - Multiple System Atrophy (**MSA**): It is characterized by a variable combination of parkinsonism, cerebellar impairment, autonomic failure and pyramidal tract signs.
- The majority of PSP and MSA patients develop clinical features that overlap those of PD.
- The correct diagnosis can be very challenging in early stages of the disease.

Introduction...

- Dysarthria is frequently an early and prominent clinical feature of PD as well as APS.
- Specific kind of dysarthria can provide insight of neurophysiological bases and localization of neurologic disease.
- This study is a continuation of our previous work on discrimination between PSP and MSA [J. Rusz et al. 2015; G. Li et al. 2018]

Objective

- Propose disease specific speech markers for differential diagnosis for PSP and MSA.
- Propose method for accurate and objective discrimination between PSP and MSA.

Speech recording

- Recording task
  - Sustained vowel /A/
  - Fast syllable repetition task /Pa-Ta-Ka/
  - Monologue
- Recording setup:
  - Head mounted microphone (Bayerdynamic Opus 55, Heilbornn, Germany).
  - Speech signal is sampled at 48kHz with 16 bit resolution.

Speech database

- Subjects
  - 13 MSA (10 MSA-P, 3 MSA-C); 6 men, 7 women
  - 12 PSP (9 PSP-RS, 2 PSP-P, 1 PAGF); 10 men, 2 women

	PSP	MSA
	Mean/SD (range)	Mean/SD (range)
General		
Age of disease onset (years)	62.1/5.5 (50-68)	57.2/5.4 (50-70)
Symptom Duration	3.8/1.4 (1-6)	3.6/1.3 (2-6)
L-dopa equivalent (mg)	800/373 (500-1500)	899/394 (260-1480)
Amantadine (mg)	200/107 (100-400)	300/89 (200-400)
NNIPPS	66.3/28.7 (19-116)	78.5/19.9 (46-123)
UPDRS III speech 18 item	2.0/1.0 (0-3)	2.0/0.7 (1-3)
Subscore		
Tremor	2.5/2.6 (0-6)	1.7/2.6 (0-9)
Rigidity	3.0/2.7 (0-7)	4.7/3.2 (0-11)
Bradykinesia	20.6/11.3 (4-40)	27.1/7.4 (16-39)
Bulbar/pseudobilbar	9.1/4.1 (3-17)	7.9/2.3 (4-12)
Pyramidal	0.3/0.5 (0-1)	0.8/1.2 (0-3)
Cerebellar	0.1/0.30 (0-1)	5.6/7.1 (0-22)

Table: Clinical information of patients

Feature set

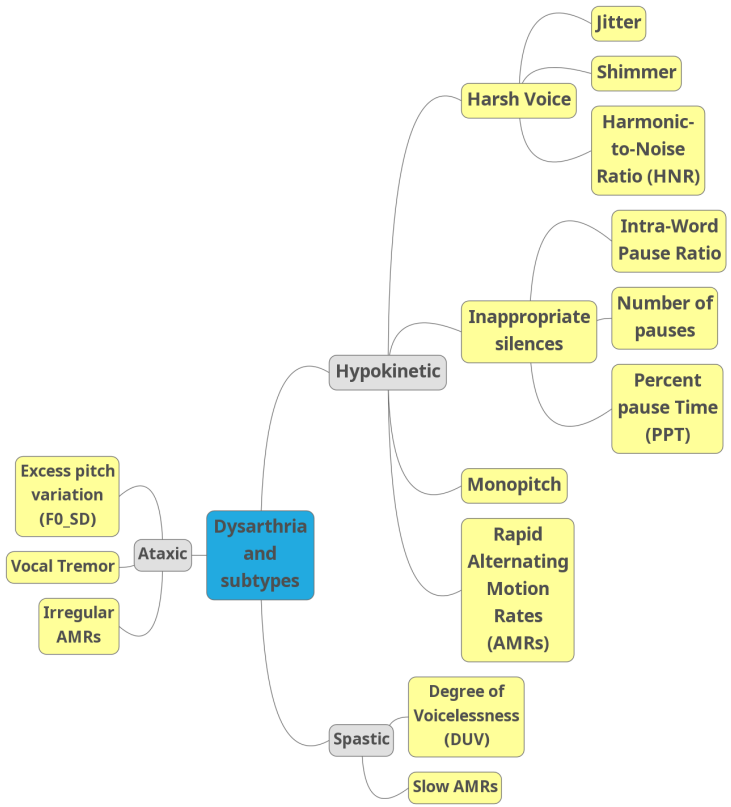
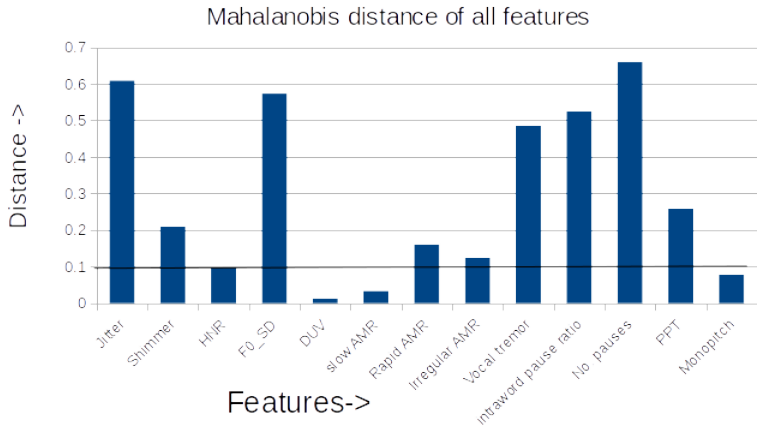


