Phonation and Articulation Analysis of Spanish Vowels for Automatic Detection of Parkinson's Disease

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Three new acoustic measures for the simultaneous analysis of phonation and articulation in patients with Parkinson's disease (PD) are presented. The new measures along with other classical features of articulation and stability of speech are evaluated in 50 patients with PD and their respective age and gender matched healthy controls (HC).
The results indicate that phonations of people with PD and HC can be separated with classification rates of up to 81.3%.

Introduction

1% of people older than 65 suffer from PD, and about 90% of patients develop speech disorders associated to motor impairments such as, rigidity, bradykinesia (slow movement), hypokinesia (decreased amplitude of movement), and tremor: hypokinetic dysarthria. Due to the abnormal control of muscles and limbs, PD patients develop phonation and articulation problems during speech production.

Three new features that provide information of articulation and phonation of speech are presented. This set of features, along with other classical acoustic measures is evaluated in a total of 100 participants (50 patients with PD and 50 HC – age and gender matched).

The classification process is performed in two steps. Only features that provide classification rates above 61% in the first step are included in the second one. According to the results, recordings from PD and HC can be classified using different articulation and phonation features with classification rates of 81.3%.

Speech Corpus

MEN – PD PATIENTS				MEN – HC	WOMEN – PD PATIENTS				WOMEN – HC
AGE	UPDRS	H&Y	Years post diagnosis	AGE	AGE	UPDRS	H&Y	Years post diagnosis	AGE
81	5	2	12	86	72	19	2	2.5	76
77	92	5	15	76	75	52	3	3	75
75	13	1	1	71	73	38	2	4	73
75	75	3	16	68	70	23	2	12	68
74	40	2.5	12	68	69	19	2	12	65
69	40	3	5	67	66	28	2	4	65
68	14	1	1	67	66	28	2	4	64
68	67	4	20	67	65	54	3	8	63
68	65	3	8	67	64	40	2	3	63
67	28	2	4	65	62	42	3	12	63
65	32	2	12	64	61	21	1	4	63
65	53	2	19	63	60	29	2	7	62
64	28	2	3	63	59	40	2	14	62
64	45	2	3	62	59	71	3	17	61
60	44	3	10	60	58	57	2	1	61
59	6	1	8	59	57	41	3	37	61
57	20	2	0.4	56	57	61	3	17	60
56	30	2	14	55	55	30	2	12	58
54	15	3	4	55	55	43	3	12	57
50	53	2	7	54	55	30	2	12	57
50	19	2	17	51	55	29	2	43	55
48	9	3	12	50	54	30	2	7	55
47	33	2	2	42	51	38	3	41	50
45	21	1	7	42	51	23	2	10	50
33	51	2	9	31	49	53	2	16	49

Characterization

Phonation features
1. Jitter
2. Shimmer
3. Correlation Dimension

Articulation features
1. $F1$ and $F2$
2. $F0$
3. VAI
4. tVSA

New features

5. **Vocal prism:** its base is tVSA and it altitude is the variability of $F0$ measured from the vowels /a/, /i/, and /u/.
6. **Vocal pentagon:** its vertexes are $F1$ and $F2$ measured from the five Spanish vowels.
7. **Vocal polyhedron:** its base is the vocal pentagon and its edges are the variability of $F0$ measured from the five Spanish vowels.

