Author Name: Vangari Prashanth

Student Id: 11645119

TASK 1

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt


def getData(filename):
  canData=[] #List to store CAN data
  f = open(filename)
  #read_file = reader(f)
  read_file =f.readlines()

  #file = list(read_file)
  speed = []
  rpm = []
  i = 0
  for row in read_file:
    #Change the positions of the values if needed
    record = {'stamp':row[1:18], 'PID':row[25:28], 'const1':row[29:33],
'change':row[33:41],'value':int(row[41:45], 16), 'value2':0 ,'attack':0}

    if record["PID"] == '254': #Processing of speed
      if record["value"] >= 4095:
        record["attack"] = 1
      record['value'] =  (record['value'] * 0.62137119) /100
      speed.append(record['value'])

    if record["PID"] == '115': #Processing of RPM
      if record["value"] >= 65535:
        record["attack"] = 1
      record['value'] =  (record['value'] * 2)
      rpm.append(record['value'])

    i = i+1
    canData.append(record)
    record={}

  f.close()
  return canData



def dict_to_df(dict):
  #load dictionary to dataframe
  df = pd.DataFrame.from_dict(dict)
  df = df.reset_index(drop=True)   # Dropping the Column Attack
  df_RPM = df.loc[(df['PID'] == '115')]
  df_Speed = df.loc[(df['PID'] == '254')]
  return df_RPM,df_Speed


#edit file name with file directory of downloaded log files
f_inj_RPM, f_inj_Speed = dict_to_df(getData("CAN Bus log - injection of FFF as the speed reading.log"))
r_inj_RPM, r_inj_Speed= dict_to_df(getData("CAN Bus log - injection of RPM readings.log"))
no_inj_RPM, no_inj_Speed = dict_to_df(getData("CAN bus log - no injection of messages.log"))
```

TASK 2: K - Means Clustering

```
f_inj_RPM.drop(['attack'], axis = 1)
f_inj_Speed.drop(['attack'], axis = 1)
r_inj_RPM.drop(['attack'], axis = 1)
r_inj_Speed.drop(['attack'], axis = 1)
no_inj_RPM.drop(['attack'], axis = 1)
```

```
no_inj_Speed.drop(['attack'], axis = 1)
```

	stamp	PID	const1	change	value	value2
20	1522004165.996440	254	918F	D364239E	0.000000	0
55	1522004166.016375	254	918F	C364339E	0.000000	0
84	1522004166.036373	254	918F	B364439E	0.000000	0
124	1522004166.056434	254	918F	A364539E	0.000000	0
157	1522004166.076394	254	918F	9364639E	0.000000	0
...	...	...	...	...	...	...
23823	1522004180.036277	254	918F	D096039F	3.386473	0
23860	1522004180.055837	254	918F	D696139F	3.249771	0
23885	1522004180.075786	254	918F	D896239F	3.144138	0
23925	1522004180.096297	254	918F	D996339F	3.038505	0
23961	1522004180.115850	254	918F	DA96439F	2.932872	0

707 rows × 6 columns

```
f_inj_RPM.reset_index(drop=True, inplace=True)
f_inj_Speed.reset_index(drop=True, inplace=True)
r_inj_RPM.reset_index(drop=True, inplace=True)
r_inj_Speed.reset_index(drop=True, inplace=True)
no_inj_RPM.reset_index(drop=True, inplace=True)
no_inj_Speed.reset_index(drop=True, inplace=True)


from sklearn.cluster import KMeans
from sklearn.preprocessing import StandardScaler

scaler = StandardScaler()

