빅데이터와 금융자료 분석

BAF660 Final Team Project _ Source Code

Team 2

김진우 20223868

류용옥 20223872

민동효 20194094

반유정 20223878

성상훈 20213844

이선우 20223888

TEAM 2 Final Project

(1) data loading

[01] Data loading

In [1]:
```
import pandas as pd
import numpy as np
import os

from joblib import Parallel, delayed

# pip install pyarrow

import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
DATA_DIR = "C:/Users/po020/Desktop/KAIST/Python Codes/03. 학과공부/004. 빅데이터분석/02. 팀프로젝트/optiver-realized-volatility-prediction-1/"
```

In [3]:
```
# train = train data


train = pd.read_csv(os.path.join(DATA_DIR, 'optiver_data', 'train.csv'))
```

In [4]:
```
# data load 함수

def load_stock_data(stock_id, directory):
    return pd.read_parquet(os.path.join(DATA_DIR, 'optiver_data', directory, f'stock_id={stock_id}'))

def load_data(stock_id, stem, block):
    if block == 'train':
        return load_stock_data(stock_id, f'{stem}_train.parquet')
    elif block == 'test':
        return load_stock_data(stock_id, f'{stem}_test.parquet')
    else:
        return pd.concat([
            load_data(stock_id, stem, 'train'),
            load_data(stock_id, stem, 'test')
        ]).reset_index(drop=True)

# load_book, load_trade을 통해 data를 로드할 수 있음.

def load_book(stock_id, block='train'):
    return load_data(stock_id, 'book', block)

def load_trade(stock_id, block='train'):
    return load_data(stock_id, 'trade', block)
```

In [5]:
```
# 예시 1
load_book(stock_id=1, block='train')
```

Out[5]:

	time_id	seconds_in_bucket	bid_price1	ask_price1	bid_price2	ask_price2	bid_size1	ask_size1	bid_size2	ask_size2
0	5	0	1.000754	1.001542	1.000689	1.001607	1	25	25	100
1	5	1	1.000754	1.001673	1.000689	1.001739	26	60	25	100
2	5	2	1.000754	1.001411	1.000623	1.001476	1	25	25	125
3	5	3	1.000754	1.001542	1.000689	1.001607	125	25	126	36
4	5	4	1.000754	1.001476	1.000623	1.001542	100	100	25	25
...	...	...	...	...	...	...	...	...	...	...
1507527	32767	588	0.998911	0.999109	0.998812	0.999208	126	42	101	100
1507528	32767	589	0.998911	0.999109	0.998812	0.999208	126	126	101	200
1507529	32767	591	0.998911	0.999109	0.998812	0.999208	126	226	101	200
1507530	32767	592	0.998911	0.999109	0.998812	0.999208	226	225	101	100
1507531	32767	593	0.998911	0.999109	0.998812	0.999208	125	225	101	100

1507532 rows × 10 columns

In [6]:
```
# 예시 2
load_book(stock_id=110, block='train')
```

Out[6]:

	time_id	seconds_in_bucket	bid_price1	ask_price1	bid_price2	ask_price2	bid_size1	ask_size1	bid_size2	ask_size2
0	5	0	0.999665	1.001620	0.999595	1.001638	12	3	11	21
1	5	3	0.999665	1.001620	0.999595	1.001638	40	1	11	10
2	5	4	0.999683	1.001620	0.999665	1.001638	38	1	12	10
3	5	6	0.999701	1.001638	0.999683	1.002184	38	10	12	1
4	5	9	0.999701	1.001638	0.999683	1.002184	40	10	10	1
...	...	...	...	...	...	...	...	...	...	...
1302555	32767	586	0.999420	1.000712	0.999156	1.001161	200	100	101	100
1302556	32767	587	0.999420	1.000422	0.999156	1.000712	200	100	101	100
1302557	32767	588	0.999420	1.000422	0.999156	1.000712	300	100	1	100
1302558	32767	590	0.999420	1.000422	0.999156	1.000712	350	100	1	100
1302559	32767	595	0.999420	1.000422	0.999156	1.000712	297	100	1	100

1302560 rows × 10 columns

In [7]:
```
# 예시 3
load_trade(stock_id=1, block='train')
```

Out[7]:

	time_id	seconds_in_bucket	price	size	order_count
0	5	28	1.002080	553	11
1	5	39	1.002460	8	3
2	5	42	1.002308	147	4
3	5	44	1.002788	1	1
4	5	51	1.002657	100	2
...	...	...	...	...	...
296205	32767	579	0.999010	81	3
296206	32767	587	0.999109	50	1
296207	32767	588	0.999010	126	2
296208	32767	592	0.999109	1	1
296209	32767	593	0.998911	1	1

296210 rows × 5 columns

In [8]:
```
# 예시 4
load_trade(stock_id=110, block='train')
```

Out[8]:

	time_id	seconds_in_bucket	price	size	order_count
0	5	41	1.001656	11	3
1	5	56	1.002202	2	2
2	5	57	1.002413	1	1
3	5	110	1.002977	1	1
4	5	188	1.001938	120	5
...	...	...	...	...	...
140067	32767	436	0.999485	203	5
140068	32767	441	0.999385	18	4
140069	32767	505	0.999763	1	1
140070	32767	567	0.999552	1	1
140071	32767	584	0.999789	4	1

140072 rows × 5 columns

(2) Feature Engineering

[01] base feature generation

In [9]:

```
# Function to calculate first WAP
def calc_wap1(df):
    wap = (df['bid_price1'] * df['ask_size1'] + df['ask_price1'] * df['bid_size1']) / (df['bid_size1'] + df['ask_size1'])
    return wap

# Function to calculate second WAP
def calc_wap2(df):
    wap = (df['bid_price2'] * df['ask_size2'] + df['ask_price2'] * df['bid_size2']) / (df['bid_size2'] + df['ask_size2'])
    return wap

# Calculate the realized volatility
def realized_volatility(series):
    return np.sqrt(np.sum(series**2))

# Function to calculate the log of the return
# Remember that logb(x / y) = logb(x) - logb(y)
def log_return(series: np.ndarray):
    return np.log(series).diff()

def log_return_df2(series: np.ndarray):
    return np.log(series).diff(2)

# prefix: book or trade
# src_names : feature 이름(columns 삽입 - agg.columns)
# faltten_name을 통해 함수 이름을 지정하여 df에 결합하는 방식
def flatten_name(prefix, src_names):
    ret = []
    for c in src_names:
        if c[0] in ['time_id', 'stock_id']:
            ret.append(c[0])
        else:
            ret.append('.'.join([prefix] + list(c)))
    return ret


def make_book_feature(stock_id, block = 'train'):
    book = load_book(stock_id, block)

    book['wap1'] = calc_wap1(book)
    book['wap2'] = calc_wap2(book)
    book['log_return1'] = book.groupby(['time_id'])['wap1'].apply(log_return)
    book['log_return2'] = book.groupby(['time_id'])['wap2'].apply(log_return)
    book['log_return_ask1'] = book.groupby(['time_id'])['ask_price1'].apply(log_return)
    book['log_return_ask2'] = book.groupby(['time_id'])['ask_price2'].apply(log_return)
    book['log_return_bid1'] = book.groupby(['time_id'])['bid_price1'].apply(log_return)
    book['log_return_bid2'] = book.groupby(['time_id'])['bid_price2'].apply(log_return)

    # Calculate wap balance
    book['wap_balance'] = abs(book['wap1'] - book['wap2'])
```

```
    # Calculate spread
    book['price_spread'] = (book['ask_price1'] - book['bid_price1']) / ((book['ask_price1'] + book['bid_price1']) / 2)
    book['bid_spread'] = book['bid_price1'] - book['bid_price2']
    book['ask_spread'] = book['ask_price1'] - book['ask_price2']
    book['total_volume'] = (book['ask_size1'] + book['ask_size2']) + (book['bid_size1'] + book['bid_size2'])
    book['volume_imbalance'] = abs((book['ask_size1'] + book['ask_size2']) - (book['bid_size1'] + book['bid_size2']))

    features = {
        'seconds_in_bucket': ['count'],
        'wap1': [np.sum, np.mean, np.std],
        'wap2': [np.sum, np.mean, np.std],
        'log_return1': [np.sum, realized_volatility, np.mean, np.std],
        'log_return2': [np.sum, realized_volatility, np.mean, np.std],
        'log_return_ask1': [np.sum, realized_volatility, np.mean, np.std],
        'log_return_ask2': [np.sum, realized_volatility, np.mean, np.std],
        'log_return_bid1': [np.sum, realized_volatility, np.mean, np.std],
        'log_return_bid2': [np.sum, realized_volatility, np.mean, np.std],
        'wap_balance': [np.sum, np.mean, np.std],
        'price_spread':[np.sum, np.mean, np.std],
        'bid_spread':[np.sum, np.mean, np.std],
        'ask_spread':[np.sum, np.mean, np.std],
        'total_volume':[np.sum, np.mean, np.std],
        'volume_imbalance':[np.sum, np.mean, np.std]
    }

    agg = book.groupby('time_id').agg(features).reset_index(drop=False)
    agg.columns = flatten_name('book', agg.columns)
    agg['stock_id'] = stock_id

# time별로 묶어서 feature 더 생성
    for time in [450, 300, 150]:
        d = book[book['seconds_in_bucket'] >= time].groupby('time_id').agg(features).reset_index(drop=False)
        d.columns = flatten_name(f'book_{time}', d.columns)
        agg = pd.merge(agg, d, on='time_id', how='left')
    return agg


def make_trade_feature(stock_id, block = 'train'):
    trade = load_trade(stock_id, block)
    trade['log_return'] = trade.groupby('time_id')['price'].apply(log_return)

    # Dict for aggregations
    features = {
        'log_return':[realized_volatility, np.max, np.min],
        'seconds_in_bucket':['count'],
        'size':[np.sum],
        'order_count':[np.mean],
    }

    agg = trade.groupby('time_id').agg(features).reset_index()
    agg.columns = flatten_name('trade', agg.columns)
    agg['stock_id'] = stock_id

    for time in [450, 300, 150]:
        d = trade[trade['seconds_in_bucket'] >= time].groupby('time_id').agg(features).reset_index(drop=False)
```

```
        d.columns = flatten_name(f'trade_{time}', d.columns)
        agg = pd.merge(agg, d, on='time_id', how='left')
    return agg


def make_features(base, block):
    stock_ids = set(base['stock_id'])

    books = Parallel(n_jobs=-1)(delayed(make_book_feature)(i, block) for i in stock_ids)
    book = pd.concat(books)

    trades = Parallel(n_jobs=-1)(delayed(make_trade_feature)(i, block) for i in stock_ids)
    trade = pd.concat(trades)

    df = pd.merge(base, book, on=['stock_id', 'time_id'], how='left')
    df = pd.merge(df, trade, on=['stock_id', 'time_id'], how='left')

    # tau : 낮을수록 좋은 지표(유동성이 풍부함)
    df['trade.tau'] = np.sqrt(1 / df['trade.seconds_in_bucket.count'])
    df['trade_150.tau'] = np.sqrt(1 / df['trade_150.seconds_in_bucket.count'])
    df['book.tau'] = np.sqrt(1 / df['book.seconds_in_bucket.count'])

    # get realized volatility columns
    vol_cols = [
        'book.log_return2.realized_volatility',
        'book.log_return_ask1.realized_volatility',
        'book.log_return_ask2.realized_volatility',
        'book.log_return1.realized_volatility',
        'book.log_return_bid1.realized_volatility',
        'book.log_return_bid2.realized_volatility',
        'book_450.log_return1.realized_volatility',
        'book_450.log_return2.realized_volatility',
        'book_450.log_return_ask1.realized_volatility',
        'book_450.log_return_ask2.realized_volatility',
        'book_450.log_return_bid1.realized_volatility',
        'book_450.log_return_bid2.realized_volatility',
        'book_300.log_return1.realized_volatility',
        'book_300.log_return2.realized_volatility',
        'book_300.log_return_ask1.realized_volatility',
        'book_300.log_return_ask2.realized_volatility',
        'book_300.log_return_bid1.realized_volatility',
        'book_300.log_return_bid2.realized_volatility',
        'book_150.log_return1.realized_volatility',
        'book_150.log_return2.realized_volatility',
        'book_150.log_return_ask1.realized_volatility',
        'book_150.log_return_ask2.realized_volatility',
        'book_150.log_return_bid1.realized_volatility',
        'book_150.log_return_bid2.realized_volatility',
        'trade.log_return.realized_volatility',
        'trade_450.log_return.realized_volatility',
        'trade_300.log_return.realized_volatility',
        'trade_150.log_return.realized_volatility']

    # Groupby stock id
    df_stock_id= df.groupby(['stock_id'])[vol_cols].agg(['max','min']).reset_index(drop=False)
```

```
    df_stock_id.columns = ['.'.join(col) for col in df_stock_id.columns]

    df_stock_id = df_stock_id.add_suffix('_' + 'stock')
    df_stock_id.rename(columns={'stock_id._stock':'stock_id'}, inplace=True)

    # Groupby time id
    df_time_id= df.groupby(['time_id'])[vol_cols].agg(['max','min']).reset_index(drop=False)
    df_time_id.columns = ['.'.join(col) for col in df_time_id.columns]

    df_time_id = df_time_id.add_suffix('_' + 'time')
    df_time_id.rename(columns={'time_id._time':'time_id'}, inplace=True)

    # Merge with og df
    df = df.merge(df_stock_id, on = ['stock_id'], how = 'left')
    df = df.merge(df_time_id, on = ['time_id'], how = 'left')

    # relative rank features 추가

    df['trade.order_count.mean'] = df.groupby('time_id')['trade.order_count.mean'].rank()
    df['book.total_volume.sum'] = df.groupby('time_id')['book.total_volume.sum'].rank()
    df['book.total_volume.mean'] = df.groupby('time_id')['book.total_volume.mean'].rank()
    df['book.total_volume.std'] = df.groupby('time_id')['book.total_volume.std'].rank()

    # 같은 symbol에 대해 비슷한 trading volume을 가진 RV의 평균 features 추가
    df.sort_values(by=['stock_id', 'book.total_volume.sum'], inplace=True)
    df.reset_index(drop=True, inplace=True)
    df['realized_volatility_roll3_by_book.total_volume.mean'] = df.groupby('stock_id')['book.log_return1.realized_volatility']₩
        .rolling(3, center=True, min_periods=1).mean().reset_index().sort_values(by=['level_1'])['book.log_return1.realized_volatility'].values
    df['realized_volatility_roll10_by_book.total_volume.mean'] = df.groupby('stock_id')['book.log_return1.realized_volatility']₩
        .rolling(10, center=True, min_periods=1).mean().reset_index().sort_values(by=['level_1'])['book.log_return1.realized_volatility'].values

    # time-id 별 trade.order_count와 book의 total_volumne에 대한 sum, mean, std값의 순위를 매긴 컬럼 추가
    df['trade.tau'] = df.groupby('time_id')['trade.tau'].rank()

    for dt in [150, 300, 450]:
        df[f'book_{dt}.total_volume.sum'] = df.groupby('time_id')[f'book_{dt}.total_volume.sum'].rank()
        df[f'book_{dt}.total_volume.mean'] = df.groupby('time_id')[f'book_{dt}.total_volume.mean'].rank()
        df[f'book_{dt}.total_volume.std'] = df.groupby('time_id')[f'book_{dt}.total_volume.std'].rank()
        df[f'trade_{dt}.order_count.mean'] = df.groupby('time_id')[f'trade_{dt}.order_count.mean'].rank()

    return df
```

In [88]:
```
# 모델 적용할때는 안돌려도 됩니다
# 처음에 데이터 생성시 필요
df = make_features(train, 'train')
```

In [89]:
```
df
```

Out[89]:

	stock_id	time_id	target	book.seconds_in_bucket.count	book.wap1.sum	book.wap1.mean	book.wap1.std	book.wap2.sum	book.wap2.mean	book.wap2.std	...	book_150.log_return_bi
0	0	5	0.004136	302	303.125061	1.003725	0.000693	303.105539	1.003661	0.000781	...	
1	0	11	0.001445	200	200.047768	1.000239	0.000262	200.041171	1.000206	0.000272	...	
2	0	16	0.002168	188	187.913849	0.999542	0.000864	187.939824	0.999680	0.000862	...	
3	0	31	0.002195	120	119.859781	0.998832	0.000757	119.835941	0.998633	0.000656	...	
4	0	62	0.001747	176	175.932865	0.999619	0.000258	175.934256	0.999626	0.000317	...	
...	...	...	...	...	...	...	...	...	...	...	...	...
428927	126	32751	0.003461	310	309.870466	0.999582	0.000486	309.871372	0.999585	0.000613	...	
428928	126	32753	0.003113	223	223.552143	1.002476	0.001264	223.580314	1.002602	0.001303	...	
428929	126	32758	0.004070	256	256.277050	1.001082	0.000466	256.255056	1.000996	0.000599	...	
428930	126	32763	0.003357	399	399.721736	1.001809	0.000456	399.714332	1.001790	0.000507	...	
428931	126	32767	0.002090	217	217.058919	1.000272	0.000384	217.079726	1.000367	0.000465	...	

428932 rows × 338 columns

[02] Dropping Missing Values

결측치가 포함된 행 제거 : 428,932개 → 427,216개

In [ ]:
```
# test.csv 값 제거
df = df.drop(df[df['target'].isnull()].index)

# null값 포함된 행 제거
df = df.dropna()
```

In [56]:
```
df
```

Out[56]:

	stock_id	time_id	target	book.seconds_in_bucket.count	book.wap1.sum	book.wap1.mean	book.wap1.std	book.wap2.sum	book.wap2.mean	book.wap2.std	...	book_150.log_return_bi
0	0	1176	0.005746	144	143.815068	0.998716	0.001774	143.849316	0.998954	0.001861	...	
1	0	8664	0.002469	147	146.899894	0.999319	0.000366	146.901871	0.999332	0.000398	...	
2	0	12758	0.002541	142	141.728688	0.998089	0.000900	141.709407	0.997954	0.000960	...	
3	0	19033	0.002515	94	93.842941	0.998329	0.000771	93.848332	0.998387	0.000798	...	
4	0	20499	0.003066	170	169.654033	0.997965	0.000716	169.650958	0.997947	0.000761	...	
...	...	...	...	...	...	...	...	...	...	...	...	...
427211	126	11589	0.003061	328	327.286943	0.997826	0.001360	327.295300	0.997852	0.001418	...	
427212	126	4927	0.005008	224	224.815252	1.003640	0.000781	224.783674	1.003499	0.000937	...	
427213	126	15155	0.018900	348	337.124379	0.968748	0.006521	336.886673	0.968065	0.006172	...	
427214	126	13316	0.010262	279	281.655248	1.009517	0.002213	281.599159	1.009316	0.002231	...	
427215	126	1464	0.005431	506	503.463445	0.994987	0.000881	503.465329	0.994991	0.000936	...	

427216 rows × 338 columns

[03] Nearest Neighbors Features generation

In [21]:
```
from sklearn.neighbors import NearestNeighbors
from sklearn.preprocessing import minmax_scale

# N 지정값
N_NEIGHBORS_MAX = 80

# NN으로 만들 vol과 trade.size.sum에 대한 df_pv 생성
df_pv = df[['stock_id', 'time_id']].copy()
df_pv['vol'] = df['book.log_return1.realized_volatility']
df_pv['trade.size.sum'] = df['book.total_volume.sum']
```

In [ ]:
```
# vol neighbor distances, indices(.neighbors) matrix 생성
pivot = df_pv.pivot('time_id', 'stock_id', 'vol')
pivot = pivot.fillna(pivot.mean())
pivot = pd.DataFrame(minmax_scale(pivot))

k_neighbors_stock_vol = NearestNeighbors(n_neighbors=80, metric='minkowski',p=1)
k_neighbors_stock_vol.fit(minmax_scale(pivot.transpose()))
k_neighbors_stock_vol.distances, k_neighbors_stock_vol.neighbors = k_neighbors_stock_vol.kneighbors(minmax_scale(pivot.transpose()), return_distance=True)
```

In [ ]:
```
# trade.size neigbor distances, indices(.neighbors) matrix 생성
pivot = df_pv.pivot('time_id', 'stock_id', 'trade.size.sum')
pivot = pivot.fillna(pivot.mean())
pivot = pd.DataFrame(minmax_scale(pivot))
```

```
k_neighbors_stock_size = NearestNeighbors(n_neighbors=80, metric='minkowski',p=1)
k_neighbors_stock_size.fit(minmax_scale(pivot.transpose()))
k_neighbors_stock_size.distances, k_neighbors_stock_size.neighbors = k_neighbors_stock_size.kneighbors(minmax_scale(pivot.transpose()), return_distance=True)
```

In [20]:
```
# stock-id 를 row로 하는 pivot을 바탕으로 feature pivot과 neighbor 반환
def make_neighbors_stock(df, k_neighbors, feature_col, n=5):
    feature_pivot = df.pivot('time_id', 'stock_id', feature_col)
    feature_pivot = feature_pivot.fillna(feature_pivot.mean())
    feature_pivot.head()

    neighbors = np.zeros((n, *feature_pivot.shape))

    for i in range(n):
        neighbors[i, :, :] += feature_pivot.values[:, k_neighbors[:, i]]

    return feature_pivot, neighbors


# nn_feature 생성 함수
def make_nn_feature(df, neighbors, columns, index, n=5, agg=np.mean, postfix='', exclude_self=False, exact=False):
    start = 1 if exclude_self else 0

    if exact:
        pivot_aggs = pd.DataFrame(neighbors[n-1,:,:], columns=columns, index=index)
    else:
        pivot_aggs = pd.DataFrame(agg(neighbors[start:n,:,:], axis=0), columns=columns, index=index)
    dst = pivot_aggs.unstack().reset_index() # unstack(level)이 의미하는 것은 multi Index의 몇번째 index를 칼럼 방향으로 stacking 할것인가임.
    dst.columns = ['stock_id', 'time_id', f'{feature_col}_cluster{n}{postfix}_{agg.__name__}']
    return dst
```

In [22]:
```
import gc #순환참조를 탐지하고 해결하기 위해 사용하는 모듈
gc.collect()

df2 = df.copy()
print(df2.shape)

## neighbor stock id 에 대한 feature
feature_cols_stock = {
    'book.log_return1.realized_volatility': [np.mean, np.min, np.max, np.std],
    'trade.seconds_in_bucket.count': [np.mean],
    'trade.tau': [np.mean],
    'trade_150.tau': [np.mean],
    'book.tau': [np.mean],
    'trade.size.sum': [np.mean],
    'book.seconds_in_bucket.count': [np.mean]
}

# ndf가 아무것도 없으면 dst 그대로 반환
# ndf가 있으면 dst의 마지막 열을 ndf에 추가해서 ndf 반환
ndf = None
cols = []
def _add_ndf(ndf, dst):
    if ndf is None:
        return dst
```

```
    else:
        ndf[dst.columns[-1]] = dst[dst.columns[-1]].astype(np.float32)
        return ndf

# stock_id에 대한 neighbor 추가
stock_id_neighbor_sizes = [10, 20, 40]

for feature_col in feature_cols_stock.keys():
    feature_pivot, neighbors_stock_vol = make_neighbors_stock(df2, k_neighbors_stock_vol.neighbors, feature_col, n=N_NEIGHBORS_MAX)
    _, neighbors_stock_size = make_neighbors_stock(df2, k_neighbors_stock_size.neighbors, feature_col, n=N_NEIGHBORS_MAX)

    columns = feature_pivot.columns
    index = feature_pivot.index

    for agg in feature_cols_stock[feature_col]:
        for n in stock_id_neighbor_sizes:
            exclude_self = True
            exact = False

            dst = make_nn_feature(df2, neighbors_stock_vol, columns, index, n=n, agg=agg, postfix='_sv', exclude_self=exclude_self, exact=exact)
            ndf = _add_ndf(ndf, dst)

            dst = make_nn_feature(df2, neighbors_stock_size, columns, index, n=n, agg=agg, postfix='_ssize',exclude_self=exclude_self)
            ndf = _add_ndf(ndf, dst)
    del feature_pivot, neighbors_stock_vol

df2 = pd.merge(df2, ndf, on=['time_id', 'stock_id'], how='left')
ndf = None

# skew correction for NN features
cols_to_log = [
    'trade.size.sum',
    'trade_150.size.sum',
    'trade_300.size.sum',
    'trade_450.size.sum',
    'volume_imbalance']

for c in df2.columns:
    for check in cols_to_log:
        if check in c:
            df2[c] = np.log(df2[c]+1)
            break

print(df2.shape)
df2.reset_index(drop=True)

del ndf
```

```
(427216, 338)
(427216, 400)
```

In [24]:
```
df2.drop(columns=['stock_id', 'time_id','target'], inplace=False)
```

Out[24]:

	book.seconds_in_bucket.count	book.wap1.sum	book.wap1.mean	book.wap1.std	book.wap2.sum	book.wap2.mean	book.wap2.std	book.log_return1.sum	book.log_return1.realized_volatili
0	144	143.815068	0.998716	0.001774	143.849316	0.998954	0.001861	-0.003499	0.00516
1	147	146.899894	0.999319	0.000366	146.901871	0.999332	0.000398	-0.000530	0.0031
2	142	141.728688	0.998089	0.000900	141.709407	0.997954	0.000960	0.000398	0.0029
3	94	93.842941	0.998329	0.000771	93.848332	0.998387	0.000798	-0.001343	0.0019
4	170	169.654033	0.997965	0.000716	169.650958	0.997947	0.000761	-0.001173	0.0020
...	...	...	...	...	...	...	...	...	...
427211	328	327.286943	0.997826	0.001360	327.295300	0.997852	0.001418	-0.004090	0.0029
427212	224	224.815252	1.003640	0.000781	224.783674	1.003499	0.000937	-0.001607	0.0054
427213	348	337.124379	0.968748	0.006521	336.886673	0.968065	0.006172	-0.024536	0.0268
427214	279	281.655248	1.009517	0.002213	281.599159	1.009316	0.002231	-0.000450	0.0126
427215	506	503.463445	0.994987	0.000881	503.465329	0.994991	0.000936	-0.001632	0.0054

427216 rows × 397 columns

In [ ]:
```
# 최종형태의 df를 data로 저장
data = df2.copy()
```

[04] Base only, Base + Nearest Neigbor dataframe 저장

In [ ]:
```
# 데이터 저장(1) - split 전의 dataframe
# 향후에 이 데이터를 불러와서 바로 적용하고자 하는 용도로 생성.
data.to_pickle('df_before_split.pkl')
```

In [26]:
```
data2 = data.copy()
```

In [28]:
```
# 데이터 저장(2) - split 전의 dataframe 2
# only base features df
data2.drop(data2.filter(regex='cluster').columns, axis=1, inplace=True)
data2.drop(data2.filter(regex='roll').columns, axis=1, inplace=True)

data2.to_pickle('df_before_split_base.pkl')
```

(3) Data Split

- missing value 제거
- sampling method 적용 X (target이 범주형이 아니어서, imbalance하지 않기 때문)
- train / val / test split

In [29]:
```
from sklearn.model_selection import train_test_split
```

X,y 데이터 분류 (Base only)

In [34]:
```
y = data2['target']
X = data2.drop(['stock_id', 'time_id', 'target'], axis=1)
print(X.shape)
```

```
(427216, 335)
```

In [35]:
```
# 결측치 확인
X.isnull().values.any()
```

Out[35]:
```
False
```

In [37]:
```
# time_id order로 맞춘 데이터에 대해서 train, val, test split 진행
# stratify는 y값이 분류형일때 적용하는 것으로 이해하여 하지 않았음
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=123)
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=1/8, random_state=456)

# train_test split data 저장
X_train.to_pickle('X_train_base.pkl')
X_test.to_pickle('X_test_base.pkl')
y_train.to_pickle('y_train_base.pkl')
y_test.to_pickle('y_test_base.pkl')
X_val.to_pickle('X_val_base.pkl')
y_val.to_pickle('y_val_base.pkl')
```

X,y 데이터 분류 (Base + Nearest Neigbor)

In [30]:
```
y = data['target']
X = data.drop(['stock_id', 'time_id', 'target'], axis=1)
print(X.shape)
```

```
(427216, 397)
```

In [31]:
```
# 결측치 확인
X.isnull().values.any()
```

Out[31]:
```
False
```

In [32]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=123)
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=1/8, random_state=456)

# train_test split data 저장
X_train.to_pickle('X_train.pkl')
X_test.to_pickle('X_test.pkl')
y_train.to_pickle('y_train.pkl')
y_test.to_pickle('y_test.pkl')
X_val.to_pickle('X_val.pkl')
y_val.to_pickle('y_val.pkl')
```

(4) Forecasting with models

In [1]:
```
import pandas as pd
import numpy as np
import os
```

In [2]:
```
data = pd.read_pickle('./df_before_split.pkl')
```

In [39]:
```
# 저장된 파일을 불러와서 사용
# 동일 디렉토리 내에 pkl 파일 확인
# 사용할 pkl목록 file_list에 저장

file_list = []

for file in os.listdir():
    if file.endswith("split.pkl"):
        pass
    elif file.endswith(".pkl"):
        print(os.path.join(file))
        file_list.append(os.path.join(file))


# 파일 저장
for files in range(len(file_list)):

    globals()['{}'.format(file_list[files][:-4])] = pd.read_pickle('{}'.format(file_list[files]))


# shape 확인
print(X_test.shape, X_train.shape, X_val.shape)
print(X_test_base.shape, X_train_base.shape, X_val_base.shape)
```

```
df_before_split_base.pkl
X_test.pkl
X_test_base.pkl
X_train.pkl
X_train_base.pkl
X_val.pkl
X_val_base.pkl
y_test.pkl
y_test_base.pkl
y_train.pkl
y_train_base.pkl
y_val.pkl
y_val_base.pkl
(85444, 397) (299050, 397) (42722, 397)
(85444, 335) (299050, 335) (42722, 335)
```

Type 1: Base → XGBoost

[01] without hyperparmeter tuning

In [ ]:
```
from xgboost import XGBRegressor
from sklearn.model_selection import RandomizedSearchCV, KFold
```

In [40]:
```
model = XGBRegressor()

params = {
    'n_estimators': 100,
    'learning_rate': 0.1,
    'colsample_bytree': 0.8,
    'subsample': 0.8
    }