Figure: List of the 13 features, grouped by dysarthria type

Methodology 1: univariate analysis



- Selected features:
  - Hypokinetic (H) = {jitter, shimmer, HNR, intra-word pause, rapid AMR, no. of pauses, PPT}
  - Ataxic (A) = {F0_SD, irregular AMR, vocal tremor}
  - Spastic (S) = {DUV, slow AMR}

Methodology 2

- Feature dimension reduction:
  - In our experiment, we are in a small dataset machine learning scenario.
  - Typically, only a 1-dimensional feature space may provide acceptable statistics.
  - We have used Fisher Discriminative Analysis (FDA) for feature dimensionality reduction.
- Classification:
  - For classification, we use a simple 1d **linear** Support Vector Machine (SVM) with $C = 1$ as classifiers.
  - Considering small amount of data, a Leave-One-Speaker-Out (LOSO) training approach is adopted in all the experiments.

Results

- FDA on each dysarthric group (H, A, S) followed by classification:

	H	A	S
Accuracy (%)	68	8	0

Table: Classification accuracy for individual dysarthric groups

- Individual dysarthria groups did not provide disease specificity.

Results...

- We now proceed to evaluate the combination of dysarthric groups.

	H+S+A	H+S	S+A	H+A
Accuracy (%)	72	60	24	**84**

Table: Classification accuracy for combined dysarthric groups

- "Mutual amount" of hypokinetic and ataxic dysarthria can allow discrimination between MSA and PSP.
- Simple linear combination provide the discrimination.

Results...

- We analyzed linear weights to understand feature's contribution.

	Hypokinetic							Ataxic		
	Jitter	Shimmer	HNR	Intra-word pause	No. of pauses	PPT	Rapid AMR	F0_SD	Irregular AMR	Vocal tremor
Weight	1.03	3.02	4.77	-0.10	-0.02	-1.11	0.80	2.14	-0.49	0.37

Table: Feature weights obtained by FDA

- Intra-word pause and no. of pauses have lower weights compared to the other feature.
- After discarding two features, selected H+A feature yields a classification score of **88%**.
- We mention however that these classification scores should be considered with precaution because of the LOSO bias (different weights at each iteration).

Results...

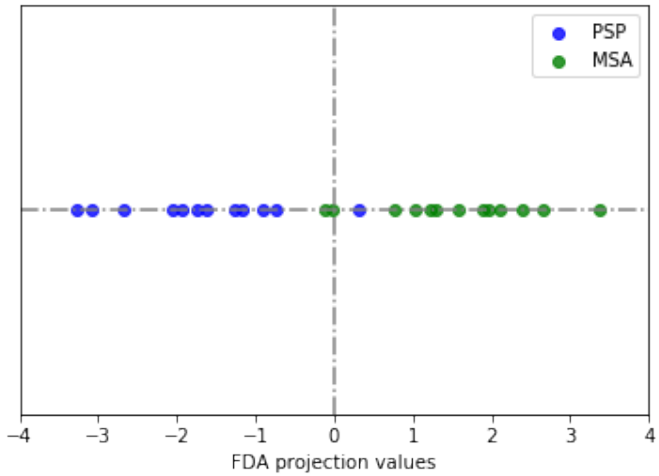


Figure: Values of the new speech feature for each patient

Conclusion and Discussion

- We addressed the difficult problem of defining disease-specific speech features which is crucial in the perspective of early differential diagnosis in Parkinsonism.
- We focused on MSA and PSP and investigated this problem under the constraint of small dataset machine learning.
- Using FDA, we ended up defining a new scalar variable which measure degree of hypokinetic and ataxic "impairment".
- This new variable can be considered as disease specific.
- We achieved 88% accuracy using hypokinetic and ataxic features is encouraging for future study.
- Above finding need to be confirmed by additional data and studies.

Thank you