18.06.2022

Master
Project Management
and Data Science

SECOM ANALYTICS - PART 2

TEAM 3

Gupta, Himansha

Pomay Polat, Ekin

Dsouza, Rashmi Carol

Pham, Quynh Dinh Hai

htw

TABLE OF CONTENTS

01

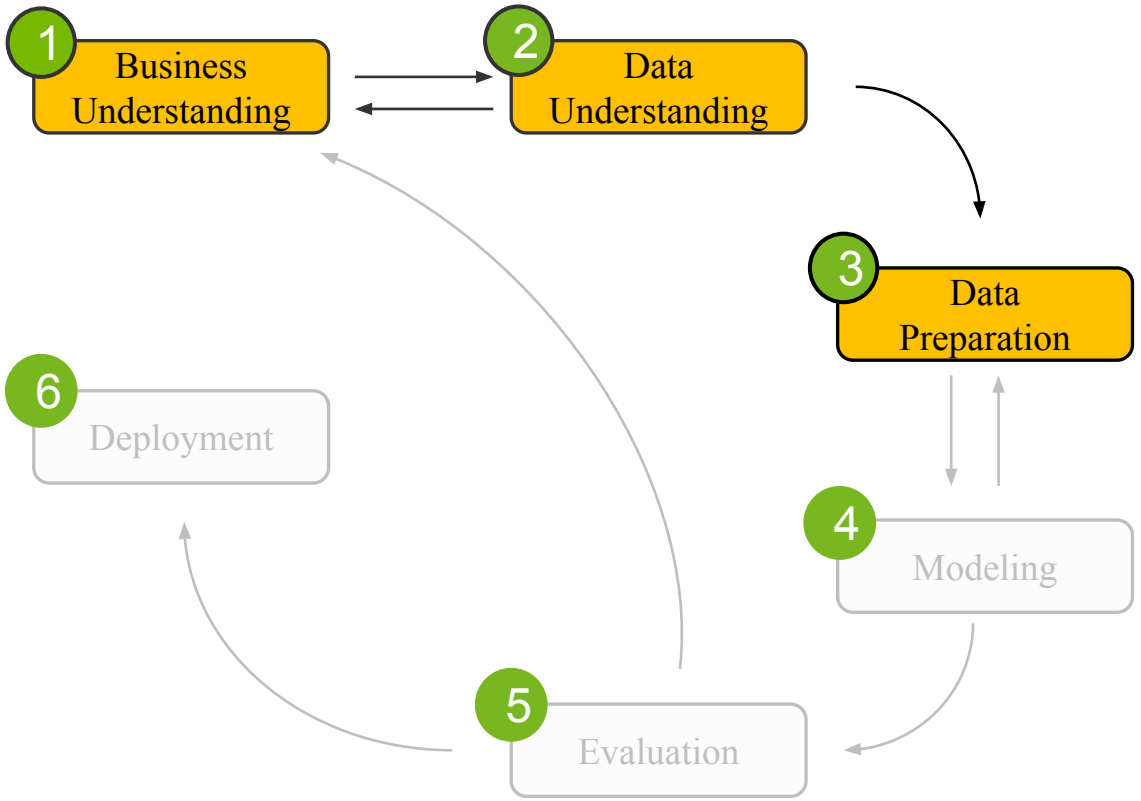
DATA PREPARATION

- Overview
- Our Approach
- Merge Data
- Separate Training & Test sets
- Data Preparation Steps
- Top 4 combination

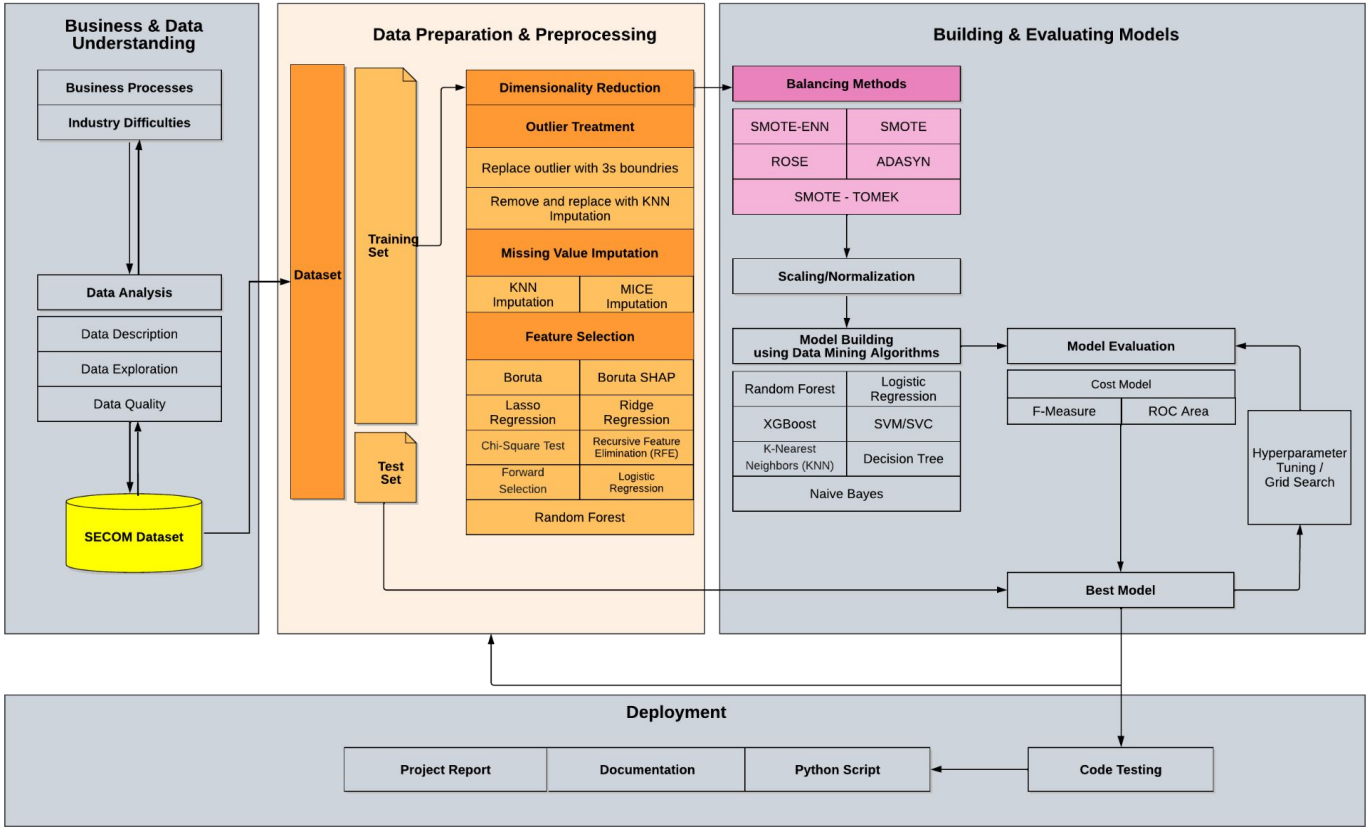
02

NEXT STEPS

01
DATA PREPARATION

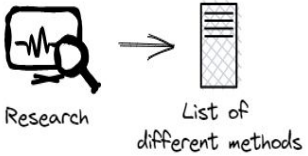


OVERVIEW


Business & Data Understanding
Business Processes
Industry Difficulties
Data Analysis
Data Description
Data Exploration
Data Quality
SECOM Dataset
Data Preparation & Preprocessing
Dataset
Training Set
Test Set
Dimensionality Reduction
Outlier Treatment
Replace outlier with 3s boundries
Remove and replace with KNN Imputation
Missing Value Imputation
KNN Imputation
MICE Imputation
Feature Selection
Boruta
Boruta SHAP
Lasso Regression
Ridge Regression
Chi-Square Test
Recursive Feature Elimination (RFE)
Forward Selection
Logistic Regression
Random Forest
Building & Evaluating Models
Balancing Methods
SMOTE-ENN
SMOTE
ROSE
ADASYN
SMOTE - TOMEK
Scaling/Normalization
Model Building using Data Mining Algorithms
Random Forest
Logistic Regression
XGBoost
SVM/SVC
K-Nearest Neighbors (KNN)
Decision Tree
Naive Bayes
Model Evaluation
Cost Model
F-Measure
ROC Area
Hyperparameter Tuning / Grid Search
Best Model
Deployment
Project Report
Documentation
Python Script
Code Testing

