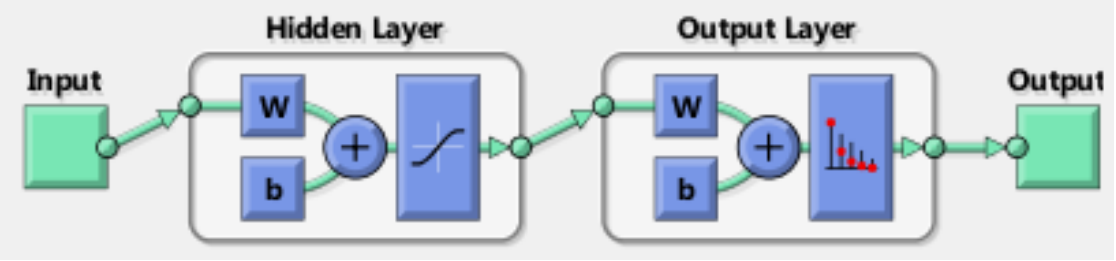
A Minimum Viable Machine Learning-based Speech Processing Solution for Facilitating Early Diagnosis of Parkinson's Disease

Luca Parisi, Auckland Bioengineering Institute (ABI), The University of Auckland
Marianne Lyne Manaog, MedIntellego®, Auckland, New Zealand

Presentation Outline

- **Problem Definition and Motivation**
- The Disease of Interest: **Parkinson's Disease**
- **High-level Objectives**
- **Value Proposition – A Minimum Viable AI Solution**
- **Findings**
- **Discussion**
- **Conclusion**



https://au.mathworks.com/help/nnet/gs/classify-patterns-with-a-neural-network.html

A Scheme of a Multi-layer Perceptron (MLP)-based Learning Classifier

Problem Definition and Motivation

motor problems → PD leads to untreatable motor symptoms [1]

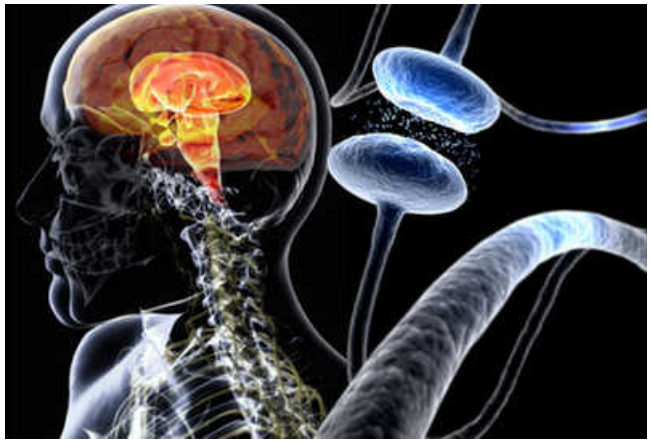
Parkinson's Disease (PD)

no proven means of slowing progression

loss of postural reflexes → dopamine replacement therapy leads to frequent complications [2]

There is no objective method for early diagnosis of PD.

Jankovic (2008)

