In [1]:
```
# To help you get started...
from IPython.display import display
import numpy as np
import pandas as pd
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.models import Model
from tensorflow.keras.layers import Input
from tensorflow.keras.layers import LSTM, SimpleRNN, GRU
from tensorflow.keras.layers import Dense
import matplotlib.pyplot as plt
import datetime as dt
from scipy import stats
from scipy.stats import scoreatpercentile
import math
from sklearn.preprocessing import minmax_scale
%matplotlib inline
```

In [2]:
```
df0 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df1 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df2 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df3 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df4 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df5 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df6 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df7 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df8 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df9 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\exa
df10 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df11 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df12 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df13 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df14 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df15 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df16 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df17 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df18 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
df19 = pd.read_csv(r'C:\Users\srika\OneDrive\Desktop\Spring20\Tagup\ex
```

Reframing all the dataframes in an understandable way

In [3]:
```
df2['Date_created']=df2.index
df2=df2.reset_index(drop=True)
df2.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df2.columns)
cols = [cols[-1]] + cols[:-1]
df2 = df2[cols]
```

Outlier Removal using standard deviation

In [4]:
```
df2=df2[abs(df2.sensor1-df2.sensor1.mean()) <= (3*df2.sensor1.std())]
df2=df2[abs(df2.sensor2-df2.sensor2.mean()) <= (3*df2.sensor2.std())]
df2=df2[abs(df2.sensor3-df2.sensor3.mean()) <= (3*df2.sensor3.std())]
df2=df2[abs(df2.sensor4-df2.sensor4.mean()) <= (3*df2.sensor4.std())]
```

In [5]:
```
df2=df2.reset_index(drop=True)
df2['Date_created'] = pd.to_datetime(df2['Date_created'], errors='coer
df2['day_of_week'] = df2['Date_created'].dt.dayofweek
df2['month'] = pd.DatetimeIndex(df2['Date_created']).month
df2['hour'] = pd.DatetimeIndex(df2['Date_created']).hour
```

Standardizing the data using minmax_scale

In [6]:
```
df2[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df2[['se
```

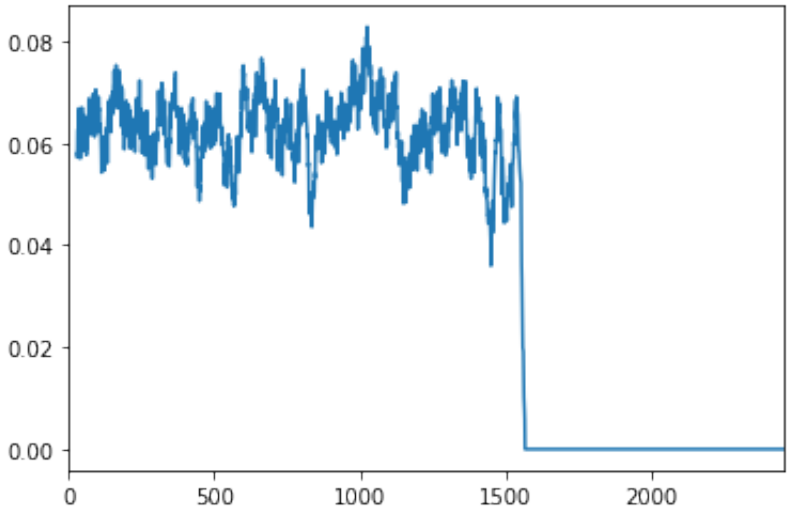
we use the moving variance to approximate the variation in the series at a point in time

In [7]:
```
df2['sensor1']=df2['sensor1'].rolling(window=30).var()
df2['sensor2']=df2['sensor2'].rolling(window=30).var()
df2['sensor3']=df2['sensor3'].rolling(window=30).var()
df2['sensor4']=df2['sensor4'].rolling(window=30).var()
```

Check when the machine is getting failed and remove the extra data

In [8]:
```
df2['sensor3'].plot()
```

Out[8]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d57364e0>
```



let us take the data till 1600 so that we can think after the machine is completely dead

In [9]:
```
df2=df2[:1600]
df2=df2.fillna(df2.mean())
df2_sensor1=pd.DataFrame(data=df2['sensor3'])
```

To use supervised learning methods, we define an anomaly flag, to equal True if an observation lies outside of Tukey's hinges across the sensor values.The anomaly flag is used to flag abnormal behaviour in the sensors

In [10]:
```
tukey_hinge=df2_sensor1.quantile(0.75)
df2_sensor1['labels']=df2_sensor1.apply(lambda row:1 if row.sensor3>tu
```

We fit a classification model to classify labels as predictors. Given that the predictors are sequence data, we consider the use of recurrent neural network (RNN) models for classifying anomalies. Traditional RNN units are unable to remember long-term dependencies and susceptible to the vanishing gradient problem, and for this purpose LSTM units may be more suitable

In [11]:
```
def create_dataset(df2_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df2_sensor1)-look_back-1):
        a = df2_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df2_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
```

Constructig Dataframe

In [12]:
```
values=create_dataset(df2_sensor1,look_back=10)
df_sensor1=pd.DataFrame(data=values[0])
df_sensor1['labels']=pd.DataFrame(data=values[1])
df2_sensor1_final=df_sensor1
df2_sensor1_final.head()
```

Out[12]:

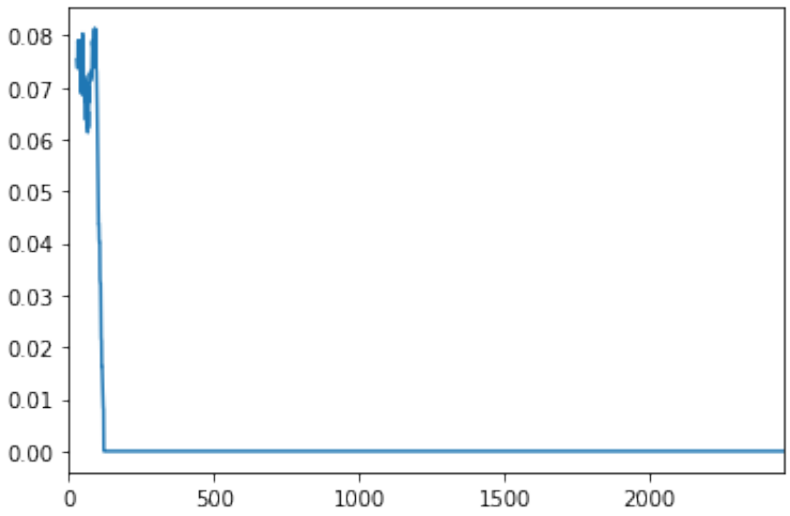
	0	1	2	3	4	5	6	7	8	
0	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0
1	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0
2	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0
3	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0
4	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0.061145	0

The exact same procedure follows for all the remaining 18 machines and 1st machine dataset can be verified for test set

In [13]:
```
df3['Date_created']=df3.index
df3=df3.reset_index(drop=True)
df3.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df3.columns)
cols = [cols[-1]] + cols[:-1]
df3 = df3[cols]
df3=df3[abs(df3.sensor1-df3.sensor1.mean()) <= (3*df3.sensor1.std())]
df3=df3[abs(df3.sensor2-df3.sensor2.mean()) <= (3*df3.sensor2.std())]
df3=df3[abs(df3.sensor3-df3.sensor3.mean()) <= (3*df3.sensor3.std())]
df3=df3[abs(df3.sensor4-df3.sensor4.mean()) <= (3*df3.sensor4.std())]
df3=df3.reset_index(drop=True)
df3['Date_created'] = pd.to_datetime(df3['Date_created'], errors='coer
df3['day_of_week'] = df3['Date_created'].dt.dayofweek
df3['month'] = pd.DatetimeIndex(df3['Date_created']).month
df3['hour'] = pd.DatetimeIndex(df3['Date_created']).hour
df3[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df3[['se
df3['sensor1']=df3['sensor1'].rolling(window=30).var()
df3['sensor2']=df3['sensor2'].rolling(window=30).var()
df3['sensor3']=df3['sensor3'].rolling(window=30).var()
df3['sensor4']=df3['sensor4'].rolling(window=30).var()
```

In [14]:
```
df3['sensor3'].plot()
```

Out[14]: <matplotlib.axes._subplots.AxesSubplot at 0x2d1d5bc20b8>



In [15]:
```
df3=df3[:130]
df3=df3.fillna(df3.mean())
df3_sensor1=pd.DataFrame(data=df3['sensor3'])
tukey_hinge=df3_sensor1.quantile(0.75)
df3_sensor1['labels']=df3_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df3_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df3_sensor1)-look_back-1):
        a = df3_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df3_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df3_sensor1,look_back=10)
df3_sensor1_final=pd.DataFrame(data=values[0])
df3_sensor1_final['labels']=pd.DataFrame(data=values[1])
df3_sensor1_final.head()
```

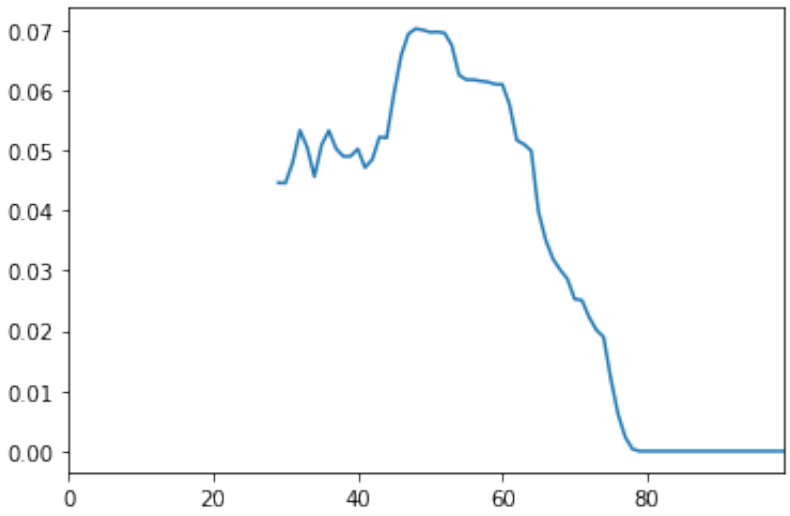
Out[15]:

	0	1	2	3	4	5	6	7	8	
0	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0
1	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0
2	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0
3	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0
4	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0.057067	0

In [16]:
```
df4['Date_created']=df4.index
df4=df4.reset_index(drop=True)
df4.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df4.columns)
cols = [cols[-1]] + cols[:-1]
df4 = df4[cols]
df4=df4[abs(df4.sensor1-df4.sensor1.mean()) <= (3*df4.sensor1.std())]
df4=df4[abs(df4.sensor2-df4.sensor2.mean()) <= (3*df4.sensor2.std())]
df4=df4[abs(df4.sensor3-df4.sensor3.mean()) <= (3*df4.sensor3.std())]
df4=df4[abs(df4.sensor4-df4.sensor4.mean()) <= (3*df4.sensor4.std())]
df4=df4.reset_index(drop=True)
df4['Date_created'] = pd.to_datetime(df4['Date_created'], errors='coer
df4['day_of_week'] = df4['Date_created'].dt.dayofweek
df4['month'] = pd.DatetimeIndex(df4['Date_created']).month
df4['hour'] = pd.DatetimeIndex(df4['Date_created']).hour
df4[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df4[['se
df4['sensor1']=df4['sensor1'].rolling(window=30).var()
df4['sensor2']=df4['sensor2'].rolling(window=30).var()
df4['sensor3']=df4['sensor3'].rolling(window=30).var()
df4['sensor4']=df4['sensor4'].rolling(window=30).var()
```

In [17]:
```
df4['sensor3'][:100].plot()
```

Out[17]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d7dbdeb8>
```



