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► **To cite this version:**

Johann Faouzi, Samir Bekadar, Olivier Colliot, Jean-Christophe Corvol. Predicting Impulse Control Disorders in Parkinson's Disease: A Challenging Task. International Congress of Parkinson's Disease and Movement Disorders, Sep 2019, Nice, France. hal-02315533

HAL Id: hal-02315533

<https://inria.hal.science/hal-02315533>

Submitted on 14 Oct 2019

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Predicting Impulse Control Disorders in Parkinson's Disease: A Challenging Task

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Introduction

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- Impulse Control Disorders (ICDs) are common in Parkinson's Disease (PD) with an estimated cumulative incidence of 46% after 5 years.¹
- A couple of publications tackle the issue of predicting ICDs in PD, but the lack of replication of these results deserve further investigations.^{2,3}
- The objective was to predict the onset of ICDs in several scenarios of interest for clinicians.

Methods

Dataset

We used the Parkinson's Progression Markers Initiative (PPMI) dataset in which ICDs were assessed using the Questionnaire for Impulsive-Compulsive Disorders in Parkinson's Disease (QUIP) at each visit.

Scenarios of interest

Predicting the presence or absence of ICDs:

1. At one given visit for each patient,
2. In a given range of years after baseline for each patient,
3. At each visit for each patient, excluding visits for patients who already developed ICDs at a previous visit,
4. At each visit for each patient.

Input variables

- Age at baseline
- Sex
- Depression score
- Anxiety score
- REM sleep score
- Derived variables based on medication consumption

Results

Variable	Patient Characteristics
Number of PD cases	420
Sex, % male (male: female)	65.7% (276: 144)
Age, years	60.63 (\pm 9.69)
Geriatric Depression Scale	5.25 (\pm 1.43)
State and Trait Anxiety Inventory	93.34 (\pm 8.06)
MDS-UPDRS part III	20.87 (\pm 8.88)
On Dopamine Agonists during FU	51.43% (216: 204)
At least one ICD during FU	35.71% (150: 270)

Table 1. Patient characteristics of the PD cases included (mean \pm SD). Characteristics at baseline when not specified. FU: follow-up.

Scenario	Number of (patient, visit) pairs with ICDs	Number of (patient, visit) pairs without ICDs
Scenario 1	87	261
Scenario 2	24	180
Scenario 3	80	1285
Scenario 4	374	2408

Table 2. Number of (patient, visit) pairs for each scenario.

Algorithm	Scenario 1	Scenario 2	Scenario 3
Logistic Regression	0.71 (\pm 0.07)	0.66 (\pm 0.08)	0.66 (\pm 0.08)
Support Vector Machine	0.70 (\pm 0.06)	0.66 (\pm 0.07)	0.66 (\pm 0.06)
Random Forest	0.66 (\pm 0.07)	0.62 (\pm 0.07)	0.62 (\pm 0.08)

Table 3. Area under the Receiver Operating Characteristic curves for each algorithm and Scenario 1, 2, 3 (mean \pm SD). Optimal hyperparameter values are computed on the training set using grid search, and predictive performance is evaluated on the test set. The mean and standard deviation are computed using 100 training / test set splits.

Algorithm	Reduction	ROC AUC	Average Precision
Logistic Regression	Baseline visit	0.74 (\pm 0.03)	0.39 (\pm 0.06)
	Previous visit	0.76 (\pm 0.02)	0.47 (\pm 0.09)
	Mean over all previous visits	0.81 (\pm 0.03)	0.47 (\pm 0.08)
Support Vector Machine	Baseline visit	0.74 (\pm 0.03)	0.39 (\pm 0.06)
	Previous visit	0.73 (\pm 0.02)	0.46 (\pm 0.09)
	Mean over all previous visits	0.81 (\pm 0.03)	0.47 (\pm 0.08)
Random Forest	Baseline visit	0.74 (\pm 0.04)	0.39 (\pm 0.07)
	Previous visit	0.77 (\pm 0.02)	0.44 (\pm 0.09)
	Mean over all previous visits	0.81 (\pm 0.03)	0.49 (\pm 0.09)
Recurrent Neural Network	None	0.82 (\pm 0.03)	0.51 (\pm 0.09)

Table 4. Area under the Receiver Operating Characteristic curves (ROC AUC) and Average Precision for each algorithm for Scenario 4 (mean \pm SD). Three reduction methods are used for the standard machine learning approaches: (i) the baseline visit only, (ii) the previous visit only, and (iii) the mean over all the previous visits. Optimal hyperparameter values are computed on the training set using grid search, and predictive performance is evaluated on the test set. The mean and standard deviation are computed using 10 training / test set splits.