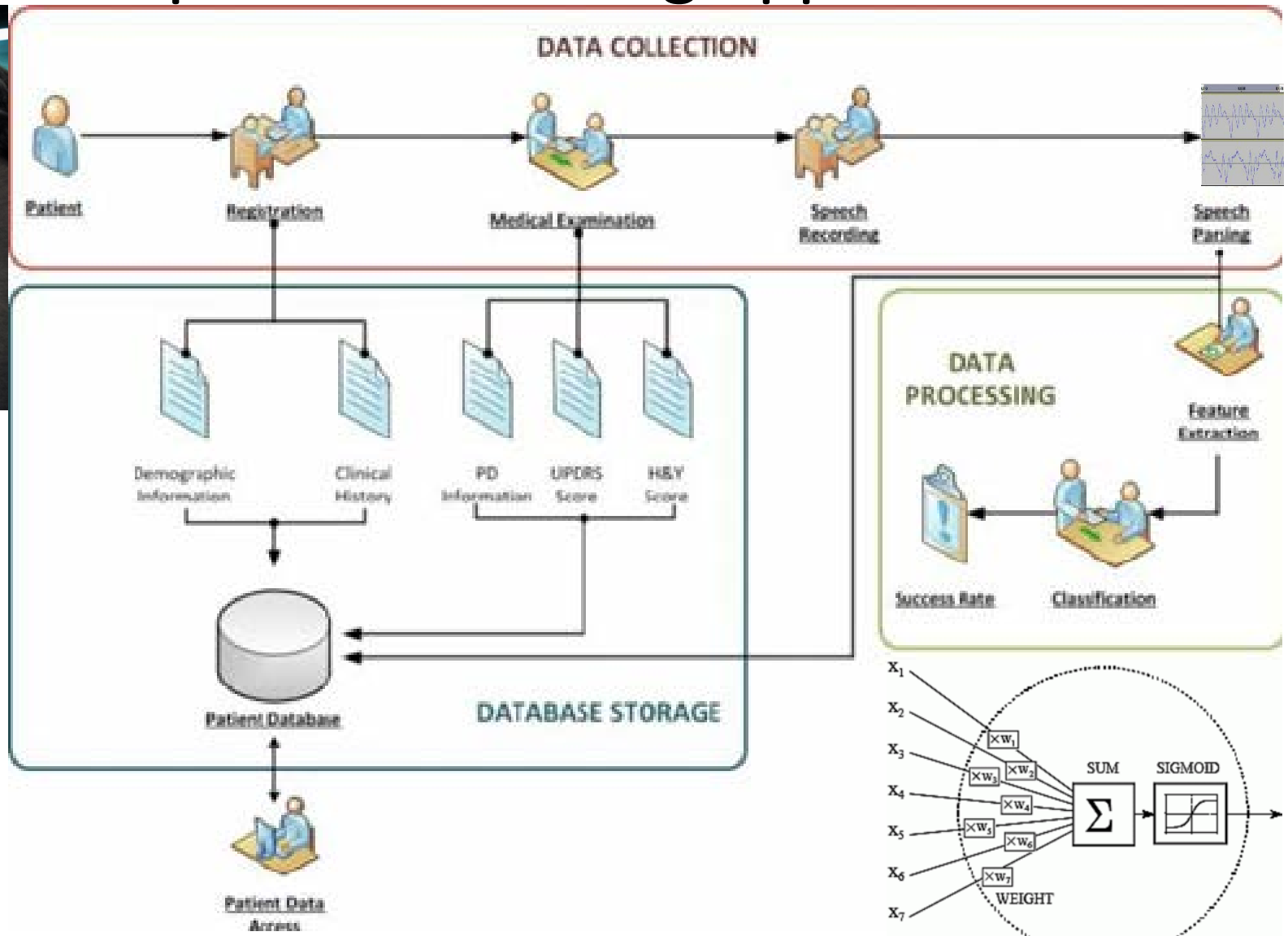


webmd.com

[1] Fahn *et al*., 2003, *Ann N Y Acad Sci*; [2] Jankovic, 2008, *J Neurol Neurosurg Psychiatry*.

Importance of Speech Processing Applications

http://msutoday.msu.edu/360/2013/detecting-parkinsons-for-better-treatment/



Sakar *et al*., 2013, *IEEE J Biomed Health Inform*

http://www.dspguide.com/graphics/F_26_6.gif

Feature	Type
Jitter (local)	**Frequency variables**
Jitter (local, absolute)	
Jitter (rap)	
Jitter (ppq5)	
Jitter (ddp)	
Number of pulses	**Pulse variables**
Number of periods	
Mean period	
Standard deviation of period	
Shimmer (local)	**Amplitude variables**
Shimmer (local, dB)	
Shimmer (apq3)	
Shimmer (apq5)	
Shimmer (apq11)	
Shimmer (dda)	
Fraction of locally unvoiced frames	**Voicing variables**
Number of voice breaks	
Degree of voice breaks	
Median pitch	**Pitch variables**
Mean pitch	
Standard deviation	
Minimum pitch	
Maximum pitch	
Autocorrelation	**Harmonicity variables**
Noise-to-harmonic	
Harmonic-to-noise	

Patient data: Dysphonia measures (in the table) and UPDRS from the UCI database.

