

*Computational Differential Diagnosis and Prognosis
for Parkinson Disease from Natural Speech*

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Outline

- Parkinson's Disease (PD)
 - PD and speech
- Possible Application
- Proposed Algorithm
 - Preprocessing
 - Feature extraction
 - Classification
- Data & Results
- Future work
 - Topological classification
- Summary and Conclusions

Parkinson's Disease

- A neurodegenerative disorder
 - “masklike” facial features
 - bradykinesia, akinesia
 - tremor at rest and muscle rigidity
 - slow or monotonic speech
- Affects approximately 1% of individuals over the age of 65
- By the time diagnosed
 - 60% of nigrostriatal neurons have degenerated
 - 80% of striatal dopamine are depleted

Parkinson's Disease (cont')

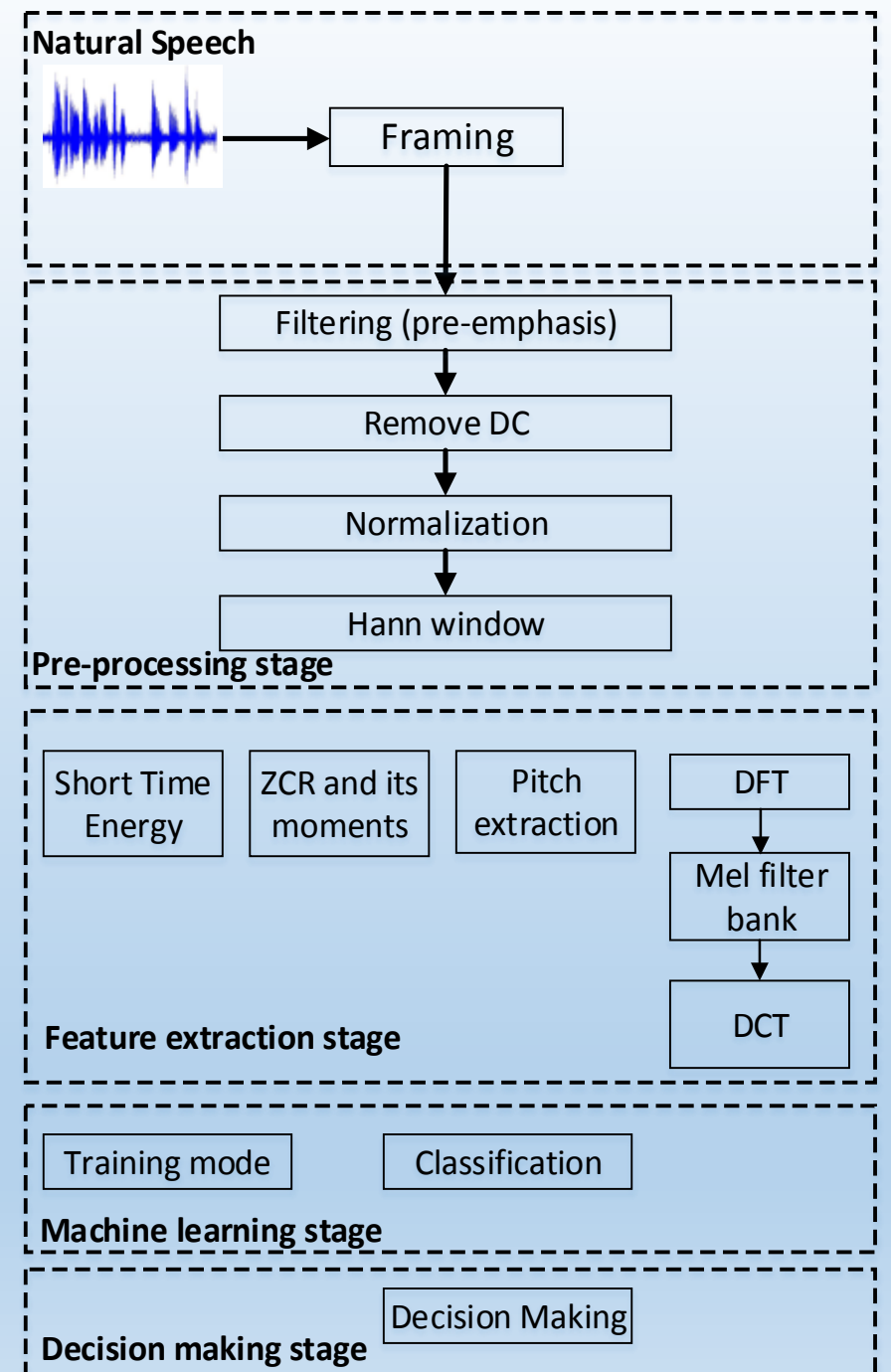
- PD can affect all of the components of speech production
 - Breathing
 - Laryngeal function
 - Articulator movement
 - As well as their coordination for smooth and fluent speech
- Resulting in:
 - Reduced volume (hypophonia)
 - Reduced pitch range (monotone)
 - Difficulty with articulation of sounds or syllables (dysarthria)
 - Slowness of the speech

