

Credit Card Fraud Detection using Machine Learning Algorithms

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Abstract: The exponential growth of digital payment systems and electronic commerce has positioned credit card fraud as one of the most pressing challenges facing modern financial institutions. While traditional rule-based detection systems have demonstrated effectiveness in controlled environments, they exhibit fundamental limitations in adaptability when confronted with the dynamic and adversarial nature of contemporary fraud schemes. This comprehensive review examines the evolution and current state of machine learning approaches for credit card fraud detection, spanning from classical supervised learning algorithms to cutting-edge deep learning architectures and graph-based methodologies. This paper addresses critical challenges inherent in fraud detection, including extreme class imbalance (fraudulent transactions typically represent less than 1% of total volumes), concept drift caused by evolving fraud strategies, asymmetric misclassification costs, and real-time processing constraints. We systematically analyze supervised learning methods such as Logistic Regression, Decision Trees, Random Forests, Support Vector Machines, and Gradient Boosting Machines (XGBoost), alongside deep learning architectures including Artificial Neural Networks, Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks, and hybrid CNN-LSTM models. A comparative analysis of existing studies from 2010 to 2025 reveals that ensemble methods and deep learning models consistently outperform traditional classifiers, with graph neural networks and attention-based architectures achieving state-of-the-art performance.

Despite significant advancements, challenges related to model interpretability, adaptive learning in non-stationary environments, computational efficiency for real-time deployment, and data privacy compliance remain unresolved. This review identifies emerging research directions—including semi-supervised learning, adaptive feature selection, and explainable AI—as promising avenues for developing robust, scalable, and transparent fraud detection systems suitable for real-world financial environments.

Keywords: Credit card fraud detection, machine learning, deep learning, class imbalance, ensemble methods, concept drift, graph neural networks, feature engineering, real-time detection, financial