Main Features to Diagnose PD

Methods:

ReliefF-, **partial least square**-, **Multi-layer Perceptron**-based algorithms.

Results:

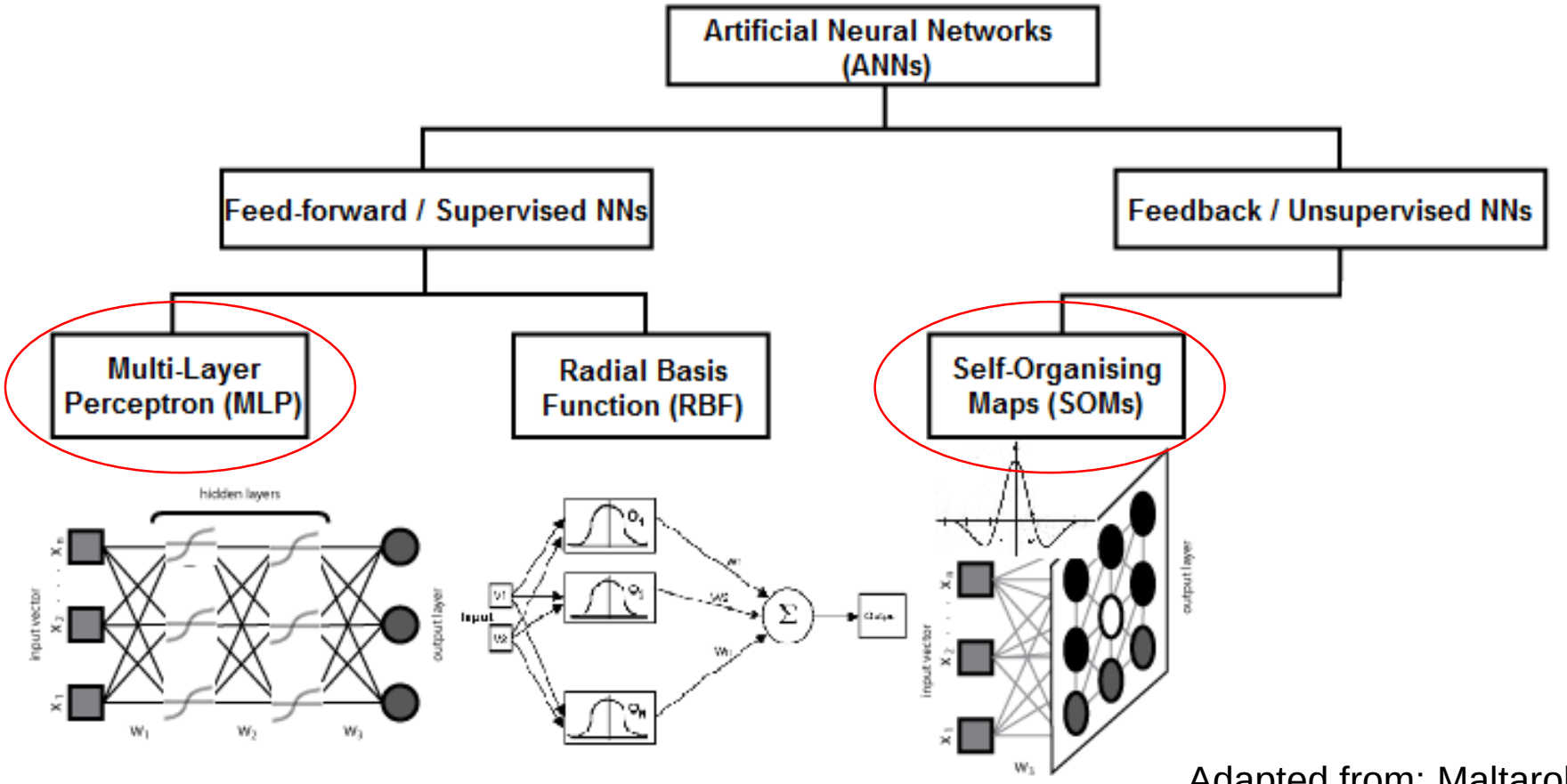
Three main diagnostic features: **UPDRS (main clinical score of PD)**, **mean pitch**, **standard deviation of the period**.

