Early Diagnosis of Parkinson's Disease
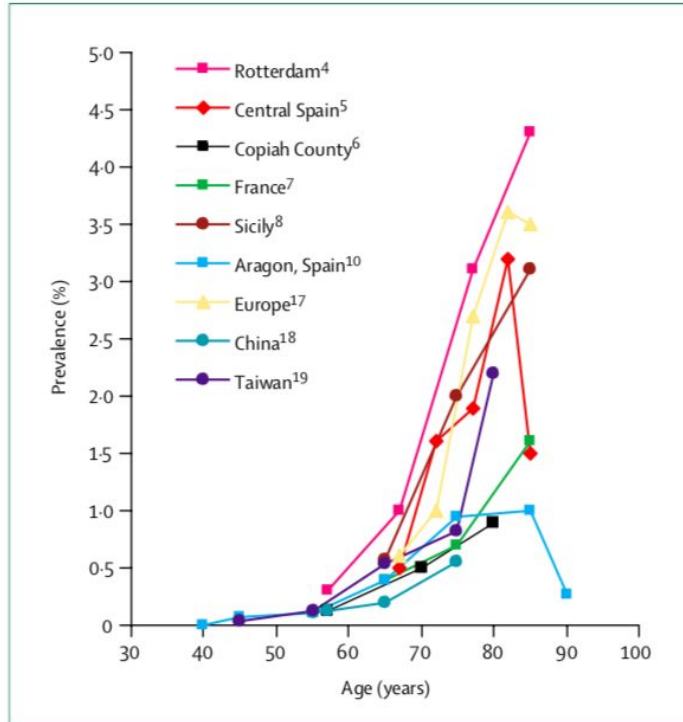
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Alexander Telepov
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25.11.2022

Parkinson Disease

Early diagnostics
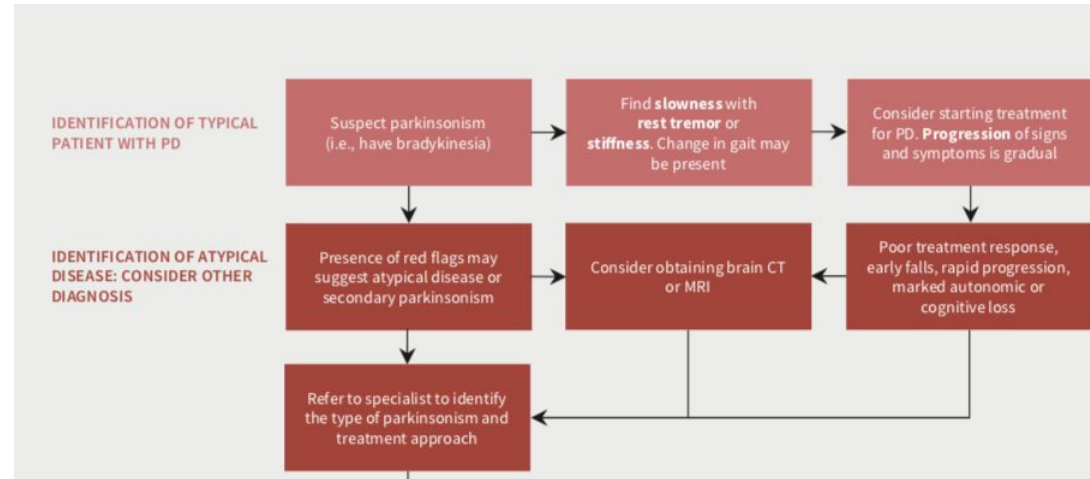
ICD-10 Version:2019: G20

Parkinson disease should be suspected in people presenting with tremor, stiffness, slowness, balance problems or gait disorders

Incidence & Prevalence

Current therapy is more effective on the **early stages of Parkinson**

[1] de Lau LM, Breteler MM. Epidemiology of Parkinson's disease. Lancet Neurol. 2006 Jun;5(6):525-35. doi: 10.1016/S1474-4422(06)70471-9. PMID: 16713924.

[2] Grimes D, Fitzpatrick M, Gordon J, Miyasaki J, Fon EA, Schlossmacher M, Suchowersky O, Rajput A, Lafontaine AL, Mestre T, Appel-Cresswell S, Kalia SK, Schoffer K, Zurowski M, Postuma RB, Udow S, Fox S, Barbeau P, Hutton B. Canadian guideline for Parkinson disease. CMAJ. 2019 Sep 9;191(36):E989-E1004. doi: 10.1503/cmaj.181504. PMID: 31501181; PMCID: PMC6733687.

