anomaly-detection-ACmotor

January 25, 2023

0.1 Problem Statement

To create a Machine Learning model to detect anomalies in a dataset consisting real time current readings of a 3-phase AC motor (3.2 hp)

Approach taken to solve this problem: The datasets are in 6 files. So combine it into a single source.

Data Analysis and Data Visualizations to understand the pattern and distribution of data

Necessary data pre-processing steps to make the data ready for modeling

As there are no target labels, this is an Unsupervised machine learning problem.

Fit the data to KMeans Clustering algorithm and split the data into 2 clusters.

The cluster value can be stored as a target column and now our problem becomes a Classification type.

Now, use the whole dataset along with target column to train and build a classification model (Random Forest Classifier)

Model is saved to a pickle file so that it can be imported and reused with any values.

The steps involved in this task: 1. Loading the tools 2. Loading the dataset 3. Exploratory Data Analysis (EDA) 4. Feature scaling 5. Model Building- KMeans Clustering algorithm 6. Model Evaluation 7. Save the model to a pickle file

0.2 1. Loading the tools

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

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

The data is spread across 6 different files. Combining all 6 files to a single file

[2]:
```
import os
os.listdir()
```

[2]:
```
['.ipynb_checkpoints',
 'anomaly-detection-ACmotor.ipynb',
 'dataset',
 'predictions']
```

[3]:
```
os.chdir("dataset")
os.listdir()
```

[3]:
```
['data0 (1).txt',
 'data109.txt',
 'data112.txt',
 'data88.txt',
 'data89.txt',
 'data9.txt']
```

[4]:
```
files = [file for file in os.listdir()]
files
```

[4]:
```
['data0 (1).txt',
 'data109.txt',
 'data112.txt',
 'data88.txt',
 'data89.txt',
 'data9.txt']
```

[5]:
```
files_df = pd.concat(map(pd.read_csv, files), ignore_index=True)
files_df.to_csv("files.csv")
```

0.3 2. Loading the dataset

[6]:
```
df=pd.read_csv("files.csv").T
df.reset_index(inplace=True)
df.columns.values[0] = "values"
df
```

[6]:
```
           values
0      Unnamed: 0
1               0
2             0.1
3             0.2
4             0.3
…             …
13590    120.2065
13591    248.1193
13592    120.2066
13593    248.1194
13594    248.1195
```

```
[13595 rows x 1 columns]
```

[7]:
```
df['values'].str.contains('Unnamed').sum()
```

[7]:
```
2
```

As there is no text (i.e. column name) before the first comma on the first line of the csv file, Unnamed is displayed. So we have to get rid of unnamed.

[8]:
```
df["current_readings"] = df["values"].str.split(": ").str[0]
df
```

[8]:
```
            values current_readings
0       Unnamed: 0          Unnamed
1                0                0
2              0.1              0.1
3              0.2              0.2
4              0.3              0.3
…                …                …
13590     120.2065         120.2065
13591     248.1193         248.1193
13592     120.2066         120.2066
13593     248.1194         248.1194
13594     248.1195         248.1195

[13595 rows x 2 columns]
```

[9]:
```
txt=df[df["current_readings"] == 'Unnamed'].index
txt
```

[9]:
```
Int64Index([0, 10001], dtype='int64')
```

[10]:
```
df.drop(txt,inplace=True)
df.drop("values",axis=1,inplace=True)
df
```

[10]:
```
      current_readings
1                    0
2                  0.1
3                  0.2
4                  0.3
5                  0.4
…                    …
13590         120.2065
13591         248.1193
13592         120.2066
13593         248.1194
```

```
13594         248.1195

[13593 rows x 1 columns]
```