#1
f_inj_Speed[['stamp', 'value']] = scaler.fit_transform(f_inj_Speed[['stamp', 'value']])
f_inj_Speed_kmeans = KMeans(n_clusters=2)
f_inj_Speed_kmeans.fit(f_inj_Speed[['stamp','value']])
f_inj_Speed['KMeans'] = f_inj_Speed_kmeans.labels_
f_inj_Speed_kmeans_centroids = f_inj_Speed_kmeans.cluster_centers_
f_inj_Speed_centroid = np.array(f_inj_Speed_kmeans_centroids)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
#2
f_inj_RPM[['stamp', 'value']] = scaler.fit_transform(f_inj_RPM[['stamp', 'value']])
f_inj_RPM_kmeans = KMeans(n_clusters=2)
f_inj_RPM_kmeans.fit(f_inj_RPM[['stamp','value']])
f_inj_RPM['KMeans'] = f_inj_RPM_kmeans.labels_
f_inj_RPM_kmeans_centroids = f_inj_RPM_kmeans.cluster_centers_
f_inj_RPM_centroid = np.array(f_inj_RPM_kmeans_centroids)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
#3
r_inj_Speed[['stamp', 'value']] = scaler.fit_transform(r_inj_Speed[['stamp', 'value']])
r_inj_Speed_kmeans = KMeans(n_clusters=2)
r_inj_Speed_kmeans.fit(r_inj_Speed[['stamp','value']])
r_inj_Speed['KMeans'] = r_inj_Speed_kmeans.labels_
r_inj_Speed_kmeans_centroids = r_inj_Speed_kmeans.cluster_centers_
r_inj_Speed_centroid = np.array(r_inj_Speed_kmeans_centroids)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
#4
r_inj_RPM[['stamp', 'value']] = scaler.fit_transform(r_inj_RPM[['stamp', 'value']])
r_inj_RPM_kmeans = KMeans(n_clusters=2)
r_inj_RPM_kmeans.fit(r_inj_RPM[['stamp','value']])
r_inj_RPM['KMeans'] = r_inj_RPM_kmeans.labels_
r_inj_RPM_kmeans_centroids = r_inj_RPM_kmeans.cluster_centers_
r_inj_RPM_centroid = np.array(r_inj_RPM_kmeans_centroids)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
#5
no_inj_Speed[['stamp', 'value']] = scaler.fit_transform(no_inj_Speed[['stamp', 'value']])
no_inj_Speed_kmeans = KMeans(n_clusters=2)
no_inj_Speed_kmeans.fit(no_inj_Speed[['stamp','value']])
no_inj_Speed['KMeans'] = no_inj_Speed_kmeans.labels_
no_inj_Speed_kmeans_centroids = no_inj_Speed_kmeans.cluster_centers_
no_inj_Speed_centroid = np.array(no_inj_Speed_kmeans_centroids)
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
#6
no_inj_RPM[['stamp', 'value']] = scaler.fit_transform(no_inj_RPM[['stamp', 'value']])
no_inj_RPM_kmeans = KMeans(n_clusters=2)
no_inj_RPM_kmeans.fit(no_inj_RPM[['stamp','value']])
no_inj_RPM['KMeans'] = no_inj_RPM_kmeans.labels_
no_inj_RPM_kmeans_centroids = no_inj_RPM_kmeans.cluster_centers_
no_inj_RPM_centroid = np.array(no_inj_RPM_kmeans_centroids)
```

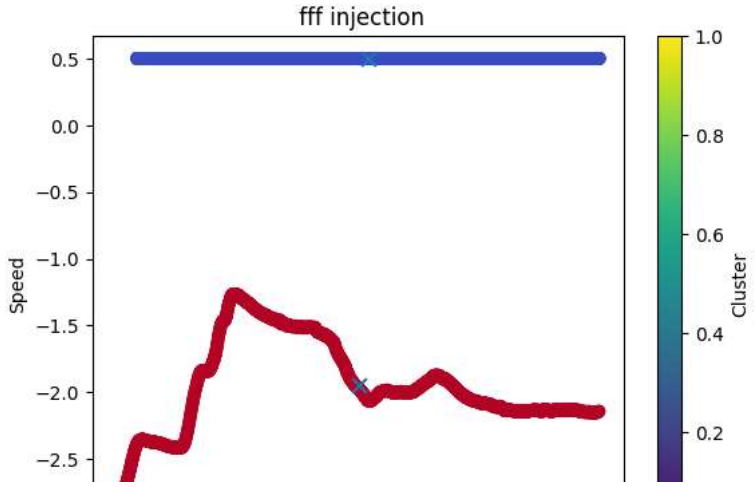
```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning: The default value of `n_init` will change from 1
  warnings.warn(
```