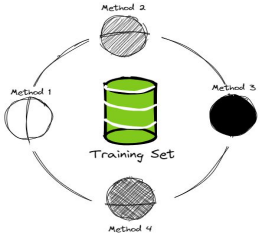
DATA PREPARATION APPROACH

01



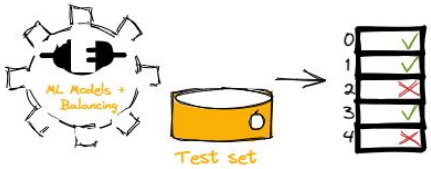
Research different methods for each step of data preparation

02



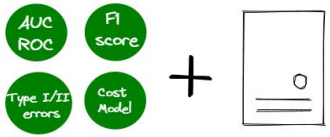
Use training set to train the machine with different method

03



Use different machine learning models, balancing methods & test set to test each method

04

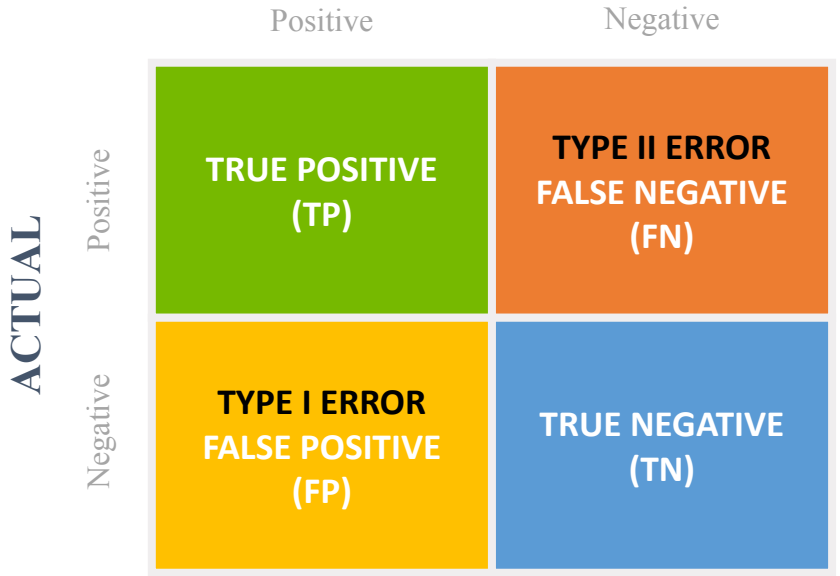


Use AUC, ROC, type I/II errors, F1 score & cost model as measures for decision making & document our findings

RESULT MEASUREMENTS

RESULT MEASURES

PREDICTION



CONFUSION MATRIX

Positive = **Pass** classification
Negative = **Fail** classification

True Positive: Pass classification correctly identified as Pass

True Negative: Fail classification correctly identified as Fail

False Positive: Pass classification identified as Fail

False Negative: Fail classification identified as Pass

RESULT MEASURES

Precision

$$\frac{TP}{TP + FP}$$

Sensitivity

$$\frac{TP}{TP + FN}$$

Specificity

$$\frac{TN}{TN + FP}$$

Negative Predictive Value

$$\frac{TN}{TN + FN}$$

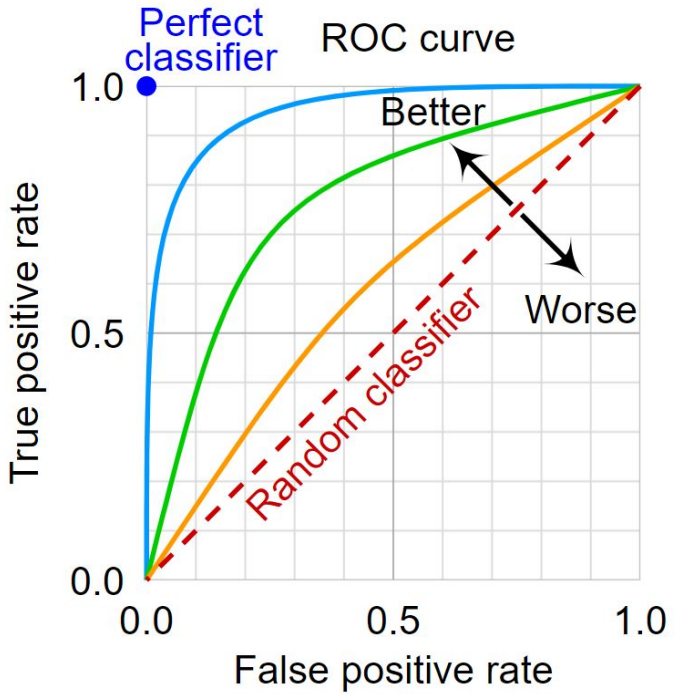
- **Sensitivity/Recall**: the ratio between how much were correctly identified as positive to how much were actually positive.
- **Specificity:** the ratio between how much were correctly classified as negative to how much was actually negative.
- **Precision:**How much were correctly classified as positive out of all positives.
- **NPV**:How much were correctly classified as negative out of all negatives

F1-Score

$$\frac{2 \times Precision \times Recall}{Precision + Recall}$$

F1 Score: combines precision and recall into one metric by calculating the harmonic mean between those two. It is primarily used to compare the performance of two classifiers. Classifier A has a higher recall, and classifier B has higher precision. In this case, the F1-scores for both the classifiers are used to determine which one produces better results.

ROC CURVE



- ROC curve is used to visualize the trade off between Sensitivity and Specificity.
- AUC is the area under the curve
- **Sensitivity** on the **Y-axis**
- **Specificity** on the **X-axis**

COST MODEL

Because of trade-off between Sensitivity & Specificity, we think in terms of business and what decision to make that is good for business, which is to **minimize the cost** as much as possible → **build a cost model** for method comparison & decision making

01
Cost of TP

02
Cost of TN

03
Type I Error
Cost of FP = $225

- Manufacturing & Shipping
- Recall cost
- Reshipping
- Damages

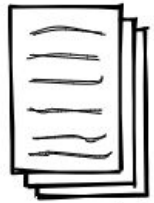
04
Type II Error
Cost of FN = $100

- Manufacturing & Shipping

DATA PREPARATION

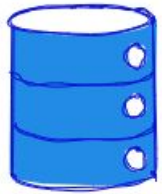
MERGING DATA

```
3030.93 2564 2187.
284 0.4734 0.0167
71 31.8843 NaN NaN
11.5074 0.1096 0.0
```

