

RSF3_G1_LingLiYa_19WMR11673

December 21, 2021

1 Script File for Final Online Assessment (FOA) Submission

1.1 BACS3013 Data Science

1.1.1 Academic Year 2021/2022

1.1.2 December Examination

It is an open-book e-assessment. You are allowed to refer to any practical notes/use cases/GitHub/Stack Overflow etc. Anyhow, you **MUST NOT** receive any help whatsoever from any other person. If you need any clarification, please directly ask the lecturer(s)-in-charge.

1.1.3 Please insert your details below:

- 1) Double click the cell below
- 2) Type your name and student id
- 3) press CTRL + Enter

Name: Ling Li Ya

Student ID: 19WMR11673

1.1.4 Step 1: Put the last three digits of your student id as the my_state_number

eg: if your id is 1902589

You should then write

my_state_number = 673

```
[ ]: # Replace 589 with the last three digits of your student id
      # and then press CTRL + Enter
      my_state_number = 673
```

1.1.5 Step 2: Read the insurance_dataset.csv

```
[ ]: import pandas as pd
      data = pd.read_csv("insurance_dataset.csv")

      data.head()
```

```
[ ]:      id  Gender  Age  Driving_License  Region_Code  Previously_Insured  \
0  167647    Male   22                1             7                1
1   17163    Male   42                1            28                0
2   32023  Female   66                1            33                0
3   87447  Female   22                1            33                0
4  501933    Male   28                1            46                1

      Vehicle_Age  Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Class
0    < 1 Year                No           2630                152      0
1    1-2 Year                Yes          43327                 26      0
2    1-2 Year                Yes          35841                124      0
3    < 1 Year                No           27645                152      0
4    < 1 Year                No           29023                152      0
```

1.1.6 Step 3: Sample the data randomly the data and save the dataframe as myData

```
[ ]: myData = data.sample(frac = .90, replace = False, random_state = my_state_number)
myData.head()
```

```
[ ]:      id  Gender  Age  Driving_License  Region_Code  Previously_Insured  \
110688  443895  Female   41                1            28                1
345988  403072    Male   25                1            15                1
209585  455581    Male   26                1            29                1
71693   197354  Female   25                1            21                1
186827  200148  Female   25                1            41                0

      Vehicle_Age  Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Class
110688    1-2 Year                No           48034                 26      0
345988    < 1 Year                No           43901                152      0
209585    < 1 Year                No           26479                152      0
71693     < 1 Year                No           30846                152      0
186827    < 1 Year                Yes           37267                152      1
```

1.1.7 Step 4: Start the Analytics using myData dataframe as the raw data

Note: Your *myData* dataframe may be different from other students' *myData* dataframe

2 Import Dependencies

Importing all libraries to be used. This project will follow the CRISP-DM standard.

```
[ ]: # start your codes

# Import libraries
import pandas as pd
import numpy as np
import seaborn as sns
```

```

import matplotlib.pyplot as plt
import graphviz
import warnings

# Import data processors
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import OneHotEncoder
from sklearn.preprocessing import MinMaxScaler

# Import miscellaneous
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV

# Import models
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier, export_graphviz
from sklearn.svm import SVC

# Import metrics
from sklearn.metrics import accuracy_score, confusion_matrix, \
    classification_report, ConfusionMatrixDisplay

```

```

[ ]: # Filter warnings

warnings.filterwarnings('ignore')

```

3 Business Understanding

The business objective of this project comes from an insurance company that is seeking to provide vehicle insurance to its customers. The company wants to build a model to **predict whether its customers are interested in purchasing vehicle insurance** so that its business models and revenue can be optimised. This is a classification problem as the model needs to predict whether the customer falls in the class of interested or not interested. It has provided an insurance dataset.

4 Data Understanding

Understanding more about the dataset.

4.1 Data Shape

```
[ ]: myData.shape
```

```
[ ]: (343939, 11)
```

The dataset contains 343939 rows of data and 11 columns of data.

4.2 Data Information

```
[ ]: myData.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 343939 entries, 110688 to 201511
Data columns (total 11 columns):
#   Column                Non-Null Count  Dtype
---  -
0   id                    343939 non-null  int64
1   Gender                343939 non-null  object
2   Age                   343939 non-null  int64
3   Driving_License       343939 non-null  int64
4   Region_Code           343939 non-null  int64
5   Previously_Insured    343939 non-null  int64
6   Vehicle_Age           343939 non-null  object
7   Vehicle_Damage        343939 non-null  object
8   Annual_Premium        343939 non-null  int64
9   Policy_Sales_Channel  343939 non-null  int64
10  Class                 343939 non-null  int64
dtypes: int64(8), object(3)
memory usage: 31.5+ MB
```

As seen above, there are 10 features in total and 1 target variable **Class**. 8 of the columns are of **int64** type except for **Gender**, **Vehicle_Age** and **Vehicle_Damage** that are of the **object** type. This means that data encoding will be required. It can be known that the dataset does not have any missing values as all columns show a count of 343939.

4.3 Nature of Data

```
[ ]: myData.head(n=10) # First ten rows
```

```
[ ]:
      id  Gender  Age  Driving_License  Region_Code  Previously_Insured  \
110688  443895  Female   41             1           28                1
345988  403072   Male   25             1           15                1
209585  455581   Male   26             1           29                1
71693   197354  Female   25             1           21                1
186827  200148  Female   25             1           41                0
195331  186692  Female   38             1           28                0
273733   94547   Male   24             1           29                1
252641  451537   Male   47             1            8                0
223199   4502   Male   44             1           25                1
168308  360846   Male   26             1           18                0
```

```
      Vehicle_Age  Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Class
110688    1-2 Year             No           48034                26      0
345988    < 1 Year             No           43901                152      0
209585    < 1 Year             No           26479                152      0
```

71693	< 1 Year	No	30846	152	0
186827	< 1 Year	Yes	37267	152	1
195331	1-2 Year	Yes	41403	26	0
273733	< 1 Year	No	34647	152	0
252641	1-2 Year	Yes	40485	26	1
223199	1-2 Year	No	2630	124	0
168308	1-2 Year	Yes	2630	157	0

```
[ ]: myData.tail(n=10) # Last ten rows
```

```
[ ]:
      id  Gender  Age  Driving_License  Region_Code  Previously_Insured  \
329934  372445   Male   62              0           28              0
321536   9354   Male   25              1           30              0
152073  326497  Female   22              1           12              1
243087  287467  Female   41              1           28              0
366143  101419   Male   43              1           43              0
95808   95372   Male   48              1           28              0
359198  159910  Female   44              1           30              0
152600   46401   Male   33              1           38              0
368483  173024   Male   20              1           39              0
201511   36183   Male   50              1            8              1
```

	Vehicle_Age	Vehicle_Damage	Annual_Premium	Policy_Sales_Channel	Class
329934	1-2 Year	Yes	49354	26	0
321536	< 1 Year	Yes	30914	152	0
152073	< 1 Year	No	36858	152	0
243087	1-2 Year	Yes	34938	26	0
366143	1-2 Year	Yes	36639	124	0
95808	1-2 Year	Yes	2630	157	0
359198	1-2 Year	Yes	21679	124	0
152600	1-2 Year	Yes	30811	26	0
368483	< 1 Year	Yes	2630	160	0
201511	1-2 Year	No	55830	26	0

From the tables above, it is known that `id` is the customer insurance ID. `Gender`, `Driving_License`, `Region_Code`, `Previously_Insured`, `Vehicle_Age`, `Vehicle_Damage`, `Policy_Sales_Channel` and `Class` are all categorical variables (some are nominal and some are ordinal), whereas the `Annual_Premium` is a numerical variable. Other than that, `Driving_License`, `Previously_Insured`, `Vehicle_Damage` and `Class` are binary variables.

```
[ ]: # Drop ID
myNewData = myData.drop(columns='id')

# Separate different data
cat_data = (myNewData.drop(columns='Annual_Premium')).columns.values
num_data = (myNewData[['Annual_Premium']]).columns.values
```

```
[ ]: print('Categorical:', cat_data)
      print('Numerical:', num_data)
```

```
Categorical: ['Gender' 'Age' 'Driving_License' 'Region_Code'
'Previously_Insured'
'Vehicle_Age' 'Vehicle_Damage' 'Policy_Sales_Channel' 'Class']
Numerical: ['Annual_Premium']
```

The id is dropped before any data analysis is conducted because it is just a random number assigned to each customer and does not offer any real meaning. The remaining columns are separated into two groups.

