



# UNIVERSITY OF BIRMINGHAM

SCHOOL OF COMPUTER SCIENCE  
COLLEGE OF ENGINEERING AND PHYSICAL SCIENCES

MSc. PROJECT

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## Machine Learning & Deep Learning Approaches to Predict Credit Card Default

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Submitted in conformity with the requirements  
for the degree of MSc. Artificial Intelligence & Computer Science  
School of Computer Science  
University of Birmingham

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## **Abstract**

The material contained within this report has not previously been submitted for a degree at the University of Birmingham or any other university. The research reported within this report has been conducted by the author unless indicated otherwise.

**Keywords** Credit Card Default Prediction, Ensemble Learning

### **Declaration**

The material contained within this report has not previously been submitted for a degree at the University of Birmingham or any other university. The research reported within this report has been conducted by the author unless indicated otherwise.

**Signed** Sarathkumar Padinjare Marath Sankaranarayanan

“You have to learn the rules of the game.  
And then you have to play better than anyone else”  
ALBERT EINSTEIN

# MSc. Project

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### Contents

#### Table of Abbreviations

#### List of Figures

<b>1</b>	<b>Introduction</b>	<b>1</b>
1.1	Definitions . . . . .	1
1.1.1	Credit Card Statement Date . . . . .	1
1.1.2	Delinquent Account . . . . .	1
1.1.3	Delinquency Rate . . . . .	1
1.1.4	Credit Card Default . . . . .	1
1.2	Motivation . . . . .	1
1.3	Aim & Approach . . . . .	2
1.4	Structure of Report . . . . .	2
<b>2</b>	<b>Background Knowledge</b>	<b>3</b>
2.1	Support Vector Machine (SVM) . . . . .	3
2.2	Decision Tree . . . . .	3
2.3	Ensemble Models . . . . .	3
2.4	Gradient Boosting Decision Tree (GBDT) . . . . .	3
2.5	Xtreme Gradient Boosting Machine (XGBoost) . . . . .	3
2.6	Light Gradient Boosting Machine (LGBM) . . . . .	3
2.7	Artificial Neural Network (ANN) . . . . .	3
2.8	Gated Recurrent Unit (GRU) . . . . .	3
2.9	Feature Selection - Select From Model . . . . .	3
2.10	Metrics . . . . .	3
2.10.1	Accuracy . . . . .	3
2.10.2	F1-Score . . . . .	3
2.10.3	Recall . . . . .	3
2.11	Cross Validation (CV) . . . . .	3
2.12	Hyper Parameter Tuning . . . . .	3
2.12.1	Grid Search CV . . . . .	3
2.13	File Format . . . . .	3
2.13.1	Parquet . . . . .	3
2.14	Summary . . . . .	3
<b>3</b>	<b>Literature Review</b>	<b>4</b>
3.1	Summary . . . . .	4
<b>4</b>	<b>Materials</b>	<b>5</b>
4.1	Dataset . . . . .	5
4.2	Tools & Software . . . . .	5
<b>5</b>	<b>Methodology</b>	<b>6</b>
5.1	Summary . . . . .	6
<b>6</b>	<b>Results &amp; Discussions</b>	<b>7</b>
6.1	Summary . . . . .	7
<b>7</b>	<b>Conclusion &amp; Summary</b>	<b>8</b>
7.1	Summary . . . . .	8
	<b>References</b>	<b>9</b>
<b>8</b>	<b>Appendix One: Code</b>	<b>10</b>
8.1	Directory Structure . . . . .	10
8.2	Running the Provided Code . . . . .	10

## Table of Abbreviations

<b>SVM</b>	Support Vector Machine
<b>ANN</b>	Artificial Neural Network
<b>GBDT</b>	Gradient Boosting Decision Tree
<b>GRU</b>	Gated Recurrent Unit
<b>LGBM</b>	Light Gradient Boosting Machine
<b>XGBoost</b>	Xtreme Gradient Boosting Machine
<b>GRU</b>	Gated Recurrent Unit
<b>CV</b>	Cross Validation

## List of Figures

1	Delinquency rate on credit card loans for the period 1992-2022 . . . . .	1
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## 1 Introduction

This section will introduce the user to definitions of terms relevant for understanding the problem, discuss the motivation behind the problem, the aim & approach taken to solve the problem, and the structure of this report.

### 1.1 Definitions

#### 1.1.1 Credit Card Statement Date

The credit card statement date is the date on which the statement/bill is generated every month. Any transaction conducted on the card post billing date will reflect in the next month's credit card statement.

#### 1.1.2 Delinquent Account

A credit card account is considered delinquent if the customer has failed to make the minimum monthly payment for 30 days from the original due date.

#### 1.1.3 Delinquency Rate

The percentage of credit card accounts within a financial institution's portfolio whose payments are delinquent.

$$\text{DelinquencyRate} = \left( \frac{\text{NumberOfDelinquentCreditCardAccounts}}{\text{TotalNumberOfCreditCardAccount}} \right) * 100 \quad (1)$$

#### 1.1.4 Credit Card Default

The customer is considered as defaulting customer in the event of nonpayment of the due amount in 120 days after the latest statement date.

### 1.2 Motivation

Delinquency rates & credit card default rates are directly proportional. According to the figure 1, the delinquency rates were at an all-time high just before the recession started in 2008; moreover, this was the same time when more & more customers began to default on credit card payments.