# eval by RMSPE
def rmspe(predictions, targets):
    return np.sqrt((((predictions - targets) / targets) ** 2).mean())
```

In [41]:
```
final_model_no_tuning = XGBRegressor(**params)
```

In [42]:
```
final_model_no_tuning.fit(X_train_base, y_train_base, eval_set =[(X_train_base, y_train_base), (X_val_base, y_val_base)],early_stopping_rounds = 30 )
y_pred = final_model_no_tuning.predict(X_test_base)
```

```
[0]	validation_0-rmse:0.44652	validation_1-rmse:0.44652
[1]	validation_0-rmse:0.40187	validation_1-rmse:0.40187
[2]	validation_0-rmse:0.36169	validation_1-rmse:0.36168
[3]	validation_0-rmse:0.32552	validation_1-rmse:0.32552
[4]	validation_0-rmse:0.29297	validation_1-rmse:0.29297
[5]	validation_0-rmse:0.26367	validation_1-rmse:0.26367
[6]	validation_0-rmse:0.23731	validation_1-rmse:0.23731
[7]	validation_0-rmse:0.21358	validation_1-rmse:0.21358
[8]	validation_0-rmse:0.19222	validation_1-rmse:0.19222
[9]	validation_0-rmse:0.17300	validation_1-rmse:0.17300
[10]	validation_0-rmse:0.15570	validation_1-rmse:0.15570
[11]	validation_0-rmse:0.14013	validation_1-rmse:0.14014
[12]	validation_0-rmse:0.12612	validation_1-rmse:0.12612
[13]	validation_0-rmse:0.11351	validation_1-rmse:0.11351
[14]	validation_0-rmse:0.10216	validation_1-rmse:0.10217
[15]	validation_0-rmse:0.09195	validation_1-rmse:0.09195
[16]	validation_0-rmse:0.08276	validation_1-rmse:0.08276
[17]	validation_0-rmse:0.07448	validation_1-rmse:0.07449
[18]	validation_0-rmse:0.06704	validation_1-rmse:0.06704
[19]	validation_0-rmse:0.06034	validation_1-rmse:0.06034
[20]	validation_0-rmse:0.05430	validation_1-rmse:0.05431
[21]	validation_0-rmse:0.04888	validation_1-rmse:0.04888
[22]	validation_0-rmse:0.04399	validation_1-rmse:0.04400
[23]	validation_0-rmse:0.03960	validation_1-rmse:0.03960
[24]	validation_0-rmse:0.03564	validation_1-rmse:0.03565
[25]	validation_0-rmse:0.03208	validation_1-rmse:0.03209
[26]	validation_0-rmse:0.02888	validation_1-rmse:0.02889
[27]	validation_0-rmse:0.02600	validation_1-rmse:0.02600
[28]	validation_0-rmse:0.02340	validation_1-rmse:0.02341
[29]	validation_0-rmse:0.02107	validation_1-rmse:0.02108
[30]	validation_0-rmse:0.01897	validation_1-rmse:0.01898
[31]	validation_0-rmse:0.01708	validation_1-rmse:0.01709
[32]	validation_0-rmse:0.01538	validation_1-rmse:0.01539
[33]	validation_0-rmse:0.01385	validation_1-rmse:0.01386
[34]	validation_0-rmse:0.01248	validation_1-rmse:0.01249
[35]	validation_0-rmse:0.01124	validation_1-rmse:0.01125
[36]	validation_0-rmse:0.01013	validation_1-rmse:0.01014
[37]	validation_0-rmse:0.00913	validation_1-rmse:0.00914
[38]	validation_0-rmse:0.00823	validation_1-rmse:0.00824
[39]	validation_0-rmse:0.00742	validation_1-rmse:0.00744
[40]	validation_0-rmse:0.00670	validation_1-rmse:0.00671
[41]	validation_0-rmse:0.00605	validation_1-rmse:0.00606
[42]	validation_0-rmse:0.00547	validation_1-rmse:0.00548
[43]	validation_0-rmse:0.00494	validation_1-rmse:0.00496
[44]	validation_0-rmse:0.00448	validation_1-rmse:0.00449
[45]	validation_0-rmse:0.00406	validation_1-rmse:0.00407
[46]	validation_0-rmse:0.00368	validation_1-rmse:0.00370
[47]	validation_0-rmse:0.00335	validation_1-rmse:0.00337
[48]	validation_0-rmse:0.00305	validation_1-rmse:0.00307
[49]	validation_0-rmse:0.00279	validation_1-rmse:0.00281
[50]	validation_0-rmse:0.00255	validation_1-rmse:0.00258
[51]	validation_0-rmse:0.00235	validation_1-rmse:0.00237
[52]	validation_0-rmse:0.00216	validation_1-rmse:0.00219
[53]	validation_0-rmse:0.00201	validation_1-rmse:0.00204
[54]	validation_0-rmse:0.00187	validation_1-rmse:0.00190
```

```
[55]    validation_0-rmse:0.00174       validation_1-rmse:0.00178
[56]    validation_0-rmse:0.00164       validation_1-rmse:0.00168
[57]    validation_0-rmse:0.00155       validation_1-rmse:0.00159
[58]    validation_0-rmse:0.00147       validation_1-rmse:0.00151
[59]    validation_0-rmse:0.00140       validation_1-rmse:0.00145
[60]    validation_0-rmse:0.00134       validation_1-rmse:0.00139
[61]    validation_0-rmse:0.00130       validation_1-rmse:0.00134
[62]    validation_0-rmse:0.00125       validation_1-rmse:0.00130
[63]    validation_0-rmse:0.00122       validation_1-rmse:0.00127
[64]    validation_0-rmse:0.00119       validation_1-rmse:0.00124
[65]    validation_0-rmse:0.00117       validation_1-rmse:0.00122
[66]    validation_0-rmse:0.00114       validation_1-rmse:0.00120
[67]    validation_0-rmse:0.00113       validation_1-rmse:0.00119
[68]    validation_0-rmse:0.00111       validation_1-rmse:0.00117
[69]    validation_0-rmse:0.00110       validation_1-rmse:0.00116
[70]    validation_0-rmse:0.00109       validation_1-rmse:0.00115
[71]    validation_0-rmse:0.00108       validation_1-rmse:0.00114
[72]    validation_0-rmse:0.00107       validation_1-rmse:0.00114
[73]    validation_0-rmse:0.00107       validation_1-rmse:0.00113
[74]    validation_0-rmse:0.00106       validation_1-rmse:0.00113
[75]    validation_0-rmse:0.00106       validation_1-rmse:0.00112
[76]    validation_0-rmse:0.00105       validation_1-rmse:0.00112
[77]    validation_0-rmse:0.00105       validation_1-rmse:0.00112
[78]    validation_0-rmse:0.00105       validation_1-rmse:0.00111
[79]    validation_0-rmse:0.00104       validation_1-rmse:0.00111
[80]    validation_0-rmse:0.00104       validation_1-rmse:0.00111
[81]    validation_0-rmse:0.00104       validation_1-rmse:0.00111
[82]    validation_0-rmse:0.00103       validation_1-rmse:0.00111
[83]    validation_0-rmse:0.00103       validation_1-rmse:0.00111
[84]    validation_0-rmse:0.00103       validation_1-rmse:0.00110
[85]    validation_0-rmse:0.00103       validation_1-rmse:0.00110
[86]    validation_0-rmse:0.00103       validation_1-rmse:0.00110
[87]    validation_0-rmse:0.00103       validation_1-rmse:0.00110
[88]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[89]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[90]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[91]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[92]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[93]    validation_0-rmse:0.00102       validation_1-rmse:0.00110
[94]    validation_0-rmse:0.00101       validation_1-rmse:0.00110
[95]    validation_0-rmse:0.00101       validation_1-rmse:0.00109
[96]    validation_0-rmse:0.00101       validation_1-rmse:0.00109
[97]    validation_0-rmse:0.00101       validation_1-rmse:0.00109
[98]    validation_0-rmse:0.00101       validation_1-rmse:0.00109
[99]    validation_0-rmse:0.00101       validation_1-rmse:0.00109
```

In [43]:
```
rmspe(y_pred, y_test)
```

Out[43]:
```
1.1510526028980976
```

[02] with hyperparameter tuning

In [ ]:
```
# Hyperparameter tuning
model = XGBRegressor()
```

```
params = {'xgb__n_estimators' :[400, 500],
          'xgb__learning_rate': [0.04, 0.05],
          'xgb__colsample_bytree': [0.8],          # 각 iteration에 사용되는 feature의 비율
          'xgb__subsample': [0.7]                  # 각 iteration에 사용되는 data의 비율
        }

grid_xgb = RandomizedSearchCV( model,
                        param_distributions = params,
                        n_iter = 25,
                        cv = KFold(5),
                        scoring = 'neg_mean_squared_error',
                        verbose = 2
                        )
grid_xgb.fit(X_train_base, y_train_base, verbose=False)

print('Best parameters: ', grid_xgb.best_params_)
print('Best score: ', grid_xgb.best_score_)
```

```
/Users/yjban/tensorflow/env/lib/python3.8/site-packages/sklearn/model_selection/_search.py:306: UserWarning: The total space of parameters 4 is smaller than n_iter=25.
Running 4 iterations. For exhaustive searches, use GridSearchCV.
  warnings.warn(
```

```
Fitting 5 folds for each of 4 candidates, totalling 20 fits
[21:31:52] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.7min
[21:33:33] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:35:19] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.7min
[21:36:59] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.7min
[21:38:39] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.7min
[21:40:19] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.7min
```

```
[21:42:02] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.7min
[21:43:45] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.8min
[21:45:31] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.7min
[21:47:16] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.04, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.9min
[21:49:09] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:50:58] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:52:48] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
```

```
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:54:34] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:56:25] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=400, xgb__subsample=0.7; total time= 1.8min
[21:58:12] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.8min
[22:00:00] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.8min
[22:01:51] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.8min
[22:03:41] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.8min
[22:05:31] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV] END xgb__colsample_bytree=0.8, xgb__learning_rate=0.05, xgb__n_estimators=500, xgb__subsample=0.7; total time= 1.9min
[22:07:23] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


Best parameters:  {'xgb__subsample': 0.7, 'xgb__n_estimators': 400, 'xgb__learning_rate': 0.04, 'xgb__colsample_bytree': 0.8}
Best score:  -1.1329899692202367e-06
```

In [ ]:

```
params = grid_xgb.best_params_
final_model_with_tuning = XGBRegressor(**params)


final_model_with_tuning.fit(X_train_base, y_train_base, eval_metric = 'rmse', eval_set =[(X_train_base, y_train_base), (X_val_base, y_val_base)],early_stopping_rounds =

# Get predictions
y_pred = final_model_with_tuning.predict(X_test_base)

# eval by RMSPE
def rmspe(predictions, targets):
    return np.sqrt((((predictions - targets) / targets) ** 2).mean())
```

```
/Users/yjban/tensorflow/env/lib/python3.8/site-packages/xgboost/sklearn.py:793: UserWarning: `eval_metric` in `fit` method is deprecated for better compatibility with s
cikit-learn, use `eval_metric` in constructor or`set_params` instead.
  warnings.warn(
/Users/yjban/tensorflow/env/lib/python3.8/site-packages/xgboost/sklearn.py:793: UserWarning: `early_stopping_rounds` in `fit` method is deprecated for better compatibil
ity with scikit-learn, use `early_stopping_rounds` in constructor or`set_params` instead.
  warnings.warn(
```

```
[22:27:05] WARNING: /Users/runner/work/xgboost/xgboost/python-package/build/temp.macosx-11.0-arm64-cpython-38/xgboost/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[0]     validation_0-rmse:0.34729       validation_1-rmse:0.34728
[1]     validation_0-rmse:0.24311       validation_1-rmse:0.24310
[2]     validation_0-rmse:0.17018       validation_1-rmse:0.17017
[3]     validation_0-rmse:0.11913       validation_1-rmse:0.11912
[4]     validation_0-rmse:0.08340       validation_1-rmse:0.08339
[5]     validation_0-rmse:0.05839       validation_1-rmse:0.05838
[6]     validation_0-rmse:0.04088       validation_1-rmse:0.04087
[7]     validation_0-rmse:0.02863       validation_1-rmse:0.02863
[8]     validation_0-rmse:0.02006       validation_1-rmse:0.02006
[9]     validation_0-rmse:0.01407       validation_1-rmse:0.01407
[10]    validation_0-rmse:0.00989       validation_1-rmse:0.00988
[11]    validation_0-rmse:0.00697       validation_1-rmse:0.00697
[12]    validation_0-rmse:0.00495       validation_1-rmse:0.00495
[13]    validation_0-rmse:0.00356       validation_1-rmse:0.00357
[14]    validation_0-rmse:0.00262       validation_1-rmse:0.00264
[15]    validation_0-rmse:0.00200       validation_1-rmse:0.00203
[16]    validation_0-rmse:0.00161       validation_1-rmse:0.00165
[17]    validation_0-rmse:0.00137       validation_1-rmse:0.00142
[18]    validation_0-rmse:0.00124       validation_1-rmse:0.00130
[19]    validation_0-rmse:0.00117       validation_1-rmse:0.00123
[20]    validation_0-rmse:0.00112       validation_1-rmse:0.00119
[21]    validation_0-rmse:0.00109       validation_1-rmse:0.00117
[22]    validation_0-rmse:0.00107       validation_1-rmse:0.00116
[23]    validation_0-rmse:0.00107       validation_1-rmse:0.00115
[24]    validation_0-rmse:0.00106       validation_1-rmse:0.00115
[25]    validation_0-rmse:0.00105       validation_1-rmse:0.00114
[26]    validation_0-rmse:0.00104       validation_1-rmse:0.00114
[27]    validation_0-rmse:0.00104       validation_1-rmse:0.00113
[28]    validation_0-rmse:0.00103       validation_1-rmse:0.00113
[29]    validation_0-rmse:0.00102       validation_1-rmse:0.00113
[30]    validation_0-rmse:0.00102       validation_1-rmse:0.00112
[31]    validation_0-rmse:0.00101       validation_1-rmse:0.00112
[32]    validation_0-rmse:0.00101       validation_1-rmse:0.00112
[33]    validation_0-rmse:0.00100       validation_1-rmse:0.00112
[34]    validation_0-rmse:0.00100       validation_1-rmse:0.00112
[35]    validation_0-rmse:0.00100       validation_1-rmse:0.00112
[36]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[37]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[38]    validation_0-rmse:0.00098       validation_1-rmse:0.00111
[39]    validation_0-rmse:0.00098       validation_1-rmse:0.00111
[40]    validation_0-rmse:0.00098       validation_1-rmse:0.00111
[41]    validation_0-rmse:0.00097       validation_1-rmse:0.00111
[42]    validation_0-rmse:0.00097       validation_1-rmse:0.00111
[43]    validation_0-rmse:0.00097       validation_1-rmse:0.00111
[44]    validation_0-rmse:0.00096       validation_1-rmse:0.00110
[45]    validation_0-rmse:0.00096       validation_1-rmse:0.00110
[46]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
```

```
[47]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[48]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[49]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[50]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[51]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[52]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[53]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[54]    validation_0-rmse:0.00093       validation_1-rmse:0.00109
[55]    validation_0-rmse:0.00093       validation_1-rmse:0.00109
[56]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[57]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[58]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[59]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[60]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[61]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[62]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[63]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[64]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[65]    validation_0-rmse:0.00090       validation_1-rmse:0.00108
[66]    validation_0-rmse:0.00090       validation_1-rmse:0.00108
[67]    validation_0-rmse:0.00090       validation_1-rmse:0.00108
[68]    validation_0-rmse:0.00090       validation_1-rmse:0.00108
[69]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[70]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[71]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[72]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[73]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[74]    validation_0-rmse:0.00089       validation_1-rmse:0.00108
[75]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[76]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[77]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[78]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[79]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[80]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[81]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[82]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[83]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[84]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[85]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[86]    validation_0-rmse:0.00086       validation_1-rmse:0.00107
[87]    validation_0-rmse:0.00086       validation_1-rmse:0.00107
[88]    validation_0-rmse:0.00086       validation_1-rmse:0.00107
[89]    validation_0-rmse:0.00086       validation_1-rmse:0.00107
[90]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[91]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[92]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[93]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[94]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[95]    validation_0-rmse:0.00085       validation_1-rmse:0.00107
[96]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[97]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[98]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[99]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
```

In [ ]:
```
rmspe(y_pred, y_test)
```

```
0.23503494514386813
```

In [ ]:
```
# 최적조합
params
```

```
{'xgb__subsample': 0.7,
 'xgb__n_estimators': 400,
 'xgb__learning_rate': 0.04,
 'xgb__colsample_bytree': 0.8}
```

Type 2: Base + Nearest Neigbor → XGBoost

[01] without hyperparameter tuning

In [48]:
```
model = XGBRegressor()

# Type1에서 선택된 best params로 tuning없이 입력
params = {'xgb__subsample': 0.7,
          'xgb__n_estimators': 400,
          'xgb__learning_rate': 0.04,
          'xgb__colsample_bytree': 0.8}

# eval by RMSPE
def rmspe(predictions, targets):
    return np.sqrt((((predictions - targets) / targets) ** 2).mean())
```

In [49]:
```
final_model_no_tuning = XGBRegressor(**params)
```

In [50]:
```
final_model_no_tuning.fit(X_train, y_train, eval_set =[(X_train, y_train), (X_val, y_val)],early_stopping_rounds = 30 )
y_pred = final_model_no_tuning.predict(X_test)
```

```
[00:14:39] WARNING: C:/Users/Administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__learning_rate", "xgb__n_estimators", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[0]     validation_0-rmse:0.34729       validation_1-rmse:0.34728
[1]     validation_0-rmse:0.24311       validation_1-rmse:0.24310
[2]     validation_0-rmse:0.17018       validation_1-rmse:0.17017
[3]     validation_0-rmse:0.11913       validation_1-rmse:0.11912
[4]     validation_0-rmse:0.08340       validation_1-rmse:0.08339
[5]     validation_0-rmse:0.05839       validation_1-rmse:0.05838
[6]     validation_0-rmse:0.04088       validation_1-rmse:0.04088
[7]     validation_0-rmse:0.02863       validation_1-rmse:0.02863
[8]     validation_0-rmse:0.02006       validation_1-rmse:0.02006
[9]     validation_0-rmse:0.01407       validation_1-rmse:0.01407
[10]    validation_0-rmse:0.00988       validation_1-rmse:0.00989
[11]    validation_0-rmse:0.00697       validation_1-rmse:0.00697
[12]    validation_0-rmse:0.00494       validation_1-rmse:0.00495
[13]    validation_0-rmse:0.00355       validation_1-rmse:0.00357
[14]    validation_0-rmse:0.00261       validation_1-rmse:0.00264
[15]    validation_0-rmse:0.00199       validation_1-rmse:0.00203
[16]    validation_0-rmse:0.00159       validation_1-rmse:0.00165
[17]    validation_0-rmse:0.00135       validation_1-rmse:0.00142
[18]    validation_0-rmse:0.00122       validation_1-rmse:0.00129
[19]    validation_0-rmse:0.00114       validation_1-rmse:0.00122
[20]    validation_0-rmse:0.00110       validation_1-rmse:0.00119
[21]    validation_0-rmse:0.00107       validation_1-rmse:0.00117
[22]    validation_0-rmse:0.00106       validation_1-rmse:0.00116
[23]    validation_0-rmse:0.00105       validation_1-rmse:0.00115
[24]    validation_0-rmse:0.00104       validation_1-rmse:0.00114
[25]    validation_0-rmse:0.00103       validation_1-rmse:0.00114
[26]    validation_0-rmse:0.00102       validation_1-rmse:0.00113
[27]    validation_0-rmse:0.00102       validation_1-rmse:0.00113
[28]    validation_0-rmse:0.00101       validation_1-rmse:0.00113
[29]    validation_0-rmse:0.00101       validation_1-rmse:0.00113
[30]    validation_0-rmse:0.00100       validation_1-rmse:0.00113
[31]    validation_0-rmse:0.00100       validation_1-rmse:0.00112
[32]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[33]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[34]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[35]    validation_0-rmse:0.00098       validation_1-rmse:0.00112
[36]    validation_0-rmse:0.00098       validation_1-rmse:0.00112
[37]    validation_0-rmse:0.00097       validation_1-rmse:0.00112
[38]    validation_0-rmse:0.00097       validation_1-rmse:0.00111
[39]    validation_0-rmse:0.00096       validation_1-rmse:0.00111
[40]    validation_0-rmse:0.00096       validation_1-rmse:0.00111
[41]    validation_0-rmse:0.00096       validation_1-rmse:0.00110
[42]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[43]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[44]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[45]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[46]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
```

```
[47]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[48]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[49]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[50]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[51]    validation_0-rmse:0.00092       validation_1-rmse:0.00110
[52]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[53]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[54]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[55]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[56]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[57]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[58]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[59]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[60]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[61]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[62]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[63]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[64]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[65]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[66]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[67]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[68]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[69]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[70]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[71]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[72]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[73]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[74]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[75]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[76]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[77]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[78]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[79]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[80]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[81]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[82]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[83]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[84]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[85]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[86]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[87]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[88]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[89]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[90]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[91]    validation_0-rmse:0.00084       validation_1-rmse:0.00108
[92]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[93]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[94]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[95]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[96]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[97]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
[98]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
[99]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
```

In [51]:
```
rmspe(y_pred, y_test)
```

Out[51]:
```
0.23180241566247223
```

[02] with hyperparameter tuning (HalvingRandomSearchCV)

In [ ]:
```
from xgboost import XGBRegressor
from sklearn.experimental import enable_halving_search_cv
from sklearn.model_selection import HalvingRandomSearchCV
from sklearn.model_selection import KFold

model = XGBRegressor()

learning_rate = []
for x in np.arange(0.008, 0.5, 0.003):
    learning_rate.append(x)

max_depth = []
for x in range(5, 20, 2):
    max_depth.append(x)

params = {
    'xgb__max_depth':max_depth,
    'xgb__learning_rate': learning_rate,
    'xgb__gamma' : [0.1,0.2,0.3,0.4,0.5,0.6,0.7],
    'xgb__colsample_bytree': [0.6, 0.7, 0.8, 0.9],
    'xgb__subsample': [0.6, 0.7, 0.8, 0.9]
}
```

In [ ]:
```
grid_xgb = HalvingRandomSearchCV( estimator=model,factor=5,verbose=3,
    param_distributions = params,
    cv = KFold(n_splits = 3, random_state = 2022, shuffle = True),
    scoring ='neg_mean_squared_error',
    resource='n_estimators', min_resources=65, max_resources=3000, n_candidates=25 )
    #resource='n_estimators', min_resources=100, max_resources=3200)

grid_xgb.fit( X_train, y_train, verbose=False)
```

```
n_iterations: 3
n_required_iterations: 3
n_possible_iterations: 3
min_resources_: 65
max_resources_: 3000
aggressive_elimination: False
factor: 5
----------
iter: 0
n_candidates: 25
n_resources: 65
Fitting 3 folds for each of 25 candidates, totalling 75 fits
[15:10:07] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.7, xgb__learning_rate=0.05899999999999999, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:11:27] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.7, xgb__learning_rate=0.05899999999999999, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:12:48] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.7, xgb__learning_rate=0.05899999999999999, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:14:09] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:15:29] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:16:49] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:18:09] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:19:29] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:20:49] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:22:09] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

```
[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:23:29] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:24:49] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:26:09] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=11, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:27:30] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=11, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:28:50] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=11, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:30:11] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.24799999999999994, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:31:31] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.24799999999999994, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:32:51] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.24799999999999994, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:34:12] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.26899999999999996, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:35:32] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.26899999999999996, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:36:52] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
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[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.26899999999999996, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:38:12] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.7, xgb__learning_rate=0.3949999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:39:32] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.7, xgb__learning_rate=0.3949999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:40:52] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.7, xgb__learning_rate=0.3949999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:42:12] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2899999999999999, xgb__max_depth=11, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:43:33] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2899999999999999, xgb__max_depth=11, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:44:53] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
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  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2899999999999999, xgb__max_depth=11, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:46:13] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.3799999999999999, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:47:33] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.3799999999999999, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:48:53] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.3799999999999999, xgb__max_depth=15, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:50:13] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.016999999999999998, xgb__max_depth=19, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:51:33] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

```
[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.016999999999999998, xgb__max_depth=19, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:52:53] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.6, xgb__learning_rate=0.016999999999999998, xgb__max_depth=19, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:54:13] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:55:34] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:56:53] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[15:58:13] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2719999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[15:59:33] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

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  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2719999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:00:53] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.2, xgb__learning_rate=0.2719999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:02:13] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.4279999999999999, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:03:34] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.4279999999999999, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:04:54] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.4279999999999999, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:06:14] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

```
[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.3, xgb__learning_rate=0.23299999999999996, xgb__max_depth=17, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:07:34] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.3, xgb__learning_rate=0.23299999999999996, xgb__max_depth=17, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:08:54] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.3, xgb__learning_rate=0.23299999999999996, xgb__max_depth=17, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:10:14] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.31699999999999995, xgb__max_depth=17, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:11:35] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.31699999999999995, xgb__max_depth=17, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:12:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.3, xgb__learning_rate=0.31699999999999995, xgb__max_depth=17, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:14:15] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.1, xgb__learning_rate=0.25399999999999995, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:15:35] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.1, xgb__learning_rate=0.25399999999999995, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:16:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.9, xgb__gamma=0.1, xgb__learning_rate=0.25399999999999995, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:18:15] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.6, xgb__learning_rate=0.12199999999999997, xgb__max_depth=7, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:19:35] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.6, xgb__learning_rate=0.12199999999999997, xgb__max_depth=7, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:20:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

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[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.6, xgb__learning_rate=0.12199999999999997, xgb__max_depth=7, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:22:15] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.46699999999999986, xgb__max_depth=11, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:23:35] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.46699999999999986, xgb__max_depth=11, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:24:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.1, xgb__learning_rate=0.46699999999999986, xgb__max_depth=11, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:26:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.7, xgb__learning_rate=0.13099999999999998, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:27:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.7, xgb__learning_rate=0.13099999999999998, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:28:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

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  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.7, xgb__learning_rate=0.13099999999999998, xgb__max_depth=15, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:30:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.23599999999999993, xgb__max_depth=9, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:31:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.23599999999999993, xgb__max_depth=9, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:32:56] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.23599999999999993, xgb__max_depth=9, xgb__subsample=0.9;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:34:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.2779999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:35:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

```
[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.2779999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:36:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.2779999999999999, xgb__max_depth=11, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:38:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.3, xgb__learning_rate=0.47599999999999987, xgb__max_depth=13, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:39:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.3, xgb__learning_rate=0.47599999999999987, xgb__max_depth=13, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:40:56] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.7, xgb__gamma=0.3, xgb__learning_rate=0.47599999999999987, xgb__max_depth=13, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:42:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.7, xgb__learning_rate=0.12499999999999997, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:43:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.7, xgb__learning_rate=0.12499999999999997, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:44:56] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.8, xgb__gamma=0.7, xgb__learning_rate=0.12499999999999997, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-0.
000, test=-0.000) total time= 1.3min
[16:46:17] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:47:37] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
[16:48:57] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=65, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 1.3min
----------
iter: 1
n_candidates: 5
n_resources: 325
Fitting 3 folds for each of 5 candidates, totalling 15 fits
[16:50:17] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[16:57:06] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:03:56] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.1, xgb__learning_rate=0.13099999999999998, xgb__max_depth=17, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:10:47] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:17:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:24:26] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```

```
[CV 3/3] END n_estimators=325, xgb__colsample_bytree=0.8, xgb__gamma=0.4, xgb__learning_rate=0.10699999999999998, xgb__max_depth=13, xgb__subsample=0.9;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:31:16] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:38:06] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:44:55] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.2, xgb__learning_rate=0.26899999999999996, xgb__max_depth=9, xgb__subsample=0.6;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:51:47] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[17:58:37] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[18:05:28] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.5, xgb__learning_rate=0.022999999999999996, xgb__max_depth=5, xgb__subsample=0.7;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[18:12:19] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[18:19:08] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 6.8min
[18:25:59] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=325, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=-
0.000, test=-0.000) total time= 6.8min
----------
iter: 2
n_candidates: 1
n_resources: 1625
Fitting 3 folds for each of 1 candidates, totalling 3 fits
[18:32:50] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 1/3] END n_estimators=1625, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=
-0.000, test=-0.000) total time=13.6min
[18:46:30] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.
```

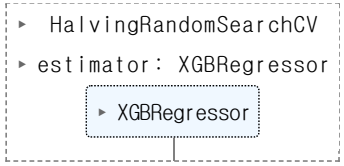
```
  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 2/3] END n_estimators=1625, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=
-0.000, test=-0.000) total time=13.8min
[19:00:21] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[CV 3/3] END n_estimators=1625, xgb__colsample_bytree=0.6, xgb__gamma=0.4, xgb__learning_rate=0.22399999999999995, xgb__max_depth=17, xgb__subsample=0.8;, score=(train=
-0.000, test=-0.000) total time=13.2min
[19:13:36] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.
```