4.4 Data Description

```
[ ]: myNewData.describe()
```

```
[ ]:
count      Age  Driving_License  Region_Code  Previously_Insured  \
count  343939.000000  343939.000000  343939.000000  343939.000000
mean    38.545201      0.998148      26.409323      0.488822
std     15.227192      0.042996      13.180893      0.499876
min     20.000000      0.000000      0.000000      0.000000
25%     25.000000      1.000000      15.000000      0.000000
50%     36.000000      1.000000      28.000000      0.000000
75%     49.000000      1.000000      35.000000      1.000000
max     85.000000      1.000000      52.000000      1.000000

count      Annual_Premium  Policy_Sales_Channel  Class
count  343939.000000  343939.000000  343939.000000
mean    30709.409381      111.958865      0.163924
std     17047.113579      54.275860      0.370208
min     2630.000000      1.000000      0.000000
25%     24546.000000      26.000000      0.000000
50%     31693.000000      145.000000      0.000000
75%     39442.500000      152.000000      0.000000
max     540165.000000      163.000000      1.000000
```

5 Data Exploration

The statistics above describe the dataset. It can be known the values of the dataset are spread across a large range. For example, **Annual_Premium** has a range of 2630 to 540165, but **Driving_License** has a range of only 0-1. The range is too different and might affect certain models such as KNN. These data values need to be scaled for better model accuracy.

5.1 Data Distribution

Exploring the dataset's general distribution pattern.

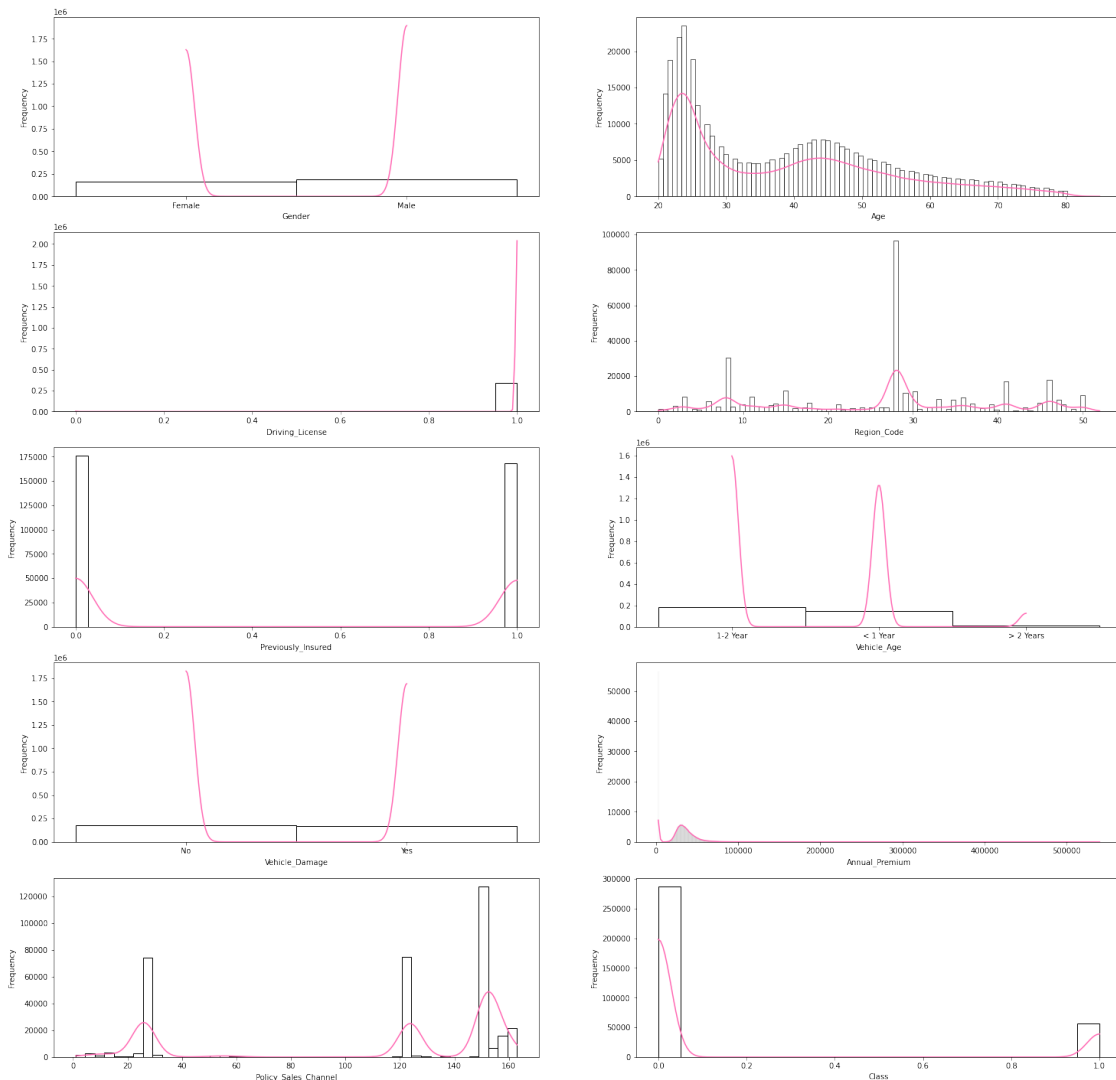
```
[ ]: # Get all column values
cols = list(myNewData.columns.values)

# Plot graph
fig, ax = plt.subplots(5, 2, figsize=(25,25))
fig.suptitle('Distribution of Dataset')

ax = ax.flatten() # ax is flattened from a 2D array to a 1D array

for i in range(len(cols)):
    sns.histplot(data=myNewData, ax=ax[i], x=cols[i], kde=True,
        color='hotpink', alpha=0)
    ax[i].set(xlabel=cols[i], ylabel='Frequency')
```

Distribution of Dataset



As shown from the graph above:

1. There are about the same number of female and male insurance customers. The gender distribution is about equal, with male customers slightly higher than female applicants.
2. Most insurance customers are around 20-30 years old. The Age variable follows a right-skewed bell distribution curve.
3. Most, if not nearly all, of the insurance customers have a driving license.
4. Most of the insurance customers come from the region with a code around 28.
5. There are slightly more customers who have not been previously insured.
6. Most customers own a vehicle of age between 1-2 years, closely followed by lesser than 1 year.
7. Almost the same number of customers has either experienced or did not experience vehicle damage before.
8. Most customers pay an annual premium between 2600 to 1000000.
9. Most of the customers come from a policy sales channel of around 150, around 30 and around 120.
10. Around 9/10 of the customers are not interested in a vehicle insurance.

