Anomaly Detection in time Series

In [1]:

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

import warnings
warnings.filterwarnings('ignore')

%matplotlib inline
```

In [2]:

```
plt.rcParams["figure.figsize"] = (9,6)
```

Read the data

This is real-life data on CPU utilization of an EC2 instance in the AWS cloud. Data was recorded every 5 minutes, starting on February 14th at 14:30. The dataset contains 4032 data points. It is available through the Numenta Anomaly Benchmark (NAB) repository under the AGPL-3.0 license.

In [3]:

```
df = pd.read_csv('Downloads/ec2_cpu_utilization_24ae8d.csv')
df.head()
```

Out[3]:

	timestamp	value
0	2014-02-14 14:30:00	0.132
1	2014-02-14 14:35:00	0.134
2	2014-02-14 14:40:00	0.134
3	2014-02-14 14:45:00	0.134
4	2014-02-14 14:50:00	0.134

In [4]:

```
anomalies_timestamp = [
    "2014-02-26 22:05:00",
    "2014-02-27 17:15:00"
]
```

In [5]:

```
df['timestamp'] = pd.to_datetime(df['timestamp'])
df.head()
```

Out[5]:

	timestamp	value
0	2014-02-14 14:30:00	0.132
1	2014-02-14 14:35:00	0.134
2	2014-02-14 14:40:00	0.134
3	2014-02-14 14:45:00	0.134

	timestamp	value
4	2014-02-14 14:50:00	0.134

In [6]:

```
df['is_anomaly'] = 1
for each in anomalies_timestamp:
    df.loc[df['timestamp'] == each, 'is_anomaly'] = -1
df.head()
```

Out[6]:

	timestamp	value	is_anomaly
0	2014-02-14 14:30:00	0.132	1
1	2014-02-14 14:35:00	0.134	1
2	2014-02-14 14:40:00	0.134	1
3	2014-02-14 14:45:00	0.134	1
4	2014-02-14 14:50:00	0.134	1

In [7]:

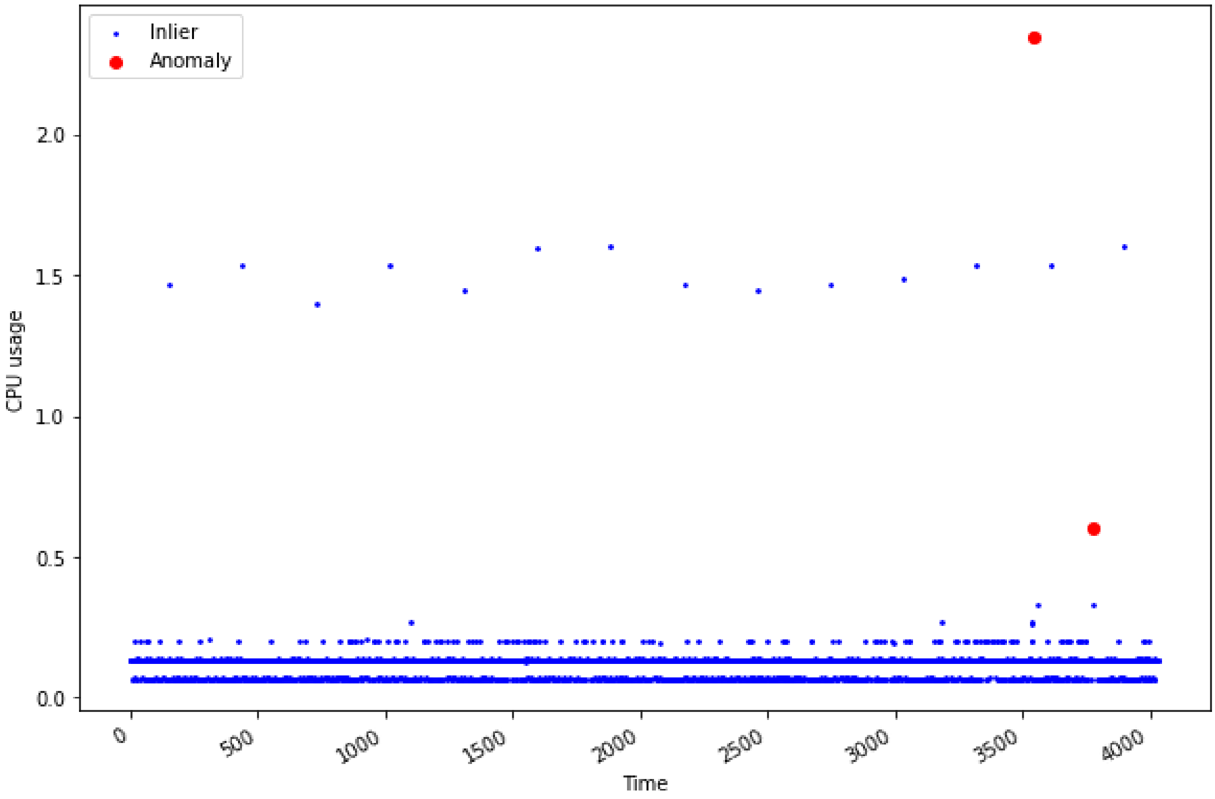
```
anomaly_df = df.loc[df['is_anomaly'] == -1]
inlier_df = df.loc[df['is_anomaly'] == 1]
```

In [8]:

```
fig, ax = plt.subplots()

ax.scatter(inlier_df.index, inlier_df['value'], color='blue', s=3, label='Inlier')
ax.scatter(anomaly_df.index, anomaly_df['value'], color='red', label='Anomaly')
ax.set_xlabel('Time')
ax.set_ylabel('CPU usage'),
ax.legend(loc=2),

plt.grid(False)
fig.autofmt_xdate()
plt.tight_layout()
```

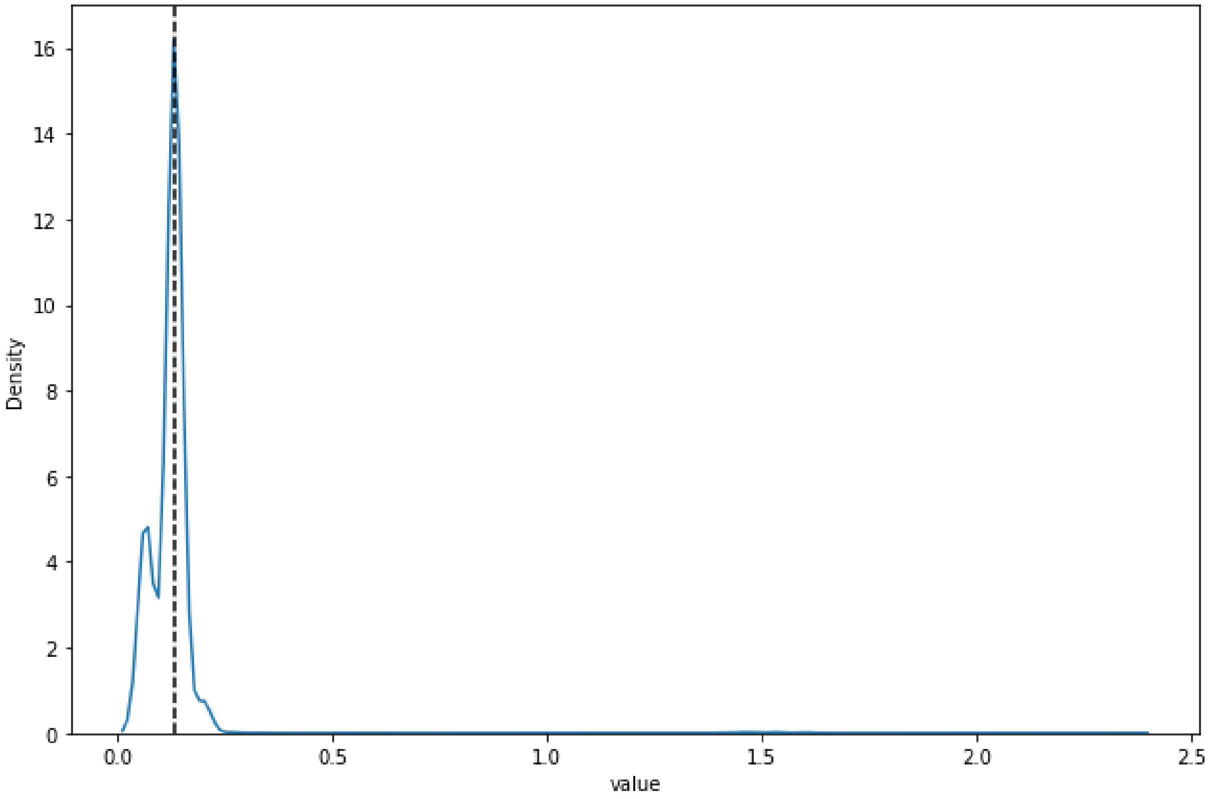


Baseline: Median Absolute Deviation (MAD)

In [9]:

```
import seaborn as sns

sns.kdeplot(df['value']);
plt.grid(False)
plt.axvline(0.134, 0, 1, c='black',ls='--')
plt.tight_layout()
```



In [10]:

```
from scipy.stats import median_abs_deviation

mad = median_abs_deviation(df['value'])
median = np.median(df['value'])

print(median)
print(mad)

def compute_robust_z_score(x):
    return .6745*(x-median)/mad
```

```
0.134
0.0020000000000000018
```

In [11]:

```
df['z-score'] = df['value'].apply(compute_robust_z_score)
df.head()
```

Out[11]:

	timestamp	value	is_anomaly	z-score
0	2014-02-14 14:30:00	0.132	1	-0.6745
1	2014-02-14 14:35:00	0.134	1	0.0000
2	2014-02-14 14:40:00	0.134	1	0.0000
3	2014-02-14 14:45:00	0.134	1	0.0000
4	2014-02-14 14:50:00	0.134	1	0.0000

In [12]:

```
df['baseline'] = 1

df.loc[df['z-score'] >=3.5, 'baseline'] = -1
df.loc[df['z-score'] <=-3.5, 'baseline'] = -1
```

Evaluation

In [13]:

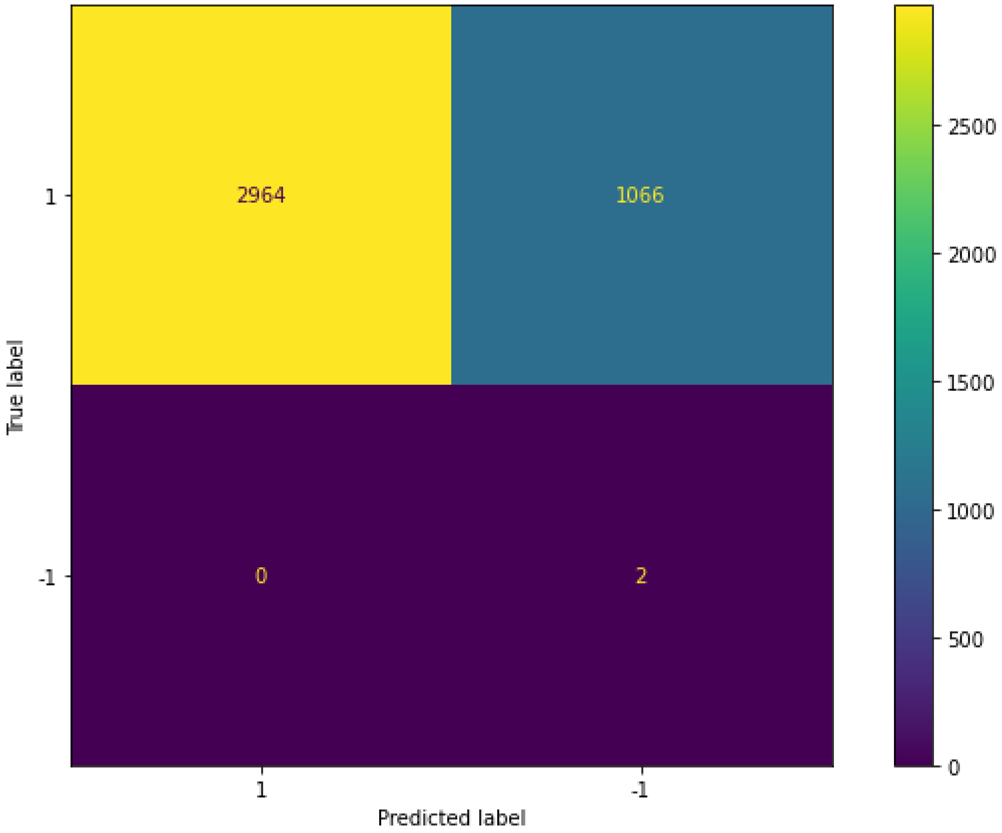
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

cm = confusion_matrix(df['is_anomaly'], df['baseline'], labels=[1, -1])

disp_cm = ConfusionMatrixDisplay(cm, display_labels = [1, -1])

disp_cm.plot();

plt.grid(False)
plt.tight_layout()
```



