DRAFT

Machine Learning Consumer Loan Processing

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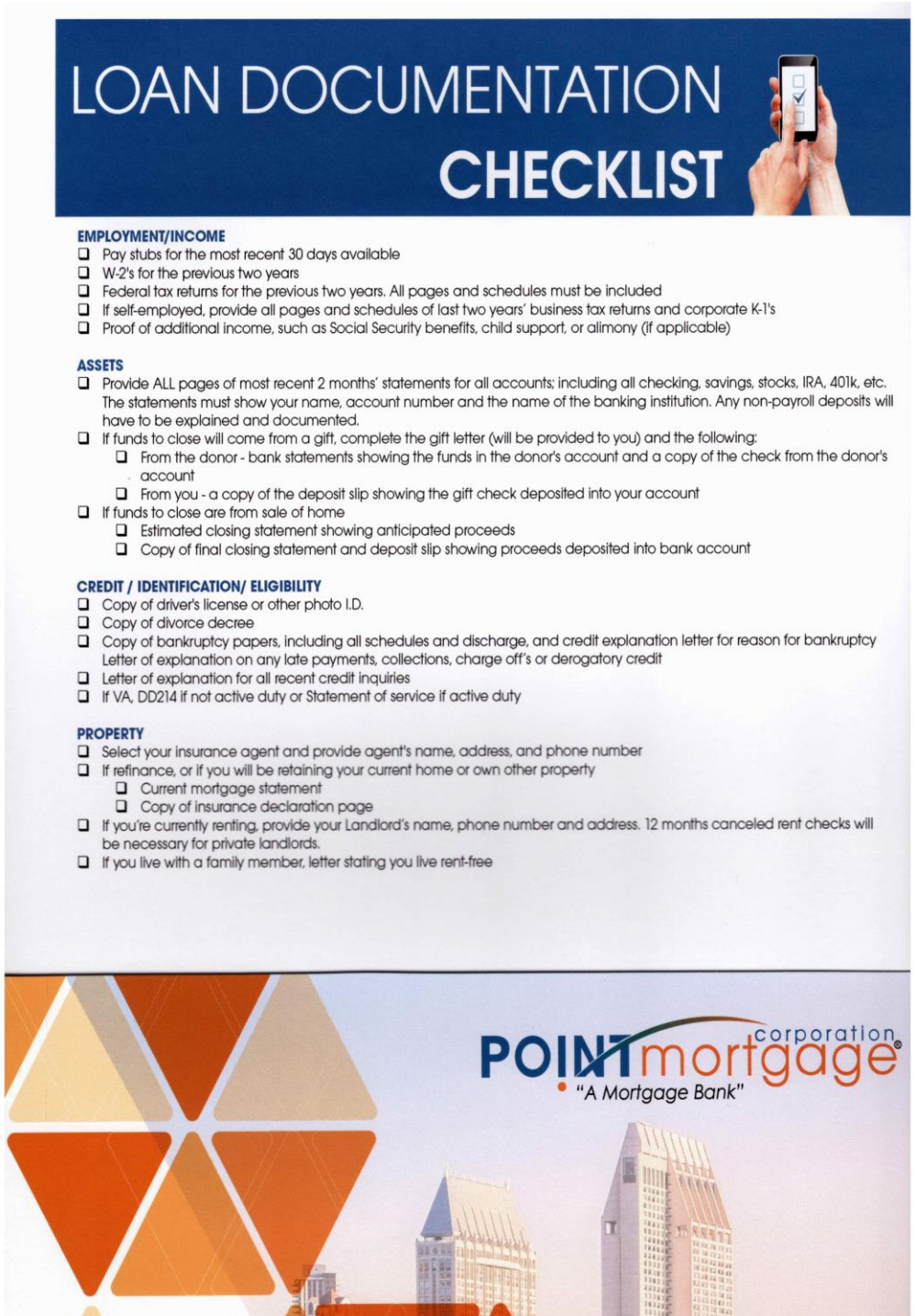
DSA 5900 Practicum

Project Definition

- Identify Credit-Worthiness of Loan Applicants at Financial Institutions
  - Apply Machine Learning Models to Evaluate whether Applicants will default on a Loan
- Identify a Process for Remote Machine Learning
- Stakeholders:
  - Agencies that Process Consumer Loans
- Dr. Radhakrishnan and Dr. Trafalis are my advisors



Data Ingestion

Data Source:

https://www.bondora.com/en/public-reports

Tableau, Python, Sckit Learn, Tensorflow/Keras,

PyTorch and PySft

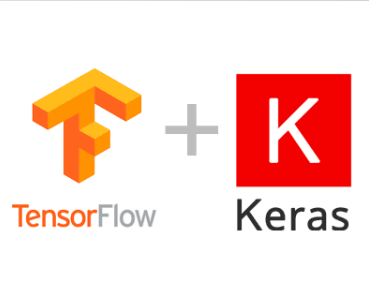
Overall Class Counts

Defaulted: 1

Not Defaulted: 0

Target Class	Count of Target Class	% of Total Count of Target Class)
0	156,588	66.0%
1	80,635	34.0%
Grand Total	237,223	100.0%

Count of Target Class and % of Total Count of Target Class) broken down by Target Class.



No of Features

111 Predictor Variables

1 Target Variable

- Defaulted : 1
- Non Defaulted : 0

Tableau : Data Viz

Python: Data Processing

Sckit Learn: ML Models

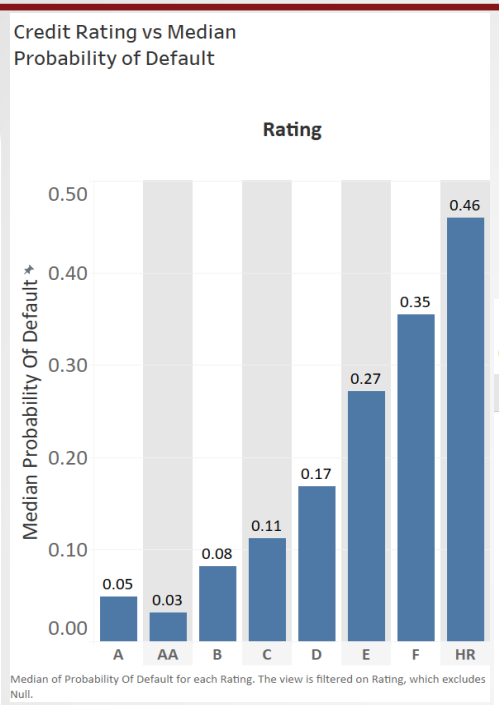
Tensorflow/Keras: Neural Net

PyTorch, PySft: Remote ML

Data Exploration and Preparation - 1

Exploratory Analysis:

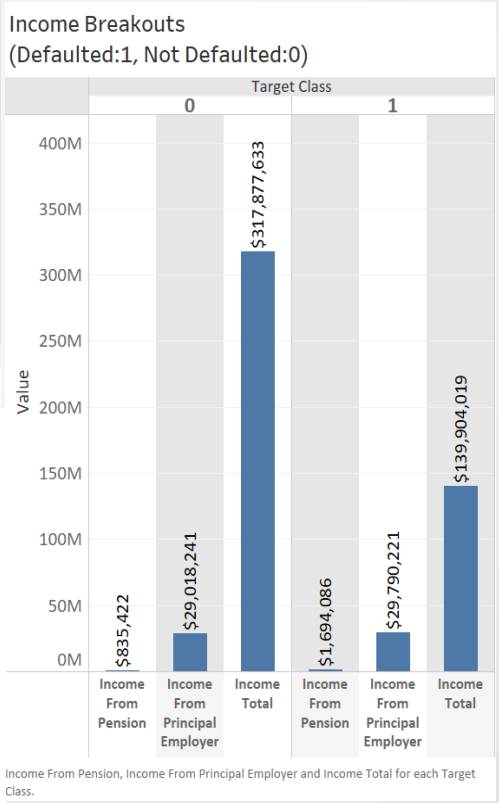
- Lower Default
  - Higher Income
  - Lower Interest Servicing
  - Better Credit Rating
  - Higher Previous Credit
  - Higher Education
  - More Prompt Payment
- No Significant Multicollinearity
- Correlation Not High Between Predictor and Target



Days to Payments By Class Percentage of Total vs Days Outstanding

Defaulted: 1; Non Defaulted: 0

Active Late Category	Target Class 0	Target Class 1	Grand Total
0-7	95.84%	4.16%	100.00%
8-15	97.51%	2.49%	100.00%
151-180	2.94%	97.06%	100.00%
180+	0.85%	99.15%	100.00%



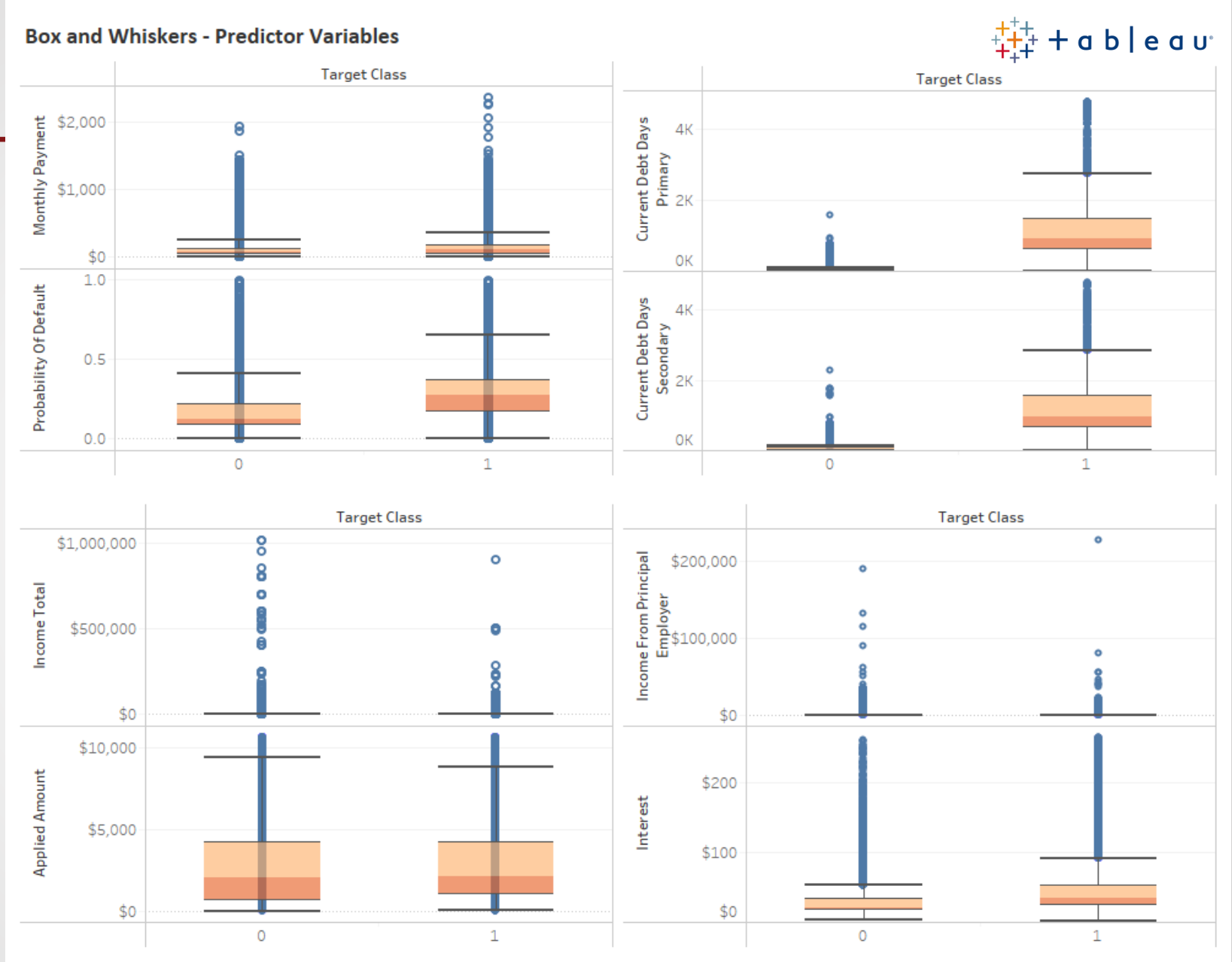
Correlation Coefficient

Variable_Name	Defaulted
EmploymentDurationCurrentEmployer_UpTo3Years	0.091
NewCreditCustomer_True	0.102
EmploymentDurationCurrentEmployer_UpTo2Years	0.108
PrincipalBalance	0.111
RefinanceLiabilities	0.119
Rating_E	0.120
IncomeFromPrincipalEmployer	0.144
MonthlyPayment	0.160
PlannedInterestTillDate	0.187
OccupationArea	0.237
DebtToIncome	0.245
Rating_HR	0.249
UseOfLoan	0.254
Rating_F	0.256
ExpectedReturn	0.273
ActiveScheduleFirstPaymentReached_True	0.277
MaritalStatus	0.282
EmploymentStatus	0.286
Country_ES	0.298
Interest	0.354
ExpectedLoss	0.409
ProbabilityOfDefault	0.432
PrincipalOverdueBySchedule	0.487
Status_Late	0.758
Defaulted	1.000

Data Exploration and Preparation - 2

Exploratory Analysis:

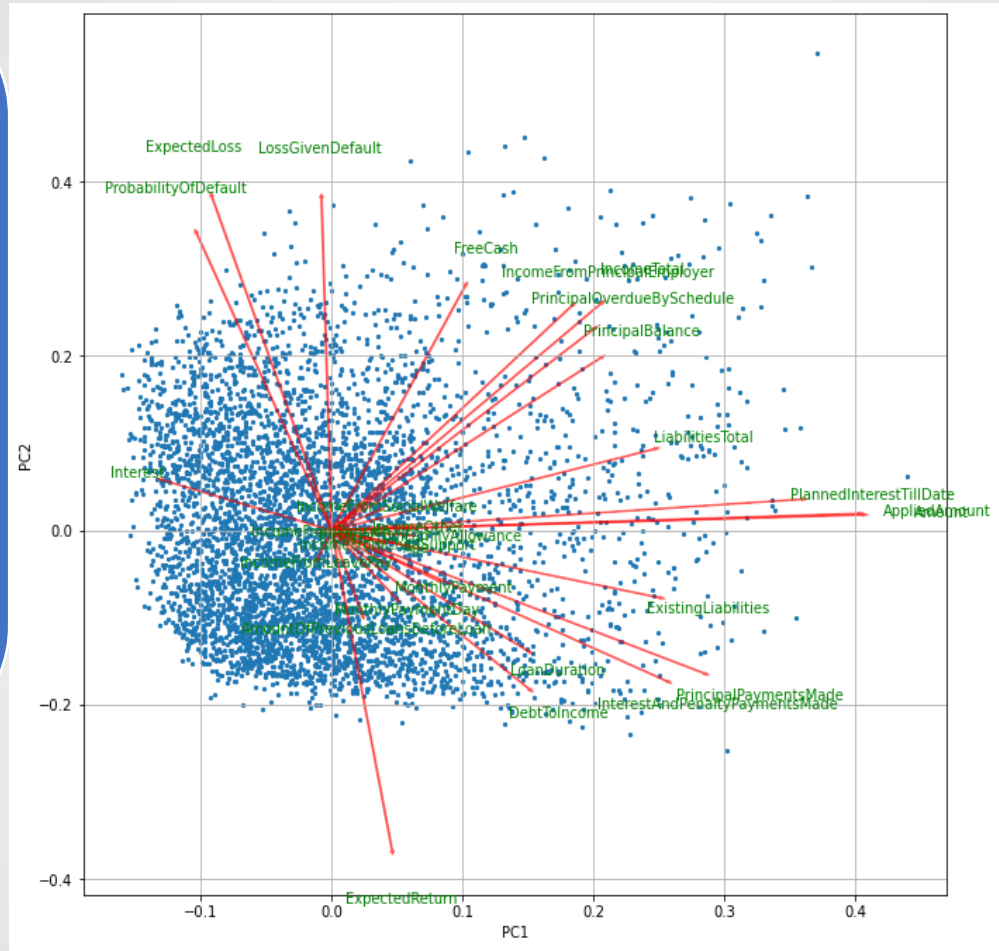
- Higher Spread and Max for Target Class 1
  - Probability of Default
  - Debt Types
  - Interest Servicing
- No Significant Differences Between Classes
  - Applied Amount
  - Income Types
- Missing Values Eliminated Preliminarily

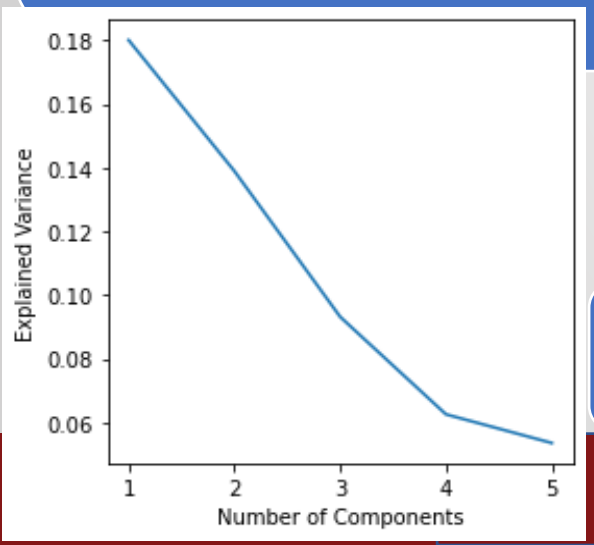


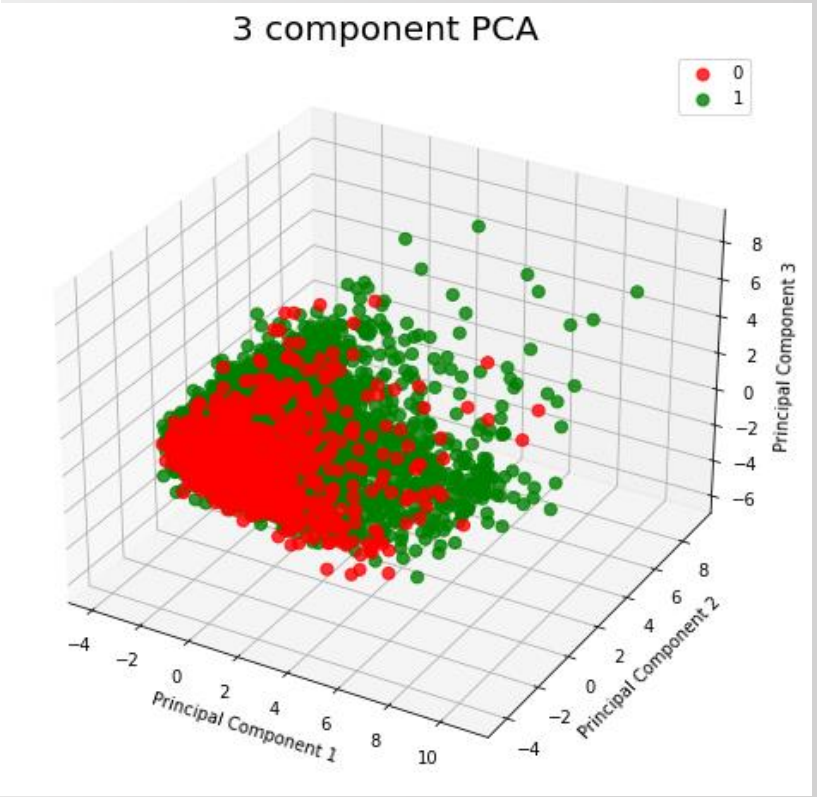
PCA Assessment

PCA Analysis:

- ✓ 5,000 Dataset Points Analyzed
- ✓ No of Continuous Variables Scaled and Transformed: 28
- ✓ Limited Variance Explained by 5 Components
- ✓ No Significant Separation Between Classes Observed from PCA 1, 2, and 3
- ✓ Bi Plot shows Explanation of Few Features from PCA 1 and 2