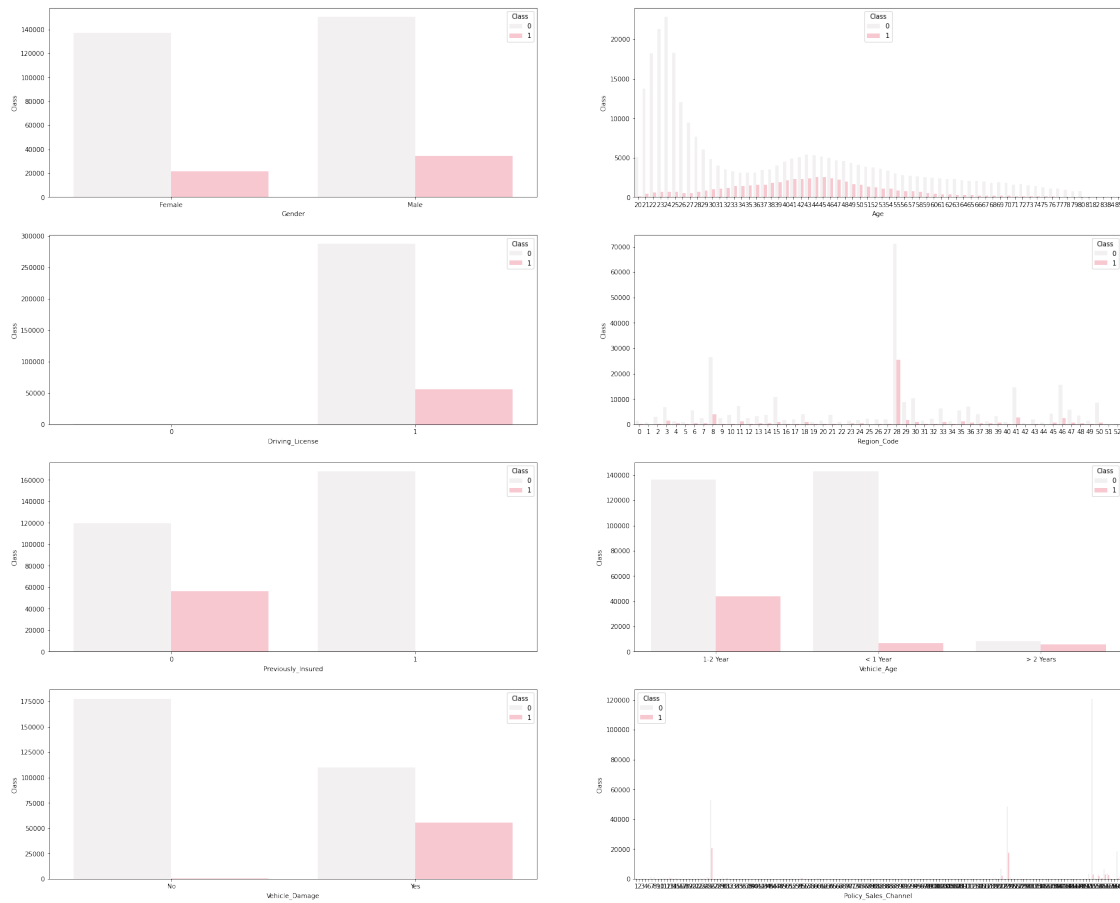
5.1.1 Categorical Data Analysis

Analysing categorical variables. Exploring the relationships between the features and the target variable (Class).

```
[ ]: fig, ax = plt.subplots(4, 2, figsize=(30,25))
fig.suptitle('Categorical Data Analysis')

ax = ax.flatten()

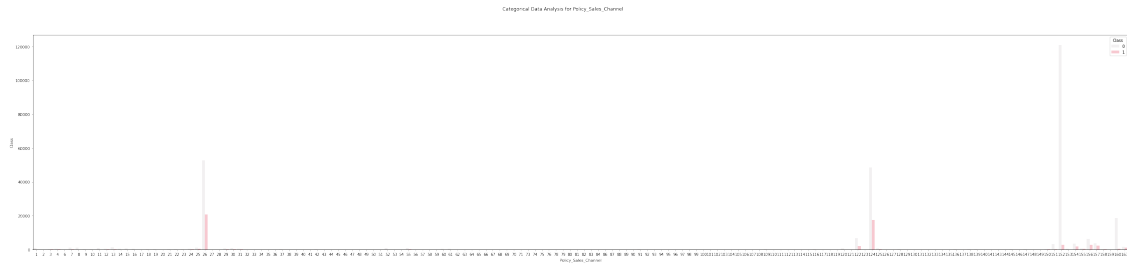
for i, v in enumerate(cat_data):
    if(v == 'Class'):
        continue
    sns.countplot(data=myNewData, ax=ax[i], x=v, hue='Class', color='pink',
    ↪alpha=1)
    ax[i].set(xlabel=v, ylabel='Class')
```

```
[ ]: # Can't see clearly so replot
fig, ax = plt.subplots(1, 1, figsize=(50,10))
fig.suptitle('Categorical Data Analysis for Policy_Sales_Channel')

sns.countplot(data=myNewData, ax=ax, x='Policy_Sales_Channel', hue='Class',
              color='pink', alpha=1)
ax.set(xlabel='Policy_Sales_Channel', ylabel='Class')
```

```
[ ]: [Text(0.5, 0, 'Policy_Sales_Channel'), Text(0, 0.5, 'Class')]
```



From the graphs above, it is known that

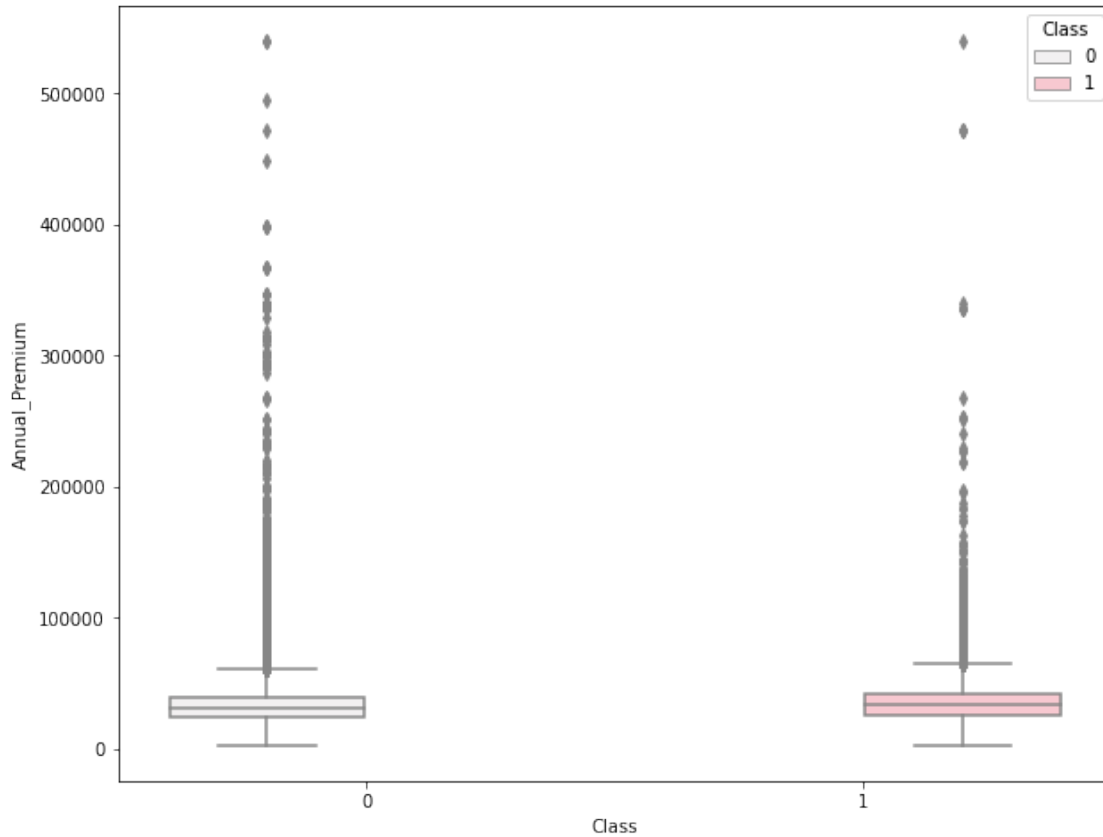
1. Around 140000 female and 140000 male customers are not interested in vehicle insurance. Generally, the effects of gender are not obvious.
2. Almost half of the customers aged between 40 - 50 generally are interested in vehicle insurance. It could be due to customers of other age groups might not have a car, especially for people aged between 20 - 30. Perhaps people older than 70 no longer use a car due to health and safety reasons.
3. Generally, around 300000 customers with driving license are not interested in vehicle insurance.
4. Generally, the region of customers does not have an effect on their interest, as most of them are not interested.
5. Almost all previously insured customers are not interested in vehicle insurance. Maybe it is because their insurance period is still in effect. However, around half of the customers who have not been insured previously are interested in vehicle insurance. This variable has a strong effect on interest.
6. More customers who have a car between 1 -2 years of age are interested in vehicle insurance. This variable has an influence on interest.
7. Almost all customers who have never encouraged a vehicle damage before are not interested in vehicle insurance, whereas about half of the customers who have experienced vehicle damage are interested in vehicle insurance. This variable has a strong effect on interest. It also makes sense as customers who have experienced damage might understand the costs of it better, and would therefore like to protect their car.
8. Generally, about half of the customers from policy 26 and 124 are interested in vehicle insurance. Maybe it is because their policy does not cover vehicle damage.

