MULTIPLE SCLEROSIS: FROM PREDICTIONS TO SENSITIVITY ANALYSIS AND ROBUST MODELS

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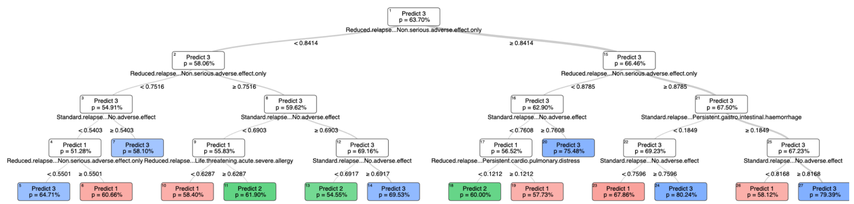
1. PROBLEM STATEMENT

- **Multiple Sclerosis (MS)** - disease of the nervous system affecting 1m US patients
- Not curable - treatments used to manage symptoms
- **Data**: 10k observations of MS patient utility data (e.g. risk of cardiac arrest)
- **3 treatment options**: High Dose* (1), Low Dose* (2), or No Treatment (3) (* of methylprednisolone)



2. MODELS FOR BEST TREATMENT

Prescription Models

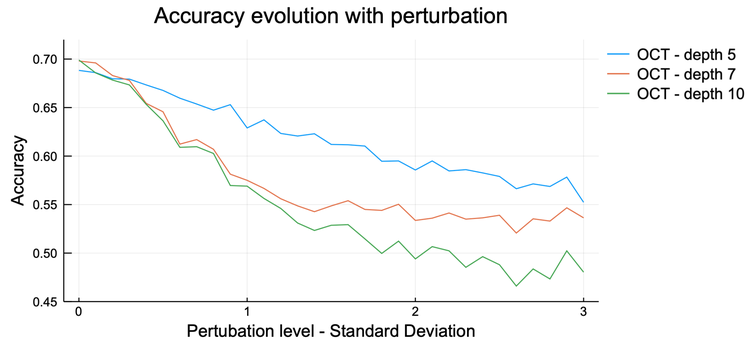
- Prescribe most common treatment of the cluster

$$\max_{z_p \in \{1,2,3\}} \sum_{p=1}^{T} \sum_{i=1}^{N} w_{pi} 1_{z_p = y_i}$$

$$\text{s.t.} \quad w_{pi} = 1 \quad \text{if p and i are in the same cluster}$$

Prediction Models

- Accuracy scores: CART (70%), OCT(69%), OCT-H (70%)
- High feature importance:
- Models rarely predict treatment option 2 because of unbalanced dataset



3. SENSITIVITY ANALYSIS

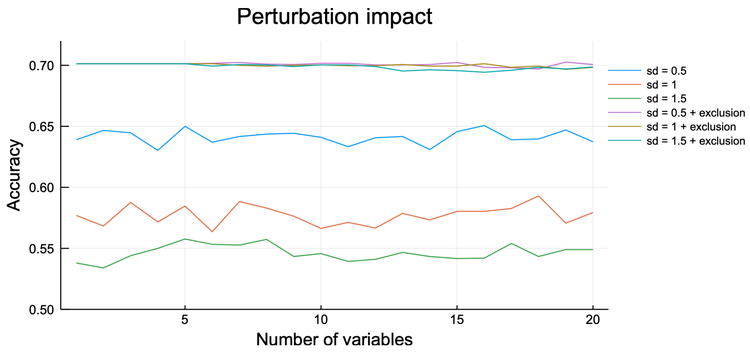
Progressive perturbation of patient utility data within ±3σ of true values

Process

1. Perturb all data
2. Perturb important features
3. Perturb other features

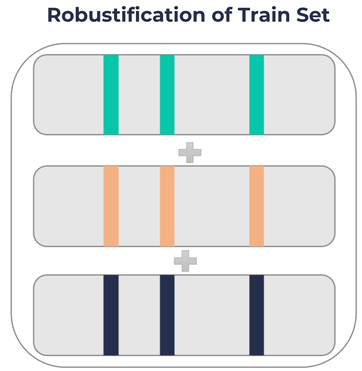
Results

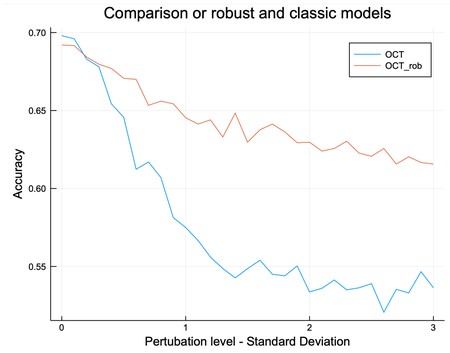
1. Accuracy decreases by 15%
2. Global decrease by 6-15%
3. No effect



4. MODELS ROBUSTIFICATION WITH PERTURBED DATA GENERATION

- OCT, OCT-H and CART models **highly sensitive to pertubations in data**
- The more complex the model the more sentive to changes
- **Robustification**: **small**, **medium** and **large** perturbing important features in the train set, and **merge the sets**
- **Results**: Models trained on this set have superior stability under perturbations, and similar accuracy on initial data





5. THE PRICE OF INTERPRETABILITY

- **Trade-off between model's interpretability and robustification**
- Due to data generation process, we no longer have an interpretable path in the tree models
- Observations are repeated (with perturbation)
- Accuracy is similar to original accuracy without perturbation
- **+10% accuracy** in highly perturbed scenarios

10K Patient Observations

70% Best Model Accuracy

±3σ Data Perturbation

-15% Accuracy Decrease

+10% Accuracy Improvement for Robust Models