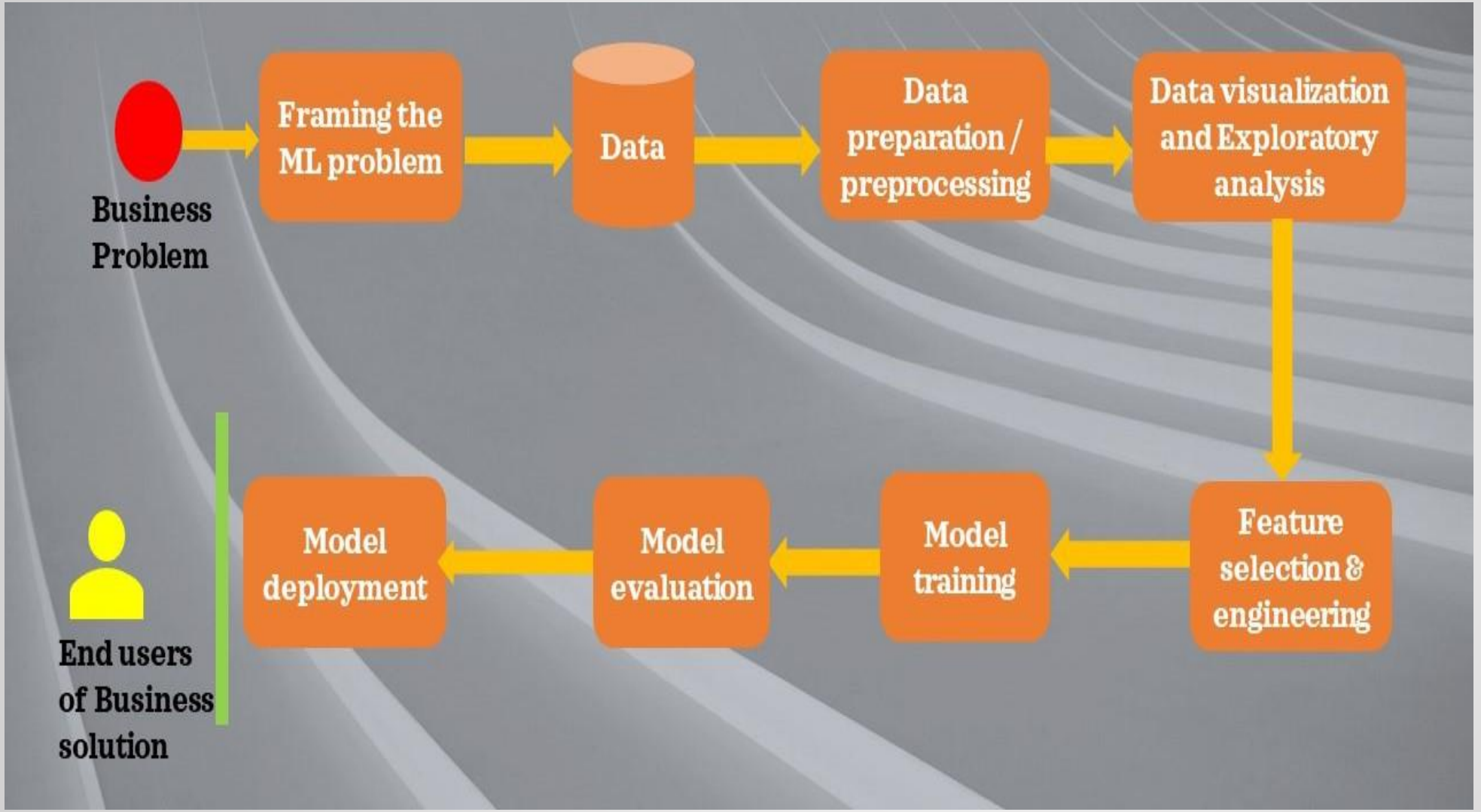






PCA Not a Significant Benefit to Model Predictability, Categorical Count Outweighs Continuous Variables

Modeling Preprocessing And Overview



- **Preprocessing with Sckit-Learn**
  - ✓ Scaled Continuous Variables
  - ✓ One hot encoded Categorical Variables
- **Modeling, Training/Testing**
  - ✓ Sckit Learn
  - ✓ Tensorflow Keras
    - Default
    - GridSearch CV Optimization
  - ✓ Remote Machine Learning – PyTorch and PySft
  - ✓ Sckit-Learn Metrics for Evaluation

Model Results - Logistic Regression and Naïve Bayes

Logistic Regression:

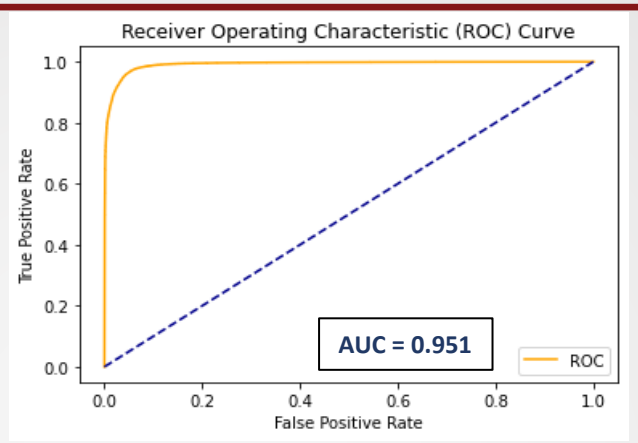
- Grid Search 5-Fold CV
- 200 Iterations
- Hyperparameters
  - ✓ Penalty: L1 and L2
  - ✓ C : 1, 5, 10
  - ✓ Solver, lbfgs, liblinear and saga

Naïve Bayes:

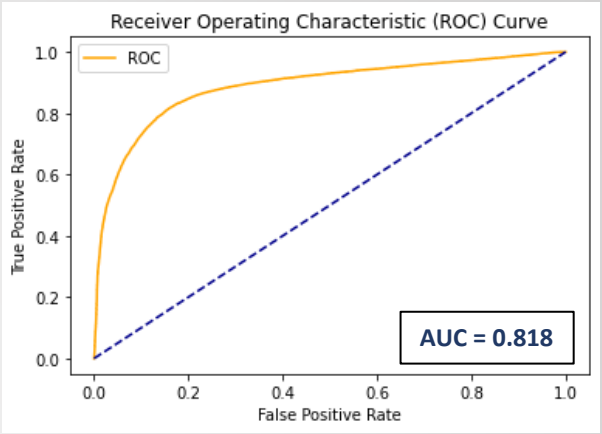
- Grid Search 5-Fold CV
- Hyperparameters
  - ✓ Alpha: 1E-4, 1E-2, 1E-1, and 1

Logistic Regression	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**26,280**	**907**
Class 1 Actual	**928**	**13,687**

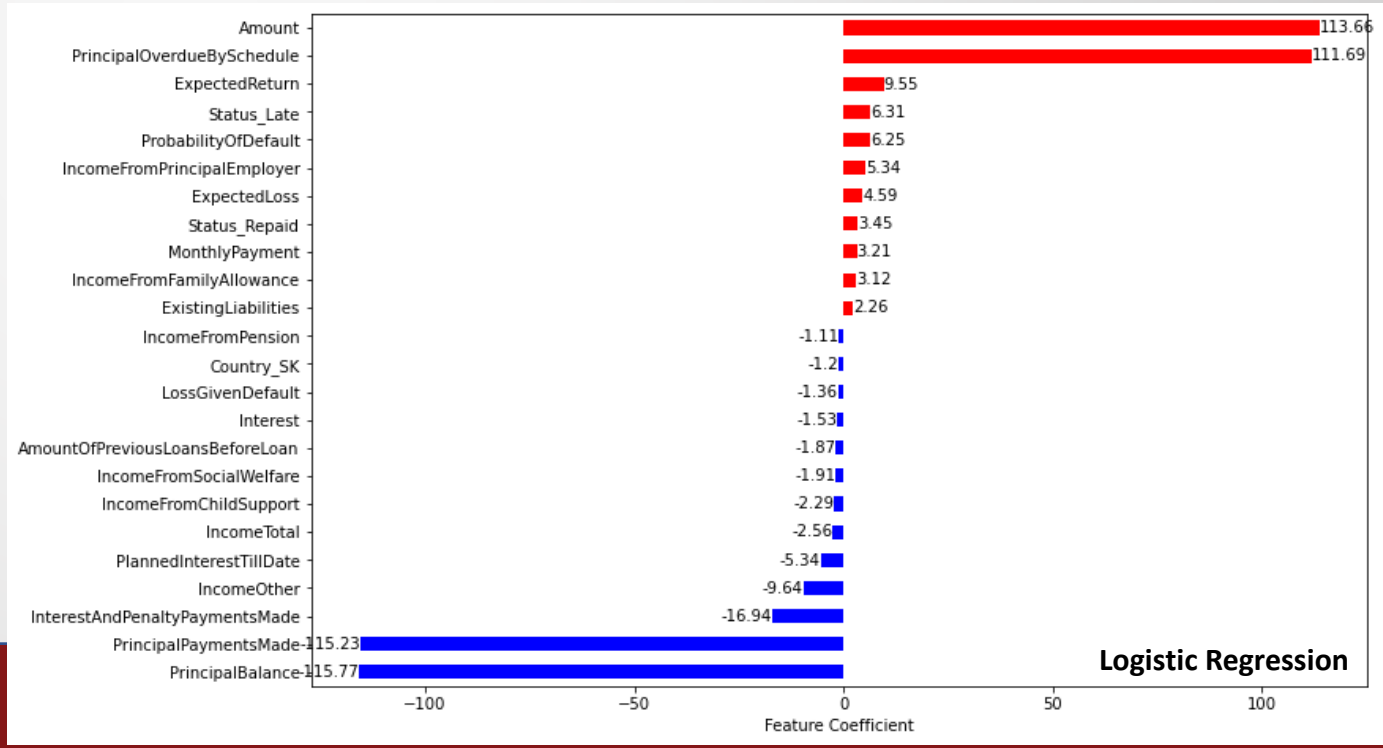
Naïve Bayes	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**24,283**	**2,904**
Class 1 Actual	**3,762**	**10,853**