Methodology

Artificial Intelligence-based classifiers:

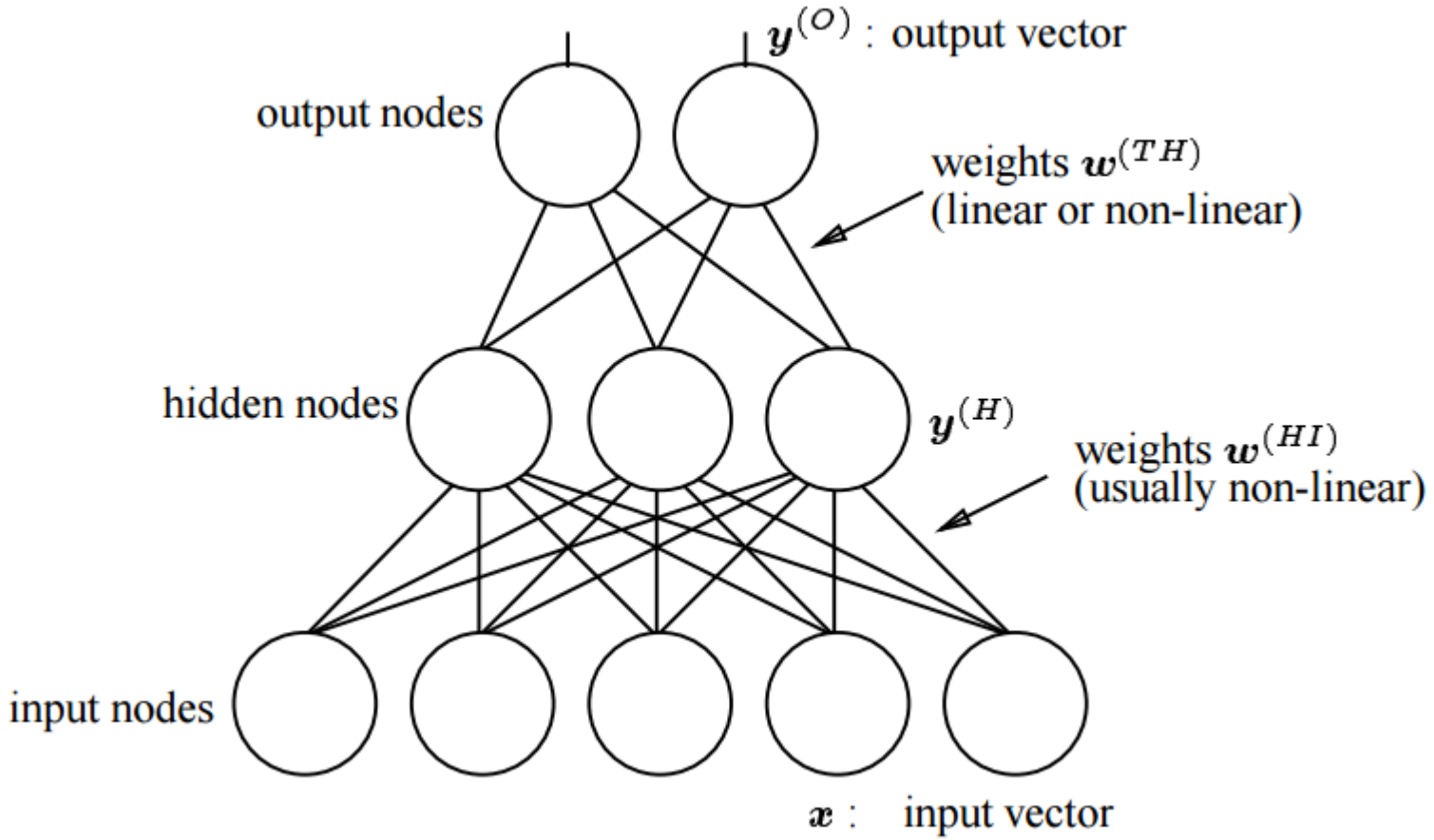
- self-organising maps,
- Lagrangian Support Vector Machine and
- multi-layer perceptron.