Possible Applications

- Home monitoring
- Remote diagnosis
- Remote sensing
- Can act as a part or a building block of a much bigger systems
 - Human machine interaction systems
- A screener or a base line for drugs evaluation

Proposed Algorithm

- Framing
- Pre-processing
- Feature Extraction
- Classification
- Decision making/monitoring



Feature Extraction

- **Time domain**

- Short Time Energy
- Zero Crossing Rate (ZCR)
- Mean and Standard Deviation of ZCR
- Skewness and Kurtosis

- **Spectral Domain**

- Pitch and its power

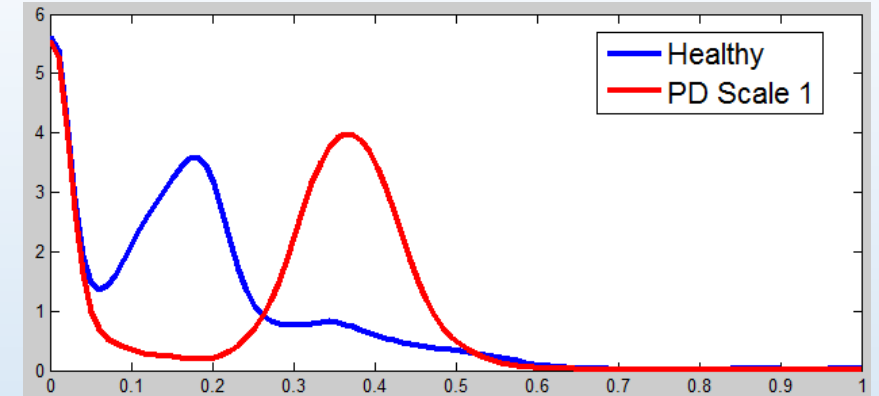
- **Cepstral Domain**

- Mel Frequency Cepstral Coefficients (MFCCs)
 - Compute the log of the magnitude spectrum
 - Group the DFT bins according to Mel frequency scale
 - Take the first 3 coefficients (out of 26)

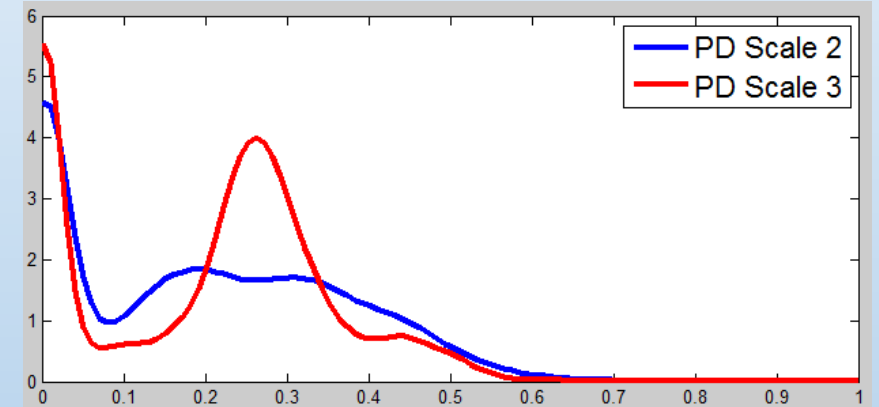
Feature Analysis Process

- Features were analyzed visually using their PDFs
- Example:
 - Pitch positions
 - std of zcr
- Can be seen that the same feature has different separation power