In [ ]:
```python
# 최적 조합과 score 출력
print('Best parameters: ', grid_xgb.best_params_)
print('Best score: ', grid_xgb.best_score_)

params = grid_xgb.best_params_

final_model_with_tuning = XGBRegressor(**params)
final_model_with_tuning.fit( X_train, y_train, eval_metric = 'rmse', W
    eval_set =[(X_train, y_train), (X_val, y_val)],early_stopping_rounds = 30 )

# Get predictions
y_pred = final_model_with_tuning.predict(X_test)

# eval by RMSPE
def rmspe(predictions, targets):
    return np.sqrt((((predictions - targets) / targets) ** 2).mean())


rmspe(y_pred, y_test)
```

```
Best parameters:  {'xgb__subsample': 0.8, 'xgb__max_depth': 17, 'xgb__learning_rate': 0.22399999999999995, 'xgb__gamma': 0.4, 'xgb__colsample_bytree': 0.6, 'n_estimators': 1625}
Best score:  -1.1041617110128093e-06
[19:36:32] WARNING: C:/Users/administrator/workspace/xgboost-win64_release_1.6.0/src/learner.cc:627:
Parameters: { "xgb__colsample_bytree", "xgb__gamma", "xgb__learning_rate", "xgb__max_depth", "xgb__subsample" } might not be used.

  This could be a false alarm, with some parameters getting used by language bindings but
  then being mistakenly passed down to XGBoost core, or some parameter actually being used
  but getting flagged wrongly here. Please open an issue if you find any such cases.


[0]     validation_0-rmse:0.34729       validation_1-rmse:0.34728
[1]     validation_0-rmse:0.24311       validation_1-rmse:0.24310
[2]     validation_0-rmse:0.17018       validation_1-rmse:0.17017
[3]     validation_0-rmse:0.11913       validation_1-rmse:0.11912
[4]     validation_0-rmse:0.08340       validation_1-rmse:0.08339
[5]     validation_0-rmse:0.05839       validation_1-rmse:0.05838
[6]     validation_0-rmse:0.04088       validation_1-rmse:0.04088
[7]     validation_0-rmse:0.02863       validation_1-rmse:0.02863
[8]     validation_0-rmse:0.02006       validation_1-rmse:0.02006
[9]     validation_0-rmse:0.01407       validation_1-rmse:0.01407
[10]    validation_0-rmse:0.00988       validation_1-rmse:0.00989
[11]    validation_0-rmse:0.00697       validation_1-rmse:0.00697
[12]    validation_0-rmse:0.00494       validation_1-rmse:0.00495
[13]    validation_0-rmse:0.00355       validation_1-rmse:0.00357
[14]    validation_0-rmse:0.00261       validation_1-rmse:0.00264
[15]    validation_0-rmse:0.00199       validation_1-rmse:0.00203
[16]    validation_0-rmse:0.00159       validation_1-rmse:0.00165
[17]    validation_0-rmse:0.00135       validation_1-rmse:0.00142
[18]    validation_0-rmse:0.00122       validation_1-rmse:0.00129
[19]    validation_0-rmse:0.00114       validation_1-rmse:0.00122
[20]    validation_0-rmse:0.00110       validation_1-rmse:0.00119
[21]    validation_0-rmse:0.00107       validation_1-rmse:0.00117
[22]    validation_0-rmse:0.00106       validation_1-rmse:0.00116
[23]    validation_0-rmse:0.00105       validation_1-rmse:0.00115
[24]    validation_0-rmse:0.00104       validation_1-rmse:0.00114
[25]    validation_0-rmse:0.00103       validation_1-rmse:0.00114
[26]    validation_0-rmse:0.00102       validation_1-rmse:0.00113
[27]    validation_0-rmse:0.00102       validation_1-rmse:0.00113
[28]    validation_0-rmse:0.00101       validation_1-rmse:0.00113
[29]    validation_0-rmse:0.00101       validation_1-rmse:0.00113
[30]    validation_0-rmse:0.00100       validation_1-rmse:0.00113
[31]    validation_0-rmse:0.00100       validation_1-rmse:0.00112
[32]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[33]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[34]    validation_0-rmse:0.00099       validation_1-rmse:0.00112
[35]    validation_0-rmse:0.00098       validation_1-rmse:0.00112
[36]    validation_0-rmse:0.00098       validation_1-rmse:0.00112
[37]    validation_0-rmse:0.00097       validation_1-rmse:0.00112
[38]    validation_0-rmse:0.00097       validation_1-rmse:0.00111
[39]    validation_0-rmse:0.00096       validation_1-rmse:0.00111
[40]    validation_0-rmse:0.00096       validation_1-rmse:0.00111
[41]    validation_0-rmse:0.00096       validation_1-rmse:0.00110
[42]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
[43]    validation_0-rmse:0.00095       validation_1-rmse:0.00110
```

```
[44]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[45]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[46]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[47]    validation_0-rmse:0.00094       validation_1-rmse:0.00110
[48]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[49]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[50]    validation_0-rmse:0.00093       validation_1-rmse:0.00110
[51]    validation_0-rmse:0.00092       validation_1-rmse:0.00110
[52]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[53]    validation_0-rmse:0.00092       validation_1-rmse:0.00109
[54]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[55]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[56]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[57]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[58]    validation_0-rmse:0.00091       validation_1-rmse:0.00109
[59]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[60]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[61]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[62]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[63]    validation_0-rmse:0.00090       validation_1-rmse:0.00109
[64]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[65]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[66]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[67]    validation_0-rmse:0.00089       validation_1-rmse:0.00109
[68]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[69]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[70]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[71]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[72]    validation_0-rmse:0.00088       validation_1-rmse:0.00108
[73]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[74]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[75]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[76]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[77]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[78]    validation_0-rmse:0.00087       validation_1-rmse:0.00108
[79]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[80]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[81]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[82]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[83]    validation_0-rmse:0.00086       validation_1-rmse:0.00108
[84]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[85]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[86]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[87]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[88]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[89]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[90]    validation_0-rmse:0.00085       validation_1-rmse:0.00108
[91]    validation_0-rmse:0.00084       validation_1-rmse:0.00108
[92]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[93]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[94]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[95]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[96]    validation_0-rmse:0.00084       validation_1-rmse:0.00107
[97]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
[98]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
```

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[99]    validation_0-rmse:0.00083       validation_1-rmse:0.00107
[100]   validation_0-rmse:0.00083       validation_1-rmse:0.00107
[101]   validation_0-rmse:0.00083       validation_1-rmse:0.00107
[102]   validation_0-rmse:0.00083       validation_1-rmse:0.00107
[103]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[104]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[105]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[106]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[107]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[108]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[109]   validation_0-rmse:0.00082       validation_1-rmse:0.00107
[110]   validation_0-rmse:0.00081       validation_1-rmse:0.00107
[111]   validation_0-rmse:0.00081       validation_1-rmse:0.00107
[112]   validation_0-rmse:0.00081       validation_1-rmse:0.00107
[113]   validation_0-rmse:0.00081       validation_1-rmse:0.00107
[114]   validation_0-rmse:0.00081       validation_1-rmse:0.00106
[115]   validation_0-rmse:0.00081       validation_1-rmse:0.00106
[116]   validation_0-rmse:0.00081       validation_1-rmse:0.00106
[117]   validation_0-rmse:0.00081       validation_1-rmse:0.00106
[118]   validation_0-rmse:0.00080       validation_1-rmse:0.00106
[119]   validation_0-rmse:0.00080       validation_1-rmse:0.00106
[120]   validation_0-rmse:0.00080       validation_1-rmse:0.00106
[121]   validation_0-rmse:0.00080       validation_1-rmse:0.00106
[122]   validation_0-rmse:0.00080       validation_1-rmse:0.00106
[123]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[124]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[125]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[126]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[127]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[128]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[129]   validation_0-rmse:0.00079       validation_1-rmse:0.00106
[130]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[131]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[132]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[133]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[134]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[135]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[136]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[137]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[138]   validation_0-rmse:0.00078       validation_1-rmse:0.00106
[139]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[140]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[141]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[142]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[143]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[144]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[145]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[146]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[147]   validation_0-rmse:0.00077       validation_1-rmse:0.00106
[148]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[149]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[150]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[151]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[152]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[153]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
```

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[154]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[155]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
[156]   validation_0-rmse:0.00076       validation_1-rmse:0.00106
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[206]   validation_0-rmse:0.00071       validation_1-rmse:0.00105
[207]   validation_0-rmse:0.00071       validation_1-rmse:0.00105
[208]   validation_0-rmse:0.00071       validation_1-rmse:0.00105
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[233]   validation_0-rmse:0.00069       validation_1-rmse:0.00105
[234]   validation_0-rmse:0.00069       validation_1-rmse:0.00105
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[250]   validation_0-rmse:0.00068       validation_1-rmse:0.00105
[251]   validation_0-rmse:0.00068       validation_1-rmse:0.00105
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[255]   validation_0-rmse:0.00068       validation_1-rmse:0.00105
[256]   validation_0-rmse:0.00068       validation_1-rmse:0.00105
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[259]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[260]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[261]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[262]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[263]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
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[264]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[265]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[266]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
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[268]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[269]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[270]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[271]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
[272]   validation_0-rmse:0.00067       validation_1-rmse:0.00105
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[284]   validation_0-rmse:0.00066       validation_1-rmse:0.00105
[285]   validation_0-rmse:0.00066       validation_1-rmse:0.00105
[286]   validation_0-rmse:0.00066       validation_1-rmse:0.00105
[287]   validation_0-rmse:0.00066       validation_1-rmse:0.00105
[288]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[289]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[290]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
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[295]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[296]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[297]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[298]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[299]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[300]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
[301]   validation_0-rmse:0.00065       validation_1-rmse:0.00105
0.22076532853794661
```

Type 3: Base → [XGBoost,1d-CNN,MLP]

[01] Base → 1d-CNN

In [ ]:
```
import tensorflow as tf
import tensorflow.keras.backend as K
from sklearn.preprocessing import MinMaxScaler, StandardScaler
from tensorflow.keras.callbacks import Callback, ReduceLROnPlateau, ModelCheckpoint, EarlyStopping
```

In [ ]:
```
# Standardization
scaler = StandardScaler()

X_train = scaler.fit_transform(X_train)
```

```
X_val = scaler.fit_transform(X_val)
X_test = scaler.fit_transform(X_test)
X_train_base = scaler.fit_transform(X_train_base)
X_val_base = scaler.fit_transform(X_val_base)
X_test_base = scaler.fit_transform(X_test_base)
```

CNN function

In [ ]:
```
def np_rmspe(y_true, y_pred):
    return np.sqrt(np.mean(np.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def CNN(X_train, y_train, num_columns, num_labels, learning_rate, epochs):
    inp = tf.keras.layers.Input(shape=(num_columns,))
    x = tf.keras.layers.BatchNormalization()(inp)
    x = tf.keras.layers.Dense(256, kernel_initializer='he_normal', activation='ELU')(x)
    x = tf.keras.layers.Reshape((16,16))(x)
    x = tf.keras.layers.Conv1D(filters=12, kernel_size=2, kernel_initializer='he_normal', activation='ELU')(x)
    x = tf.keras.layers.AveragePooling1D(pool_size=2)(x)
    x = tf.keras.layers.Flatten()(x)

    for i in range(3):
        x = tf.keras.layers.Dense(64//(2**i), kernel_initializer='he_normal', activation='ELU')(x)
        x = tf.keras.layers.BatchNormalization()(x)
        x = tf.keras.layers.GaussianNoise(0.01)(x)
        x = tf.keras.layers.Dropout(0.20)(x)

    x = tf.keras.layers.Dense(num_labels)(x)

    model = tf.keras.models.Model(inputs=inp, outputs=x)
    model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate), loss=rmspe)

    rlr = ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=5, min_delta=1e-5, verbose=2)
    es = EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=31, restore_best_weights=True, verbose=2)

    history = model.fit(X_train, y_train, epochs=epochs,validation_data=(X_val, y_val), validation_batch_size=len(y_val),W
        batch_size=batch_size, verbose=1, callbacks=[rlr,es])

    return model, history
```

Base feature + CNN

In [ ]:
```
num_columns = X_train_base.shape[1]
num_labels = 1
learning_rate = 6e-3
```

In [ ]:
```
tf.random.set_seed(777)
batch_size = 1024
learning_rate = 6e-3
```

```
epochs = 1000
model_base = CNN(X_train_base, y_train_base, num_columns, num_labels, learning_rate, epochs)
```

```
Metal device set to: Apple M1 Pro

systemMemory: 16.00 GB
maxCacheSize: 5.33 GB


2022-10-25 01:40:48.018285: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305] Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA support.
2022-10-25 01:40:48.018498: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id: <undefined>)
Epoch 1/1000
2022-10-25 01:40:48.371657: W tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU frequency: 0 Hz
2022-10-25 01:40:48.890571: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
293/293 [==============================] - 10s 29ms/step - loss: 42.1389 - val_loss: 0.8074 - lr: 0.0060
Epoch 2/1000
  1/293 [..............................] - ETA: 8s - loss: 0.7784
2022-10-25 01:40:57.729150: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.6073 - val_loss: 0.5278 - lr: 0.0060
Epoch 3/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.6212 - val_loss: 0.4274 - lr: 0.0060
Epoch 4/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.5175 - val_loss: 0.3780 - lr: 0.0060
Epoch 5/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4837 - val_loss: 0.5797 - lr: 0.0060
Epoch 6/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4592 - val_loss: 0.4721 - lr: 0.0060
Epoch 7/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4378 - val_loss: 0.4582 - lr: 0.0060
Epoch 8/1000
293/293 [==============================] - 9s 30ms/step - loss: 0.4205 - val_loss: 0.3872 - lr: 0.0060
Epoch 9/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.4167 - val_loss: 0.3265 - lr: 0.0060
Epoch 10/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.4084 - val_loss: 0.6083 - lr: 0.0060
Epoch 11/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.4022 - val_loss: 0.9834 - lr: 0.0060
Epoch 12/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4135 - val_loss: 0.6631 - lr: 0.0060
Epoch 13/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4088 - val_loss: 0.6742 - lr: 0.0060
Epoch 14/1000
293/293 [==============================] - ETA: 0s - loss: 0.3836
Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
293/293 [==============================] - 8s 28ms/step - loss: 0.3836 - val_loss: 0.4511 - lr: 0.0060
Epoch 15/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3123 - val_loss: 0.3245 - lr: 0.0030
Epoch 16/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3076 - val_loss: 0.2492 - lr: 0.0030
Epoch 17/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3136 - val_loss: 0.2748 - lr: 0.0030
Epoch 18/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.3178 - val_loss: 0.3933 - lr: 0.0030
Epoch 19/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.3080 - val_loss: 0.3835 - lr: 0.0030
Epoch 20/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.3060 - val_loss: 0.3447 - lr: 0.0030
Epoch 21/1000
293/293 [==============================] - ETA: 0s - loss: 0.3013
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
293/293 [==============================] - 8s 27ms/step - loss: 0.3013 - val_loss: 0.3618 - lr: 0.0030
Epoch 22/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2833 - val_loss: 0.3002 - lr: 0.0015
Epoch 23/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2870 - val_loss: 0.2671 - lr: 0.0015
Epoch 24/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2863 - val_loss: 0.3092 - lr: 0.0015
Epoch 25/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2786 - val_loss: 0.3354 - lr: 0.0015
Epoch 26/1000
293/293 [==============================] - ETA: 0s - loss: 0.2895
Epoch 26: ReduceLROnPlateau reducing learning rate to 0.0007500000006519258.
293/293 [==============================] - 8s 28ms/step - loss: 0.2895 - val_loss: 0.3429 - lr: 0.0015
```

```
Epoch 27/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2717 - val_loss: 0.2927 - lr: 7.5000e-04
Epoch 28/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2707 - val_loss: 0.2617 - lr: 7.5000e-04
Epoch 29/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2694 - val_loss: 0.2358 - lr: 7.5000e-04
Epoch 30/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2703 - val_loss: 0.2722 - lr: 7.5000e-04
Epoch 31/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2722 - val_loss: 0.2714 - lr: 7.5000e-04
Epoch 32/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2651 - val_loss: 0.2586 - lr: 7.5000e-04
Epoch 33/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2653 - val_loss: 0.2517 - lr: 7.5000e-04
Epoch 34/1000
291/293 [============================>.] - ETA: 0s - loss: 0.2672
Epoch 34: ReduceLROnPlateau reducing learning rate to 0.000375000003259629.
293/293 [==============================] - 8s 28ms/step - loss: 0.2672 - val_loss: 0.2502 - lr: 7.5000e-04
Epoch 35/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2583 - val_loss: 0.2336 - lr: 3.7500e-04
Epoch 36/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2572 - val_loss: 0.2413 - lr: 3.7500e-04
Epoch 37/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2573 - val_loss: 0.2631 - lr: 3.7500e-04
Epoch 38/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2567 - val_loss: 0.2528 - lr: 3.7500e-04
Epoch 39/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2563 - val_loss: 0.2401 - lr: 3.7500e-04
Epoch 40/1000
293/293 [==============================] - ETA: 0s - loss: 0.2569
Epoch 40: ReduceLROnPlateau reducing learning rate to 0.0001875000016298145.
293/293 [==============================] - 8s 28ms/step - loss: 0.2569 - val_loss: 0.2349 - lr: 3.7500e-04
Epoch 41/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2524 - val_loss: 0.2321 - lr: 1.8750e-04
Epoch 42/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2513 - val_loss: 0.2321 - lr: 1.8750e-04
Epoch 43/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2506 - val_loss: 0.2340 - lr: 1.8750e-04
Epoch 44/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2514 - val_loss: 0.2351 - lr: 1.8750e-04
Epoch 45/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2498 - val_loss: 0.2371 - lr: 1.8750e-04
Epoch 46/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2508 - val_loss: 0.2285 - lr: 1.8750e-04
Epoch 47/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2491 - val_loss: 0.2300 - lr: 1.8750e-04
Epoch 48/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2491 - val_loss: 0.2341 - lr: 1.8750e-04
Epoch 49/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2476 - val_loss: 0.2332 - lr: 1.8750e-04
Epoch 50/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2477 - val_loss: 0.2280 - lr: 1.8750e-04
Epoch 51/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2483 - val_loss: 0.2480 - lr: 1.8750e-04
Epoch 52/1000
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.2458 - val_loss: 0.2306 - lr: 1.8750e-04
Epoch 53/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2454 - val_loss: 0.2343 - lr: 1.8750e-04
Epoch 54/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2458 - val_loss: 0.2308 - lr: 1.8750e-04
Epoch 55/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2458 - val_loss: 0.2236 - lr: 1.8750e-04
Epoch 56/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2458 - val_loss: 0.2344 - lr: 1.8750e-04
Epoch 57/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2430 - val_loss: 0.2226 - lr: 1.8750e-04
Epoch 58/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2433 - val_loss: 0.2224 - lr: 1.8750e-04
Epoch 59/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2420 - val_loss: 0.2573 - lr: 1.8750e-04
Epoch 60/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2419 - val_loss: 0.2327 - lr: 1.8750e-04
Epoch 61/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2416 - val_loss: 0.2244 - lr: 1.8750e-04
Epoch 62/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2417 - val_loss: 0.2221 - lr: 1.8750e-04
Epoch 63/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2420 - val_loss: 0.2261 - lr: 1.8750e-04
Epoch 64/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2412 - val_loss: 0.2323 - lr: 1.8750e-04
Epoch 65/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2406 - val_loss: 0.2300 - lr: 1.8750e-04
Epoch 66/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2395 - val_loss: 0.2227 - lr: 1.8750e-04
Epoch 67/1000
292/293 [============================>.] - ETA: 0s - loss: 0.2384
Epoch 67: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
293/293 [==============================] - 8s 29ms/step - loss: 0.2384 - val_loss: 0.2230 - lr: 1.8750e-04
Epoch 68/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2367 - val_loss: 0.2295 - lr: 9.3750e-05
Epoch 69/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2367 - val_loss: 0.2255 - lr: 9.3750e-05
Epoch 70/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2369 - val_loss: 0.2261 - lr: 9.3750e-05
Epoch 71/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2355 - val_loss: 0.2313 - lr: 9.3750e-05
Epoch 72/1000
293/293 [==============================] - ETA: 0s - loss: 0.2369
Epoch 72: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2369 - val_loss: 0.2305 - lr: 9.3750e-05
Epoch 73/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2349 - val_loss: 0.2190 - lr: 4.6875e-05
Epoch 74/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2347 - val_loss: 0.2231 - lr: 4.6875e-05
Epoch 75/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2341 - val_loss: 0.2241 - lr: 4.6875e-05
Epoch 76/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2348 - val_loss: 0.2202 - lr: 4.6875e-05
Epoch 77/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2349 - val_loss: 0.2228 - lr: 4.6875e-05
```

```
Epoch 78/1000
291/293 [============================>.] - ETA: 0s - loss: 0.2339
Epoch 78: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2339 - val_loss: 0.2273 - lr: 4.6875e-05
Epoch 79/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2335 - val_loss: 0.2228 - lr: 2.3438e-05
Epoch 80/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2332 - val_loss: 0.2197 - lr: 2.3438e-05
Epoch 81/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2335 - val_loss: 0.2224 - lr: 2.3438e-05
Epoch 82/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2331 - val_loss: 0.2208 - lr: 2.3438e-05
Epoch 83/1000
293/293 [==============================] - ETA: 0s - loss: 0.2331
Epoch 83: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2331 - val_loss: 0.2231 - lr: 2.3438e-05
Epoch 84/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2330 - val_loss: 0.2214 - lr: 1.1719e-05
Epoch 85/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2328 - val_loss: 0.2213 - lr: 1.1719e-05
Epoch 86/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2332 - val_loss: 0.2213 - lr: 1.1719e-05
Epoch 87/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2327 - val_loss: 0.2202 - lr: 1.1719e-05
Epoch 88/1000
293/293 [==============================] - ETA: 0s - loss: 0.2329
Epoch 88: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
293/293 [==============================] - 8s 28ms/step - loss: 0.2329 - val_loss: 0.2204 - lr: 1.1719e-05
Epoch 89/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2325 - val_loss: 0.2210 - lr: 5.8594e-06
Epoch 90/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2333 - val_loss: 0.2229 - lr: 5.8594e-06
Epoch 91/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2330 - val_loss: 0.2210 - lr: 5.8594e-06
Epoch 92/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2329 - val_loss: 0.2212 - lr: 5.8594e-06
Epoch 93/1000
293/293 [==============================] - ETA: 0s - loss: 0.2323
Epoch 93: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
293/293 [==============================] - 8s 29ms/step - loss: 0.2323 - val_loss: 0.2208 - lr: 5.8594e-06
Epoch 94/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2324 - val_loss: 0.2208 - lr: 2.9297e-06
Epoch 95/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2327 - val_loss: 0.2205 - lr: 2.9297e-06
Epoch 96/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2325 - val_loss: 0.2215 - lr: 2.9297e-06
Epoch 97/1000
293/293 [==============================] - 9s 30ms/step - loss: 0.2328 - val_loss: 0.2220 - lr: 2.9297e-06
Epoch 98/1000
293/293 [==============================] - ETA: 0s - loss: 0.2322
Epoch 98: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
293/293 [==============================] - 9s 30ms/step - loss: 0.2322 - val_loss: 0.2206 - lr: 2.9297e-06
Epoch 99/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.2325 - val_loss: 0.2204 - lr: 1.4648e-06
Epoch 100/1000
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.2329 - val_loss: 0.2209 - lr: 1.4648e-06
Epoch 101/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.2323 - val_loss: 0.2212 - lr: 1.4648e-06
Epoch 102/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2325 - val_loss: 0.2214 - lr: 1.4648e-06
Epoch 103/1000
293/293 [==============================] - ETA: 0s - loss: 0.2321
Epoch 103: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
293/293 [==============================] - 8s 28ms/step - loss: 0.2321 - val_loss: 0.2215 - lr: 1.4648e-06
Epoch 104/1000
293/293 [==============================] - ETA: 0s - loss: 0.2321Restoring model weights from the end of the best epoch: 73.
293/293 [==============================] - 8s 29ms/step - loss: 0.2321 - val_loss: 0.2210 - lr: 7.3242e-07
Epoch 104: early stopping
```

In [ ]:
```
model_base[0].summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 335)]             0

 batch_normalization (BatchN  (None, 335)              1340
 ormalization)

 dense (Dense)               (None, 256)               86016

 reshape (Reshape)           (None, 16, 16)            0

 conv1d (Conv1D)             (None, 15, 12)            396

 average_pooling1d (AverageP  (None, 7, 12)            0
 ooling1D)

 flatten (Flatten)           (None, 84)                0

 dense_1 (Dense)             (None, 64)                5440

 batch_normalization_1 (Batc  (None, 64)               256
 hNormalization)

 gaussian_noise (GaussianNoi  (None, 64)               0
 se)

 dropout (Dropout)           (None, 64)                0

 dense_2 (Dense)             (None, 32)                2080

 batch_normalization_2 (Batc  (None, 32)               128
 hNormalization)

 gaussian_noise_1 (GaussianN  (None, 32)               0
 oise)

 dropout_1 (Dropout)         (None, 32)                0

 dense_3 (Dense)             (None, 16)                528

 batch_normalization_3 (Batc  (None, 16)               64
 hNormalization)

 gaussian_noise_2 (GaussianN  (None, 16)               0
 oise)

 dropout_2 (Dropout)         (None, 16)                0

 dense_4 (Dense)             (None, 1)                 17

=================================================================
Total params: 96,265
Trainable params: 95,371
```

```
Non-trainable params: 894
_________________________________________________________________
```

In [ ]:
```python
def get_mse(y_true, y_pred):
    return np.square((y_true - y_pred)/y_true)
```

In [ ]:
```python
for i in range(85):
    globals()['y_pred{}'.format(i+1)] = model_base[0].predict(X_test_base[1000*i:1000*(i+1)])
    globals()['y_pred{}'.format(i+1)] = globals()['y_pred{}'.format(i+1)].reshape(1000,)
    globals()['y_test{}'.format(i+1)] = y_test_base[1000*i:1000*(i+1)]

    if i == 84:
        globals()['y_pred{}'.format(i+2)] = model_base[0].predict(X_test_base[1000*(i+1):])
        globals()['y_pred{}'.format(i+2)] = globals()['y_pred{}'.format(i+2)].reshape(-1,)
        globals()['y_test{}'.format(i+2)] = y_test_base[1000*(i+1):]
```

```
 8/32 [======>.....................] - ETA: 0s
2022-10-25 01:58:50.562506: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
32/32 [==============================] - 0s 8ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 9ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 8ms/step
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32/32 [==============================] - 0s 7ms/step
```

```
32/32 [==============================] - 0s 7ms/step
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32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 6ms/step
32/32 [==============================] - 0s 8ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 8ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 9ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
14/14 [==============================] - 0s 9ms/step
```

In [ ]:
```
pred = {}
test = {}
for i in range(86):
    pred[i+1] = globals()['y_pred{}'.format(i+1)]
    test[i+1] = globals()['y_test{}'.format(i+1)]
```

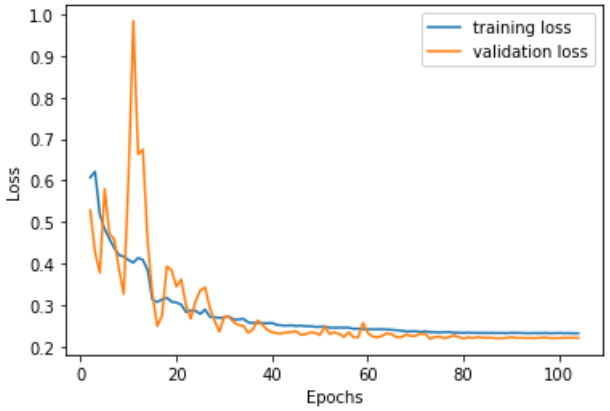
In [ ]:
```
mse = []
for i in range(86):
    sqr_mse = get_mse(test[i+1],pred[i+1])
    mse.append(np.sum(sqr_mse))
```

In [ ]:
```
final_rmspe_base = np.sqrt(sum(mse)/y_test_base.shape[0])
final_rmspe_base
```

0.2173172831690662

In [ ]:
```
import matplotlib.pyplot as plt
epochs = np.arange(2, len(model_base[1].history['loss'])+1)
plt.plot(epochs, model_base[1].history['loss'][1:],label='training loss')
plt.plot(epochs, model_base[1].history['val_loss'][1:],label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
```

```
plt.legend()
plt.show()
```