Vocal Pentagon

tVSA
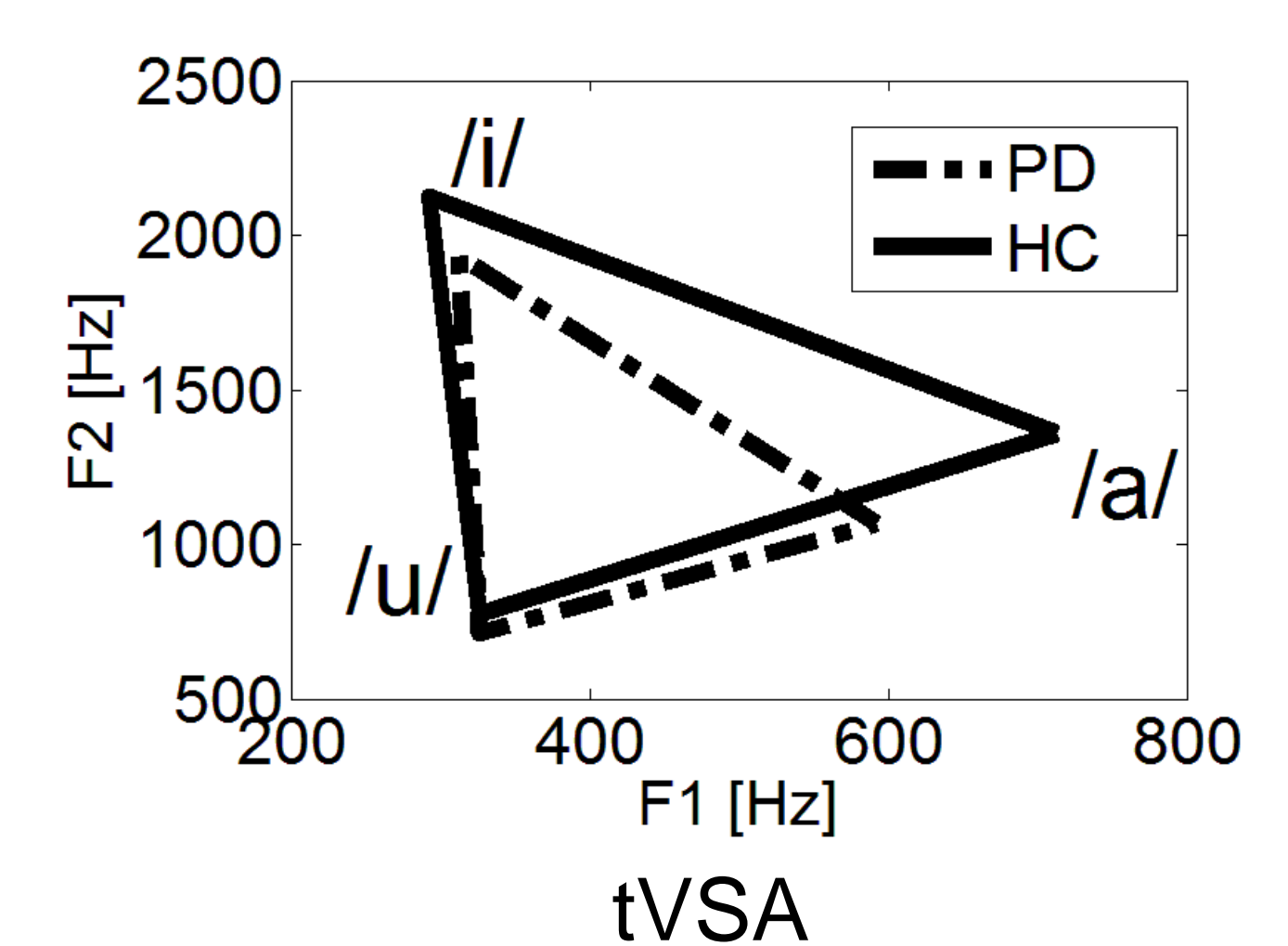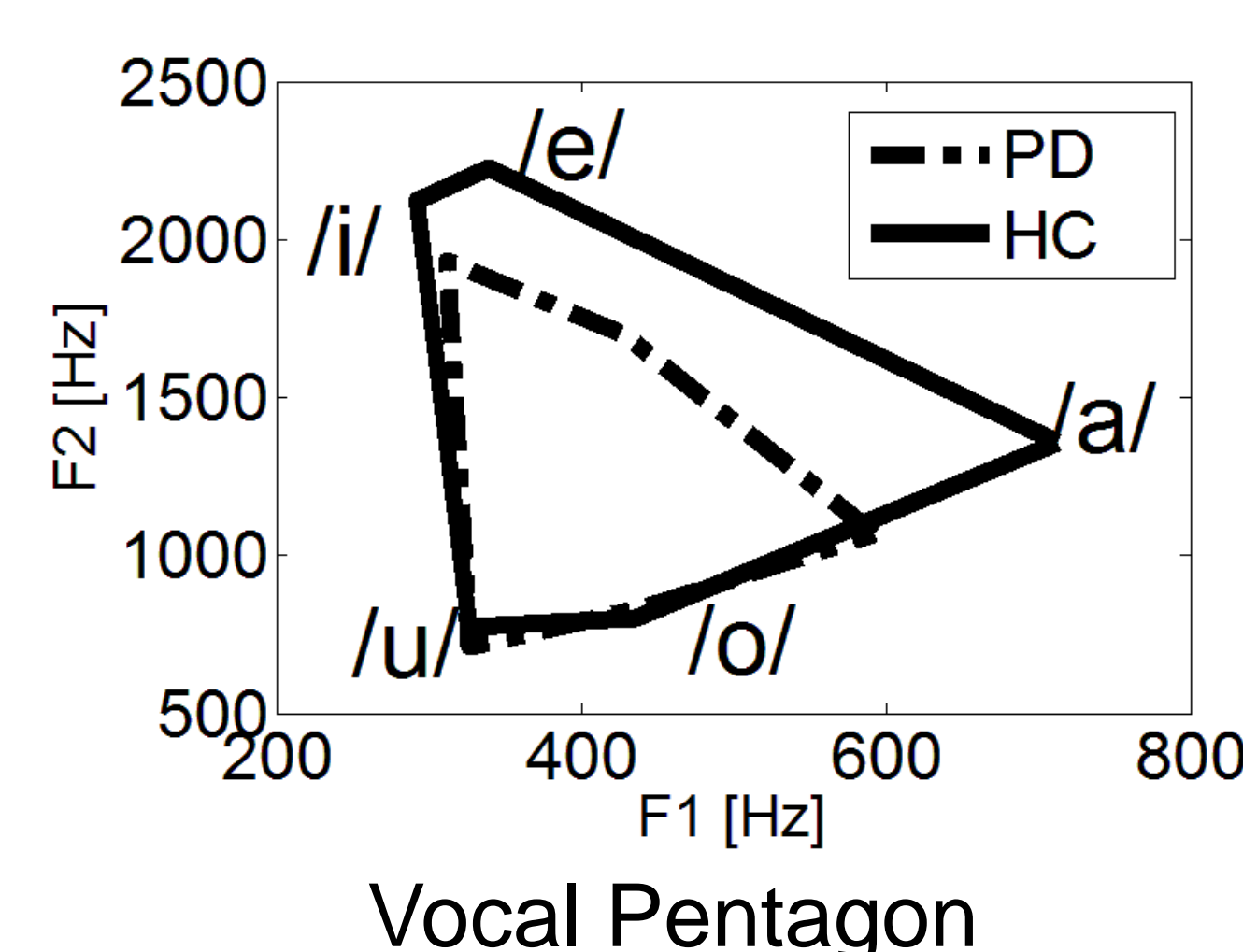
The final classification stage is performed using a support vector machine which is tested following a 10-folds cross-validation strategy *(speaker independent)*.