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Mechanism Of Action (MOA)

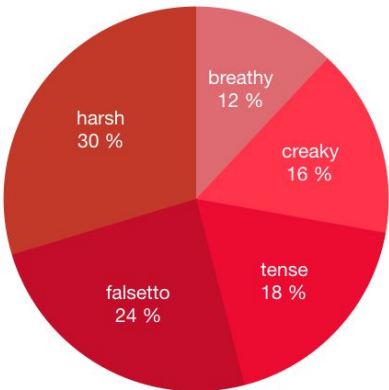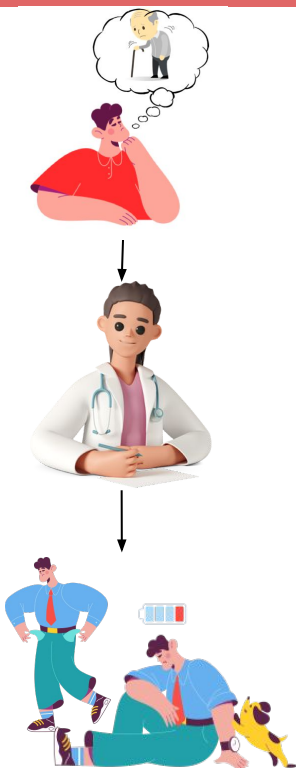78% of early untreated PD subjects indicate vocal impairment.

Fig.1 Composition voice quality in Parkinson's speech

Table.1 Relative characteristics of symptomatic biomarkers

|	Sensitivity	Specificity
Rapid eye movement sleep behavior disorder	Low (~50% of PD patients occur RBD in 2 years)	High (76% risk of PD at 10 years)
Olfactory dysfunction	High (>80% of early PD)	Low
Voice	High (65-98.35% according to ~30 papers)	High (67-91.06% according to ~30 papers)

Old Method

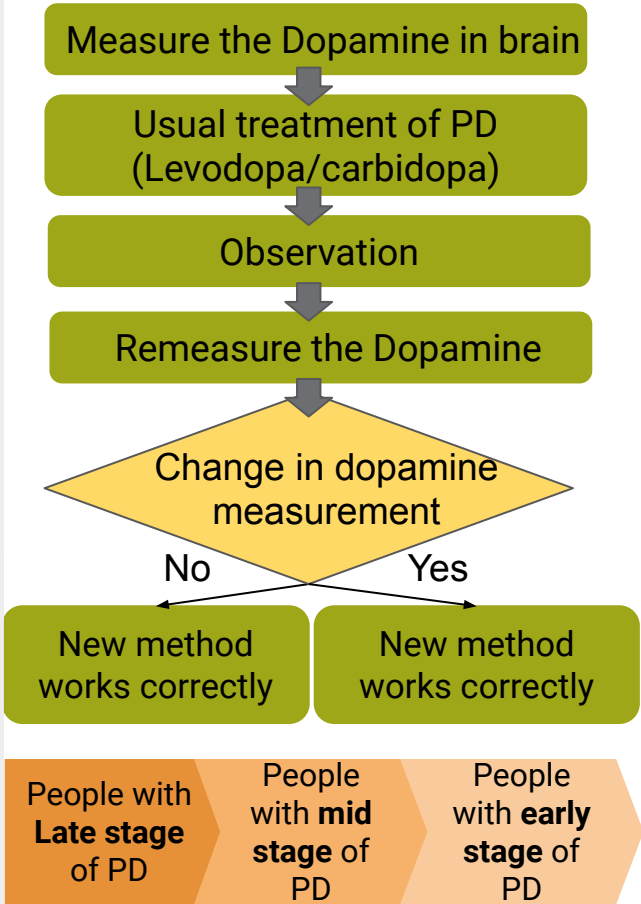Go to a doctor wasting money and time with accuracy 74%