Isolation forest

In [14]:

```
from sklearn.ensemble import IsolationForest
```

In [15]:

```
train = df[:3550]
test = df[3550:]
```

In [16]:

```
contamination = 1/len(train)

iso_forest = IsolationForest(contamination = contamination, random_state =42)

X_train = train['value'].values.reshape(-1, 1)

iso_forest.fit(X_train)
```

Out[16]:

```
IsolationForest(contamination=0.00028169014084507044, random_state=42)
```

In [17]:

```
preds_iso_forest = iso_forest.predict(test['value'].values.reshape(-1, 1))
```

In [20]:

```
df.tail()
```

Out[20]:

	timestamp	value	is_anomaly	z-score	baseline
4027	2014-02-28 14:05:00	0.132	1	-0.6745	1
4028	2014-02-28 14:10:00	0.134	1	0.0000	1
4029	2014-02-28 14:15:00	0.134	1	0.0000	1

	timestamp	value	is_anomaly	z-score	baseline
4030	2014-02-28 14:20:00	0.134	1	0.0000	1
4031	2014-02-28 14:25:00	0.134	1	0.0000	1

Evaluation

In [21]:

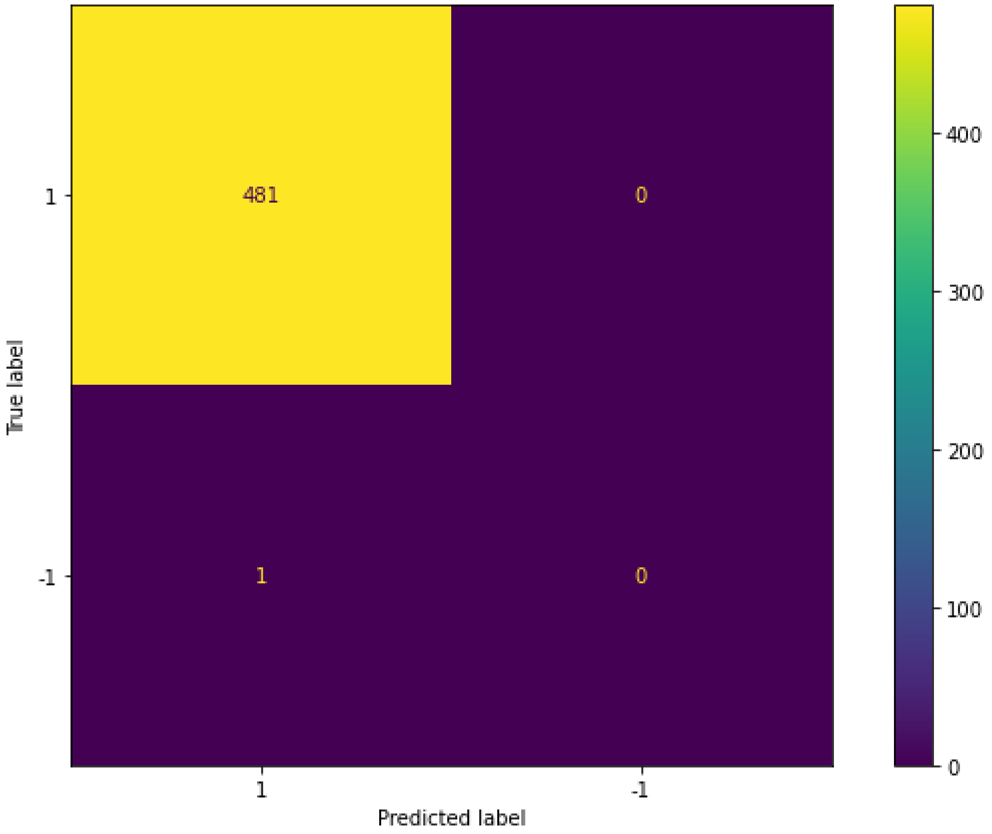
```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

cm = confusion_matrix(test['is_anomaly'], preds_iso_forest, labels=[1, -1])

disp_cm = ConfusionMatrixDisplay(cm, display_labels = [1, -1])

disp_cm.plot();

plt.grid(False)
plt.tight_layout()
```