In [18]:
```
df4=df4[:80]
df4=df4.fillna(df4.mean())
df4_sensor1=pd.DataFrame(data=df4['sensor3'])
tukey_hinge=df4_sensor1.quantile(0.75)
df4_sensor1['labels']=df4_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df4_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df4_sensor1)-look_back-1):
        a = df4_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df4_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df4_sensor1,look_back=10)
df4_sensor1_final=pd.DataFrame(data=values[0])
df4_sensor1_final['labels']=pd.DataFrame(data=values[1])
df4_sensor1_final.head()
```

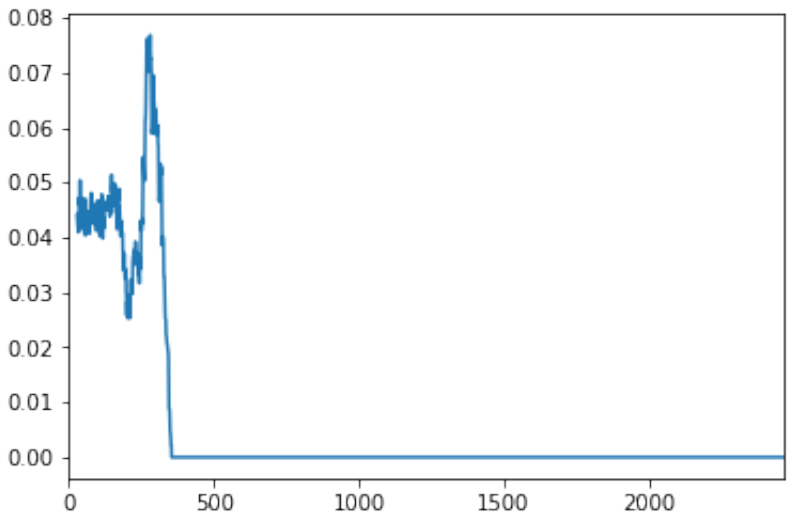
Out[18]:

	0	1	2	3	4	5	6	7	8	
0	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0
1	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0
2	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0
3	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0
4	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0.045847	0

In [19]:
```
df5['Date_created']=df5.index
df5=df5.reset_index(drop=True)
df5.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df5.columns)
cols = [cols[-1]] + cols[:-1]
df5 = df5[cols]
df5=df5[abs(df5.sensor1-df5.sensor1.mean()) <= (3*df5.sensor1.std())]
df5=df5[abs(df5.sensor2-df5.sensor2.mean()) <= (3*df5.sensor2.std())]
df5=df5[abs(df5.sensor3-df5.sensor3.mean()) <= (3*df5.sensor3.std())]
df5=df5[abs(df5.sensor4-df5.sensor4.mean()) <= (3*df5.sensor4.std())]
df5=df5.reset_index(drop=True)
df5['Date_created'] = pd.to_datetime(df5['Date_created'], errors='coer
df5['day_of_week'] = df5['Date_created'].dt.dayofweek
df5['month'] = pd.DatetimeIndex(df5['Date_created']).month
df5['hour'] = pd.DatetimeIndex(df5['Date_created']).hour
df5[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df5[['se
df5['sensor1']=df5['sensor1'].rolling(window=30).var()
df5['sensor2']=df5['sensor2'].rolling(window=30).var()
df5['sensor3']=df5['sensor3'].rolling(window=30).var()
df5['sensor4']=df5['sensor4'].rolling(window=30).var()
```

In [20]:
```
df5['sensor3'].plot()
```

Out[20]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d5985b70>
```



In [21]:
```
df5=df5[:370]
df5=df5.fillna(df5.mean())
df5_sensor1=pd.DataFrame(data=df5['sensor3'])
tukey_hinge=df5_sensor1.quantile(0.75)
df5_sensor1['labels']=df5_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df5_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df5_sensor1)-look_back-1):
        a = df5_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df5_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df5_sensor1,look_back=10)
df5_sensor1_final=pd.DataFrame(data=values[0])
df5_sensor1_final['labels']=pd.DataFrame(data=values[1])
df5_sensor1_final.head()
```

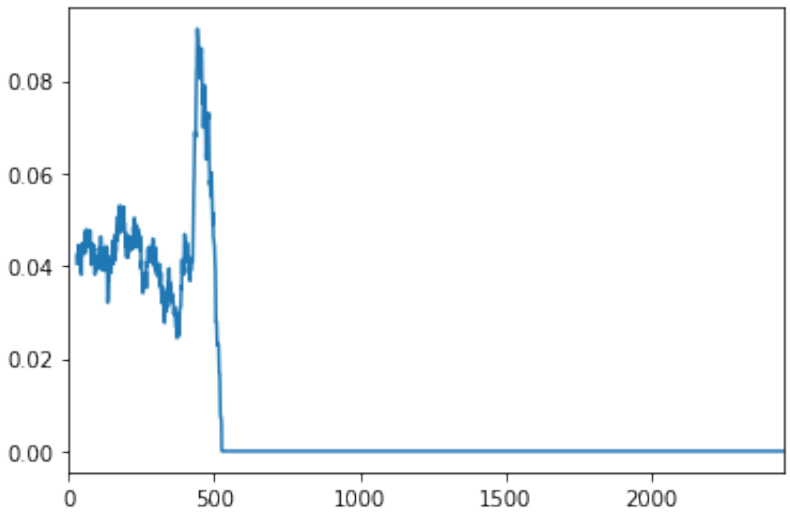
Out[21]:

	0	1	2	3	4	5	6	7	8	
0	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0
1	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0
2	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0
3	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0
4	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0.041574	0

In [22]:
```
df6['Date_created']=df6.index
df6=df6.reset_index(drop=True)
df6.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df6.columns)
cols = [cols[-1]] + cols[:-1]
df6 = df6[cols]
df6=df6[abs(df6.sensor1-df6.sensor1.mean()) <= (3*df6.sensor1.std())]
df6=df6[abs(df6.sensor2-df6.sensor2.mean()) <= (3*df6.sensor2.std())]
df6=df6[abs(df6.sensor3-df6.sensor3.mean()) <= (3*df6.sensor3.std())]
df6=df6[abs(df6.sensor4-df6.sensor4.mean()) <= (3*df6.sensor4.std())]
df6=df6.reset_index(drop=True)
df6['Date_created'] = pd.to_datetime(df6['Date_created'], errors='coer
df6['day_of_week'] = df6['Date_created'].dt.dayofweek
df6['month'] = pd.DatetimeIndex(df6['Date_created']).month
df6['hour'] = pd.DatetimeIndex(df6['Date_created']).hour
df6[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df6[['se
df6['sensor1']=df6['sensor1'].rolling(window=30).var()
df6['sensor2']=df6['sensor2'].rolling(window=30).var()
df6['sensor3']=df6['sensor3'].rolling(window=30).var()
df6['sensor4']=df6['sensor4'].rolling(window=30).var()
```

In [23]:
```
df6['sensor3'].plot()
```

Out[23]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d593b208>
```



In [24]:
```
df6=df6[:550]
df6=df6.fillna(df6.mean())
df6_sensor1=pd.DataFrame(data=df6['sensor3'])
tukey_hinge=df6_sensor1.quantile(0.75)
df6_sensor1['labels']=df6_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df6_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df6_sensor1)-look_back-1):
        a = df6_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df6_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df6_sensor1,look_back=10)
df6_sensor1_final=pd.DataFrame(data=values[0])
df6_sensor1_final['labels']=pd.DataFrame(data=values[1])
df6_sensor1_final.head()
```

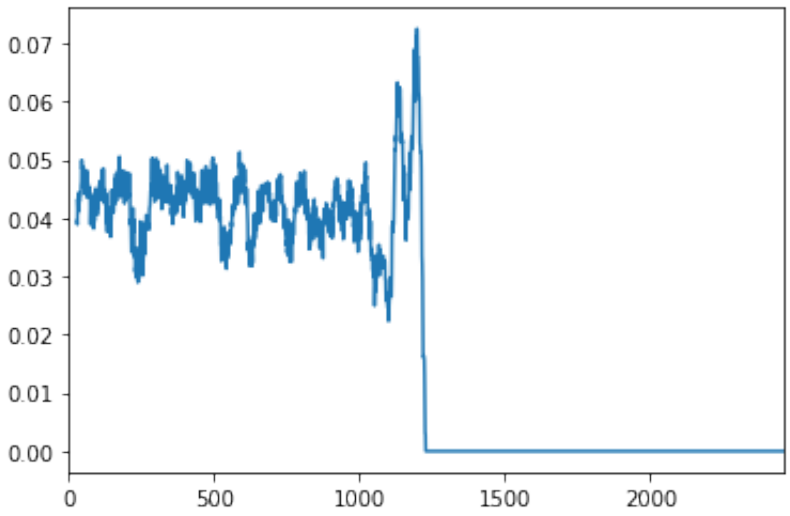
Out[24]:

