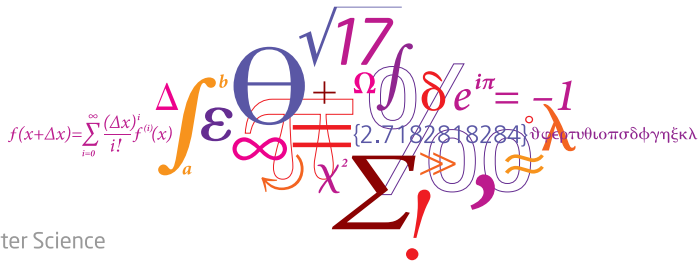


# (Bio)-markers and AI in Voice Disorders (Parkinson's Disease): Opportunities and Challenges

Sneha Das

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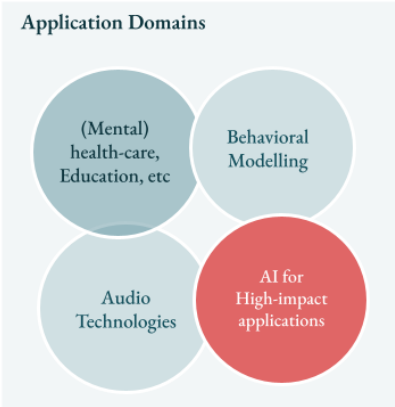
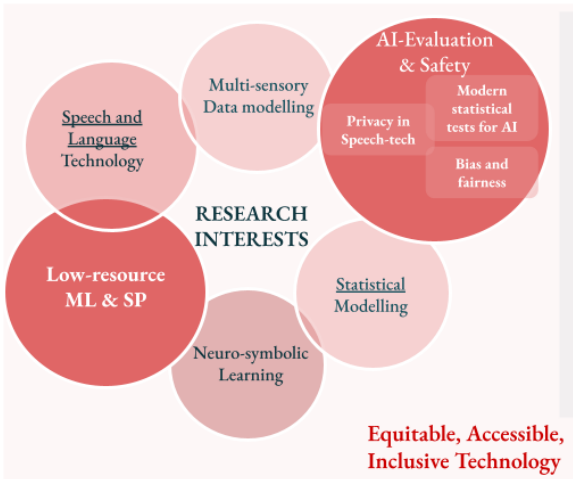


DTU Compute

Department of Applied Mathematics and Computer Science

# About me

## Research focus

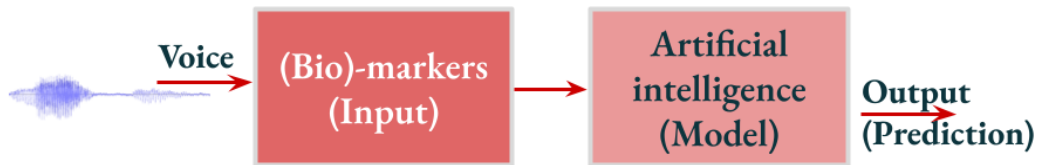


# Outline

- Biomarkers in Voice Disorders
- Opportunities
- Challenges
- Our investigation (Work in progress)

## Voice Disorders in Parkinson's Disease

- Common voice disorders in PD: hypophonia, dysarthria
- Symptoms: reduced volume, monotone speech, imprecise articulation
- Impact on quality of life

**Acoustic Biomarkers (Non-invasive marker)**

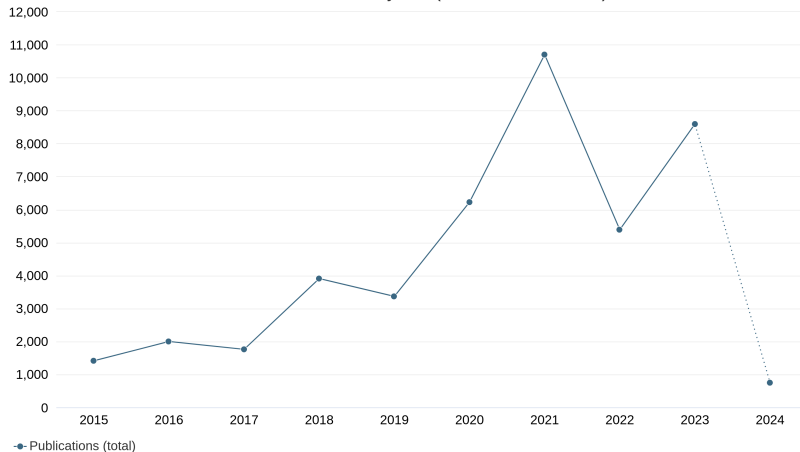
- Fundamental frequency (F0)
- Jitter and shimmer
- Harmonics-to-noise ratio (HNR)
- Formant frequencies

- Early and accurate diagnosis
- Personalized treatment plans
- Continuous monitoring and telehealth applications
- Enhanced research capabilities

# Opportunities

## Academic outcome

Publications in each year. (Criteria: see below)



Source: <https://app.dimensions.ai>

Exported: May 20, 2024

Criteria: 'machine learning to process voice samples for identification of Parkinson's disease' in full data.