```
# printing the centroids
print("f_inj_Speed_centroid:",f_inj_Speed_centroid)
print("f_inj_RPM_centroid:",f_inj_RPM_centroid)
print("r_inj_Speed_centroid:",r_inj_Speed_centroid)
print("r_inj_RPM_centroid:",r_inj_RPM_centroid)
print("no_inj_Speed_centroid:",no_inj_Speed_centroid)
print("no_inj_RPM_centroid:",no_inj_RPM_centroid)
```

```
f_inj_Speed_centroid: [[ 0.0147652   0.50089906]
 [-0.05743875 -1.94856666]]
f_inj_RPM_centroid: [[-0.86156837  0.61731336]
 [ 0.8489947  -0.60830435]]
r_inj_Speed_centroid: [[ 0.95305006  1.0487455 ]
 [-0.77899649 -0.85721514]]
r_inj_RPM_centroid: [[ 0.10991432  0.64166953]
 [-0.26694906 -1.55842462]]
no_inj_Speed_centroid: [[-1.185739   -0.93419799]
 [ 0.54632192  0.43042593]]
no_inj_RPM_centroid: [[ 1.1050571  -0.95013065]
 [-0.62699574  0.53909243]]
```

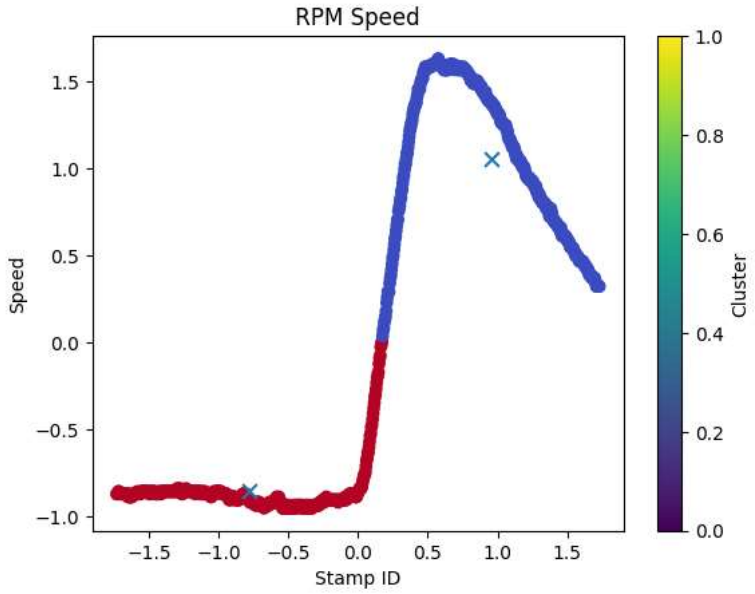
Compare the graphs for speed

```
plt.scatter(x=f_inj_Speed['stamp'],y=f_inj_Speed['value'],c=f_inj_Speed['KMeans'],cmap='coolwarm')
plt.scatter(x=np.array(f_inj_Speed_centroid[:,0]),y=np.array(f_inj_Speed_centroid[:,1]),s = 60,marker="x")
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title(" fff injection")
plt.colorbar(label='Cluster')
plt.show()
```

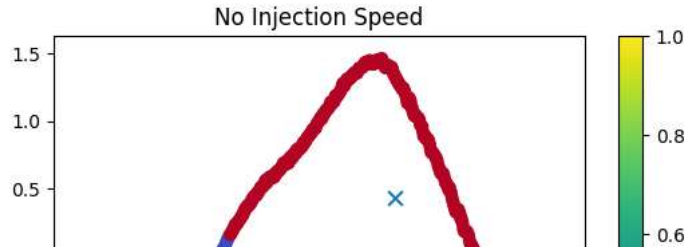