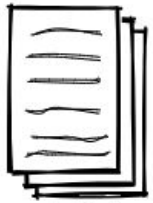


Secom.data

SECOM Dataset



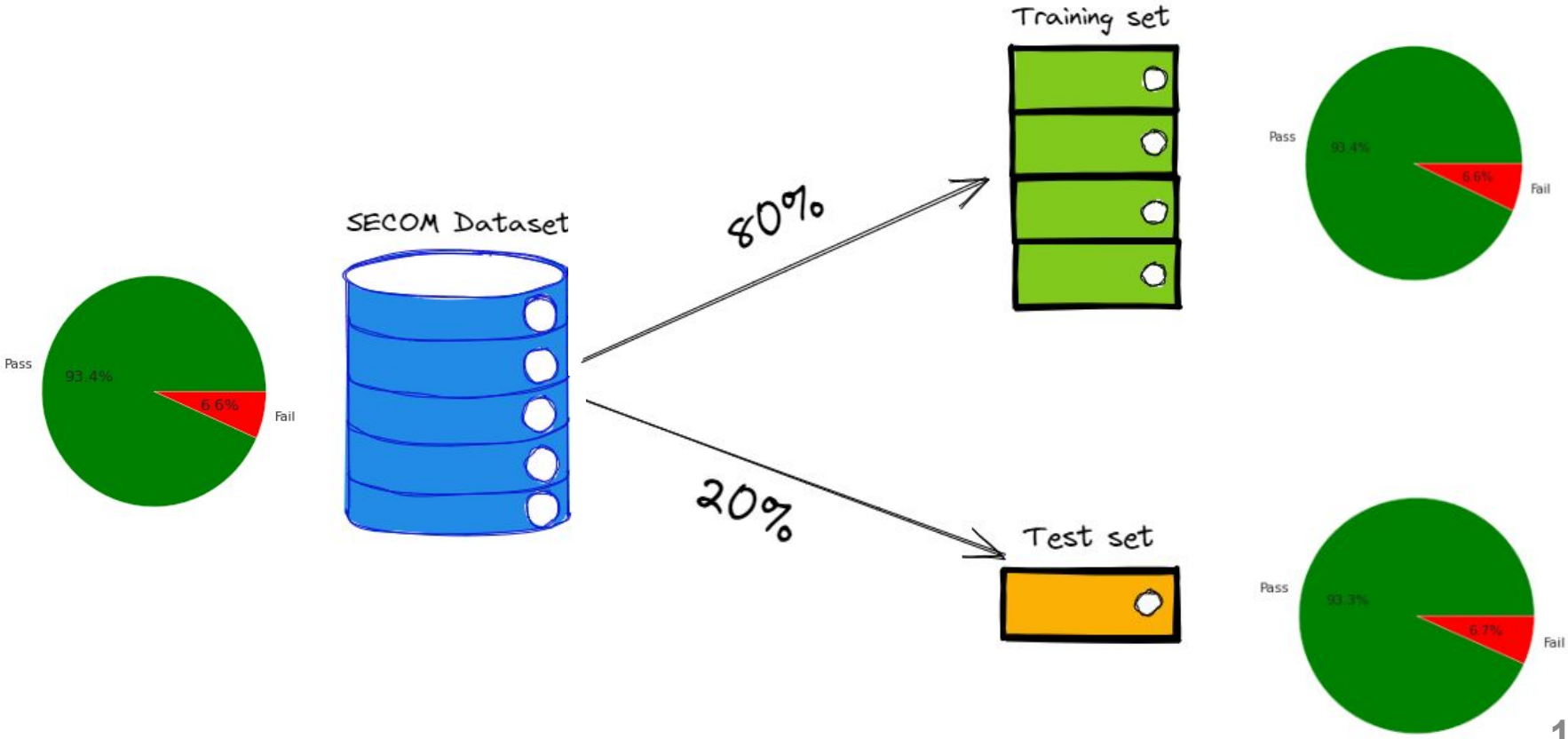
```
-1 "19/07/2008 11:55:00"
-1 "19/07/2008 12:32:00"
1 "19/07/2008 13:17:00"
-1 "19/07/2008 14:43:00"
-1 "19/07/2008 15:22:00"
-1 "19/07/2008 17:53:00"
```



Secom_labels.dat

	Classification	Timestamp	Feature_1	Feature_2	Feature_3	Feature_4	Feature_5	Feature_6	Feature_7	Feature_8	...
0	-1	2008-07-19 11:55:00	3030.93	2564.00	2187.7333	1411.1265	1.3602	100.0	97.6133	0.1242	...
1	-1	2008-07-19 12:32:00	3095.78	2465.14	2230.4222	1463.6606	0.8294	100.0	102.3433	0.1247	...
2	1	2008-07-19 13:17:00	2932.61	2559.94	2186.4111	1698.0172	1.5102	100.0	95.4878	0.1241	...
3	-1	2008-07-19 14:43:00	2988.72	2479.90	2199.0333	909.7926	1.3204	100.0	104.2367	0.1217	...

SEPARATE TRAINING & TEST DATA



DIMENSIONALITY REDUCTION

1. Remove the Timestamp feature
2. Remove features with missing values

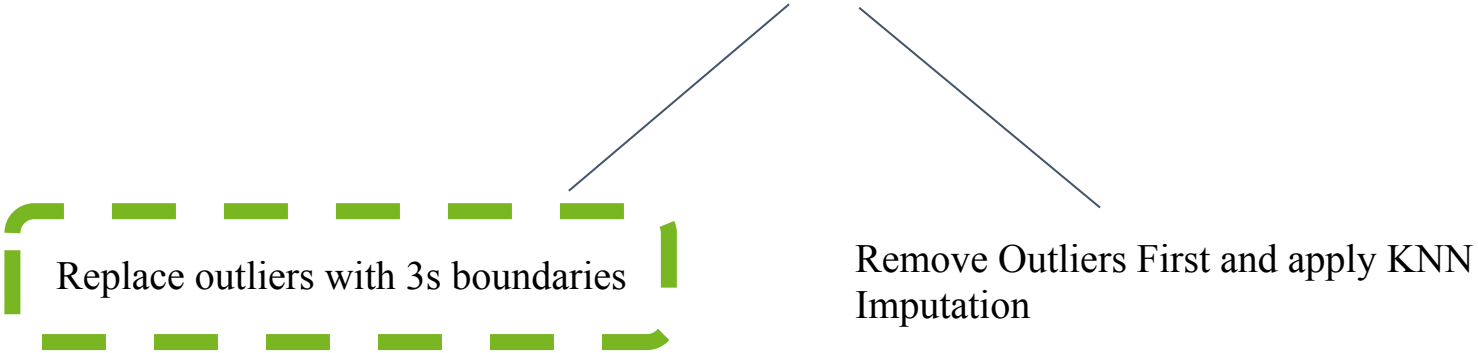
Threshold:
Features with more than 50% missing value

```
] def percent(dataframe, threshold):
      columns = dataframe.columns[(dataframe.isna().sum()/dataframe.shape[1])>threshold]
      return columns.tolist()

  na_columns = percent(X_train, 0.5)
  X_train_na = X_train.drop(na_columns, axis=1)
  X_test_na = X_test.drop(na_columns, axis=1)
  n_features1 = X_train_na.shape[1]
  print(f'Removed = {len(na_columns)} , Left = {n_features1}')

  Removed = 32 , Left = 558
```

OUTLIER TREATMENT



We tried both methods and we get a better result with replacing outliers with 3s boundaries => **we chose to replace the outliers with 3s boundaries**

