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
```

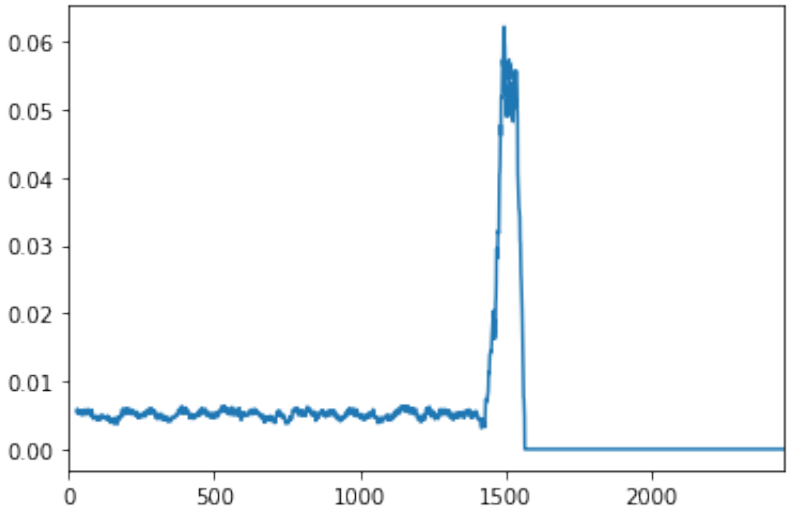
we use the moving variance to approximate the variation in the series at a point in time

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['sensor4'].plot()
```

Out[8]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d0b62e8>
```



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['sensor4'])
```

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.sensor4>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['sensor4'][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]:

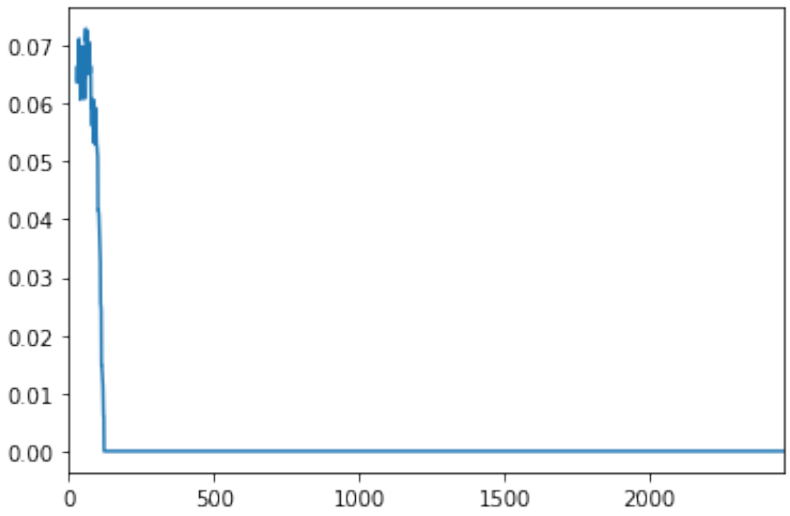
	0	1	2	3	4	5	6	7	8	
0	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0
1	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0
2	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0
3	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0
4	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	0.007545	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['sensor4'].plot()
```

Out[14]: <matplotlib.axes._subplots.AxesSubplot at 0x20e0f6fa2b0>



In [15]:
```
df3=df3[:130]
df3=df3.fillna(df3.mean())
df3_sensor1=pd.DataFrame(data=df3['sensor4'])
tukey_hinge=df3_sensor1.quantile(0.75)
df3_sensor1['labels']=df3_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df3_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df3_sensor1)-look_back-1):
        a = df3_sensor1['sensor4'][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()
```

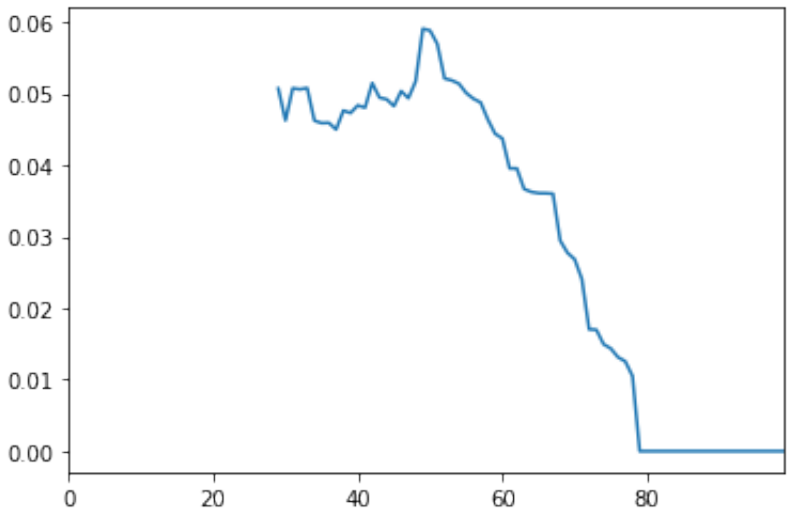
Out[15]:

	0	1	2	3	4	5	6	7	8	
0	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0
1	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0
2	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0
3	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0
4	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	0.050123	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['sensor4'][:100].plot()
```