	0	1	2	3	4	5	6	7	8	
0	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0
1	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0
2	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0
3	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0
4	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0.042249	0

In [25]:
```
df7['Date_created']=df7.index
df7=df7.reset_index(drop=True)
df7.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df7.columns)
cols = [cols[-1]] + cols[:-1]
df7 = df7[cols]
df7=df7[abs(df7.sensor1-df7.sensor1.mean()) <= (3*df7.sensor1.std())]
df7=df7[abs(df7.sensor2-df7.sensor2.mean()) <= (3*df7.sensor2.std())]
df7=df7[abs(df7.sensor3-df7.sensor3.mean()) <= (3*df7.sensor3.std())]
df7=df7[abs(df7.sensor4-df7.sensor4.mean()) <= (3*df7.sensor4.std())]
df7=df7.reset_index(drop=True)
df7['Date_created'] = pd.to_datetime(df7['Date_created'], errors='coer
df7['day_of_week'] = df7['Date_created'].dt.dayofweek
df7['month'] = pd.DatetimeIndex(df7['Date_created']).month
df7['hour'] = pd.DatetimeIndex(df7['Date_created']).hour
df7[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df7[['se
df7['sensor1']=df7['sensor1'].rolling(window=30).var()
df7['sensor2']=df7['sensor2'].rolling(window=30).var()
df7['sensor3']=df7['sensor3'].rolling(window=30).var()
df7['sensor4']=df7['sensor4'].rolling(window=30).var()
```

In [26]:
```
df7['sensor3'].plot()
```

Out[26]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d7da8a90>
```



In [27]:
```
df7=df7[:1300]
df7=df7.fillna(df7.mean())
df7_sensor1=pd.DataFrame(data=df7['sensor3'])
tukey_hinge=df7_sensor1.quantile(0.75)
df7_sensor1['labels']=df7_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df7_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df7_sensor1)-look_back-1):
        a = df7_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df7_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df7_sensor1,look_back=10)
df7_sensor1_final=pd.DataFrame(data=values[0])
df7_sensor1_final['labels']=pd.DataFrame(data=values[1])
df7_sensor1_final.head()
```

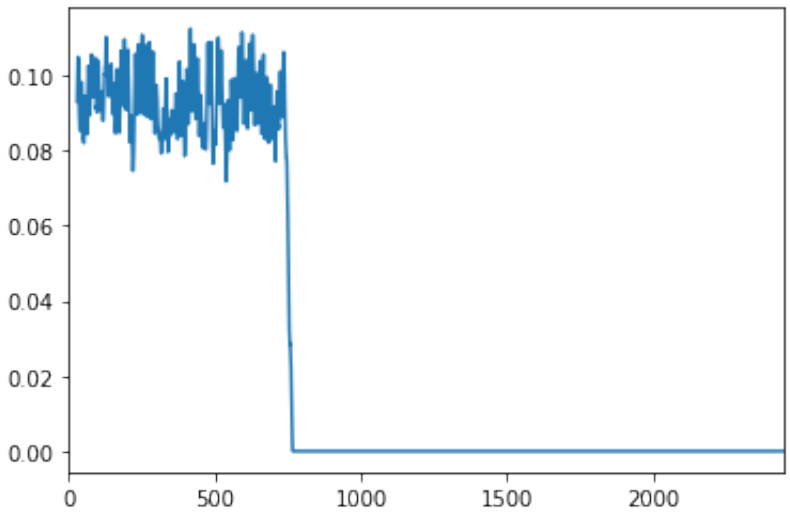
Out[27]:

	0	1	2	3	4	5	6	7	8	
0	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0
1	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0
2	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0
3	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0
4	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0.039599	0

In [29]:
```
df8['Date_created']=df8.index
df8=df8.reset_index(drop=True)
df8.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df8.columns)
cols = [cols[-1]] + cols[:-1]
df8 = df8[cols]
df8=df8[abs(df8.sensor1-df8.sensor1.mean()) <= (3*df8.sensor1.std())]
df8=df8[abs(df8.sensor2-df8.sensor2.mean()) <= (3*df8.sensor2.std())]
df8=df8[abs(df8.sensor3-df8.sensor3.mean()) <= (3*df8.sensor3.std())]
df8=df8[abs(df8.sensor4-df8.sensor4.mean()) <= (3*df8.sensor4.std())]
df8=df8.reset_index(drop=True)
df8['Date_created'] = pd.to_datetime(df8['Date_created'], errors='coer
df8['day_of_week'] = df8['Date_created'].dt.dayofweek
df8['month'] = pd.DatetimeIndex(df8['Date_created']).month
df8['hour'] = pd.DatetimeIndex(df8['Date_created']).hour
df8[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df8[['se
df8['sensor1']=df8['sensor1'].rolling(window=30).var()
df8['sensor2']=df8['sensor2'].rolling(window=30).var()
df8['sensor3']=df8['sensor3'].rolling(window=30).var()
df8['sensor4']=df8['sensor4'].rolling(window=30).var()
```

In [459]:
```
df8['sensor3'].plot()
```

Out[459]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2260a96c780>
```



In [30]:
```
df8=df8[:900]
df8=df8.fillna(df8.mean())
df8_sensor1=pd.DataFrame(data=df8['sensor3'])
tukey_hinge=df8_sensor1.quantile(0.75)
df8_sensor1['labels']=df8_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df8_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df8_sensor1)-look_back-1):
        a = df8_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df8_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df8_sensor1,look_back=10)
df8_sensor1_final=pd.DataFrame(data=values[0])
df8_sensor1_final['labels']=pd.DataFrame(data=values[1])
df8_sensor1_final.head()
```

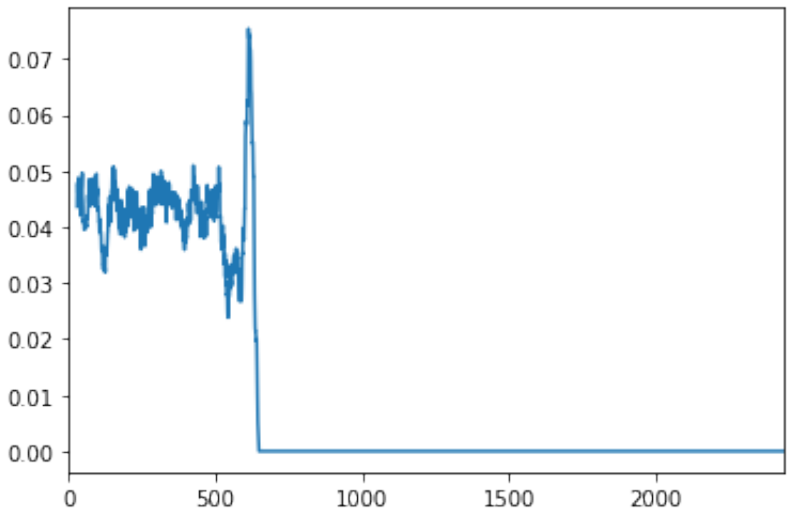
Out[30]:

	0	1	2	3	4	5	6	7	8	
0	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0
1	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0
2	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0
3	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0
4	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0.004124	0

In [31]:
```
df9['Date_created']=df9.index
df9=df9.reset_index(drop=True)
df9.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df9.columns)
cols = [cols[-1]] + cols[:-1]
df9 = df9[cols]
df9=df9[abs(df9.sensor1-df9.sensor1.mean()) <= (3*df9.sensor1.std())]
df9=df9[abs(df9.sensor2-df9.sensor2.mean()) <= (3*df9.sensor2.std())]
df9=df9[abs(df9.sensor3-df9.sensor3.mean()) <= (3*df9.sensor3.std())]
df9=df9[abs(df9.sensor4-df9.sensor4.mean()) <= (3*df9.sensor4.std())]
df9=df9.reset_index(drop=True)
df9['Date_created'] = pd.to_datetime(df9['Date_created'], errors='coer
df9['day_of_week'] = df9['Date_created'].dt.dayofweek
df9['month'] = pd.DatetimeIndex(df9['Date_created']).month
df9['hour'] = pd.DatetimeIndex(df9['Date_created']).hour
df9[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df9[['se
df9['sensor1']=df9['sensor1'].rolling(window=30).var()
df9['sensor2']=df9['sensor2'].rolling(window=30).var()
df9['sensor3']=df9['sensor3'].rolling(window=30).var()
df9['sensor4']=df9['sensor4'].rolling(window=30).var()
```