FEATURE EXPLORATION

SELECTION AND ELIMINATION

	Type I error	Type II error	F1 score	AUC	Cost	Remaining features
KNN - Boruta - SMOTE	11	74	72	70	$ 98.75	12
KNN - Boruta - SMOTE-ENN	10	88	69	73	$ 110.50	12
KNN - Boruta - SMOTE-TOMEK	11	67	75	68	$ 91.75	12
KNN - Boruta - ADASYN	12	79	71	63	$ 106.00	12
KNN - Boruta - ROSE	10	53	79	72	$ 75.50	12
KNN - Chi-Square Test - SMOTE	13	43	82	67	$ 72.25	29
KNN - Chi-Square Test - SMOTE-ENN	11	61	77	69	$ 85.75	29
KNN - Chi-Square Test - SMOTE-TOMEK	14	41	82	68	$ 72.50	29
KNN - Chi-Square Test - ADASYN	12	42	82	68	$ 69.00	29
KNN - Chi-Square Test - ROSE					$ -	29
KNN - Lasso Regression - SMOTE	14	25	87	73	$ 56.50	29
KNN - Lasso Regression – SMOTE-ENN	11	62	76	72	$ 86.75	29
KNN - Lasso Regression – SMOTE-TOMEK	16	20	87	72	$ 56.00	29
KNN - Lasso Regression - ADASYN	14	34	84	71	$ 65.50	29
KNN - Lasso Regression - ROSE					$ -	29
KNN - Boruta SHAP - SMOTE					$ -	
KNN - Forward Selection - SMOTE	13	30	86	70	$ 59.25	15
KNN - Forward Selection - SMOTE-ENN	9	49	81	73	$ 69.25	15
KNN - Forward Selection - SMOTE-TOMEK	13	30	86	72	$ 59.25	15
KNN - Forward Selection - ADASYN	14	30	85	73	$ 61.50	15
KNN - Forward Selection - ROSE	11	28	87	75	$ 52.75	15
KNN - RFE - SMOTE	14	45	81	73	$ 76.50	15
KNN - RFE - SMOTE-ENN	11	77	71	70	$ 101.75	15

	Type I error	Type II error	F1 score	AUC	Cost	Remaining Features
MICE - Boruta - SMOTE	11	76	68	72	$100.75	12
MICE - Boruta - SMOTE-ENN	9	84	74	70	$104.25	12
MICE - Boruta - SMOTE-TOMEK	11	78	71	69	$102.75	12
MICE - Boruta - ADASYN	11	82	70	63	$106.75	12
MICE - Boruta - ROSE	9	53	80	71	$ 73.25	12
MICE - Chi-Square Test - SMOTE	14	43	81	65	$ 74.50	29
MICE - Chi-Square Test - SMOTE-ENN	13	61	76	67	$ 90.25	29
MICE - Chi-Square Test - SMOTE-TOMEK	15	46	80	66	$ 79.75	29
MICE - Chi-Square Test - ADASYN	11	42	83	67	$ 66.75	29
MICE - Chi-Square Test - ROSE					$ -	29
MICE - Lasso Regression - SMOTE	14	26	87	74	$ 57.50	29
MICE - Lasso Regression - SMOTE-ENN	10	64	76	71	$ 86.50	29
MICE - Lasso Regression - SMOTE-TOMEK	14	26	87	74	$ 57.50	29
MICE - Lasso Regression - ADASYN	15	36	83	74	$ 69.75	29
MICE - Lasso Regression - ROSE					$ -	29
MICE - Boruta SHAP - SMOTE					$ -	6
MICE - Forward Selection - SMOTE	12	29	86	73	$ 56.00	
MICE - Forward Selection - SMOTE-ENN	10	46	82	70	$ 68.50	
MICE - Forward Selection - SMOTE-TOMEK	14	27	86	71	$ 58.50	
MICE - Forward Selection - ADASYN	12	32	85	72	$ 59.00	
MICE - Forward Selection - ROSE	10	35	85	76	$ 57.50	

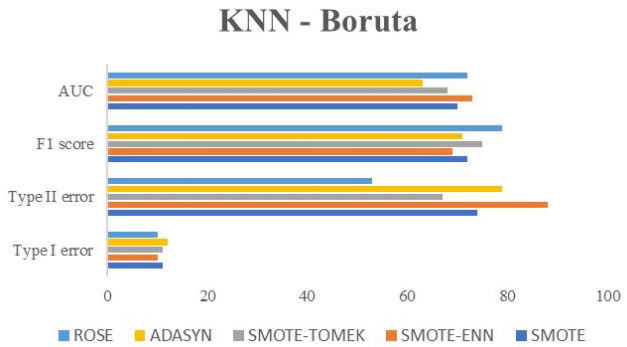
There is *no best feature selection method*. Instead, we have discovered what works best for the specific problems related to this Dataset using careful systematic experimentation/trial and error method. We tried a range of different models fit on different subsets of features chosen via different statistical measures and *discovered the ones works best*.

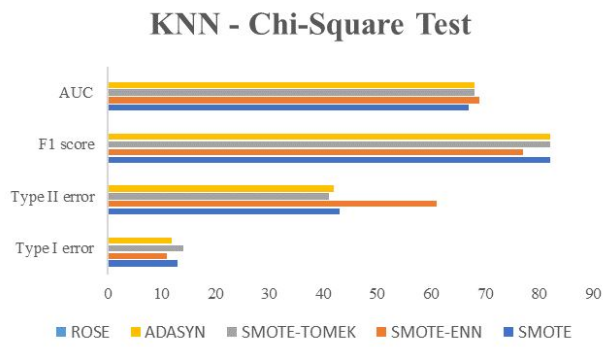
COMBINATIONS

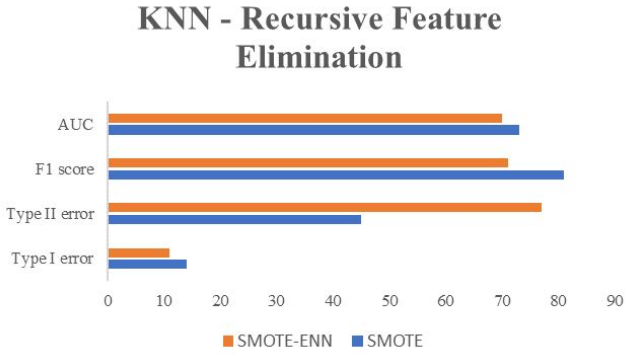
Missing Value Imputation	Feature Selection	Balancing
KNN imputation	Boruta	SMOTE-ENN
MICE imputation	Boruta SHAP	SMOTE
	Lasso Regression	ROSE
	Ridge Regression	ADASYN
	Chi-Square Test	SMOTE-TOMEK
	Recursive Feature Elimination (RFE)	
	Forward Selection	
	Logistic Regression	
	Random Forest	

1. Missing Value Imputation
2. Feature Selection
3. Balancing

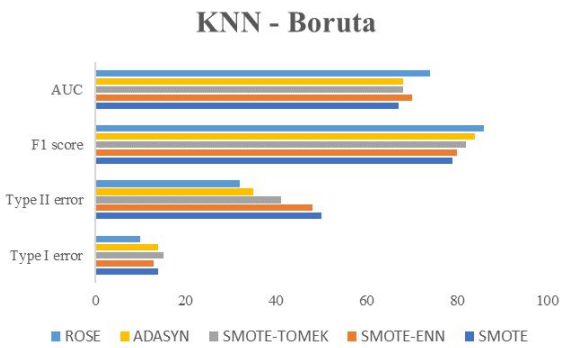
EVALUATION METRICS (KNN)