Our Product

Use smartphone to diagnose PD with accuracy 93.84%

Features Extraction

Elimination of irrelevant features

NN with Accuracy 93.84%

Possibility of PD
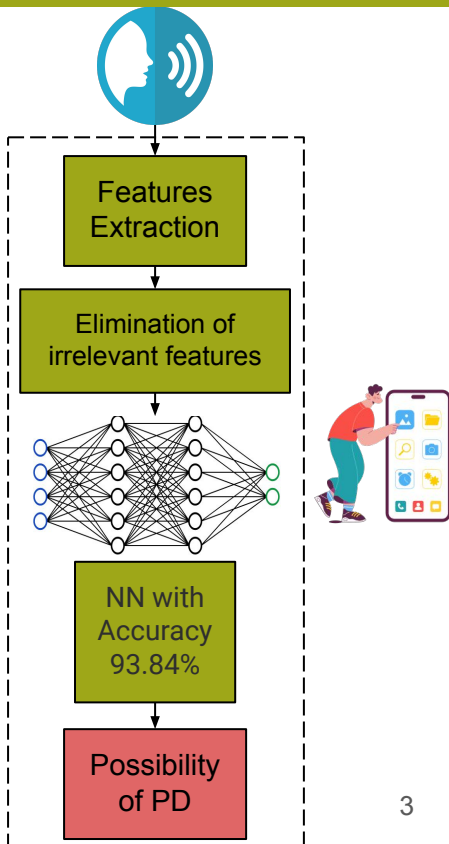
[1] J. Rusz, R. Cmejla, H. Ruzickova, E. Ruzicka, Quantitative acoustic measurements for characterization of speech and voice disorders in early untreated Parkinson's disease, J. Acoust. Soc. Am. 129 (1) (2011) 350–367.
[2] Cernak, Milos, et al. "Characterisation of voice quality of Parkinson's disease using differential phonological posterior features." Computer Speech & Language 46 (2017): 196-208.
[3] Ngo QC, Motin MA, Pah ND, Drotár P, Kempster P, Kumar D. Computerized analysis of speech and voice for Parkinson's disease: A systematic review. Comput Methods Programs Biomed. 2022 Nov;226:107133. doi: 10.1016/j.cmpb.2022.107133. Epub 2022 Sep 16. PMID: 36183641..
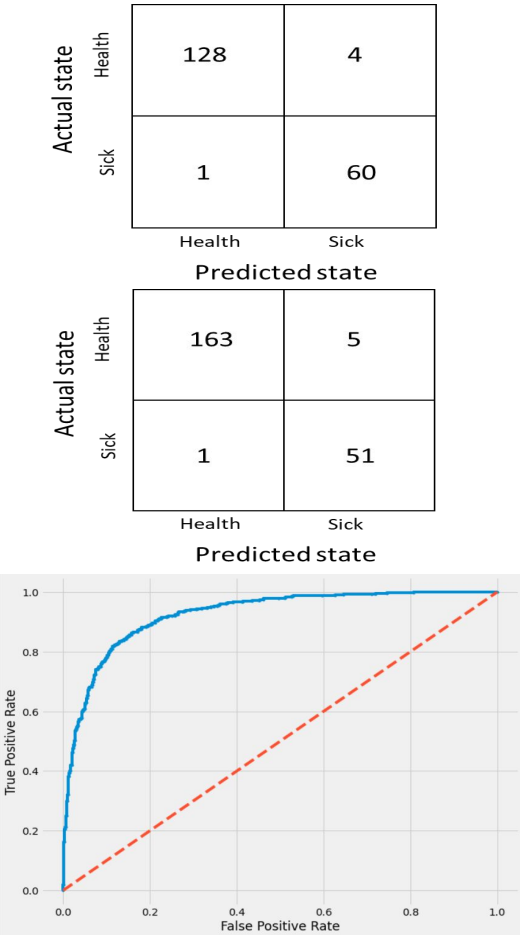
Proof Of Concept (POC)

Measure the Dopamine in brain

↓

Usual treatment of PD (Levodopa/carbidopa)

↓

Observation

↓

Remeasure the Dopamine

↓

Change in dopamine measurement

No — Yes

New method works correctly

New method works correctly

| People with **Late stage** of PD | People with **mid stage** of PD | People with **early stage** of PD |

Experiment Design

- Detecting PD in voice works on both genders accuracy above 93%.
- The voice recordings dataset was collected and used by Sakar et al. (2013)

	PD	Healthy
Total	113	200
Male/Fem	54% - 46%	66% - 34%
Before/After 60 yo	32% - 68%	57% - 43%
Early - mid - late PD stage	16% - 24% - 60%	...

Stage	1st-type error	2nd-type error
Early	0.04	0.02
Mid	0.02	0.01
Late	0.01	0.01

Experiment Results

[1] Ali, Liaqat, et al. "Early diagnosis of Parkinson's disease from multiple voice recordings by simultaneous sample and feature selection." *Expert Systems with Applications* 137 (2019): 22-28.
[2] Ngo, Quoc Cuong, et al. "Computerized analysis of speech and voice for Parkinson's disease: A systematic review." *Computer Methods and Programs in Biomedicine* (2022): 107133.