```
plt.scatter(x=r_inj_Speed['stamp'],y=r_inj_Speed['value'],c=r_inj_Speed['KMeans'],cmap='coolwarm')
plt.scatter(x=np.array(r_inj_Speed_centroid[:,0]),y=np.array(r_inj_Speed_centroid[:,1]),s = 60,marker="x")
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title(" RPM Speed ")
plt.colorbar(label='Cluster')

plt.show()
```

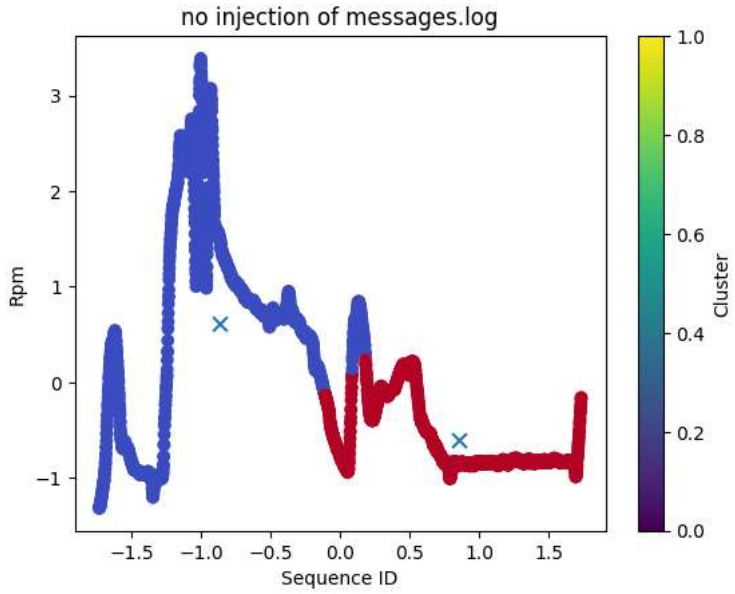



```
plt.scatter(x=no_inj_Speed['stamp'], y=no_inj_Speed['value'], c=no_inj_Speed['KMeans'], cmap='coolwarm')
plt.scatter(x=np.array(no_inj_Speed_centroid[:,0]), y=np.array(no_inj_Speed_centroid[:,1]), s=60, marker="x")
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title("No Injection Speed")
plt.colorbar(label='Cluster')
plt.show()
```

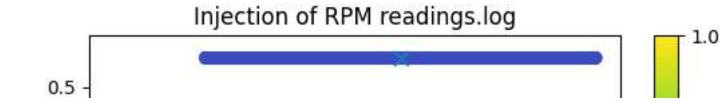


Compare the plots for RPM

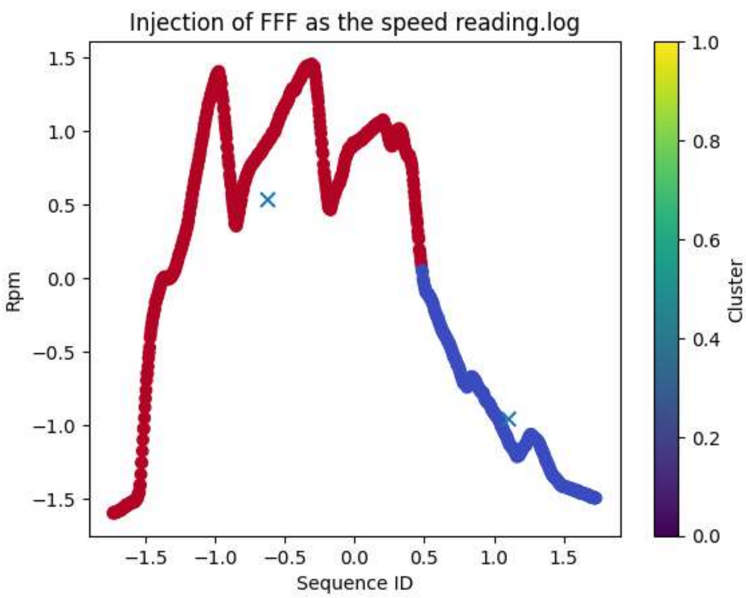
```
plt.scatter(x=f_inj_RPM['stamp'],y=f_inj_RPM['value'],c=f_inj_RPM['KMeans'],cmap='coolwarm')
plt.scatter(x=np.array(f_inj_RPM_centroid[:,0]),y=np.array(f_inj_RPM_centroid[:,1]),s = 60,marker="x")
plt.xlabel("Sequence ID")
plt.ylabel("Rpm")
plt.colorbar(label='Cluster')
plt.title("no injection of messages.log")
plt.show()
```