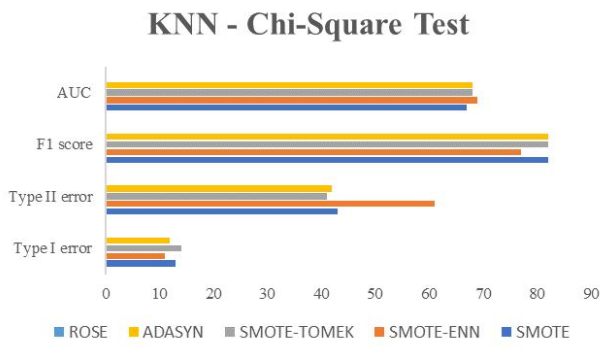


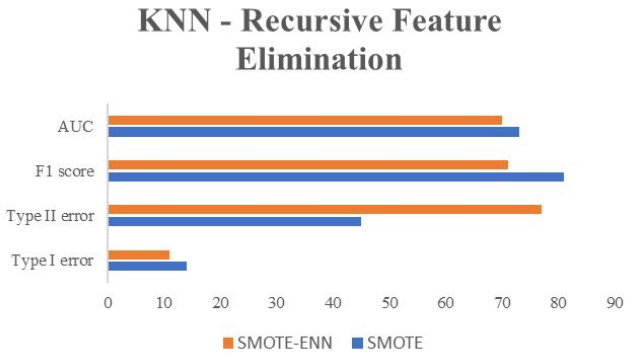




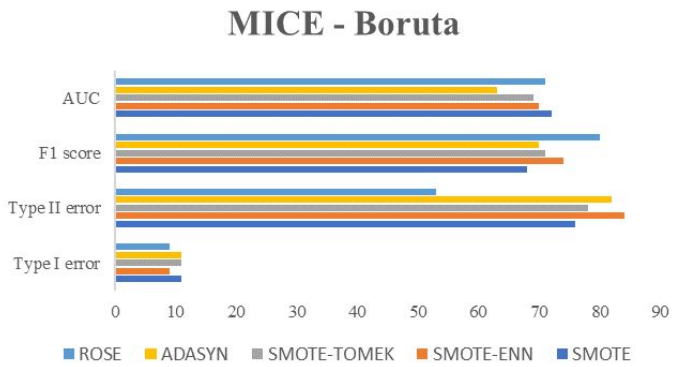
EVALUATION METRICS (KNN)

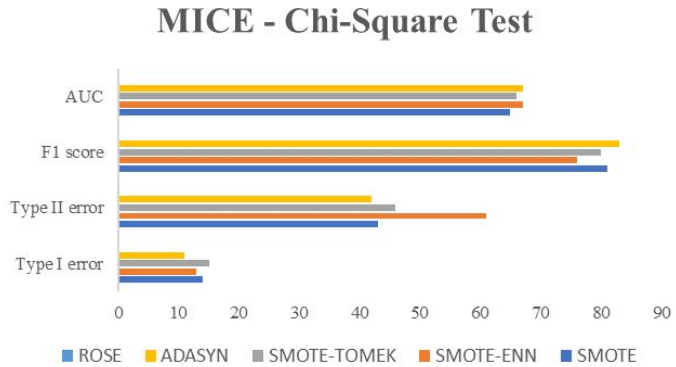


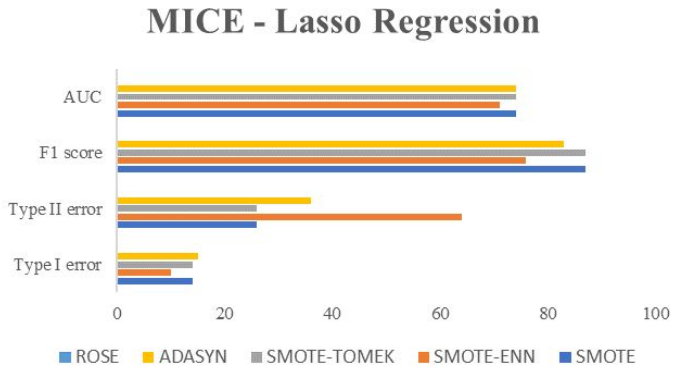


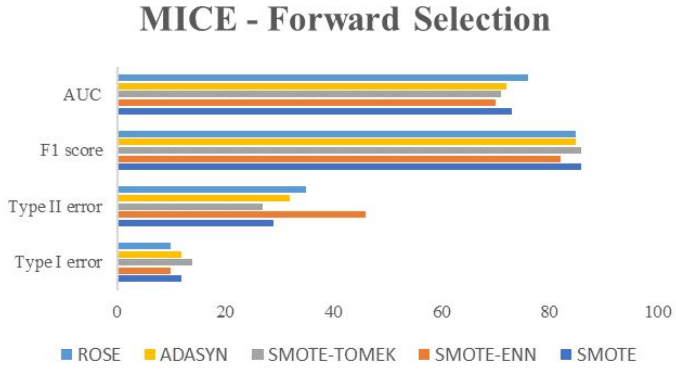


EVALUATION METRICS (MICE)