Out[17]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f7364a8>
```



In [18]:
```
df4=df4[:80]
df4=df4.fillna(df4.mean())
df4_sensor1=pd.DataFrame(data=df4['sensor4'])
tukey_hinge=df4_sensor1.quantile(0.75)
df4_sensor1['labels']=df4_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df4_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df4_sensor1)-look_back-1):
        a = df4_sensor1['sensor4'][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()
```

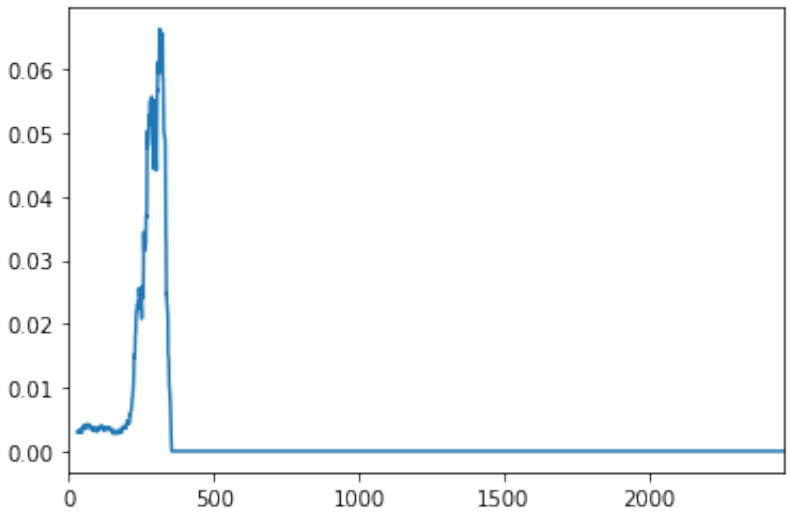
Out[18]:

	0	1	2	3	4	5	6	7	8	
0	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	C
1	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	C
2	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	C
3	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	C
4	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	0.040261	C

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['sensor4'].plot()
```

Out[20]: <matplotlib.axes._subplots.AxesSubplot at 0x20e0f7bf6d8>



In [21]:
```
df5=df5[:370]
df5=df5.fillna(df5.mean())
df5_sensor1=pd.DataFrame(data=df5['sensor4'])
tukey_hinge=df5_sensor1.quantile(0.75)
df5_sensor1['labels']=df5_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df5_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df5_sensor1)-look_back-1):
        a = df5_sensor1['sensor4'][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()
```

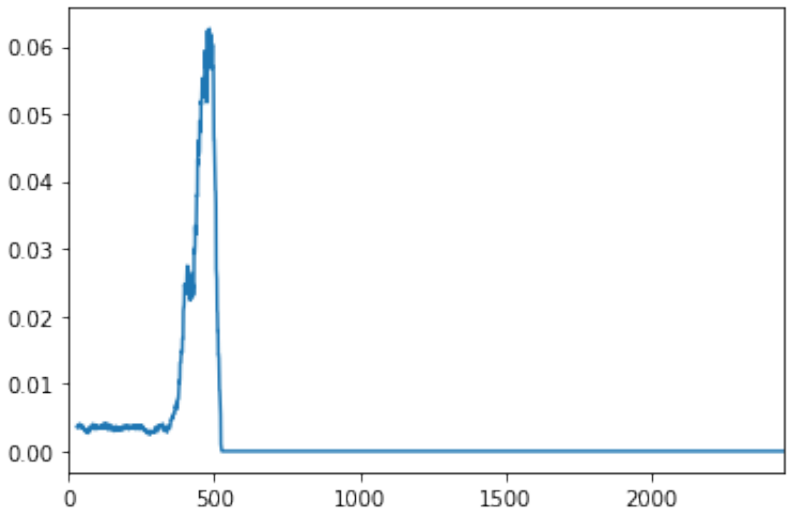
Out[21]:

	0	1	2	3	4	5	6	7	8	
0	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0
1	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0
2	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0
3	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0
4	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	0.016676	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['sensor4'].plot()
```

Out[23]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f740240>
```



In [24]:
```
df6=df6[:550]
df6=df6.fillna(df6.mean())
df6_sensor1=pd.DataFrame(data=df6['sensor4'])
tukey_hinge=df6_sensor1.quantile(0.75)
df6_sensor1['labels']=df6_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df6_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df6_sensor1)-look_back-1):
        a = df6_sensor1['sensor4'][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()
```

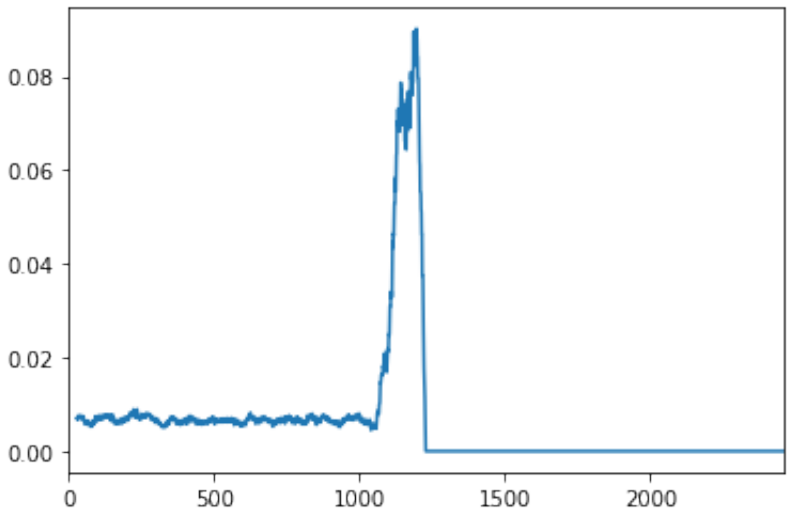
Out[24]:

	0	1	2	3	4	5	6	7	8	
0	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0
1	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0
2	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0
3	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0
4	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	0.012261	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['sensor4'].plot()
```

Out[26]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f7334e0>
```