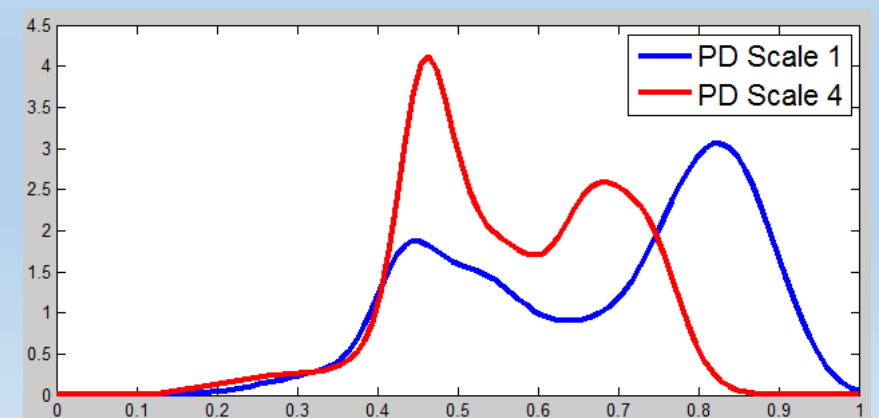
Pitch positions



Pitch positions



STD of ZCR



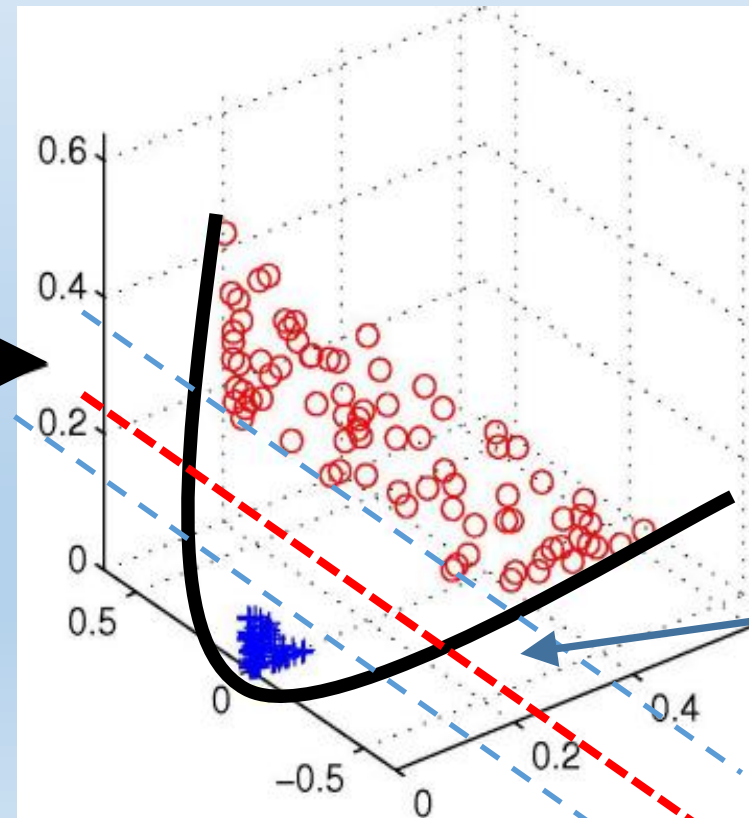
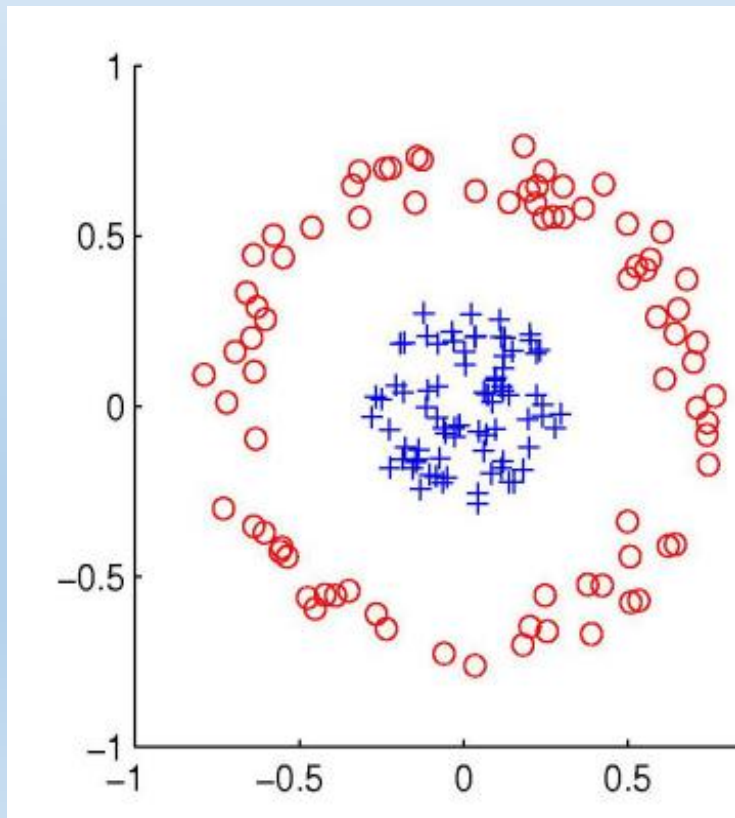
Classification using SVM