In [32]:
```
df9['sensor3'].plot()
```

Out[32]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d7da7588>
```



In [33]:
```
df9=df9[:750]
df9=df9.fillna(df9.mean())
df9_sensor1=pd.DataFrame(data=df9['sensor3'])
tukey_hinge=df9_sensor1.quantile(0.75)
df9_sensor1['labels']=df9_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df9_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df9_sensor1)-look_back-1):
        a = df9_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df9_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df9_sensor1,look_back=10)
df9_sensor1_final=pd.DataFrame(data=values[0])
df9_sensor1_final['labels']=pd.DataFrame(data=values[1])
df9_sensor1_final.head()
```

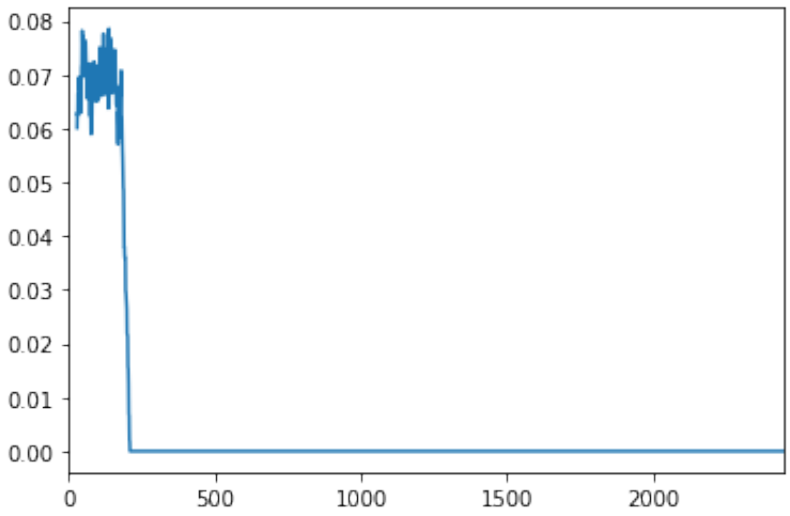
Out[33]:

	0	1	2	3	4	5	6	7	8	
0	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0
1	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0
2	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0
3	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0
4	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0.036288	0

In [34]:
```
df10['Date_created']=df10.index
df10=df10.reset_index(drop=True)
df10.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df10.columns)
cols = [cols[-1]] + cols[:-1]
df10 = df10[cols]
df10=df10[abs(df10.sensor1-df10.sensor1.mean()) <= (3*df10.sensor1.std
df10=df10[abs(df10.sensor2-df10.sensor2.mean()) <= (3*df10.sensor2.std
df10=df10[abs(df10.sensor3-df10.sensor3.mean()) <= (3*df10.sensor3.std
df10=df10[abs(df10.sensor4-df10.sensor4.mean()) <= (3*df10.sensor4.std
df10=df10.reset_index(drop=True)
df10['Date_created'] = pd.to_datetime(df10['Date_created'], errors='co
df10['day_of_week'] = df10['Date_created'].dt.dayofweek
df10['month'] = pd.DatetimeIndex(df10['Date_created']).month
df10['hour'] = pd.DatetimeIndex(df10['Date_created']).hour
df10[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df10[['
df10['sensor1']=df10['sensor1'].rolling(window=30).var()
df10['sensor2']=df10['sensor2'].rolling(window=30).var()
df10['sensor3']=df10['sensor3'].rolling(window=30).var()
df10['sensor4']=df10['sensor4'].rolling(window=30).var()
```

In [35]:
```
df10['sensor3'].plot()
```

Out[35]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d593b5c0>
```



In [36]:
```
df10=df10[:750]
df10=df10.fillna(df10.mean())
df10_sensor1=pd.DataFrame(data=df10['sensor3'])
tukey_hinge=df10_sensor1.quantile(0.75)
df10_sensor1['labels']=df10_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df10_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df10_sensor1)-look_back-1):
        a = df10_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df10_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df10_sensor1,look_back=10)
df10_sensor1_final=pd.DataFrame(data=values[0])
df10_sensor1_final['labels']=pd.DataFrame(data=values[1])
df10_sensor1_final.head()
```

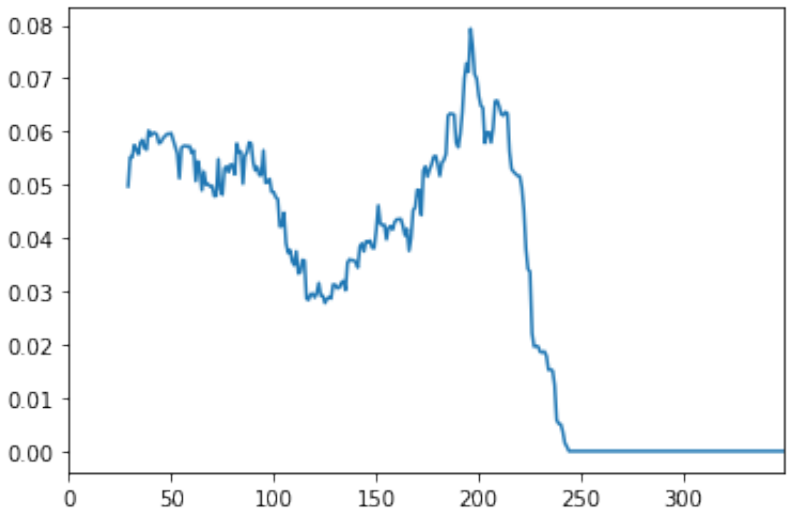
Out[36]:

	0	1	2	3	4	5	6	7	8	
0	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0
1	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0
2	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0
3	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0
4	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0.015893	0

In [37]:
```
df11['Date_created']=df11.index
df11=df11.reset_index(drop=True)
df11.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df11.columns)
cols = [cols[-1]] + cols[:-1]
df11 = df11[cols]
df11=df11[abs(df11.sensor1-df11.sensor1.mean()) <= (3*df11.sensor1.std
df11=df11[abs(df11.sensor2-df11.sensor2.mean()) <= (3*df11.sensor2.std
df11=df11[abs(df11.sensor3-df11.sensor3.mean()) <= (3*df11.sensor3.std
df11=df11[abs(df11.sensor4-df11.sensor4.mean()) <= (3*df11.sensor4.std
df11=df11.reset_index(drop=True)
df11['Date_created'] = pd.to_datetime(df11['Date_created'], errors='co
df11['day_of_week'] = df11['Date_created'].dt.dayofweek
df11['month'] = pd.DatetimeIndex(df11['Date_created']).month
df11['hour'] = pd.DatetimeIndex(df11['Date_created']).hour
df11[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df11[['
df11['sensor1']=df11['sensor1'].rolling(window=30).var()
df11['sensor2']=df11['sensor2'].rolling(window=30).var()
df11['sensor3']=df11['sensor3'].rolling(window=30).var()
df11['sensor4']=df11['sensor4'].rolling(window=30).var()
```

In [38]:
```
df11['sensor3'][:350].plot()
```

Out[38]: <matplotlib.axes._subplots.AxesSubplot at 0x2d1d7efb5c0>



In [39]:
```
df11=df11[:250]
df11=df11.fillna(df11.mean())
df11_sensor1=pd.DataFrame(data=df11['sensor3'])
tukey_hinge=df11_sensor1.quantile(0.75)
df11_sensor1['labels']=df11_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df11_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df11_sensor1)-look_back-1):
        a = df11_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df11_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df11_sensor1,look_back=10)
df11_sensor1_final=pd.DataFrame(data=values[0])
df11_sensor1_final['labels']=pd.DataFrame(data=values[1])
df11_sensor1_final.head()
```

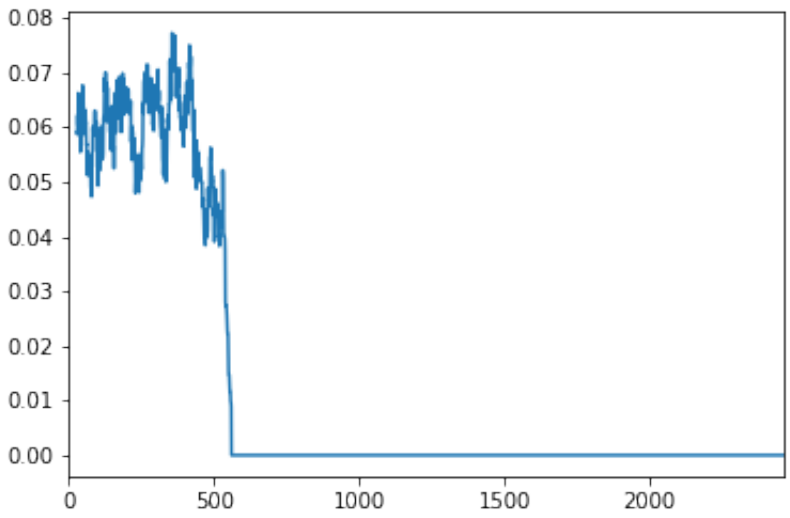
Out[39]:

	0	1	2	3	4	5	6	7	8	
0	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0
1	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0
2	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0
3	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0
4	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0.045103	0

In [40]:
```
df12['Date_created']=df12.index
df12=df12.reset_index(drop=True)
df12.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df12.columns)
cols = [cols[-1]] + cols[:-1]
df12 = df12[cols]
df12=df12[abs(df12.sensor1-df12.sensor1.mean()) <= (3*df12.sensor1.std
df12=df12[abs(df12.sensor2-df12.sensor2.mean()) <= (3*df12.sensor2.std
df12=df12[abs(df12.sensor3-df12.sensor3.mean()) <= (3*df12.sensor3.std
df12=df12[abs(df12.sensor4-df12.sensor4.mean()) <= (3*df12.sensor4.std
df12=df12.reset_index(drop=True)
df12['Date_created'] = pd.to_datetime(df12['Date_created'], errors='co
df12['day_of_week'] = df12['Date_created'].dt.dayofweek
df12['month'] = pd.DatetimeIndex(df12['Date_created']).month
df12['hour'] = pd.DatetimeIndex(df12['Date_created']).hour
df12[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df12[['
df12['sensor1']=df12['sensor1'].rolling(window=30).var()
df12['sensor2']=df12['sensor2'].rolling(window=30).var()
df12['sensor3']=df12['sensor3'].rolling(window=30).var()
df12['sensor4']=df12['sensor4'].rolling(window=30).var()
```