[11]:
```
df['current_readings'].str.contains('Unnamed').sum()
```

[11]:
```
0
```

[12]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 13593 entries, 1 to 13594
Data columns (total 1 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   current_readings  13593 non-null  object
dtypes: object(1)
memory usage: 212.4+ KB
```

[13]:
```
df["current_readings"] = df["current_readings"].astype(float)
```

[14]:
```
df.dtypes
```

[14]:
```
current_readings    float64
dtype: object
```

0.4 3. Exploratory Data Analysis

[15]:
```
df.describe()
```

[15]:

	current_readings
count	13593.000000
mean	52.371722
std	80.108110
min	0.000000
25%	0.405600
50%	0.711400
75%	120.200500
max	248.999000

Mean = 52.37

Median = 0.71

SD = 80.10

Findings:

There is very gradual increase in values till the Q2 value (Median).

Values in the Third Quartile suddenly increases and there is a wide dispersion

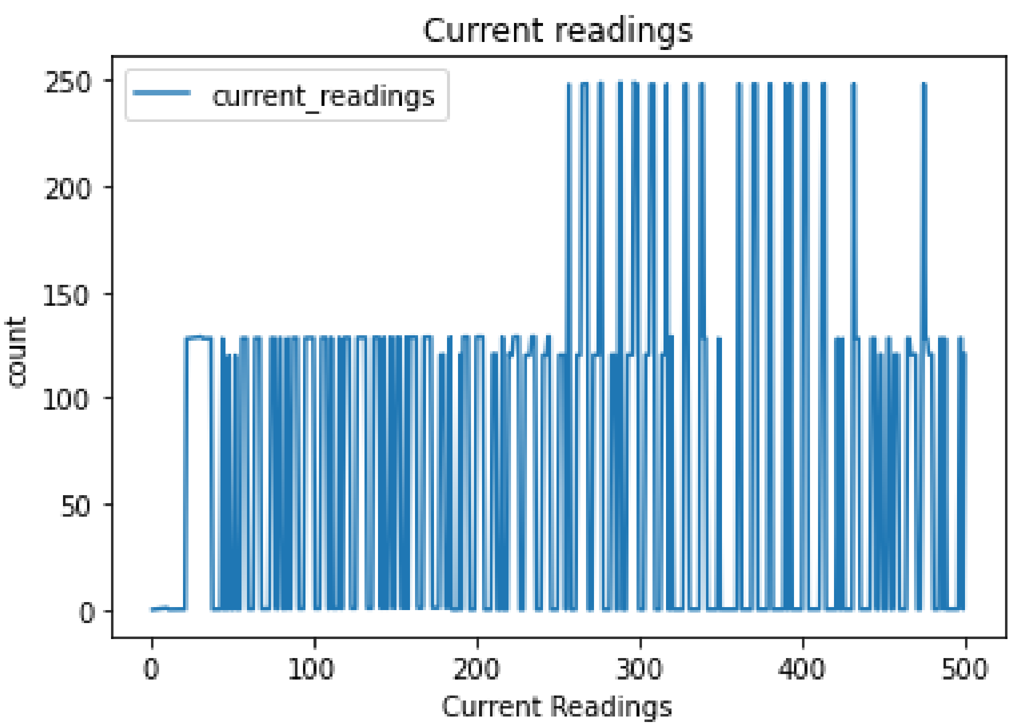
0.4.1 Line graph

[16]:
```
# Visualizing only the first 500 values to view it clearly
plt.figure(dpi=300)

df[:500].plot()
plt.xlabel("Current Readings")
plt.ylabel("count")
plt.title("Current readings")
```

[16]:
```
Text(0.5, 1.0, 'Current readings')
```

```
<Figure size 1800x1200 with 0 Axes>
```

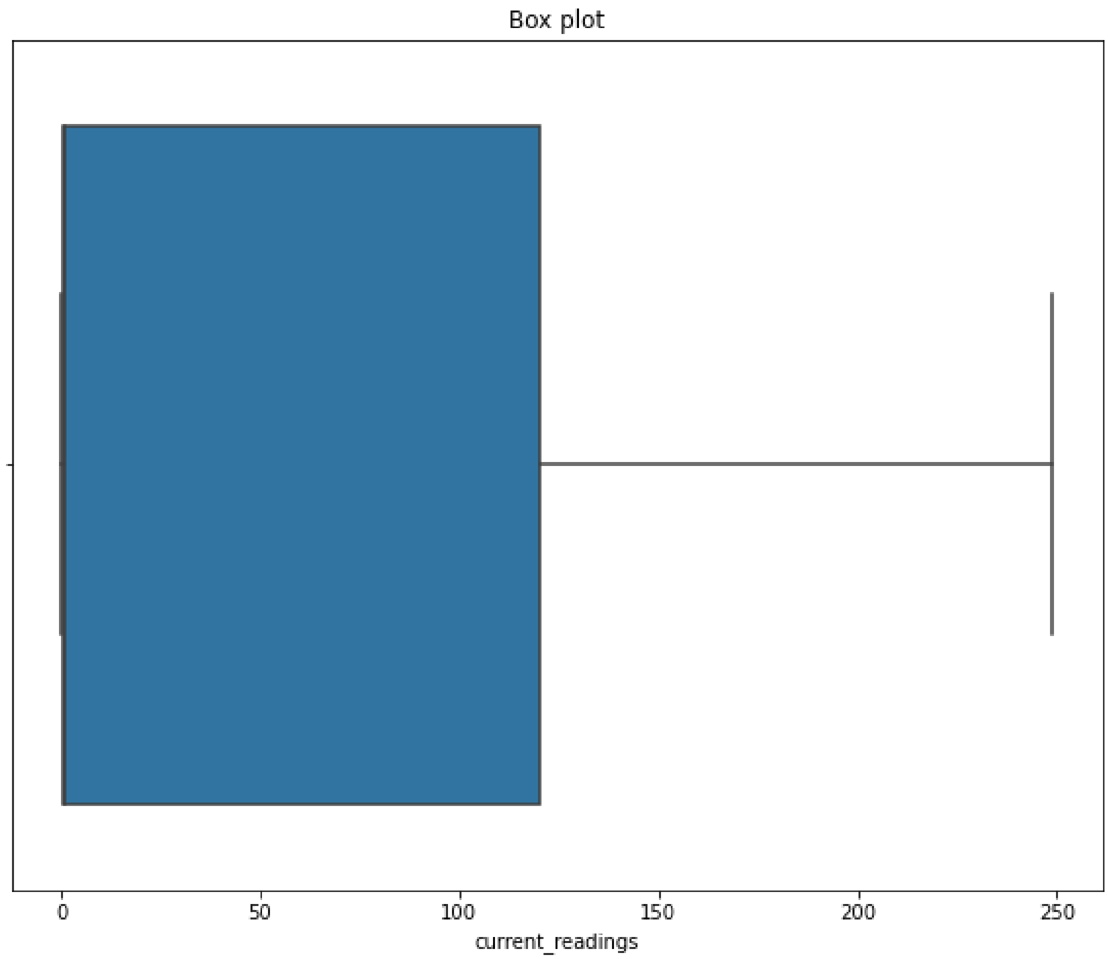


0.4.2 Box Plot

[17]:
```
# box plot
plt.figure(dpi=300)
plt.figure(figsize=(10,8))
sns.boxplot(data=df,x='current_readings');
plt.title('Box plot', fontsize = 12)
```

[17]:
```
Text(0.5, 1.0, 'Box plot')
```