Novelty

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Patent	Voice-driven small sample learning method for Parkinson disease multi-symptom characteristic parameters	Synthesizing patient-specific speech models	Apparatus and method of diagnosing health by using voice	Our Method
Code	CN112820279A China, 2021	WO2022003451A2 United States, 2020	US9198613B2 United States, 2015	
Advantages	• Utilizing a bidirectional long-time and short-time memory cyclic neural network, so that the Parkinson disease is rapidly researched and judged.	• Speaker adapted model is more accurate than non adapted ones. • The model is build on native language of the user. • Mentioned that any audio recording device can be utilized.	• A health diagnosing apparatus that diagnose user's voice by comparing the extracted voice feature with a reference. • Select <u>one</u> feature in voice depending on the selected disease to do the diagnosis.	• A method depending on the 5 features to diagnose PD. • The features are "Harsh, falsetto, tense, crikey and breath". • Analyse the frequency of all the features and use Mel frequency. • We train a NN to be able to diagnose from the smallest amount of data from the user. • We guarantee 93% of accuracy. • We integrate our method with a smartphone.
Drawbacks	• Only the method is described • The model is trained on short sentences not on the natural speech	• Model focuses on distinguishing "stable" from "unstable" speech which is not always the case for Parkinson	• The feature is not determined for each disease. • No device is invented but a described method. • No accuracy provided.	

Non Obviousness

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Our method show unexpectedly good performance for female > 60 y.o

We suppose that this is due to prevalence* of high frequencies in older female voice, which is significant source of parkinson voice features deviations[1]

Sex	Age	1st-type error	2nd-type error
Male	18-40	0.068	0.022
	40-60	0.025	0.017
	>60	0.012	0.011
Female	18-40	0.053	0.022
	40-60	0.021	0.013
	>60	0.005	0.001
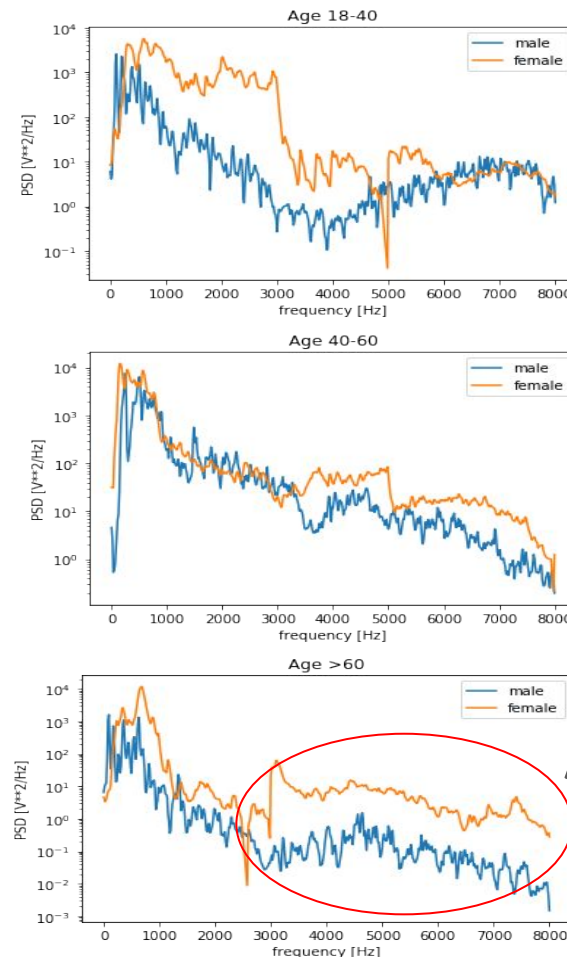
*Selective feature

[1] Ali, Liaqat, et al. "Early diagnosis of Parkinson's disease from multiple voice recordings by simultaneous sample and feature selection." *Expert Systems with Applications* 137 (2019): 22-28.

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Utility

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-Women after 60
-Have some obstacles doing medical check ups
-Can't validate the seriousness of the symptoms

-Conscious about the relatives' future
-Live apart from relatives, can't spot the symptomes/changes

Emotional impact

Feels validated in their struggles

Feels responsible and involved

Quantifiable impact (how much is saved)

Cost 370$

Time 3h

Kilometers 160km

[1] Shalash A, Spindler M, Cubo E. Global Perspective on Telemedicine for Parkinson's Disease. J Parkinsons Dis. 2021;11(s1):S11-S18. doi: 10.3233/JPD-202411. PMID: 33579872; PMCID: PMC8385495

Patent Claims

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1) A software capable to extract the five voice features "Harsh, falsetto, tense, crikey, breath" from the voice sample.
2) The software according to claim 1 capable using said features to determine an early diagnosis of Parkinson's disease.
3) The software according to claim 1 for diagnosing Parkinson's disease for female older than 60 years old with more than 99% accuracy.

Team Role

Team ParkDiag

Belukhina Svetlana

Life Science MOA+POC
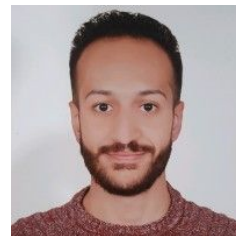
Oussama Alyounes

SES, QC and patent

Kovalev Vyacheslav

Manuf + QC

Telepov Alexander

DS, Preclin+Reg+Clin