In [27]:
```
df7=df7[:1300]
df7=df7.fillna(df7.mean())
df7_sensor1=pd.DataFrame(data=df7['sensor4'])
tukey_hinge=df7_sensor1.quantile(0.75)
df7_sensor1['labels']=df7_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df7_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df7_sensor1)-look_back-1):
        a = df7_sensor1['sensor4'][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()
```

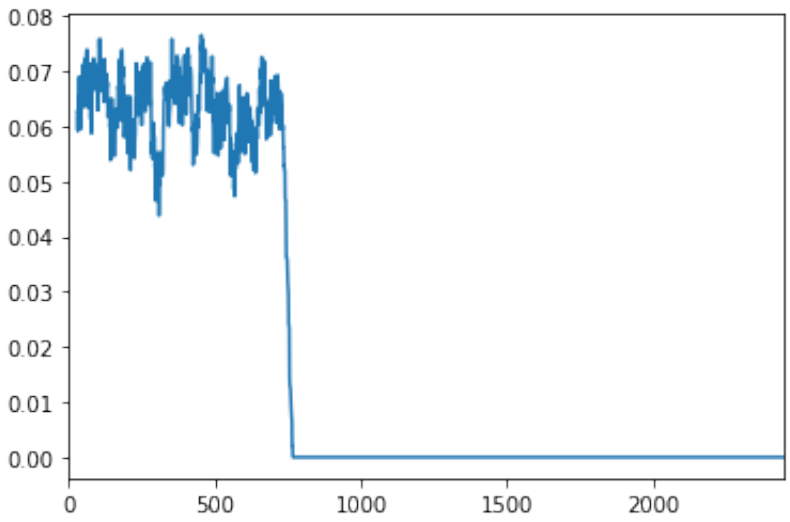
Out[27]:

	0	1	2	3	4	5	6	7	8	
0	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0
1	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0
2	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0
3	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0
4	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0.012051	0

In [28]:
```
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 [29]:
```
df8['sensor4'].plot()
```

Out[29]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d2916a0>
```



In [30]:
```
df8=df8[:900]
df8=df8.fillna(df8.mean())
df8_sensor1=pd.DataFrame(data=df8['sensor4'])
tukey_hinge=df8_sensor1.quantile(0.75)
df8_sensor1['labels']=df8_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df8_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df8_sensor1)-look_back-1):
        a = df8_sensor1['sensor4'][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()
```

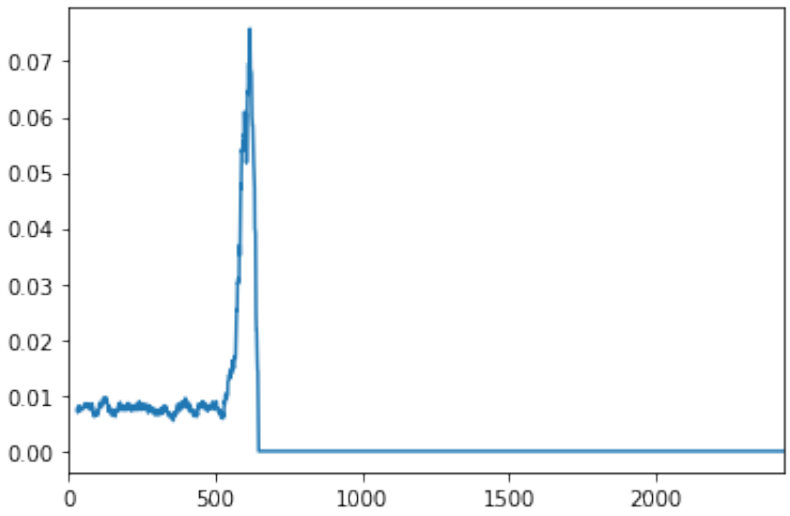
Out[30]:

	0	1	2	3	4	5	6	7	8	
0	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0
1	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0
2	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0
3	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0
4	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	0.052603	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['sensor4'].plot()
```

Out[32]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f832f28>
```



In [33]:
```
df9=df9[:750]
df9=df9.fillna(df9.mean())
df9_sensor1=pd.DataFrame(data=df9['sensor4'])
tukey_hinge=df9_sensor1.quantile(0.75)
df9_sensor1['labels']=df9_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df9_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df9_sensor1)-look_back-1):
        a = df9_sensor1['sensor4'][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()
```

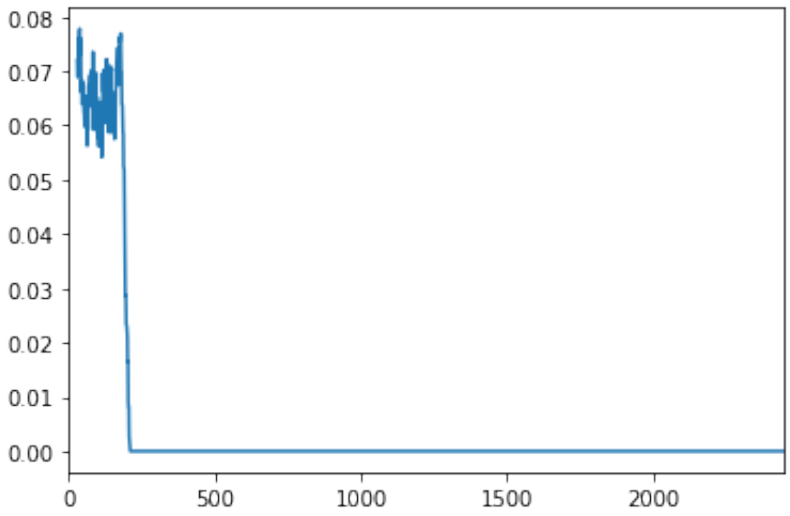
Out[33]:

	0	1	2	3	4	5	6	7	8	
0	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0
1	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0
2	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0
3	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0
4	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	0.011101	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['sensor4'].plot()
```

Out[35]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f945978>
```



In [36]:
```
df10=df10[:750]
df10=df10.fillna(df10.mean())
df10_sensor1=pd.DataFrame(data=df10['sensor4'])
tukey_hinge=df10_sensor1.quantile(0.75)
df10_sensor1['labels']=df10_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df10_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df10_sensor1)-look_back-1):
        a = df10_sensor1['sensor4'][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()
```

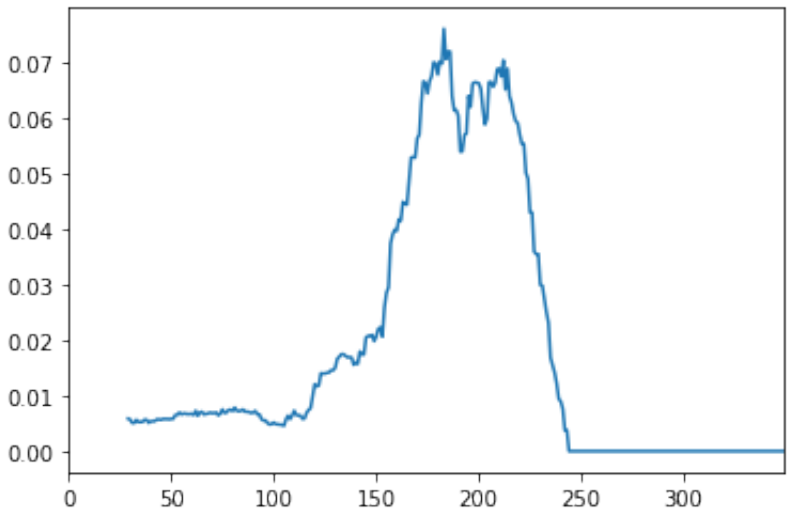
Out[36]:

	0	1	2	3	4	5	6	7	8	9	la
0	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	
1	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	
2	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	
3	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	
4	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	0.01525	

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['sensor4'][:350].plot()
```

Out[38]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d476828>
```



In [39]:
```
df11=df11[:250]
df11=df11.fillna(df11.mean())
df11_sensor1=pd.DataFrame(data=df11['sensor4'])
tukey_hinge=df11_sensor1.quantile(0.75)
df11_sensor1['labels']=df11_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df11_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df11_sensor1)-look_back-1):
        a = df11_sensor1['sensor4'][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()
```

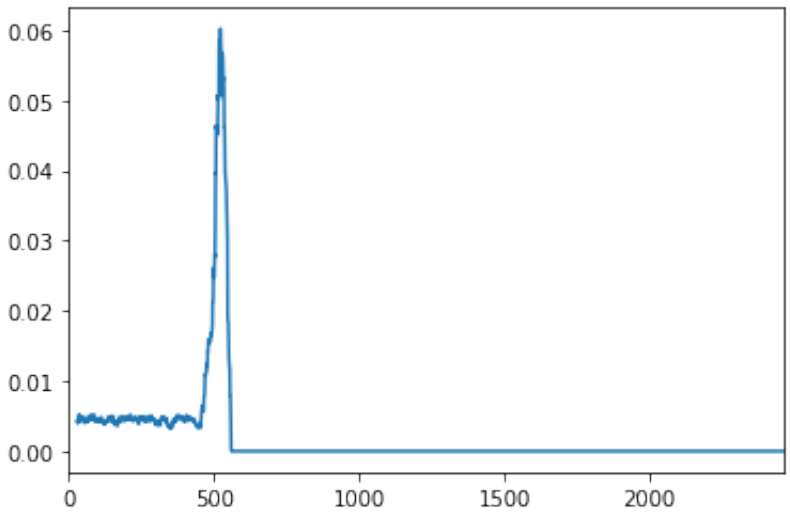
Out[39]:

	0	1	2	3	4	5	6	7	8	
0	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0
1	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0
2	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0
3	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0
4	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	0.025888	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['sensor4'].plot()
```

Out[41]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d11a550>
```



In [42]:
```
df12=df12[:600]
df12=df12.fillna(df12.mean())
df12_sensor1=pd.DataFrame(data=df12['sensor4'])
tukey_hinge=df12_sensor1.quantile(0.75)
df12_sensor1['labels']=df12_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df12_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df12_sensor1)-look_back-1):
        a = df12_sensor1['sensor4'][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()
```

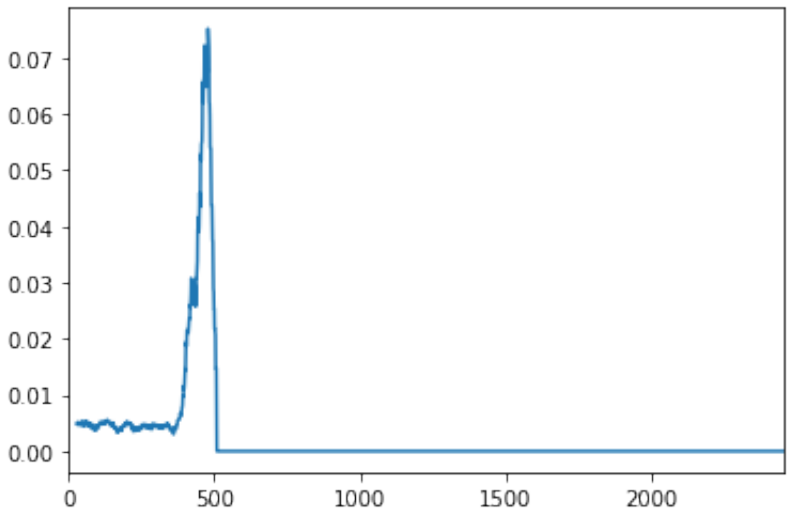
Out[42]:

	0	1	2	3	4	5	6	7	8	
0	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0
1	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0
2	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0
3	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0
4	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0.008375	0

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['sensor4'].plot()
```

Out[44]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f807d68>
```



In [45]:
```
df13=df13[:500]
df13=df13.fillna(df13.mean())
df13_sensor1=pd.DataFrame(data=df13['sensor4'])
tukey_hinge=df13_sensor1.quantile(0.75)
df13_sensor1['labels']=df13_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df13_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df13_sensor1)-look_back-1):
        a = df13_sensor1['sensor4'][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()
```

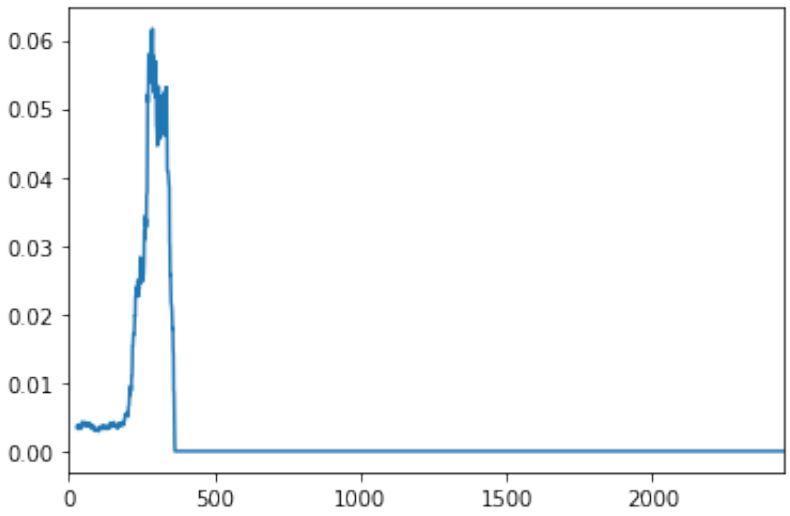
Out[45]:

	0	1	2	3	4	5	6	7	8	9	la
0	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	
1	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	
2	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	
3	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	
4	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	0.01268	

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['sensor4'].plot()
```

Out[47]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f760710>
```



In [48]:
```
df14=df14[:500]
df14=df14.fillna(df14.mean())
df14_sensor1=pd.DataFrame(data=df14['sensor4'])
tukey_hinge=df14_sensor1.quantile(0.75)
df14_sensor1['labels']=df14_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df14_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df14_sensor1)-look_back-1):
        a = df14_sensor1['sensor4'][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()
```

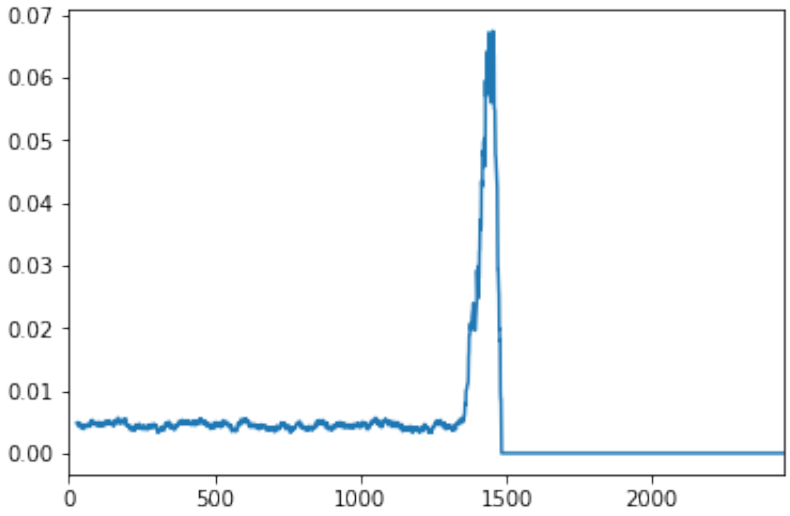
Out[48]:

	0	1	2	3	4	5	6	7	8	
0	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0
1	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0
2	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0
3	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0
4	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0.013304	0

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['sensor4'].plot()
```

Out[50]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0f859198>
```



In [51]:
```
df15=df15[:1450]
df15=df15.fillna(df15.mean())
df15_sensor1=pd.DataFrame(data=df15['sensor4'])
tukey_hinge=df15_sensor1.quantile(0.75)
df15_sensor1['labels']=df15_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df15_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df15_sensor1)-look_back-1):
        a = df15_sensor1['sensor4'][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()
```

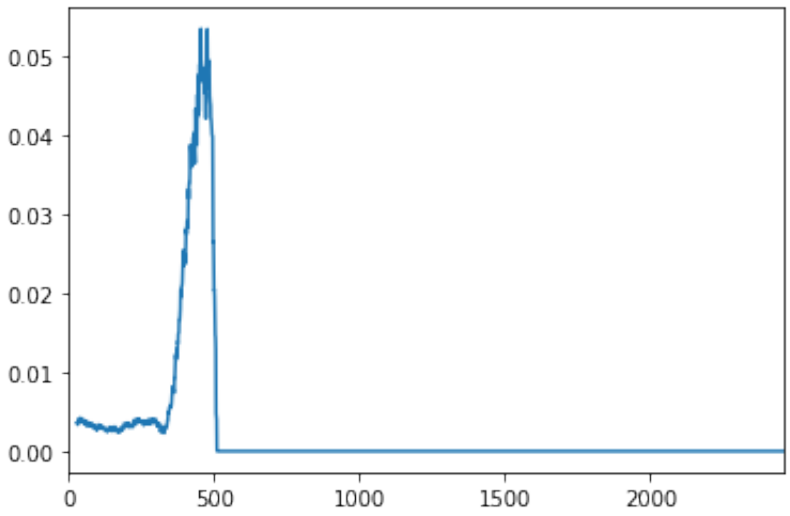
Out[51]:

	0	1	2	3	4	5	6	7	8	
0	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0
1	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0
2	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0
3	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0
4	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0.006393	0

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['sensor4'].plot()
```

Out[53]: <matplotlib.axes._subplots.AxesSubplot at 0x20e0d58f0b8>



In [54]:
```
df16=df16[:500]
df16=df16.fillna(df16.mean())
df16_sensor1=pd.DataFrame(data=df16['sensor4'])
tukey_hinge=df16_sensor1.quantile(0.75)
df16_sensor1['labels']=df16_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df16_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df16_sensor1)-look_back-1):
        a = df16_sensor1['sensor4'][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()
```

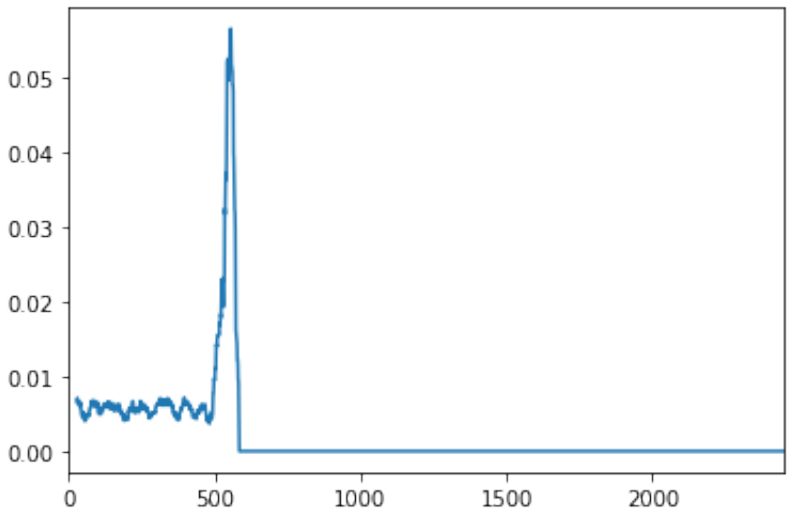
Out[54]:

	0	1	2	3	4	5	6	7	8	
0	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0
1	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0
2	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0
3	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0
4	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	0.012476	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['sensor4'].plot()
```

Out[56]: <matplotlib.axes._subplots.AxesSubplot at 0x20e10a574e0>



In [57]:
```
df17=df17[:550]
df17=df17.fillna(df17.mean())
df17_sensor1=pd.DataFrame(data=df17['sensor4'])
tukey_hinge=df17_sensor1.quantile(0.75)
df17_sensor1['labels']=df17_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df17_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df17_sensor1)-look_back-1):
        a = df17_sensor1['sensor4'][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()
```

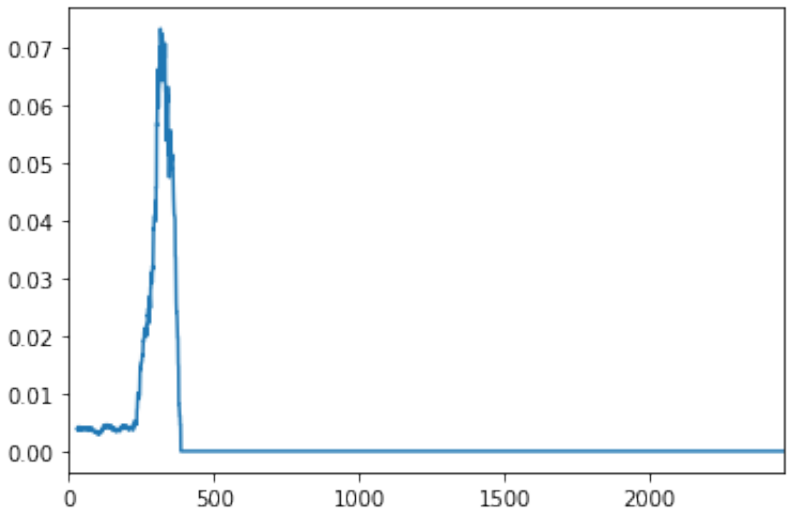
Out[57]:

	0	1	2	3	4	5	6	7	8	
0	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0
1	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0
2	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0
3	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0
4	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	0.007485	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['sensor4'].plot()
```

Out[59]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d10cc50>
```



In [60]:
```
df18=df18[:450]
df18=df18.fillna(df18.mean())
df18_sensor1=pd.DataFrame(data=df18['sensor4'])
tukey_hinge=df18_sensor1.quantile(0.75)
df18_sensor1['labels']=df18_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df18_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df18_sensor1)-look_back-1):
        a = df18_sensor1['sensor4'][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()
```