[02] Base → MLP

In [ ]:

```
import numpy as np
import pandas as pd
import tensorflow as tf
import tensorflow.keras.backend as K
import matplotlib.pyplot as plt
import pandas as pd

from tensorflow import keras
from keras.models import Model
from sklearn.preprocessing import StandardScaler

def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))

X_train = pd.read_pickle('./397/X_train_base.pkl').astype(float)
y_train = pd.read_pickle('./397/y_train_base.pkl').astype(float)
X_val = pd.read_pickle('./397/X_val_base.pkl').astype(float)
y_val = pd.read_pickle('./397/y_val_base.pkl').astype(float)
X_test = pd.read_pickle('./397/X_test_base.pkl').astype(float)
y_test = pd.read_pickle('./397/y_test_base.pkl').astype(float)

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_val = scaler.fit_transform(X_val)
X_test = scaler.fit_transform(X_test)
X_train.shape[1]

inputs= tf.keras.Input(
        shape=(X_train.shape[1],)
    )
hidden1=tf.keras.layers.Dense(
        units=int(np.round(X_train.shape[1]/2, 0)),
```

```
        kernel_initializer='he_uniform',
        activation='LeakyReLU'
    )(inputs)
hidden2=tf.keras.layers.Dense(
        units=int(np.round(X_train.shape[1]/4, 0)),
        kernel_initializer='he_uniform',
        activation='LeakyReLU'
    )(hidden1)
outputs=tf.keras.layers.Dense(
        units=1,
)(hidden2)

model = Model(inputs, outputs)
model.summary()

model.compile(optimizer=tf.keras.optimizers.Adam(0.001),
              loss=rmspe)

rlr = tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=3, min_delta=1e-5, min_lr=1e-5, verbose=1)
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=11, restore_best_weights=True, verbose=1)
callback_list = [rlr, es]
history = model.fit(X_train, y_train,
                    batch_size=500, epochs=1000, verbose=1,
                    validation_data=(X_val, y_val), callbacks=callback_list
)
pd.DataFrame(history.history)
epochs=np.arange(1, len(history.history['loss'])+1)
plt.plot(epochs, history.history['loss'], label='training loss')
plt.plot(epochs, history.history['val_loss'], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()

epochs=np.arange(2, len(history.history['loss'])+1)
plt.plot(epochs, history.history['loss'][1:], label='training loss')
plt.plot(epochs, history.history['val_loss'][1:], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()

a = np.array([]).reshape(0, 1)

for x in range (1, 42):
    length = int((X_test.shape[0] / 41))
    test = X_test[length*(x-1):length*(x)]

    y_hat = model.predict(test)
    #print(y_hat)
    a = np.append(a, y_hat)

rmse = np.sqrt(np.mean(np.square(((a - y_test) / y_test)), axis=0))
print('RMSPE :', rmse)
```

```
Model: "model_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_2 (InputLayer)         [(None, 335)]             0
_________________________________________________________________
dense_3 (Dense)              (None, 168)               56448
_________________________________________________________________
dense_4 (Dense)              (None, 84)                14196
_________________________________________________________________
dense_5 (Dense)              (None, 1)                 85
=================================================================
Total params: 70,729
Trainable params: 70,729
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
  1/599 [..............................] - ETA: 3:41 - loss: 411.8736
2022-10-25 00:20:12.371673: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
599/599 [==============================] - ETA: 0s - loss: 46.1778
2022-10-25 00:20:17.149243: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
```

```
599/599 [==============================] - 5s 8ms/step - loss: 46.1778 - val_loss: 26.6992
Epoch 2/1000
599/599 [==============================] - 4s 7ms/step - loss: 12.8448 - val_loss: 6.7880
Epoch 3/1000
599/599 [==============================] - 4s 7ms/step - loss: 7.1539 - val_loss: 7.1758
Epoch 4/1000
599/599 [==============================] - 4s 7ms/step - loss: 4.5133 - val_loss: 3.1471
Epoch 5/1000
599/599 [==============================] - 4s 7ms/step - loss: 3.6160 - val_loss: 5.1376
Epoch 6/1000
599/599 [==============================] - 5s 8ms/step - loss: 3.2463 - val_loss: 6.6600
Epoch 7/1000
599/599 [==============================] - 4s 7ms/step - loss: 2.1526 - val_loss: 4.3992

Epoch 00007: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
Epoch 8/1000
599/599 [==============================] - 4s 7ms/step - loss: 1.0641 - val_loss: 0.8936
Epoch 9/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.7797 - val_loss: 1.3126
Epoch 10/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.6585 - val_loss: 0.5281
Epoch 11/1000
599/599 [==============================] - 4s 7ms/step - loss: 1.0175 - val_loss: 0.4120
Epoch 12/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.8812 - val_loss: 1.3328
Epoch 13/1000
599/599 [==============================] - 4s 7ms/step - loss: 1.4628 - val_loss: 0.6329
Epoch 14/1000
599/599 [==============================] - 4s 7ms/step - loss: 1.1804 - val_loss: 0.3970
Epoch 15/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.9205 - val_loss: 1.2048
Epoch 16/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.6410 - val_loss: 0.4734
Epoch 17/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.5429 - val_loss: 0.8190

Epoch 00017: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
Epoch 18/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.3424 - val_loss: 0.8860
Epoch 19/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.3900 - val_loss: 0.4165
Epoch 20/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.4760 - val_loss: 0.3795
Epoch 21/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.3344 - val_loss: 0.5427
Epoch 22/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.5196 - val_loss: 0.8382
Epoch 23/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.5408 - val_loss: 0.4303

Epoch 00023: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
Epoch 24/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2935 - val_loss: 0.5007
Epoch 25/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2992 - val_loss: 0.2424
```

```
Epoch 26/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2932 - val_loss: 0.2705
Epoch 27/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.3412 - val_loss: 0.6398
Epoch 28/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.3067 - val_loss: 0.2534

Epoch 00028: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
Epoch 29/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2548 - val_loss: 0.2375
Epoch 30/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2504 - val_loss: 0.2422
Epoch 31/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2493 - val_loss: 0.2382
Epoch 32/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2451 - val_loss: 0.2503

Epoch 00032: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
Epoch 33/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2350 - val_loss: 0.2337
Epoch 34/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2358 - val_loss: 0.2341
Epoch 35/1000
599/599 [==============================] - 6s 10ms/step - loss: 0.2353 - val_loss: 0.2385
Epoch 36/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2365 - val_loss: 0.2343

Epoch 00036: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
Epoch 37/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2270 - val_loss: 0.2315
Epoch 38/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2269 - val_loss: 0.2310
Epoch 39/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2291 - val_loss: 0.2287
Epoch 40/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2276 - val_loss: 0.2272
Epoch 41/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2262 - val_loss: 0.2352
Epoch 42/1000
599/599 [==============================] - 3s 4ms/step - loss: 0.2266 - val_loss: 0.2298
Epoch 43/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2267 - val_loss: 0.2271
Epoch 44/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2268 - val_loss: 0.2330
Epoch 45/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2256 - val_loss: 0.2283
Epoch 46/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2261 - val_loss: 0.2286

Epoch 00046: ReduceLROnPlateau reducing learning rate to 7.812500371073838e-06.
Epoch 47/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2216 - val_loss: 0.2256
Epoch 48/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2221 - val_loss: 0.2258
Epoch 49/1000
```

```
599/599 [==============================] - 5s 8ms/step - loss: 0.2214 - val_loss: 0.2260
Epoch 50/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2215 - val_loss: 0.2257

Epoch 00050: ReduceLROnPlateau reducing learning rate to 3.906250185536919e-06.
Epoch 51/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2193 - val_loss: 0.2264
Epoch 52/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2192 - val_loss: 0.2246
Epoch 53/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2193 - val_loss: 0.2249
Epoch 54/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2194 - val_loss: 0.2248
Epoch 55/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2190 - val_loss: 0.2251

Epoch 00055: ReduceLROnPlateau reducing learning rate to 1.9531250927684596e-06.
Epoch 56/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2181 - val_loss: 0.2251
Epoch 57/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2180 - val_loss: 0.2249
Epoch 58/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2180 - val_loss: 0.2242
Epoch 59/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2180 - val_loss: 0.2246
Epoch 60/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2179 - val_loss: 0.2240
Epoch 61/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2180 - val_loss: 0.2248
Epoch 62/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2180 - val_loss: 0.2239
Epoch 63/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2179 - val_loss: 0.2260
Epoch 64/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2178 - val_loss: 0.2245
Epoch 65/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2177 - val_loss: 0.2249

Epoch 00065: ReduceLROnPlateau reducing learning rate to 9.765625463842298e-07.
Epoch 66/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2173 - val_loss: 0.2244
Epoch 67/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2172 - val_loss: 0.2242
Epoch 68/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2172 - val_loss: 0.2242

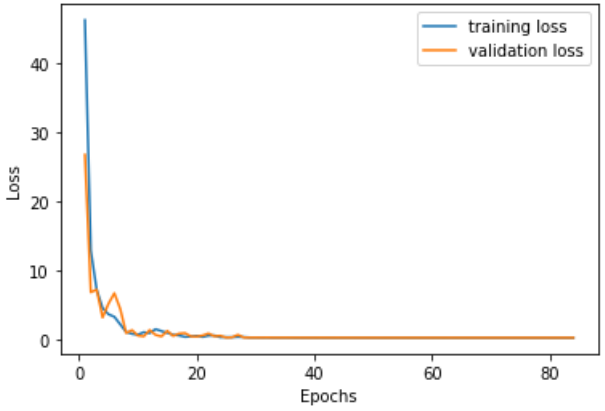
Epoch 00068: ReduceLROnPlateau reducing learning rate to 4.882812731921149e-07.
Epoch 69/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2169 - val_loss: 0.2239
Epoch 70/1000
599/599 [==============================] - 6s 9ms/step - loss: 0.2169 - val_loss: 0.2240
Epoch 71/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2169 - val_loss: 0.2240
Epoch 72/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2169 - val_loss: 0.2246
```

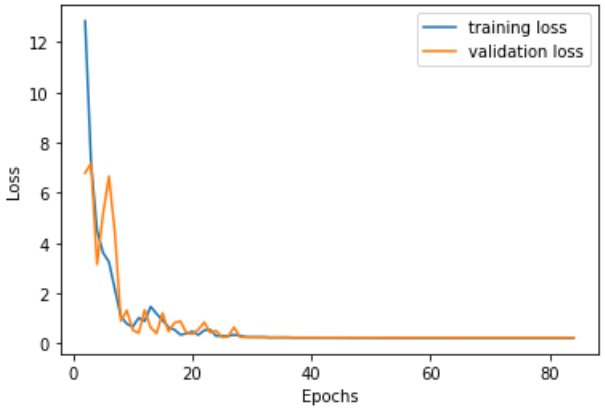
```
Epoch 00072: ReduceLROnPlateau reducing learning rate to 2.4414063659605745e-07.
Epoch 73/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2168 - val_loss: 0.2238
Epoch 74/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2167 - val_loss: 0.2239
Epoch 75/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2167 - val_loss: 0.2243
Epoch 76/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2167 - val_loss: 0.2242

Epoch 00076: ReduceLROnPlateau reducing learning rate to 1.2207031829802872e-07.
Epoch 77/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2167 - val_loss: 0.2239
Epoch 78/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2167 - val_loss: 0.2240
Epoch 79/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2167 - val_loss: 0.2238

Epoch 00079: ReduceLROnPlateau reducing learning rate to 6.103515914901436e-08.
Epoch 80/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2166 - val_loss: 0.2239
Epoch 81/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2166 - val_loss: 0.2238
Epoch 82/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2166 - val_loss: 0.2239

Epoch 00082: ReduceLROnPlateau reducing learning rate to 3.051757957450718e-08.
Epoch 83/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2166 - val_loss: 0.2239
Epoch 84/1000
599/599 [==============================] - 4s 7ms/step - loss: 0.2166 - val_loss: 0.2239
Restoring model weights from the end of the best epoch.
Epoch 00084: early stopping
```






```
2022-10-25 00:26:22.147857: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
RMSPE : 0.22679906769660024
```

[03] Ensemble

CV stacking Assemble with base features

In [ ]:
```
import os
from tqdm import tqdm
import numpy as np
from xgboost import XGBRegressor
import pandas as pd
import tensorflow as tf
import tensorflow.keras.backend as K

from keras.models import Model
from sklearn.preprocessing import MinMaxScaler, StandardScaler
from sklearn.model_selection import KFold
from tensorflow.keras.callbacks import Callback, ReduceLROnPlateau, ModelCheckpoint, EarlyStopping
```

In [ ]:
```
file_list = []

for file in os.listdir():
    if file.endswith(".pkl"):
        print(os.path.join(file))
        file_list.append(os.path.join(file))

for files in range(len(file_list)):

    globals()['{}'.format(file_list[files][:-4])] = pd.read_pickle('{}'.format(file_list[files]))
```

```
y_train.pkl
X_test.pkl
y_test.pkl
y_val.pkl
X_train.pkl
y_test_base.pkl
X_val.pkl
y_val_base.pkl
X_test_base.pkl
X_val_base.pkl
y_train_base.pkl
X_train_base.pkl
```

In [ ]:
```
scaler = StandardScaler()
X_train_base_scaled = scaler.fit_transform(X_train_base)
X_val_base_scaled = scaler.fit_transform(X_val_base)
X_test_base_scaled = scaler.fit_transform(X_test_base)
```

XGBoost

In [ ]:
```
n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
train_fold_predict = np.zeros((X_train_base.shape[0], 1))
test_predict = np.zeros((X_test_base.shape[0], n_folds))
```

In [ ]:
```
xgboost_reg = XGBRegressor(n_estimators = 400,
                           learning_rate = 0.04,
                           colsample_bytree = 0.8,
                           subsample = 0.7 )
```

In [ ]:
```
for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train_base))):
    X_train_base_ = X_train_base.iloc[train_index,:]
    y_train_base_ = y_train_base.iloc[train_index]
    X_val_base_ = X_train_base.iloc[val_index,:]

    xgboost_reg.fit(X_train_base_,y_train_base_)

    train_fold_predict[val_index,:] = xgboost_reg.predict(X_val_base_).reshape(-1,1)
    test_predict[:,cv_num] = xgboost_reg.predict(X_test_base)

xgb_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
xgb_train_predict = train_fold_predict
```

```
3it [11:49, 236.43s/it]
```

CNN

In [ ]:
```
def np_rmspe(y_true, y_pred):
    return np.sqrt(np.mean(np.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def CNN(X_train, y_train, X_val, y_val, num_columns, num_labels, learning_rate, epochs):

    inp = tf.keras.layers.Input(shape=(num_columns,))
    x = tf.keras.layers.BatchNormalization()(inp)
    x = tf.keras.layers.Dense(256, kernel_initializer='he_normal', activation='ELU')(x)
    x = tf.keras.layers.Reshape((16,16))(x)
    x = tf.keras.layers.Conv1D(filters=12, kernel_size=2, kernel_initializer='he_normal', activation='ELU')(x)
    x = tf.keras.layers.AveragePooling1D(pool_size=2)(x)
    x = tf.keras.layers.Flatten()(x)

    for i in range(3):
        x = tf.keras.layers.Dense(64//(2**i), kernel_initializer='he_normal', activation='ELU')(x)
        x = tf.keras.layers.BatchNormalization()(x)
        x = tf.keras.layers.GaussianNoise(0.01)(x)
        x = tf.keras.layers.Dropout(0.20)(x)

    x = tf.keras.layers.Dense(num_labels)(x)

    model = tf.keras.models.Model(inputs=inp, outputs=x)
    model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate), loss=rmspe)

    rlr = ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=5, min_delta=1e-5, verbose=2)
    es = EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=31, restore_best_weights=True, verbose=2)

    history = model.fit(X_train, y_train, epochs=epochs,validation_data=(X_val, y_val), validation_batch_size=len(y_val),batch_size=batch_size,verbose=1, callbacks=[rl

    return model, history
```

In [ ]:
```
tf.random.set_seed(777)
num_columns = X_train_base_scaled.shape[1]
num_labels = 1
learning_rate = 6e-3
batch_size = 1024
dropout_rates = 0
epochs = 1000

n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
train_fold_predict = np.zeros((X_train_base_scaled.shape[0], 1))
test_predict = np.zeros((X_test_base_scaled.shape[0], n_folds))

for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train_base_scaled))):
    X_train_base_ = X_train_base_scaled[train_index,:]
    y_train_base_ = y_train_base.iloc[train_index]
    X_val_base_ = X_train_base_scaled[val_index,:]

    model = CNN(X_train_base_, y_train_base_, X_val_base_scaled, y_val_base, num_columns, num_labels, learning_rate, epochs)

    train_fold_predict[val_index,:] = model[0].predict(X_val_base_).reshape(-1,1)
    test_predict[:,cv_num] = model[0].predict(np.array(X_test_base_scaled)).reshape(-1)

cnn_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
cnn_train_predict = train_fold_predict
```

0it [00:00, ?it/s]

```
Epoch 1/1000
195/195 [==============================] - 5s 17ms/step - loss: 35.0853 - val_loss: 0.7947 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.9537 - val_loss: 0.5388 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.5703 - val_loss: 0.5016 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.5289 - val_loss: 0.3123 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.4528 - val_loss: 0.3698 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.4604 - val_loss: 0.3258 - lr: 0.0060
Epoch 7/1000
195/195 [==============================] - 4s 21ms/step - loss: 0.4217 - val_loss: 0.3435 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.4317 - val_loss: 0.3308 - lr: 0.0060
Epoch 9/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.3761 - val_loss: 0.2947 - lr: 0.0060
Epoch 10/1000
195/195 [==============================] - 3s 18ms/step - loss: 0.4004 - val_loss: 0.2591 - lr: 0.0060
Epoch 11/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.3959 - val_loss: 0.2927 - lr: 0.0060
Epoch 12/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.3704 - val_loss: 0.2847 - lr: 0.0060
Epoch 13/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.3890 - val_loss: 0.3858 - lr: 0.0060
Epoch 14/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.3651 - val_loss: 0.3414 - lr: 0.0060
Epoch 15/1000
195/195 [==============================] - ETA: 0s - loss: 0.3357
Epoch 15: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 3s 17ms/step - loss: 0.3357 - val_loss: 0.5489 - lr: 0.0060
Epoch 16/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.3180 - val_loss: 0.2400 - lr: 0.0030
Epoch 17/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.3010 - val_loss: 0.2486 - lr: 0.0030
Epoch 18/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.3057 - val_loss: 0.2694 - lr: 0.0030
Epoch 19/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.3153 - val_loss: 0.2470 - lr: 0.0030
Epoch 20/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.3102 - val_loss: 0.2613 - lr: 0.0030
Epoch 21/1000
195/195 [==============================] - ETA: 0s - loss: 0.3110
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 3s 16ms/step - loss: 0.3110 - val_loss: 0.3269 - lr: 0.0030
Epoch 22/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2881 - val_loss: 0.2424 - lr: 0.0015
Epoch 23/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2889 - val_loss: 0.2525 - lr: 0.0015
Epoch 24/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2849 - val_loss: 0.2546 - lr: 0.0015
Epoch 25/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.3025 - val_loss: 0.2625 - lr: 0.0015
Epoch 26/1000
```

```
194/195 [============================>.] - ETA: 0s - loss: 0.2789
Epoch 26: ReduceLROnPlateau reducing learning rate to 0.000750000006519258.
195/195 [==============================] - 3s 16ms/step - loss: 0.2788 - val_loss: 0.2423 - lr: 0.0015
Epoch 27/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2780 - val_loss: 0.2614 - lr: 7.5000e-04
Epoch 28/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2743 - val_loss: 0.2457 - lr: 7.5000e-04
Epoch 29/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2776 - val_loss: 0.2407 - lr: 7.5000e-04
Epoch 30/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2711 - val_loss: 0.2347 - lr: 7.5000e-04
Epoch 31/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2741 - val_loss: 0.2334 - lr: 7.5000e-04
Epoch 32/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2713 - val_loss: 0.2329 - lr: 7.5000e-04
Epoch 33/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2781 - val_loss: 0.2487 - lr: 7.5000e-04
Epoch 34/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2699 - val_loss: 0.2426 - lr: 7.5000e-04
Epoch 35/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2726 - val_loss: 0.2399 - lr: 7.5000e-04
Epoch 36/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2756 - val_loss: 0.2363 - lr: 7.5000e-04
Epoch 37/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2679
Epoch 37: ReduceLROnPlateau reducing learning rate to 0.000375000003259629.
195/195 [==============================] - 4s 19ms/step - loss: 0.2680 - val_loss: 0.2429 - lr: 7.5000e-04
Epoch 38/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2630 - val_loss: 0.2324 - lr: 3.7500e-04
Epoch 39/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2647 - val_loss: 0.2513 - lr: 3.7500e-04
Epoch 40/1000
195/195 [==============================] - 4s 22ms/step - loss: 0.2616 - val_loss: 0.2310 - lr: 3.7500e-04
Epoch 41/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2616 - val_loss: 0.2290 - lr: 3.7500e-04
Epoch 42/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2637 - val_loss: 0.2369 - lr: 3.7500e-04
Epoch 43/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2629 - val_loss: 0.2430 - lr: 3.7500e-04
Epoch 44/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2602 - val_loss: 0.2350 - lr: 3.7500e-04
Epoch 45/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2622 - val_loss: 0.2341 - lr: 3.7500e-04
Epoch 46/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2583
Epoch 46: ReduceLROnPlateau reducing learning rate to 0.000187500001629814 5.
195/195 [==============================] - 3s 17ms/step - loss: 0.2583 - val_loss: 0.2365 - lr: 3.7500e-04
Epoch 47/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2566 - val_loss: 0.2283 - lr: 1.8750e-04
Epoch 48/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2550 - val_loss: 0.2387 - lr: 1.8750e-04
Epoch 49/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2587 - val_loss: 0.2336 - lr: 1.8750e-04
Epoch 50/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2559 - val_loss: 0.2266 - lr: 1.8750e-04
```

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Epoch 51/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2557 - val_loss: 0.2259 - lr: 1.8750e-04
Epoch 52/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2554 - val_loss: 0.2480 - lr: 1.8750e-04
Epoch 53/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2548 - val_loss: 0.2423 - lr: 1.8750e-04
Epoch 54/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2548 - val_loss: 0.2473 - lr: 1.8750e-04
Epoch 55/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2554 - val_loss: 0.2341 - lr: 1.8750e-04
Epoch 56/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2545
Epoch 56: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
195/195 [==============================] - 3s 16ms/step - loss: 0.2544 - val_loss: 0.2367 - lr: 1.8750e-04
Epoch 57/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2511 - val_loss: 0.2286 - lr: 9.3750e-05
Epoch 58/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2503 - val_loss: 0.2258 - lr: 9.3750e-05
Epoch 59/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2524 - val_loss: 0.2328 - lr: 9.3750e-05
Epoch 60/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2513 - val_loss: 0.2285 - lr: 9.3750e-05
Epoch 61/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2487 - val_loss: 0.2303 - lr: 9.3750e-05
Epoch 62/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2495 - val_loss: 0.2349 - lr: 9.3750e-05
Epoch 63/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2507
Epoch 63: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
195/195 [==============================] - 3s 16ms/step - loss: 0.2507 - val_loss: 0.2386 - lr: 9.3750e-05
Epoch 64/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2488 - val_loss: 0.2255 - lr: 4.6875e-05
Epoch 65/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2488 - val_loss: 0.2269 - lr: 4.6875e-05
Epoch 66/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2482 - val_loss: 0.2284 - lr: 4.6875e-05
Epoch 67/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2482 - val_loss: 0.2254 - lr: 4.6875e-05
Epoch 68/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2489 - val_loss: 0.2243 - lr: 4.6875e-05
Epoch 69/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2482 - val_loss: 0.2250 - lr: 4.6875e-05
Epoch 70/1000
195/195 [==============================] - 3s 18ms/step - loss: 0.2493 - val_loss: 0.2253 - lr: 4.6875e-05
Epoch 71/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2481 - val_loss: 0.2287 - lr: 4.6875e-05
Epoch 72/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2488 - val_loss: 0.2283 - lr: 4.6875e-05
Epoch 73/1000
195/195 [==============================] - ETA: 0s - loss: 0.2461
Epoch 73: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 3s 16ms/step - loss: 0.2461 - val_loss: 0.2299 - lr: 4.6875e-05
Epoch 74/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2471 - val_loss: 0.2284 - lr: 2.3438e-05
Epoch 75/1000
```

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195/195 [==============================] - 3s 16ms/step - loss: 0.2469 - val_loss: 0.2239 - lr: 2.3438e-05
Epoch 76/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2480 - val_loss: 0.2240 - lr: 2.3438e-05
Epoch 77/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2477 - val_loss: 0.2275 - lr: 2.3438e-05
Epoch 78/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2470 - val_loss: 0.2254 - lr: 2.3438e-05
Epoch 79/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2463 - val_loss: 0.2274 - lr: 2.3438e-05
Epoch 80/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2464
Epoch 80: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
195/195 [==============================] - 3s 15ms/step - loss: 0.2464 - val_loss: 0.2243 - lr: 2.3438e-05
Epoch 81/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2467 - val_loss: 0.2258 - lr: 1.1719e-05
Epoch 82/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2459 - val_loss: 0.2249 - lr: 1.1719e-05
Epoch 83/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2470 - val_loss: 0.2261 - lr: 1.1719e-05
Epoch 84/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2456 - val_loss: 0.2259 - lr: 1.1719e-05
Epoch 85/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2461
Epoch 85: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 3s 15ms/step - loss: 0.2461 - val_loss: 0.2255 - lr: 1.1719e-05
Epoch 86/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2453 - val_loss: 0.2245 - lr: 5.8594e-06
Epoch 87/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2451 - val_loss: 0.2245 - lr: 5.8594e-06
Epoch 88/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2457 - val_loss: 0.2245 - lr: 5.8594e-06
Epoch 89/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2460 - val_loss: 0.2241 - lr: 5.8594e-06
Epoch 90/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2457
Epoch 90: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 3s 16ms/step - loss: 0.2457 - val_loss: 0.2253 - lr: 5.8594e-06
Epoch 91/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2459 - val_loss: 0.2244 - lr: 2.9297e-06
Epoch 92/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2450 - val_loss: 0.2255 - lr: 2.9297e-06
Epoch 93/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2456 - val_loss: 0.2243 - lr: 2.9297e-06
Epoch 94/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2459 - val_loss: 0.2237 - lr: 2.9297e-06
Epoch 95/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2455 - val_loss: 0.2247 - lr: 2.9297e-06
Epoch 96/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2453 - val_loss: 0.2247 - lr: 2.9297e-06
Epoch 97/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.2446 - val_loss: 0.2250 - lr: 2.9297e-06
Epoch 98/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2450 - val_loss: 0.2248 - lr: 2.9297e-06
Epoch 99/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2455
```