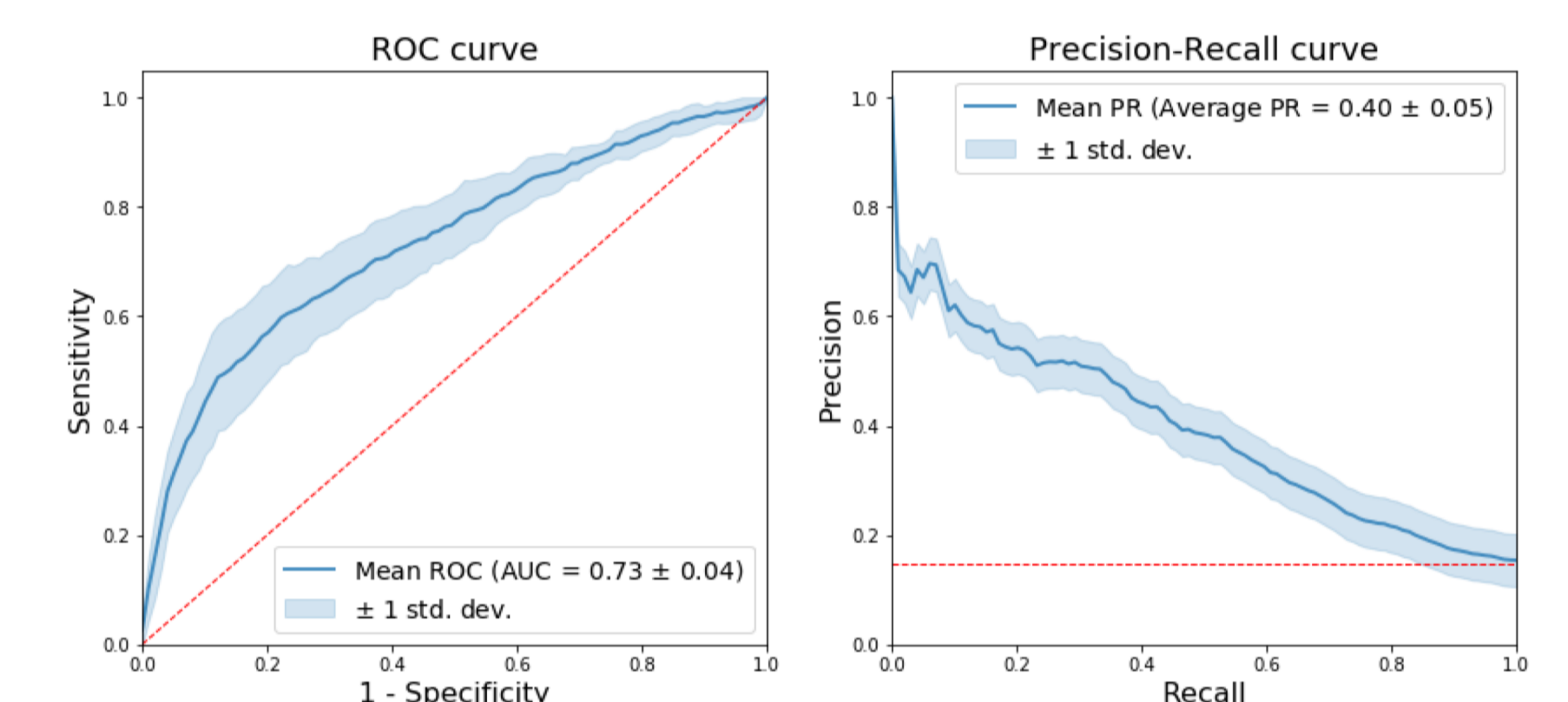


Figure 1. ROC and Precision-Recall curves for the Support Vector Machine classifier using the baseline visit for Scenario 4.