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# Opportunities Translation into real-world products

Canary has fully modeled the following conditions for proactive screening.  
We're researching new applications for our technology every day.



#### BEHAVIORAL

Symptoms and states of depression, anxiety, stress, and mood present in acoustic and linguistic features. Canary's technology allows for real-time assessment of mood states and proactive care.

Anxiety and Stress



#### NEURODEGENERATIVE

Vocal biomarkers signal the presence and severity of Alzheimer's, Huntington's, Parkinson's, and other neurodegenerative disorders. Canary Speech models the acoustic and linguistic features specific to each condition to proactively screen for deterioration.

Depression and Mood

Parkinson's Disease



#### CLINICAL CHANGES

Canary allows cost-effective, non-invasive monitoring for mild cognitive impairment and general clinical transitions - detecting issues earlier and preventing readmission.

Energy Levels

Vocal Energy



nature  
medicine

PERSPECTIVE

<https://doi.org/10.1038/s41591-019-0548-6>

Corrected: Author Correction

## Do no harm: a roadmap for responsible machine learning for health care

Jenna Wiens <sup>1,20\*</sup>, Suchi Saria<sup>2,3,4,20</sup>, Mark Sendak <sup>5</sup>, Marzyeh Ghassemi<sup>6,7,8</sup>, Vincent X. Liu<sup>9</sup>, Finale Doshi-Velez<sup>10</sup>, Kenneth Jung<sup>11</sup>, Katherine Heller<sup>12,13</sup>, David Kale<sup>14</sup>, Mohammed Saeed<sup>15</sup>, Pilar N. Ossorio<sup>16</sup>, Sonoo Thadaney-Israni<sup>17</sup> and Anna Goldenberg<sup>6,8,18,19,20\*</sup>

Biases, inflated statistical strength, inappropriate model evaluation, lack of reproducibility.

Our investigation (Work in progress)

## Our work

Challenges (Eg: Medical imaging) → Assessment in Voice domain →  
Recommendations for AI in voice disorders.

Evaluation, validation and testing of AI for voice biomarker discovery and detection of voice disorders (Parkinson's): **Towards clinical level standards for use of AI in voice disorders.**

**Mette, Vitus, Sneha**



The Royal Society of Medicine

### LITERATURE SEARCH

**"Voice Parameters in Parkinson's Disease"**

Prepared by

The Royal Society of Medicine Library  
for

Our investigation (Work in progress)

## Machine-learning and Deep-learning Techniques

AI in Voice Disorder Diagnosis:

- Machine learning (ML) and deep learning (DL) techniques
- Benefits of AI: accuracy, scalability, and efficiency

### Machine-learning

- Supervised learning: classification and regression
- Common algorithms: support vector machines (SVMs), decision trees
- Feature extraction and selection

### Deep-learning

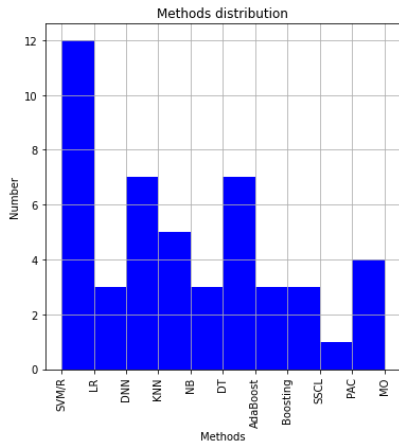
- Convolutional Neural Networks (CNNs) for feature extraction
- Recurrent Neural Networks (RNNs) for sequential data
- Applications in voice analysis

Our investigation (Work in progress)

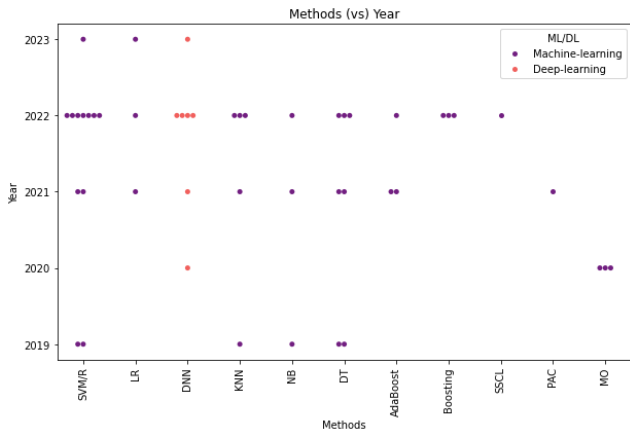
## Machine-learning and Deep-learning Techniques