5.1.2 Numerical Data Analysis

Analysing numerical variables.

```
[ ]: fig, ax = plt.subplots(1, 1, figsize=(10,8))

for i, v in enumerate(num_data):
    if(v == 'LoanStatus'):
        continue
    sns.boxplot(data=myNewData, ax=ax, x='Class', y=v, hue='Class',
    ↪color='pink')
    ax.set(xlabel='Class', ylabel=v)
```



It seems that **Annual_Premium** does not have a significant relationship to **Class** as the boxes of 0 and 1 do not have a significant difference between them. The boxplot is constructed based on the interquartile range score (IQR), and anything below $1/5$ IQR below Q1 or more than 1.5 IQR above Q3 are considered as outliers. However, **Annual_Premium** would only have natural outliers, which means these outliers are not a result of measurement error. Non-natural outliers are outliers resulted by measurement error, such as a measurement for the temperature. Hence, these natural outliers should not be dropped as they can reflect the true conditions of the company sales. Therefore, there will not be dropping of outliers.

6 Data Preprocessing

6.1 Null Value Check

Checking for missing values.

```
[ ]: myNewData.isnull().sum()
```

```
[ ]: Gender          0
      Age            0
      Driving_License 0
      Region_Code     0
```

```

Previously_Insured      0
Vehicle_Age             0
Vehicle_Damage          0
Annual_Premium          0
Policy_Sales_Channel    0
Class                   0
dtype: int64

```

As stated previously, there is no missing values in this dataset, so no further processing will be needed.

6.2 Data Encoding

Changing words to numbers because the computer can only understand numbers.

6.2.1 Label Encoding

This approach is to give a label to the string data. In this project, label encoding is be used for binary features that are of the `object` type, which are `Gender` and `Vehicle_Damage`. These feature columns are renamed in such a way that **0 is false and 1 is true** for the column to replicate the effect of one-hot encoding. The reason of not directly applying one-hot encoding to these columns is because it is quite redundant to do so, since the columns are already binary and very close to the form of one-hot encoding.

```

[ ]: # Define features to be processed with label encoding
label_data = ['Gender', 'Vehicle_Damage']

# Instantiate encoder
label_encoder = LabelEncoder()

# Process columns
for _, v in enumerate(label_data):
    myNewData[v] = label_encoder.fit_transform(myNewData[v])

# Rename feature for easier understanding
myNewData2 = myNewData.rename(columns={'Gender': 'Male'}) # Vehicle_Damage is_
↳ already a good name
myNewData2

```

```

[ ]:
   Male  Age  Driving_License  Region_Code  Previously_Insured  \
110688   0   41              1           28                1
345988   1   25              1           15                1
209585   1   26              1           29                1
71693    0   25              1           21                1
186827   0   25              1           41                0
...     ...   ...           ...           ...                ...
95808    1   48              1           28                0
359198   0   44              1           30                0

```

152600	1	33	1	38	0
368483	1	20	1	39	0
201511	1	50	1	8	1

	Vehicle_Age	Vehicle_Damage	Annual_Premium	Policy_Sales_Channel	\
110688	1-2 Year	0	48034		26
345988	< 1 Year	0	43901		152
209585	< 1 Year	0	26479		152
71693	< 1 Year	0	30846		152
186827	< 1 Year	1	37267		152
...	
95808	1-2 Year	1	2630		157
359198	1-2 Year	1	21679		124
152600	1-2 Year	1	30811		26
368483	< 1 Year	1	2630		160
201511	1-2 Year	0	55830		26

	Class
110688	0
345988	0
209585	0
71693	0
186827	1
...	...
95808	0
359198	0
152600	0
368483	0
201511	0

[343939 rows x 10 columns]

6.2.2 One-Hot Encoding

The `Vehicle_Age` feature will be encoded using one-hot encoding. This means that each unique data will be a new binary feature. This is to avoid biasness in models such as KNN that might rank a nominal data. Since each unique value in the column will be transformed into a new feature, **one feature can be dropped because if all other related features are false**, the value must be the last feature. Hence, to avoid multicollinearity and redundancy, the `drop='first'` parameter is used to remove the first column of the categories.

```
[ ]: # Define columns to be processed
onehot_data = ['Vehicle_Age']

myNewData3 = myNewData2

# Instantiate encoder
```

```

onehot_encoder = OneHotEncoder(sparse=False, drop='first')

# Process columns
for _, v in enumerate(onehot_data):
    tmp = onehot_encoder.fit_transform(np.reshape(myNewData2[v].values, (-1, 1)))

    # Join returned array to dataframe
    categories = onehot_encoder.categories_[0][1:]
    myNewData3[categories] = tmp

    # Drop the original feature
    myNewData3 = myNewData3.drop(columns=[v])

    # Rename new derived features fpr easier processing
    for _, w in enumerate(categories):
        myNewData3 = myNewData3.rename(columns={w: v + "_" + w})

myNewData3

```

```

[ ]:
      Male  Age  Driving_License  Region_Code  Previously_Insured  \
110688    0   41                1           28                   1
345988    1   25                1           15                   1
209585    1   26                1           29                   1
71693     0   25                1           21                   1
186827    0   25                1           41                   0
...      ...  ...                ...         ...                   ...
95808     1   48                1           28                   0
359198    0   44                1           30                   0
152600    1   33                1           38                   0
368483    1   20                1           39                   0
201511    1   50                1            8                   1

      Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Class  \
110688              0           48034                26      0
345988              0           43901               152      0
209585              0           26479               152      0
71693               0           30846               152      0
186827              1           37267               152      1
...              ...                ...         ...         ...
95808              1           2630                157      0
359198              1           21679               124      0
152600              1           30811                26      0
368483              1           2630               160      0
201511              0           55830                26      0

```

Vehicle_Age_< 1 Year Vehicle_Age_> 2 Years

110688	0.0	0.0
345988	1.0	0.0
209585	1.0	0.0
71693	1.0	0.0
186827	1.0	0.0
...
95808	0.0	0.0
359198	0.0	0.0
152600	0.0	0.0
368483	1.0	0.0
201511	0.0	0.0

[343939 rows x 11 columns]

```
[ ]: myNewData3.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 343939 entries, 110688 to 201511
Data columns (total 11 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Male                  343939 non-null  int64
1   Age                   343939 non-null  int64
2   Driving_License       343939 non-null  int64
3   Region_Code           343939 non-null  int64
4   Previously_Insured    343939 non-null  int64
5   Vehicle_Damage        343939 non-null  int64
6   Annual_Premium        343939 non-null  int64
7   Policy_Sales_Channel  343939 non-null  int64
8   Class                 343939 non-null  int64
9   Vehicle_Age_< 1 Year  343939 non-null  float64
10  Vehicle_Age_> 2 Years 343939 non-null  float64
dtypes: float64(2), int64(9)
memory usage: 39.6 MB
```

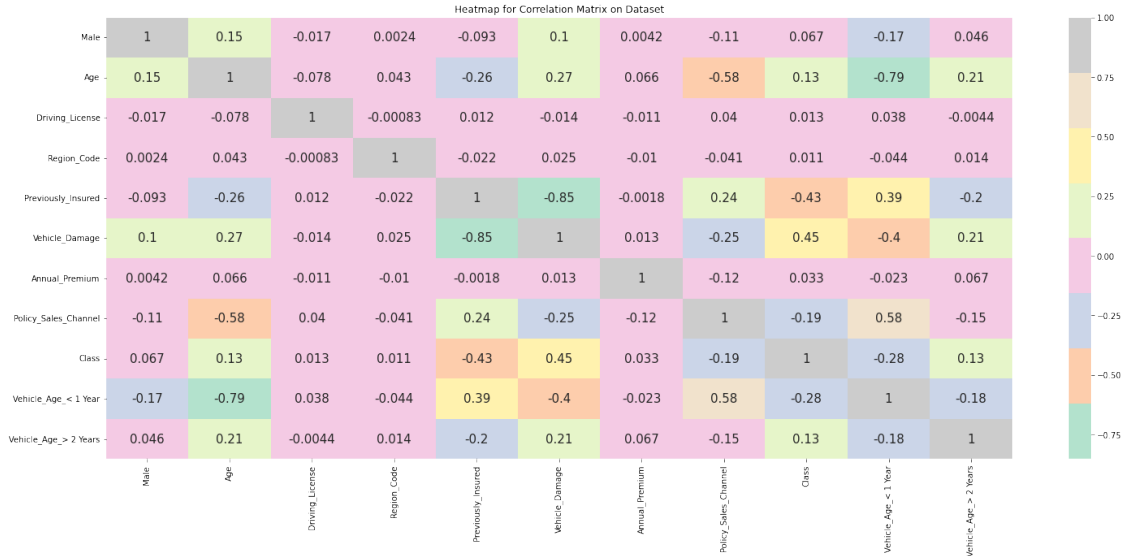
After encoding, all of the data is in numbers.