Predicting credit defaults is essential for managing risk in the consumer lending industry. Credit default prediction enables lenders to make the best possible lending decisions, improving customer satisfaction and fostering strong company economics.

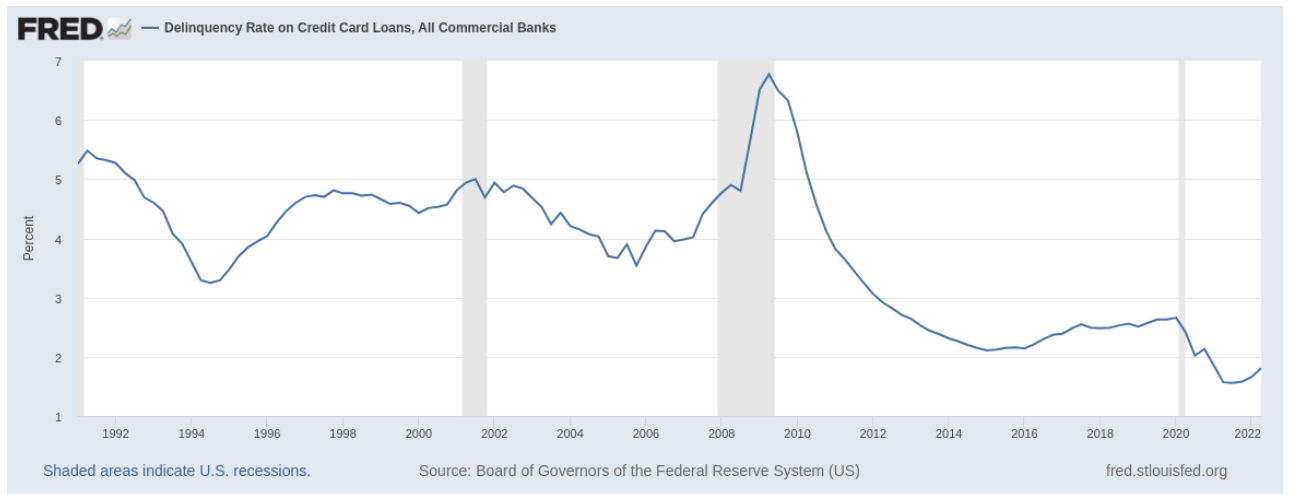


Figure 1: Delinquency rate on credit card loans for the period 1992-2022(Board of Governors of the Federal Reserve System (US) 2022).

Existing models can be used to manage risk. However, developing models that perform better than those in use is feasible.



### **1.3 Aim & Approach**

The objective of this project was to explore different machine learning algorithms & deep learning architectures on the American Express default prediction dataset(American Express 2022) to predict if a customer will default on the payment in the future. The project work started by developing a model using classic machine learning algorithm Support Vector Machine (SVM) followed by creating multiple models using Random Forest Classifier & Gradient Boosting Decision Tree (GBDT) algorithms. Artificial Neural Network (ANN), Gated Recurrent Unit (GRU) & Custom ensemble model created by model combining ANN, GRU and GBDT were created as part of exploring deep learning architectures. Finally created a lean model, using less features & optimized parameters using GBDT which provided comparable performances to the previously explored models.

### **1.4 Structure of Report**

The remainder of the report is structured as follows: in Section 2 background information on different machine learning & deep learning algorithms along with metrics explanation is provided. Then in Section 3 a literature review related to the credit card default prediction research is given. Section 4 & 5 provides detailed explanations on the dataset, tools & software used in the project, and methodology followed for creating the models. Model evaluation results and the comparison is given in Section 6. Finally Section 7 discusses the conclusion of the project.

## **2 Background Knowledge**

This section provides the reader with the required background information on the machine learning algorithms, deep learning architectures & metrics.

### **2.1 Support Vector Machine (SVM)**

### **2.2 Decision Tree**

### **2.3 Ensemble Models**

### **2.4 Gradient Boosting Decision Tree (GBDT)**

### **2.5 Xtreme Gradient Boosting Machine (XGBoost)**

### **2.6 Light Gradient Boosting Machine (LGBM)**

### **2.7 Artificial Neural Network (ANN)**

### **2.8 Gated Recurrent Unit (GRU)**

### **2.9 Feature Selection - Select From Model**

### **2.10 Metrics**

#### **2.10.1 Accuracy**

#### **2.10.2 F1-Score**

#### **2.10.3 Recall**

### **2.11 Cross Validation (CV)**

### **2.12 Hyper Parameter Tuning**

#### **2.12.1 Grid Search CV**

### **2.13 File Format**

#### **2.13.1 Parquet**

### **2.14 Summary**

### **3 Literature Review**

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#### **3.1 Summary**

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## **4 Materials**

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### **4.1 Dataset**

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### **4.2 Tools & Software**

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## **5 Methodology**

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### **5.1 Summary**

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## **6 Results & Discussions**

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### **6.1 Summary**

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## **7 Conclusion & Summary**

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### **7.1 Summary**

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## References

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<https://www.kaggle.com/competitions/amex-default-prediction/data>.

Board of Governors of the Federal Reserve System (US) (2022), 'Delinquency Rate on Credit Card Loans, All Commercial Banks [DRCCLACBS]', Available:  
<https://fred.stlouisfed.org/series/DRCCLACBS>. Data retrieved from FRED, Federal Reserve Bank of St. Louis;.



## **8 Appendix One: Code**

### **8.1 Directory Structure**

### **8.2 Running the Provided Code**