###Projekt Sieci Neuronowe Dominik Ossowski

W tym projekcie zająłem się badaniem hipotezy: "czy charakter przebiegu i zmian w sieci w każdym z godzinowych odcinków doby, zgodnie z czasem lokalnym, jest podobny do analogicznych odcinków w innych dobach, niezależnie od pory roku, wakacji itp."

```
from pathlib import Path

import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import *
from tensorflow.keras.callbacks import ModelCheckpoint
from tensorflow.keras.losses import MeanSquaredError
from tensorflow.keras.metrics import RootMeanSquaredError
from tensorflow.keras.optimizers import Adam
import tensorflow as tf
from sklearn.linear_model import LinearRegression
from datetime import datetime
from sklearn.model_selection import train_test_split
from sklearn.metrics import r2_score
from sklearn.preprocessing import StandardScaler
from tensorflow import keras
from tensorflow.keras import layers
import tensorflow_addons as tfa
from tensorflow.keras.utils import to_categorical
from sklearn.metrics import classification_report
```

```
!pip3 install tensorflow-addons
```

```
Looking in indexes: https://pypi.org/simple, https://us-
python.pkg.dev/colab-wheels/public/simple/
Collecting tensorflow-addons
  Downloading tensorflow_addons-0.20.0-cp310-cp310-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (591 kB)
━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 591.0/591.0 kB 9.3 MB/s eta
0:00:00
ent already satisfied: packaging in /usr/local/lib/python3.10/dist-
packages (from tensorflow-addons) (23.1)
Collecting typeguard<3.0.0,>=2.7 (from tensorflow-addons)
  Downloading typeguard-2.13.3-py3-none-any.whl (17 kB)
Installing collected packages: typeguard, tensorflow-addons
Successfully installed tensorflow-addons-0.20.0 typeguard-2.13.3
```

1. Pierwszym etapem projektu jest wczytanie danych i dokonanie ich analizy

```
def load_zip(zip):
    df = pd.read_csv(zip)
    df.columns = ['time', 'value']
```

```
    df['time'] = pd.to_datetime(df['time'], unit='ms')
    df['value'] = df['value'].astype('float32')
    return df


zips = Path('drive/MyDrive/data1').glob('*.zip')
dfs = (load_zip(zip) for zip in zips)
df = pd.concat(dfs).set_index('time')
df = df.sort_index()

df.head()
```

```
                            value
time
2022-01-01 00:00:01.530  228.977997
2022-01-01 00:00:02.530  228.975006
2022-01-01 00:00:03.528  228.964996
2022-01-01 00:00:04.530  228.979004
2022-01-01 00:00:05.530  228.934006
```

```
def generate_day_plot(df):
    df = df
    df_grouped = df.groupby([df.index.minute,
df.index.hour]).mean().unstack()['value']
    df_day = pd.concat([df_grouped[i] for i in
range(24)]).reset_index(drop=True)
    df_day.index = pd.to_timedelta(df_day.index, unit='m')
    df_day.plot(kind='line', figsize=(20, 5))
    print(df)
    print(df.info())
```

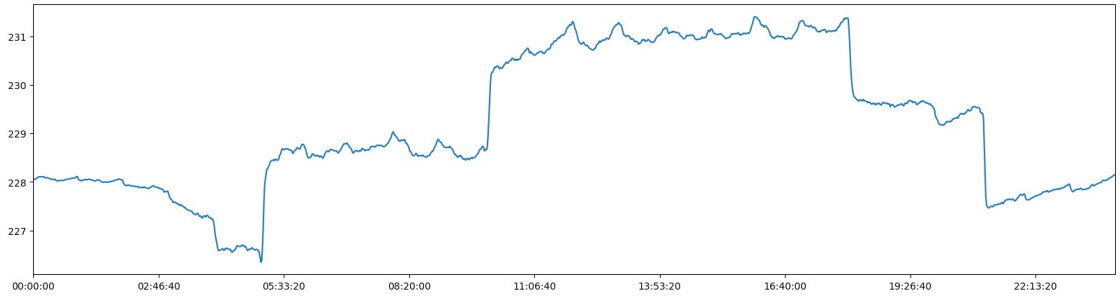
Funkcja generate_day_plot przyjmuje obiekt DataFrame df i generuje wykres liniowy, który przedstawia średnie wartości dla każdej minuty w ciągu całego dnia. Funkcja grupuje dane według godziny i minuty, oblicza średnie wartości dla każdej grupy, a następnie generuje wykres liniowy. Na końcu wyświetlane są informacje o przekazanym obiekcie DataFrame df.

```
generate_day_plot(df)
```

```
                            value
time
2022-01-01 00:00:01.530  228.977997
2022-01-01 00:00:02.530  228.975006
2022-01-01 00:00:03.528  228.964996
2022-01-01 00:00:04.530  228.979004
2022-01-01 00:00:05.530  228.934006
...                             ...
2022-12-31 23:59:55.154  230.076996
2022-12-31 23:59:56.154  230.121994
2022-12-31 23:59:57.153  230.123993
2022-12-31 23:59:58.152  230.141998
```

```
2022-12-31 23:59:59.152  230.143997

[31485233 rows x 1 columns]
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 31485233 entries, 2022-01-01 00:00:01.530000 to 2022-
12-31 23:59:59.152000
Data columns (total 1 columns):
 #   Column  Dtype
---  ------  -----
 0   value   float32
dtypes: float32(1)
memory usage: 360.3 MB
None
```



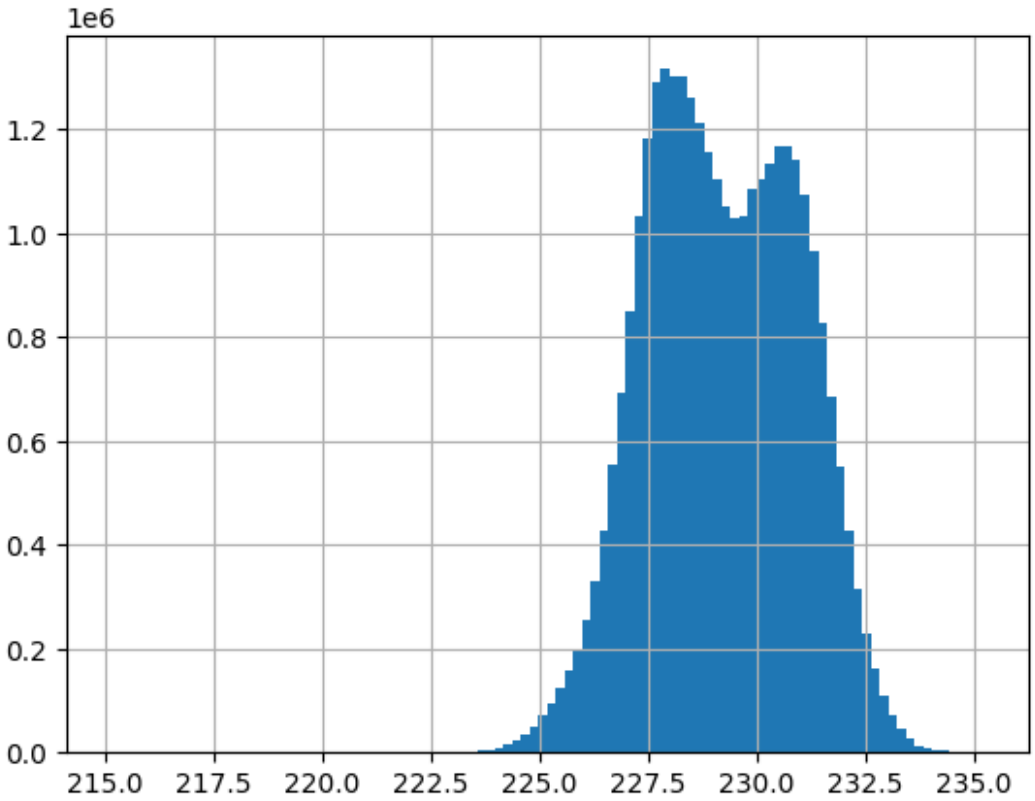
Rozkład napięcia w ciągu jednego dnia

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
DatetimeIndex: 31485233 entries, 2022-01-01 00:00:01.530000 to 2022-
12-31 23:59:59.152000
Data columns (total 1 columns):
 #   Column  Dtype
---  ------  -----
 0   value   float32
dtypes: float32(1)
memory usage: 360.3 MB
```