Logistic Regression



Naïve Bayes



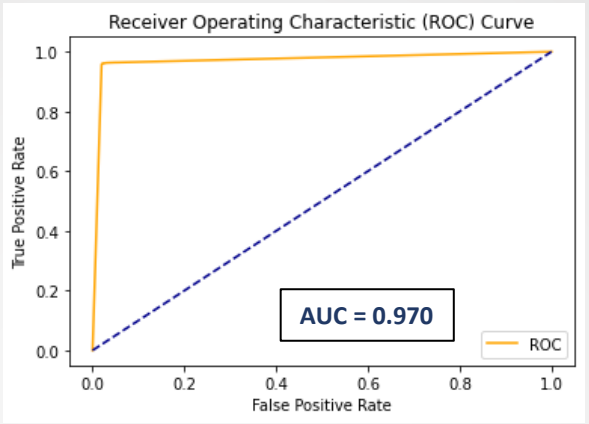
Model Results - Decision Trees and Ensemble Forests

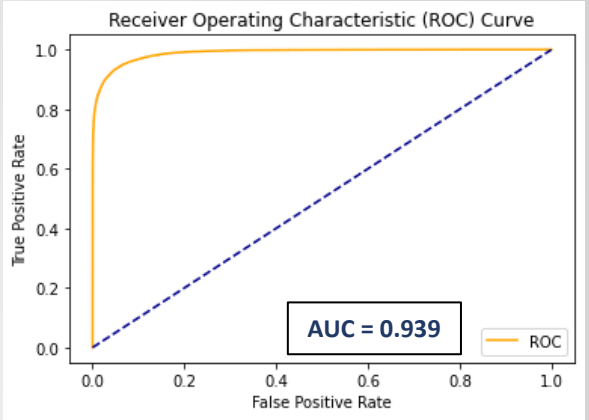
Decision Trees:

- Grid Search 5-Fold CV
- Hyperparameters
  - ✓ Criterion : gini, entropy
  - ✓ Max_depth : 5,10,20

Ensemble Forests:

- Grid Search 5-Fold CV
- Hyperparameters
  - ✓ N_estimators: 5,10,20, 50, 100
  - ✓ Learning_Rate: 0.1, 0.5, 1. 0, 2.0, 5.0



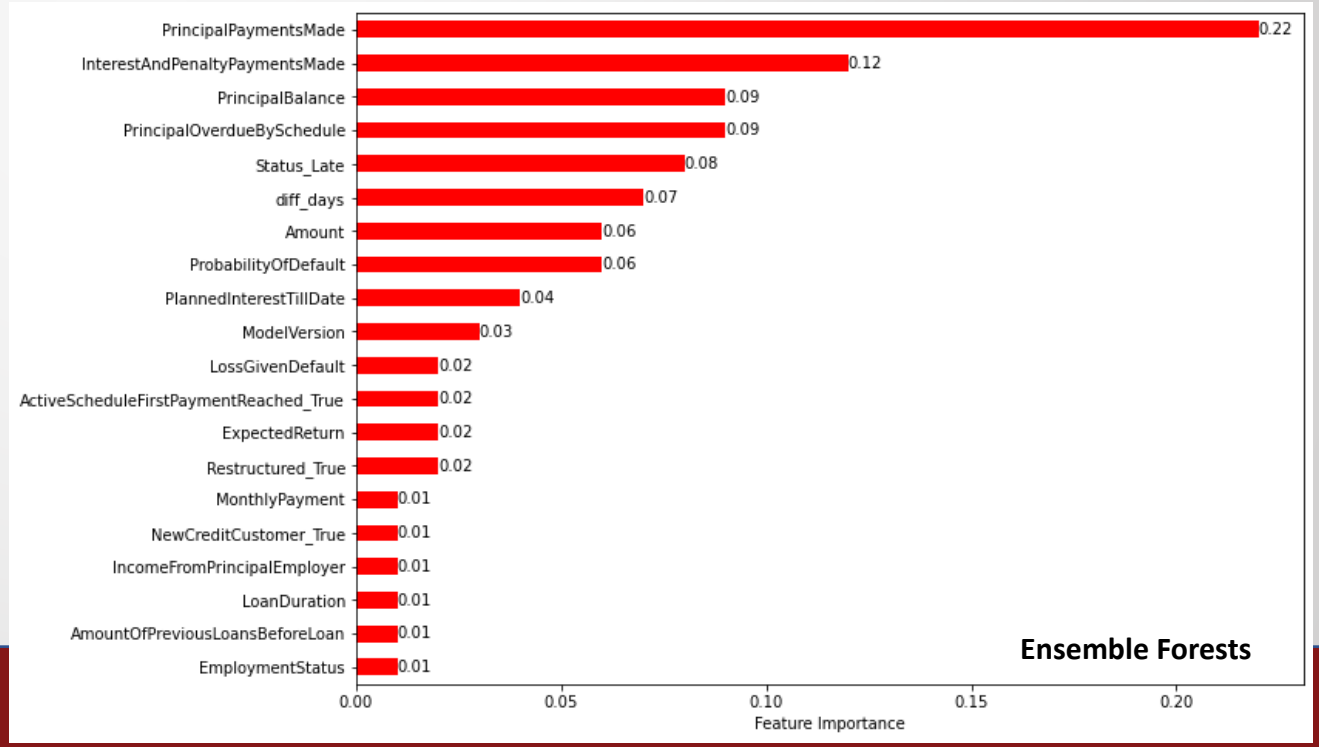


Decision Trees	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**26,663**	**554**
Class 1 Actual	**591**	**14,024**

Ensemble Forests	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**26,238**	**949**
Class 1 Actual	**1,276**	**13,339**

