GRACE: Graph-based Dimensionality Reduction & Context-Enhanced Explainability

[1] Phase 1: Knowledge Graph Creation

create_kg.py

- Generate Keywords
- ArXiv Literature Search
- Research Report Generation
- Feature Interaction Mapping

Initial Knowledge Graph

[2] Phase 2: SHAP Optimization

grace_shap.py

- Calculate SHAP Values
- Optuna Multi-objective Optimization
- 5-Fold Cross-Validation
- Filter Features & Edges

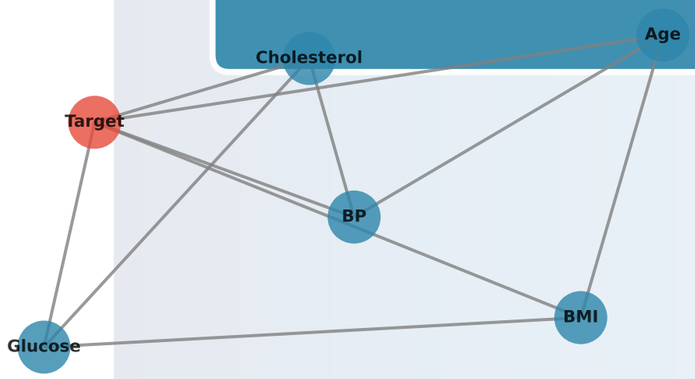
SHAP Interaction Matrix

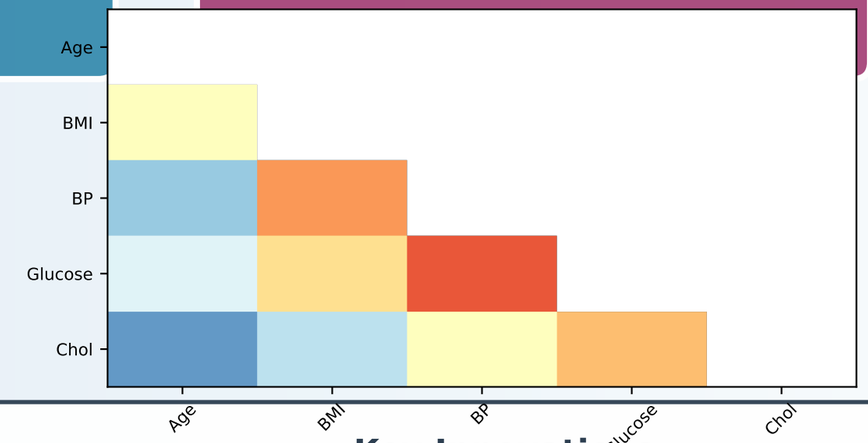
[3] Phase 3: Final Model

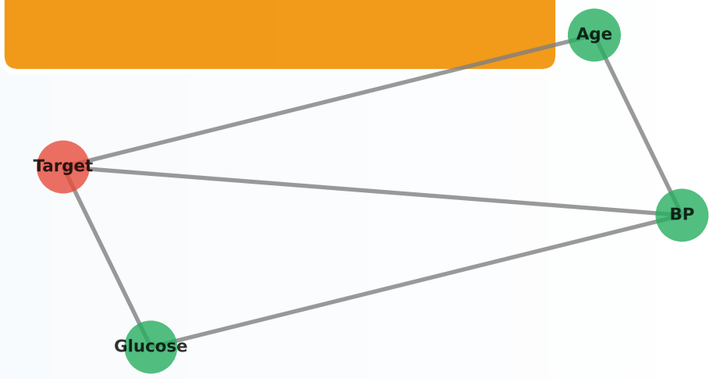
main.py

- Train Optimized Model
- Test Set Evaluation
- Save Results & Metrics

Optimized Knowledge Graph







Key Innovations

- Literature-driven KG: ArXiv papers → Feature interactions
- Multi-objective optimization: Performance vs. interpretability
- SHAP-guided selection: Feature importance & interaction strength
- Cross-validation robustness: 5-fold CV for stable results

GRACE Advantages

Reduced Complexity
67 → 28 features (58% reduction)
1200 → 350 edges (71% reduction)

Faster Inference
Fewer features = faster computation
Optimized model architecture

Better Explainability
Domain-informed interactions
Literature-backed explanations

Performance: Test AUC 0.8105 (+8% vs baseline) | Feature Reduction: 58% | Edge Reduction: 71%