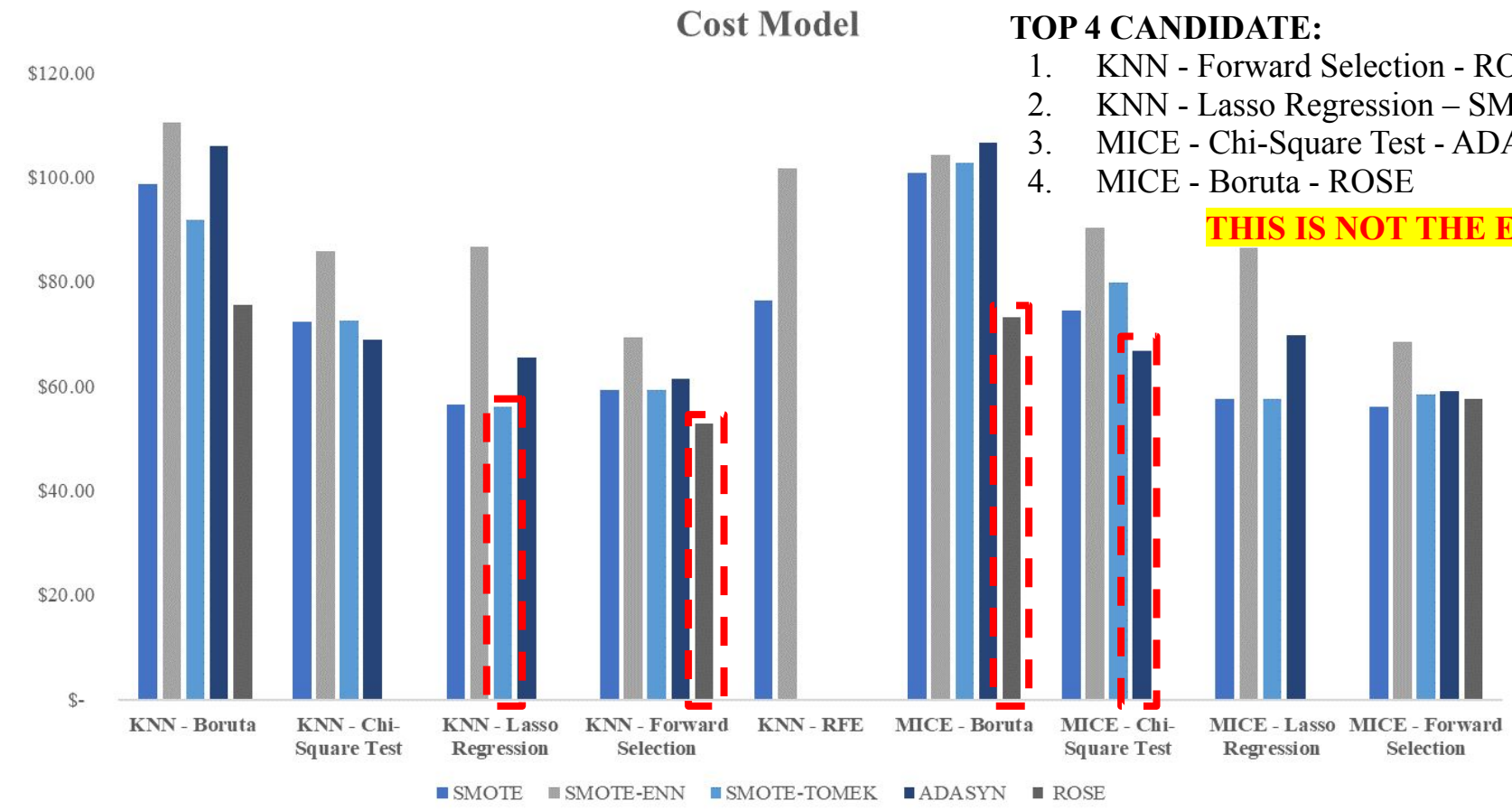


TRIAL RESULTS

Cost Model

	SMOTE	SMOTE-ENN	SMOTE-TOMEK	ADASYN	ROSE
KNN - Boruta	$98.75	$110.50	$91.75	$106.00	$75.50
KNN - Chi-Square Test	$72.25	$85.75	$72.50	$69.00	$0.00
KNN - Lasso Regression	$56.50	$86.75	$56.00	$65.50	$0.00
KNN - Forward Selection	$59.25	$69.25	$59.25	$61.50	$52.75
KNN - RFE	$76.50	$101.75			
MICE - Boruta	$100.75	$104.25	$102.75	$106.75	$73.25
MICE - Chi-Square Test	$74.50	$90.25	$79.75	$66.75	$0.00
MICE - Lasso Regression	$57.50	$86.50	$57.50	$69.75	$0.00
MICE - Forward Selection	$56.00	$68.50	$58.50	$59.00	$57.50

TRIAL RESULTS



TOP 4 CANDIDATE:

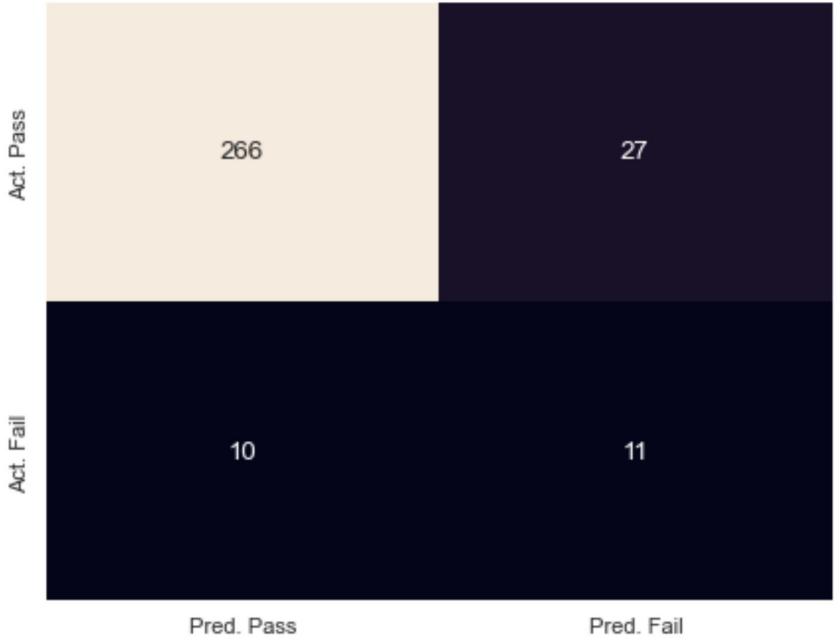
1. KNN - Forward Selection - ROSE
2. KNN - Lasso Regression – SMOTE-TOMEK
3. MICE - Chi-Square Test - ADASYN
4. MICE - Boruta - ROSE