```
plt.scatter(x=r_inj_RPM['stamp'],y=r_inj_RPM['value'],c=r_inj_RPM['KMeans'],cmap='coolwarm')
plt.scatter(x=np.array(r_inj_RPM_centroid[:,0]),y=np.array(r_inj_RPM_centroid[:,1]),s = 60,marker="x")
plt.xlabel("Sequence ID")
plt.ylabel("Rpm")
plt.colorbar(label='Cluster')
plt.title("Injection of RPM readings.log")
plt.show()
```




```
plt.scatter(x=no_inj_RPM['stamp'],y=no_inj_RPM['value'],c=no_inj_RPM['KMeans'],cmap='coolwarm')
plt.scatter(x=np.array(no_inj_RPM_centroid[:,0]),y=np.array(no_inj_RPM_centroid[:,1]),s = 60,marker="x")
plt.xlabel("Sequence ID")
plt.ylabel("Rpm")
plt.colorbar(label='Cluster')
plt.title("Injection of FFF as the speed reading.log")
plt.show()
```



TASK 3

```
from sklearn.ensemble import IsolationForest
import seaborn as sns
import math
```

```
IF_f_inj_Speed = IsolationForest(contamination=0.5)
IF_f_inj_Speed.fit(f_inj_Speed[['value']])
IF_r_inj_Speed = IsolationForest(contamination=0.5)
IF_r_inj_Speed.fit(r_inj_Speed[['value']])
IF_no_inj_Speed = IsolationForest(contamination=0.5)
IF_no_inj_Speed.fit(no_inj_Speed[['value']])
IF_f_inj_RPM = IsolationForest(contamination=0.5)
IF_f_inj_RPM.fit(f_inj_RPM[['value']])
IF_r_inj_RPM = IsolationForest(contamination=0.5)
IF_r_inj_RPM.fit(r_inj_RPM[['value']])
IF_no_inj_RPM = IsolationForest(contamination=0.5)
IF_no_inj_RPM.fit(no_inj_RPM[['value']])
```

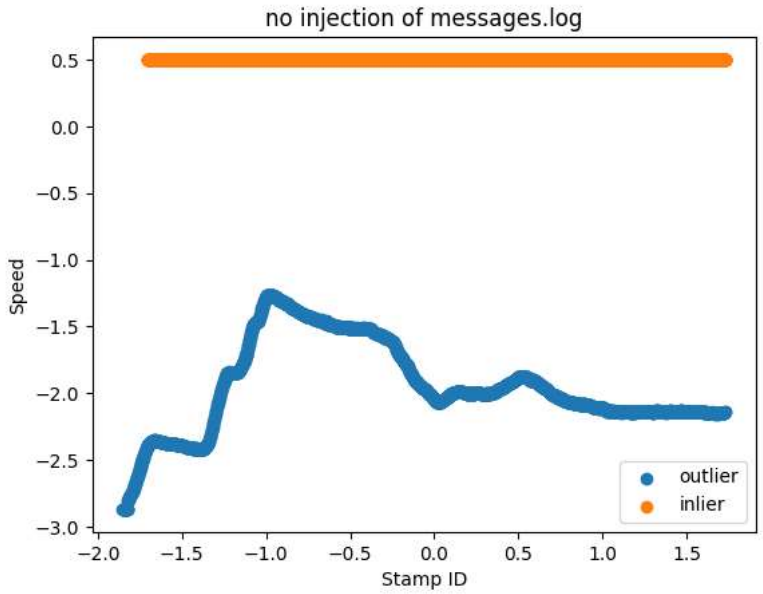
```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but IsolationForest was f
  warnings.warn(
▾ IsolationForest
IsolationForest(contamination=0.5)
```