```
<Figure size 1800x1200 with 0 Axes>
```



0.5 Histogram

[18]:
```
bins=np.arange(0,400,100)
plt.hist(df["current_readings"],bins,facecolor="red",edgecolor="yellow",alpha=0.
 ↪5);
plt.xticks(bins)
plt.title("Current readings distribution")
plt.xlabel("Current Readings")
plt.ylabel("count")
plt.show()
```

Findings:

It can be seen that 0 to 120 is the normal range.

Values > 200 are outliers and considered anomaly

The distribution is Right Skewed (Positive Skewness)

0.6 4. Feature Scaling

[19]:
```
# In order to fit data to the model, it has to be reshaped.
x = np.asarray(df['current_readings'])
x = x.reshape(-1,1)
x
```

[19]:
```
array([[0.000000e+00],
       [1.000000e-01],
       [2.000000e-01],
       …,
       [1.202066e+02],
       [2.481194e+02],
       [2.481195e+02]])
```

[20]:
```
# Perform Standard Scaling to restrict models from being biased towards␣
↪features having higher / lower magnitude values.
```

```
sc = StandardScaler()
x = sc.fit_transform(x)
x
```

[20]:
```
array([[-0.6537871 ],
       [-0.65253874],
       [-0.65129038],
       …,
       [ 0.8468228 ],
       [ 2.44363373],
       [ 2.44363498]])
```

[21]:
```
x.shape
```

[21]:
```
(13593, 1)
```

The data is now pre-processed and ready for modelling.

0.7 5. Model Building

Apprach for building model:

As there are no target labels, this is an Unsupervised machine learning problem.

Fit the data to KMeans Clustering algorithm and split the data into 2 clusters.

The cluster value can be stored as a target column and now our problem becomes a Classification type.

So use the whole dataset along with target column to train and build a classification model (Random Forest Classifier)

[22]:
```
## kmeans clustering algorithm

kmeans=KMeans(n_clusters=2, init='k-means++', random_state=0)
y = kmeans.fit_predict(x)
```

[23]:
```
kmeans.labels_
```

[23]:
```
array([0, 0, 0, …, 1, 1, 1])
```

[24]:
```
kmeans.cluster_centers_
```

[24]:
```
array([[-0.64743859],
       [ 1.3000349 ]])
```

[25]:
```
# append the predicted values to a new column

df["labels"]=kmeans.labels_
df
```

[25]:
```
        current_readings  labels
1                 0.0000       0
2                 0.1000       0
3                 0.2000       0
4                 0.3000       0
5                 0.4000       0
…                    …      …
13590           120.2065       1
13591           248.1193       1
13592           120.2066       1
13593           248.1194       1
13594           248.1195       1

[13593 rows x 2 columns]
```

The KMeans model has grouped the data into clusters 0 and 1. It can be interpreted as : > 0 = no (There is no anomaly) ; 1= yes (This is an anomaly)

[26]:
```
# making a copy of df
clustered_df = df.copy()
clustered_df
```

[26]:
```
        current_readings  labels
1                 0.0000       0
2                 0.1000       0
3                 0.2000       0
4                 0.3000       0
5                 0.4000       0
…                    …      …
13590           120.2065       1
13591           248.1193       1
13592           120.2066       1
13593           248.1194       1
13594           248.1195       1

