ISE 625 Project Proposal

Stable decision trees for suicide experience prediction

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Problem Context and Background

We aim to develop a model to predict suicidal experiences among youth experiencing homelessness (YEH). The provided decision tree (DT) model for the current YEH dataset shows instability with respect to changes in train-test splits. We aim to address the following:

- **Core Question:** Can we design a robust, stable decision tree that remains invariant under shifts in data distributions while still identifying the key features indicative of suicidal ideation and attempts?

Proposed Plan

4.1 Understand the Instability of the Provided Decision Trees

- Objective: Determine how and why the existing decision tree implementation using scikit-learn's DecisionTreeClassifier with selected constraints on depth and splitting changes with different train-test splits.
- Steps:
  - Examine the two provided Python files (`suicidea` and `suicattemp`).
  - Create a controlled experiment by generating deterministic splits.
  - Empirically measure differences in the predicted splits across these splits.

4.2 Implement a Stable Decision Tree (Based on Bertsimas et al. 2023)

1. Initial Training (T0): Train an initial set of decision trees on a subset of the data.
2. Full Data Training (T): Train a second set of decision trees on the full dataset.
3. Distance Computation: Calculate the average distance between each tree in T and the trees in T0. The distance between two trees is defined as:

$$d(\mathcal{T}_1, \mathcal{T}_2) = \min_{\{x\}} \sum_{p \in \mathcal{P}(\mathcal{T}_1)} \sum_{p \in \mathcal{P}(\mathcal{T}_2)} d(p, q) x_{p,q} + \sum_{p \in \mathcal{P}(\mathcal{T}_1)} w(p) x_p$$

4. Performance Metrics: Compute performance metrics (such as AUC) on a validation/test set.
5. Pareto Optimization: Select Pareto optimal trees that balance predictive performance and stability. This is expressed as:

$$\mathbb{T}^* = \text{argmax} f(d_b, a_b)$$

4.3 Measuring the Effectiveness of the Proposed Model

- Comparison Metrics: Compare the performance of the new stable decision trees against the original decision tree using defined metrics (e.g., AUC, feature stability).
- Evaluation: Assess both the predictive accuracy and the consistency of feature selection to ensure the model's robustness and interpretability.

Expected Outcomes and Impact

- Outcomes:
  - A robust, stable decision tree model
  - Empirical evidence supporting the stability of the tree by minimizing the variability in feature selection due to random train-test splits..
- Impact:
  - Enhanced interpretability of the predictive model for suicide risk among YEH.
  - Potential to influence policy and intervention strategies by reliably identifying key risk factors.

Future Work

- Model Generalization: Explore the possibility of applying the stable decision tree methodology to other imbalanced or sensitive datasets.
- Extensions: Integrate additional stability metrics or consider ensemble approaches that combine stable decision trees with other machine learning models.