```
df['value'].hist(bins=100)
```

```
<Axes: >
```



1. Drugim etapem projektu jest sprawdzanie hipotezy używając technik uczenia maszynowego. Przeszukując dostępne źródła nie natknąłem się na żadne rozwiązania. Wygląda na to, że tym rodzajem problemu nikt się jeszcze nie zajmował, albo zajmował, ale nie udostępnił wyników. Wracając do użytych technik, wywnioskowałem, że muszą istnieć 2 podejścia do time series dataset:

2. Domyślna - regresja

3. Zrezygnowanie z aspektu szeregu czasowego danych i stworzenie klasyfikacji

Regresja jest powszechnie używaną techniką radzenia sobie z time series data i dzieli się na 2 modele:

```
1. RNN (a dokładnie LSTM)
2. Regresja liniowa
```

Klasyfikacja zakłada rezygnację z szeregowości czasowej danych i bierze pod uwagę 24 klasy po 3600 wierszy danych.

2a. LSTM

```
df.isnull().values.any()
```

```
False
```

```
df_resampled = df.resample('1h').mean()
```

```
df_resampled.head()
```

```
                           value
time
2022-01-01 00:00:00  229.130783
2022-01-01 01:00:00  229.179276
2022-01-01 02:00:00  229.599426
2022-01-01 03:00:00  229.603622
2022-01-01 04:00:00  229.962280
```

```
df_resampled.isnull().values.any()
```

```
True
```

```
df_resampled['value'].fillna(method='ffill', inplace=True)
```

```
df_resampled.isnull().values.any()
```

```
False
```

Aby dane nadawały się do treningu należy sprowadzić timestampy do rónych odległości w czasie (w moim przypadku do 1 godziny) - do tego służy metoda .resample(). Funkcja ta produkuje niestety wartości null, które należy zastąpić za pomocą metody .fillna().

Przygotowanie danych do treningu

```
train_size = int(len(df_resampled) * 0.8)
train_data = df_resampled.iloc[:train_size]
test_data = df_resampled.iloc[train_size:]

def create_sequences(data, sequence_length):
    sequences = []
    for i in range(len(data) - sequence_length):
        sequence = data[i:i+sequence_length+1]
        sequences.append(sequence)
    return sequences
```

Ten fragment kodu obejmuje dwie operacje.

Pierwsza operacja to podział zbioru danych df_resampled na zbiory treningowy i testowy. Zbiór treningowy stanowi 80% danych, a zbiór testowy to pozostałe 20%.

Druga operacja definiuje funkcję create_sequences, która służy do tworzenia sekwencji danych. Funkcja przyjmuje dane i długość sekwencji. Następnie iteruje przez dane i tworzy sekwencje o zadanej długości, dodając do nich jeden dodatkowy element. Utworzone sekwencje są zwracane jako wynik funkcji.

```
sequence_length = 3
train_sequences = create_sequences(train_data['value'].values,
sequence_length)
test_sequences = create_sequences(test_data['value'].values,
sequence_length)
```

```
def split_sequences(sequences):
    X = []
    y = []
    for sequence in sequences:
        X.append(sequence[:-1])
        y.append(sequence[-1])
    return np.array(X), np.array(y)

X_train, y_train = split_sequences(train_sequences)
X_test, y_test = split_sequences(test_sequences)
```

Ten fragment kodu zawiera operacje związane z tworzeniem sekwencji danych i podziałem ich na zestawy treningowe i testowe:

sequence_length = 3: Ustalenie długości sekwencji na 3.

train_sequences = create_sequences(train_data['value'].values, sequence_length): Tworzenie sekwencji treningowych na podstawie wartości kolumny 'value' ze zbioru treningowego.

test_sequences = create_sequences(test_data['value'].values, sequence_length): Tworzenie sekwencji testowych na podstawie wartości kolumny 'value' ze zbioru testowego.

split_sequences(sequences): Funkcja, która przyjmuje sekwencje danych i dzieli je na cechy (X) i etykiety (y).

X_train, y_train = split_sequences(train_sequences): Podział sekwencji treningowych na cechy treningowe (X_train) i etykiety treningowe (y_train).

X_test, y_test = split_sequences(test_sequences): Podział sekwencji testowych na cechy testowe (X_test) i etykiety testowe (y_test).

```
X_train.shape
```

```
(7005, 3)
```

```
y_train.shape
```

```
(7005,)
```

```
model10 = Sequential()
model10.add(InputLayer(input_shape=(sequence_length, 1)))
model10.add(LSTM(64,return_sequences=False))
model10.add(Dense(8, 'relu'))
model10.add(Dense(1, 'linear'))

model10.summary()
```

```
Model: "sequential_4"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
```

```
 lstm_3 (LSTM)               (None, 64)                16896

 dense_6 (Dense)             (None, 8)                 520

 dense_7 (Dense)             (None, 1)                 9

=================================================================
Total params: 17,425
Trainable params: 17,425
Non-trainable params: 0
_________________________________________________________________
```

Model model10 jest sekwencyjnym modelem sieci neuronowej, który składa się z warstwy wejściowej o kształcie (sequence_length, 1), jednej warstwy LSTM z 64 jednostkami, dwóch warstw gęstych z funkcją aktywacji ReLU i jednej warstwy wyjściowej. Model ten ma łącznie 9 parametrów do trenowania.

```
cp1 = ModelCheckpoint('model1/', save_best_only=True)
model10.compile(loss=MeanSquaredError(),
optimizer=Adam(learning_rate=0.001), metrics=[RootMeanSquaredError()])

history = model10.fit(X_train, y_train, epochs=100, callbacks=[cp1])

Epoch 1/100
213/219 [============================>.] - ETA: 0s - loss: 46031.8984
- root_mean_squared_error: 214.5505

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 4s 5ms/step - loss:
45827.3438 - root_mean_squared_error: 214.0732
Epoch 2/100
216/219 [============================>.] - ETA: 0s - loss: 29190.4473
- root_mean_squared_error: 170.8521

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss:
29070.2578 - root_mean_squared_error: 170.5000
Epoch 3/100
214/219 [============================>.] - ETA: 0s - loss: 12404.9561
- root_mean_squared_error: 111.3775

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss:
12263.1035 - root_mean_squared_error: 110.7389
Epoch 4/100
```

```
212/219 [============================>.] - ETA: 0s - loss: 2740.6743 -
root_mean_squared_error: 52.3515

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss:
2676.3745 - root_mean_squared_error: 51.7337
Epoch 5/100
211/219 [===========================>..] - ETA: 0s - loss: 226.4625 -
root_mean_squared_error: 15.0487

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss:
219.5103 - root_mean_squared_error: 14.8159
Epoch 6/100
219/219 [==============================] - ETA: 0s - loss: 10.7151 -
root_mean_squared_error: 3.2734