Artificial Neural Networks to Aid Diagnosis of PD



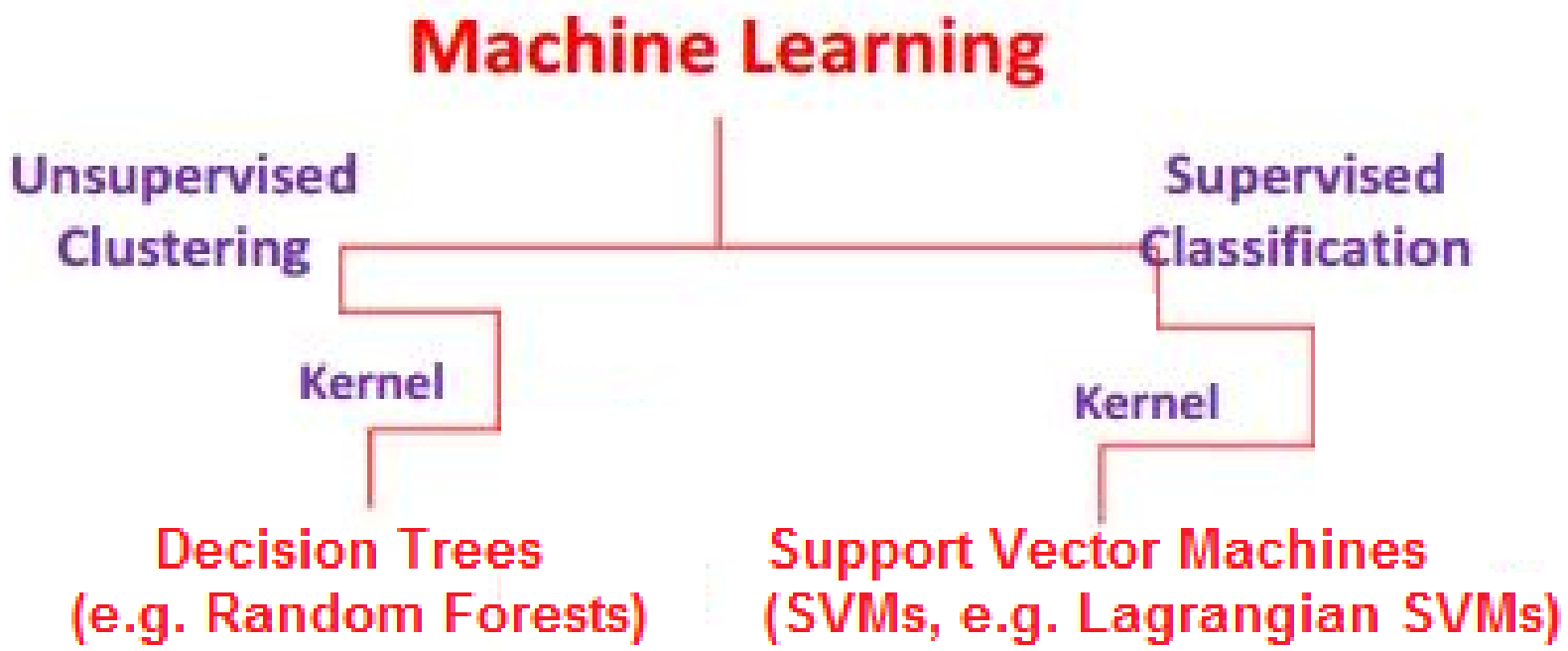
Adapted from: Maltarollo *et al*., 2013

Multi-layer Perceptron (MLP)