Decision Trees

Ensemble Forests

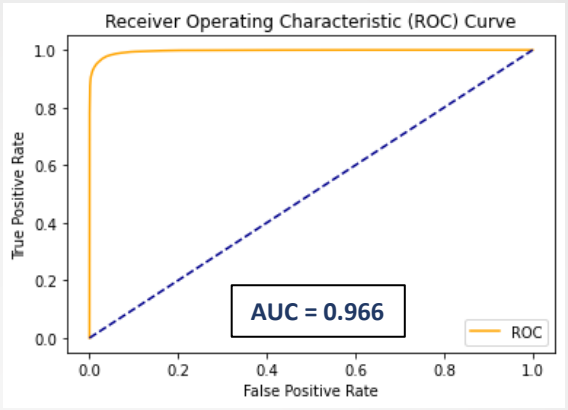


Model Results Random Forests

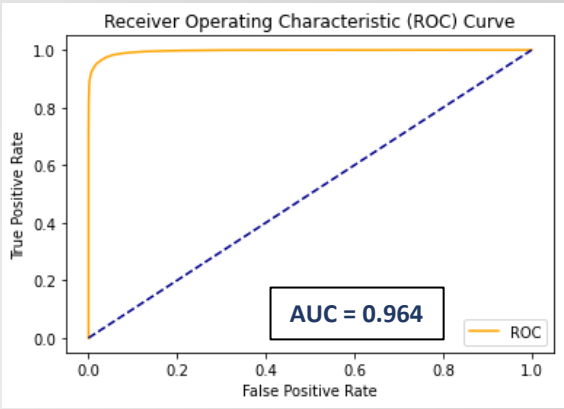
Random Forests:

- **Grid Search 5-Fold CV**
- **Hyperparameters**
  - ✓ **N_estimators: 50, 100,200**
  - ✓ **Criterion: gini, entropy**
  - ✓ **Max_features: sqrt, log2, auto**

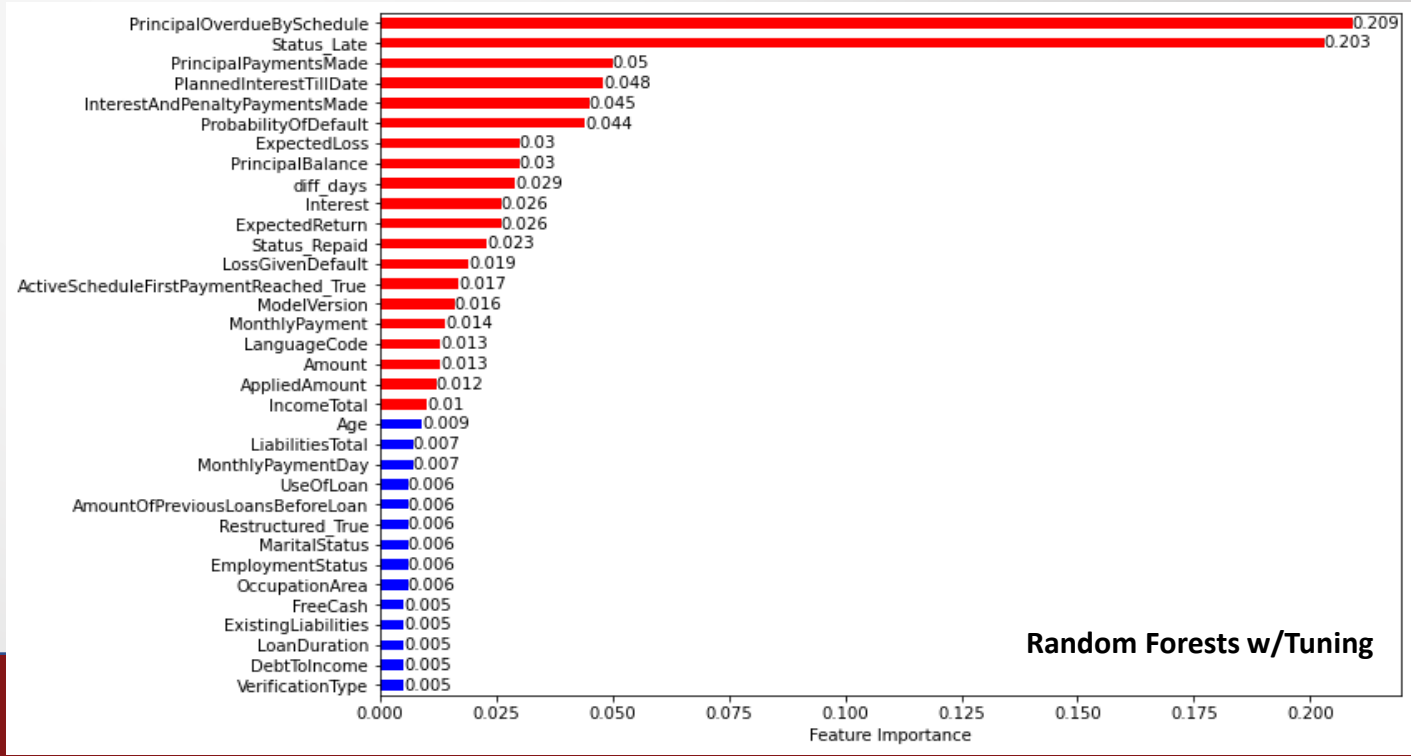
Random Forests	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**26,854**	**333**
Class 1 Actual	**826**	**13,789**



Random Forests w/Tuning



Random Forests w/o Tuning

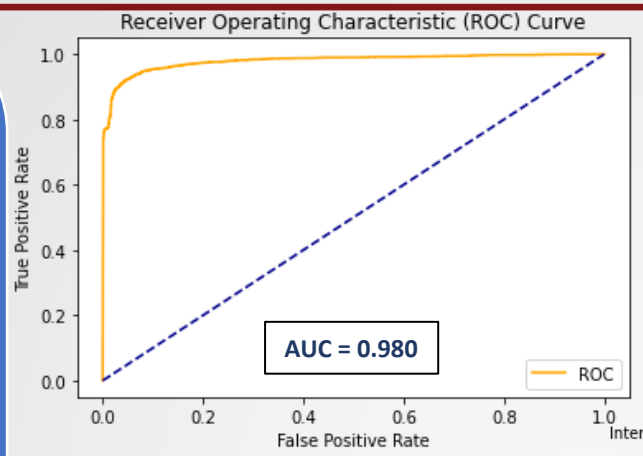


Model Results - Neural Nets, Keras/Tensorflow

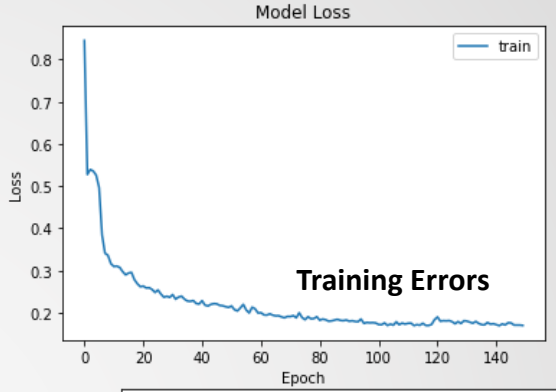
Neural Net:

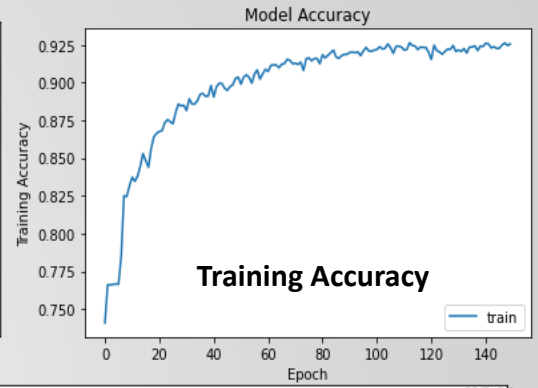
- ✓ 3 Hidden Layers: 100, 50, and 25 Neurons, Relu Activation
- ✓ 1 Output Layer, 1 Neuron, Sigmoid Activation
- ✓ Grid Search CV = 3
- ✓ Hyperparameters
- • Optimizer: rmsprop, adam
- • inits: glorot_uniform, normal, uniform
- • Epochs: 50,100
- • Batches: 5,20

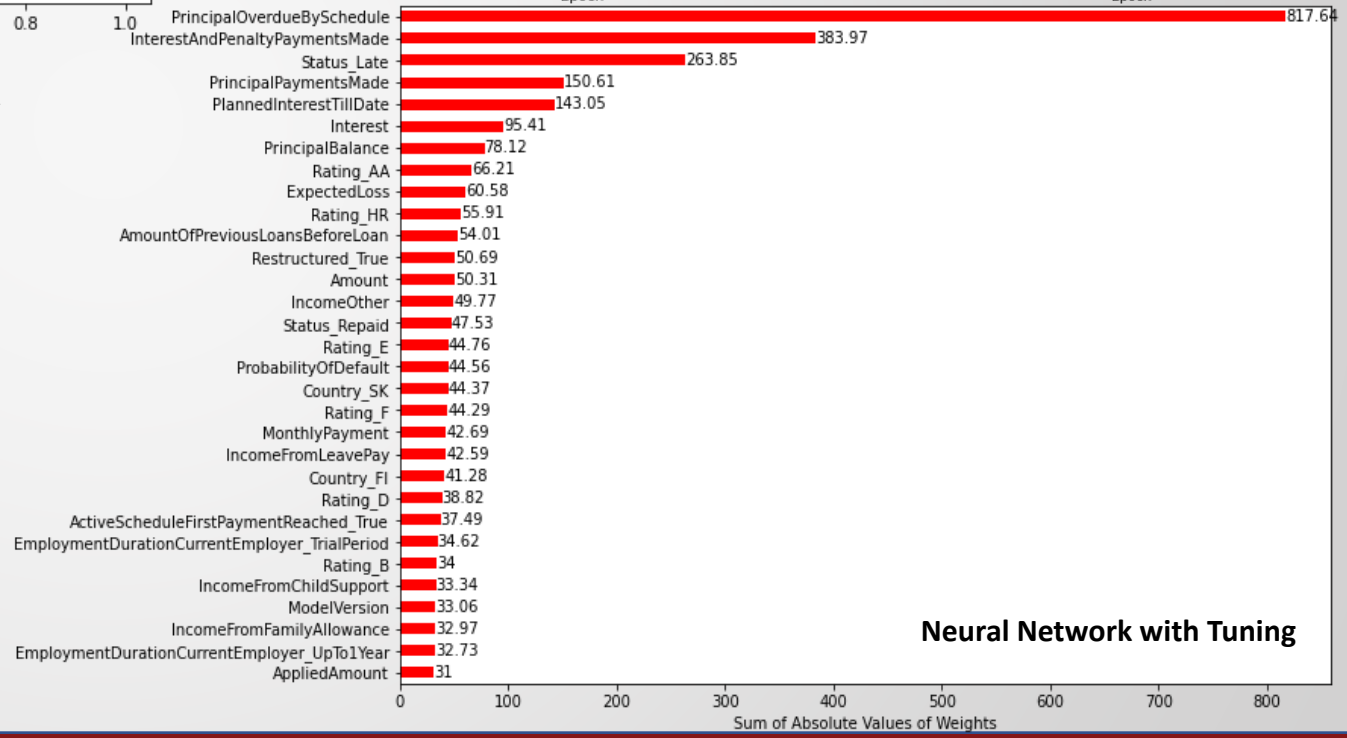
Neural Net	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**630**	**308**
Class 1 Actual	**44**	**3,018**