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss:
10.7151 - root_mean_squared_error: 3.2734
Epoch 7/100
209/219 [===========================>..] - ETA: 0s - loss: 2.8153 -
root_mean_squared_error: 1.6779

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8249
- root_mean_squared_error: 1.6807
Epoch 8/100
208/219 [===========================>..] - ETA: 0s - loss: 2.8130 -
root_mean_squared_error: 1.6772

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8040
- root_mean_squared_error: 1.6745
Epoch 9/100
212/219 [============================>.] - ETA: 0s - loss: 2.7959 -
root_mean_squared_error: 1.6721

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8039
- root_mean_squared_error: 1.6745
```

```
Epoch 10/100
214/219 [============================>.] - ETA: 0s - loss: 2.8020 -
root_mean_squared_error: 1.6739

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.8034
- root_mean_squared_error: 1.6743
Epoch 11/100
217/219 [============================>.] - ETA: 0s - loss: 2.8054 -
root_mean_squared_error: 1.6749

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8046
- root_mean_squared_error: 1.6747
Epoch 12/100
210/219 [============================>..] - ETA: 0s - loss: 2.8063 -
root_mean_squared_error: 1.6752

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.8039
- root_mean_squared_error: 1.6745
Epoch 13/100
218/219 [============================>.] - ETA: 0s - loss: 2.8030 -
root_mean_squared_error: 1.6742

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8038
- root_mean_squared_error: 1.6744
Epoch 14/100
216/219 [============================>.] - ETA: 0s - loss: 2.7995 -
root_mean_squared_error: 1.6732

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8044
- root_mean_squared_error: 1.6746
Epoch 15/100
210/219 [============================>..] - ETA: 0s - loss: 2.8016 -
root_mean_squared_error: 1.6738

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 5ms/step - loss: 2.8042
- root_mean_squared_error: 1.6746
Epoch 16/100
216/219 [============================>.] - ETA: 0s - loss: 2.8044 -
root_mean_squared_error: 1.6746

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.8044
- root_mean_squared_error: 1.6746
Epoch 17/100
210/219 [===========================>..] - ETA: 0s - loss: 2.7837 -
root_mean_squared_error: 1.6685

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.8052
- root_mean_squared_error: 1.6749
Epoch 18/100
216/219 [============================>.] - ETA: 0s - loss: 2.8025 -
root_mean_squared_error: 1.6741

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8053
- root_mean_squared_error: 1.6749
Epoch 19/100
216/219 [============================>.] - ETA: 0s - loss: 2.8088 -
root_mean_squared_error: 1.6760

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8062
- root_mean_squared_error: 1.6752
Epoch 20/100
219/219 [==============================] - ETA: 0s - loss: 2.8052 -
root_mean_squared_error: 1.6749

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8052
- root_mean_squared_error: 1.6749
Epoch 21/100
219/219 [==============================] - ETA: 0s - loss: 2.8063 -
root_mean_squared_error: 1.6752

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 5ms/step - loss: 2.8063
- root_mean_squared_error: 1.6752
Epoch 22/100
213/219 [============================>.] - ETA: 0s - loss: 2.8144 -
root_mean_squared_error: 1.6776

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 2.8077
- root_mean_squared_error: 1.6756
Epoch 23/100
219/219 [==============================] - ETA: 0s - loss: 2.8083 -
root_mean_squared_error: 1.6758

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8083
- root_mean_squared_error: 1.6758
Epoch 24/100
219/219 [==============================] - ETA: 0s - loss: 2.8078 -
root_mean_squared_error: 1.6757

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8078
- root_mean_squared_error: 1.6757
Epoch 25/100
211/219 [===========================>..] - ETA: 0s - loss: 2.8010 -
root_mean_squared_error: 1.6736

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 2.8083
- root_mean_squared_error: 1.6758
Epoch 26/100
217/219 [============================>.] - ETA: 0s - loss: 2.8054 -
root_mean_squared_error: 1.6749

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8062
- root_mean_squared_error: 1.6752
Epoch 27/100
212/219 [============================>.] - ETA: 0s - loss: 2.8024 -
root_mean_squared_error: 1.6740

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 2.8099
- root_mean_squared_error: 1.6763
Epoch 28/100
211/219 [===========================>..] - ETA: 0s - loss: 2.7999 -
root_mean_squared_error: 1.6733

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8068
- root_mean_squared_error: 1.6753
Epoch 29/100
211/219 [===========================>..] - ETA: 0s - loss: 2.8155 -
root_mean_squared_error: 1.6780

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8122
- root_mean_squared_error: 1.6769
Epoch 30/100
211/219 [===========================>..] - ETA: 0s - loss: 2.8015 -
root_mean_squared_error: 1.6738

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8081
- root_mean_squared_error: 1.6757
Epoch 31/100
212/219 [============================>.] - ETA: 0s - loss: 2.8238 -
root_mean_squared_error: 1.6804

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8163
- root_mean_squared_error: 1.6782
Epoch 32/100
209/219 [===========================>..] - ETA: 0s - loss: 2.8183 -
root_mean_squared_error: 1.6788

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8107
- root_mean_squared_error: 1.6765
Epoch 33/100
215/219 [============================>.] - ETA: 0s - loss: 2.8098 -
root_mean_squared_error: 1.6763

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 5ms/step - loss: 2.8143
- root_mean_squared_error: 1.6776
Epoch 34/100
213/219 [============================>.] - ETA: 0s - loss: 2.8178 -
root_mean_squared_error: 1.6786

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8145
- root_mean_squared_error: 1.6777
Epoch 35/100
215/219 [============================>.] - ETA: 0s - loss: 2.8150 -
root_mean_squared_error: 1.6778

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8099
- root_mean_squared_error: 1.6763
Epoch 36/100
218/219 [============================>.] - ETA: 0s - loss: 2.8062 -
root_mean_squared_error: 1.6752

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8054
- root_mean_squared_error: 1.6749
Epoch 37/100
215/219 [============================>.] - ETA: 0s - loss: 2.8182 -
root_mean_squared_error: 1.6788

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 2.8179
- root_mean_squared_error: 1.6787
Epoch 38/100
208/219 [===========================>..] - ETA: 0s - loss: 2.8228 -
root_mean_squared_error: 1.6801

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8166
- root_mean_squared_error: 1.6783
Epoch 39/100
212/219 [============================>.] - ETA: 0s - loss: 2.8254 -
root_mean_squared_error: 1.6809

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 5ms/step - loss: 2.8186
- root_mean_squared_error: 1.6789
Epoch 40/100
210/219 [===========================>..] - ETA: 0s - loss: 2.8273 -
root_mean_squared_error: 1.6815

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8262
- root_mean_squared_error: 1.6811
Epoch 41/100
211/219 [===========================>..] - ETA: 0s - loss: 2.8200 -
root_mean_squared_error: 1.6793

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8216
- root_mean_squared_error: 1.6797
Epoch 42/100
210/219 [===========================>..] - ETA: 0s - loss: 2.8222 -
root_mean_squared_error: 1.6799

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8242
- root_mean_squared_error: 1.6805
Epoch 43/100
217/219 [============================>.] - ETA: 0s - loss: 2.8288 -
root_mean_squared_error: 1.6819

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8196
- root_mean_squared_error: 1.6792
Epoch 44/100
217/219 [============================>.] - ETA: 0s - loss: 2.8201 -
root_mean_squared_error: 1.6793

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8218
- root_mean_squared_error: 1.6798
Epoch 45/100
217/219 [============================>.] - ETA: 0s - loss: 2.8133 -
root_mean_squared_error: 1.6773