In [41]:
```
df12['sensor3'].plot()
```

Out[41]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d7e042b0>
```



In [42]:
```
df12=df12[:600]
df12=df12.fillna(df12.mean())
df12_sensor1=pd.DataFrame(data=df12['sensor3'])
tukey_hinge=df12_sensor1.quantile(0.75)
df12_sensor1['labels']=df12_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df12_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df12_sensor1)-look_back-1):
        a = df12_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df12_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df12_sensor1,look_back=10)
df12_sensor1_final=pd.DataFrame(data=values[0])
df12_sensor1_final['labels']=pd.DataFrame(data=values[1])
df12_sensor1_final.head()
```

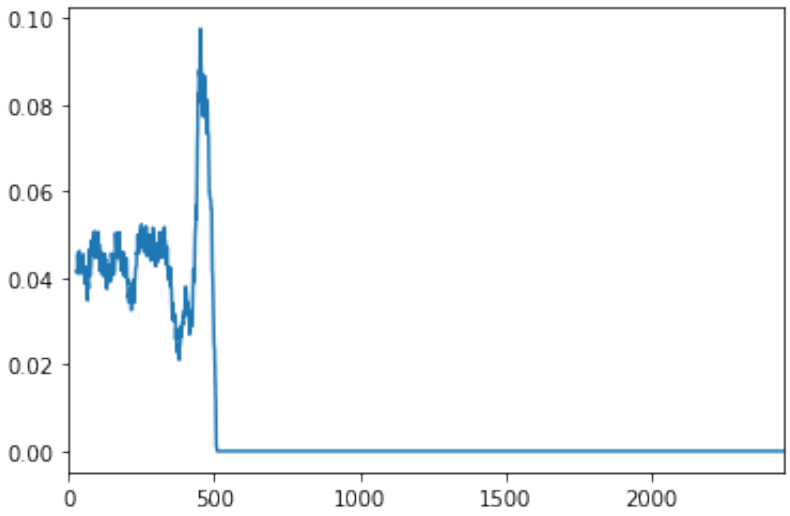
Out[42]:

	0	1	2	3	4	5	6	7	8	
0	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	C
1	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	C
2	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	C
3	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	C
4	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	0.053268	C

In [43]:
```
df13['Date_created']=df13.index
df13=df13.reset_index(drop=True)
df13.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df13.columns)
cols = [cols[-1]] + cols[:-1]
df13 = df13[cols]
df13=df13[abs(df13.sensor1-df13.sensor1.mean()) <= (3*df13.sensor1.std
df13=df13[abs(df13.sensor2-df13.sensor2.mean()) <= (3*df13.sensor2.std
df13=df13[abs(df13.sensor3-df13.sensor3.mean()) <= (3*df13.sensor3.std
df13=df13[abs(df13.sensor4-df13.sensor4.mean()) <= (3*df13.sensor4.std
df13=df13.reset_index(drop=True)
df13['Date_created'] = pd.to_datetime(df13['Date_created'], errors='co
df13['day_of_week'] = df13['Date_created'].dt.dayofweek
df13['month'] = pd.DatetimeIndex(df13['Date_created']).month
df13['hour'] = pd.DatetimeIndex(df13['Date_created']).hour
df13[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df13[['
df13['sensor1']=df13['sensor1'].rolling(window=30).var()
df13['sensor2']=df13['sensor2'].rolling(window=30).var()
df13['sensor3']=df13['sensor3'].rolling(window=30).var()
df13['sensor4']=df13['sensor4'].rolling(window=30).var()
```

In [44]:
```
df13['sensor3'].plot()
```

Out[44]: <matplotlib.axes._subplots.AxesSubplot at 0x2d1d57c4b70>



In [45]:
```
df13=df13[:500]
df13=df13.fillna(df13.mean())
df13_sensor1=pd.DataFrame(data=df13['sensor3'])
tukey_hinge=df13_sensor1.quantile(0.75)
df13_sensor1['labels']=df13_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df13_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df13_sensor1)-look_back-1):
        a = df13_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df13_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df13_sensor1,look_back=10)
df13_sensor1_final=pd.DataFrame(data=values[0])
df13_sensor1_final['labels']=pd.DataFrame(data=values[1])
df13_sensor1_final.head()
```

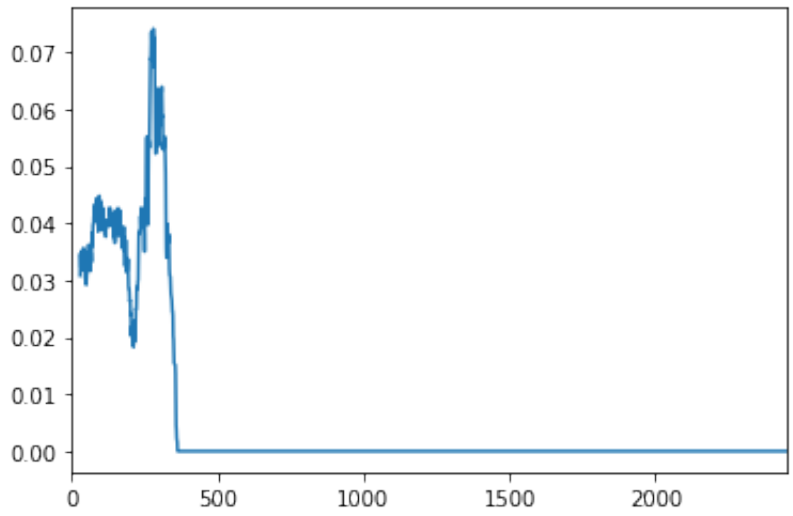
Out[45]:

	0	1	2	3	4	5	6	7	8	
0	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0
1	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0
2	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0
3	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0
4	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0.045635	0

In [46]:
```
df14['Date_created']=df14.index
df14=df14.reset_index(drop=True)
df14.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df14.columns)
cols = [cols[-1]] + cols[:-1]
df14 = df14[cols]
df14=df14[abs(df14.sensor1-df14.sensor1.mean()) <= (3*df14.sensor1.std
df14=df14[abs(df14.sensor2-df14.sensor2.mean()) <= (3*df14.sensor2.std
df14=df14[abs(df14.sensor3-df14.sensor3.mean()) <= (3*df14.sensor3.std
df14=df14[abs(df14.sensor4-df14.sensor4.mean()) <= (3*df14.sensor4.std
df14=df14.reset_index(drop=True)
df14['Date_created'] = pd.to_datetime(df14['Date_created'], errors='co
df14['day_of_week'] = df14['Date_created'].dt.dayofweek
df14['month'] = pd.DatetimeIndex(df14['Date_created']).month
df14['hour'] = pd.DatetimeIndex(df14['Date_created']).hour
df14[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df14[['
df14['sensor1']=df14['sensor1'].rolling(window=30).var()
df14['sensor2']=df14['sensor2'].rolling(window=30).var()
df14['sensor3']=df14['sensor3'].rolling(window=30).var()
df14['sensor4']=df14['sensor4'].rolling(window=30).var()
```

In [47]:
```
df14['sensor3'].plot()
```

Out[47]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d57ec518>
```



In [48]:
```
df14=df14[:500]
df14=df14.fillna(df14.mean())
df14_sensor1=pd.DataFrame(data=df14['sensor3'])
tukey_hinge=df14_sensor1.quantile(0.75)
df14_sensor1['labels']=df14_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df14_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df14_sensor1)-look_back-1):
        a = df14_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df14_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df14_sensor1,look_back=10)
df14_sensor1_final=pd.DataFrame(data=values[0])
df14_sensor1_final['labels']=pd.DataFrame(data=values[1])
df14_sensor1_final.head()
```

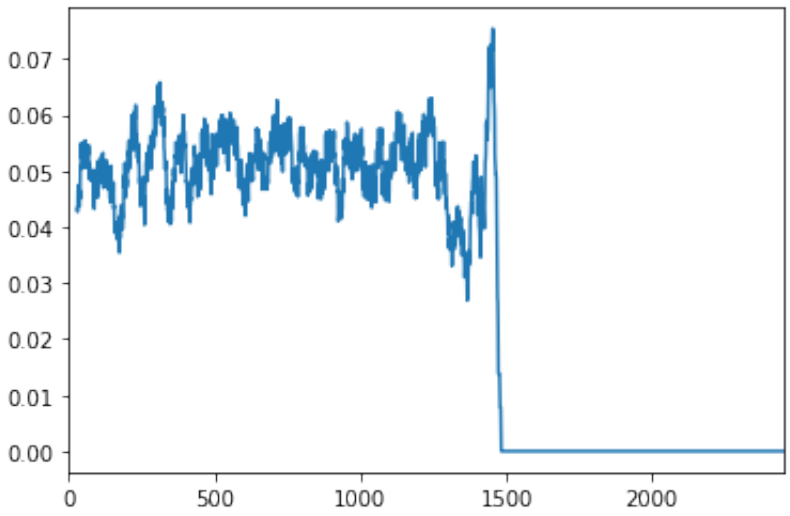
Out[48]:

	0	1	2	3	4	5	6	7	8	9	la
0	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	
1	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	
2	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	
3	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	
4	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	0.02792	

In [49]:
```
df15['Date_created']=df15.index
df15=df15.reset_index(drop=True)
df15.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df15.columns)
cols = [cols[-1]] + cols[:-1]
df15 = df15[cols]
df15=df15[abs(df15.sensor1-df15.sensor1.mean()) <= (3*df15.sensor1.std
df15=df15[abs(df15.sensor2-df15.sensor2.mean()) <= (3*df15.sensor2.std
df15=df15[abs(df15.sensor3-df15.sensor3.mean()) <= (3*df15.sensor3.std
df15=df15[abs(df15.sensor4-df15.sensor4.mean()) <= (3*df15.sensor4.std
df15=df15.reset_index(drop=True)
df15['Date_created'] = pd.to_datetime(df15['Date_created'], errors='co
df15['day_of_week'] = df15['Date_created'].dt.dayofweek
df15['month'] = pd.DatetimeIndex(df15['Date_created']).month
df15['hour'] = pd.DatetimeIndex(df15['Date_created']).hour
df15[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df15[['
df15['sensor1']=df15['sensor1'].rolling(window=30).var()
df15['sensor2']=df15['sensor2'].rolling(window=30).var()
df15['sensor3']=df15['sensor3'].rolling(window=30).var()
df15['sensor4']=df15['sensor4'].rolling(window=30).var()
```