Neural Network







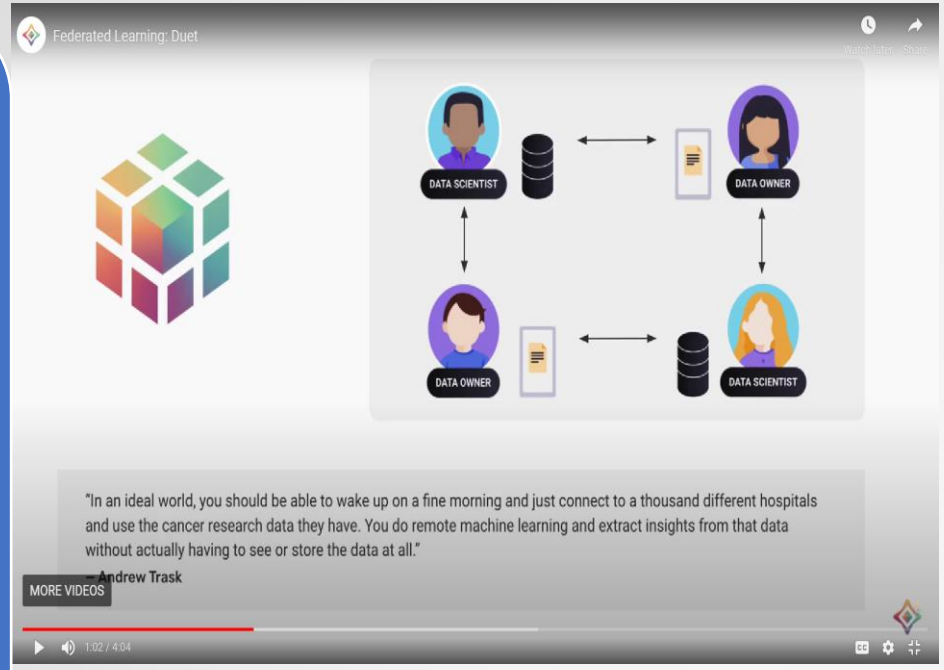
Remote Machine Learning - Overview

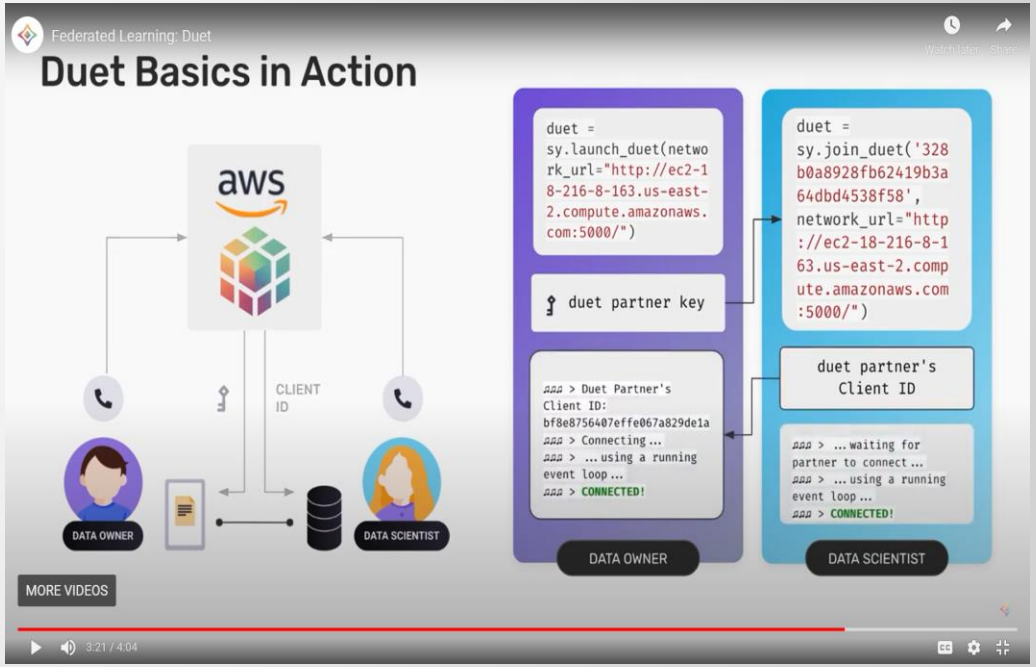
Why Useful?

- ✓ Keeps Data Private
- ✓ Data Owner has Control Over Data
- ✓ Machine Learner Benefits from Access to Distributed Data

Process?

- ✓ PySft Wrapper to ML Package
- ✓ Encryption and Privacy Maintained
- ✓ Machine Learner Can Access Multiple Data Sources Simultaneously
- ✓ Models Trained Remotely and can be Aggregated for Use





Remote Machine Learning –PyTorch/PySft Results

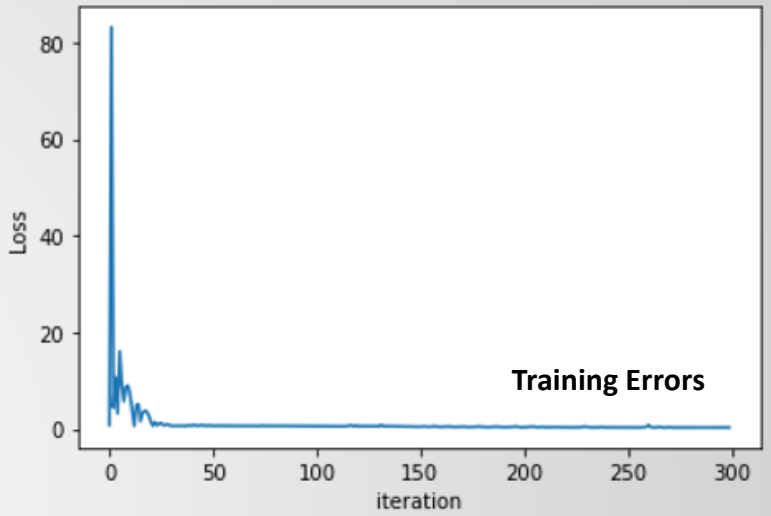
Remote Learning Process:

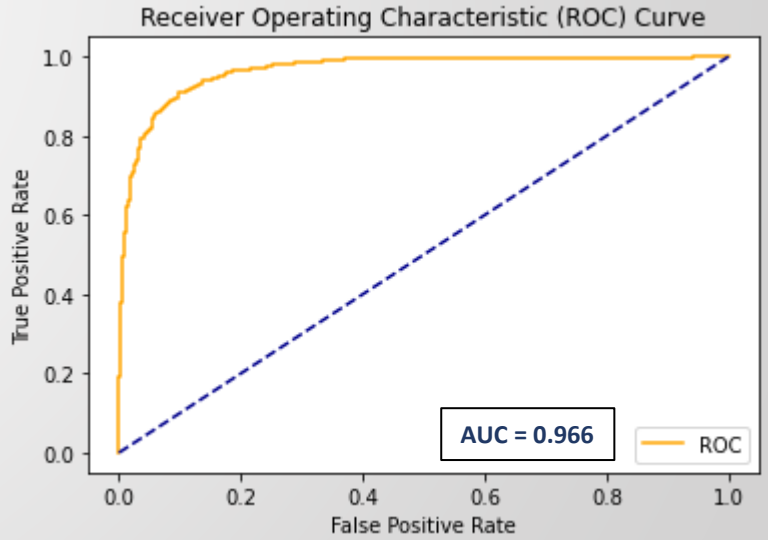
- ✓ Data Owner/Data Scientist interact via PySyft and PyGrid/AWS
- ✓ Data Owner sends data to Data Scientist
- ✓ Data Scientist makes requests via Pysft to Data Owner
- ✓ Data Scientist creates model
- ✓ Data Scientist sends model to Owner
- ✓ Training on Remote Server
- ✓ Model Sent to Data Scientist Once Trained
- ✓ Data Scientist Tests Model – Sckit Learn Packages

PyTorch and PySft:

- ✓ 2 Hidden Layers: 100 and 100 Neurons, Relu Activation
- ✓ 1 Output Layer, 2 Neurons, Log_soft_max Activation
- ✓ 300 Epochs
- ✓ Optimizer: Adam
- ✓ learning_rate = .01
- ✓ nn.functional.nll_loss

PyTorch/ PySft	Class 0 Predicted	Class 1 Predicted
Class 0 Actual	**1,262**	**99**
Class 1 Actual	**95**	**634**





Model Evaluation – Performance Metrics

	Hyperparameters	RMSE	Accuracy	Precision	Recall	F_1Score	AUC
Logistic Regression	L1 Penalty, liblinear Solver, C =5	**0.209**	**0.956**	**0.938**	**0.936**	**0.937**	**0.951**
Naïve Bayes	Alpha = 1.0	**0.399**	**0.841**	**0.789**	**0.743**	**0.765**	**0.818**
Decision Tree	Criterion – entropy, Max_depth = 20	**0.166**	**0.973**	**0.962**	**0.960**	**0.961**	**0.970**
Ensemble Forest	N_estimators= 100 l_rate = 1.0	**0.231**	**0.947**	**0.934**	**0.913**	**0.923**	**0.939**
Random Forest	N_estimators = 200, Criterion – entropy, Max_ features = auto	**0.166**	**0.972**	**0.976**	**0.943**	**0.960**	**0.966**
Neural Net – Keras/Tensorflow	Batch_size = 5, epochs=150, init- glorot_uniform, optimizer= adam	**0.249**	**0.912**	**0.907**	**0.986**	**0.945**	**0.980**
Neural Net - PyTorch	To be Developed		**0.907**	**0.865**	**0.869**	**0.867**	**0.966**

CONCLUSIONS - FORTHCOMING

Next Steps, To be Developed

- What is the significance of your project?
- How are the stakeholders affected by the outcome of your project?
- What are your recommendations for improvements for researchers who may continue your work?
- How will you build on this project in your work or academic career (optional)?

Questions