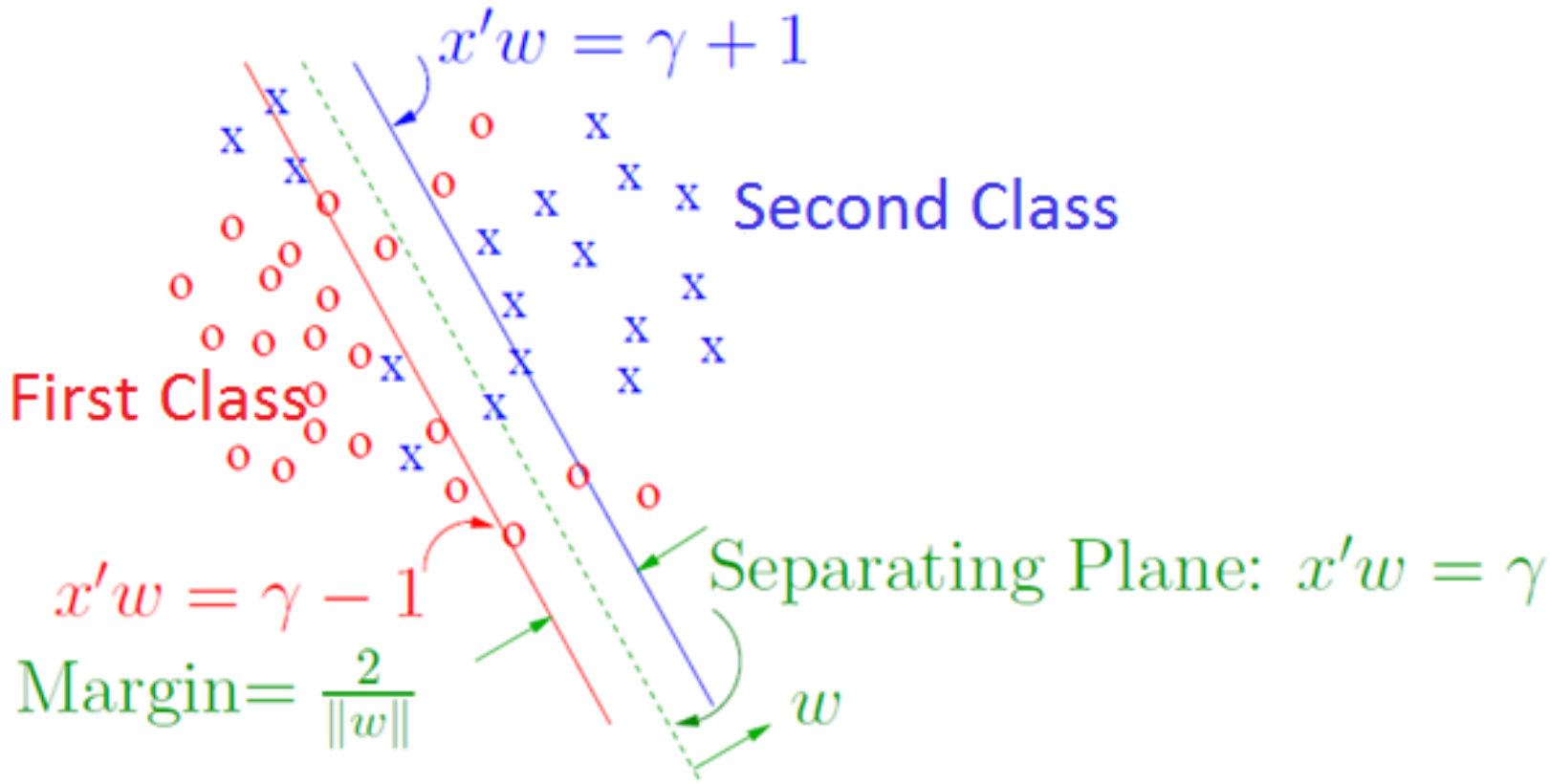
Michie *et al*., 1994

Machine Learning (ML) to Aid Diagnosis of PD



Adapted from: Cross Validated, 2014

Lagrangian Support Vector Machine



Adapted from Mangasarian and Musicant, 2001

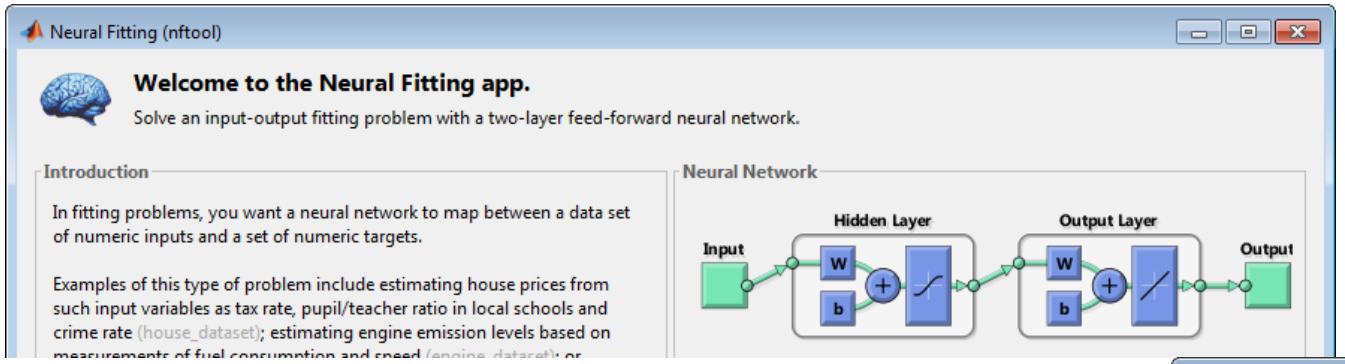
Overly Sophisticated Attempts of Diagnosing PD

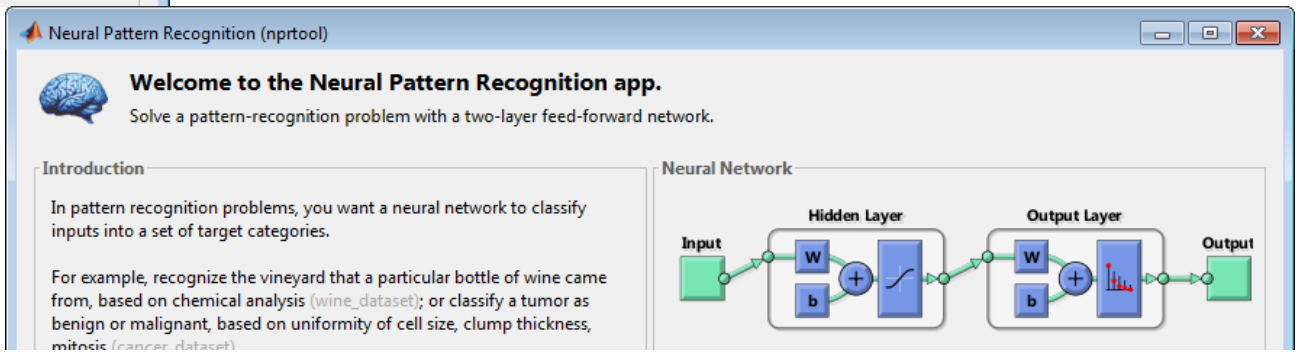
Author/s	Year	Journal	PWP	Controls	Algorithm/s	Accuracy	Reliability
Hariharan *et al*.	2014	*Comput Methods Programs Biomed*	23/48	8/20	One FP, four FSs, three LCs	100%	Five PMs
Alemami and Almazaydeh	2014	*J Am Sci*	48/48	20/20	Two LCs	93.30%	Two PMs
Yang *et al*.	2014	*PLoS ONE*	23/48	8/20	Two FSs, three LCs	91.80%	Three PMs
Behroozi and Sami	2016	*Int J Telemed Appl*	20/48	20/20	Two FSs, four LCs	87.50%	Three PMs
Zhang *et al*.	2016	*BioMed Eng OnLine*	48/48	20/20	Two FSs, two LCs	87.80%	Two PMs

FP = feature pre-processing; FS = feature selection; LC = learning classifier; PM = performance measure

The importance of Deploying MATLAB

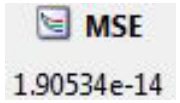
MATLAB toolboxes “nftool” and “nprtool” → Reduced development time and easy-to-use visualisation tools.