```
f_inj_Speed['scores'] = IF_f_inj_Speed.decision_function(f_inj_Speed[['value']])
f_inj_Speed['anomaly'] = IF_f_inj_Speed.predict(f_inj_Speed[['value']])
r_inj_Speed['scores'] = IF_r_inj_Speed.decision_function(r_inj_Speed[['value']])
r_inj_Speed['anomaly'] = IF_r_inj_Speed.predict(r_inj_Speed[['value']])
no_inj_Speed['scores'] = IF_no_inj_Speed.decision_function(no_inj_Speed[['value']])
no_inj_Speed['anomaly'] = IF_no_inj_Speed.predict(no_inj_Speed[['value']])
f_inj_RPM['scores'] = IF_f_inj_RPM.decision_function(f_inj_RPM[['value']])
f_inj_RPM['anomaly'] = IF_f_inj_RPM.predict(f_inj_RPM[['value']])
r_inj_RPM['scores'] = IF_r_inj_RPM.decision_function(r_inj_RPM[['value']])
r_inj_RPM['anomaly'] = IF_r_inj_RPM.predict(r_inj_RPM[['value']])
no_inj_RPM['scores'] = IF_no_inj_RPM.decision_function(no_inj_RPM[['value']])
no_inj_RPM['anomaly'] = IF_no_inj_RPM.predict(no_inj_RPM[['value']])
```

Comparing graph for Speed

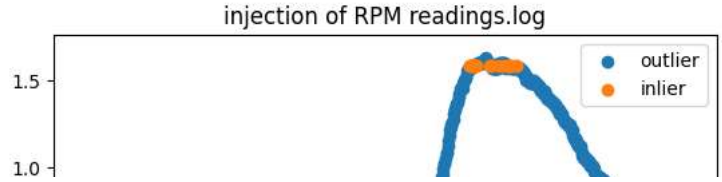
```
# Plotting the graph NO injection as the speed reading.log and speed data
plt.scatter(data=f_inj_Speed.loc[f_inj_Speed['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=f_inj_Speed.loc[f_inj_Speed['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title("no injection of messages.log")
```

```
Text(0.5, 1.0, 'no injection of messages.log')
```



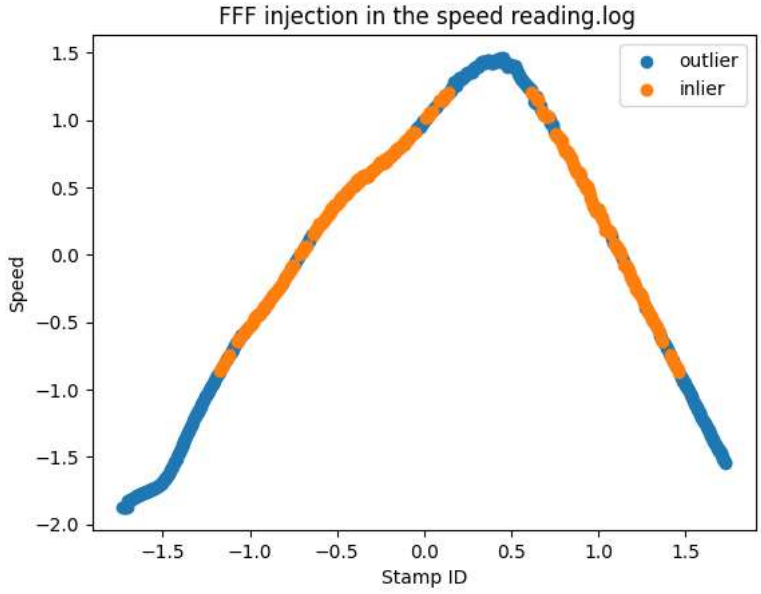

```
# Plotting the graph RPM injection as the speed reading.log and speed data
plt.scatter(data=r_inj_Speed.loc[r_inj_Speed['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=r_inj_Speed.loc[r_inj_Speed['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title("injection of RPM readings.log")
```