In [50]:
```
df15['sensor3'].plot()
```

Out[50]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d80040b8>
```



In [51]:
```
df15=df15[:1450]
df15=df15.fillna(df15.mean())
df15_sensor1=pd.DataFrame(data=df15['sensor3'])
tukey_hinge=df15_sensor1.quantile(0.75)
df15_sensor1['labels']=df15_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df15_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df15_sensor1)-look_back-1):
        a = df15_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df15_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df15_sensor1,look_back=10)
df15_sensor1_final=pd.DataFrame(data=values[0])
df15_sensor1_final['labels']=pd.DataFrame(data=values[1])
df15_sensor1_final.head()
```

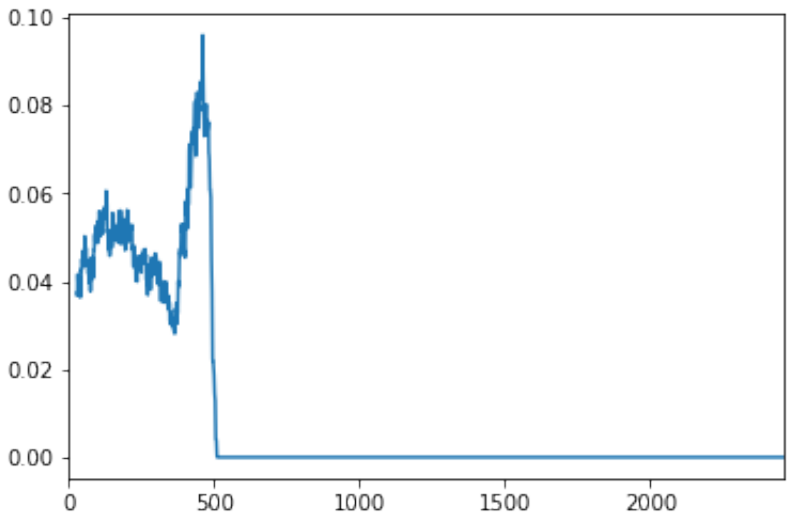
Out[51]:

	0	1	2	3	4	5	6	7	8	9	la
0	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	
1	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	
2	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	
3	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	
4	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	0.05075	

In [52]:
```
df16['Date_created']=df16.index
df16=df16.reset_index(drop=True)
df16.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df16.columns)
cols = [cols[-1]] + cols[:-1]
df16 = df16[cols]
df16=df16[abs(df16.sensor1-df16.sensor1.mean()) <= (3*df16.sensor1.std
df16=df16[abs(df16.sensor2-df16.sensor2.mean()) <= (3*df16.sensor2.std
df16=df16[abs(df16.sensor3-df16.sensor3.mean()) <= (3*df16.sensor3.std
df16=df16[abs(df16.sensor4-df16.sensor4.mean()) <= (3*df16.sensor4.std
df16=df16.reset_index(drop=True)
df16['Date_created'] = pd.to_datetime(df16['Date_created'], errors='co
df16['day_of_week'] = df16['Date_created'].dt.dayofweek
df16['month'] = pd.DatetimeIndex(df16['Date_created']).month
df16['hour'] = pd.DatetimeIndex(df16['Date_created']).hour
df16[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df16[['
df16['sensor1']=df16['sensor1'].rolling(window=30).var()
df16['sensor2']=df16['sensor2'].rolling(window=30).var()
df16['sensor3']=df16['sensor3'].rolling(window=30).var()
df16['sensor4']=df16['sensor4'].rolling(window=30).var()
```

In [53]:
```
df16['sensor3'].plot()
```

Out[53]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d7ea8400>
```



In [54]:
```
df16=df16[:500]
df16=df16.fillna(df16.mean())
df16_sensor1=pd.DataFrame(data=df16['sensor3'])
tukey_hinge=df16_sensor1.quantile(0.75)
df16_sensor1['labels']=df16_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df16_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df16_sensor1)-look_back-1):
        a = df16_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df16_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df16_sensor1,look_back=10)
df16_sensor1_final=pd.DataFrame(data=values[0])
df16_sensor1_final['labels']=pd.DataFrame(data=values[1])
df16_sensor1_final.head()
```

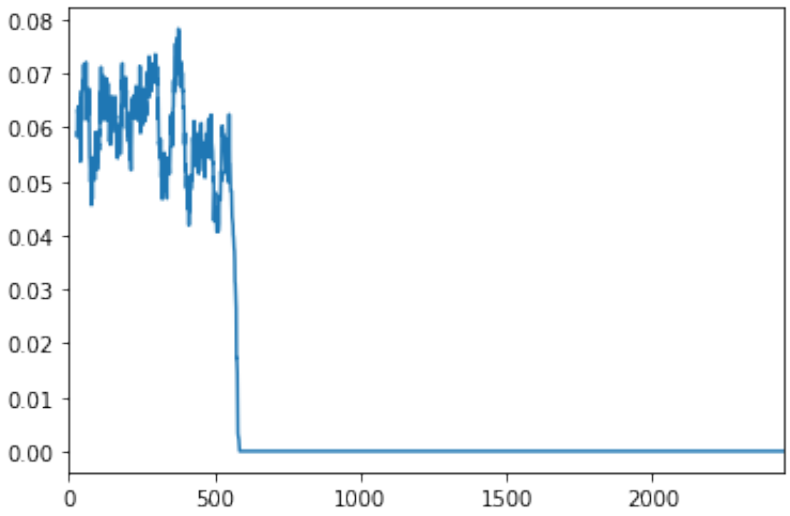
Out[54]:

	0	1	2	3	4	5	6	7	8	
0	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0
1	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0
2	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0
3	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0
4	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0.049889	0

In [55]:
```
df17['Date_created']=df17.index
df17=df17.reset_index(drop=True)
df17.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df17.columns)
cols = [cols[-1]] + cols[:-1]
df17 = df17[cols]
df17=df17[abs(df17.sensor1-df17.sensor1.mean()) <= (3*df17.sensor1.std
df17=df17[abs(df17.sensor2-df17.sensor2.mean()) <= (3*df17.sensor2.std
df17=df17[abs(df17.sensor3-df17.sensor3.mean()) <= (3*df17.sensor3.std
df17=df17[abs(df17.sensor4-df17.sensor4.mean()) <= (3*df17.sensor4.std
df17=df17.reset_index(drop=True)
df17['Date_created'] = pd.to_datetime(df17['Date_created'], errors='co
df17['day_of_week'] = df17['Date_created'].dt.dayofweek
df17['month'] = pd.DatetimeIndex(df17['Date_created']).month
df17['hour'] = pd.DatetimeIndex(df17['Date_created']).hour
df17[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df17[['
df17['sensor1']=df17['sensor1'].rolling(window=30).var()
df17['sensor2']=df17['sensor2'].rolling(window=30).var()
df17['sensor3']=df17['sensor3'].rolling(window=30).var()
df17['sensor4']=df17['sensor4'].rolling(window=30).var()
```

In [56]:
```
df17['sensor3'].plot()
```

Out[56]: <matplotlib.axes._subplots.AxesSubplot at 0x2d1d9098c50>



In [57]:
```
df17=df17[:550]
df17=df17.fillna(df17.mean())
df17_sensor1=pd.DataFrame(data=df17['sensor3'])
tukey_hinge=df17_sensor1.quantile(0.75)
df17_sensor1['labels']=df17_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df17_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df17_sensor1)-look_back-1):
        a = df17_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df17_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df17_sensor1,look_back=10)
df17_sensor1_final=pd.DataFrame(data=values[0])
df17_sensor1_final['labels']=pd.DataFrame(data=values[1])
df17_sensor1_final.head()
```

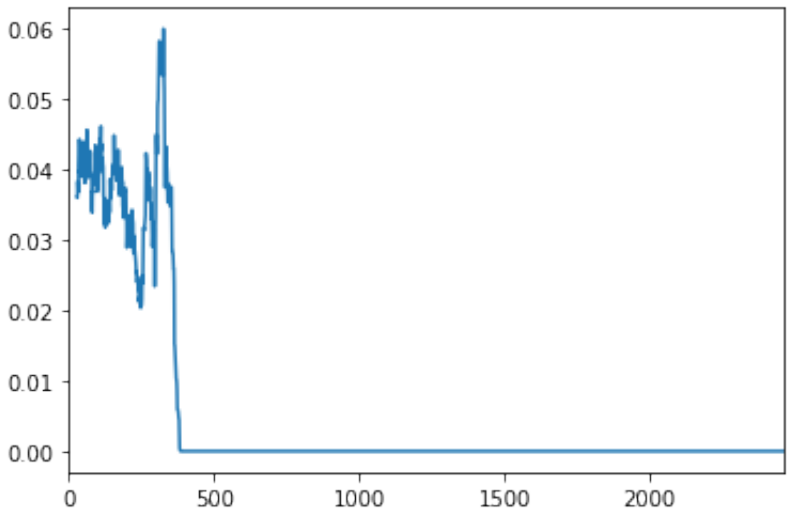
Out[57]:

	0	1	2	3	4	5	6	7	8	
0	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0
1	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0
2	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0
3	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0
4	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0.059883	0

In [58]:
```
df18['Date_created']=df18.index
df18=df18.reset_index(drop=True)
df18.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df18.columns)
cols = [cols[-1]] + cols[:-1]
df18 = df18[cols]
df18=df18[abs(df18.sensor1-df18.sensor1.mean()) <= (3*df18.sensor1.std
df18=df18[abs(df18.sensor2-df18.sensor2.mean()) <= (3*df18.sensor2.std
df18=df18[abs(df18.sensor3-df18.sensor3.mean()) <= (3*df18.sensor3.std
df18=df18[abs(df18.sensor4-df18.sensor4.mean()) <= (3*df18.sensor4.std
df18=df18.reset_index(drop=True)
df18['Date_created'] = pd.to_datetime(df18['Date_created'], errors='co
df18['day_of_week'] = df18['Date_created'].dt.dayofweek
df18['month'] = pd.DatetimeIndex(df18['Date_created']).month
df18['hour'] = pd.DatetimeIndex(df18['Date_created']).hour
df18[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df18[['
df18['sensor1']=df18['sensor1'].rolling(window=30).var()
df18['sensor2']=df18['sensor2'].rolling(window=30).var()
df18['sensor3']=df18['sensor3'].rolling(window=30).var()
df18['sensor4']=df18['sensor4'].rolling(window=30).var()
```