THIS IS NOT THE END RESULTS

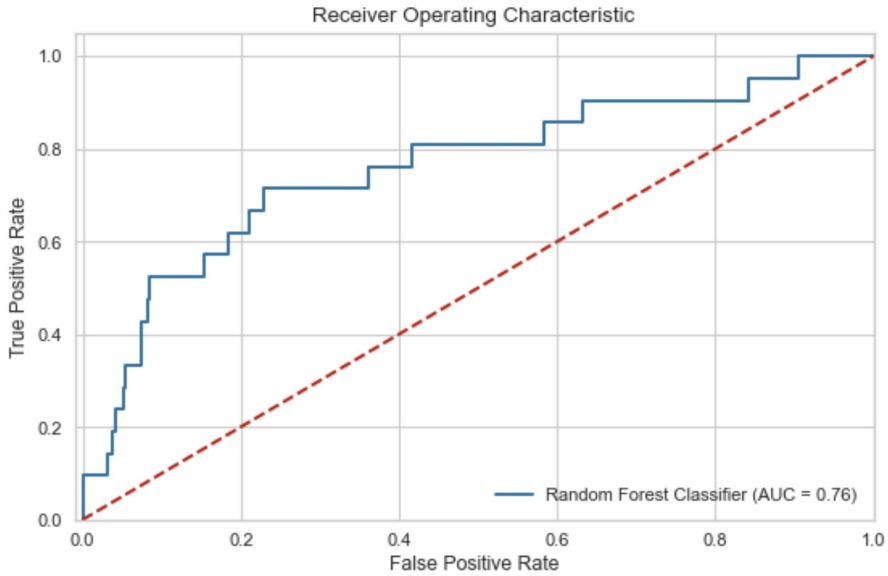
KNN + Forward Selection + ROSE

KNN - Forward Selection - ROSE

Confusion Matrix



AUC/ROC

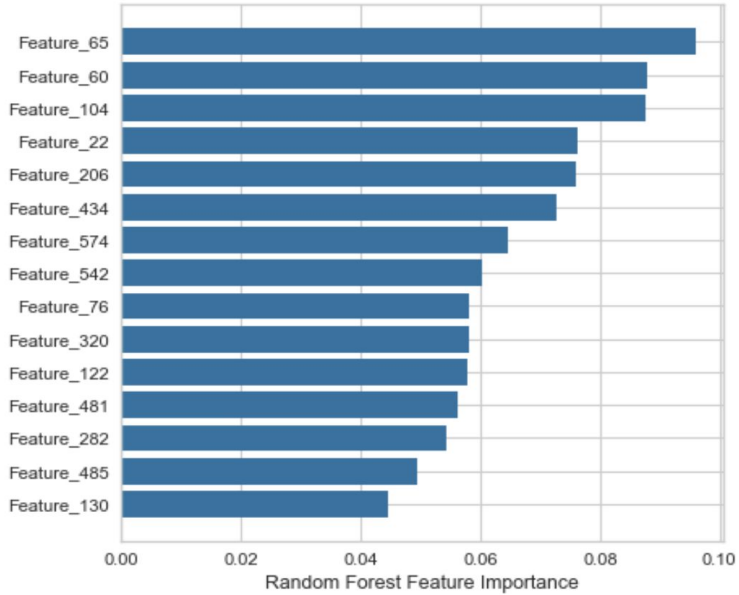


Total cost: $ 49,500

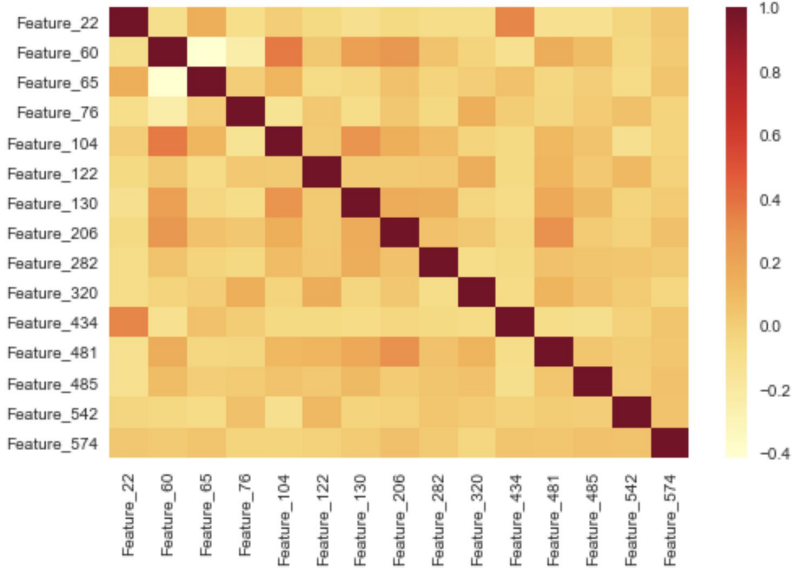
Number of remaining features:15

KNN - Forward Selection - ROSE

Feature Importance



Correlation between remaining features

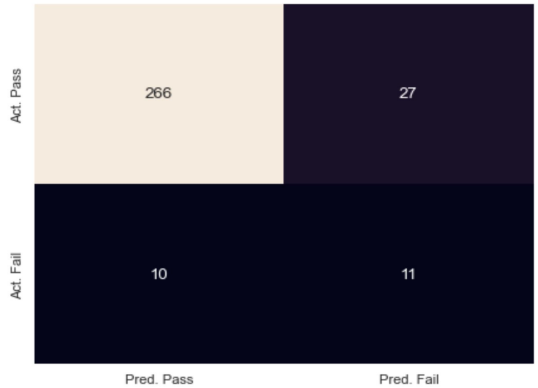


COMPARATIVE ANALYSIS

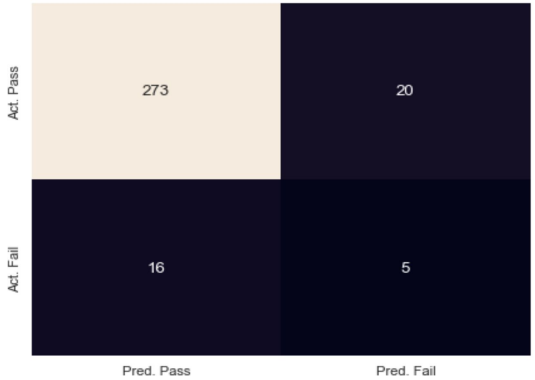
Master
Project Management
and Data Science

COMPARISON

KNN - Forward Selection - ROSE
$49,000; 15 Features



KNN - Lasso Regression – SMOTE-TOMEK
$56,000; 29 Features

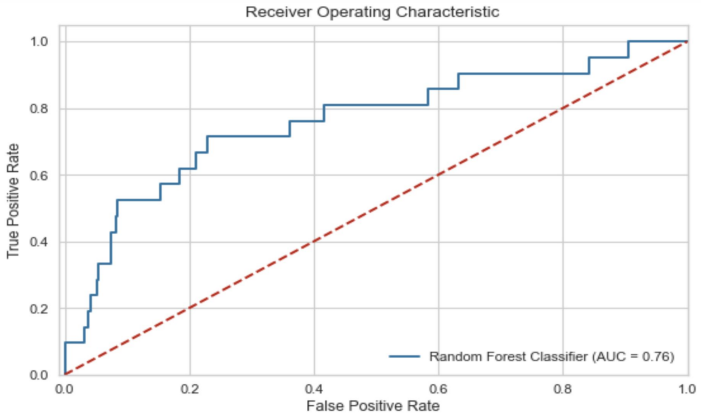


MICE - Boruta - ROSE
$72,500; 12 Features

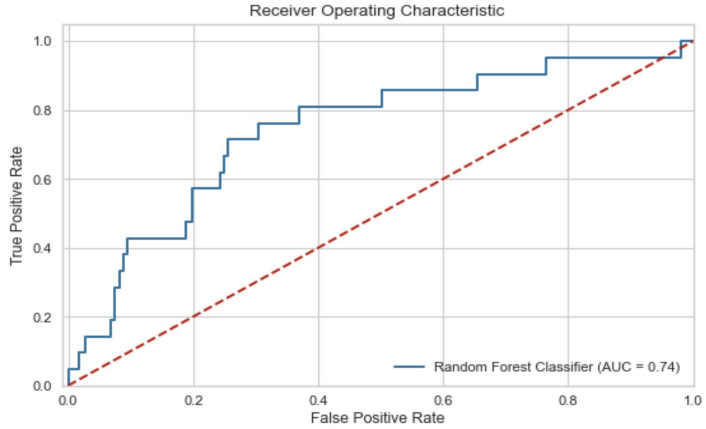
MICE - Chi-Square Test - ADASYN
$67,000; 29 Features