	Authors	Year	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
1	Costantini,	2023	SVM	LR	CNN							
2	Lim, Wee S	2022	SVM	KNN	NB	LR	DT	RF	AdaBoost	GBM	LightGBM	DNN
3	Dao, Son V	2022	SVM	KNN	DT	LightGBM						
4	Bao, Guido	2022	SVM	KNN	SSCL							
5	Pah, Nemu	2022	SVM									
6	Yu, Qian e	2022	SVM									
7	Suppa, An	2022	SVM	FF-NN								
8	Rajeswari,	2022	SVM	CNN	LSTM							
9	Rajasekar,	2021	SVM	KNN	NB	DT	RF	AdaBoost				
10	Gaballah, J	2021	LR	SVR								
11	Jain, Anub	2021	CRNN	PAC								
12	Park, J.E. e	2020	DNN									
13	Altay, Elif \	2020	NICGAR	QAR-CIP-N	MOPNAR							
14	Viswanath	2021	AdaBoost									
15	Morello, A	2020										
16	Viswanath	2019	SVM									
17	Sheibani, f	2019	SVM	KNN	NB	DT						
18	Manor, Y. e	2024										
19	Arora, Sidh	2019	RF									

# Machine-learning and Deep-learning Techniques



(a) Methods from 2019-2023



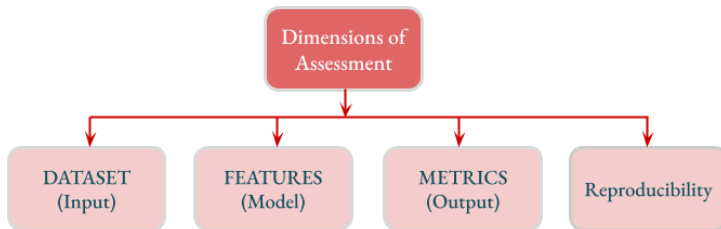
(b) Methods versus year

REVIEW ARTICLE **OPEN**

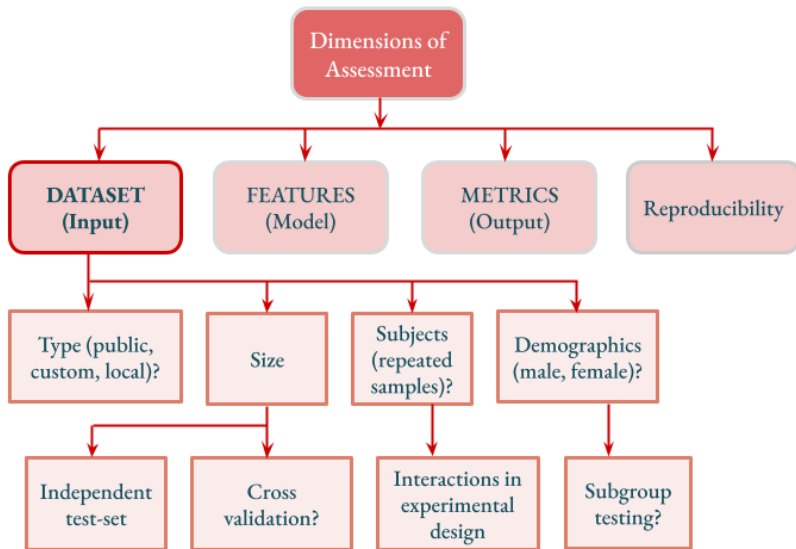


# Machine learning for medical imaging: **methodological failures and recommendations** for the future

Gaël Varoquaux<sup>1,2,3</sup> and Veronika Cheplygina<sup>4</sup>



## Dataset assessment

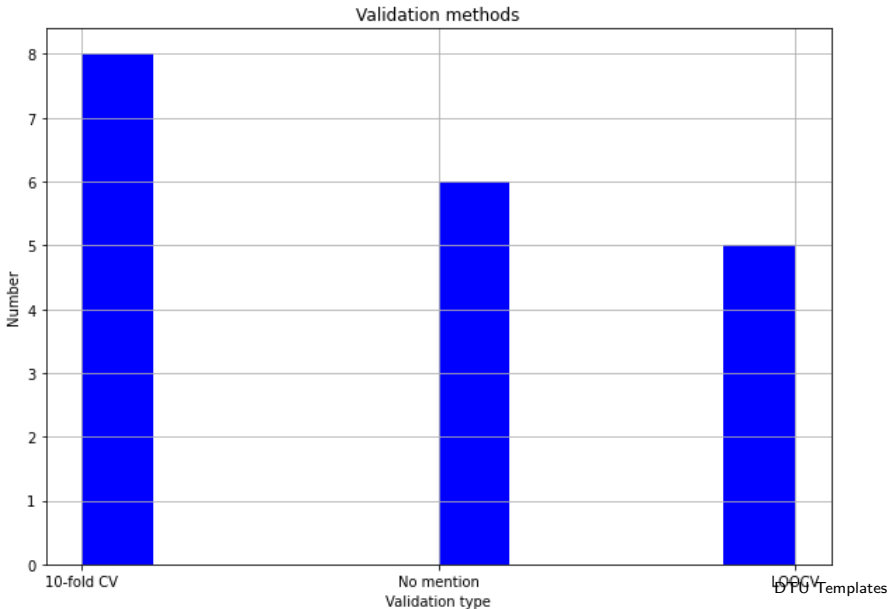


## Model-validation

	Authors	2019-2023	C1	C2	C4	Final_validation
1	Costantini, Giovanni et al.	Artificial Intelligence-Base	Binary, multiclass		10-fold Cro	10-fold CV
2	Lim, Wee Shin et al.	An integrated biometric vo	AdaBoost best valida		10-fold cro	10-fold CV
3	Dao, Son V T et al.	An Analysis of Vocal Features for Pa	NA		NA	No mention