In [59]:
```
df18['sensor3'].plot()
```

Out[59]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d90c9a90>
```



In [60]:
```
df18=df18[:450]
df18=df18.fillna(df18.mean())
df18_sensor1=pd.DataFrame(data=df18['sensor3'])
tukey_hinge=df18_sensor1.quantile(0.75)
df18_sensor1['labels']=df18_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df18_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df18_sensor1)-look_back-1):
        a = df18_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df18_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df18_sensor1,look_back=10)
df18_sensor1_final=pd.DataFrame(data=values[0])
df18_sensor1_final['labels']=pd.DataFrame(data=values[1])
df18_sensor1_final.head()
```

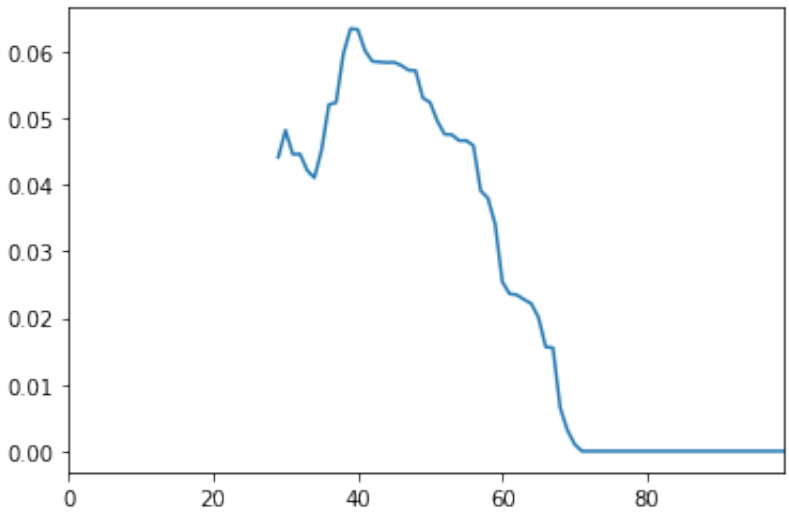
Out[60]:

	0	1	2	3	4	5	6	7	8	
0	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	C
1	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	C
2	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	C
3	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	C
4	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	0.029974	C

In [61]:
```
df19['Date_created']=df19.index
df19=df19.reset_index(drop=True)
df19.rename(columns={'0':'sensor1',
                     '1':'sensor2',
                     '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df19.columns)
cols = [cols[-1]] + cols[:-1]
df19 = df19[cols]
df19=df19[abs(df19.sensor1-df19.sensor1.mean()) <= (3*df19.sensor1.std
df19=df19[abs(df19.sensor2-df19.sensor2.mean()) <= (3*df19.sensor2.std
df19=df19[abs(df19.sensor3-df19.sensor3.mean()) <= (3*df19.sensor3.std
df19=df19[abs(df19.sensor4-df19.sensor4.mean()) <= (3*df19.sensor4.std
df19=df19.reset_index(drop=True)
df19['Date_created'] = pd.to_datetime(df19['Date_created'], errors='co
df19['day_of_week'] = df19['Date_created'].dt.dayofweek
df19['month'] = pd.DatetimeIndex(df19['Date_created']).month
df19['hour'] = pd.DatetimeIndex(df19['Date_created']).hour
df19[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df19[['
df19['sensor1']=df19['sensor1'].rolling(window=30).var()
df19['sensor2']=df19['sensor2'].rolling(window=30).var()
df19['sensor3']=df19['sensor3'].rolling(window=30).var()
df19['sensor4']=df19['sensor4'].rolling(window=30).var()
```

In [62]:
```
df19['sensor3'][:100].plot()
```

Out[62]: <matplotlib.axes._subplots.AxesSubplot at 0x2d1d7ec4dd8>



In [63]:
```
df19=df19[:70]
df19=df19.fillna(df19.mean())
df19_sensor1=pd.DataFrame(data=df19['sensor3'])
tukey_hinge=df19_sensor1.quantile(0.75)
df19_sensor1['labels']=df19_sensor1.apply(lambda row:1 if row.sensor3>
def create_dataset(df19_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df19_sensor1)-look_back-1):
        a = df19_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df19_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df19_sensor1,look_back=10)
df19_sensor1_final=pd.DataFrame(data=values[0])
df19_sensor1_final['labels']=pd.DataFrame(data=values[1])
df19_sensor1_final.head()
```

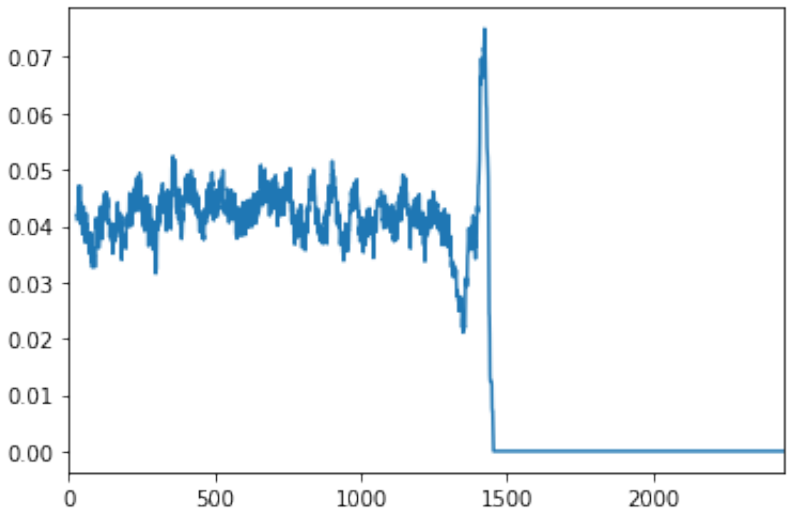
Out[63]:

	0	1	2	3	4	5	6	7	8	
0	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0
1	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0
2	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0
3	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0
4	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0.042593	0

In [64]:
```
df1['Date_created']=df1.index
df1=df1.reset_index(drop=True)
df1.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df1.columns)
cols = [cols[-1]] + cols[:-1]
df1 = df1[cols]
df1=df1[abs(df1.sensor1-df1.sensor1.mean()) <= (3*df1.sensor1.std())]
df1=df1[abs(df1.sensor2-df1.sensor2.mean()) <= (3*df1.sensor2.std())]
df1=df1[abs(df1.sensor3-df1.sensor3.mean()) <= (3*df1.sensor3.std())]
df1=df1[abs(df1.sensor4-df1.sensor4.mean()) <= (3*df1.sensor4.std())]
df1=df1.reset_index(drop=True)
df1['Date_created'] = pd.to_datetime(df1['Date_created'], errors='coer
df1['day_of_week'] = df1['Date_created'].dt.dayofweek
df1['month'] = pd.DatetimeIndex(df1['Date_created']).month
df1['hour'] = pd.DatetimeIndex(df1['Date_created']).hour
df1[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df1[['se
df1['sensor1']=df1['sensor1'].rolling(window=30).var()
df1['sensor2']=df1['sensor2'].rolling(window=30).var()
df1['sensor3']=df1['sensor3'].rolling(window=30).var()
df1['sensor4']=df1['sensor4'].rolling(window=30).var()
```

In [65]:
```
df1['sensor3'].plot()
```

Out[65]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d5cdf748>
```



In [66]:
```
df1=df1[:1500]
df1=df1.fillna(df1.mean())
df1_sensor1=pd.DataFrame(data=df1['sensor3'])
tukey_hinge=df1_sensor1.quantile(0.75)
df1_sensor1['labels']=df1_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df1_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df1_sensor1)-look_back-1):
        a = df1_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df1_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df1_sensor1,look_back=10)
df1_sensor1_final=pd.DataFrame(data=values[0])
df1_sensor1_final['labels']=pd.DataFrame(data=values[1])
df1_sensor1_final.head()
```

Out[66]:

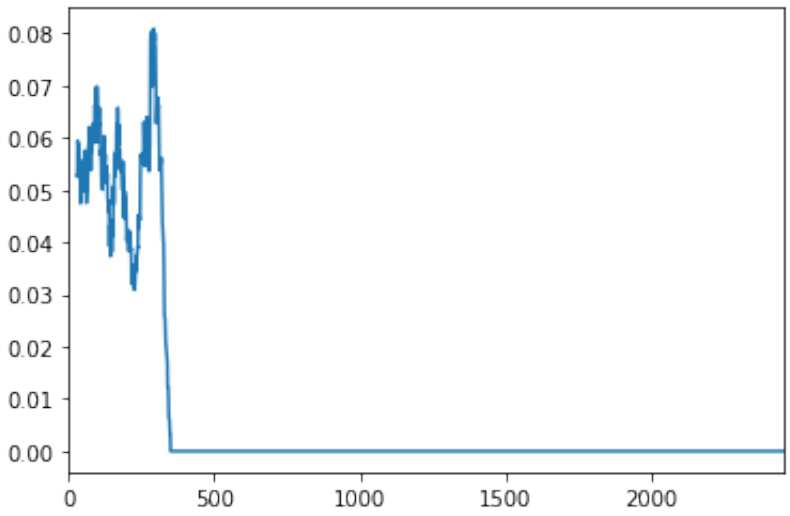
	0	1	2	3	4	5	6	7	8	
0	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0
1	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0
2	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0
3	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0
4	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0.040446	0