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 5ms/step - loss: 2.8175
- root_mean_squared_error: 1.6785
Epoch 46/100
216/219 [============================>.] - ETA: 0s - loss: 2.8403 -
root_mean_squared_error: 1.6853

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8424
- root_mean_squared_error: 1.6859
Epoch 47/100
212/219 [============================>.] - ETA: 0s - loss: 2.8408 -
root_mean_squared_error: 1.6855

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.8335
- root_mean_squared_error: 1.6833
Epoch 48/100
218/219 [============================>.] - ETA: 0s - loss: 2.8627 -
root_mean_squared_error: 1.6920

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.8653
- root_mean_squared_error: 1.6927
Epoch 49/100
216/219 [============================>.] - ETA: 0s - loss: 2.8404 -
root_mean_squared_error: 1.6854

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 8ms/step - loss: 2.8356
- root_mean_squared_error: 1.6839
Epoch 50/100
218/219 [============================>.] - ETA: 0s - loss: 2.8472 -
root_mean_squared_error: 1.6874

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 2s 7ms/step - loss: 2.8449
- root_mean_squared_error: 1.6867
Epoch 51/100
217/219 [============================>.] - ETA: 0s - loss: 2.8590 -
root_mean_squared_error: 1.6909

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 7ms/step - loss: 2.8592
- root_mean_squared_error: 1.6909
Epoch 52/100
210/219 [============================>..] - ETA: 0s - loss: 2.8054 -
root_mean_squared_error: 1.6749

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 2.8230
- root_mean_squared_error: 1.6802
Epoch 53/100
219/219 [==============================] - ETA: 0s - loss: 2.7805 -
root_mean_squared_error: 1.6675

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.7805
- root_mean_squared_error: 1.6675
Epoch 54/100
214/219 [============================>.] - ETA: 0s - loss: 2.8334 -
root_mean_squared_error: 1.6833

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.8189
- root_mean_squared_error: 1.6790
Epoch 55/100
213/219 [============================>.] - ETA: 0s - loss: 2.7999 -
root_mean_squared_error: 1.6733

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.8033
- root_mean_squared_error: 1.6743
Epoch 56/100
209/219 [============================>..] - ETA: 0s - loss: 2.7818 -
root_mean_squared_error: 1.6679

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.7872
- root_mean_squared_error: 1.6695
Epoch 57/100
212/219 [============================>.] - ETA: 0s - loss: 2.7746 -
root_mean_squared_error: 1.6657

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 2.7769
- root_mean_squared_error: 1.6664
Epoch 58/100
219/219 [==============================] - ETA: 0s - loss: 2.7196 -
root_mean_squared_error: 1.6491

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.7196
- root_mean_squared_error: 1.6491
Epoch 59/100
213/219 [============================>.] - ETA: 0s - loss: 2.6606 -
root_mean_squared_error: 1.6311

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.6593
- root_mean_squared_error: 1.6307
Epoch 60/100
206/219 [===========================>..] - ETA: 0s - loss: 2.7403 -
root_mean_squared_error: 1.6554

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.7425
- root_mean_squared_error: 1.6561
Epoch 61/100
208/219 [===========================>..] - ETA: 0s - loss: 2.5676 -
root_mean_squared_error: 1.6024

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.5675
- root_mean_squared_error: 1.6024
Epoch 62/100
215/219 [============================>.] - ETA: 0s - loss: 2.5337 -
root_mean_squared_error: 1.5918

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.5345
- root_mean_squared_error: 1.5920
Epoch 63/100
218/219 [============================>.] - ETA: 0s - loss: 2.4288 -
root_mean_squared_error: 1.5584

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 7ms/step - loss: 2.4311
- root_mean_squared_error: 1.5592
Epoch 64/100
216/219 [============================>.] - ETA: 0s - loss: 2.2161 -
root_mean_squared_error: 1.4887

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.2125
- root_mean_squared_error: 1.4874
Epoch 65/100
214/219 [============================>.] - ETA: 0s - loss: 2.2106 -
root_mean_squared_error: 1.4868

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 7ms/step - loss: 2.2077
- root_mean_squared_error: 1.4858
Epoch 66/100
217/219 [============================>.] - ETA: 0s - loss: 2.3057 -
root_mean_squared_error: 1.5185

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.3040
- root_mean_squared_error: 1.5179
Epoch 67/100
215/219 [============================>.] - ETA: 0s - loss: 2.0999 -
root_mean_squared_error: 1.4491

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 2.1017
- root_mean_squared_error: 1.4497
Epoch 68/100
213/219 [============================>.] - ETA: 0s - loss: 1.9285 -
root_mean_squared_error: 1.3887

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.9214
- root_mean_squared_error: 1.3861
Epoch 69/100
212/219 [============================>.] - ETA: 0s - loss: 1.9755 -
root_mean_squared_error: 1.4055

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 1.9800
- root_mean_squared_error: 1.4071
Epoch 70/100
207/219 [===========================>..] - ETA: 0s - loss: 1.7991 -
root_mean_squared_error: 1.3413

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.8028
- root_mean_squared_error: 1.3427
Epoch 71/100
212/219 [============================>.] - ETA: 0s - loss: 1.6950 -
root_mean_squared_error: 1.3019

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.7053
- root_mean_squared_error: 1.3059
Epoch 72/100
211/219 [===========================>..] - ETA: 0s - loss: 1.7159 -
root_mean_squared_error: 1.3099

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.7181
- root_mean_squared_error: 1.3108
Epoch 73/100
210/219 [===========================>..] - ETA: 0s - loss: 1.7362 -
root_mean_squared_error: 1.3176

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.7357
- root_mean_squared_error: 1.3175
Epoch 74/100
208/219 [===========================>..] - ETA: 0s - loss: 1.6335 -
root_mean_squared_error: 1.2781

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.6349
- root_mean_squared_error: 1.2786
Epoch 75/100
210/219 [===========================>..] - ETA: 0s - loss: 1.5234 -
root_mean_squared_error: 1.2343

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 1.5338
- root_mean_squared_error: 1.2385
Epoch 76/100
216/219 [============================>.] - ETA: 0s - loss: 1.4604 -
root_mean_squared_error: 1.2085

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.4579
- root_mean_squared_error: 1.2075
Epoch 77/100
212/219 [============================>.] - ETA: 0s - loss: 1.4492 -
root_mean_squared_error: 1.2038

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 1.4606
- root_mean_squared_error: 1.2086
Epoch 78/100
217/219 [============================>.] - ETA: 0s - loss: 1.4029 -
root_mean_squared_error: 1.1844

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 1.4042
- root_mean_squared_error: 1.1850
Epoch 79/100
215/219 [============================>.] - ETA: 0s - loss: 1.4117 -
root_mean_squared_error: 1.1881

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 1.4113
- root_mean_squared_error: 1.1880
Epoch 80/100
205/219 [===========================>..] - ETA: 0s - loss: 1.2996 -
root_mean_squared_error: 1.1400

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 5ms/step - loss: 1.2891
- root_mean_squared_error: 1.1354
Epoch 81/100
205/219 [===========================>..] - ETA: 0s - loss: 1.4441 -
root_mean_squared_error: 1.2017

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 1.4406
- root_mean_squared_error: 1.2003
Epoch 82/100
215/219 [============================>.] - ETA: 0s - loss: 1.4130 -
root_mean_squared_error: 1.1887

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.4291
- root_mean_squared_error: 1.1954
Epoch 83/100
219/219 [==============================] - ETA: 0s - loss: 1.2643 -
root_mean_squared_error: 1.1244

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.2643
- root_mean_squared_error: 1.1244
Epoch 84/100
208/219 [===========================>..] - ETA: 0s - loss: 1.3113 -
root_mean_squared_error: 1.1451