6.3 Column Dropping

Dropping columns to avoid multicollinearity. Multicollinearity is when two or more features are highly correlated with one another. This effect might reduce the reliability in determining the effect of each independent feature on the target variable (**Class**), making it hard to interpret the model. A correlation matrix is computed and a heatmap is used to visualise the results.

```
[ ]: plt.figure(figsize=(25, 10))
plt.title('Heatmap for Correlation Matrix on Dataset')
cor = myNewData3.corr()
sns.heatmap(cor, cmap='Pastel2', annot=True, annot_kws={'size': 15})
```

```
[ ]: <AxesSubplot:title={'center':'Heatmap for Correlation Matrix on Dataset'}>
```



From the heatmap, it is known that **Previously_Insured**, **Vehicle_Damage** and **Vehicle_Age** derived features have a higher correlation to the **Class** target. To avoid overfitting, only these features with a correlation higher than or equal to absolute 0.1 will be used to train the models.

```
[ ]: # Get the correlation of the feature with the target variable
cor_target = abs(cor['Class'])

# Select highly correlated features
relevant_features = cor_target[cor_target >= 0.1]
relevant_features
```

```
[ ]: Age                0.133641
Previously_Insured      0.431100
Vehicle_Damage          0.448492
Policy_Sales_Channel    0.185005
Class                   1.000000
Vehicle_Age_< 1 Year     0.280885
Vehicle_Age_> 2 Years   0.132574
Name: Class, dtype: float64
```

Only the features above are selected to train the model.

```
[ ]: # Convert to dataframe
cor_df = pd.DataFrame(relevant_features)

# Transpose columns and rows
cor_df = cor_df.T
```



```
relevant_features = cor_df.columns.values

myNewData4 = myNewData3[relevant_features]
myNewData4
```

```
[ ]:      Age  Previously_Insured  Vehicle_Damage  Policy_Sales_Channel  Class  \
110688   41                   1                0                26        0
345988   25                   1                0               152        0
209585   26                   1                0               152        0
71693    25                   1                0               152        0
186827   25                   0                1               152        1
...     ...                   ...              ...              ...      ...
95808    48                   0                1               157        0
359198   44                   0                1               124        0
152600   33                   0                1                26        0
368483   20                   0                1               160        0
201511   50                   1                0                26        0
```

```
      Vehicle_Age_< 1 Year  Vehicle_Age_> 2 Years
110688                   0.0                   0.0
345988                   1.0                   0.0
209585                   1.0                   0.0
71693                    1.0                   0.0
186827                   1.0                   0.0
...                       ...                   ...
95808                    0.0                   0.0
359198                   0.0                   0.0
152600                   0.0                   0.0
368483                   1.0                   0.0
201511                   0.0                   0.0
```

[343939 rows x 7 columns]

```
[ ]: # Rename df
df = myNewData4
```

```
[ ]: df.describe()
```

```
[ ]:      Age  Previously_Insured  Vehicle_Damage  \
count  343939.000000      343939.000000      343939.000000
mean    38.545201          0.488822          0.480879
std     15.227192          0.499876          0.499635
min     20.000000          0.000000          0.000000
25%     25.000000          0.000000          0.000000
50%     36.000000          0.000000          0.000000
75%     49.000000          1.000000          1.000000
max     85.000000          1.000000          1.000000
```

	Policy_Sales_Channel	Class	Vehicle_Age_< 1 Year \
count	343939.000000	343939.000000	343939.000000
mean	111.958865	0.163924	0.435353
std	54.275860	0.370208	0.495804
min	1.000000	0.000000	0.000000
25%	26.000000	0.000000	0.000000
50%	145.000000	0.000000	0.000000
75%	152.000000	0.000000	1.000000
max	163.000000	1.000000	1.000000

	Vehicle_Age_> 2 Years
count	343939.000000
mean	0.041033
std	0.198368
min	0.000000
25%	0.000000
50%	0.000000
75%	0.000000
max	1.000000

6.4 Data Splitting

Splitting of features and target label. The dataset has already been randomised earlier on. Split dataset into training and test sets using the 70:30 ratio for training:testing. Due to computer resources constraint, only 5000 records will be used.

```
[ ]: X_df = df.drop('Class', axis=1)
X_df = X_df[:5000]
y_df = df['Class']
y_df = y_df[:5000]

# Split 70:30 ratio
X_train, X_test, y_train, y_test = train_test_split(X_df, y_df, test_size = 0.3)
```

6.5 Data Scaling

As per the Data Description section, data scaling is much needed for this dataset. Algorithms based on gradient descent such as **linear regression** and **neural network** perform better with scaled data because the data values will affect the step size of the gradient descent. The gradient descent will converge more quickly towards the minima when using data on a similar scale. Distance-based algorithms such as **KNN** and **SVM** are most affected by the range of data values as they calculate the distances between data points to find the similarity. The algorithms will stress more on features with data of a higher value, causing the model to be biased. **Tree-based algorithms** are quite insensitive to the data scales because the tree splits on a feature without taking other features into consideration.

6.5.1 Normalisation

There are two main scaling techniques, that are **normalisation** and **standardisation**. Normalisation will transform all values to fit in the range of 0 and 1, also known as min-max scaling. Standardisation turns the mean value into 0 and the other values centred around the mean value will have a unit standard deviation. There is no particular range to this scaling method. Normalisation is used when the data distribution does not follow a Gaussian distribution, especially for KNN and neural networks, but it is very prone to outliers. Standardisation is helpful when the data follows a Gaussian distribution, but it is not necessarily so. Outliers in the data will not be affected by standardisation. The mean and standard deviation will be rescaled in such a way that they are very close to 0 and 1 respectively. In this case, the dataset will be standardised using the `MinMaxScaler` because this dataset does not have any non-natural outliers. Besides, it is easier to implement because most of the features are binary or data value 0 or 1. Scaling the data to fit a range between 0 and 1 is more logical.

```
[ ]: # Define scaler
scaler = MinMaxScaler()

# Fit and transform
X_train = scaler.fit_transform(X_train)
X_test = scaler.transform(X_test)
X_train

[ ]: array([[0.46774194, 0.          , 1.          , 0.15432099, 0.          ,
              0.          ],
            [0.27419355, 0.          , 1.          , 0.74691358, 0.          ,
              0.          ],
            [0.59677419, 0.          , 1.          , 0.15432099, 0.          ,
              0.          ],
            ...,
            [0.58064516, 1.          , 0.          , 0.75925926, 0.          ,
              0.          ],
            [0.88709677, 0.          , 1.          , 0.15432099, 0.          ,
              0.          ],
            [0.06451613, 1.          , 0.          , 0.93209877, 1.          ,
              0.          ]])
```

7 Model Selection

First of all, this is a classification problem as the goal is to predict whether the customer is interested in a vehicle insurance, which means the model is required to classify the applicant into `Class 0` or 1, where 0 = not interested and 1 = interested. Therefore, the models that will be trained and evaluated for comparison are k neighbour classifier, decision tree classifier and support vector machine.

```
[ ]: def predict(model, X_train, X_test, y_train, y_test):
      # Train model
      model.fit(X_train, y_train)
```

```

# Make training data prediction
pred = model.predict(X_train)

# Calculate training data accuracy
train_acc = accuracy_score(y_train, pred)
print("Training Accuracy:", train_acc)

# Make prediction
pred = model.predict(X_test)

# Test accuracy
test_acc = accuracy_score(y_test, pred)
print("Testing Accuracy:", test_acc)

# Confusion Matrix
conf_matr = confusion_matrix(y_test, pred, labels=model.classes_)

# Visualise confusion matrix
disp = ConfusionMatrixDisplay(confusion_matrix=conf_matr,
↪display_labels=model.classes_)
disp.plot()
plt.title('Confusion Matrix')
plt.show()

# Show classification report
class_report = classification_report(y_test, pred, output_dict=True)
print("Classification Report:\n", classification_report(y_test, pred))

return train_acc, test_acc, conf_matr, class_report

```

The above is a reusable function for all models.

7.1 K Neighbour Classifier

KNN is a very simple model that can sometimes outperform complex models such as ANNs and SVMs. It basically utilises the distance between two data points. There will be a circle of data points, and one data point is compared to the other data points. The closest data points will be grouped together. The typical K value to start with is 3.