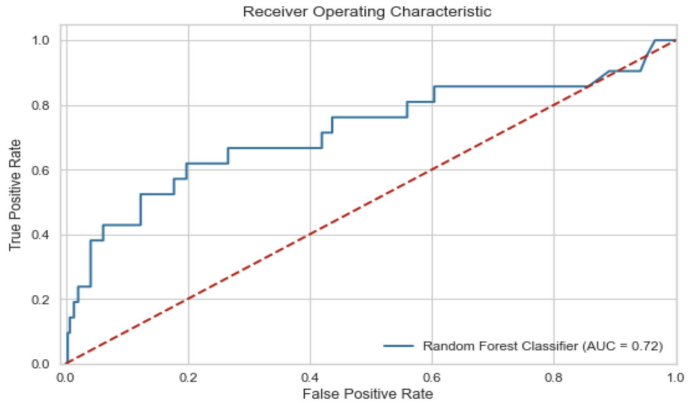
AUC/ROC

KNN - Forward Selection - ROSE

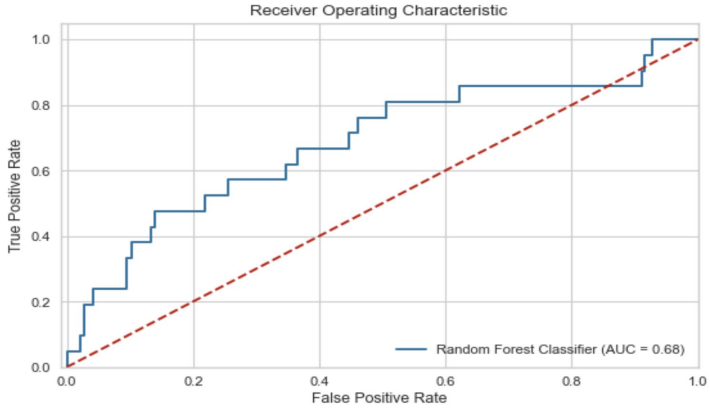


KNN - Lasso Regression – SMOTE-TOMEK





MICE - Boruta - ROSE

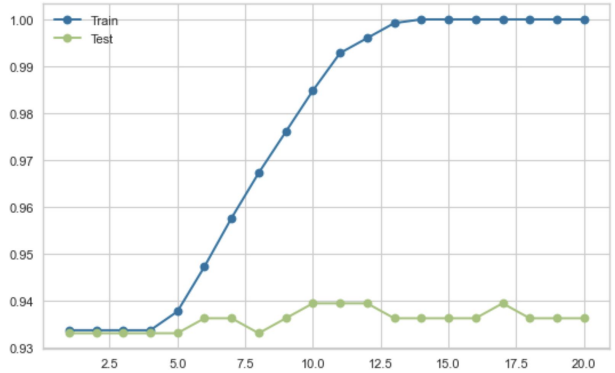


MICE - Chi-Square Test - ADASYN

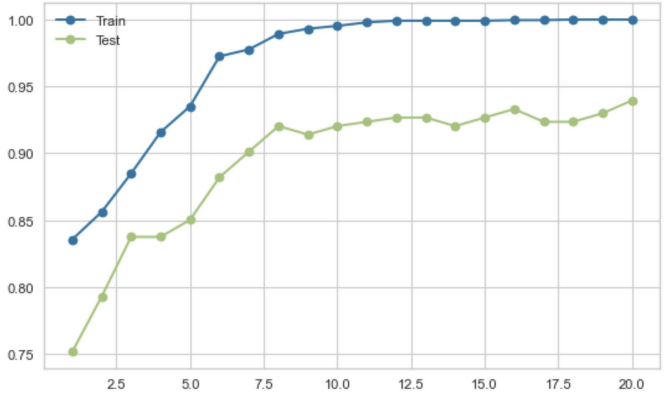
UNDERSTANDING MODELLING

OVERFITTING ANALYSIS

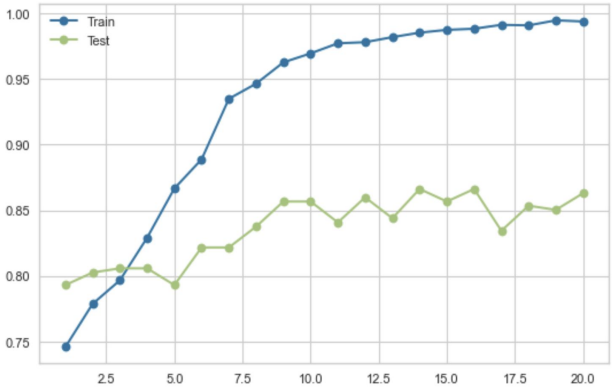
KNN - Forward Selection - ROSE



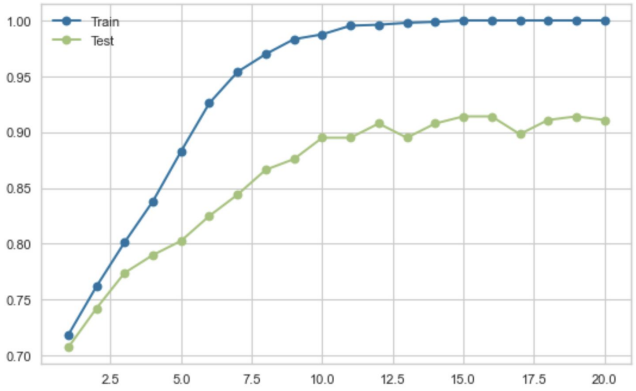
KNN - Lasso Regression – SMOTE-TOMEK



MICE - Boruta - ROSE



MICE - Chi-Square Test - ADASYN

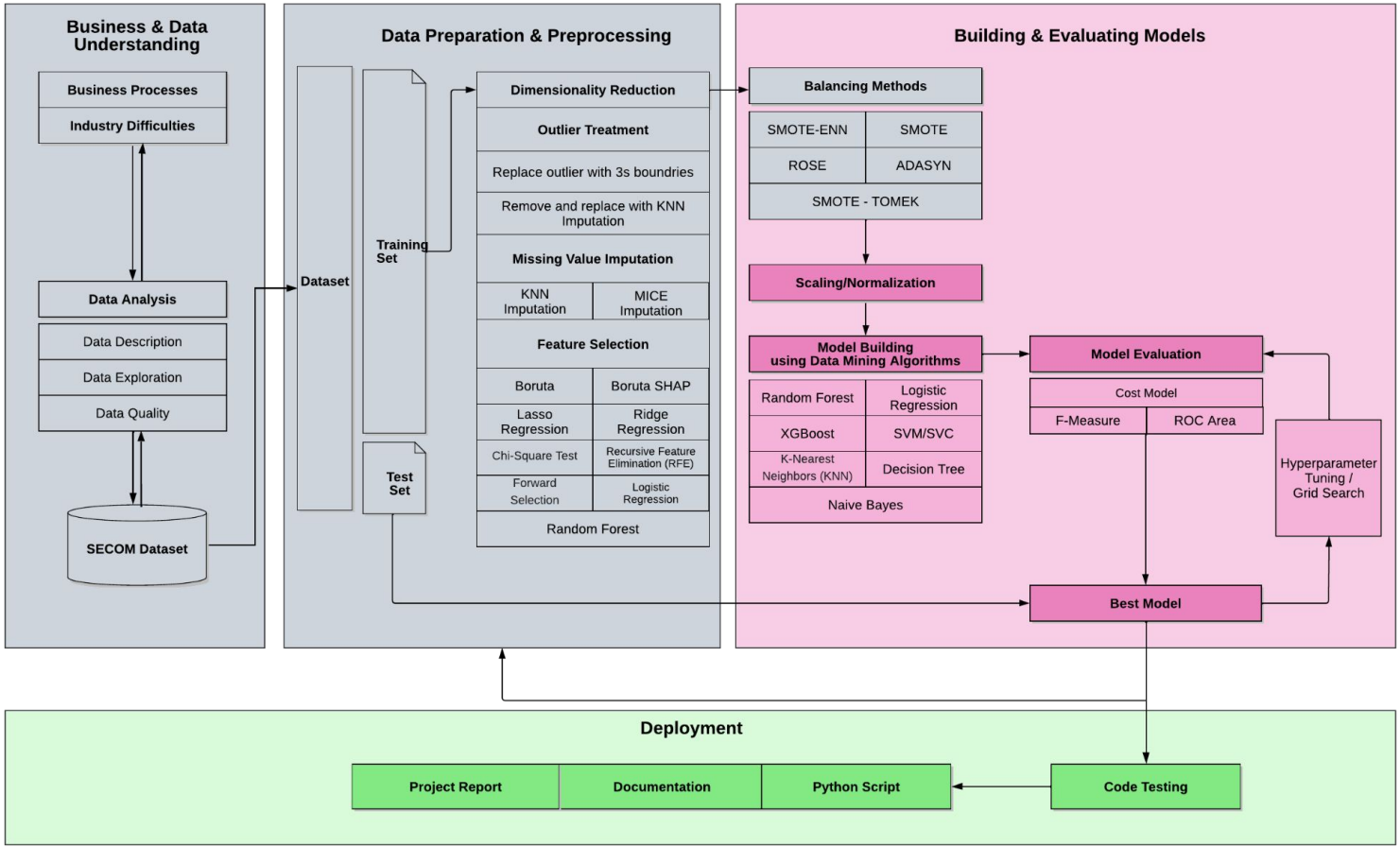


02

Next Steps

- Modeling
- Evaluation
- Deployment

Upcoming…


Business & Data Understanding
Business Processes
Industry Difficulties
Data Analysis
Data Description
Data Exploration
Data Quality
SECOM Dataset
Dataset
Data Preparation & Preprocessing
Training Set
Test Set
Dimensionality Reduction
Outlier Treatment
Replace outlier with 3s boundries
Remove and replace with KNN Imputation
Missing Value Imputation
KNN Imputation
MICE Imputation
Feature Selection
Boruta
Boruta SHAP
Lasso Regression
Ridge Regression
Chi-Square Test
Recursive Feature Elimination (RFE)
Forward Selection
Logistic Regression
Random Forest
Building & Evaluating Models
Balancing Methods
SMOTE-ENN
SMOTE
ROSE
ADASYN
SMOTE - TOMEK
Scaling/Normalization
Model Building using Data Mining Algorithms
Random Forest
Logistic Regression
XGBoost
SVM/SVC
K-Nearest Neighbors (KNN)
Decision Tree
Naive Bayes
Model Evaluation
Cost Model
F-Measure
ROC Area
Hyperparameter Tuning / Grid Search
Best Model
Deployment
Project Report
Documentation
Python Script
Code Testing

Master
Project Management
and Data Science

Vielen Dank!

Gupta, Himansha
Himansha.Gupta@student.htw-berlin.de

Pomay Polat, Ekin
Ekin.PomayPolat@student.htw-berlin.de

Dsouza, Rashmi Carol
Rashmi.Dsouza@Student.HTW-Berlin.de

Pham, Quynh Dinh Hai
Quynh.Pham@Student.HTW-Berlin.de

www.mpmd.htw-berlin.de

htw