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.3192
- root_mean_squared_error: 1.1486
Epoch 85/100
212/219 [============================>.] - ETA: 0s - loss: 1.2417 -
root_mean_squared_error: 1.1143

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.2368
- root_mean_squared_error: 1.1121
Epoch 86/100
212/219 [============================>.] - ETA: 0s - loss: 1.3675 -
root_mean_squared_error: 1.1694

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.3712
- root_mean_squared_error: 1.1710
Epoch 87/100
216/219 [============================>.] - ETA: 0s - loss: 1.2402 -
root_mean_squared_error: 1.1136

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 1.2387
- root_mean_squared_error: 1.1130
Epoch 88/100
213/219 [============================>.] - ETA: 0s - loss: 1.3966 -
root_mean_squared_error: 1.1818

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.3906
- root_mean_squared_error: 1.1792
Epoch 89/100
219/219 [==============================] - ETA: 0s - loss: 1.2082 -
root_mean_squared_error: 1.0992

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.2082
- root_mean_squared_error: 1.0992
Epoch 90/100
218/219 [============================>.] - ETA: 0s - loss: 1.2403 -
root_mean_squared_error: 1.1137

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.2410
- root_mean_squared_error: 1.1140
Epoch 91/100
214/219 [============================>.] - ETA: 0s - loss: 1.1443 -
root_mean_squared_error: 1.0697

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.1484
- root_mean_squared_error: 1.0716
Epoch 92/100
216/219 [============================>.] - ETA: 0s - loss: 1.1421 -
root_mean_squared_error: 1.0687

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 1.1456
- root_mean_squared_error: 1.0703
Epoch 93/100
215/219 [============================>.] - ETA: 0s - loss: 1.1423 -
root_mean_squared_error: 1.0688

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 6ms/step - loss: 1.1436
- root_mean_squared_error: 1.0694
Epoch 94/100
211/219 [===========================>..] - ETA: 0s - loss: 1.3151 -
root_mean_squared_error: 1.1468

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 1.3082
- root_mean_squared_error: 1.1438
Epoch 95/100
214/219 [============================>.] - ETA: 0s - loss: 1.3289 -
root_mean_squared_error: 1.1528

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 6ms/step - loss: 1.3210
- root_mean_squared_error: 1.1493
Epoch 96/100
212/219 [============================>.] - ETA: 0s - loss: 1.3402 -
root_mean_squared_error: 1.1577

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.3330
- root_mean_squared_error: 1.1545
Epoch 97/100
211/219 [===========================>..] - ETA: 0s - loss: 1.0779 -
root_mean_squared_error: 1.0382

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.0782
- root_mean_squared_error: 1.0384
Epoch 98/100
215/219 [============================>.] - ETA: 0s - loss: 1.0284 -
root_mean_squared_error: 1.0141

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.0292
- root_mean_squared_error: 1.0145
Epoch 99/100
218/219 [============================>.] - ETA: 0s - loss: 1.1813 -
root_mean_squared_error: 1.0869

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.
```

```
 219/219 [==============================] - 1s 4ms/step - loss: 1.1790
- root_mean_squared_error: 1.0858
Epoch 100/100
217/219 [============================>.] - ETA: 0s - loss: 1.2033 -
root_mean_squared_error: 1.0969

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 219/219 [==============================] - 1s 4ms/step - loss: 1.2005
- root_mean_squared_error: 1.0957
```

```
from tensorflow.keras.models import load_model
model1 = load_model('model1/')
```

```
train_predictions = model1.predict(X_train).flatten()
train_results = pd.DataFrame(data={'Train
Predictions':train_predictions, 'Actuals':y_train})
train_results
```

```
219/219 [==============================] - 0s 2ms/step
```

	Train Predictions	Actuals
0	229.156342	229.972504
1	229.156357	230.266754
2	229.156357	230.446320
3	229.156357	230.619217
4	229.156342	230.294601
...	...	...
6995	229.156357	230.094009
6996	229.156357	230.502975
6997	229.156357	229.392166
6998	229.156342	229.942551
6999	229.156357	229.020035

[7000 rows x 2 columns]

```
test_predictions = model1.predict(X_test).flatten()
test_results = pd.DataFrame(data={'Test Predictions':test_predictions,
'Actuals':y_test})
test_results
```

```
32/32 [==============================] - 0s 2ms/step
```

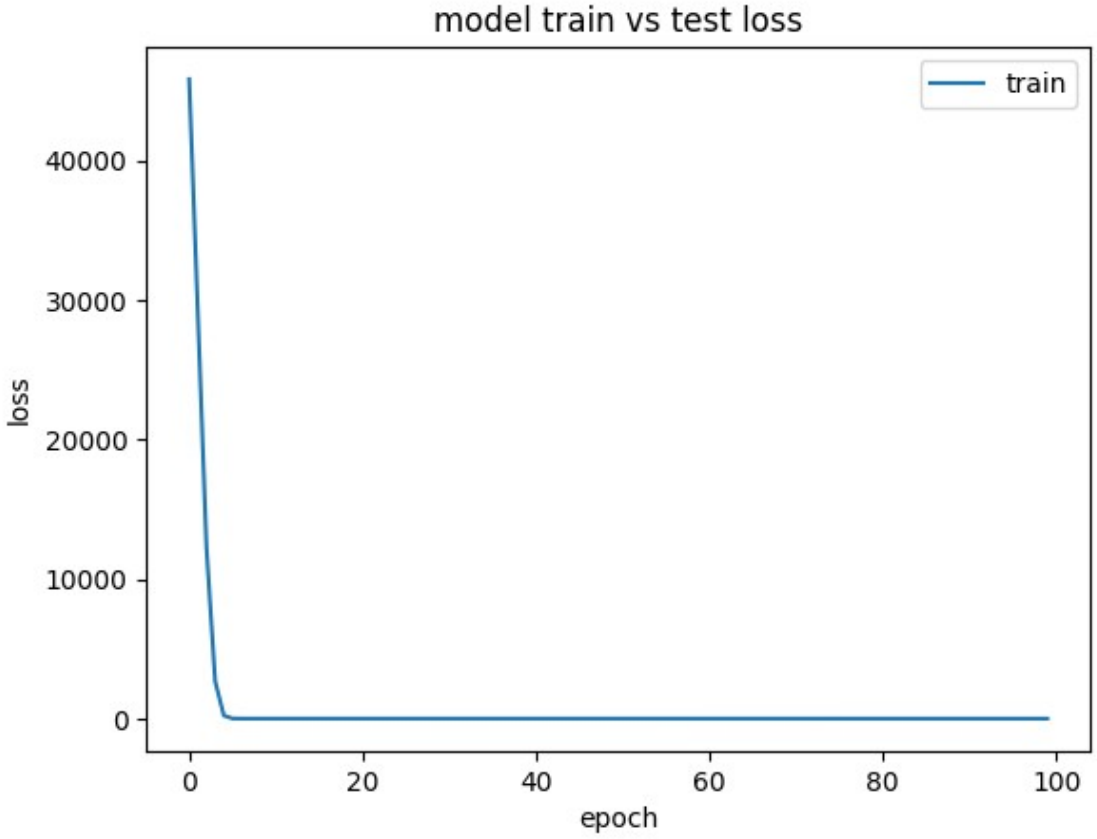
	Test Predictions	Actuals
0	229.156342	229.377472
1	229.156342	229.310104
2	229.156357	229.173431
3	229.156357	229.036972
4	229.156357	230.725174
..	...	...
995	229.156357	229.219894

```
996        229.156357  229.810226
997        229.156357  229.984299
998        229.156357  230.499542
999        229.156372  230.446625

[1000 rows x 2 columns]
```

```
from matplotlib import pyplot

pyplot.plot(history.history['loss'])
pyplot.title('model train vs test loss')
pyplot.ylabel('loss')
pyplot.xlabel('epoch')
pyplot.legend(['train', 'test'], loc='upper right')
pyplot.show()
```



Model wytrenował się bardzo dobrze -> niski loss i predykcje zbliżone do wartości true. Niestey, nasz model nauczył się przewidiywać value na podstawie czasu, a nie na odwrót. Spowodowane jest to implementacją sieci lstm, która zawsze jako input przyjmuje dane zmnienione na szereg czasowy i przez to predykcja czasu od wartości jest niemożliwa w tym przypadku.

2b. Regresja liniowa

Regresja liniowa może przyjąć szereg czasowy jako input, o ile jest on w formacie UNIX Timestamp i dokonywać predykcji z zadawalającą dokładnością.