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Epoch 99: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 3s 18ms/step - loss: 0.2455 - val_loss: 0.2261 - lr: 2.9297e-06
Epoch 100/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2452 - val_loss: 0.2249 - lr: 1.4648e-06
Epoch 101/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2459 - val_loss: 0.2249 - lr: 1.4648e-06
Epoch 102/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2455 - val_loss: 0.2247 - lr: 1.4648e-06
Epoch 103/1000
195/195 [==============================] - 3s 18ms/step - loss: 0.2457 - val_loss: 0.2248 - lr: 1.4648e-06
Epoch 104/1000
195/195 [==============================] - ETA: 0s - loss: 0.2453
Epoch 104: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
195/195 [==============================] - 3s 16ms/step - loss: 0.2453 - val_loss: 0.2250 - lr: 1.4648e-06
Epoch 105/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2454 - val_loss: 0.2246 - lr: 7.3242e-07
Epoch 106/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2449 - val_loss: 0.2250 - lr: 7.3242e-07
Epoch 107/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2452 - val_loss: 0.2250 - lr: 7.3242e-07
Epoch 108/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2451 - val_loss: 0.2251 - lr: 7.3242e-07
Epoch 109/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2453
Epoch 109: ReduceLROnPlateau reducing learning rate to 3.6621094068323146e-07.
195/195 [==============================] - 3s 16ms/step - loss: 0.2453 - val_loss: 0.2250 - lr: 7.3242e-07
Epoch 110/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2454 - val_loss: 0.2250 - lr: 3.6621e-07
Epoch 111/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2448 - val_loss: 0.2251 - lr: 3.6621e-07
Epoch 112/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2459 - val_loss: 0.2249 - lr: 3.6621e-07
Epoch 113/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2456 - val_loss: 0.2246 - lr: 3.6621e-07
Epoch 114/1000
195/195 [==============================] - ETA: 0s - loss: 0.2454
Epoch 114: ReduceLROnPlateau reducing learning rate to 1.8310547034161573e-07.
195/195 [==============================] - 3s 17ms/step - loss: 0.2454 - val_loss: 0.2248 - lr: 3.6621e-07
Epoch 115/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2451 - val_loss: 0.2247 - lr: 1.8311e-07
Epoch 116/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2456 - val_loss: 0.2250 - lr: 1.8311e-07
Epoch 117/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2450 - val_loss: 0.2253 - lr: 1.8311e-07
Epoch 118/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2454 - val_loss: 0.2250 - lr: 1.8311e-07
Epoch 119/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2453
Epoch 119: ReduceLROnPlateau reducing learning rate to 9.155273517080786e-08.
195/195 [==============================] - 3s 16ms/step - loss: 0.2452 - val_loss: 0.2249 - lr: 1.8311e-07
Epoch 120/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2457 - val_loss: 0.2249 - lr: 9.1553e-08
Epoch 121/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.2450 - val_loss: 0.2247 - lr: 9.1553e-08
Epoch 122/1000
```

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195/195 [==============================] - 3s 18ms/step - loss: 0.2454 - val_loss: 0.2250 - lr: 9.1553e-08
Epoch 123/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2448 - val_loss: 0.2249 - lr: 9.1553e-08
Epoch 124/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2451
Epoch 124: ReduceLROnPlateau reducing learning rate to 4.577636758540393e-08.
195/195 [==============================] - 4s 20ms/step - loss: 0.2451 - val_loss: 0.2249 - lr: 9.1553e-08
Epoch 125/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2457Restoring model weights from the end of the best epoch: 94.
195/195 [==============================] - 4s 18ms/step - loss: 0.2456 - val_loss: 0.2249 - lr: 4.5776e-08
Epoch 125: early stopping
3116/3116 [==============================] - 4s 1ms/step
2671/2671 [==============================] - 4s 1ms/step
1it [06:59, 419.46s/it]
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Epoch 1/1000
195/195 [==============================] - 4s 17ms/step - loss: 47.6198 - val_loss: 0.6938 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.8605 - val_loss: 0.5139 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.6000 - val_loss: 0.4103 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.5541 - val_loss: 0.3951 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.5486 - val_loss: 0.4332 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.5296 - val_loss: 0.4099 - lr: 0.0060
Epoch 7/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.5116 - val_loss: 0.7641 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4652 - val_loss: 0.3078 - lr: 0.0060
Epoch 9/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.4534 - val_loss: 0.4720 - lr: 0.0060
Epoch 10/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.4765 - val_loss: 0.3329 - lr: 0.0060
Epoch 11/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4725 - val_loss: 0.4564 - lr: 0.0060
Epoch 12/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.4170 - val_loss: 0.3815 - lr: 0.0060
Epoch 13/1000
193/195 [============================>.] - ETA: 0s - loss: 0.4247
Epoch 13: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 5s 28ms/step - loss: 0.4238 - val_loss: 0.3117 - lr: 0.0060
Epoch 14/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3358 - val_loss: 0.2624 - lr: 0.0030
Epoch 15/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3424 - val_loss: 0.3020 - lr: 0.0030
Epoch 16/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.3256 - val_loss: 0.2645 - lr: 0.0030
Epoch 17/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3302 - val_loss: 0.2794 - lr: 0.0030
Epoch 18/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.3237 - val_loss: 0.2661 - lr: 0.0030
Epoch 19/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.3429 - val_loss: 0.2489 - lr: 0.0030
Epoch 20/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.3171 - val_loss: 0.2548 - lr: 0.0030
Epoch 21/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.3248 - val_loss: 0.2924 - lr: 0.0030
Epoch 22/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.3221 - val_loss: 0.2474 - lr: 0.0030
Epoch 23/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3436 - val_loss: 0.3259 - lr: 0.0030
Epoch 24/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3281 - val_loss: 0.2915 - lr: 0.0030
Epoch 25/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3226 - val_loss: 0.2472 - lr: 0.0030
Epoch 26/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3111 - val_loss: 0.2711 - lr: 0.0030
Epoch 27/1000
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195/195 [==============================] - 6s 29ms/step - loss: 0.3066 - val_loss: 0.2616 - lr: 0.0030
Epoch 28/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.3226 - val_loss: 0.2349 - lr: 0.0030
Epoch 29/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3161 - val_loss: 0.2932 - lr: 0.0030
Epoch 30/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3211 - val_loss: 0.4347 - lr: 0.0030
Epoch 31/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3120 - val_loss: 0.2657 - lr: 0.0030
Epoch 32/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2962 - val_loss: 0.3255 - lr: 0.0030
Epoch 33/1000
194/195 [============================>.] - ETA: 0s - loss: 0.3004
Epoch 33: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 5s 25ms/step - loss: 0.3004 - val_loss: 0.2614 - lr: 0.0030
Epoch 34/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2793 - val_loss: 0.2615 - lr: 0.0015
Epoch 35/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2792 - val_loss: 0.2356 - lr: 0.0015
Epoch 36/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2783 - val_loss: 0.2618 - lr: 0.0015
Epoch 37/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2803 - val_loss: 0.2413 - lr: 0.0015
Epoch 38/1000
195/195 [==============================] - ETA: 0s - loss: 0.2746
Epoch 38: ReduceLROnPlateau reducing learning rate to 0.000750000006519258.
195/195 [==============================] - 6s 30ms/step - loss: 0.2746 - val_loss: 0.2608 - lr: 0.0015
Epoch 39/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2674 - val_loss: 0.2435 - lr: 7.5000e-04
Epoch 40/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2663 - val_loss: 0.2320 - lr: 7.5000e-04
Epoch 41/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2679 - val_loss: 0.2420 - lr: 7.5000e-04
Epoch 42/1000
195/195 [==============================] - 7s 33ms/step - loss: 0.2682 - val_loss: 0.2279 - lr: 7.5000e-04
Epoch 43/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2638 - val_loss: 0.2669 - lr: 7.5000e-04
Epoch 44/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2653 - val_loss: 0.2340 - lr: 7.5000e-04
Epoch 45/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2664 - val_loss: 0.2477 - lr: 7.5000e-04
Epoch 46/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2642 - val_loss: 0.2453 - lr: 7.5000e-04
Epoch 47/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2657
Epoch 47: ReduceLROnPlateau reducing learning rate to 0.000375000003259629.
195/195 [==============================] - 6s 30ms/step - loss: 0.2657 - val_loss: 0.2342 - lr: 7.5000e-04
Epoch 48/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2579 - val_loss: 0.2359 - lr: 3.7500e-04
Epoch 49/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2614 - val_loss: 0.2349 - lr: 3.7500e-04
Epoch 50/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2584 - val_loss: 0.2536 - lr: 3.7500e-04
Epoch 51/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2589 - val_loss: 0.2357 - lr: 3.7500e-04
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Epoch 52/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2578 - val_loss: 0.2267 - lr: 3.7500e-04
Epoch 53/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2544 - val_loss: 0.2279 - lr: 3.7500e-04
Epoch 54/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2581 - val_loss: 0.2423 - lr: 3.7500e-04
Epoch 55/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2559 - val_loss: 0.2317 - lr: 3.7500e-04
Epoch 56/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2580 - val_loss: 0.2264 - lr: 3.7500e-04
Epoch 57/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2533 - val_loss: 0.2263 - lr: 3.7500e-04
Epoch 58/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2541 - val_loss: 0.2377 - lr: 3.7500e-04
Epoch 59/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2527 - val_loss: 0.2342 - lr: 3.7500e-04
Epoch 60/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2524 - val_loss: 0.2301 - lr: 3.7500e-04
Epoch 61/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2544 - val_loss: 0.2276 - lr: 3.7500e-04
Epoch 62/1000
195/195 [==============================] - ETA: 0s - loss: 0.2531
Epoch 62: ReduceLROnPlateau reducing learning rate to 0.0001875000016298145.
195/195 [==============================] - 5s 27ms/step - loss: 0.2531 - val_loss: 0.2555 - lr: 3.7500e-04
Epoch 63/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2511 - val_loss: 0.2272 - lr: 1.8750e-04
Epoch 64/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2480 - val_loss: 0.2289 - lr: 1.8750e-04
Epoch 65/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2490 - val_loss: 0.2315 - lr: 1.8750e-04
Epoch 66/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2487 - val_loss: 0.2310 - lr: 1.8750e-04
Epoch 67/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2486 - val_loss: 0.2258 - lr: 1.8750e-04
Epoch 68/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2480 - val_loss: 0.2317 - lr: 1.8750e-04
Epoch 69/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2484 - val_loss: 0.2280 - lr: 1.8750e-04
Epoch 70/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2464 - val_loss: 0.2306 - lr: 1.8750e-04
Epoch 71/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2477 - val_loss: 0.2243 - lr: 1.8750e-04
Epoch 72/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2471 - val_loss: 0.2243 - lr: 1.8750e-04
Epoch 73/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2470 - val_loss: 0.2288 - lr: 1.8750e-04
Epoch 74/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2455 - val_loss: 0.2307 - lr: 1.8750e-04
Epoch 75/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2461 - val_loss: 0.2263 - lr: 1.8750e-04
Epoch 76/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2449 - val_loss: 0.2259 - lr: 1.8750e-04
Epoch 77/1000
195/195 [==============================] - ETA: 0s - loss: 0.2438
Epoch 77: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
```

```
195/195 [==============================] - 6s 29ms/step - loss: 0.2438 - val_loss: 0.2356 - lr: 1.8750e-04
Epoch 78/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2428 - val_loss: 0.2233 - lr: 9.3750e-05
Epoch 79/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2426 - val_loss: 0.2275 - lr: 9.3750e-05
Epoch 80/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2429 - val_loss: 0.2477 - lr: 9.3750e-05
Epoch 81/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.2415 - val_loss: 0.2322 - lr: 9.3750e-05
Epoch 82/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2423 - val_loss: 0.2276 - lr: 9.3750e-05
Epoch 83/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2419 - val_loss: 0.2226 - lr: 9.3750e-05
Epoch 84/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2415 - val_loss: 0.2290 - lr: 9.3750e-05
Epoch 85/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2408 - val_loss: 0.2226 - lr: 9.3750e-05
Epoch 86/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2417 - val_loss: 0.2298 - lr: 9.3750e-05
Epoch 87/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2406 - val_loss: 0.2216 - lr: 9.3750e-05
Epoch 88/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2406 - val_loss: 0.2259 - lr: 9.3750e-05
Epoch 89/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2402 - val_loss: 0.2300 - lr: 9.3750e-05
Epoch 90/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2413 - val_loss: 0.2339 - lr: 9.3750e-05
Epoch 91/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2398 - val_loss: 0.2257 - lr: 9.3750e-05
Epoch 92/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2402
Epoch 92: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
195/195 [==============================] - 6s 32ms/step - loss: 0.2402 - val_loss: 0.2234 - lr: 9.3750e-05
Epoch 93/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2388 - val_loss: 0.2263 - lr: 4.6875e-05
Epoch 94/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2390 - val_loss: 0.2272 - lr: 4.6875e-05
Epoch 95/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2381 - val_loss: 0.2300 - lr: 4.6875e-05
Epoch 96/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2391 - val_loss: 0.2272 - lr: 4.6875e-05
Epoch 97/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2386
Epoch 97: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 5s 25ms/step - loss: 0.2386 - val_loss: 0.2217 - lr: 4.6875e-05
Epoch 98/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2384 - val_loss: 0.2218 - lr: 2.3438e-05
Epoch 99/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2386 - val_loss: 0.2232 - lr: 2.3438e-05
Epoch 100/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2381 - val_loss: 0.2226 - lr: 2.3438e-05
Epoch 101/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2377 - val_loss: 0.2220 - lr: 2.3438e-05
Epoch 102/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2377
```

```
Epoch 102: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
195/195 [==============================] - 6s 29ms/step - loss: 0.2376 - val_loss: 0.2254 - lr: 2.3438e-05
Epoch 103/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2370 - val_loss: 0.2243 - lr: 1.1719e-05
Epoch 104/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2370 - val_loss: 0.2222 - lr: 1.1719e-05
Epoch 105/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2376 - val_loss: 0.2232 - lr: 1.1719e-05
Epoch 106/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2370 - val_loss: 0.2231 - lr: 1.1719e-05
Epoch 107/1000
195/195 [==============================] - ETA: 0s - loss: 0.2374
Epoch 107: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 6s 33ms/step - loss: 0.2374 - val_loss: 0.2217 - lr: 1.1719e-05
Epoch 108/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2374 - val_loss: 0.2229 - lr: 5.8594e-06
Epoch 109/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2367 - val_loss: 0.2227 - lr: 5.8594e-06
Epoch 110/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2370 - val_loss: 0.2227 - lr: 5.8594e-06
Epoch 111/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2375 - val_loss: 0.2245 - lr: 5.8594e-06
Epoch 112/1000
195/195 [==============================] - ETA: 0s - loss: 0.2366
Epoch 112: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 6s 30ms/step - loss: 0.2366 - val_loss: 0.2228 - lr: 5.8594e-06
Epoch 113/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2368 - val_loss: 0.2237 - lr: 2.9297e-06
Epoch 114/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2368 - val_loss: 0.2233 - lr: 2.9297e-06
Epoch 115/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2367 - val_loss: 0.2235 - lr: 2.9297e-06
Epoch 116/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2367 - val_loss: 0.2238 - lr: 2.9297e-06
Epoch 117/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2369
Epoch 117: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 5s 27ms/step - loss: 0.2369 - val_loss: 0.2220 - lr: 2.9297e-06
Epoch 118/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2366Restoring model weights from the end of the best epoch: 87.
195/195 [==============================] - 6s 29ms/step - loss: 0.2366 - val_loss: 0.2233 - lr: 1.4648e-06
Epoch 118: early stopping
3116/3116 [==============================] - 10s 3ms/step
2671/2671 [==============================] - 8s 3ms/step
2it [18:24, 575.67s/it]
```

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Epoch 1/1000
195/195 [==============================] - 11s 34ms/step - loss: 62.9662 - val_loss: 1.2761 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 6s 31ms/step - loss: 1.2337 - val_loss: 0.6230 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.6020 - val_loss: 0.5027 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.5607 - val_loss: 0.4451 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.5478 - val_loss: 0.4459 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4846 - val_loss: 0.3799 - lr: 0.0060
Epoch 7/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4828 - val_loss: 0.4645 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.4835 - val_loss: 0.3622 - lr: 0.0060
Epoch 9/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.4407 - val_loss: 0.4792 - lr: 0.0060
Epoch 10/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.4543 - val_loss: 0.3447 - lr: 0.0060
Epoch 11/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.4119 - val_loss: 0.4127 - lr: 0.0060
Epoch 12/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.4205 - val_loss: 0.2868 - lr: 0.0060
Epoch 13/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.4113 - val_loss: 0.2799 - lr: 0.0060
Epoch 14/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.4285 - val_loss: 0.3093 - lr: 0.0060
Epoch 15/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.4069 - val_loss: 0.3680 - lr: 0.0060
Epoch 16/1000
195/195 [==============================] - 8s 40ms/step - loss: 0.3822 - val_loss: 0.2681 - lr: 0.0060
Epoch 17/1000
195/195 [==============================] - 8s 41ms/step - loss: 0.3779 - val_loss: 0.3696 - lr: 0.0060
Epoch 18/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.3857 - val_loss: 0.2777 - lr: 0.0060
Epoch 19/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3555 - val_loss: 0.2832 - lr: 0.0060
Epoch 20/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.3524 - val_loss: 0.4713 - lr: 0.0060
Epoch 21/1000
195/195 [==============================] - ETA: 0s - loss: 0.3697
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 6s 31ms/step - loss: 0.3697 - val_loss: 0.3813 - lr: 0.0060
Epoch 22/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3130 - val_loss: 0.2375 - lr: 0.0030
Epoch 23/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.3027 - val_loss: 0.2531 - lr: 0.0030
Epoch 24/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3073 - val_loss: 0.2908 - lr: 0.0030
Epoch 25/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3040 - val_loss: 0.2535 - lr: 0.0030
Epoch 26/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2947 - val_loss: 0.2389 - lr: 0.0030
Epoch 27/1000
```

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193/195 [============================>.] - ETA: 0s - loss: 0.3027
Epoch 27: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 6s 30ms/step - loss: 0.3040 - val_loss: 0.3162 - lr: 0.0030
Epoch 28/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2856 - val_loss: 0.2457 - lr: 0.0015
Epoch 29/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2842 - val_loss: 0.2679 - lr: 0.0015
Epoch 30/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2865 - val_loss: 0.2509 - lr: 0.0015
Epoch 31/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2825 - val_loss: 0.2729 - lr: 0.0015
Epoch 32/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2863
Epoch 32: ReduceLROnPlateau reducing learning rate to 0.0007500000006519258.
195/195 [==============================] - 7s 34ms/step - loss: 0.2864 - val_loss: 0.2444 - lr: 0.0015
Epoch 33/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2733 - val_loss: 0.2462 - lr: 7.5000e-04
Epoch 34/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2754 - val_loss: 0.2421 - lr: 7.5000e-04
Epoch 35/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2724 - val_loss: 0.2539 - lr: 7.5000e-04
Epoch 36/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.2712 - val_loss: 0.2322 - lr: 7.5000e-04
Epoch 37/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2698 - val_loss: 0.2427 - lr: 7.5000e-04
Epoch 38/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2718 - val_loss: 0.2293 - lr: 7.5000e-04
Epoch 39/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2753 - val_loss: 0.2587 - lr: 7.5000e-04
Epoch 40/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2714 - val_loss: 0.2422 - lr: 7.5000e-04
Epoch 41/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.2693 - val_loss: 0.2329 - lr: 7.5000e-04
Epoch 42/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2737 - val_loss: 0.2387 - lr: 7.5000e-04
Epoch 43/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2673
Epoch 43: ReduceLROnPlateau reducing learning rate to 0.0003750000003259629.
195/195 [==============================] - 3s 18ms/step - loss: 0.2674 - val_loss: 0.2564 - lr: 7.5000e-04
Epoch 44/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2648 - val_loss: 0.2452 - lr: 3.7500e-04
Epoch 45/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.2656 - val_loss: 0.2443 - lr: 3.7500e-04
Epoch 46/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2638 - val_loss: 0.2467 - lr: 3.7500e-04
Epoch 47/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.2647 - val_loss: 0.2380 - lr: 3.7500e-04
Epoch 48/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2620
Epoch 48: ReduceLROnPlateau reducing learning rate to 0.0001875000016298145.
195/195 [==============================] - 4s 18ms/step - loss: 0.2620 - val_loss: 0.2437 - lr: 3.7500e-04
Epoch 49/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2583 - val_loss: 0.2306 - lr: 1.8750e-04
Epoch 50/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2587 - val_loss: 0.2364 - lr: 1.8750e-04
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Epoch 51/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2590 - val_loss: 0.2338 - lr: 1.8750e-04
Epoch 52/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2589 - val_loss: 0.2363 - lr: 1.8750e-04
Epoch 53/1000
195/195 [==============================] - ETA: 0s - loss: 0.2583
Epoch 53: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
195/195 [==============================] - 4s 20ms/step - loss: 0.2583 - val_loss: 0.2296 - lr: 1.8750e-04
Epoch 54/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2563 - val_loss: 0.2298 - lr: 9.3750e-05
Epoch 55/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2572 - val_loss: 0.2364 - lr: 9.3750e-05
Epoch 56/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2564 - val_loss: 0.2327 - lr: 9.3750e-05
Epoch 57/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.2564 - val_loss: 0.2408 - lr: 9.3750e-05
Epoch 58/1000
195/195 [==============================] - ETA: 0s - loss: 0.2584
Epoch 58: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
195/195 [==============================] - 4s 19ms/step - loss: 0.2584 - val_loss: 0.2331 - lr: 9.3750e-05
Epoch 59/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2558 - val_loss: 0.2304 - lr: 4.6875e-05
Epoch 60/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2552 - val_loss: 0.2315 - lr: 4.6875e-05
Epoch 61/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2543 - val_loss: 0.2448 - lr: 4.6875e-05
Epoch 62/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2547 - val_loss: 0.2321 - lr: 4.6875e-05
Epoch 63/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2533 - val_loss: 0.2286 - lr: 4.6875e-05
Epoch 64/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2544 - val_loss: 0.2271 - lr: 4.6875e-05
Epoch 65/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2532 - val_loss: 0.2326 - lr: 4.6875e-05
Epoch 66/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2535 - val_loss: 0.2332 - lr: 4.6875e-05
Epoch 67/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2534 - val_loss: 0.2274 - lr: 4.6875e-05
Epoch 68/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2530 - val_loss: 0.2279 - lr: 4.6875e-05
Epoch 69/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2526
Epoch 69: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 3s 15ms/step - loss: 0.2526 - val_loss: 0.2286 - lr: 4.6875e-05
Epoch 70/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2519 - val_loss: 0.2359 - lr: 2.3438e-05
Epoch 71/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2518 - val_loss: 0.2281 - lr: 2.3438e-05
Epoch 72/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2519 - val_loss: 0.2300 - lr: 2.3438e-05
Epoch 73/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2528 - val_loss: 0.2274 - lr: 2.3438e-05
Epoch 74/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2530
Epoch 74: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
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195/195 [==============================] - 3s 16ms/step - loss: 0.2529 - val_loss: 0.2328 - lr: 2.3438e-05
Epoch 75/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2519 - val_loss: 0.2290 - lr: 1.1719e-05
Epoch 76/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2510 - val_loss: 0.2280 - lr: 1.1719e-05
Epoch 77/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2514 - val_loss: 0.2268 - lr: 1.1719e-05
Epoch 78/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2517 - val_loss: 0.2281 - lr: 1.1719e-05
Epoch 79/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2519 - val_loss: 0.2294 - lr: 1.1719e-05
Epoch 80/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2519 - val_loss: 0.2272 - lr: 1.1719e-05
Epoch 81/1000
195/195 [==============================] - 3s 18ms/step - loss: 0.2503 - val_loss: 0.2270 - lr: 1.1719e-05
Epoch 82/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2522
Epoch 82: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 4s 18ms/step - loss: 0.2522 - val_loss: 0.2293 - lr: 1.1719e-05
Epoch 83/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.2509 - val_loss: 0.2274 - lr: 5.8594e-06
Epoch 84/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2511 - val_loss: 0.2286 - lr: 5.8594e-06
Epoch 85/1000
195/195 [==============================] - 4s 19ms/step - loss: 0.2510 - val_loss: 0.2290 - lr: 5.8594e-06
Epoch 86/1000
195/195 [==============================] - 4s 18ms/step - loss: 0.2513 - val_loss: 0.2279 - lr: 5.8594e-06
Epoch 87/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2502
Epoch 87: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 4s 18ms/step - loss: 0.2503 - val_loss: 0.2279 - lr: 5.8594e-06
Epoch 88/1000
195/195 [==============================] - 3s 18ms/step - loss: 0.2509 - val_loss: 0.2277 - lr: 2.9297e-06
Epoch 89/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2501 - val_loss: 0.2275 - lr: 2.9297e-06
Epoch 90/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2500 - val_loss: 0.2283 - lr: 2.9297e-06
Epoch 91/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2502 - val_loss: 0.2284 - lr: 2.9297e-06
Epoch 92/1000
192/195 [============================>.] - ETA: 0s - loss: 0.2501
Epoch 92: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 3s 17ms/step - loss: 0.2500 - val_loss: 0.2283 - lr: 2.9297e-06
Epoch 93/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2502 - val_loss: 0.2280 - lr: 1.4648e-06
Epoch 94/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2507 - val_loss: 0.2282 - lr: 1.4648e-06
Epoch 95/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2505 - val_loss: 0.2284 - lr: 1.4648e-06
Epoch 96/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2504 - val_loss: 0.2279 - lr: 1.4648e-06
Epoch 97/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2508
Epoch 97: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
195/195 [==============================] - 3s 16ms/step - loss: 0.2509 - val_loss: 0.2278 - lr: 1.4648e-06
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Epoch 98/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2509 - val_loss: 0.2281 - lr: 7.3242e-07
Epoch 99/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2501 - val_loss: 0.2278 - lr: 7.3242e-07
Epoch 100/1000
195/195 [==============================] - 3s 15ms/step - loss: 0.2503 - val_loss: 0.2281 - lr: 7.3242e-07
Epoch 101/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2511 - val_loss: 0.2281 - lr: 7.3242e-07
Epoch 102/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2500
Epoch 102: ReduceLROnPlateau reducing learning rate to 3.6621094068323146e-07.
195/195 [==============================] - 3s 15ms/step - loss: 0.2500 - val_loss: 0.2280 - lr: 7.3242e-07
Epoch 103/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2507 - val_loss: 0.2279 - lr: 3.6621e-07
Epoch 104/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2504 - val_loss: 0.2286 - lr: 3.6621e-07
Epoch 105/1000
195/195 [==============================] - 3s 16ms/step - loss: 0.2509 - val_loss: 0.2285 - lr: 3.6621e-07
Epoch 106/1000
195/195 [==============================] - 3s 17ms/step - loss: 0.2497 - val_loss: 0.2287 - lr: 3.6621e-07
Epoch 107/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2508
Epoch 107: ReduceLROnPlateau reducing learning rate to 1.8310547034161573e-07.
195/195 [==============================] - 3s 17ms/step - loss: 0.2507 - val_loss: 0.2283 - lr: 3.6621e-07
Epoch 108/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2503Restoring model weights from the end of the best epoch: 77.
195/195 [==============================] - 3s 17ms/step - loss: 0.2503 - val_loss: 0.2281 - lr: 1.8311e-07
Epoch 108: early stopping
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 4s 2ms/step
3it [26:29, 529.81s/it]
```

MLP

In [ ]:
```
def np_rmspe(y_true, y_pred):
    return np.sqrt(np.mean(np.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def MLP(X_train, y_train, X_val, y_val):

    inputs= tf.keras.Input(
            shape=(X_train.shape[1],)
        )
    hidden1=tf.keras.layers.Dense(
            units=int(np.round(X_train.shape[1]/2, 0)),
            kernel_initializer='he_uniform',
            activation='LeakyReLU'
        )(inputs)
    hidden2=tf.keras.layers.Dense(
            units=int(np.round(X_train.shape[1]/4, 0)),
            kernel_initializer='he_uniform',
```

```
            activation='LeakyReLU'
        )(hidden1)
    outputs=tf.keras.layers.Dense(
            units=1,
    )(hidden2)

    model = Model(inputs, outputs)
    model.summary()

    model.compile(optimizer=tf.keras.optimizers.Adam(0.001),
                loss=rmspe)

    rlr = tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=3, min_delta=1e-5, min_lr=1e-5, verbose=1)
    es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=11, restore_best_weights=True, verbose=1)
    callback_list = [rlr, es]
    history = model.fit(X_train, y_train,
                        batch_size=500, epochs=1000, verbose=1,
                        validation_data=(X_val, y_val), callbacks=callback_list
    )

    return model
```

In [ ]:
```
tf.random.set_seed(777)

n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
train_fold_predict = np.zeros((X_train_base_scaled.shape[0], 1))
test_predict = np.zeros((X_test_base_scaled.shape[0], n_folds))

for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train_base_scaled))):
    X_train_ = X_train_base_scaled[train_index,:]
    y_train_ = y_train_base.iloc[train_index]
    X_val_ = X_train_base_scaled[val_index,:]

    model = MLP(X_train_, y_train_, X_val_base_scaled, y_val_base)

    train_fold_predict[val_index,:] = model.predict(X_val_).reshape(-1,1)
    test_predict[:,cv_num] = model.predict(np.array(X_test_base_scaled)).reshape(-1)

mlp_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
mlp_train_predict = train_fold_predict
```

```
0it [00:00, ?it/s]
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 335)]             0

 dense_3 (Dense)             (None, 168)               56448

 dense_4 (Dense)             (None, 84)                14196

 dense_5 (Dense)             (None, 1)                 85

=================================================================
Total params: 70,729
Trainable params: 70,729
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
2022-10-25 10:10:19.474012: W tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU frequency: 0 Hz
2022-10-25 10:10:19.763163: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
399/399 [==============================] - ETA: 0s - loss: 60.0168
2022-10-25 10:10:24.232786: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
399/399 [==============================] - 5s 8ms/step - loss: 60.0168 - val_loss: 28.5333 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 24.4328 - val_loss: 24.9338 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 2s 6ms/step - loss: 17.1971 - val_loss: 8.5610 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 2s 6ms/step - loss: 9.8065 - val_loss: 9.0592 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.1794 - val_loss: 4.1182 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.9615 - val_loss: 9.0428 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.1869 - val_loss: 5.4708 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.2721 - val_loss: 1.8554 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.6384 - val_loss: 1.2705 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.7238 - val_loss: 0.9431 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.2894 - val_loss: 0.6777 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.2907 - val_loss: 1.6683 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.0300 - val_loss: 1.1683 - lr: 0.0010
Epoch 14/1000
395/399 [============================>.] - ETA: 0s - loss: 2.6143
Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 2.6017 - val_loss: 1.2311 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.6922 - val_loss: 0.4779 - lr: 5.0000e-04
Epoch 16/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.8761 - val_loss: 1.3636 - lr: 5.0000e-04
Epoch 17/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.0052 - val_loss: 1.2110 - lr: 5.0000e-04
Epoch 18/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.7865 - val_loss: 0.3424 - lr: 5.0000e-04
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.6220 - val_loss: 0.3453 - lr: 5.0000e-04
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.9317 - val_loss: 0.6634 - lr: 5.0000e-04
Epoch 21/1000
396/399 [============================>.] - ETA: 0s - loss: 0.7661
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 0.7725 - val_loss: 1.7296 - lr: 5.0000e-04
Epoch 22/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5740 - val_loss: 0.8730 - lr: 2.5000e-04
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4152 - val_loss: 0.3046 - lr: 2.5000e-04
Epoch 24/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.3686 - val_loss: 0.5396 - lr: 2.5000e-04
Epoch 25/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4055 - val_loss: 0.2888 - lr: 2.5000e-04
Epoch 26/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4491 - val_loss: 0.5363 - lr: 2.5000e-04
```

```
Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4121 - val_loss: 0.4310 - lr: 2.5000e-04
Epoch 28/1000
390/399 [============================>.] - ETA: 0s - loss: 0.3829
Epoch 28: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.3887 - val_loss: 0.6916 - lr: 2.5000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3068 - val_loss: 0.2461 - lr: 1.2500e-04
Epoch 30/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2850 - val_loss: 0.2526 - lr: 1.2500e-04
Epoch 31/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3073 - val_loss: 0.3440 - lr: 1.2500e-04
Epoch 32/1000
390/399 [============================>.] - ETA: 0s - loss: 0.2863
Epoch 32: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2859 - val_loss: 0.2562 - lr: 1.2500e-04
Epoch 33/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2629 - val_loss: 0.2466 - lr: 6.2500e-05
Epoch 34/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2550 - val_loss: 0.2592 - lr: 6.2500e-05
Epoch 35/1000
399/399 [==============================] - ETA: 0s - loss: 0.2576
Epoch 35: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2576 - val_loss: 0.2494 - lr: 6.2500e-05
Epoch 36/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2382 - val_loss: 0.2417 - lr: 3.1250e-05
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2359 - val_loss: 0.2357 - lr: 3.1250e-05
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2348 - val_loss: 0.2368 - lr: 3.1250e-05
Epoch 39/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2360 - val_loss: 0.2376 - lr: 3.1250e-05
Epoch 40/1000
391/399 [============================>.] - ETA: 0s - loss: 0.2415
Epoch 40: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2414 - val_loss: 0.2368 - lr: 3.1250e-05
Epoch 41/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2287 - val_loss: 0.2316 - lr: 1.5625e-05
Epoch 42/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2296 - val_loss: 0.2322 - lr: 1.5625e-05
Epoch 43/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2295 - val_loss: 0.2334 - lr: 1.5625e-05
Epoch 44/1000
390/399 [============================>.] - ETA: 0s - loss: 0.2309
Epoch 44: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2309 - val_loss: 0.2369 - lr: 1.5625e-05
Epoch 45/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2266 - val_loss: 0.2364 - lr: 1.0000e-05
Epoch 46/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2255 - val_loss: 0.2327 - lr: 1.0000e-05
Epoch 47/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2260 - val_loss: 0.2366 - lr: 1.0000e-05
Epoch 48/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2258 - val_loss: 0.2354 - lr: 1.0000e-05
Epoch 49/1000
```

```
399/399 [==============================] - 2s 6ms/step - loss: 0.2259 - val_loss: 0.2312 - lr: 1.0000e-05
Epoch 50/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2259 - val_loss: 0.2315 - lr: 1.0000e-05
Epoch 51/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2256 - val_loss: 0.2332 - lr: 1.0000e-05
Epoch 52/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2263 - val_loss: 0.2333 - lr: 1.0000e-05
Epoch 53/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2256 - val_loss: 0.2328 - lr: 1.0000e-05
Epoch 54/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2247 - val_loss: 0.2318 - lr: 1.0000e-05
Epoch 55/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2249 - val_loss: 0.2329 - lr: 1.0000e-05
Epoch 56/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2248 - val_loss: 0.2304 - lr: 1.0000e-05
Epoch 57/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2256 - val_loss: 0.2320 - lr: 1.0000e-05
Epoch 58/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2250 - val_loss: 0.2328 - lr: 1.0000e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2237 - val_loss: 0.2327 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2237 - val_loss: 0.2299 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2233 - val_loss: 0.2315 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2245 - val_loss: 0.2351 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2230 - val_loss: 0.2297 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2242 - val_loss: 0.2308 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2243 - val_loss: 0.2340 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2227 - val_loss: 0.2332 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2231 - val_loss: 0.2311 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2226 - val_loss: 0.2318 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2255 - val_loss: 0.2359 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2225 - val_loss: 0.2305 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2228 - val_loss: 0.2284 - lr: 1.0000e-05
Epoch 72/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2227 - val_loss: 0.2310 - lr: 1.0000e-05
Epoch 73/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2226 - val_loss: 0.2323 - lr: 1.0000e-05
Epoch 74/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2235 - val_loss: 0.2350 - lr: 1.0000e-05
Epoch 75/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2230 - val_loss: 0.2319 - lr: 1.0000e-05
Epoch 76/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2220 - val_loss: 0.2296 - lr: 1.0000e-05
```

```
Epoch 77/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2224 - val_loss: 0.2286 - lr: 1.0000e-05
Epoch 78/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2224 - val_loss: 0.2308 - lr: 1.0000e-05
Epoch 79/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2207 - val_loss: 0.2307 - lr: 1.0000e-05
Epoch 80/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2220 - val_loss: 0.2282 - lr: 1.0000e-05
Epoch 81/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2219 - val_loss: 0.2364 - lr: 1.0000e-05
Epoch 82/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2210 - val_loss: 0.2303 - lr: 1.0000e-05
Epoch 83/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2218 - val_loss: 0.2305 - lr: 1.0000e-05
Epoch 84/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2208 - val_loss: 0.2294 - lr: 1.0000e-05
Epoch 85/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2210 - val_loss: 0.2278 - lr: 1.0000e-05
Epoch 86/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2217 - val_loss: 0.2298 - lr: 1.0000e-05
Epoch 87/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2206 - val_loss: 0.2456 - lr: 1.0000e-05
Epoch 88/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2210 - val_loss: 0.2302 - lr: 1.0000e-05
Epoch 89/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2216 - val_loss: 0.2291 - lr: 1.0000e-05
Epoch 90/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2216 - val_loss: 0.2300 - lr: 1.0000e-05
Epoch 91/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2208 - val_loss: 0.2299 - lr: 1.0000e-05
Epoch 92/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2203 - val_loss: 0.2317 - lr: 1.0000e-05
Epoch 93/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2204 - val_loss: 0.2291 - lr: 1.0000e-05
Epoch 94/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2206 - val_loss: 0.2296 - lr: 1.0000e-05
Epoch 95/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2203 - val_loss: 0.2361 - lr: 1.0000e-05
Epoch 96/1000
398/399 [============================>.] - ETA: 0s - loss: 0.2202Restoring model weights from the end of the best epoch: 85.
399/399 [==============================] - 2s 6ms/step - loss: 0.2202 - val_loss: 0.2336 - lr: 1.0000e-05
Epoch 96: early stopping
  90/3116 [..............................] - ETA: 5s
2022-10-25 10:14:04.953422: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 4s 2ms/step
1it [03:57, 237.02s/it]
```

```
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_3 (InputLayer)        [(None, 335)]             0

 dense_6 (Dense)             (None, 168)               56448

 dense_7 (Dense)             (None, 84)                14196

 dense_8 (Dense)             (None, 1)                 85

=================================================================
Total params: 70,729
Trainable params: 70,729
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
 11/399 [..............................] - ETA: 2s - loss: 516.4849
2022-10-25 10:14:16.711903: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
399/399 [==============================] - ETA: 0s - loss: 62.7475
2022-10-25 10:14:19.191970: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
399/399 [==============================] - 3s 7ms/step - loss: 62.7475 - val_loss: 23.2274 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 21.0719 - val_loss: 79.5261 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 3s 6ms/step - loss: 14.4721 - val_loss: 18.0169 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.3595 - val_loss: 3.6663 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.6377 - val_loss: 3.1764 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.6904 - val_loss: 2.1571 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.5628 - val_loss: 13.9645 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.1566 - val_loss: 1.6225 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.0379 - val_loss: 1.3942 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.3205 - val_loss: 1.1709 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.7008 - val_loss: 0.9945 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.7426 - val_loss: 1.5186 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.4082 - val_loss: 1.1147 - lr: 0.0010
Epoch 14/1000
393/399 [============================>.] - ETA: 0s - loss: 1.8444
Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 1.8337 - val_loss: 1.8445 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.9011 - val_loss: 1.0988 - lr: 5.0000e-04
Epoch 16/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.8243 - val_loss: 0.5291 - lr: 5.0000e-04
Epoch 17/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.7265 - val_loss: 0.7048 - lr: 5.0000e-04
Epoch 18/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5223 - val_loss: 0.3830 - lr: 5.0000e-04
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5560 - val_loss: 1.0017 - lr: 5.0000e-04
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.2734 - val_loss: 0.7563 - lr: 5.0000e-04
Epoch 21/1000
391/399 [============================>.] - ETA: 0s - loss: 0.7653
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 0.7670 - val_loss: 0.5892 - lr: 5.0000e-04
Epoch 22/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3765 - val_loss: 0.3771 - lr: 2.5000e-04
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3807 - val_loss: 0.4184 - lr: 2.5000e-04
Epoch 24/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3660 - val_loss: 0.3465 - lr: 2.5000e-04
Epoch 25/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4057 - val_loss: 0.4211 - lr: 2.5000e-04
Epoch 26/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4538 - val_loss: 0.3266 - lr: 2.5000e-04
```