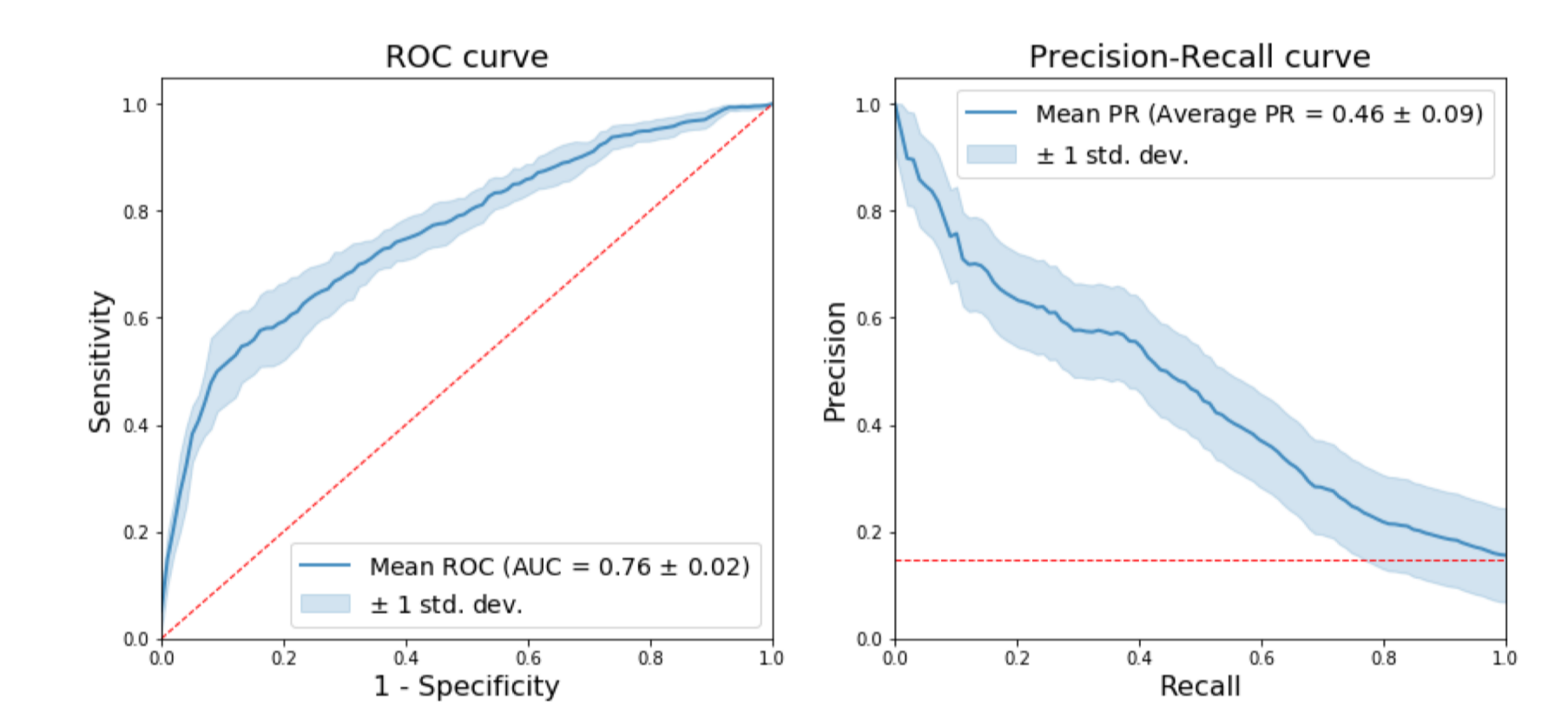


Figure 2. ROC and Precision-Recall curves for the Support Vector Machine classifier using the previous visit for Scenario 4.