```
Text(0.5, 1.0, 'injection of RPM readings.log')
```




```
# Plotting the graph FFF injection as the speed reading.log and speed data
plt.scatter(data=no_inj_Speed.loc[no_inj_Speed['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=no_inj_Speed.loc[no_inj_Speed['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title(" FFF injection in the speed reading.log")
```

```
Text(0.5, 1.0, ' FFF injection in the speed reading.log')
```



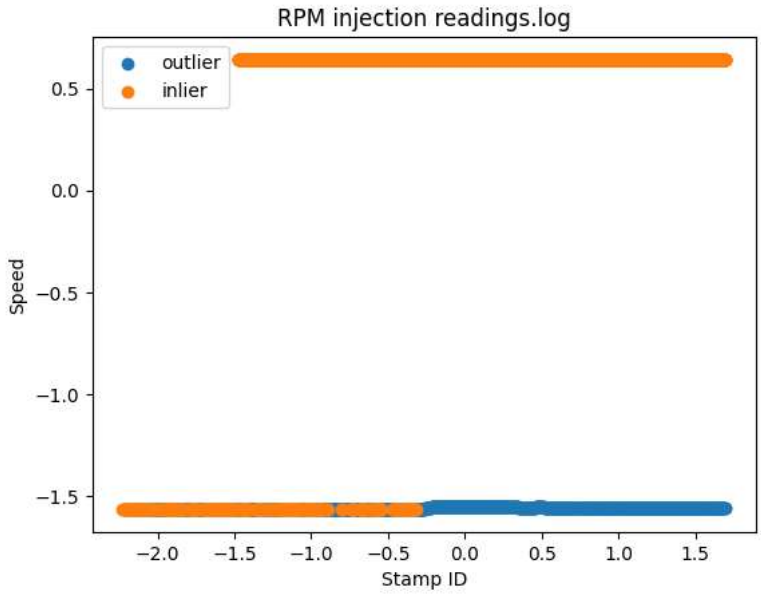
Comparing the graphs for RPM

```
# Plotting the graph for NO Injection
plt.scatter(data=f_inj_RPM.loc[f_inj_RPM['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=f_inj_RPM.loc[f_inj_RPM['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title(" no injection in messages.log")
```

```
Text(0.5, 1.0, ' no injection in messages.log')
```

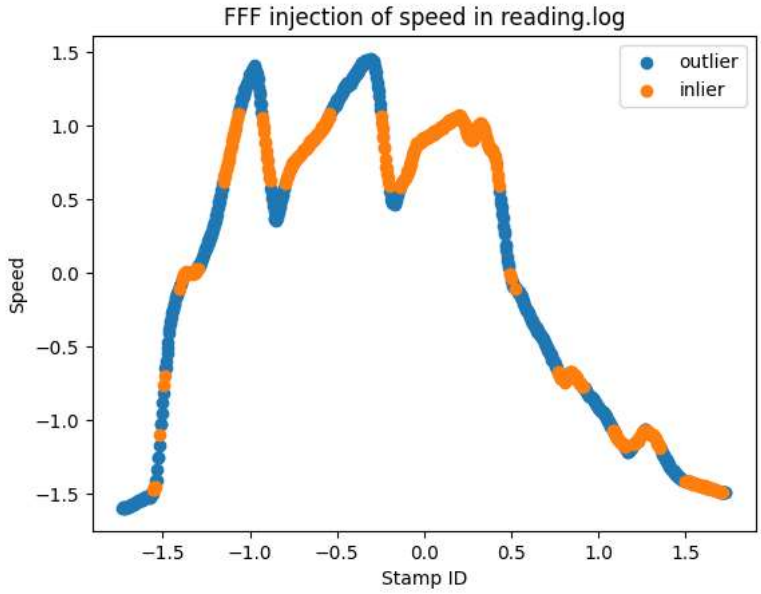