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Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5499 - val_loss: 0.4177 - lr: 2.5000e-04
Epoch 28/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4055 - val_loss: 0.2840 - lr: 2.5000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3934 - val_loss: 0.2984 - lr: 2.5000e-04
Epoch 30/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4976 - val_loss: 0.5486 - lr: 2.5000e-04
Epoch 31/1000
399/399 [==============================] - ETA: 0s - loss: 0.4425
Epoch 31: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.4425 - val_loss: 0.2876 - lr: 2.5000e-04
Epoch 32/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2765 - val_loss: 0.2602 - lr: 1.2500e-04
Epoch 33/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2827 - val_loss: 0.2583 - lr: 1.2500e-04
Epoch 34/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2957 - val_loss: 0.3358 - lr: 1.2500e-04
Epoch 35/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3104 - val_loss: 0.2579 - lr: 1.2500e-04
Epoch 36/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3227 - val_loss: 0.2691 - lr: 1.2500e-04
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2927 - val_loss: 0.2464 - lr: 1.2500e-04
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3288 - val_loss: 0.2956 - lr: 1.2500e-04
Epoch 39/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3046 - val_loss: 0.2598 - lr: 1.2500e-04
Epoch 40/1000
391/399 [============================>.] - ETA: 0s - loss: 0.2987
Epoch 40: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2989 - val_loss: 0.3011 - lr: 1.2500e-04
Epoch 41/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2532 - val_loss: 0.2439 - lr: 6.2500e-05
Epoch 42/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2588 - val_loss: 0.2423 - lr: 6.2500e-05
Epoch 43/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2478 - val_loss: 0.2962 - lr: 6.2500e-05
Epoch 44/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2605 - val_loss: 0.2353 - lr: 6.2500e-05
Epoch 45/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2503 - val_loss: 0.2390 - lr: 6.2500e-05
Epoch 46/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2570 - val_loss: 0.2546 - lr: 6.2500e-05
Epoch 47/1000
390/399 [============================>.] - ETA: 0s - loss: 0.2491
Epoch 47: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2489 - val_loss: 0.2446 - lr: 6.2500e-05
Epoch 48/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2375 - val_loss: 0.2314 - lr: 3.1250e-05
Epoch 49/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2360 - val_loss: 0.2381 - lr: 3.1250e-05
Epoch 50/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2349 - val_loss: 0.2343 - lr: 3.1250e-05
Epoch 51/1000
```

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399/399 [==============================] - 2s 6ms/step - loss: 0.2348 - val_loss: 0.2305 - lr: 3.1250e-05
Epoch 52/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2339 - val_loss: 0.2405 - lr: 3.1250e-05
Epoch 53/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2338 - val_loss: 0.2411 - lr: 3.1250e-05
Epoch 54/1000
396/399 [============================>.] - ETA: 0s - loss: 0.2365
Epoch 54: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2366 - val_loss: 0.2394 - lr: 3.1250e-05
Epoch 55/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2277 - val_loss: 0.2303 - lr: 1.5625e-05
Epoch 56/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2265 - val_loss: 0.2360 - lr: 1.5625e-05
Epoch 57/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2283 - val_loss: 0.2347 - lr: 1.5625e-05
Epoch 58/1000
393/399 [============================>.] - ETA: 0s - loss: 0.2273
Epoch 58: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2272 - val_loss: 0.2304 - lr: 1.5625e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2237 - val_loss: 0.2312 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2238 - val_loss: 0.2293 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2234 - val_loss: 0.2301 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2237 - val_loss: 0.2311 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2228 - val_loss: 0.2340 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2227 - val_loss: 0.2294 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2231 - val_loss: 0.2312 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2235 - val_loss: 0.2281 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2234 - val_loss: 0.2304 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2229 - val_loss: 0.2298 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2233 - val_loss: 0.2289 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2219 - val_loss: 0.2286 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2227 - val_loss: 0.2306 - lr: 1.0000e-05
Epoch 72/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2229 - val_loss: 0.2316 - lr: 1.0000e-05
Epoch 73/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2218 - val_loss: 0.2302 - lr: 1.0000e-05
Epoch 74/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2222 - val_loss: 0.2285 - lr: 1.0000e-05
Epoch 75/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2212 - val_loss: 0.2311 - lr: 1.0000e-05
Epoch 76/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2224 - val_loss: 0.2290 - lr: 1.0000e-05
```

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Epoch 77/1000
393/399 [============================>.] - ETA: 0s - loss: 0.2218Restoring model weights from the end of the best epoch: 66.
399/399 [==============================] - 2s 6ms/step - loss: 0.2218 - val_loss: 0.2301 - lr: 1.0000e-05
Epoch 77: early stopping
  92/3116 [..............................] - ETA: 5s
2022-10-25 10:17:12.248702: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 5s 2ms/step
2it [07:04, 207.89s/it]
Model: "model_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_4 (InputLayer)        [(None, 335)]             0

 dense_9 (Dense)             (None, 168)               56448

 dense_10 (Dense)            (None, 84)                14196

 dense_11 (Dense)            (None, 1)                 85

=================================================================
Total params: 70,729
Trainable params: 70,729
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
 16/399 [>.............................] - ETA: 2s - loss: 266.5225
2022-10-25 10:17:24.044481: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
395/399 [============================>.] - ETA: 0s - loss: 67.7633
2022-10-25 10:17:26.427446: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

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399/399 [==============================] - 3s 6ms/step - loss: 67.3691 - val_loss: 25.7980 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 23.2081 - val_loss: 18.8620 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 2s 6ms/step - loss: 14.8701 - val_loss: 10.1082 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 3s 7ms/step - loss: 12.2958 - val_loss: 11.7212 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 9.3111 - val_loss: 8.4377 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.5411 - val_loss: 4.7902 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.4646 - val_loss: 3.3024 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.3221 - val_loss: 9.7150 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 8.3661 - val_loss: 8.3122 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.3192 - val_loss: 2.7984 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.5355 - val_loss: 1.8630 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.3827 - val_loss: 1.6077 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.6667 - val_loss: 2.2971 - lr: 0.0010
Epoch 14/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.6140 - val_loss: 6.7252 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.1663 - val_loss: 1.4393 - lr: 0.0010
Epoch 16/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.9321 - val_loss: 0.5078 - lr: 0.0010
Epoch 17/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.0916 - val_loss: 3.2193 - lr: 0.0010
Epoch 18/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.3957 - val_loss: 1.8547 - lr: 0.0010
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.0445 - val_loss: 0.4926 - lr: 0.0010
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.4854 - val_loss: 11.0094 - lr: 0.0010
Epoch 21/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.7012 - val_loss: 1.5681 - lr: 0.0010
Epoch 22/1000
391/399 [============================>.] - ETA: 0s - loss: 1.7100
Epoch 22: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 1.6972 - val_loss: 2.2069 - lr: 0.0010
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.6256 - val_loss: 0.3578 - lr: 5.0000e-04
Epoch 24/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5050 - val_loss: 1.0205 - lr: 5.0000e-04
Epoch 25/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.6068 - val_loss: 0.9544 - lr: 5.0000e-04
Epoch 26/1000
397/399 [============================>.] - ETA: 0s - loss: 0.5654
Epoch 26: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 0.5647 - val_loss: 0.5333 - lr: 5.0000e-04
```

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Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3154 - val_loss: 0.9672 - lr: 2.5000e-04
Epoch 28/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3478 - val_loss: 0.2537 - lr: 2.5000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2987 - val_loss: 0.2587 - lr: 2.5000e-04
Epoch 30/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3452 - val_loss: 0.3371 - lr: 2.5000e-04
Epoch 31/1000
392/399 [============================>.] - ETA: 0s - loss: 0.6466
Epoch 31: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.6879 - val_loss: 1.8255 - lr: 2.5000e-04
Epoch 32/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4101 - val_loss: 0.3236 - lr: 1.2500e-04
Epoch 33/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3101 - val_loss: 0.2477 - lr: 1.2500e-04
Epoch 34/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3099 - val_loss: 0.2485 - lr: 1.2500e-04
Epoch 35/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2907 - val_loss: 0.3699 - lr: 1.2500e-04
Epoch 36/1000
392/399 [============================>.] - ETA: 0s - loss: 0.2736
Epoch 36: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2735 - val_loss: 0.2847 - lr: 1.2500e-04
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2391 - val_loss: 0.2406 - lr: 6.2500e-05
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2421 - val_loss: 0.2367 - lr: 6.2500e-05
Epoch 39/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2517 - val_loss: 0.2434 - lr: 6.2500e-05
Epoch 40/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2450 - val_loss: 0.2362 - lr: 6.2500e-05
Epoch 41/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2424 - val_loss: 0.6532 - lr: 6.2500e-05
Epoch 42/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2561 - val_loss: 0.4068 - lr: 6.2500e-05
Epoch 43/1000
394/399 [============================>.] - ETA: 0s - loss: 0.2495
Epoch 43: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2503 - val_loss: 0.3806 - lr: 6.2500e-05
Epoch 44/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2370 - val_loss: 0.2330 - lr: 3.1250e-05
Epoch 45/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2351 - val_loss: 0.2352 - lr: 3.1250e-05
Epoch 46/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2308 - val_loss: 0.2472 - lr: 3.1250e-05
Epoch 47/1000
393/399 [============================>.] - ETA: 0s - loss: 0.2411
Epoch 47: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2410 - val_loss: 0.2381 - lr: 3.1250e-05
Epoch 48/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2258 - val_loss: 0.2298 - lr: 1.5625e-05
Epoch 49/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2266 - val_loss: 0.2378 - lr: 1.5625e-05
Epoch 50/1000
```

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399/399 [==============================] - 3s 7ms/step - loss: 0.2264 - val_loss: 0.2407 - lr: 1.5625e-05
Epoch 51/1000
399/399 [==============================] - ETA: 0s - loss: 0.2266
Epoch 51: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2266 - val_loss: 0.2496 - lr: 1.5625e-05
Epoch 52/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2251 - val_loss: 0.2277 - lr: 1.0000e-05
Epoch 53/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2230 - val_loss: 0.2275 - lr: 1.0000e-05
Epoch 54/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2226 - val_loss: 0.2267 - lr: 1.0000e-05
Epoch 55/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2242 - val_loss: 0.2271 - lr: 1.0000e-05
Epoch 56/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2223 - val_loss: 0.2273 - lr: 1.0000e-05
Epoch 57/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2231 - val_loss: 0.2265 - lr: 1.0000e-05
Epoch 58/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2228 - val_loss: 0.2265 - lr: 1.0000e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2225 - val_loss: 0.2282 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2226 - val_loss: 0.2296 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2229 - val_loss: 0.2277 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2213 - val_loss: 0.2267 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2217 - val_loss: 0.2262 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2211 - val_loss: 0.2264 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2212 - val_loss: 0.2263 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2213 - val_loss: 0.2277 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2225 - val_loss: 0.2271 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2230 - val_loss: 0.2266 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2204 - val_loss: 0.2308 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2221 - val_loss: 0.2253 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2204 - val_loss: 0.2267 - lr: 1.0000e-05
Epoch 72/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2201 - val_loss: 0.2296 - lr: 1.0000e-05
Epoch 73/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2214 - val_loss: 0.2259 - lr: 1.0000e-05
Epoch 74/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2204 - val_loss: 0.2250 - lr: 1.0000e-05
Epoch 75/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2200 - val_loss: 0.2304 - lr: 1.0000e-05
Epoch 76/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2202 - val_loss: 0.2248 - lr: 1.0000e-05
```

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Epoch 77/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2202 - val_loss: 0.2300 - lr: 1.0000e-05
Epoch 78/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2202 - val_loss: 0.2315 - lr: 1.0000e-05
Epoch 79/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2205 - val_loss: 0.2272 - lr: 1.0000e-05
Epoch 80/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2195 - val_loss: 0.2302 - lr: 1.0000e-05
Epoch 81/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2192 - val_loss: 0.2304 - lr: 1.0000e-05
Epoch 82/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2197 - val_loss: 0.2266 - lr: 1.0000e-05
Epoch 83/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2190 - val_loss: 0.2255 - lr: 1.0000e-05
Epoch 84/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2194 - val_loss: 0.2252 - lr: 1.0000e-05
Epoch 85/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2195 - val_loss: 0.2251 - lr: 1.0000e-05
Epoch 86/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2189 - val_loss: 0.2286 - lr: 1.0000e-05
Epoch 87/1000
390/399 [============================>.] - ETA: 0s - loss: 0.2205Restoring model weights from the end of the best epoch: 76.
399/399 [==============================] - 2s 6ms/step - loss: 0.2206 - val_loss: 0.2302 - lr: 1.0000e-05
Epoch 87: early stopping
  88/3116 [..............................] - ETA: 5s
2022-10-25 10:20:42.319807: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 4s 2ms/step
3it [10:33, 211.22s/it]
```

Stacking

In [ ]:
```
new_X_train = np.concatenate((xgb_train_predict_base, cnn_train_predict_base, mlp_train_predict_base), axis=1)
new_X_test = np.concatenate((xgb_test_predict_mean_base, cnn_test_predict_mean_base, mlp_test_predict_mean_base), axis=1)

print(new_X_train.shape, new_X_test.shape)
```

```
(299050, 3) (85444, 3)
```

Meta-learner fitting

In [ ]:
```
final_model = LinearRegression()
final_model.fit(new_X_train, y_train)
y_pred_final = final_model.predict(new_X_test)
```

Prediction & Evaluation

In [ ]:
```
y_pred_final
```

```
array([0.00354715, 0.00237233, 0.00245136, ..., 0.00574381, 0.00278258,
       0.00375834])
```

In [ ]:
```
np_rmspe(y_test, y_pred_final)
```

0.2433471604414482

Type 4: Base + Nearest Neigbor → [XGBoost,1d-CNN,MLP]

In [ ]:
```
y_pred_final
```

```
array([0.00354715, 0.00237233, 0.00245136, ..., 0.00574381, 0.00278258,
       0.00375834])
```

In [ ]:
```
np_rmspe(y_test, y_pred_final)
```

```
0.2433471604414482
```

[01] Base + Nearest Neigbor → 1d-CNN

In [ ]:
```
num_columns = X_train.shape[1]
num_labels = 1
learning_rate = 6e-3
```

In [ ]:
```
tf.random.set_seed(777)
batch_size = 1024
learning_rate = 6e-3
epochs = 1000
model = CNN(X_train, y_train, num_columns, num_labels, learning_rate, epochs)
```

```
2022-10-25 02:09:52.099166: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305] Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA support.
2022-10-25 02:09:52.099304: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id: <undefined>)
Metal device set to: Apple M1 Pro

systemMemory: 16.00 GB
maxCacheSize: 5.33 GB

Epoch 1/1000
2022-10-25 02:09:52.507034: W tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU frequency: 0 Hz
2022-10-25 02:09:53.043321: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
293/293 [==============================] - 10s 30ms/step - loss: 44.5666 - val_loss: 0.8009 - lr: 0.0060
Epoch 2/1000
  1/293 [..............................] - ETA: 8s - loss: 0.8940
2022-10-25 02:10:02.075625: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.6598 - val_loss: 0.8218 - lr: 0.0060
Epoch 3/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.5873 - val_loss: 0.4361 - lr: 0.0060
Epoch 4/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.5194 - val_loss: 0.6895 - lr: 0.0060
Epoch 5/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.5140 - val_loss: 0.5418 - lr: 0.0060
Epoch 6/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4529 - val_loss: 0.5140 - lr: 0.0060
Epoch 7/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4519 - val_loss: 0.4356 - lr: 0.0060
Epoch 8/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4118 - val_loss: 0.4650 - lr: 0.0060
Epoch 9/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4306 - val_loss: 0.4049 - lr: 0.0060
Epoch 10/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4083 - val_loss: 0.5623 - lr: 0.0060
Epoch 11/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3856 - val_loss: 0.5838 - lr: 0.0060
Epoch 12/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.4203 - val_loss: 0.6495 - lr: 0.0060
Epoch 13/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3964 - val_loss: 0.4498 - lr: 0.0060
Epoch 14/1000
293/293 [==============================] - ETA: 0s - loss: 0.3616
Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
293/293 [==============================] - 8s 28ms/step - loss: 0.3616 - val_loss: 0.4378 - lr: 0.0060
Epoch 15/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3063 - val_loss: 0.2995 - lr: 0.0030
Epoch 16/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3082 - val_loss: 0.2867 - lr: 0.0030
Epoch 17/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3062 - val_loss: 0.2887 - lr: 0.0030
Epoch 18/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3104 - val_loss: 0.4769 - lr: 0.0030
Epoch 19/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.3166 - val_loss: 0.4310 - lr: 0.0030
Epoch 20/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2985 - val_loss: 0.3385 - lr: 0.0030
Epoch 21/1000
293/293 [==============================] - ETA: 0s - loss: 0.2991
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
293/293 [==============================] - 8s 28ms/step - loss: 0.2991 - val_loss: 0.4025 - lr: 0.0030
Epoch 22/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2789 - val_loss: 0.4030 - lr: 0.0015
Epoch 23/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2803 - val_loss: 0.2837 - lr: 0.0015
Epoch 24/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2807 - val_loss: 0.3561 - lr: 0.0015
Epoch 25/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2759 - val_loss: 0.2887 - lr: 0.0015
Epoch 26/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2822 - val_loss: 0.3321 - lr: 0.0015
Epoch 27/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2735 - val_loss: 0.3458 - lr: 0.0015
```

```
Epoch 28/1000
293/293 [==============================] - ETA: 0s - loss: 0.2728
Epoch 28: ReduceLROnPlateau reducing learning rate to 0.000750000006519258.
293/293 [==============================] - 8s 28ms/step - loss: 0.2728 - val_loss: 0.3374 - lr: 0.0015
Epoch 29/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2616 - val_loss: 0.2405 - lr: 7.5000e-04
Epoch 30/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2647 - val_loss: 0.2578 - lr: 7.5000e-04
Epoch 31/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2638 - val_loss: 0.2621 - lr: 7.5000e-04
Epoch 32/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2604 - val_loss: 0.2775 - lr: 7.5000e-04
Epoch 33/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2590 - val_loss: 0.2688 - lr: 7.5000e-04
Epoch 34/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2636 - val_loss: 0.2317 - lr: 7.5000e-04
Epoch 35/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2578 - val_loss: 0.2402 - lr: 7.5000e-04
Epoch 36/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2540 - val_loss: 0.2208 - lr: 7.5000e-04
Epoch 37/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2557 - val_loss: 0.3312 - lr: 7.5000e-04
Epoch 38/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2565 - val_loss: 0.2217 - lr: 7.5000e-04
Epoch 39/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2539 - val_loss: 0.3046 - lr: 7.5000e-04
Epoch 40/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2528 - val_loss: 0.2486 - lr: 7.5000e-04
Epoch 41/1000
291/293 [============================>.] - ETA: 0s - loss: 0.2522
Epoch 41: ReduceLROnPlateau reducing learning rate to 0.000375000003259629.
293/293 [==============================] - 8s 27ms/step - loss: 0.2522 - val_loss: 0.2269 - lr: 7.5000e-04
Epoch 42/1000
293/293 [==============================] - 8s 27ms/step - loss: 0.2448 - val_loss: 0.2370 - lr: 3.7500e-04
Epoch 43/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2415 - val_loss: 0.2187 - lr: 3.7500e-04
Epoch 44/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2445 - val_loss: 0.2311 - lr: 3.7500e-04
Epoch 45/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2406 - val_loss: 0.2405 - lr: 3.7500e-04
Epoch 46/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2423 - val_loss: 0.2273 - lr: 3.7500e-04
Epoch 47/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2393 - val_loss: 0.2250 - lr: 3.7500e-04
Epoch 48/1000
293/293 [==============================] - ETA: 0s - loss: 0.2416
Epoch 48: ReduceLROnPlateau reducing learning rate to 0.000187500000162981450.
293/293 [==============================] - 8s 28ms/step - loss: 0.2416 - val_loss: 0.2213 - lr: 3.7500e-04
Epoch 49/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2354 - val_loss: 0.2212 - lr: 1.8750e-04
Epoch 50/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2359 - val_loss: 0.2191 - lr: 1.8750e-04
Epoch 51/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2369 - val_loss: 0.2449 - lr: 1.8750e-04
Epoch 52/1000
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.2350 - val_loss: 0.2211 - lr: 1.8750e-04
Epoch 53/1000
293/293 [==============================] - ETA: 0s - loss: 0.2350
Epoch 53: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2350 - val_loss: 0.2288 - lr: 1.8750e-04
Epoch 54/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2329 - val_loss: 0.2216 - lr: 9.3750e-05
Epoch 55/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2328 - val_loss: 0.2171 - lr: 9.3750e-05
Epoch 56/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2332 - val_loss: 0.2148 - lr: 9.3750e-05
Epoch 57/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2322 - val_loss: 0.2196 - lr: 9.3750e-05
Epoch 58/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2326 - val_loss: 0.2144 - lr: 9.3750e-05
Epoch 59/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2335 - val_loss: 0.2177 - lr: 9.3750e-05
Epoch 60/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2321 - val_loss: 0.2155 - lr: 9.3750e-05
Epoch 61/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2316 - val_loss: 0.2181 - lr: 9.3750e-05
Epoch 62/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2328 - val_loss: 0.2236 - lr: 9.3750e-05
Epoch 63/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2327 - val_loss: 0.2140 - lr: 9.3750e-05
Epoch 64/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2320 - val_loss: 0.2411 - lr: 9.3750e-05
Epoch 65/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2326 - val_loss: 0.2169 - lr: 9.3750e-05
Epoch 66/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2314 - val_loss: 0.2235 - lr: 9.3750e-05
Epoch 67/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.2304 - val_loss: 0.2158 - lr: 9.3750e-05
Epoch 68/1000
293/293 [==============================] - ETA: 0s - loss: 0.2301
Epoch 68: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2301 - val_loss: 0.2187 - lr: 9.3750e-05
Epoch 69/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.2296 - val_loss: 0.2192 - lr: 4.6875e-05
Epoch 70/1000
293/293 [==============================] - 9s 30ms/step - loss: 0.2299 - val_loss: 0.2183 - lr: 4.6875e-05
Epoch 71/1000
293/293 [==============================] - 9s 29ms/step - loss: 0.2290 - val_loss: 0.2178 - lr: 4.6875e-05
Epoch 72/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2296 - val_loss: 0.2167 - lr: 4.6875e-05
Epoch 73/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2293 - val_loss: 0.2134 - lr: 4.6875e-05
Epoch 74/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2290 - val_loss: 0.2163 - lr: 4.6875e-05
Epoch 75/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2287 - val_loss: 0.2194 - lr: 4.6875e-05
Epoch 76/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2288 - val_loss: 0.2142 - lr: 4.6875e-05
Epoch 77/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2293 - val_loss: 0.2190 - lr: 4.6875e-05
```

```
Epoch 78/1000
292/293 [============================>.] - ETA: 0s - loss: 0.2284
Epoch 78: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2284 - val_loss: 0.2202 - lr: 4.6875e-05
Epoch 79/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2281 - val_loss: 0.2188 - lr: 2.3438e-05
Epoch 80/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2279 - val_loss: 0.2146 - lr: 2.3438e-05
Epoch 81/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2283 - val_loss: 0.2162 - lr: 2.3438e-05
Epoch 82/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2277 - val_loss: 0.2169 - lr: 2.3438e-05
Epoch 83/1000
293/293 [==============================] - ETA: 0s - loss: 0.2279
Epoch 83: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
293/293 [==============================] - 8s 28ms/step - loss: 0.2279 - val_loss: 0.2182 - lr: 2.3438e-05
Epoch 84/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2275 - val_loss: 0.2155 - lr: 1.1719e-05
Epoch 85/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2273 - val_loss: 0.2149 - lr: 1.1719e-05
Epoch 86/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2281 - val_loss: 0.2167 - lr: 1.1719e-05
Epoch 87/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2274 - val_loss: 0.2145 - lr: 1.1719e-05
Epoch 88/1000
293/293 [==============================] - ETA: 0s - loss: 0.2280
Epoch 88: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
293/293 [==============================] - 8s 28ms/step - loss: 0.2280 - val_loss: 0.2153 - lr: 1.1719e-05
Epoch 89/1000
293/293 [==============================] - 8s 29ms/step - loss: 0.2274 - val_loss: 0.2148 - lr: 5.8594e-06
Epoch 90/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2277 - val_loss: 0.2170 - lr: 5.8594e-06
Epoch 91/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2275 - val_loss: 0.2158 - lr: 5.8594e-06
Epoch 92/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2279 - val_loss: 0.2151 - lr: 5.8594e-06
Epoch 93/1000
293/293 [==============================] - ETA: 0s - loss: 0.2275
Epoch 93: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
293/293 [==============================] - 8s 28ms/step - loss: 0.2275 - val_loss: 0.2151 - lr: 5.8594e-06
Epoch 94/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2275 - val_loss: 0.2154 - lr: 2.9297e-06
Epoch 95/1000
293/293 [==============================] - 9s 32ms/step - loss: 0.2274 - val_loss: 0.2152 - lr: 2.9297e-06
Epoch 96/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2272 - val_loss: 0.2161 - lr: 2.9297e-06
Epoch 97/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2277 - val_loss: 0.2159 - lr: 2.9297e-06
Epoch 98/1000
293/293 [==============================] - ETA: 0s - loss: 0.2271
Epoch 98: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
293/293 [==============================] - 8s 28ms/step - loss: 0.2271 - val_loss: 0.2153 - lr: 2.9297e-06
Epoch 99/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2275 - val_loss: 0.2149 - lr: 1.4648e-06
Epoch 100/1000
```

```
293/293 [==============================] - 8s 28ms/step - loss: 0.2276 - val_loss: 0.2153 - lr: 1.4648e-06
Epoch 101/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2270 - val_loss: 0.2156 - lr: 1.4648e-06
Epoch 102/1000
293/293 [==============================] - 8s 28ms/step - loss: 0.2273 - val_loss: 0.2159 - lr: 1.4648e-06
Epoch 103/1000
293/293 [==============================] - ETA: 0s - loss: 0.2267
Epoch 103: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
293/293 [==============================] - 8s 28ms/step - loss: 0.2267 - val_loss: 0.2157 - lr: 1.4648e-06
Epoch 104/1000
293/293 [==============================] - ETA: 0s - loss: 0.2272Restoring model weights from the end of the best epoch: 73.
293/293 [==============================] - 8s 28ms/step - loss: 0.2272 - val_loss: 0.2151 - lr: 7.3242e-07
Epoch 104: early stopping
```

In [ ]:
```
model[0].summary()
```

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 397)]             0

 batch_normalization (BatchN  (None, 397)              1588
 ormalization)

 dense (Dense)               (None, 256)               101888

 reshape (Reshape)           (None, 16, 16)            0

 conv1d (Conv1D)             (None, 15, 12)            396

 average_pooling1d (AverageP  (None, 7, 12)            0
 ooling1D)

 flatten (Flatten)           (None, 84)                0

 dense_1 (Dense)             (None, 64)                5440

 batch_normalization_1 (Batc  (None, 64)               256
 hNormalization)

 gaussian_noise (GaussianNoi  (None, 64)               0
 se)

 dropout (Dropout)           (None, 64)                0

 dense_2 (Dense)             (None, 32)                2080

 batch_normalization_2 (Batc  (None, 32)               128
 hNormalization)

 gaussian_noise_1 (GaussianN  (None, 32)               0
 oise)

 dropout_1 (Dropout)         (None, 32)                0

 dense_3 (Dense)             (None, 16)                528

 batch_normalization_3 (Batc  (None, 16)               64
 hNormalization)

 gaussian_noise_2 (GaussianN  (None, 16)               0
 oise)

 dropout_2 (Dropout)         (None, 16)                0

 dense_4 (Dense)             (None, 1)                 17

=================================================================
Total params: 112,385
Trainable params: 111,367
```