Local Outlier Factor(LOF)

In [25]:

```
from sklearn.neighbors import LocalOutlierFactor

lof = LocalOutlierFactor(contamination=contamination, novelty = True)

lof.fit(X_train)
```

Out[25]:

```
LocalOutlierFactor(contamination=0.00028169014084507044, novelty=True)
```

In [26]:

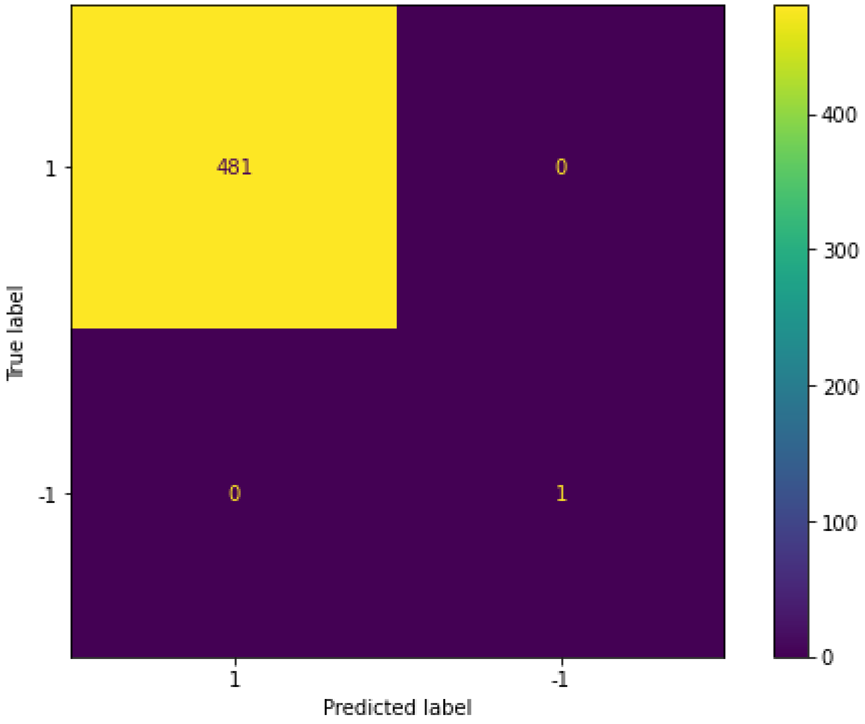
```
preds_lof = lof.predict(test['value'].values.reshape(-1,1))
```

In [28]:

```
cm = confusion_matrix(test['is_anomaly'], preds_lof, labels= [1,-1])

disp_cm = ConfusionMatrixDisplay(cm, display_labels =[1, -1])

disp_cm.plot();
```



In [ ]:

```

```