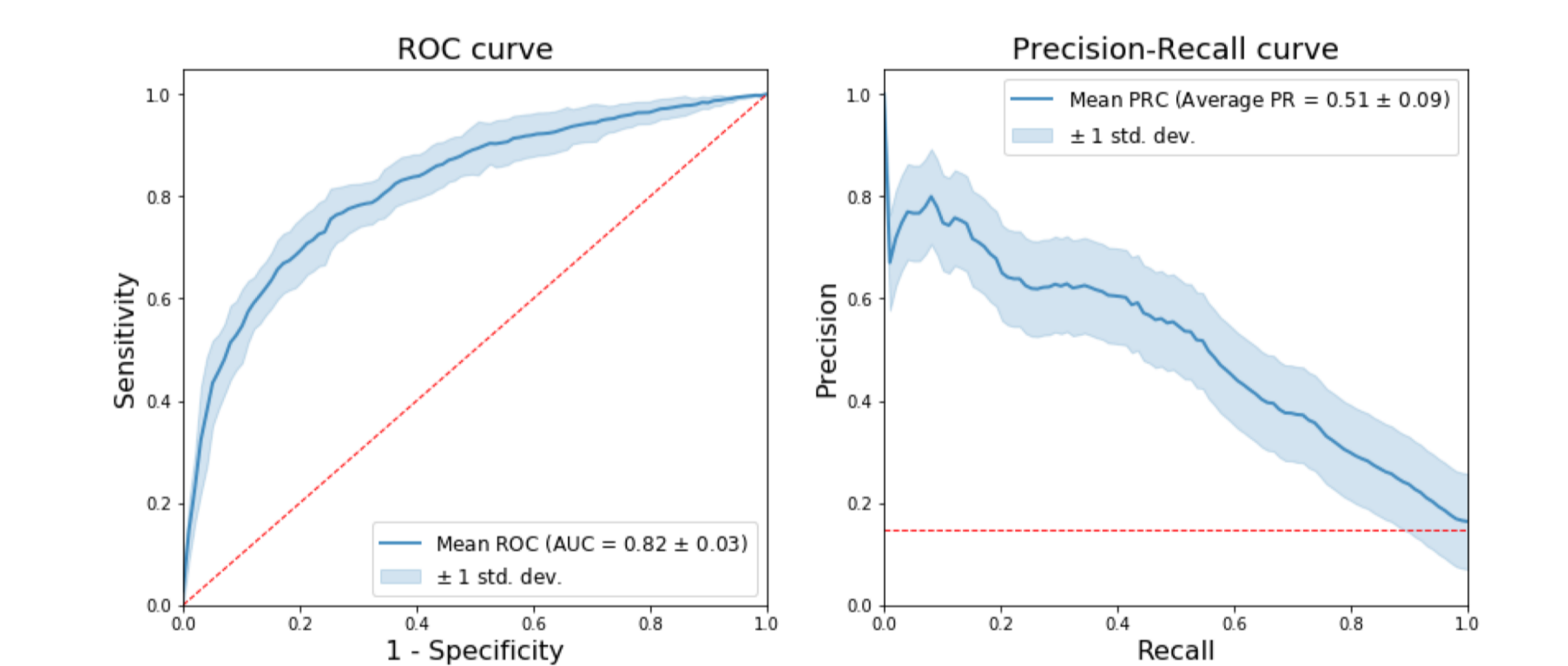


Figure 3. ROC and Precision-Recall curves for the Recurrent Neural Network classifier using all the previous visits for Scenario 4.

Conclusion and Future Work

- Predicting ICDs in PD is a challenging task.
- The predictive performance is significantly better than chance but too low for use in a clinical routine.
- The predictive performance depends more on the task than the algorithm.
- The Recurrent Neural Network approach leads to a slightly higher performance.
- Using genetic data might improve the predictive performance.
- Evaluating the predictive performance unbiasedly with cross-validation is necessary to avoid any overestimation of the performance.

References

- ¹ Jean-Christophe Corvol et al., "Longitudinal Analysis of Impulse Control Disorders in Parkinson Disease," *Neurology* 91, no. 3 (July 17, 2018): e189-201, <https://doi.org/10.1212/WNL.0000000000005816>.
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- ³ Aleksander H. Erga et al., "Dopaminergic and Opioid Pathways Associated with Impulse Control Disorders in Parkinson's Disease," *Frontiers in Neurology* 9 (2018), <https://doi.org/10.3389/fneur.2018.00109>.