```
Non-trainable params: 1,018
_________________________________________________________________
```

In [ ]:
```python
for i in range(85):
    globals()['y_pred{}'.format(i+1)] = model[0].predict(X_test[1000*i:1000*(i+1)])
    globals()['y_pred{}'.format(i+1)] = globals()['y_pred{}'.format(i+1)].reshape(1000,)
    globals()['y_test{}'.format(i+1)] = y_test[1000*i:1000*(i+1)]

    if i == 84:
        globals()['y_pred{}'.format(i+2)] = model[0].predict(X_test[1000*(i+1):])
        globals()['y_pred{}'.format(i+2)] = globals()['y_pred{}'.format(i+2)].reshape(-1,)
        globals()['y_test{}'.format(i+2)] = y_test[1000*(i+1):]
```

```
16/32 [==============>..............] - ETA: 0s
2022-10-25 02:24:34.117264: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
32/32 [==============================] - 0s 8ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 8ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
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32/32 [==============================] - 0s 7ms/step
32/32 [==============================] - 0s 7ms/step
14/14 [==============================] - 0s 9ms/step
```

In [ ]:

```
pred = {}
test = {}
for i in range(86):
    pred[i+1] = globals()['y_pred{}'.format(i+1)]
    test[i+1] = globals()['y_test{}'.format(i+1)]
```

In [ ]:

```
mse = []
for i in range(86):
    sqr_mse = get_mse(test[i+1],pred[i+1])
    mse.append(np.sum(sqr_mse))
```

In [ ]:

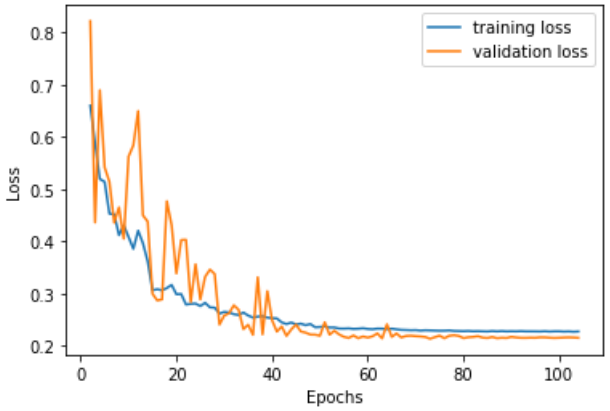
```
final_rmspe = np.sqrt(sum(mse)/y_test.shape[0])
final_rmspe
```

```
0.21326511067106527
```

In [ ]:

```
import matplotlib.pyplot as plt
epochs = np.arange(2, len(model[1].history['loss'])+1)
plt.plot(epochs, model[1].history['loss'][1:],label='training loss')
plt.plot(epochs, model[1].history['val_loss'][1:],label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
```

```
plt.legend()
plt.show()
```



[02] Base + Nearest Neigbor → MLP

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))

X_train = pd.read_pickle('./397/X_train_tf.pkl').astype(float)
y_train = pd.read_pickle('./397/y_train_tf.pkl').astype(float)
X_val = pd.read_pickle('./397/X_val_tf.pkl').astype(float)
y_val = pd.read_pickle('./397/y_val_tf.pkl').astype(float)
X_test = pd.read_pickle('./397/X_test_tf.pkl').astype(float)
y_test = pd.read_pickle('./397/y_test_tf.pkl').astype(float)

scaler = StandardScaler()
X_train = scaler.fit_transform(X_train)
X_val = scaler.fit_transform(X_val)
X_test = scaler.fit_transform(X_test)

inputs= tf.keras.Input(
        shape=(X_train.shape[1],)
    )
hidden1=tf.keras.layers.Dense(
        units=int(np.round(X_train.shape[1]/2, 0)),
        kernel_initializer='he_uniform',
        activation='LeakyReLU'
    )(inputs)
hidden2=tf.keras.layers.Dense(
        units=int(np.round(X_train.shape[1]/4, 0)),
        kernel_initializer='he_uniform',
        activation='LeakyReLU'
    )(hidden1)

outputs=tf.keras.layers.Dense(
        units=1,
)(hidden2)
```

```
model = Model(inputs, outputs)
model.summary()

model.compile(optimizer=tf.keras.optimizers.Adam(0.001),
              loss=rmspe)

rlr = tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=3, min_delta=1e-5, min_lr=1e-5, verbose=1)
es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=11, restore_best_weights=True, verbose=1)
callback_list = [rlr, es]
history = model.fit(X_train, y_train,
                    batch_size=500, epochs=1000, verbose=1,
                    validation_data=(X_val, y_val), callbacks=callback_list
)

print(pd.DataFrame(history.history))
epochs=np.arange(1, len(history.history['loss'])+1)
plt.plot(epochs, history.history['loss'], label='training loss')
plt.plot(epochs, history.history['val_loss'], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()

epochs=np.arange(2, len(history.history['loss'])+1)
plt.plot(epochs, history.history['loss'][1:], label='training loss')
plt.plot(epochs, history.history['val_loss'][1:], label='validation loss')
plt.xlabel('Epochs')
plt.ylabel('Loss')
plt.legend()
plt.show()

a = np.array([]).reshape(0, 1)

for x in range (1, 42):
    length = int((X_test.shape[0] / 41))
    test = X_test[length*(x-1):length*(x)]

    y_hat = model.predict(test)
    #print(y_hat)
    a = np.append(a, y_hat)

rmse = np.sqrt(np.mean(np.square(((a - y_test) / y_test)), axis=0))
print('RMSPE :', rmse)
```

```
2022-10-25 00:13:46.022035: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305] Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA support.
2022-10-25 00:13:46.022158: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id: <undefined>)
```

```
Metal device set to: Apple M1

systemMemory: 16.00 GB
maxCacheSize: 5.33 GB

Model: "model"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
input_1 (InputLayer)         [(None, 397)]             0
_________________________________________________________________
dense (Dense)                (None, 198)               78804
_________________________________________________________________
dense_1 (Dense)              (None, 99)                19701
_________________________________________________________________
dense_2 (Dense)              (None, 1)                 100
=================================================================
Total params: 98,605
Trainable params: 98,605
Non-trainable params: 0
_________________________________________________________________
2022-10-25 00:13:46.454625: W tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU frequency: 0 Hz
Epoch 1/1000
  1/599 [..............................] - ETA: 4:02 - loss: 759.5681
2022-10-25 00:13:46.694529: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
599/599 [==============================] - ETA: 0s - loss: 50.2582
2022-10-25 00:13:52.096756: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
```

```
599/599 [==============================] - 6s 9ms/step - loss: 50.2582 - val_loss: 15.5751
Epoch 2/1000
599/599 [==============================] - 6s 9ms/step - loss: 11.9734 - val_loss: 6.5775
Epoch 3/1000
599/599 [==============================] - 6s 9ms/step - loss: 8.4742 - val_loss: 4.2420
Epoch 4/1000
599/599 [==============================] - 6s 10ms/step - loss: 4.1670 - val_loss: 3.3291
Epoch 5/1000
599/599 [==============================] - 8s 13ms/step - loss: 5.1838 - val_loss: 8.1014
Epoch 6/1000
599/599 [==============================] - 8s 13ms/step - loss: 4.7891 - val_loss: 1.5712
Epoch 7/1000
599/599 [==============================] - 6s 11ms/step - loss: 1.4386 - val_loss: 1.7858
Epoch 8/1000
599/599 [==============================] - 6s 9ms/step - loss: 4.9061 - val_loss: 1.0529
Epoch 9/1000
599/599 [==============================] - 6s 10ms/step - loss: 2.6540 - val_loss: 0.7541
Epoch 10/1000
599/599 [==============================] - 5s 9ms/step - loss: 1.5177 - val_loss: 1.1508
Epoch 11/1000
599/599 [==============================] - 5s 9ms/step - loss: 1.5002 - val_loss: 0.8628
Epoch 12/1000
599/599 [==============================] - 5s 9ms/step - loss: 5.6441 - val_loss: 10.3644

Epoch 00012: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
Epoch 13/1000
599/599 [==============================] - 6s 9ms/step - loss: 2.3718 - val_loss: 6.4129
Epoch 14/1000
599/599 [==============================] - 5s 9ms/step - loss: 1.0834 - val_loss: 0.4136
Epoch 15/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.5140 - val_loss: 0.5662
Epoch 16/1000
599/599 [==============================] - 6s 9ms/step - loss: 0.4889 - val_loss: 0.3067
Epoch 17/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.5048 - val_loss: 0.4684
Epoch 18/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.9546 - val_loss: 1.2026
Epoch 19/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.6250 - val_loss: 0.4570

Epoch 00019: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
Epoch 20/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.3526 - val_loss: 0.3718
Epoch 21/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.4007 - val_loss: 0.2435
Epoch 22/1000
599/599 [==============================] - 6s 10ms/step - loss: 0.3299 - val_loss: 0.3125
Epoch 23/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.3319 - val_loss: 0.4009
Epoch 24/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.4944 - val_loss: 0.4492

Epoch 00024: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
Epoch 25/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.3864 - val_loss: 0.2882
```

```
Epoch 26/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2769 - val_loss: 0.2501
Epoch 27/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2953 - val_loss: 0.2391
Epoch 28/1000
599/599 [==============================] - 6s 10ms/step - loss: 0.2688 - val_loss: 0.2703
Epoch 29/1000
599/599 [==============================] - 6s 10ms/step - loss: 0.2735 - val_loss: 0.2324
Epoch 30/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2885 - val_loss: 0.2427
Epoch 31/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2738 - val_loss: 0.2347
Epoch 32/1000
599/599 [==============================] - 6s 10ms/step - loss: 0.2662 - val_loss: 0.2385

Epoch 00032: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
Epoch 33/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2372 - val_loss: 0.2387
Epoch 34/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2347 - val_loss: 0.2257
Epoch 35/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2320 - val_loss: 0.2352
Epoch 36/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2455 - val_loss: 0.2273
Epoch 37/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2340 - val_loss: 0.3082

Epoch 00037: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
Epoch 38/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2251 - val_loss: 0.2236
Epoch 39/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2232 - val_loss: 0.2208
Epoch 40/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2241 - val_loss: 0.2265
Epoch 41/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2229 - val_loss: 0.2244
Epoch 42/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2218 - val_loss: 0.2302

Epoch 00042: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
Epoch 43/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2164 - val_loss: 0.2237
Epoch 44/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2163 - val_loss: 0.2216
Epoch 45/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2161 - val_loss: 0.2249

Epoch 00045: ReduceLROnPlateau reducing learning rate to 7.812500371073838e-06.
Epoch 46/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2136 - val_loss: 0.2186
Epoch 47/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2133 - val_loss: 0.2189
Epoch 48/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2129 - val_loss: 0.2182
Epoch 49/1000
```

```
599/599 [==============================] - 5s 9ms/step - loss: 0.2129 - val_loss: 0.2183
Epoch 50/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2128 - val_loss: 0.2183
Epoch 51/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2124 - val_loss: 0.2188

Epoch 00051: ReduceLROnPlateau reducing learning rate to 3.906250185536919e-06.
Epoch 52/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2114 - val_loss: 0.2182
Epoch 53/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2107 - val_loss: 0.2187
Epoch 54/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2108 - val_loss: 0.2206

Epoch 00054: ReduceLROnPlateau reducing learning rate to 1.9531250927684596e-06.
Epoch 55/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2102 - val_loss: 0.2184
Epoch 56/1000
599/599 [==============================] - 5s 8ms/step - loss: 0.2102 - val_loss: 0.2173
Epoch 57/1000
599/599 [==============================] - 6s 9ms/step - loss: 0.2101 - val_loss: 0.2185
Epoch 58/1000
599/599 [==============================] - 6s 9ms/step - loss: 0.2100 - val_loss: 0.2175
Epoch 59/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2100 - val_loss: 0.2183

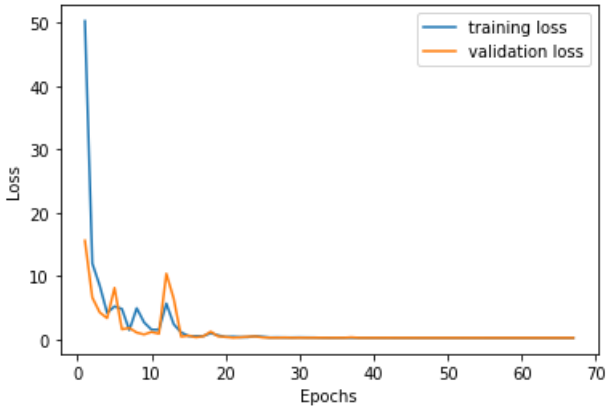
Epoch 00059: ReduceLROnPlateau reducing learning rate to 9.765625463842298e-07.
Epoch 60/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2096 - val_loss: 0.2175
Epoch 61/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2096 - val_loss: 0.2185
Epoch 62/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2096 - val_loss: 0.2175

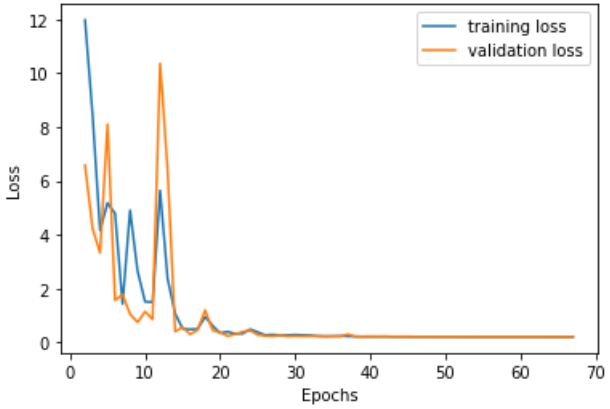
Epoch 00062: ReduceLROnPlateau reducing learning rate to 4.882812731921149e-07.
Epoch 63/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2094 - val_loss: 0.2178
Epoch 64/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2094 - val_loss: 0.2177
Epoch 65/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2094 - val_loss: 0.2178

Epoch 00065: ReduceLROnPlateau reducing learning rate to 2.4414063659605745e-07.
Epoch 66/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2093 - val_loss: 0.2176
Epoch 67/1000
599/599 [==============================] - 5s 9ms/step - loss: 0.2092 - val_loss: 0.2177
Restoring model weights from the end of the best epoch.
Epoch 00067: early stopping
         loss   val_loss            lr
0   50.258221  15.575092  1.000000e-03
1   11.973442   6.577546  1.000000e-03
2    8.474157   4.241951  1.000000e-03
3    4.166983   3.329058  1.000000e-03
4    5.183785   8.101426  1.000000e-03
```

```
..        ...       ...           ...
62    0.209410  0.217827  4.882813e-07
63    0.209366  0.217685  4.882813e-07
64    0.209371  0.217792  4.882813e-07
65    0.209266  0.217637  2.441406e-07
66    0.209246  0.217732  2.441406e-07

[67 rows x 3 columns]
```






```
2022-10-25 00:19:51.022622: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:112] Plugin optimizer for device_type GPU is enabled.
RMSPE : 0.21806930129850519
```

[03] Ensemble

CV stacking Assemble with base features

XGBoost

In [ ]:
```
n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
```

```
train_fold_predict = np.zeros((X_train.shape[0], 1))
test_predict = np.zeros((X_test.shape[0], n_folds))
```

In [ ]:
```
xgboost_reg = XGBRegressor(n_estimators = 1625,
                           learning_rate = 0.22399999999999995,
                           colsample_bytree = 0.6,
                           gamma=0.4,
                           max_depth=17,
                           subsample = 0.8 )
```

In [ ]:
```
for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train))):
    X_train_ = X_train.iloc[train_index,:]
    y_train_ = y_train.iloc[train_index]
    X_val_ = X_train.iloc[val_index,:]

    xgboost_reg.fit(X_train_,y_train_)

    train_fold_predict[val_index,:] = xgboost_reg.predict(X_val_).reshape(-1,1)
    test_predict[:,cv_num] = xgboost_reg.predict(X_test)

xgb_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
xgb_train_predict = train_fold_predict
```

```
3it [3:38:43, 4374.52s/it]
```

In [ ]:
```
print(xgb_test_predict_mean.shape, xgb_train_predict.shape)
```

```
(85444, 1) (299050, 1)
```

CNN

In [ ]:
```
def np_rmspe(y_true, y_pred):
    return np.sqrt(np.mean(np.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def CNN(X_train, y_train, X_val, y_val, num_columns, num_labels, learning_rate, epochs):
    inp = tf.keras.layers.Input(shape=(num_columns,))
    x = tf.keras.layers.BatchNormalization()(inp)
    x = tf.keras.layers.Dense(256, activation='LeakyReLU')(x)
    x = tf.keras.layers.Reshape((16,16))(x)
    x = tf.keras.layers.Conv1D(filters=12, kernel_size=2, strides=1, activation='LeakyReLU')(x)
    x = tf.keras.layers.MaxPooling1D(pool_size=2)(x)
    x = tf.keras.layers.Flatten()(x)

    for i in range(3):
        x = tf.keras.layers.Dense(64//(2**i), activation='LeakyReLU')(x)
        x = tf.keras.layers.BatchNormalization()(x)
        x = tf.keras.layers.GaussianNoise(0.01)(x)
        x = tf.keras.layers.Dropout(0.20)(x)

    x = tf.keras.layers.Dense(num_labels)(x)
```

```
    model = tf.keras.models.Model(inputs=inp, outputs=x)
    model.compile(optimizer=tf.keras.optimizers.Adam(learning_rate=learning_rate), loss=rmspe)

    rlr = ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=5, min_delta=1e-5, verbose=2)
    es = EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=31, restore_best_weights=True, verbose=2)

    history = model.fit(X_train, y_train, epochs=epochs,validation_data=(X_val, y_val), validation_batch_size=len(y_val),batch_size=batch_size,verbose=1, callbacks=[rl

    return model, history
```

In [ ]:

```
tf.random.set_seed(777)
num_columns = X_train_scaled.shape[1]
num_labels = 1
learning_rate = 6e-3
batch_size = 1024
dropout_rates = 0
epochs = 1000

n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
train_fold_predict = np.zeros((X_train_scaled.shape[0], 1))
test_predict = np.zeros((X_test_scaled.shape[0], n_folds))

for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train_scaled))):
    X_train_ = X_train_scaled[train_index,:]
    y_train_ = y_train.iloc[train_index]
    X_val_ = X_train_scaled[val_index,:]

    model = CNN(X_train_, y_train_, X_val_scaled, y_val, num_columns, num_labels, learning_rate, epochs)

    train_fold_predict[val_index,:] = model[0].predict(X_val_).reshape(-1,1)
    test_predict[:,cv_num] = model[0].predict(np.array(X_test_scaled)).reshape(-1)

cnn_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
cnn_train_predict = train_fold_predict
```

```
0it [00:00, ?it/s]
```

```
Epoch 1/1000
195/195 [==============================] - 8s 29ms/step - loss: 73.6797 - val_loss: 1.1478 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.8414 - val_loss: 0.7853 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.5736 - val_loss: 0.3568 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.5933 - val_loss: 0.3412 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.5320 - val_loss: 0.6416 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.5088 - val_loss: 0.3315 - lr: 0.0060
Epoch 7/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.5271 - val_loss: 0.4434 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.4698 - val_loss: 0.3290 - lr: 0.0060
Epoch 9/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.5152 - val_loss: 0.3179 - lr: 0.0060
Epoch 10/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4773 - val_loss: 0.4609 - lr: 0.0060
Epoch 11/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.4591 - val_loss: 0.3448 - lr: 0.0060
Epoch 12/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.4371 - val_loss: 0.5600 - lr: 0.0060
Epoch 13/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.4401 - val_loss: 0.3124 - lr: 0.0060
Epoch 14/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.4438 - val_loss: 0.2902 - lr: 0.0060
Epoch 15/1000
195/195 [==============================] - 5s 24ms/step - loss: 0.3947 - val_loss: 0.3591 - lr: 0.0060
Epoch 16/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.4505 - val_loss: 0.2609 - lr: 0.0060
Epoch 17/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.4085 - val_loss: 0.3747 - lr: 0.0060
Epoch 18/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3945 - val_loss: 0.3174 - lr: 0.0060
Epoch 19/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.3906 - val_loss: 0.3868 - lr: 0.0060
Epoch 20/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.3732 - val_loss: 0.3246 - lr: 0.0060
Epoch 21/1000
195/195 [==============================] - ETA: 0s - loss: 0.3781
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 6s 30ms/step - loss: 0.3781 - val_loss: 0.3298 - lr: 0.0060
Epoch 22/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.3327 - val_loss: 0.2435 - lr: 0.0030
Epoch 23/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.3153 - val_loss: 0.3729 - lr: 0.0030
Epoch 24/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.3160 - val_loss: 0.2447 - lr: 0.0030
Epoch 25/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.3238 - val_loss: 0.2979 - lr: 0.0030
Epoch 26/1000
195/195 [==============================] - 6s 29ms/step - loss: 0.3111 - val_loss: 0.2379 - lr: 0.0030
Epoch 27/1000
```

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195/195 [==============================] - 5s 28ms/step - loss: 0.3096 - val_loss: 0.2563 - lr: 0.0030
Epoch 28/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.3163 - val_loss: 0.2396 - lr: 0.0030
Epoch 29/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.3142 - val_loss: 0.2473 - lr: 0.0030
Epoch 30/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.3220 - val_loss: 0.2755 - lr: 0.0030
Epoch 31/1000
194/195 [============================>.] - ETA: 0s - loss: 0.3022
Epoch 31: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 5s 28ms/step - loss: 0.3022 - val_loss: 0.2425 - lr: 0.0030
Epoch 32/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2857 - val_loss: 0.2478 - lr: 0.0015
Epoch 33/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2911 - val_loss: 0.2331 - lr: 0.0015
Epoch 34/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2751 - val_loss: 0.2400 - lr: 0.0015
Epoch 35/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2777 - val_loss: 0.2351 - lr: 0.0015
Epoch 36/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2847 - val_loss: 0.2467 - lr: 0.0015
Epoch 37/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2740 - val_loss: 0.2339 - lr: 0.0015
Epoch 38/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2829
Epoch 38: ReduceLROnPlateau reducing learning rate to 0.0007500000006519258.
195/195 [==============================] - 5s 27ms/step - loss: 0.2827 - val_loss: 0.2335 - lr: 0.0015
Epoch 39/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2668 - val_loss: 0.2559 - lr: 7.5000e-04
Epoch 40/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2696 - val_loss: 0.2396 - lr: 7.5000e-04
Epoch 41/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2634 - val_loss: 0.2279 - lr: 7.5000e-04
Epoch 42/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2690 - val_loss: 0.2236 - lr: 7.5000e-04
Epoch 43/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2643 - val_loss: 0.2322 - lr: 7.5000e-04
Epoch 44/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2671 - val_loss: 0.2326 - lr: 7.5000e-04
Epoch 45/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2638 - val_loss: 0.2448 - lr: 7.5000e-04
Epoch 46/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2627 - val_loss: 0.2706 - lr: 7.5000e-04
Epoch 47/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2642
Epoch 47: ReduceLROnPlateau reducing learning rate to 0.0003750000003259629.
195/195 [==============================] - 5s 26ms/step - loss: 0.2641 - val_loss: 0.2636 - lr: 7.5000e-04
Epoch 48/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2584 - val_loss: 0.2295 - lr: 3.7500e-04
Epoch 49/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2546 - val_loss: 0.2335 - lr: 3.7500e-04
Epoch 50/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2535 - val_loss: 0.2220 - lr: 3.7500e-04
Epoch 51/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2545 - val_loss: 0.2235 - lr: 3.7500e-04
```

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Epoch 52/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2536 - val_loss: 0.2436 - lr: 3.7500e-04
Epoch 53/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2544 - val_loss: 0.2210 - lr: 3.7500e-04
Epoch 54/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2542 - val_loss: 0.2316 - lr: 3.7500e-04
Epoch 55/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2553 - val_loss: 0.2441 - lr: 3.7500e-04
Epoch 56/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2541 - val_loss: 0.2316 - lr: 3.7500e-04
Epoch 57/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2538 - val_loss: 0.2342 - lr: 3.7500e-04
Epoch 58/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2534
Epoch 58: ReduceLROnPlateau reducing learning rate to 0.0001875000016298145.
195/195 [==============================] - 5s 27ms/step - loss: 0.2533 - val_loss: 0.2229 - lr: 3.7500e-04
Epoch 59/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2461 - val_loss: 0.2439 - lr: 1.8750e-04
Epoch 60/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2481 - val_loss: 0.2197 - lr: 1.8750e-04
Epoch 61/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2476 - val_loss: 0.2253 - lr: 1.8750e-04
Epoch 62/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2467 - val_loss: 0.2411 - lr: 1.8750e-04
Epoch 63/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2468 - val_loss: 0.2541 - lr: 1.8750e-04
Epoch 64/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2449 - val_loss: 0.2183 - lr: 1.8750e-04
Epoch 65/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2453 - val_loss: 0.2298 - lr: 1.8750e-04
Epoch 66/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2472 - val_loss: 0.2222 - lr: 1.8750e-04
Epoch 67/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2440 - val_loss: 0.2222 - lr: 1.8750e-04
Epoch 68/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2444 - val_loss: 0.2202 - lr: 1.8750e-04
Epoch 69/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2424
Epoch 69: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
195/195 [==============================] - 5s 27ms/step - loss: 0.2426 - val_loss: 0.2389 - lr: 1.8750e-04
Epoch 70/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2409 - val_loss: 0.2188 - lr: 9.3750e-05
Epoch 71/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2402 - val_loss: 0.2178 - lr: 9.3750e-05
Epoch 72/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2417 - val_loss: 0.2214 - lr: 9.3750e-05
Epoch 73/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2406 - val_loss: 0.2259 - lr: 9.3750e-05
Epoch 74/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2416 - val_loss: 0.2228 - lr: 9.3750e-05
Epoch 75/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2424 - val_loss: 0.2281 - lr: 9.3750e-05
Epoch 76/1000
193/195 [============================>.] - ETA: 15s - loss: 0.2419
Epoch 76: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
```

```
195/195 [==============================] - 1475s 8s/step - loss: 0.2419 - val_loss: 0.2186 - lr: 9.3750e-05
Epoch 77/1000
195/195 [==============================] - 4s 20ms/step - loss: 0.2395 - val_loss: 0.2181 - lr: 4.6875e-05
Epoch 78/1000
195/195 [==============================] - 6s 30ms/step - loss: 0.2389 - val_loss: 0.2190 - lr: 4.6875e-05
Epoch 79/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.2383 - val_loss: 0.2205 - lr: 4.6875e-05
Epoch 80/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2394 - val_loss: 0.2177 - lr: 4.6875e-05
Epoch 81/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2383 - val_loss: 0.2196 - lr: 4.6875e-05
Epoch 82/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2376 - val_loss: 0.2187 - lr: 4.6875e-05
Epoch 83/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2375 - val_loss: 0.2190 - lr: 4.6875e-05
Epoch 84/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2385 - val_loss: 0.2163 - lr: 4.6875e-05
Epoch 85/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.2373 - val_loss: 0.2192 - lr: 4.6875e-05
Epoch 86/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.2381 - val_loss: 0.2189 - lr: 4.6875e-05
Epoch 87/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2375 - val_loss: 0.2163 - lr: 4.6875e-05
Epoch 88/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2379 - val_loss: 0.2223 - lr: 4.6875e-05
Epoch 89/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2373 - val_loss: 0.2165 - lr: 4.6875e-05
Epoch 90/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.2371 - val_loss: 0.2157 - lr: 4.6875e-05
Epoch 91/1000
195/195 [==============================] - 6s 28ms/step - loss: 0.2369 - val_loss: 0.2163 - lr: 4.6875e-05
Epoch 92/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2369 - val_loss: 0.2171 - lr: 4.6875e-05
Epoch 93/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2366 - val_loss: 0.2178 - lr: 4.6875e-05
Epoch 94/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2371 - val_loss: 0.2156 - lr: 4.6875e-05
Epoch 95/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2365 - val_loss: 0.2273 - lr: 4.6875e-05
Epoch 96/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2369 - val_loss: 0.2199 - lr: 4.6875e-05
Epoch 97/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2369 - val_loss: 0.2173 - lr: 4.6875e-05
Epoch 98/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2363 - val_loss: 0.2192 - lr: 4.6875e-05
Epoch 99/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2361
Epoch 99: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 5s 28ms/step - loss: 0.2361 - val_loss: 0.2159 - lr: 4.6875e-05
Epoch 100/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2352 - val_loss: 0.2168 - lr: 2.3438e-05
Epoch 101/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2365 - val_loss: 0.2153 - lr: 2.3438e-05
Epoch 102/1000
195/195 [==============================] - 5s 25ms/step - loss: 0.2354 - val_loss: 0.2230 - lr: 2.3438e-05
```