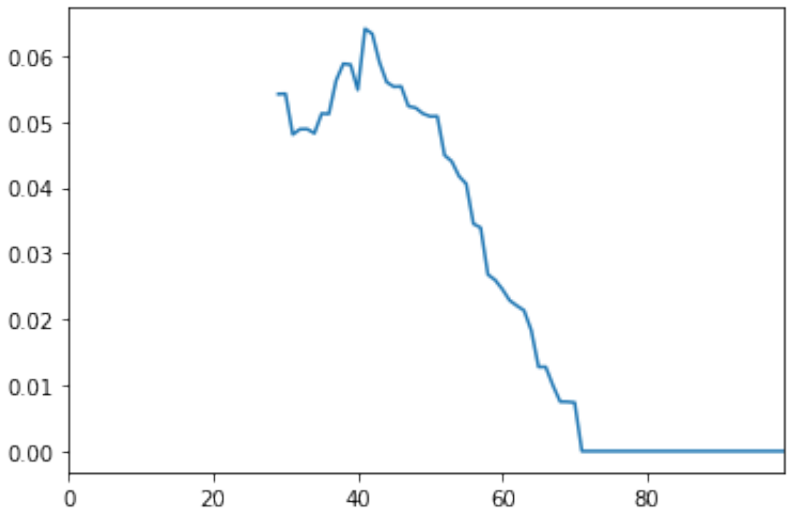
Out[60]:

	0	1	2	3	4	5	6	7	8	
0	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0
1	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0
2	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0
3	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0
4	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0.015406	0

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['sensor4'][:100].plot()
```

Out[62]: <matplotlib.axes._subplots.AxesSubplot at 0x20e10aef828>



In [63]:
```
df19=df19[:70]
df19=df19.fillna(df19.mean())
df19_sensor1=pd.DataFrame(data=df19['sensor4'])
tukey_hinge=df19_sensor1.quantile(0.75)
df19_sensor1['labels']=df19_sensor1.apply(lambda row:1 if row.sensor4>
def create_dataset(df19_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df19_sensor1)-look_back-1):
        a = df19_sensor1['sensor4'][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()
```

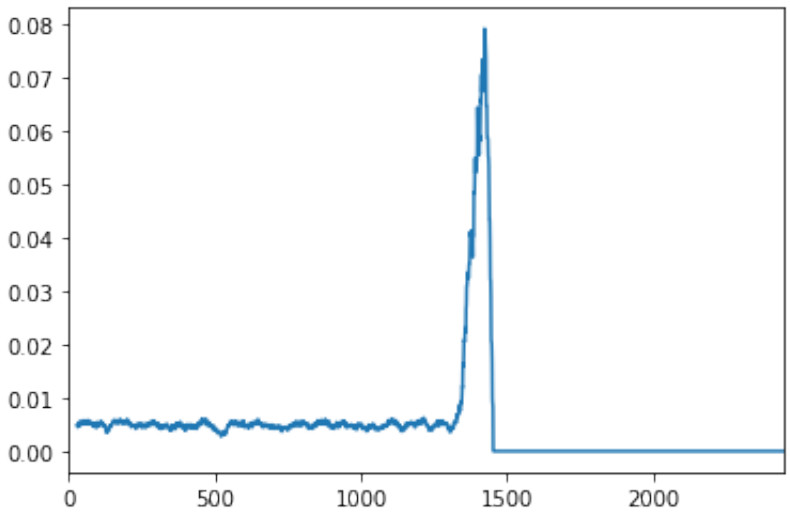
Out[63]:

	0	1	2	3	4	5	6	7	8	9	la
0	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	
1	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	
2	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	
3	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	
4	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	0.04139	

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['sensor4'].plot()
```

Out[65]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d632940>
```



In [66]:
```
df1=df1[:1500]
df1=df1.fillna(df1.mean())
df1_sensor1=pd.DataFrame(data=df1['sensor4'])
tukey_hinge=df1_sensor1.quantile(0.75)
df1_sensor1['labels']=df1_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df1_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df1_sensor1)-look_back-1):
        a = df1_sensor1['sensor4'][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]:

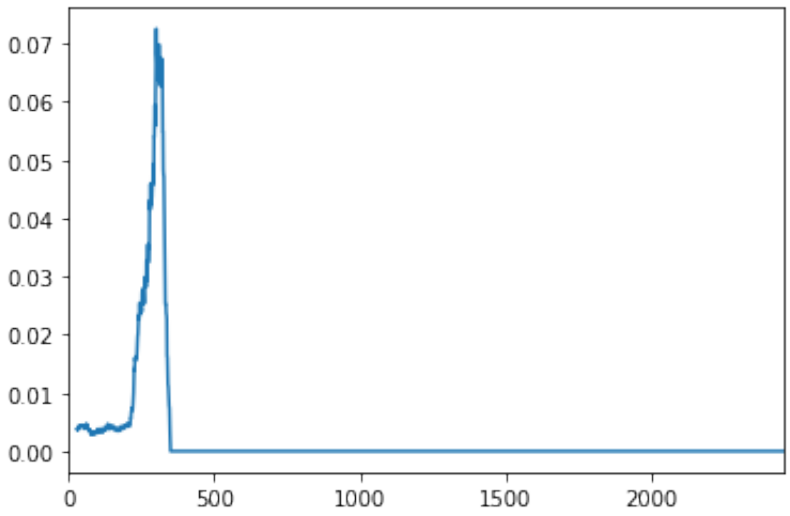
	0	1	2	3	4	5	6	7	8	
0	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0
1	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0
2	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0
3	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0
4	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	0.007662	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['sensor4'].plot()
```

Out[68]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x20e0d698a90>
```



