# FRAUD DETECTION IN FINANCIAL TRANSACTIONS USING LSTM AND XAI WITH ONTOLOGICAL VALIDATION

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Thesis submitted in partial fulfillment of the requirements for the degree of

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# DECLARATION

I declare that this is my own work, and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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…… ……..

Signature of the Student: Date:

The candidate above has carried out research for the Master's thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Prof A.T.P Silva

01/07/2025

…… ……

Signature of the Supervisor: Date:

# DEDICATION

This thesis is dedicated to my family and friends, whose unwavering support, encouragement, and belief in me made this journey possible. I also extend my heartfelt dedication to my supervisor, Professor A.T.P Silva, for their invaluable guidance, and insightful advice during this research and to all the lecturers of the Department of Computational Mathematics, Faculty of Information Technology, University of Moratuwa, for their continuous inspiration and support. Finally, I dedicate this work to everyone who continues to inspire me to pursue knowledge with passion and perseverance.

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# ABSTRACT

The escalation of digital financial services has increased the occurrence of credit card fraud, demanding the development of advanced, trustworthy fraud detection systems. Traditional and simple rule-based and classical machine learning techniques, while useful, often fail to detect complex, evolving fraud patterns and lack sufficient interpretability for high-stakes financial decision-making. This research proposes a novel, integrated approach combining Long Short-Term Memory networks, Explainable AI techniques, and ontology-based semantic validation to address these challenges. The Long Short-Term Memory model captures sequential transaction behaviors effectively, identifying anomalies indicative of fraud. To overcome the inherent black-box nature of deep learning models, Local Interpretable Model-agnostic Explanations is employed, providing transaction-level interpretability and enabling stakeholders to understand the factors behind each prediction. Further, an ontology is developed to embed domain-specific knowledge, offering semantic validation of the model outputs. This ensures that predictions not only rely on learned patterns but also align with predefined risk rules and expert knowledge. Experimental results demonstrate high accuracy and recall rates, confirming the model's effectiveness in detecting fraudulent activities, while the ontology layer enhances trust and reliability. This hybrid framework thus advances fraud detection by combining predictive power, explainability, and semantic validation, contributing to the development of more secure and transparent financial systems.

**Keywords**: Credit Card Fraud Detection, Long Short-Term Memory Network, Explainable AI, Ontology-Based Validation, Interpretability

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| Abbreviation | Description |
|---|---|
| AI | Artificial Intelligence |
| LSTM | Long Short-Term Memory |
| ML | Machine Learning |
| RNN | Recurrent Neural Network |
| DL | Deep Learning |
| DNN | Deep Neural Network |
| GRU | Gated Recurrent Unit |
| XAI | Explainable Artificial Intelligence |
| SHAP | SHapley Additive exPlanations |
| LIME | Local Interpretable Model-Agnostic Explanations |
| GNN | Graph Neural Network |
| CNN | Convolutional Neural Network |
| SVM | Support Vector Machine |
| AUC-ROC | Area Under the Receiver Operating Characteristic Curve |
| SMOTE | Synthetic Minority Over-sampling Technique |