Preparing test data

In [67]:
```
df0['Date_created']=df0.index
df0=df0.reset_index(drop=True)
df0.rename(columns={'0':'sensor1',
                            '1':'sensor2',
                            '2':'sensor3','3':'sensor4'},inplace=True)
cols = list(df0.columns)
cols = [cols[-1]] + cols[:-1]
df0 = df0[cols]
df0=df0[abs(df0.sensor1-df0.sensor1.mean()) <= (3*df0.sensor1.std())]
df0=df0[abs(df0.sensor2-df0.sensor2.mean()) <= (3*df0.sensor2.std())]
df0=df0[abs(df0.sensor3-df0.sensor3.mean()) <= (3*df0.sensor3.std())]
df0=df0[abs(df0.sensor4-df0.sensor4.mean()) <= (3*df0.sensor4.std())]
df0=df0.reset_index(drop=True)
df0['Date_created'] = pd.to_datetime(df0['Date_created'], errors='coer
df0['day_of_week'] = df0['Date_created'].dt.dayofweek
df0['month'] = pd.DatetimeIndex(df0['Date_created']).month
df0['hour'] = pd.DatetimeIndex(df0['Date_created']).hour
df0[['sensor1','sensor2','sensor3','sensor4']] = minmax_scale(df0[['se
df0['sensor1']=df0['sensor1'].rolling(window=30).var()
df0['sensor2']=df0['sensor2'].rolling(window=30).var()
df0['sensor3']=df0['sensor3'].rolling(window=30).var()
df0['sensor4']=df0['sensor4'].rolling(window=30).var()
```

In [68]:
```
df0['sensor3'].plot()
```

Out[68]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x2d1d90dd908>
```



In [69]:
```
df0=df0[:400]
df0=df0.fillna(df0.mean())
df0_sensor1=pd.DataFrame(data=df0['sensor3'])
tukey_hinge=df0_sensor1.quantile(0.75)
df0_sensor1['labels']=df0_sensor1.apply(lambda row:1 if row.sensor3>tu
def create_dataset(df0_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df0_sensor1)-look_back-1):
        a = df0_sensor1['sensor3'][i:(i+look_back)]
        dataX.append(a)
        dataY.append(df0_sensor1['labels'][i + look_back])
    return np.array(dataX), np.array(dataY)
values=create_dataset(df0_sensor1,look_back=10)
df0_sensor1_final=pd.DataFrame(data=values[0])
df0_sensor1_final['labels']=pd.DataFrame(data=values[1])
df0_sensor1_final.head()
```

Out[69]:

	0	1	2	3	4	5	6	7	8	
0	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	C
1	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	C
2	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	C
3	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	C
4	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	0.044417	C

Generating the data that needs to be sent for LSTM network

In [70]:
```
def generate_data(lst):
    features = []
    labels = []
    for df in lst:
        f = np.array(df.iloc[:,0:10])
        l = np.array(df.iloc[:,10].astype(int))
        features.append(f)
        labels.append(l)
        feature_output = np.concatenate(features)
    return feature_output.reshape(feature_output.shape[0], feature_out
```

Sensor1 values of all the dataframes will be used as trainset

In [71]:
```
x_train, y_train = generate_data([df1_sensor1_final,df2_sensor1_final,
```

Model building for LSTM network

In [72]:
```
model = Sequential()
model.add(LSTM(100, input_shape=(10,1)))
model.add(Dense(10, activation='relu'))
model.add(Dense(10, activation='relu'))
model.add(Dense(1, activation='sigmoid'))
model.compile(loss='binary_crossentropy', optimizer='adam')
print(model.summary())
```

```
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
lstm (LSTM)                  (None, 100)               40800     
_________________________________________________________________
dense (Dense)                (None, 10)                1010      
_________________________________________________________________
dense_1 (Dense)              (None, 10)                110       
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 11        
=================================================================
Total params: 41,931
Trainable params: 41,931
Non-trainable params: 0
_________________________________________________________________
None
```

In [73]:
```
model_GRU = Sequential()
model_GRU.add(LSTM(100, input_shape=(10,1)))
model_GRU.add(Dense(10, activation='relu'))
model_GRU.add(Dense(10, activation='relu'))
model_GRU.add(Dense(1, activation='sigmoid'))
model_GRU.compile(loss='binary_crossentropy', optimizer='adam')
print(model_GRU.summary())
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
lstm_1 (LSTM)                (None, 100)               40800
_________________________________________________________________
dense_3 (Dense)              (None, 10)                1010
_________________________________________________________________
dense_4 (Dense)              (None, 10)                110
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 11
=================================================================
Total params: 41,931
Trainable params: 41,931
Non-trainable params: 0
_________________________________________________________________
None
```

Fitting the model

In [74]:
```
model.fit(x_train, y_train, epochs=20)
```

```
Train on 12591 samples
Epoch 1/20
12591/12591 [==============================] - 4s 309us/sample - loss
: 0.5526
Epoch 2/20
12591/12591 [==============================] - 2s 186us/sample - loss
: 0.5035
Epoch 3/20
12591/12591 [==============================] - 2s 185us/sample - loss
: 0.4965
Epoch 4/20
12591/12591 [==============================] - 2s 189us/sample - loss
: 0.4960
Epoch 5/20
12591/12591 [==============================] - 2s 186us/sample - loss
: 0.4957
Epoch 6/20
```

```
12591/12591 [==============================] - 2s 186us/sample - loss
: 0.4893
Epoch 7/20
12591/12591 [==============================] - 2s 187us/sample - loss
: 0.4885
Epoch 8/20
12591/12591 [==============================] - 2s 187us/sample - loss
: 0.4885
Epoch 9/20
12591/12591 [==============================] - 2s 187us/sample - loss
: 0.4846
Epoch 10/20
12591/12591 [==============================] - 2s 188us/sample - loss
: 0.4771
Epoch 11/20
12591/12591 [==============================] - 2s 186us/sample - loss
: 0.4748
Epoch 12/20
12591/12591 [==============================] - 2s 190us/sample - loss
: 0.4715
Epoch 13/20
12591/12591 [==============================] - 2s 192us/sample - loss
: 0.4685
Epoch 14/20
12591/12591 [==============================] - 2s 190us/sample - loss
: 0.4673
Epoch 15/20
12591/12591 [==============================] - 2s 187us/sample - loss
: 0.4656
Epoch 16/20
12591/12591 [==============================] - 2s 191us/sample - loss
: 0.4625
Epoch 17/20
12591/12591 [==============================] - 3s 207us/sample - loss
: 0.4614
Epoch 18/20
12591/12591 [==============================] - 3s 208us/sample - loss
: 0.4630
Epoch 19/20
12591/12591 [==============================] - 2s 198us/sample - loss
: 0.4605
Epoch 20/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.4601
```

Out[74]: <tensorflow.python.keras.callbacks.History at 0x2d1da8599b0>

In [75]:
```
model_GRU.fit(x_train, y_train, epochs=20)
```

```
Train on 12591 samples
```

```
Epoch 1/20
12591/12591 [==============================] - 4s 355us/sample - loss
: 0.6533
Epoch 2/20
12591/12591 [==============================] - 2s 191us/sample - loss
: 0.6032
Epoch 3/20
12591/12591 [==============================] - 2s 190us/sample - loss
: 0.5798
Epoch 4/20
12591/12591 [==============================] - 3s 200us/sample - loss
: 0.5700
Epoch 5/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.5666
Epoch 6/20
12591/12591 [==============================] - 3s 202us/sample - loss
: 0.5655
Epoch 7/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.5652
Epoch 8/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.5652
Epoch 9/20
12591/12591 [==============================] - 3s 199us/sample - loss
: 0.5651
Epoch 10/20
12591/12591 [==============================] - 3s 200us/sample - loss
: 0.5652
Epoch 11/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.5652
Epoch 12/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.5652
Epoch 13/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.5652
Epoch 14/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.5652
Epoch 15/20
12591/12591 [==============================] - 2s 199us/sample - loss
: 0.5652
Epoch 16/20
12591/12591 [==============================] - 3s 210us/sample - loss
: 0.5652
Epoch 17/20
12591/12591 [==============================] - 3s 199us/sample - loss
```

```
: 0.5652
Epoch 18/20
12591/12591 [==============================] - 3s 218us/sample - loss
: 0.5652
Epoch 19/20
12591/12591 [==============================] - 3s 201us/sample - loss
: 0.5652
Epoch 20/20
12591/12591 [==============================] - 2s 198us/sample - loss
: 0.5652
```

Out[75]: <tensorflow.python.keras.callbacks.History at 0x2d1de04e208>

Creating the test_data

In [76]:
```
test_data,test_label=generate_data([df0_sensor1_final])
```

Checking for the accuracy

In [77]:
```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
```

In [78]:
```
def predict(model, test_data, test_label):
    pred = model.predict(test_data)
    pred = pred.round()
    try:
        tn, fp, fn, tp = confusion_matrix(pred.flatten(), test_label).
    except:
        tn = 0
        fp = 0
        fn = 0
        tp = 0

    acc = (pred.flatten() == test_label.flatten()).sum()/ len(test_lab
    pred_conc = np.concatenate([np.zeros(10),pred.flatten()])
    return {
        'pred': pred.flatten(),
        'pred_conc':pred_conc,
        'conf_mat': (tn, fp, fn, tp),
        'acc': acc
    }
```

In [79]:
```
predict_values_LSTM=predict(model,test_data,test_label)
```

In [80]:
```
predict_values_GRU=predict(model_GRU,test_data,test_label)
```

In [81]:
```
print(predict_values_LSTM)
```

```
{'pred': array([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., 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., 1., 1., 1., 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., 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., 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., 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., 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.
, 0.,
       0., 0., 1., 1., 1., 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., 0., 0., 1., 1., 1., 1., 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.
, 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., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.],
```

```
      dtype=float32), 'pred_conc': array([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.
, 1., 
       1., 1., 1., 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., 1., 1., 1., 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., 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., 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.
, 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., 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., 0., 0., 0., 1., 1., 1., 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., 0.
, 0., 
       1., 1., 1., 1., 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., 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., 0., 0.
, 0., 
       0., 0., 0., 0., 0., 0., 0., 0.]), 'conf_mat': (284, 60, 5, 40)
, 'acc': 0.8329048843187661}
```

In [82]:
```
print(predict_values_GRU)
```

```
{'pred': array([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.,
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, 'acc': 0.7429305912596401}
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Sensor3 values are little bad than compared to sensor1,sensor2, and sensor4 values