7.1.1 First Round

```

[ ]: def first_round(model):
        return predict(model, X_train[:1000], X_test[:1000], y_train[:1000],
↪y_test[:1000])

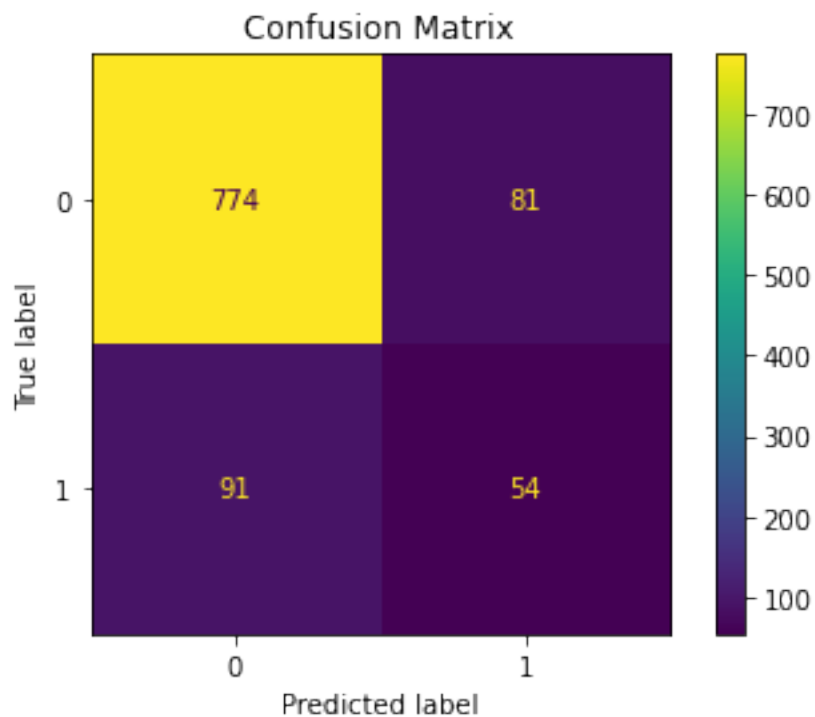
```

```
[ ]: # Instantiate model
knn_model = KNeighborsClassifier(n_neighbors=3)

knn_train_acc, knn_acc, knn_cm, knn_cr = first_round(knn_model)
```

Training Accuracy: 0.896

Testing Accuracy: 0.828



Classification Report:

	precision	recall	f1-score	support
0	0.89	0.91	0.90	855
1	0.40	0.37	0.39	145
accuracy			0.83	1000
macro avg	0.65	0.64	0.64	1000
weighted avg	0.82	0.83	0.83	1000

The training accuracy of the KNN model is higher than the testing accuracy at the first round, which indicates that the model is overfitting. Therefore, grid search is used to tackle this overfitting problem.

7.1.2 Grid Search

Finding the best K value and weights for KNN to improve the model performance.

```
[ ]: # Grid Search function
def grid_search(params, model):
    gs = GridSearchCV(
        model,
        param_grid=params,
        verbose=1
    )

    # Take only the first 1000 records
    gs_results = gs.fit(X_train[:1000], y_train[:1000])

    print("Best Score:", gs_results.best_score_)
    print("Best Estimator:", gs_results.best_estimator_)
    print("Best Params:", gs_results.best_params_)
```

```
[ ]: # Define parameters
params = {
    'n_neighbors': [3, 5, 7],
    'weights': ['uniform', 'distance']
}

grid_search(params, KNeighborsClassifier())
```

Fitting 5 folds for each of 6 candidates, totalling 30 fits

Best Score: 0.8400000000000001

Best Estimator: KNeighborsClassifier(n_neighbors=3)

Best Params: {'n_neighbors': 3, 'weights': 'uniform'}

From the grid search conducted above, the best cross-validated score of the best estimator is shown. The K value is also shown here with the suitable weights.

7.1.3 Fine-tuning

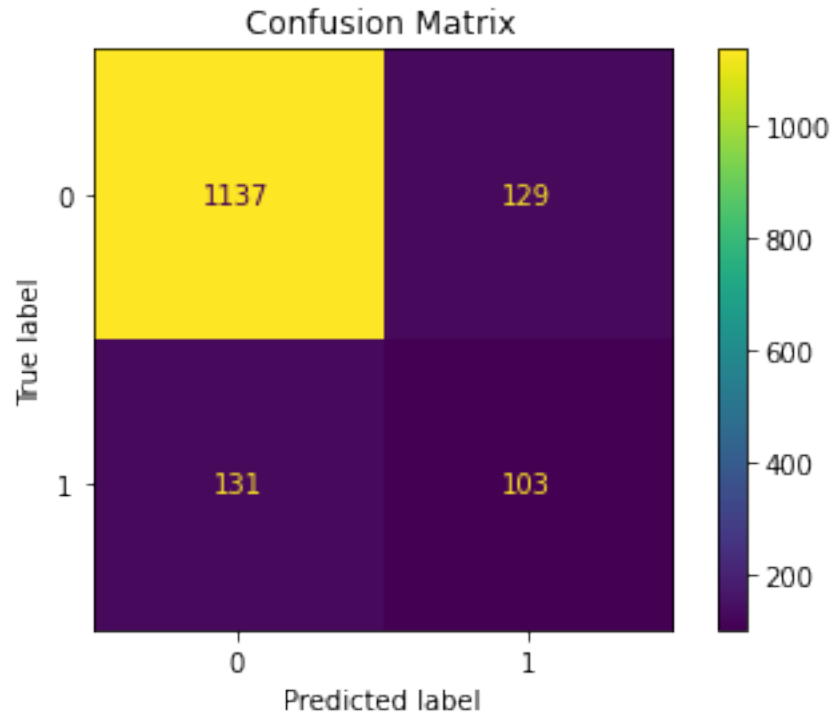
Using the grid search results above, another KNN model is instantiated and trained.

```
[ ]: # Instantiate model
knn_model = KNeighborsClassifier(n_neighbors=3, weights='uniform')

knn_train_acc, knn_acc, knn_cm, knn_cr = predict(knn_model, X_train, X_test,
↪ y_train, y_test)
```

Training Accuracy: 0.8714285714285714

Testing Accuracy: 0.8266666666666667



Classification Report:

	precision	recall	f1-score	support
0	0.90	0.90	0.90	1266
1	0.44	0.44	0.44	234
accuracy			0.83	1500
macro avg	0.67	0.67	0.67	1500
weighted avg	0.83	0.83	0.83	1500

Generally, the performance of the model is not good as it still tends to overfit the data. It is good at identifying non-interested customers, as shown in the confusion matrix. However, it is known that the model misclassifies almost half of the interested customers as not interested in vehicle insurance.

7.2 Decision Tree Classifier

A decision tree basically works by splitting a node when it evaluates on an attribute. Each branch is the outcome of the test and each leaf node represents the class label.

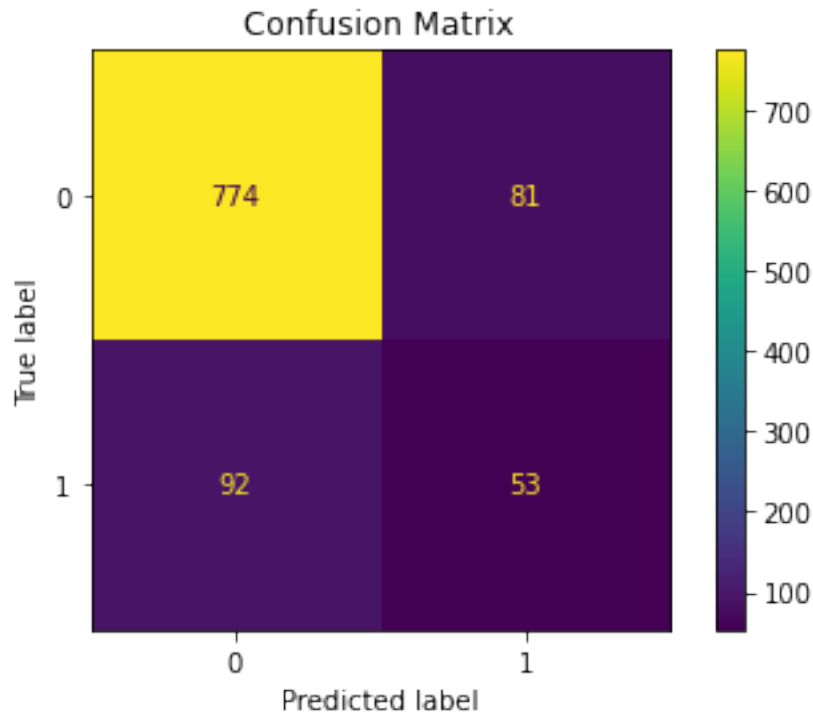
7.2.1 First Round

```
[ ]: # Instantiate the model
tree_model = DecisionTreeClassifier()

tree_train_acc, tree_acc, tree_cm, tree_cr = first_round(tree_model)
```