A Support Vector Machine **maps** non-linear **separable** data to higher dimensional space and performs separation in that space.

Divide your data into three sets, training set , testing set and validation set. Learn on the training, verify on the testing and validate the model on the last.

Classification using SVM (cont')

- The kernel 'trick'
 - Kernel functions transforms features to a linearly separable space



Maximal
Margin
classifier

Data

- A total of 52 patients were used
 - 9 controls and 43 from different grades
- 0 to 5 grades were used with 0.5 resolution
- Patients were recorded reading the “Rainbow Passage” in natural manner
 - Considered phonetically balanced paragraph

Training Procedure

- Leave-M-Out
 - Used for calculating results and validate generalizability of the results
- Only 10% of the windows were used for training
 - The windows were randomly sampled
- Over-sampling
 - To balance the data during training process
- Grid Search methodology applied for finding best parameters
 - Logarithmic and then finer linear
- SVM Kernel
 - Radial Basis Kernel (RBF) is used

Results (cont.)

		Class 1					
		1	1.5	2	2.5	3	4
Class 2	0	83.39% (17.47, 15.75)	83.3% (18.46, 14.93)	79.6% (19.77, 21.01)	78.51% (22.54, 20.43)	86.3% (10.57, 17.45)	76.18% (32, 15.63)
	1		78.41% (18.2, 24.97)	79.08% (21.92, 19.92)	81.7% (17.71, 18.89)	85.14% (15.13, 14.58)	85.57% (16.05, 12.80)
	1.5			83.39% (16.93, 16.29)	84.03% (15.04, 16.89)	74.45% (22.78, 28.30)	86.1% (15.42, 12.38)
	2				76.7% (22.35, 24.24)	83.37% (15.64, 17.6)	81.11% (24.76, 13.01)
	2.5					85.81% (13.51, 14.86)	79.49% (23.92, 17.1)
	3						86.57% (17.52, 9.33)

Summary

- **Interestingly**
 - 20ms windows carries much information for diagnosis
 - The windows can be sampled (we don't have to use all the data)
 - The classification is done on sub-phonetic level of speech
 - Nose carries important information, so we need to be careful in pre-processing

Future Work

- Try other languages and dialects
 - Currently we repeated same experiment on German language
- Multi-Class Classification
 - Topological multi-class classifier
- Add more features
 - To increase the classification rate
- Come up with automatic features extraction process
 - Instead of manually examine the PDFs
- Try more neurological diseases
 - dementia, stroke and speech pathologies

	Healthy	Mild	Moderate	Severe
Healthy	60%	12%	10%	9%
Mild	14%	58%	9%	9%
Moderate	8%	15%	61%	16%
Severe	13%	14%	16%	57%

Thank you!

Questions?

The “Rainbow Passage”

“When the sunlight strikes rain drops in the air, they act like a prism and form a rainbow. The rainbow is a division of white light into many beautiful colors. These take the shape of a long, round arch, with its path high above and its two ends apparently beyond the horizon. There is, according to legend, a boiling pot of gold at one end. People look, but never finds it. When a man looks for something beyond its reach, his friends say he is looking for the pot of gold at the end of the rainbow. Throughout the centuries men have explained the rainbow in various ways. Some have accepted it as a miracle without physical explanation. To the Hebrews it was a token that there will be no more universal floods. “