```
df_resampled_c = df.resample('1h').mean()
```

```
df_resampled_c=df_resampled.reset_index('time')
```

```
df_resampled_c.head()
```

```
                 time       value
0 2022-01-01 00:00:00  229.130783
1 2022-01-01 01:00:00  229.179276
2 2022-01-01 02:00:00  229.599426
3 2022-01-01 03:00:00  229.603622
4 2022-01-01 04:00:00  229.962280
```

```
df_resampled_c['time'] = df_resampled_c['time'].apply(lambda x:
int(datetime.timestamp(x)))
```

```
df_resampled_c.head()
```

```
         time       value
0  1640995200  229.130783
1  1640998800  229.179276
2  1641002400  229.599426
3  1641006000  229.603622
4  1641009600  229.962280
```

```
X = df_resampled_c[['value']]
y = df_resampled_c['time']
```

W tym przypadku po operacji resamplingu musiałem "wyciągnać" dane o czasie z indeksu i zamienić je na unixowy format, ponieważ LinearRegression() nie przyjmuje innych formatów czasu.

```
X_train_c, X_test_c, y_train_c, y_test_c = train_test_split(X, y,
test_size=0.1)
```

```
model = LinearRegression()
model.fit(X_train_c, y_train_c)
```

```
LinearRegression()
```

```
y_pred = model.predict(X_test_c)
```

```
r2_scored = r2_score(y_test_c, y_pred)
r2_scored
```

```
0.0027106549875104413
```

W tym przypadku ciężo ocenić model, ponieważ nie normalizowałem danych, aby nie stracić interpretowalności i przez to r^2 nie jest najlepszą miarą jakości.

```
new_data = pd.DataFrame({'value': [228]})
predicted_timestamp = model.predict(new_data)
predicted_timestamp
```

```
array([1.65748045e+09])
```

https://www.epochconverter.com/

Według tego konwertera model przewidział godzinę 21

Jak widać regresja liniowa poradziła sobie z tym zdaniem i udało mi się przewidzieć godzinę na podstawie wartości napięcia fazy.

2c. Klasyfikacja

```
zips1 = Path('drive/MyDrive/data1').glob('*.zip')
dfs1 = (load_zip(zip) for zip in zips1)
df1 = pd.concat(dfs1).set_index('time')
df1 = df.sort_index()

df_resampled_k = df1.resample('1h').mean()

df_resampled_k.isnull().values.any()
```

```
True
```

```
df_resampled_k['value'].fillna(method='ffill', inplace=True)

df_resampled_k.isnull().values.any()
```

```
False
```

```
df_resampled_k
```

```
                         value
time
2022-01-01 00:00:00  229.130783
2022-01-01 01:00:00  229.179276
2022-01-01 02:00:00  229.599426
2022-01-01 03:00:00  229.603622
2022-01-01 04:00:00  229.962280
...                         ...
2022-12-31 19:00:00  229.219894
2022-12-31 20:00:00  229.810226
2022-12-31 21:00:00  229.984299
2022-12-31 22:00:00  230.499542
2022-12-31 23:00:00  230.446625

[8760 rows x 1 columns]
```

```
df_resampled_k['class'] = df_resampled_k.index.hour

df_resampled_k.shape
```

```
(8760, 2)
```

Utworzyłem dodatkową kolumnę 'class' w której przechowuję informację o klasie wartości napięcia. Klas jest 24 - jedna na każdą godzinę.

```
X1 = df_resampled_k['value'].values
y1 = df_resampled_k['class'].values

X1_train, X1_test, y1_train, y1_test = train_test_split(X1, y1,
test_size=0.1, random_state=42)

scaler = StandardScaler()
X1_train = scaler.fit_transform(X1_train.reshape(-1, 1))
X1_test = scaler.transform(X1_test.reshape(-1, 1))

num_classes = len(np.unique(y1_train))

y1_train = to_categorical(y1_train, num_classes)
y1_test = to_categorical(y1_test, num_classes)
```

Dane zostały znormalizowane i przygotowane do wprowadzenia do modelu.

```
num_classes
```

```
24
```

```
X1_train.shape
```

```
(7884, 1)
```

```
y1_train.shape
```

```
(7884, 24)
```

```
model = keras.Sequential([
    layers.Dense(64, activation='relu', input_shape=(1,)),
    layers.Dense(32, activation='relu'),
    layers.Dense(num_classes, activation='softmax')
])

cp2 = ModelCheckpoint('model2/', save_best_only=True)
model.compile(optimizer=Adam(learning_rate=0.001),
loss='categorical_crossentropy',
metrics=['accuracy',tfa.metrics.F1Score(num_classes=24,
                                        average='macro',
                                        threshold=0.5)])

model.fit(X1_train, y1_train, epochs=50, callbacks=[cp2])
```

```
Epoch 1/50
235/247 [===========================>..] - ETA: 0s - loss: 2.8625 -
accuracy: 0.0896 - f1_score: 0.0000e+00
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.8536
- accuracy: 0.0897 - f1_score: 0.0000e+00
Epoch 2/50
235/247 [===========================>..] - ETA: 0s - loss: 2.6140 -
accuracy: 0.1150 - f1_score: 0.0011

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.6147
- accuracy: 0.1154 - f1_score: 0.0010
Epoch 3/50
232/247 [===========================>..] - ETA: 0s - loss: 2.5718 -
accuracy: 0.1257 - f1_score: 0.0065

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5738
- accuracy: 0.1266 - f1_score: 0.0078
Epoch 4/50
223/247 [==========================>...] - ETA: 0s - loss: 2.5596 -
accuracy: 0.1282 - f1_score: 0.0133

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5604
- accuracy: 0.1294 - f1_score: 0.0143
Epoch 5/50
231/247 [===========================>..] - ETA: 0s - loss: 2.5563 -
accuracy: 0.1308 - f1_score: 0.0172

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5567
- accuracy: 0.1309 - f1_score: 0.0176
Epoch 6/50
240/247 [============================>.] - ETA: 0s - loss: 2.5516 -
accuracy: 0.1267 - f1_score: 0.0178

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5532
- accuracy: 0.1266 - f1_score: 0.0176
Epoch 7/50
226/247 [==========================>...] - ETA: 0s - loss: 2.5559 -
accuracy: 0.1325 - f1_score: 0.0184
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5526
- accuracy: 0.1343 - f1_score: 0.0187
Epoch 8/50
244/247 [============================>.] - ETA: 0s - loss: 2.5534 -
accuracy: 0.1313 - f1_score: 0.0178

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5519
- accuracy: 0.1318 - f1_score: 0.0178
Epoch 9/50
238/247 [===========================>..] - ETA: 0s - loss: 2.5527 -
accuracy: 0.1338 - f1_score: 0.0190

