MLDS 490-0-1: Interpretable ML for Finance

Instructor

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Schedule

Start Date: April 1, 2025

End Date: May 5, 2025

Delivery: Asynchronous online delivery with 3 hours of lectures per week

Course Overview

The course emphasizes interpretable machine learning techniques and their applications in the financial services industry. Students will develop machine learning models, explain predictions, and build stakeholder confidence through transparent model outputs. Financial applications include client acquisition, credit underwriting, and fraud detection. Through hands-on exercises with industry-relevant datasets and open-source tools, students will design interpretable models that drive strategy and mitigate risks.

Learning Objectives

1. Interpret, visualize, and effectively communicate machine learning model results to technical and non-technical stakeholders.
2. Develop prescreen models to identify and target prospective clients, ensuring interpretability for actionable marketing strategies.
3. Build interpretable scorecard models to support loan approval decisions and generate adverse action codes for rejected applicants.
4. Design interpretable models to monitor and detect fraudulent transactions in highly imbalanced datasets.

Course Materials

Recommended Books and Papers

Erickson, Nick. *AutoGluon-Tabular: Robust and Accurate AutoML for Structured Data*. arXiv, https://arxiv.org/abs/2003.06505. Accessed October 19, 2024.

Molnar, Christoph. *Interpretable Machine Learning: A Guide for Making Black Box Models Explainable*. 3rd ed. https://christophm.github.io/interpretable-ml-book/. Accessed on March 28, 2025.

Molnar, Christoph. *Interpreting Machine Learning Models With SHAP: A Guide With Python Examples and Theory on Shapley Values*. Independent publication, 2023.

Le Borgne, Yann-Aël. *Reproducible Machine Learning for Credit Card Fraud Detection - Practical Handbook*. https://fraud-detection-handbook.github.io/fraud-detection-handbook. Accessed October 19, 2024.

Optional Books and Papers

Siddiqi, Naeem. *Intelligent Credit Scoring: Building and Implementing Better Credit Risk Scorecards*. 2nd ed., Wiley, 2016.

Software and Tools

- VS Code
- Conda
- GitHub Copilot

Students are encouraged to use tools like GitHub Copilot or ChatGPT. Students are responsible for checking the accuracy of the LLM outputs before submitting their assignments.

GitHub Repo

https://github.com/crossxwill/IML4Finance

Course Work and Grading

1. Your course grade depends on four auto-graded problem sets in Canvas
2. Each problem set:
    a. Corresponds to 1 week from the Course Schedule
    b. Contains multiple quizzes
    c. Is worth 25 points
3. Your course grade will be based on the total points from all problem sets

TotalPoints	Letter Grade
>= 90	A
>= 80	B
>= 70	C
>= 60	D
< 60	F

Late Policy

You can submit problem sets until May 5, 2025. However, it is highly encouraged that you complete a quiz after each recorded video.

Course Schedule

Week 1: Prescreen Models for Acquiring New Clients

- Course Overview
- Introduction to Retail Banking
- Role of credit bureaus and bureau attributes
- Acquiring new clients through direct mail campaigns
- Conda environments and VS code profiles
- Return on Investment (ROI) of past campaigns
- Exploratory Data Analysis (EDA)
    - Special values in bureau attributes
    - Correlation metrics: Pearson vs. Spearman
    - Curse of dimensionality
- Automated Machine Learning using AutoGluon (Erickson)
    - Data processing
    - Encoding categorical features
    - Repeated K-fold bagging and out-of-fold predictions
    - Scikit-learn pipelines
    - Comparing evaluation metrics: Gini vs. Entropy
    - Stacked ensembles
    - Model performance vs. prediction latency
- Assignments:
    - Problem Set 1 (due April 8, 2025)

Week 2: Interpreting and Evaluating Prescreen Models

- Probability Calibration
    - Shortcomings of ROC-AUC
    - Overfitting and “double-dipping”
    - Platt scaling and isotonic regression
    - Evaluations metrics for well-calibrated predictions
- Permutation Feature Importance (Molnar 3ed, 23)
- Explaining Model Relationships between Features and Predictions
    - Partial Dependence Plots (PDP) (Molnar 3ed, 19)
    - Accumulated Local Effects (ALE) Plot (Molnar 3ed, 20)
- Measuring model effectiveness
    - Cumulative gains chart
    - Lift chart
- Optimizing the decision threshold with the F1-score
- A/B Testing the Marketing Campaign
- Assignments:
    - Problem Set 2 (due April 15, 2025)

Week 3: Scorecard Models for Underwriting Decisions

- Feature Reduction Methods
    - Filter methods
    - Embedded methods
    - Wrapper methods
- Credit application process.
- The history and role of credit scores.
- Loan types (term loans, lines of credit, secured, unsecured)
- Sample bias in the training data due to rejected applicants
- Data segmentation to improve model performance and as an alternative to high-order feature interactions
- Enforcing monotonic relationships between features and predictions
- Limiting feature interactions to improve interpretability
- Evaluating model performance with proper scoring rules
    - Log Loss
    - Brier Score
- Fuzzy augmentation for rejected applicants (i.e., reject inference)
- Developing a credit score range and points to double odds (PDO)
- Retrospective analysis using the Kolmogorov–Smirnov (KS) statistic
- Optimizing the decision threshold
- Readings: Siddiqi 2016.
- Assignments:
    - Problem Set 3 (due April 22, 2025)

Week 4: Interpreting Scorecard Models

- Fair Credit Reporting Act (FCRA).
- Equal Credit Opportunity Act (ECOA).
- Providing Adverse Action Codes.
- Counterfactual explanations and corrective actions (Molnar 3ed, 15)
    - Measuring distances with Manhattan (L1), Euclidean (L2), and Gower
    - Explanations using heuristic filtering and sorting
    - Explanations using optimization (i.e., Wachter and Dandl)
- Decomposing Predictions into Feature Contributions
    - Individual Conditional Expectation (ICE) Plots (Molnar 3ed, 13)
    - Shapley values and SHAP explainers (Molnar 3ed, 17-18)
    - SHAP dependence plots (Molnar 3ed, 18)
    - Dealing with interrelated features in SHAP (Molnar 2023)
- Global Feature Importance Techniques
    - Revisiting permutation feature importance
    - SHAP-based feature importance (Molnar 3ed, 18)
- Assignments:
    - Problem Set 4 (due April 29, 2025)

Week 5: Fraud Models for Transactions Monitoring

- Special Topics
- Anomaly detection in financial transactions.
- Detecting fraudulent credit card transactions
- Severe class imbalance and resampling strategies
    - Random oversampling (ROS)
    - Synthetic Minority Oversampling Technique (SMOTE)
    - Random undersampling (RUS)
    - Criticisms of resampling strategies
- Alternatives to resampling
    - Cost-sensitive learning (observation weights)
    - Stack ensembles with Out-of-Fold (OOF) predictions
- Hyperparameter Optimization (HPO) Strategies
    - Grid Search
    - Bayesian Optimization
    - Stepwise Selection
- Readings: Erickson; Le Borgne
- No Assignments