4	Bao, Guidong et al.	Classification of Dysphoni	10-fold		10-fold Cro	10-fold CV
5	Pah, Nemuel D. et al.	Phonemes based detectio	"leave-one-out"		"leave-one	LOOCV
6	Yu, Qian et al.	Parkinson's disease patier	10-fold		10-fold Cro	10-fold CV
7	Suppa, Antonio et al.	Voice in Parkinson's Dise;	10-fold		10-fold Cro	10-fold CV
8	Rajeswari, Sreeja Sasidhar	Prediction of Parkinson's c	10-fold		10-fold Cro	10-fold CV
9	Rajasekar, S.J.S et al.	Park-AI-an AI based tool f	"leave-one-out"		"leave-one	LOOCV
10	Gaballah, Amr et al.	Improved Estimation of Parkinsonian	NA		NA	No mention
11	Jain, Anubhav et al.	Voice Analysis to Different	"leave-one-out"		"leave-one	LOOCV
12	Park, J.E. et al.	Say "AH~": Vocal Analysi	"leave-one-out"		LOSO (Le	LOOCV
13	Altay, Elif Varol et al.	Association analysis of Parkinson dis	NA		NA	No mention
14	Viswanathan, Rekha et al.	Estimation of Parkinson's disease se	NA		NA	No mention
15	Morello, Aline Nunes Da C	Dysphonia and Dysarthria in People	NA		NA	No mention
16	Viswanathan, Rekha et al.	Complexity measures of v	"leave-one-out"		"leave-one	LOOCV
17	Sheibani, Razieh et al.	An ensemble method for c	10-fold		10-fold Cro	10-fold CV
18	Manor, Y. et al.	Machine learning classifiers and subj	NA		NA	No mention
19	Arora, Siddharth et al.	Developing a large scale p	10-fold		10-fold Cro	10-fold CV



Our investigation (Work in progress)  
**Model-validation**





Original Report

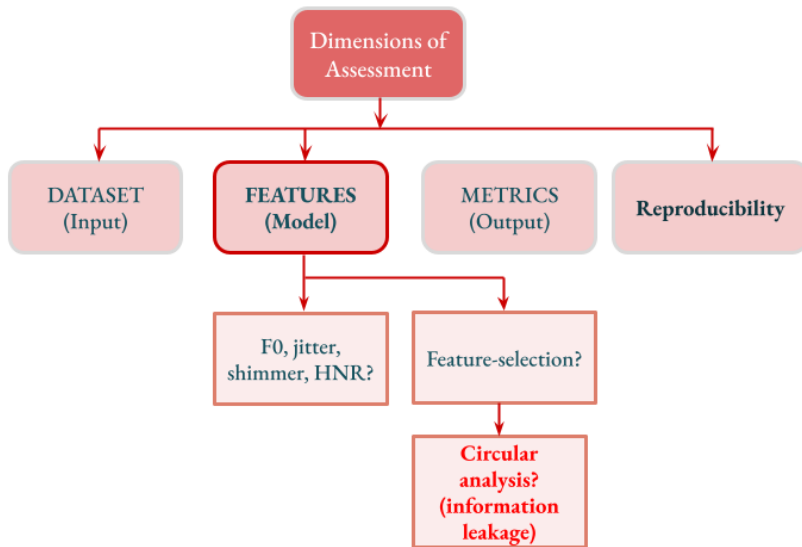
### **Current Practices in Voice Data Collection and Limitations to Voice AI Research: A National Survey**