Training Accuracy: 0.937

Testing Accuracy: 0.827



Classification Report:

	precision	recall	f1-score	support
0	0.89	0.91	0.90	855
1	0.40	0.37	0.38	145
accuracy			0.83	1000
macro avg	0.64	0.64	0.64	1000
weighted avg	0.82	0.83	0.82	1000

The training accuracy of the tree model is much higher than the testing accuracy at the first round, which indicates that the model is overfitting. Therefore, grid search is used to tackle this overfitting problem.

7.2.2 Grid Search

The `max_depth` of the tree needs to be limited for a better performance. There should also be a `min_samples_leaf` for each leaf to avoid overfitting.

```
[ ]: # Define parameters
params = {'max_depth': [x for x in range(3, 11)], 'min_samples_leaf': [x for x in range(1, 10, 3)]}

grid_search(params, DecisionTreeClassifier())
```

Fitting 5 folds for each of 24 candidates, totalling 120 fits

Best Score: 0.859

Best Estimator: `DecisionTreeClassifier(max_depth=6, min_samples_leaf=4)`

Best Params: `{'max_depth': 6, 'min_samples_leaf': 4}`

From the grid search conducted above, the best cross-validated score of the best estimator is shown. It is known the best `max_depth` for the decision tree is 3.

7.2.3 Fine-tuning

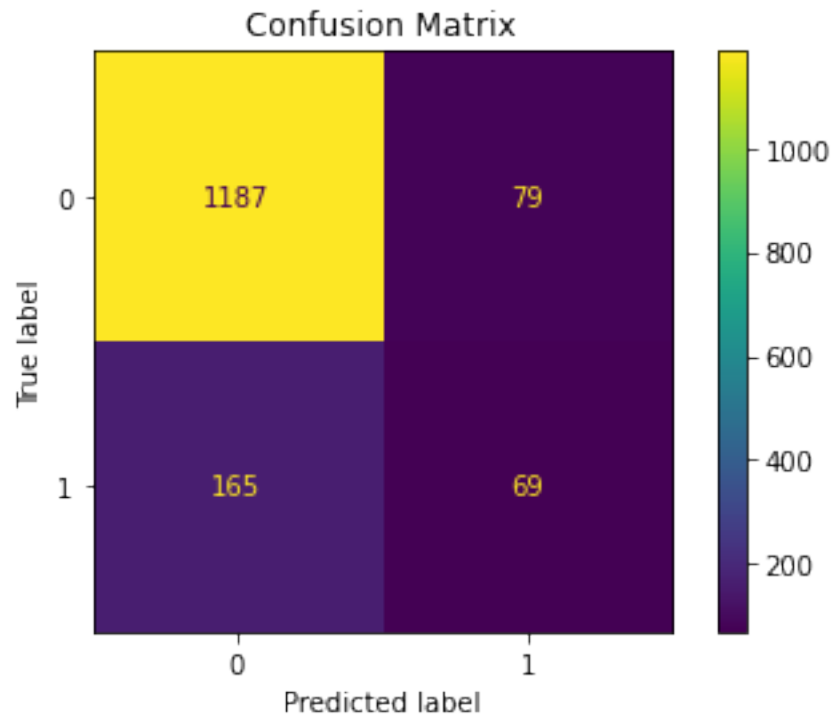
Fine-tuning the tree model using the parameters above.

```
[ ]: tree_model = DecisionTreeClassifier(max_depth=6, min_samples_leaf=4)

tree_train_acc, tree_acc, tree_cm, tree_cr = predict(tree_model, X_train, X_test, y_train, y_test)
```

Training Accuracy: 0.8431428571428572

Testing Accuracy: 0.8373333333333334



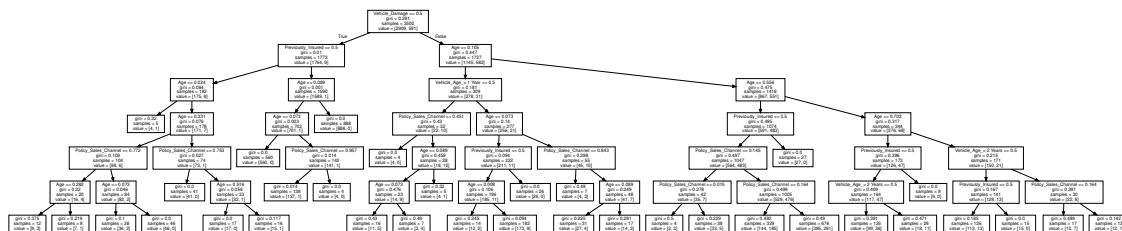
Classification Report:

	precision	recall	f1-score	support
0	0.88	0.94	0.91	1266
1	0.47	0.29	0.36	234
accuracy			0.84	1500
macro avg	0.67	0.62	0.63	1500
weighted avg	0.81	0.84	0.82	1500

Generally, the performance of the tree model is also not good as it still tends to overfit the data by a little. Looking at its precision and recall for label 1, its performance for classifying interested customers has decreased a bit.

```
[ ]: dot_data = export_graphviz(tree_model, feature_names=X_df.columns.tolist())
graph = graphviz.Source(dot_data)
graph
```

[]:



The above is the visualisation of the decision tree.

7.3 Support Vector Machines

The model classifies data by using the best hyper plane that separates two data classes, utilising the margin from the plane to the data point.

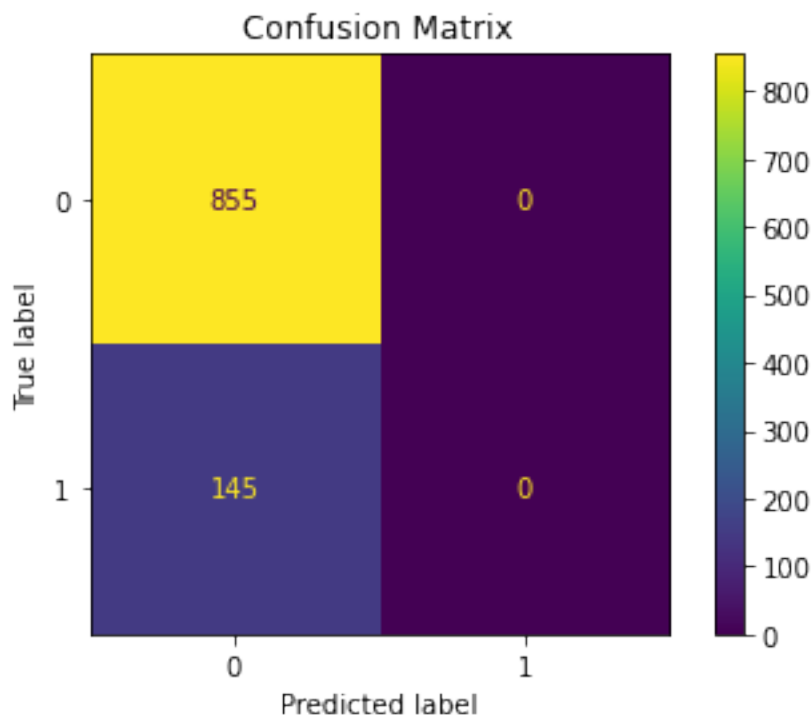
7.3.1 First Round

```
[ ]: # Instantiate model
svm_model = SVC(kernel='rbf', C=1)

# Predict
svm_train_acc, svm_acc, svm_cm, svm_cr = first_round(svm_model)
```

Training Accuracy: 0.851

Testing Accuracy: 0.855



Classification Report:

	precision	recall	f1-score	support
0	0.85	1.00	0.92	855
1	0.00	0.00	0.00	145
accuracy			0.85	1000
macro avg	0.43	0.50	0.46	1000
weighted avg	0.73	0.85	0.79	1000

The SVM model is unable to correctly classify interested customers at all as evidently shown by the 0 precision and recall score for label 1. It needs to be fine-tuned.