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5506
- accuracy: 0.1329 - f1_score: 0.0191
Epoch 10/50
240/247 [============================>.] - ETA: 0s - loss: 2.5499 -
accuracy: 0.1376 - f1_score: 0.0198

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5512
- accuracy: 0.1379 - f1_score: 0.0196
Epoch 11/50
236/247 [===========================>..] - ETA: 0s - loss: 2.5495 -
accuracy: 0.1314 - f1_score: 0.0196

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5495
- accuracy: 0.1313 - f1_score: 0.0196
Epoch 12/50
232/247 [===========================>..] - ETA: 0s - loss: 2.5490 -
accuracy: 0.1325 - f1_score: 0.0203

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5486
- accuracy: 0.1328 - f1_score: 0.0200
Epoch 13/50
237/247 [===========================>..] - ETA: 0s - loss: 2.5478 -
accuracy: 0.1329 - f1_score: 0.0201
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5469
- accuracy: 0.1324 - f1_score: 0.0201
Epoch 14/50
233/247 [===========================>..] - ETA: 0s - loss: 2.5488 -
accuracy: 0.1318 - f1_score: 0.0199

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5485
- accuracy: 0.1334 - f1_score: 0.0202
Epoch 15/50
232/247 [===========================>..] - ETA: 0s - loss: 2.5476 -
accuracy: 0.1342 - f1_score: 0.0201

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5478
- accuracy: 0.1334 - f1_score: 0.0200
Epoch 16/50
227/247 [==========================>...] - ETA: 0s - loss: 2.5420 -
accuracy: 0.1410 - f1_score: 0.0204

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5486
- accuracy: 0.1389 - f1_score: 0.0200
Epoch 17/50
236/247 [===========================>..] - ETA: 0s - loss: 2.5451 -
accuracy: 0.1315 - f1_score: 0.0204

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5455
- accuracy: 0.1327 - f1_score: 0.0205
Epoch 18/50
237/247 [===========================>..] - ETA: 0s - loss: 2.5459 -
accuracy: 0.1337 - f1_score: 0.0205

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5471
- accuracy: 0.1337 - f1_score: 0.0203
Epoch 19/50
245/247 [===========================>.] - ETA: 0s - loss: 2.5466 -
accuracy: 0.1347 - f1_score: 0.0198
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 3ms/step - loss: 2.5463
- accuracy: 0.1342 - f1_score: 0.0198
Epoch 20/50
229/247 [==========================>...] - ETA: 0s - loss: 2.5463 -
accuracy: 0.1339 - f1_score: 0.0208

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5465
- accuracy: 0.1350 - f1_score: 0.0207
Epoch 21/50
237/247 [===========================>..] - ETA: 0s - loss: 2.5481 -
accuracy: 0.1383 - f1_score: 0.0206

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5455
- accuracy: 0.1390 - f1_score: 0.0207
Epoch 22/50
227/247 [==========================>...] - ETA: 0s - loss: 2.5447 -
accuracy: 0.1320 - f1_score: 0.0196

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 3ms/step - loss: 2.5446
- accuracy: 0.1329 - f1_score: 0.0203
Epoch 23/50
231/247 [===========================>..] - ETA: 0s - loss: 2.5437 -
accuracy: 0.1353 - f1_score: 0.0207

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 3ms/step - loss: 2.5456
- accuracy: 0.1365 - f1_score: 0.0205
Epoch 24/50
236/247 [===========================>..] - ETA: 0s - loss: 2.5443 -
accuracy: 0.1316 - f1_score: 0.0208

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5463
- accuracy: 0.1313 - f1_score: 0.0205
Epoch 25/50
243/247 [============================>.] - ETA: 0s - loss: 2.5451 -
accuracy: 0.1359 - f1_score: 0.0201
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 3ms/step - loss: 2.5446
- accuracy: 0.1360 - f1_score: 0.0199
Epoch 26/50
242/247 [============================>.] - ETA: 0s - loss: 2.5448 -
accuracy: 0.1322 - f1_score: 0.0204

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5443
- accuracy: 0.1322 - f1_score: 0.0205
Epoch 27/50
228/247 [==========================>...] - ETA: 0s - loss: 2.5458 -
accuracy: 0.1342 - f1_score: 0.0207

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5450
- accuracy: 0.1341 - f1_score: 0.0205
Epoch 28/50
235/247 [===========================>..] - ETA: 0s - loss: 2.5460 -
accuracy: 0.1366 - f1_score: 0.0198

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5442
- accuracy: 0.1367 - f1_score: 0.0198
Epoch 29/50
241/247 [============================>.] - ETA: 0s - loss: 2.5433 -
accuracy: 0.1324 - f1_score: 0.0209

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5445
- accuracy: 0.1315 - f1_score: 0.0207
Epoch 30/50
237/247 [===========================>..] - ETA: 0s - loss: 2.5456 -
accuracy: 0.1344 - f1_score: 0.0200

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5447
- accuracy: 0.1352 - f1_score: 0.0199
Epoch 31/50
228/247 [==========================>...] - ETA: 0s - loss: 2.5448 -
accuracy: 0.1336 - f1_score: 0.0198
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5444
- accuracy: 0.1338 - f1_score: 0.0203
Epoch 32/50
236/247 [===========================>..] - ETA: 0s - loss: 2.5472 -
accuracy: 0.1353 - f1_score: 0.0205

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5450
- accuracy: 0.1347 - f1_score: 0.0202
Epoch 33/50
230/247 [==========================>...] - ETA: 0s - loss: 2.5417 -
accuracy: 0.1359 - f1_score: 0.0204

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5429
- accuracy: 0.1357 - f1_score: 0.0203
Epoch 34/50
232/247 [===========================>..] - ETA: 0s - loss: 2.5434 -
accuracy: 0.1334 - f1_score: 0.0210

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5439
- accuracy: 0.1329 - f1_score: 0.0206
Epoch 35/50
235/247 [===========================>..] - ETA: 0s - loss: 2.5439 -
accuracy: 0.1380 - f1_score: 0.0207

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5428
- accuracy: 0.1374 - f1_score: 0.0205
Epoch 36/50
222/247 [=========================>....] - ETA: 0s - loss: 2.5454 -
accuracy: 0.1322 - f1_score: 0.0206

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5432
- accuracy: 0.1317 - f1_score: 0.0204
Epoch 37/50
235/247 [===========================>..] - ETA: 0s - loss: 2.5444 -
accuracy: 0.1364 - f1_score: 0.0202
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5438
- accuracy: 0.1361 - f1_score: 0.0201
Epoch 38/50
227/247 [==========================>...] - ETA: 0s - loss: 2.5416 -
accuracy: 0.1375 - f1_score: 0.0195

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5434
- accuracy: 0.1360 - f1_score: 0.0198
Epoch 39/50
232/247 [===========================>..] - ETA: 0s - loss: 2.5419 -
accuracy: 0.1329 - f1_score: 0.0212

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5434
- accuracy: 0.1334 - f1_score: 0.0208
Epoch 40/50
238/247 [===========================>..] - ETA: 0s - loss: 2.5395 -
accuracy: 0.1337 - f1_score: 0.0191

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5420
- accuracy: 0.1334 - f1_score: 0.0192
Epoch 41/50
233/247 [===========================>..] - ETA: 0s - loss: 2.5472 -
accuracy: 0.1320 - f1_score: 0.0200

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5440
- accuracy: 0.1332 - f1_score: 0.0198
Epoch 42/50
230/247 [==========================>...] - ETA: 0s - loss: 2.5429 -
accuracy: 0.1342 - f1_score: 0.0203