Emily Evangelista MS, Rohan Kale BSc, Desiree McCutcheon BA, Anais Rameau MD, MPhil, MS, Alexander Gelbard MD, Maria Powell PhD, Michael Johns MD, Anthony Law MD ... [See all authors](#) ▾

## Dataset-type

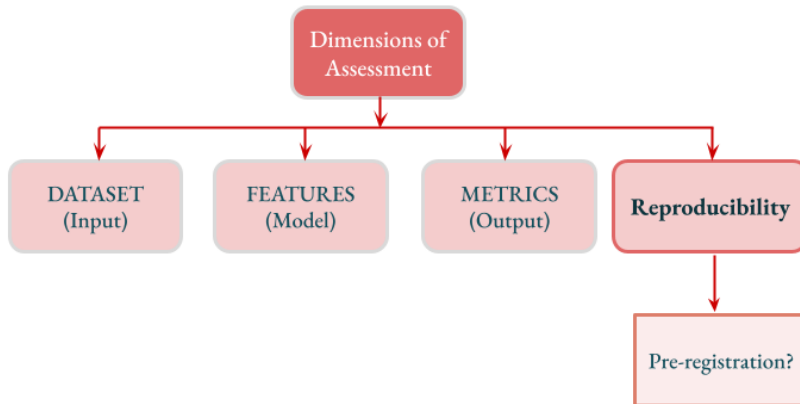
	Authors		
1	Costantini, Giovanni et al.	Voice Analysis	custom-made dataset
2	Lim, Wee Shin et al.	sustained vowels	local dataset (Telephone)
3	Dao, Son V T et al.	NA	Public Speech dataset
4	Bao, Guidong et al.	sustained vowels	own data of normal speech
5	Pah, Nemuel D. et al.	sustained vowels	PC-GITA dataset
6	Yu, Qian et al.	sustained vowels	Local dataset
7	Suppa, Antonio et al.	sustained vowel	Local dataset
8	Rajeswari, Sreeja Sasidharan et al.	sustained vowel	UCI ML dataset
9	Rajasekar, S.J.S et al.	NA	A range of voice measures
10	Gaballah, Amr et al.	sustained vowels	Local dataset
11	Jain, Anubhav et al.	sustained vowels	Local dataset
12	Park, J.E. et al.	sustained vowel	Local dataset
13	Altay, Elif Varol et al.	NA	Local dataset
14	Viswanathan, Rekha et al.	sustained vowels	Local dataset
15	Morello, Aline Nunes Da Cruz et al.	sustained vowel	local dataset
16	Viswanathan, Rekha et al.	sustained vowels	Local dataset
17	Sheibani, Razieh et al.	NA	external dataset
18	Manor, Y. et al.	sustained vowels	Local dataset
19	Arora, Siddharth et al.	NA	external dataset

Our investigation (Work in progress)  
**Features**



## Features

	Authors	amount (features)	F0, jitter, shimmer
1	Costantini, Giovanni et al.	453	F0, jitter, shimmer
2	Lim, Wee Shin et al.	2	F0 (SD)
3	Dao, Son V T et al.	7	F0, jitter, shimmer
4	Bao, Guidong et al.	NA	NA
5	Pah, Nemuel D. et al.	9	F0 (SD), jitter, shimmer
6	Yu, Qian et al.	27	F0, jitter
7	Suppa, Antonio et al.	NA	F0, shimmer
8	Rajeswari, Sreeja Sasidharan et al.	7	jitter,shimmer
9	Rajasekar, S.J.S et al.	7	F0,jitter, shimmer
10	Gaballah, Amr et al.	3	NA
11	Jain, Anubhav et al.	4	F0, jitter, shimmer
12	Park, J.E. et al.	2	NA
13	Altay, Elif Varol et al.	NA	NA
14	Viswanathan, Rekha et al.	6	NA
15	Morello, Aline Nunes Da Cruz et al.	1	NA
16	Viswanathan, Rekha et al.	3	NA
17	Sheibani, Razieh et al.	5	shimmer
18	Manor, Y. et al.	NA	F0
19	Arora, Siddharth et al.		F0, jitter,shimmer



Questions, Comments?