7.3.2 Grid Search

Finding the best kernel, C and gamma values.

```
[ ]: # Define parameters
params = {'C': [0.1, 1, 10, 100], 'gamma': [1, 0.1, 0.01, 0.001], 'kernel': ['rbf',
    'poly', 'sigmoid']}

grid_search(params, SVC())
```

Fitting 5 folds for each of 48 candidates, totalling 240 fits

Best Score: 0.8560000000000001

Best Estimator: SVC(C=100, gamma=1)

Best Params: {'C': 100, 'gamma': 1, 'kernel': 'rbf'}

From the grid search conducted above, the best cross-validated score of the best estimator is shown. The C and gamma value are also shown here with the suitable kernel.

7.3.3 Fine-tuning

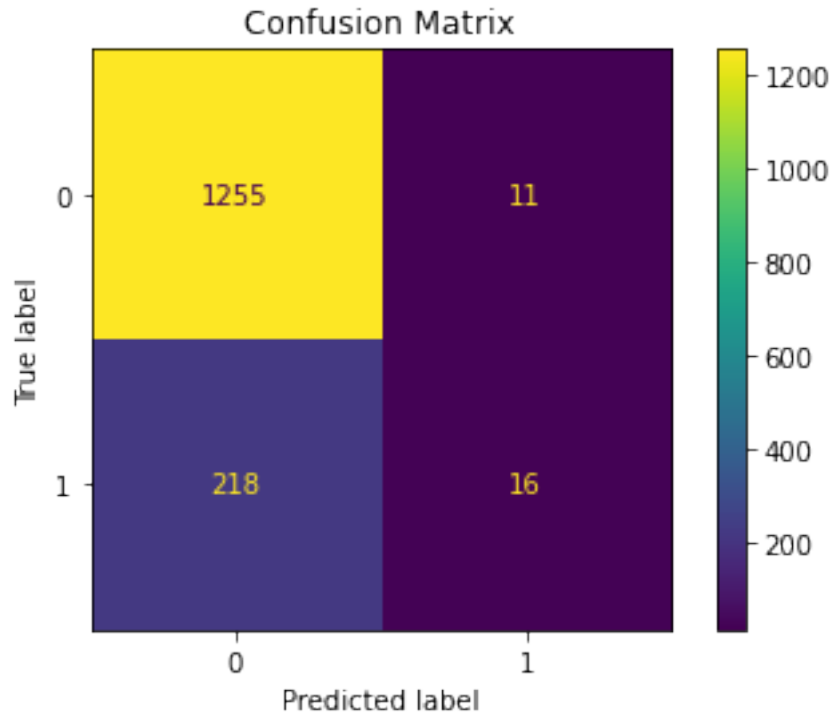
Fine-tuning the model using the parameters above.

```
[ ]: # Instantiate model
svm_model = SVC(kernel='rbf', C=100, gamma=1)

# Predict
svm_train_acc, svm_acc, svm_cm, svm_cr = predict(svm_model, X_train, X_test,
    y_train, y_test)
```

Training Accuracy: 0.8345714285714285

Testing Accuracy: 0.8473333333333334



Classification Report:

	precision	recall	f1-score	support
0	0.85	0.99	0.92	1266
1	0.59	0.07	0.12	234
accuracy			0.85	1500
macro avg	0.72	0.53	0.52	1500
weighted avg	0.81	0.85	0.79	1500

Although the accuracy score for the SVM model decreased, it actually improved by being able to identify some of the interested customers.

8 Evaluation

Evaluating the models using pointplot.

```
[ ]: y = {
    'accuracy': [knn_acc, tree_acc, svm_acc],
    'precision': [knn_cr['1']['precision'], tree_cr['1']['precision'],
    ↪svm_cr['1']['precision']],
    'recall': [knn_cr['1']['recall'], tree_cr['1']['recall'],
    ↪svm_cr['1']['recall']],
```

```

    'models': ['knn', 'tree', 'svm']
}

y = pd.DataFrame(y)
y

```

```

[ ]:
accuracy precision recall models
0  0.826667  0.443966  0.440171  knn
1  0.837333  0.466216  0.294872  tree
2  0.847333  0.592593  0.068376  svm

```

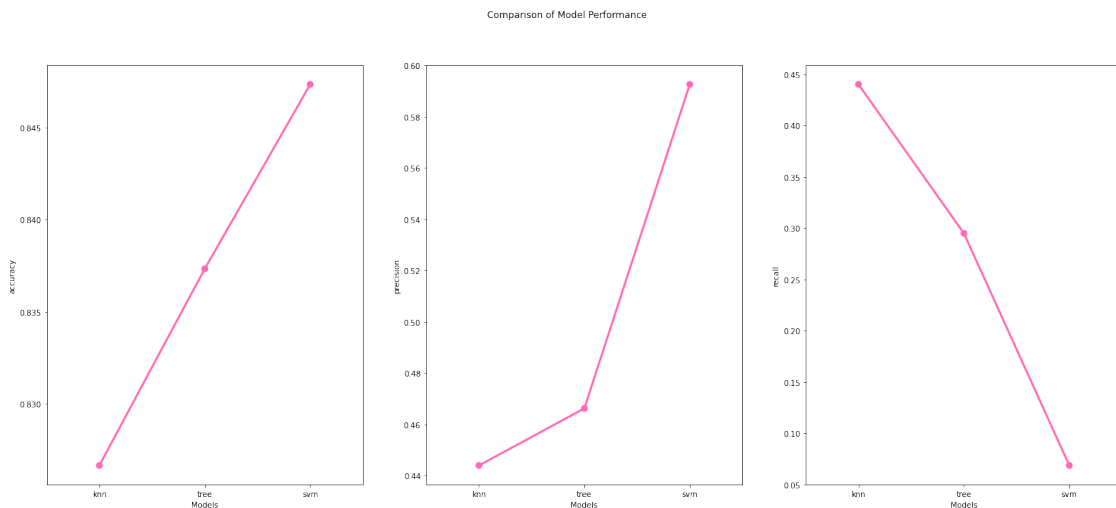
```

[ ]: fig, ax = plt.subplots(1, 3, figsize=(25, 10))
ax = ax.flatten()

fig.suptitle('Comparison of Model Performance')

for i, v in enumerate(y):
    if(v == 'models'):
        break
    sns.pointplot(data=y, ax=ax[i], x=y['models'], y=y[v], color='hotpink')
    ax[i].set(xlabel='Models', ylabel=v)

```



As shown in the graph, the testing accuracy and precision of SVM is the highest, with KNN being the lowest. However, the KNN outperforms other models in terms of recall. Before a suitable model is selected, let us revisit the objective of this project. The objective of this project is to classify customers whether they are interested in purchasing a vehicle insurance, so a high accuracy alone does not mean a lot. A high accuracy at most shows that the models are good at finding uninterested customers.

In this case, the positive (1) refers to an interested customer, and the negative (0) refers to an uninterested customer.

1. A true positive is an interested customer being classified correctly as an interested customer.
2. A false positive is when an uninterested customer is classified as an interested customer.
3. A true negative is a uninterested customer being classified correctly as an uninterested customer.
4. A false negative is a interested customer being classified as a uninterested customer.

Out of the four cases above, other than correctly classifying the customers (which gives a **high accuracy**), it is better for the model to classify interested customers as uninterested customers (which gives a high **false negative**). Because classifying uninterested customers as interested customers (which gives a **high false positive**) might lead the company to launch a new vehicle insurance, only to find out that the demand is not as high as expected, causing them to lose revenue and profit. Therefore, **false negatives should be higher than the false positives**.

A high precision means that out of the total actual positives, the model got it correct most of the time (high true positive). Recall is higher means that out of all the total positives predicted, it has high true positive. Following the logic that false negatives should be more than false positives, due to the formulae of precision and recall, a lower false positive will give a **higher precision**, and a higher false negative will give a **lower recall**.

The model that satisfies a higher precision, lower recall and good accuracy is the SVM model. Therefore, the ideal model to be selected is the **support vector machine**, for a more conservative prediction and estimation of demand for the new vehicle insurance package.