[13593 rows x 2 columns]
```

[29]:
```
# For easy readability of dataset, change the target column to categorical
clustered_df["anomaly"] = "no"
clustered_df["anomaly"] = np.where(clustered_df["labels"] == 1, "yes",␣
 ↪clustered_df["anomaly"])
clustered_df.drop("labels",axis=1,inplace=True)
clustered_df
```

[29]:
```
        current_readings anomaly
1                 0.0000      no
2                 0.1000      no
3                 0.2000      no
```

```
4                 0.3000      no
5                 0.4000      no
…                   …       …
13590           120.2065     yes
13591           248.1193     yes
13592           120.2066     yes
13593           248.1194     yes
13594           248.1195     yes

[13593 rows x 2 columns]
```

[30]:
```python
clustered_df.head()
```

[30]:
```
   current_readings anomaly
1               0.0      no
2               0.1      no
3               0.2      no
4               0.3      no
5               0.4      no
```

[31]:
```python
clustered_df.tail()
```

[31]:
```
       current_readings anomaly
13590          120.2065     yes
13591          248.1193     yes
13592          120.2066     yes
13593          248.1194     yes
13594          248.1195     yes
```

[32]:
```python
# export the dataset to a csv file

clustered_df.to_csv("C:/Users/Kalpagam/udemy_bootcamp/ml_projects/
 ↪anomaly_detection/predictions/predicted.csv")
```

Now, readings which are outliers or anomalies are indicated as yes in the "anomaly" column.

Now, the problem has reduced to a classification problem

Data preprocessing

[35]:
```python
## split the dataset as train and test

from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test =␣
 ↪train_test_split(df["current_readings"],df["labels"])
x_train.shape, x_test.shape,y_train.shape,y_test.shape
```

[35]: ((10194,), (3399,), (10194,), (3399,))

[44]:
```
# reshape

x_train=np.asarray(x_train).reshape(-1,1)
y_train=np.asarray(y_train).reshape(-1,1)
x_test=np.asarray(x_test).reshape(-1,1)
y_test=np.asarray(y_test).reshape(-1,1)
x_train.shape,y_train.shape,x_test.shape,y_test.shape
```

[44]:
```
((10194, 1), (10194, 1), (3399, 1), (3399, 1))
```

[42]:
```
# classification model building

from sklearn.ensemble import RandomForestClassifier

# Instantiate model
model = RandomForestClassifier(n_jobs=-1)

# Fit the model
model.fit(x_train,y_train)
```

```
C:\Users\Kalpagam\AppData\Local\Temp\ipykernel_15376\1544301963.py:9:
DataConversionWarning: A column-vector y was passed when a 1d array was
expected. Please change the shape of y to (n_samples,), for example using
ravel().
  model.fit(x_train,y_train)
```

[42]:
```
RandomForestClassifier(n_jobs=-1)
```

[45]:
```
y_pred = model.predict(x_test)
```

[46]:
```
y_pred
```

[46]:
```
array([0, 1, 0, …, 0, 0, 0])
```

0.8 6. Model Evaluation

[48]:
```
model.score(x_test,y_test)
```

[48]:
```
1.0
```

[49]:
```
from sklearn.metrics import confusion_matrix, classification_report

print(confusion_matrix(y_test,y_pred))
```

```
[[2309    0]
 [   0 1090]]
```

[54]:
```
print(classification_report(y_test,y_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      2309
           1       1.00      1.00      1.00      1090

    accuracy                           1.00      3399
   macro avg       1.00      1.00      1.00      3399
weighted avg       1.00      1.00      1.00      3399
```

0.8.1 7. Save the model to a pickle file

The model is saved to a pickle file so that it can be imported and reused

[57]:
```
import pickle
file = open('C:/Users/Kalpagam/udemy_bootcamp/ml_projects/anomaly_detection/
 ↪trained_model.pkl','wb')
pickle.dump(model,file)
```

[58]:
```
model = open('C:/Users/Kalpagam/udemy_bootcamp/ml_projects/anomaly_detection/
 ↪trained_model.pkl','rb')
trained_model = pickle.load(model)
```

[66]:
```
sample_xtest_values = np.arange(0,150,2).reshape(-1,1)
sample_xtest_values.shape
```

[66]:
```
(75, 1)
```

giving some random test values to see if it classifies it

[67]:
```
result = trained_model.predict(sample_xtest_values)
print("Result:",result)
```

```
Result: [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 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 1 1 1 1 1
 1]
```