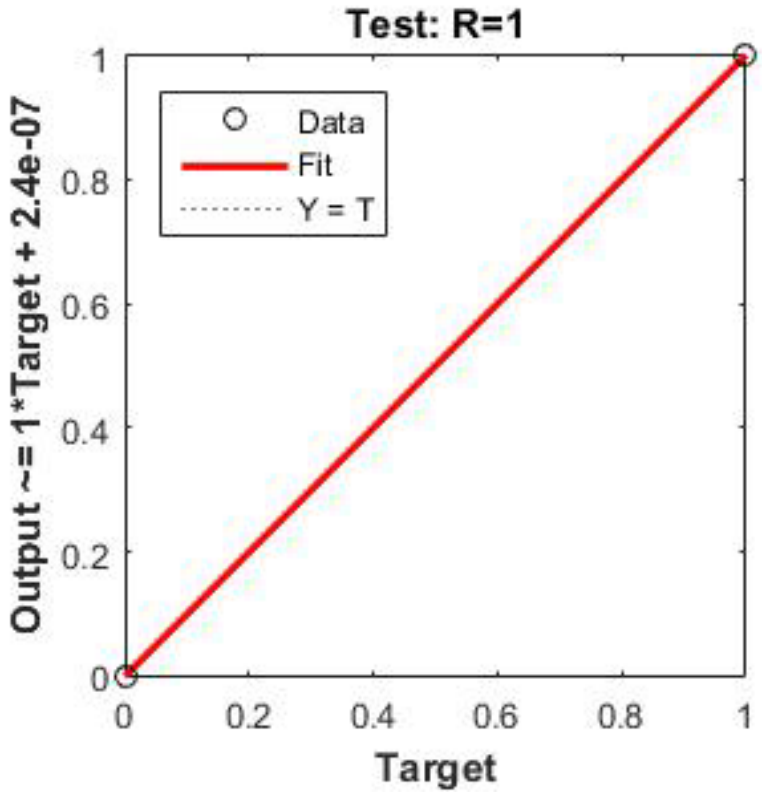


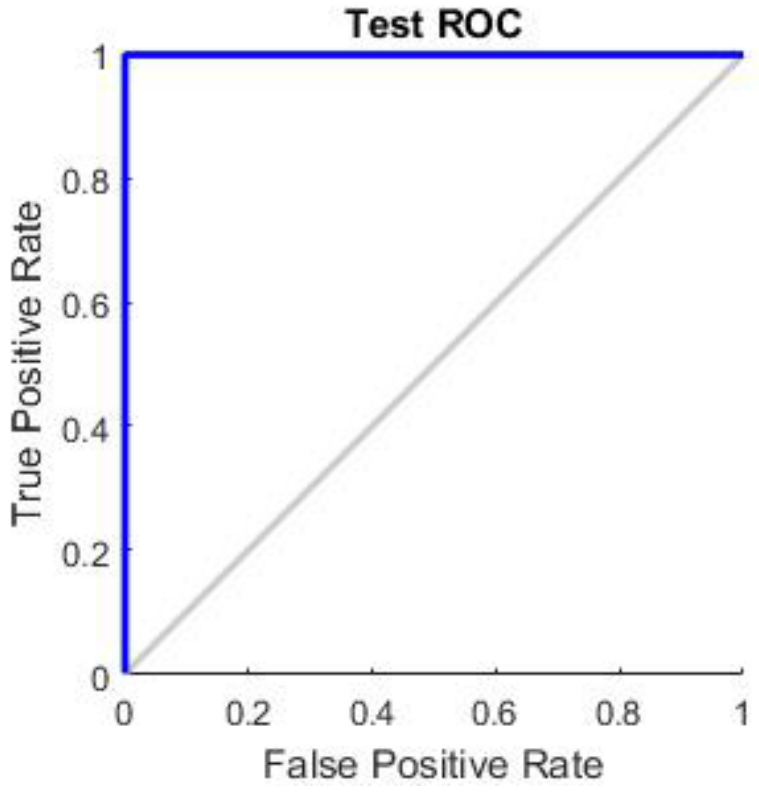


Results

- Classification accuracies: 84.52% for self-organising maps, 98.27% for Lagrangian Support Vector Machine and **100% for Multi-layer Perceptron**.
- Mean squared error (MSE): 1.91×10^{-14}.
- Area under the Receiving Operating Characteristic curve (AUC): 1.







Conclusion

- **Assessment of clinical potential** of Artificial Intelligence-based classifiers;
- **Feature selection** of parameters for early diagnosis of PD;
- **Simple method for early diagnosis of PD: Multi-layer perceptron**;
- **Applications in a clinical setting**.

Acknowledgements

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Thank you

Any questions