Results
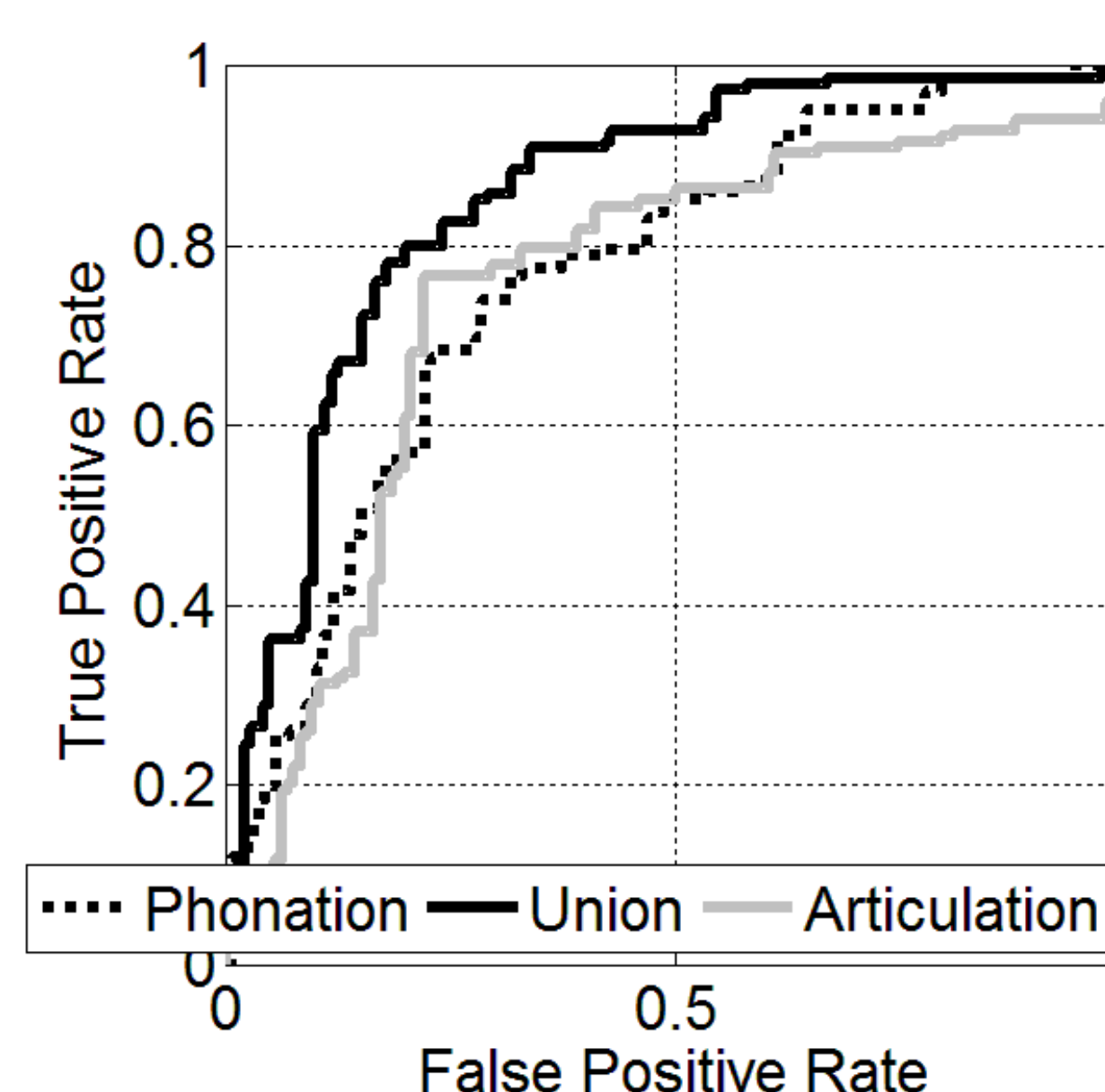
	Accuracy	AUC
Articulation	79.3%	0.76
Phonation	74%	0.74
Union	81.3%	0.85

Conclusions

- New features for the simultaneous analysis of phonation and articulation of speech are presented.
- The set of features is analyzed with discriminative criteria in two stages of classification. Only those features that exceeded 61% of accuracy in the first stage were included in the second one.
- The features considered in the second stage of classification include variability of $F0$, $F1$, and $F2$ of different vowels, and two of the proposed feature, i.e. the area of the vocal pentagon and the volume of the vocal prism.
- The highest classification rate is achieved when phonation and articulation features (classical and new) are combined.

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