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5422
- accuracy: 0.1339 - f1_score: 0.0205
Epoch 43/50
237/247 [===========================>..] - ETA: 0s - loss: 2.5441 -
accuracy: 0.1370 - f1_score: 0.0208
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5422
- accuracy: 0.1379 - f1_score: 0.0206
Epoch 44/50
233/247 [===========================>..] - ETA: 0s - loss: 2.5466 -
accuracy: 0.1373 - f1_score: 0.0203

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5435
- accuracy: 0.1370 - f1_score: 0.0204
Epoch 45/50
224/247 [==========================>...] - ETA: 0s - loss: 2.5431 -
accuracy: 0.1341 - f1_score: 0.0196

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5417
- accuracy: 0.1343 - f1_score: 0.0205
Epoch 46/50
234/247 [===========================>..] - ETA: 0s - loss: 2.5415 -
accuracy: 0.1317 - f1_score: 0.0201

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5420
- accuracy: 0.1322 - f1_score: 0.0207
Epoch 47/50
227/247 [==========================>...] - ETA: 0s - loss: 2.5436 -
accuracy: 0.1352 - f1_score: 0.0208

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 0s 2ms/step - loss: 2.5428
- accuracy: 0.1358 - f1_score: 0.0205
Epoch 48/50
242/247 [============================>.] - ETA: 0s - loss: 2.5418 -
accuracy: 0.1335 - f1_score: 0.0206

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5422
- accuracy: 0.1329 - f1_score: 0.0207
Epoch 49/50
230/247 [==========================>...] - ETA: 0s - loss: 2.5423 -
accuracy: 0.1326 - f1_score: 0.0201
```

```
WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 2ms/step - loss: 2.5427
- accuracy: 0.1333 - f1_score: 0.0206
Epoch 50/50
244/247 [============================>.] - ETA: 0s - loss: 2.5423 -
accuracy: 0.1367 - f1_score: 0.0206

WARNING:tensorflow:Can save best model only with val_loss available,
skipping.

 247/247 [==============================] - 1s 3ms/step - loss: 2.5425
- accuracy: 0.1362 - f1_score: 0.0206

<keras.callbacks.History at 0x7f8377cf3a30>
```

Model jest sekwencyjnym modelem sieci neuronowej z trzema warstwami gęstymi. Oto krótki opis poszczególnych warstw:

Warstwa gęsta (Dense): Ma 64 neurony z funkcją aktywacji ReLU. Przyjmuje wejście o kształcie (1,).

Warstwa gęsta (Dense): Ma 32 neurony z funkcją aktywacji ReLU.

Warstwa gęsta (Dense): Ma liczbę neuronów odpowiadającą num_classes (liczba klas w zadaniu) i używa funkcji aktywacji softmax.

Model jest skompilowany z optymalizatorem Adam o współczynniku nauki 0,001, funkcją straty categorical_crossentropy oraz metrykami accuracy i F1 Score. Metryka F1 Score jest obliczana dla num_classes (24) klas i średnia jest obliczana w sposób "macro".

Model jest trenowany na danych treningowych X1_train i y1_train przez 50 epok. Zastosowany jest callback ModelCheckpoint w celu zapisania najlepszego modelu.

```
loss, accuracy, f1_score = model.evaluate(X1_test, y1_test)
print(f'Test loss: {loss}, Test accuracy: {accuracy}, Test F1 Score:
{f1_score}')

predictions = model.predict(X1_test)
y1_pred = np.argmax(predictions, axis=1)


y1_test = np.argmax(y1_test, axis=1)

report = classification_report(y1_test, y1_pred)
print(report)
```

```
28/28 [==============================] - 0s 2ms/step - loss: 2.5968 -
accuracy: 0.1404 - f1_score: 0.0146
Test loss: 2.596766710281372, Test accuracy: 0.14041095972061157, Test
F1 Score: 0.014550263993442059
```

```
28/28 [==============================] - 0s 1ms/step
              precision    recall  f1-score   support

           0       0.00      0.00      0.00        38
           1       0.00      0.00      0.00        33
           2       0.00      0.00      0.00        38
           3       0.16      0.19      0.17        32
           4       0.42      0.40      0.41        43
           5       0.11      0.12      0.12        32
           6       0.00      0.00      0.00        40
           7       0.00      0.00      0.00        46
           8       0.08      0.39      0.14        33
           9       0.00      0.00      0.00        38
          10       0.16      0.27      0.20        37
          11       0.14      0.10      0.12        31
          12       0.00      0.00      0.00        39
          13       0.00      0.00      0.00        29
          14       0.11      0.37      0.17        38
          15       0.00      0.00      0.00        36
          16       0.00      0.00      0.00        31
          17       0.19      0.46      0.27        35
          18       0.00      0.00      0.00        38
          19       0.19      0.43      0.26        42
          20       0.11      0.25      0.15        40
          21       0.09      0.34      0.15        35
          22       0.00      0.00      0.00        40
          23       0.00      0.00      0.00        32

    accuracy                           0.14       876
   macro avg       0.07      0.14      0.09       876
weighted avg       0.08      0.14      0.09       876


/usr/local/lib/python3.10/dist-packages/sklearn/metrics/
_classification.py:1344: UndefinedMetricWarning: Precision and F-score
are ill-defined and being set to 0.0 in labels with no predicted
samples. Use `zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classificatio
n.py:1344: UndefinedMetricWarning: Precision and F-score are ill-
defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classificatio
n.py:1344: UndefinedMetricWarning: Precision and F-score are ill-
defined and being set to 0.0 in labels with no predicted samples. Use
`zero_division` parameter to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Wyniki oceny modelu są bardzo słabe. Osiągnięto niską dokładność (14.04%) oraz niski wynik F1 (1.45%). Analiza raportu klasyfikacji pokazuje, że model ma trudności w poprawnym przewidywaniu większości klas, co jest widoczne w niskich wartościach precyzji, czułości i wyniku F1 dla większości klas. Istnieje również wiele klas, dla których model nie przewiduje żadnej próbki, co jest zaznaczone w ostrzeżeniach "UndefinedMetricWarning" w raporcie klasyfikacji.

Niska dokładność: Model osiągnął tylko 14.04% dokładności na danych testowych, co oznacza, że ma trudności w poprawnym przewidywaniu klas.

Niski wynik F1: Wynik F1 wynosi zaledwie 1.45%, co wskazuje na słabą zdolność modelu do równoczesnego uwzględniania precyzji i czułości.

Brak przewidywań dla wielu klas: Model nie przewiduje żadnych próbek dla wielu klas, co sugeruje, że istnieje problem z wyodrębnianiem wzorców i dokonywaniem trafnych predykcji dla tych klas.

###Wnioski

Niestety, nie udało się osiągnąć zadawalających wyników i tym samym potwierdzić tezę, że "charakter przebiegu i zmian w sieci w każdym z godzinowych odcinków doby, zgodnie z czasem lokalnym, jest podobny do analogicznych odcinków w innych dobach, niezależnie od pory roku, wakacji itp."

Wynika to z problematycznej natury zagadnienia - przewidywanie czasu (w tym przypadku godziny) na podstawie jakiegoś parametru jest niepraktycznie i raczej nigdzie niestosowane.

Informacji na temat tego zagadnienia nie znalazłem również w innych źródłach i, tak jak wspomniałem, wynika to prawdopodobnie z jego nietypowości.

Najlepsze wyniki osiągnął model regresji liniowej i nie rozumiem do końca dlaczego (spodziewałem się, żę lepiej poradzi sobie model klasyfikacji)