In [69]:
```
df0=df0[:400]
df0=df0.fillna(df0.mean())
df0_sensor1=pd.DataFrame(data=df0['sensor4'])
tukey_hinge=df0_sensor1.quantile(0.75)
df0_sensor1['labels']=df0_sensor1.apply(lambda row:1 if row.sensor4>tu
def create_dataset(df0_sensor1, look_back=10):
    dataX, dataY = [], []
    for i in range(len(df0_sensor1)-look_back-1):
        a = df0_sensor1['sensor4'][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	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0
1	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0
2	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0
3	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0
4	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0.014506	0

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 331us/sample - loss
: 0.4772
Epoch 2/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4321
Epoch 3/20
12591/12591 [==============================] - 2s 193us/sample - loss
: 0.4212
Epoch 4/20
12591/12591 [==============================] - 3s 204us/sample - loss
: 0.4225
Epoch 5/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4196
Epoch 6/20
```

```
12591/12591 [==============================] - 2s 197us/sample - loss
: 0.4163
Epoch 7/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4127
Epoch 8/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4144
Epoch 9/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4123
Epoch 10/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4081
Epoch 11/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4093
Epoch 12/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4029
Epoch 13/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4022
Epoch 14/20
12591/12591 [==============================] - 2s 194us/sample - loss
: 0.4026
Epoch 15/20
12591/12591 [==============================] - 2s 196us/sample - loss
: 0.3985
Epoch 16/20
12591/12591 [==============================] - 3s 206us/sample - loss
: 0.3971
Epoch 17/20
12591/12591 [==============================] - 3s 205us/sample - loss
: 0.3964
Epoch 18/20
12591/12591 [==============================] - 3s 208us/sample - loss
: 0.3920
Epoch 19/20
12591/12591 [==============================] - 3s 206us/sample - loss
: 0.3883
Epoch 20/20
12591/12591 [==============================] - 3s 211us/sample - loss
: 0.3902
```

Out[74]: <tensorflow.python.keras.callbacks.History at 0x20e12224d68>

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

```
Train on 12591 samples
```

```
Epoch 1/20
12591/12591 [==============================] - 4s 311us/sample - loss
: 0.5460
Epoch 2/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4389
Epoch 3/20
12591/12591 [==============================] - 2s 195us/sample - loss
: 0.4315
Epoch 4/20
12591/12591 [==============================] - 3s 210us/sample - loss
: 0.4251
Epoch 5/20
12591/12591 [==============================] - 3s 206us/sample - loss
: 0.4276
Epoch 6/20
12591/12591 [==============================] - 3s 205us/sample - loss
: 0.4178
Epoch 7/20
12591/12591 [==============================] - 3s 210us/sample - loss
: 0.4181
Epoch 8/20
12591/12591 [==============================] - 3s 205us/sample - loss
: 0.4146
Epoch 9/20
12591/12591 [==============================] - 3s 206us/sample - loss
: 0.4094
Epoch 10/20
12591/12591 [==============================] - 3s 220us/sample - loss
: 0.4070
Epoch 11/20
12591/12591 [==============================] - 3s 207us/sample - loss
: 0.4083
Epoch 12/20
12591/12591 [==============================] - 3s 207us/sample - loss
: 0.4011
Epoch 13/20
12591/12591 [==============================] - 3s 207us/sample - loss
: 0.4023
Epoch 14/20
12591/12591 [==============================] - 3s 208us/sample - loss
: 0.3971
Epoch 15/20
12591/12591 [==============================] - 3s 225us/sample - loss
: 0.3973
Epoch 16/20
12591/12591 [==============================] - 3s 210us/sample - loss
: 0.3923
Epoch 17/20
12591/12591 [==============================] - 3s 210us/sample - loss
```

```
: 0.3957
Epoch 18/20
12591/12591 [==============================] - 3s 240us/sample - loss
: 0.3899
Epoch 19/20
12591/12591 [==============================] - 3s 215us/sample - loss
: 0.3875
Epoch 20/20
12591/12591 [==============================] - 3s 218us/sample - loss
: 0.3863
```

Out[75]: <tensorflow.python.keras.callbacks.History at 0x20e10b0b978>

Creating the test_data

In [77]:
```
test_data,test_label=generate_data([df0_sensor1_final])
```

Checking for the accuracy

In [78]:
```
from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
```

In [79]:
```
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 [80]:
```
predict_values_LSTM=predict(model,test_data,test_label)
```

In [81]:
```
predict_values_GRU=predict(model_GRU,test_data,test_label)
```

In [82]:
```
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., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 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., 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., 1.
, 1.,
       1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 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.],
```

```
       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.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 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., 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., 1., 1., 1., 1., 1., 1., 1., 1.
, 1.,
       1., 1., 1., 1., 1., 1., 1., 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.]), 'conf_mat': (277, 0, 12, 100
), 'acc': 0.9691516709511568}
```

In [83]:
```
print(predict_values_GRU)
```

```
{'pred': array([1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 1., 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., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 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., 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.
, 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., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
, 0.,
       0., 0., 0., 0., 0., 0., 0., 0., 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., 1., 1., 1., 1., 1., 1., 1.,
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, 0.,
        0., 0., 0., 0., 0., 0., 0., 0.]), 'conf_mat': (254, 0, 35, 100
), 'acc': 0.910025706940874}
```

How the model works:

1.Removing the outliers or noise in the initial stages of Data Preparation

2.Applying Moving Variance for the sensor values in DataFrame

3.Considering Tukey hinge into account and labeling the values which are greater than 0.75 quantile(threshold)

4.If we have labeled Y_values according to threshold(s(t)>threshold) values then the next step is to make X_values as s(t-1),s(t-2),...s(t-10)

5.Passing all the values into different models like LSTM, GRU and predicting the values by the past 10 time steps

6.In this case, I have taken machine_0 values as testset and concatenated all the remaining machine values for each different sensor

Models used:

LSTM, GRU

Accuracies:

LSTM:

Confusion Matrix: (277, 0, 12, 100)

Accuracy:96.91

GRU:

Confusion Matrix: (254, 0, 35, 100)

Accuracy:91.00