PACE Solver Description

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Overview

This is a Hitting Set problem solver developed for the heuristic track of the PACE 2025 Challenge. It works by first reading the input and building a hypergraph representation of the instance. For each element in the graph, it computes structural features and uses a machine learning model to predict whether that element should be part of the hitting set. Based on these predictions, the solver prunes and simplifies the graph. Finally, it applies the NuSC heuristic to solve the reduced problem within the time limit.

Runtime Strategy

The solver is designed to run within a total time limit of 250 seconds to stay under the PACE 5-minute requirement.

The initial phase computes features and applies the trained machine learning model for pruning. The remaining wall-clock time is then allocated to solving the pruned instance using the NuSC algorithm. The time division is computed dynamically so that NuSC always gets at least 15 seconds.

Feature Selection

Each element is assigned a set of 11 features derived from the hypergraph:

- Normalized degree over elements
- Normalized degree over sets
- Minimum degree among neighbors (normalized)
- Maximum degree among neighbors (normalized)
- Average degree of neighbors (normalized)

- Sum of neighbor degrees (normalized)
- Local Clustering Coefficient
- Betweenness centrality (normalized, used the estimated version from NetworKit)
- Closeness centrality (normalized, used the estimated version from NetworKit)
- Node core number (from NetworKit)
- Ground truth label: 1 if in optimal solution (used for training only)

Machine Learning Model

A Random Forest Classifier is trained on cleaned CSV data from labeled hitting set instances. At runtime, the model predicts a label (0 or 1) with a confidence score. Elements are added to the solution if predicted 1 with confidence ≥ 0.65 and pruned if predicted 0 with confidence ≥ 0.6.

References

Chuan Luo, Wenqian Xing, Shaowei Cai, and Chunming Hu. *NuSC: An Effective Local Search Algorithm for Solving the Set Covering Problem.* To appear in *IEEE Transactions on Cybernetics.*