```
# Plotting the graph for RPM Injection
plt.scatter(data=r_inj_RPM.loc[r_inj_RPM['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=r_inj_RPM.loc[r_inj_RPM['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title("RPM injection readings.log")
```

```
Text(0.5, 1.0, 'RPM injection readings.log')
```




```
# Plotting the graph for FFF Injection
plt.scatter(data=no_inj_RPM.loc[no_inj_RPM['anomaly']==-1],x="stamp",y="value")
plt.scatter(data=no_inj_RPM.loc[no_inj_RPM['anomaly']==1],x="stamp",y="value")
plt.legend(["outlier","inlier"])
plt.xlabel("Stamp ID")
plt.ylabel("Speed")
plt.title("FFF injection of speed in reading.log")
```

```
Text(0.5, 1.0, 'FFF injection of speed in reading.log')
```



TASK 4 - Hidden Markov

```
!pip install hmmlearn
```

```
Requirement already satisfied: hmmlearn in /usr/local/lib/python3.10/dist-packages (0.3.0)
Requirement already satisfied: numpy>=1.10 in /usr/local/lib/python3.10/dist-packages (from hmmlearn) (1.23.5)
Requirement already satisfied: scikit-learn!=0.22.0,>=0.16 in /usr/local/lib/python3.10/dist-packages (from hmmlearn) (1.2.2)
Requirement already satisfied: scipy>=0.19 in /usr/local/lib/python3.10/dist-packages (from hmmlearn) (1.11.3)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn!=0.22.0,>=0.16->hmmlearn) (1
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn!=0.22.0,>=0.16->hmmle
```

```
from hmmlearn.hmm import GaussianHMM
from sklearn.metrics import accuracy_score
```

```
def HMModel(data):
  hMmodel = GaussianHMM(n_components=2, random_state=42)
  dataframe_ = np.array(data["value"]).reshape(-1,1)
  hMmodel.fit(dataframe_)
  output = list(hMmodel.predict(dataframe_))
  print("Actual Value:", list(data['attack']))
  print("Predicted Value:", output)
  print("Accuracy:", accuracy_score(list(data['attack']), output))
```

```
# Hidden Markov Model for fff Injection, RPM
HMModel(f_inj_RPM)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
Accuracy: 0.5797379354426334
```

```
# Hidden Markov Model for fff Injection, Speed
HMModel(f_inj_Speed)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
Accuracy: 0.0
```

```
# Hidden Markov Model for RPM Injection, RPM
HMModel(r_inj_RPM)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
Accuracy: 0.0
```

```
# Hidden Markov Model for RPM Injection, Speed
HMModel(r_inj_Speed)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Accuracy: 0.5367647058823529
```

```
# Hidden Markov Model for NO Injection RPM
HMModel(no_inj_RPM)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
Accuracy: 0.6093418259023354
```

```
# Hidden Markov Model for NO Injection Speed
HMModel(no_inj_Speed)
```

```
Actual Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Predicted Value: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
Accuracy: 0.7906647807637907
```

Task 5

1. What were the shortcomings/limitations of using unsupervised ML on this problem?

Unsupervised learning(K-means and Isolation Forest) has several limitations.

a. In unsupervised learning, the labeled data is not present which makes model peformance evaluation challenging. b. The assumption that similar data points should belong to the same cluster may not be true in the complex datasets. c. In K-means, K value should be chosen very correctly. Else, if the k value is not chosen correctly the entire model may not give accurate results.

2. What could be done to make the models perform better? Dimensionality reduction techniques like PCA can be applied before clustering to improve the accuracy of the model. Using multiple clustering algorithms and ensemble methods can also improve the results. Also, employing feature engineering techniques helps in creating more meaningful features.
3. What do you suggest doing to solve the problem? I would suggest that refining data pre-processing methods are helpful, to ensure that the data is properly cleaned and prepared. Trying out various clustering algorithms and optimizing their parameters can help in achieving more accurate results. For unsupervised learning, visualizations and exploratory data analysis are important to understand the nature of the data. Finally, trying out the different models, tuning parameters, and comparing results with the other models can help in increasing the accuracy.