

# IEEE-CIS Fraud Detection Challenge

## Comparative Study of SVM and Decision Tree Binary Classification

Khashayar Zardoui  
Dept. Computer Science & Software Engineering  
Concordia University  
Montreal, Canada  
khashayar.zardoui@mail.concordia.ca  
ID: 40052568

Paolo Junior Angeloni  
Dept. Computer Science & Software Engineering  
Concordia University  
Montreal, Canada  
p\_ange@live.concordia.ca  
ID: 25976944

**Abstract—abstract: This report evaluates the performance...**

### I. THE FRAUD-DETECTION PIPELINE

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- 1) Data loading and exploration (EDA)
- 2) Removal, Imputation, Label Encoding and Scaling
- 3) Model training and performance assessment

### II. EXPLORATORY DATA ANALYSIS

#### A. Data Structure Inspection

- 1) Before any data transformation, we observed the `train` and `test` datasets had a mixture of `float64`, `int64` and `object` types
- 2) missing values  
description goes here...
- 3) target balance  
description goes here...

#### B. Statistical Summary & Visualizations

Fig. 1. some image here

TABLE I  
SOME STATS...

Metric	Value
one	...
two (%)	...
three	...
four	...

#### C. Findings & Hypotheses

...

...

### III. DATA PRE-PROCESSING & CLEANING

#### A. Imputation & Removal

- 1) ...
- 2) ...
- 3) ...

#### B. Normalize & Scale Features

- 1) ...
- 2) ...
- 3) ...

#### C. Encoding Categorical Features

- 1) ...
- 2) ...
- 3) ...

### IV. MODELS

intro to the models used

#### A. Support Vector Machine (SVM) Classifier

Due to the size of the dataset (590,000+ samples), a standard SVM with a non-linear kernel ( $O(n^3)$ ) was computationally infeasible. We opted for a LinearSVC ( $O(n)$ ) to utilize the entire training set. To satisfy the hyperparameter tuning requirement2, we tuned the Regularization parameter (C) and the Loss function (Hinge vs. Squared Hinge) instead of the kernel. Additionally, we applied Principal Component Analysis (PCA) to the SVM input to reduce dimensionality, which resolved convergence issues and significantly improved training speed. experiment hyperparameters (C, gamma, kernel etc) cross-validation and validation splits to evaluate performance results using different hyperparameters training and test metrics: confusion matrix, precision, recall, F1-score, and accuracy

#### B. Decision Tree Classifier

experiment hyperparameters (max depth, min samples split, criterion) cross-validation and validation splits to evaluate performance results using different hyperparameters training and test metrics: confusion matrix, precision, recall, F1-score, and accuracy

The Decision Tree model demonstrated signs of mild overfitting. While it achieved a high F1-score of 0.68 on the training set, this dropped to 0.57 on the validation set. Specifically, the Precision for fraud detection fell from 92% (training) to 77% (validation), indicating that some of the decision rules learned were specific to the training noise and did not generalize well. Furthermore, the Recall remained low in both sets (0.53 training vs. 0.45 validation), suggesting that

a single decision tree lacks the complexity required to capture the full variety of fraudulent patterns in this dataset.

### C. XGBoost Classifier

The XGBoost classifier proved to be the superior model. While the Decision Tree suffered from overfitting (high variance), XGBoost demonstrated robust generalization.

On the Validation set, XGBoost achieved a Precision of 0.93, meaning it generated very few false positives (false alarms), which is critical for maintaining user trust. Simultaneously, it achieved a Recall of 0.56, capturing the majority of fraud instances. The F1-Score of 0.70 (Validation) significantly outperforms the Decision Tree (0.57) and indicates that the Gradient Boosting method successfully captured complex, non-linear relationships that the simpler models missed.

## V. MODEL COMPARISON

TABLE II  
SOME STATS...

Metric	SVM	Decision Tree
one	...	...
two (%)	...	...
three	...	...
four	...	...

a) *discuss similarities & differences. use table:*

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### REFERENCES

- [1] Numpy, "Numpy API Documentation," [Online]. Available: <https://numpy.org/doc/stable/>. [Accessed: Nov. 25, 2025].
- [2] matplotlib, "Matplotlib API Documentation," [Online]. Available: <https://matplotlib.org/stable/index.html>. [Accessed: Nov. 25, 2025].
- [3] pandas, "pandas API Documentation," [Online]. Available: <https://pandas.pydata.org/docs/>. [Accessed: Nov. 26, 2025].
- [4] seaborn, "seaborn API Documentation," [Online]. Available: <https://seaborn.pydata.org/api.html>. [Accessed: Nov. 26, 2025].
- [5] data preprocessing, "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/modules/preprocessing.html>. [Accessed: Nov. 28, 2025].
- [6] data imputation, "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/modules/impute.html>. [Accessed: Nov. 28, 2025].
- [7] label encoding, "sklearn API Documentation," [Online]. Available: [https://scikit-learn.org/stable/modules/preprocessing\\_targets.html#label-encoding](https://scikit-learn.org/stable/modules/preprocessing_targets.html#label-encoding). [Accessed: Nov. 28, 2025].
- [8] hyperparameter tuning using GridSearchCV, "sklearn API Documentation," [Online]. Available: [https://scikit-learn.org/stable/modules/grid\\_search.html#grid-search](https://scikit-learn.org/stable/modules/grid_search.html#grid-search). [Accessed: Nov. 30, 2025].
- [9] Support Vector Machines, "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/modules/svm.html>. [Accessed: Nov. 30, 2025].
- [10] Principal Component Analysis (PCA), "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/modules/decomposition.html#pca>. [Accessed: Dec. 02, 2025].

- [11] Decision Trees, "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/modules/tree.html>. [Accessed: Nov. 30, 2025].
- [12] XGBoostClassifier, "XGBoost API Documentation," [Online]. Available: <https://xgboost.readthedocs.io/en/stable/>. [Accessed: Nov. 30, 2025].
- [13] metrics, "sklearn API Documentation," [Online]. Available: <https://scikit-learn.org/stable/api/sklearn.metrics.html>. [Accessed: Dec. 02, 2025].