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Epoch 103/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2355 - val_loss: 0.2163 - lr: 2.3438e-05
Epoch 104/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2344 - val_loss: 0.2191 - lr: 2.3438e-05
Epoch 105/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2350 - val_loss: 0.2180 - lr: 2.3438e-05
Epoch 106/1000
195/195 [==============================] - ETA: 0s - loss: 0.2354
Epoch 106: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
195/195 [==============================] - 5s 27ms/step - loss: 0.2354 - val_loss: 0.2180 - lr: 2.3438e-05
Epoch 107/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2340 - val_loss: 0.2167 - lr: 1.1719e-05
Epoch 108/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2346 - val_loss: 0.2165 - lr: 1.1719e-05
Epoch 109/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2348 - val_loss: 0.2157 - lr: 1.1719e-05
Epoch 110/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2345 - val_loss: 0.2159 - lr: 1.1719e-05
Epoch 111/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2338
Epoch 111: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 5s 27ms/step - loss: 0.2338 - val_loss: 0.2174 - lr: 1.1719e-05
Epoch 112/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2339 - val_loss: 0.2176 - lr: 5.8594e-06
Epoch 113/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2340 - val_loss: 0.2181 - lr: 5.8594e-06
Epoch 114/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2342 - val_loss: 0.2163 - lr: 5.8594e-06
Epoch 115/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2344 - val_loss: 0.2169 - lr: 5.8594e-06
Epoch 116/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2344
Epoch 116: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 5s 27ms/step - loss: 0.2344 - val_loss: 0.2158 - lr: 5.8594e-06
Epoch 117/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2337 - val_loss: 0.2156 - lr: 2.9297e-06
Epoch 118/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2344 - val_loss: 0.2164 - lr: 2.9297e-06
Epoch 119/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2346 - val_loss: 0.2175 - lr: 2.9297e-06
Epoch 120/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2344 - val_loss: 0.2166 - lr: 2.9297e-06
Epoch 121/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2343
Epoch 121: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 5s 27ms/step - loss: 0.2342 - val_loss: 0.2159 - lr: 2.9297e-06
Epoch 122/1000
195/195 [==============================] - 5s 26ms/step - loss: 0.2341 - val_loss: 0.2164 - lr: 1.4648e-06
Epoch 123/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2335 - val_loss: 0.2170 - lr: 1.4648e-06
Epoch 124/1000
195/195 [==============================] - 5s 28ms/step - loss: 0.2335 - val_loss: 0.2170 - lr: 1.4648e-06
Epoch 125/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2346 - val_loss: 0.2166 - lr: 1.4648e-06
Epoch 126/1000
```

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194/195 [============================>.] - ETA: 0s - loss: 0.2341
Epoch 126: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
195/195 [==============================] - 5s 27ms/step - loss: 0.2341 - val_loss: 0.2166 - lr: 1.4648e-06
Epoch 127/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2332 - val_loss: 0.2167 - lr: 7.3242e-07
Epoch 128/1000
195/195 [==============================] - 5s 27ms/step - loss: 0.2342 - val_loss: 0.2166 - lr: 7.3242e-07
Epoch 129/1000
195/195 [==============================] - 6s 31ms/step - loss: 0.2347 - val_loss: 0.2168 - lr: 7.3242e-07
Epoch 130/1000
195/195 [==============================] - 6s 32ms/step - loss: 0.2338 - val_loss: 0.2166 - lr: 7.3242e-07
Epoch 131/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2345
Epoch 131: ReduceLROnPlateau reducing learning rate to 3.6621094068323146e-07.
195/195 [==============================] - 7s 36ms/step - loss: 0.2345 - val_loss: 0.2166 - lr: 7.3242e-07
Epoch 132/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2345Restoring model weights from the end of the best epoch: 101.
195/195 [==============================] - 8s 43ms/step - loss: 0.2345 - val_loss: 0.2165 - lr: 3.6621e-07
Epoch 132: early stopping
3116/3116 [==============================] - 14s 3ms/step
2671/2671 [==============================] - 13s 3ms/step
1it [36:49, 2209.59s/it]
```

```
Epoch 1/1000
195/195 [==============================] - 18s 54ms/step - loss: 39.0062 - val_loss: 0.9894 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 9s 47ms/step - loss: 0.6998 - val_loss: 0.4474 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.6012 - val_loss: 0.4183 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.5855 - val_loss: 0.3534 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.5032 - val_loss: 0.4601 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.5018 - val_loss: 0.3577 - lr: 0.0060
Epoch 7/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.4885 - val_loss: 0.4275 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.4576 - val_loss: 0.2983 - lr: 0.0060
Epoch 9/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.4342 - val_loss: 0.3291 - lr: 0.0060
Epoch 10/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.4869 - val_loss: 0.4466 - lr: 0.0060
Epoch 11/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.4303 - val_loss: 0.3781 - lr: 0.0060
Epoch 12/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.4087 - val_loss: 0.3138 - lr: 0.0060
Epoch 13/1000
195/195 [==============================] - ETA: 0s - loss: 0.3875
Epoch 13: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 7s 34ms/step - loss: 0.3875 - val_loss: 0.3672 - lr: 0.0060
Epoch 14/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3338 - val_loss: 0.2631 - lr: 0.0030
Epoch 15/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3390 - val_loss: 0.2609 - lr: 0.0030
Epoch 16/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3223 - val_loss: 0.2838 - lr: 0.0030
Epoch 17/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3188 - val_loss: 0.2816 - lr: 0.0030
Epoch 18/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3200 - val_loss: 0.2857 - lr: 0.0030
Epoch 19/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3150 - val_loss: 0.2448 - lr: 0.0030
Epoch 20/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3192 - val_loss: 0.2716 - lr: 0.0030
Epoch 21/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3163 - val_loss: 0.3450 - lr: 0.0030
Epoch 22/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3336 - val_loss: 0.3252 - lr: 0.0030
Epoch 23/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3173 - val_loss: 0.2570 - lr: 0.0030
Epoch 24/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3154 - val_loss: 0.2387 - lr: 0.0030
Epoch 25/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3094 - val_loss: 0.2503 - lr: 0.0030
Epoch 26/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3052 - val_loss: 0.2811 - lr: 0.0030
Epoch 27/1000
```

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195/195 [==============================] - 7s 35ms/step - loss: 0.3048 - val_loss: 0.2844 - lr: 0.0030
Epoch 28/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3041 - val_loss: 0.2550 - lr: 0.0030
Epoch 29/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2991
Epoch 29: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 7s 35ms/step - loss: 0.2990 - val_loss: 0.2674 - lr: 0.0030
Epoch 30/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2808 - val_loss: 0.2471 - lr: 0.0015
Epoch 31/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2778 - val_loss: 0.2274 - lr: 0.0015
Epoch 32/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2737 - val_loss: 0.2440 - lr: 0.0015
Epoch 33/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2718 - val_loss: 0.2656 - lr: 0.0015
Epoch 34/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2822 - val_loss: 0.2421 - lr: 0.0015
Epoch 35/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2765 - val_loss: 0.2358 - lr: 0.0015
Epoch 36/1000
195/195 [==============================] - ETA: 0s - loss: 0.2789
Epoch 36: ReduceLROnPlateau reducing learning rate to 0.0007500000006519258.
195/195 [==============================] - 7s 35ms/step - loss: 0.2789 - val_loss: 0.2421 - lr: 0.0015
Epoch 37/1000
195/195 [==============================] - 7s 37ms/step - loss: 0.2617 - val_loss: 0.2244 - lr: 7.5000e-04
Epoch 38/1000
195/195 [==============================] - 7s 37ms/step - loss: 0.2600 - val_loss: 0.2238 - lr: 7.5000e-04
Epoch 39/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2634 - val_loss: 0.2558 - lr: 7.5000e-04
Epoch 40/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2626 - val_loss: 0.2263 - lr: 7.5000e-04
Epoch 41/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2586 - val_loss: 0.2400 - lr: 7.5000e-04
Epoch 42/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2624 - val_loss: 0.2219 - lr: 7.5000e-04
Epoch 43/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2560 - val_loss: 0.3179 - lr: 7.5000e-04
Epoch 44/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2613 - val_loss: 0.2236 - lr: 7.5000e-04
Epoch 45/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2604 - val_loss: 0.2397 - lr: 7.5000e-04
Epoch 46/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2583 - val_loss: 0.2552 - lr: 7.5000e-04
Epoch 47/1000
195/195 [==============================] - ETA: 0s - loss: 0.2614
Epoch 47: ReduceLROnPlateau reducing learning rate to 0.0003750000003259629.
195/195 [==============================] - 7s 35ms/step - loss: 0.2614 - val_loss: 0.2248 - lr: 7.5000e-04
Epoch 48/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2523 - val_loss: 0.2239 - lr: 3.7500e-04
Epoch 49/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2530 - val_loss: 0.2327 - lr: 3.7500e-04
Epoch 50/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2510 - val_loss: 0.2447 - lr: 3.7500e-04
Epoch 51/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2507 - val_loss: 0.2266 - lr: 3.7500e-04
```

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Epoch 52/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2515
Epoch 52: ReduceLROnPlateau reducing learning rate to 0.0001875000016298145.
195/195 [==============================] - 7s 35ms/step - loss: 0.2515 - val_loss: 0.2242 - lr: 3.7500e-04
Epoch 53/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2461 - val_loss: 0.2257 - lr: 1.8750e-04
Epoch 54/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2474 - val_loss: 0.2280 - lr: 1.8750e-04
Epoch 55/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2466 - val_loss: 0.2205 - lr: 1.8750e-04
Epoch 56/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2470 - val_loss: 0.2223 - lr: 1.8750e-04
Epoch 57/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2471 - val_loss: 0.2308 - lr: 1.8750e-04
Epoch 58/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2466 - val_loss: 0.2336 - lr: 1.8750e-04
Epoch 59/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2450 - val_loss: 0.2218 - lr: 1.8750e-04
Epoch 60/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2455
Epoch 60: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
195/195 [==============================] - 7s 35ms/step - loss: 0.2455 - val_loss: 0.2271 - lr: 1.8750e-04
Epoch 61/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2447 - val_loss: 0.2211 - lr: 9.3750e-05
Epoch 62/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2439 - val_loss: 0.2228 - lr: 9.3750e-05
Epoch 63/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2426 - val_loss: 0.2209 - lr: 9.3750e-05
Epoch 64/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2439 - val_loss: 0.2267 - lr: 9.3750e-05
Epoch 65/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2433
Epoch 65: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
195/195 [==============================] - 7s 35ms/step - loss: 0.2432 - val_loss: 0.2246 - lr: 9.3750e-05
Epoch 66/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2416 - val_loss: 0.2209 - lr: 4.6875e-05
Epoch 67/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2408 - val_loss: 0.2229 - lr: 4.6875e-05
Epoch 68/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2414 - val_loss: 0.2201 - lr: 4.6875e-05
Epoch 69/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2416 - val_loss: 0.2293 - lr: 4.6875e-05
Epoch 70/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2412 - val_loss: 0.2246 - lr: 4.6875e-05
Epoch 71/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2420 - val_loss: 0.2209 - lr: 4.6875e-05
Epoch 72/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2412 - val_loss: 0.2280 - lr: 4.6875e-05
Epoch 73/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2414
Epoch 73: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 7s 35ms/step - loss: 0.2414 - val_loss: 0.2231 - lr: 4.6875e-05
Epoch 74/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2410 - val_loss: 0.2179 - lr: 2.3438e-05
Epoch 75/1000
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195/195 [==============================] - 7s 35ms/step - loss: 0.2400 - val_loss: 0.2221 - lr: 2.3438e-05
Epoch 76/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2401 - val_loss: 0.2212 - lr: 2.3438e-05
Epoch 77/1000
195/195 [==============================] - 3750s 19s/step - loss: 0.2398 - val_loss: 0.2202 - lr: 2.3438e-05
Epoch 78/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2402 - val_loss: 0.2196 - lr: 2.3438e-05
Epoch 79/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2399
Epoch 79: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
195/195 [==============================] - 7s 37ms/step - loss: 0.2398 - val_loss: 0.2205 - lr: 2.3438e-05
Epoch 80/1000
195/195 [==============================] - 8s 39ms/step - loss: 0.2405 - val_loss: 0.2183 - lr: 1.1719e-05
Epoch 81/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2395 - val_loss: 0.2216 - lr: 1.1719e-05
Epoch 82/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2394 - val_loss: 0.2198 - lr: 1.1719e-05
Epoch 83/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2398 - val_loss: 0.2224 - lr: 1.1719e-05
Epoch 84/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2391
Epoch 84: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 7s 34ms/step - loss: 0.2391 - val_loss: 0.2203 - lr: 1.1719e-05
Epoch 85/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2390 - val_loss: 0.2201 - lr: 5.8594e-06
Epoch 86/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2393 - val_loss: 0.2196 - lr: 5.8594e-06
Epoch 87/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2387 - val_loss: 0.2198 - lr: 5.8594e-06
Epoch 88/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2390 - val_loss: 0.2202 - lr: 5.8594e-06
Epoch 89/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2387
Epoch 89: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 7s 36ms/step - loss: 0.2388 - val_loss: 0.2199 - lr: 5.8594e-06
Epoch 90/1000
195/195 [==============================] - 6s 33ms/step - loss: 0.2391 - val_loss: 0.2204 - lr: 2.9297e-06
Epoch 91/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2382 - val_loss: 0.2205 - lr: 2.9297e-06
Epoch 92/1000
195/195 [==============================] - 7s 37ms/step - loss: 0.2389 - val_loss: 0.2212 - lr: 2.9297e-06
Epoch 93/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2392 - val_loss: 0.2205 - lr: 2.9297e-06
Epoch 94/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2393
Epoch 94: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 7s 35ms/step - loss: 0.2393 - val_loss: 0.2201 - lr: 2.9297e-06
Epoch 95/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2389 - val_loss: 0.2205 - lr: 1.4648e-06
Epoch 96/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2394 - val_loss: 0.2200 - lr: 1.4648e-06
Epoch 97/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2387 - val_loss: 0.2196 - lr: 1.4648e-06
Epoch 98/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2400 - val_loss: 0.2205 - lr: 1.4648e-06
```

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Epoch 99/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2398
Epoch 99: ReduceLROnPlateau reducing learning rate to 7.324218813664629e-07.
195/195 [==============================] - 7s 34ms/step - loss: 0.2399 - val_loss: 0.2196 - lr: 1.4648e-06
Epoch 100/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2393 - val_loss: 0.2201 - lr: 7.3242e-07
Epoch 101/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2388 - val_loss: 0.2206 - lr: 7.3242e-07
Epoch 102/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2392 - val_loss: 0.2200 - lr: 7.3242e-07
Epoch 103/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2386 - val_loss: 0.2203 - lr: 7.3242e-07
Epoch 104/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2394
Epoch 104: ReduceLROnPlateau reducing learning rate to 3.6621094068323146e-07.
195/195 [==============================] - 7s 35ms/step - loss: 0.2395 - val_loss: 0.2201 - lr: 7.3242e-07
Epoch 105/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2385Restoring model weights from the end of the best epoch: 74.
195/195 [==============================] - 7s 35ms/step - loss: 0.2385 - val_loss: 0.2202 - lr: 3.6621e-07
Epoch 105: early stopping
3116/3116 [==============================] - 13s 3ms/step
2671/2671 [==============================] - 12s 3ms/step
2it [1:51:50, 3557.51s/it]
```

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Epoch 1/1000
195/195 [==============================] - 17s 54ms/step - loss: 48.5780 - val_loss: 0.7856 - lr: 0.0060
Epoch 2/1000
195/195 [==============================] - 9s 47ms/step - loss: 0.6693 - val_loss: 0.3426 - lr: 0.0060
Epoch 3/1000
195/195 [==============================] - 9s 47ms/step - loss: 0.5643 - val_loss: 0.4065 - lr: 0.0060
Epoch 4/1000
195/195 [==============================] - 9s 46ms/step - loss: 0.5316 - val_loss: 0.5191 - lr: 0.0060
Epoch 5/1000
195/195 [==============================] - 9s 47ms/step - loss: 0.5161 - val_loss: 0.3444 - lr: 0.0060
Epoch 6/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.4799 - val_loss: 0.6131 - lr: 0.0060
Epoch 7/1000
194/195 [============================>.] - ETA: 0s - loss: 0.4526
Epoch 7: ReduceLROnPlateau reducing learning rate to 0.0030000000026077032.
195/195 [==============================] - 7s 35ms/step - loss: 0.4522 - val_loss: 0.3879 - lr: 0.0060
Epoch 8/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3624 - val_loss: 0.3401 - lr: 0.0030
Epoch 9/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3584 - val_loss: 0.3655 - lr: 0.0030
Epoch 10/1000
195/195 [==============================] - 11s 57ms/step - loss: 0.3691 - val_loss: 0.3978 - lr: 0.0030
Epoch 11/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3597 - val_loss: 0.3137 - lr: 0.0030
Epoch 12/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3559 - val_loss: 0.2800 - lr: 0.0030
Epoch 13/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3525 - val_loss: 0.3052 - lr: 0.0030
Epoch 14/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3529 - val_loss: 0.2956 - lr: 0.0030
Epoch 15/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.3552 - val_loss: 0.3707 - lr: 0.0030
Epoch 16/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3644 - val_loss: 0.2525 - lr: 0.0030
Epoch 17/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3658 - val_loss: 0.2948 - lr: 0.0030
Epoch 18/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3481 - val_loss: 0.2822 - lr: 0.0030
Epoch 19/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3637 - val_loss: 0.2709 - lr: 0.0030
Epoch 20/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3362 - val_loss: 0.3200 - lr: 0.0030
Epoch 21/1000
193/195 [============================>.] - ETA: 0s - loss: 0.3435
Epoch 21: ReduceLROnPlateau reducing learning rate to 0.0015000000013038516.
195/195 [==============================] - 7s 35ms/step - loss: 0.3431 - val_loss: 0.2848 - lr: 0.0030
Epoch 22/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.3028 - val_loss: 0.2545 - lr: 0.0015
Epoch 23/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.3002 - val_loss: 0.2310 - lr: 0.0015
Epoch 24/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2986 - val_loss: 0.2393 - lr: 0.0015
Epoch 25/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2938 - val_loss: 0.2628 - lr: 0.0015
Epoch 26/1000
```

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195/195 [==============================] - 7s 34ms/step - loss: 0.2943 - val_loss: 0.2460 - lr: 0.0015
Epoch 27/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2913 - val_loss: 0.2589 - lr: 0.0015
Epoch 28/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2964
Epoch 28: ReduceLROnPlateau reducing learning rate to 0.000750000006519258.
195/195 [==============================] - 7s 33ms/step - loss: 0.2964 - val_loss: 0.2635 - lr: 0.0015
Epoch 29/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2803 - val_loss: 0.2507 - lr: 7.5000e-04
Epoch 30/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2820 - val_loss: 0.2499 - lr: 7.5000e-04
Epoch 31/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2828 - val_loss: 0.2300 - lr: 7.5000e-04
Epoch 32/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2806 - val_loss: 0.2581 - lr: 7.5000e-04
Epoch 33/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2836 - val_loss: 0.2524 - lr: 7.5000e-04
Epoch 34/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2765 - val_loss: 0.2397 - lr: 7.5000e-04
Epoch 35/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2790 - val_loss: 0.2795 - lr: 7.5000e-04
Epoch 36/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2780
Epoch 36: ReduceLROnPlateau reducing learning rate to 0.000375000003259629.
195/195 [==============================] - 7s 34ms/step - loss: 0.2781 - val_loss: 0.2308 - lr: 7.5000e-04
Epoch 37/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2693 - val_loss: 0.2525 - lr: 3.7500e-04
Epoch 38/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2677 - val_loss: 0.2398 - lr: 3.7500e-04
Epoch 39/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2717 - val_loss: 0.2297 - lr: 3.7500e-04
Epoch 40/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2683 - val_loss: 0.2378 - lr: 3.7500e-04
Epoch 41/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2667 - val_loss: 0.2368 - lr: 3.7500e-04
Epoch 42/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2678 - val_loss: 0.2336 - lr: 3.7500e-04
Epoch 43/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2678 - val_loss: 0.2338 - lr: 3.7500e-04
Epoch 44/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2653
Epoch 44: ReduceLROnPlateau reducing learning rate to 0.000187500000162981 45.
195/195 [==============================] - 7s 35ms/step - loss: 0.2653 - val_loss: 0.2410 - lr: 3.7500e-04
Epoch 45/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2623 - val_loss: 0.2441 - lr: 1.8750e-04
Epoch 46/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2628 - val_loss: 0.2342 - lr: 1.8750e-04
Epoch 47/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2604 - val_loss: 0.2340 - lr: 1.8750e-04
Epoch 48/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2608 - val_loss: 0.2489 - lr: 1.8750e-04
Epoch 49/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2585
Epoch 49: ReduceLROnPlateau reducing learning rate to 9.375000081490725e-05.
195/195 [==============================] - 7s 34ms/step - loss: 0.2585 - val_loss: 0.2304 - lr: 1.8750e-04
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Epoch 50/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2561 - val_loss: 0.2227 - lr: 9.3750e-05
Epoch 51/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2568 - val_loss: 0.2284 - lr: 9.3750e-05
Epoch 52/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2565 - val_loss: 0.2336 - lr: 9.3750e-05
Epoch 53/1000
195/195 [==============================] - 7s 37ms/step - loss: 0.2554 - val_loss: 0.2367 - lr: 9.3750e-05
Epoch 54/1000
195/195 [==============================] - 7s 37ms/step - loss: 0.2559 - val_loss: 0.2245 - lr: 9.3750e-05
Epoch 55/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2569
Epoch 55: ReduceLROnPlateau reducing learning rate to 4.6875000407453626e-05.
195/195 [==============================] - 7s 34ms/step - loss: 0.2568 - val_loss: 0.2336 - lr: 9.3750e-05
Epoch 56/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2538 - val_loss: 0.2356 - lr: 4.6875e-05
Epoch 57/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2539 - val_loss: 0.2243 - lr: 4.6875e-05
Epoch 58/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2545 - val_loss: 0.2270 - lr: 4.6875e-05
Epoch 59/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2547 - val_loss: 0.2326 - lr: 4.6875e-05
Epoch 60/1000
195/195 [==============================] - ETA: 0s - loss: 0.2545
Epoch 60: ReduceLROnPlateau reducing learning rate to 2.3437500203726813e-05.
195/195 [==============================] - 7s 34ms/step - loss: 0.2545 - val_loss: 0.2283 - lr: 4.6875e-05
Epoch 61/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2528 - val_loss: 0.2258 - lr: 2.3438e-05
Epoch 62/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2518 - val_loss: 0.2317 - lr: 2.3438e-05
Epoch 63/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2518 - val_loss: 0.2231 - lr: 2.3438e-05
Epoch 64/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2533 - val_loss: 0.2231 - lr: 2.3438e-05
Epoch 65/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2512
Epoch 65: ReduceLROnPlateau reducing learning rate to 1.1718750101863407e-05.
195/195 [==============================] - 7s 34ms/step - loss: 0.2512 - val_loss: 0.2242 - lr: 2.3438e-05
Epoch 66/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2516 - val_loss: 0.2249 - lr: 1.1719e-05
Epoch 67/1000
195/195 [==============================] - 8s 40ms/step - loss: 0.2513 - val_loss: 0.2233 - lr: 1.1719e-05
Epoch 68/1000
195/195 [==============================] - 7s 36ms/step - loss: 0.2516 - val_loss: 0.2249 - lr: 1.1719e-05
Epoch 69/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2519 - val_loss: 0.2249 - lr: 1.1719e-05
Epoch 70/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2507
Epoch 70: ReduceLROnPlateau reducing learning rate to 5.859375050931703e-06.
195/195 [==============================] - 7s 34ms/step - loss: 0.2507 - val_loss: 0.2312 - lr: 1.1719e-05
Epoch 71/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2517 - val_loss: 0.2239 - lr: 5.8594e-06
Epoch 72/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2504 - val_loss: 0.2242 - lr: 5.8594e-06
Epoch 73/1000
```

```
195/195 [==============================] - 7s 34ms/step - loss: 0.2513 - val_loss: 0.2268 - lr: 5.8594e-06
Epoch 74/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2518 - val_loss: 0.2267 - lr: 5.8594e-06
Epoch 75/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2508
Epoch 75: ReduceLROnPlateau reducing learning rate to 2.9296875254658516e-06.
195/195 [==============================] - 7s 35ms/step - loss: 0.2509 - val_loss: 0.2259 - lr: 5.8594e-06
Epoch 76/1000
195/195 [==============================] - 7s 35ms/step - loss: 0.2513 - val_loss: 0.2242 - lr: 2.9297e-06
Epoch 77/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2511 - val_loss: 0.2249 - lr: 2.9297e-06
Epoch 78/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2504 - val_loss: 0.2246 - lr: 2.9297e-06
Epoch 79/1000
195/195 [==============================] - 7s 34ms/step - loss: 0.2512 - val_loss: 0.2257 - lr: 2.9297e-06
Epoch 80/1000
194/195 [============================>.] - ETA: 0s - loss: 0.2503
Epoch 80: ReduceLROnPlateau reducing learning rate to 1.4648437627329258e-06.
195/195 [==============================] - 7s 35ms/step - loss: 0.2504 - val_loss: 0.2249 - lr: 2.9297e-06
Epoch 81/1000
193/195 [============================>.] - ETA: 0s - loss: 0.2505Restoring model weights from the end of the best epoch: 50.
195/195 [==============================] - 7s 35ms/step - loss: 0.2504 - val_loss: 0.2252 - lr: 1.4648e-06
Epoch 81: early stopping
3116/3116 [==============================] - 14s 3ms/step
2671/2671 [==============================] - 11s 3ms/step
3it [2:01:53, 2437.73s/it]
```

In [ ]:
```
print(cnn_test_predict_mean.shape, cnn_train_predict.shape)
```

```
(85444, 1) (299050, 1)
```

MLP

In [ ]:
```
def np_rmspe(y_true, y_pred):
    return np.sqrt(np.mean(np.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def rmspe(y_true, y_pred):
    return K.sqrt(K.mean(K.square((y_true-y_pred)/y_true)))
```

In [ ]:
```
def MLP(X_train, y_train, X_val, y_val):

    inputs= tf.keras.Input(
            shape=(X_train.shape[1],)
        )
    hidden1=tf.keras.layers.Dense(
            units=int(np.round(X_train.shape[1]/2, 0)),
            kernel_initializer='he_uniform',
            activation='LeakyReLU'
        )(inputs)
    hidden2=tf.keras.layers.Dense(
            units=int(np.round(X_train.shape[1]/4, 0)),
            kernel_initializer='he_uniform',
            activation='LeakyReLU'
        )(hidden1)
```

```
    outputs=tf.keras.layers.Dense(
            units=1,
    )(hidden2)

    model = Model(inputs, outputs)
    model.summary()

    model.compile(optimizer=tf.keras.optimizers.Adam(0.001),
                loss=rmspe)

    rlr = tf.keras.callbacks.ReduceLROnPlateau(monitor='val_loss', factor=0.5, patience=3, min_delta=1e-5, min_lr=1e-5, verbose=1)
    es = tf.keras.callbacks.EarlyStopping(monitor='val_loss', min_delta=1e-5, patience=11, restore_best_weights=True, verbose=1)
    callback_list = [rlr, es]
    history = model.fit(X_train, y_train,
                        batch_size=500, epochs=1000, verbose=1,
                        validation_data=(X_val, y_val), callbacks=callback_list
    )

    return model
```

In [ ]:

```
tf.random.set_seed(777)

n_folds = 3
kfold = KFold(n_splits=n_folds, shuffle=True, random_state=0)
train_fold_predict = np.zeros((X_train_scaled.shape[0], 1))
test_predict = np.zeros((X_test_scaled.shape[0], n_folds))

for cv_num, (train_index, val_index) in tqdm(enumerate(kfold.split(X_train_scaled))):
    X_train_ = X_train_scaled[train_index,:]
    y_train_ = y_train.iloc[train_index]
    X_val_ = X_train_scaled[val_index,:]

    model = MLP(X_train_, y_train_, X_val_scaled, y_val)

    train_fold_predict[val_index,:] = model.predict(X_val_).reshape(-1,1)
    test_predict[:,cv_num] = model.predict(np.array(X_test_scaled)).reshape(-1)

mlp_test_predict_mean = np.mean(test_predict, axis=1).reshape(-1,1)
mlp_train_predict = train_fold_predict
```

```
0it [00:00, ?it/s]
```

```
Metal device set to: Apple M1 Pro

systemMemory: 16.00 GB
maxCacheSize: 5.33 GB

Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 397)]             0

 dense (Dense)               (None, 198)               78804

 dense_1 (Dense)             (None, 99)                19701

 dense_2 (Dense)             (None, 1)                 100

=================================================================
Total params: 98,605
Trainable params: 98,605
Non-trainable params: 0
_________________________________________________________________
2022-10-26 13:06:15.364116: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:305] Could not identify NUMA node of platform GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA support.
2022-10-26 13:06:15.365287: I tensorflow/core/common_runtime/pluggable_device/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhost/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevice (device: 0, name: METAL, pci bus id: <undefined>)
Epoch 1/1000
2022-10-26 13:06:15.744569: W tensorflow/core/platform/profile_utils/cpu_utils.cc:128] Failed to get CPU frequency: 0 Hz
2022-10-26 13:06:15.985953: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
399/399 [==============================] - ETA: 0s - loss: 69.8917
2022-10-26 13:06:19.247883: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
399/399 [==============================] - 4s 7ms/step - loss: 69.8917 - val_loss: 28.7251 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 22.1466 - val_loss: 27.9419 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 2s 6ms/step - loss: 13.8049 - val_loss: 9.1604 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 2s 6ms/step - loss: 11.2866 - val_loss: 11.4837 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 11.0396 - val_loss: 6.0285 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.0630 - val_loss: 3.8864 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.0541 - val_loss: 3.4878 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 13.6172 - val_loss: 7.4633 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 10.1712 - val_loss: 3.7653 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.2801 - val_loss: 2.5314 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.5208 - val_loss: 2.0445 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.5997 - val_loss: 1.8459 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.3807 - val_loss: 1.6711 - lr: 0.0010
Epoch 14/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.8939 - val_loss: 3.2889 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.1837 - val_loss: 2.5656 - lr: 0.0010
Epoch 16/1000
399/399 [==============================] - ETA: 0s - loss: 12.0589
Epoch 16: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 12.0589 - val_loss: 6.4767 - lr: 0.0010
Epoch 17/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.7669 - val_loss: 1.0650 - lr: 5.0000e-04
Epoch 18/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.5689 - val_loss: 4.5493 - lr: 5.0000e-04
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.3350 - val_loss: 0.4042 - lr: 5.0000e-04
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.9297 - val_loss: 2.9385 - lr: 5.0000e-04
Epoch 21/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.7966 - val_loss: 0.7453 - lr: 5.0000e-04
Epoch 22/1000
398/399 [============================>.] - ETA: 0s - loss: 1.3116
Epoch 22: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 1.3152 - val_loss: 4.0306 - lr: 5.0000e-04
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.1190 - val_loss: 0.9466 - lr: 2.5000e-04
Epoch 24/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.4868 - val_loss: 0.8561 - lr: 2.5000e-04
Epoch 25/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5550 - val_loss: 0.3112 - lr: 2.5000e-04
Epoch 26/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4700 - val_loss: 0.8035 - lr: 2.5000e-04
```

```
Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4326 - val_loss: 0.2678 - lr: 2.5000e-04
Epoch 28/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4051 - val_loss: 0.8855 - lr: 2.5000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4400 - val_loss: 0.2985 - lr: 2.5000e-04
Epoch 30/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3788 - val_loss: 0.2535 - lr: 2.5000e-04
Epoch 31/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5785 - val_loss: 0.9196 - lr: 2.5000e-04
Epoch 32/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.8049 - val_loss: 0.3076 - lr: 2.5000e-04
Epoch 33/1000
392/399 [============================>.] - ETA: 0s - loss: 0.4365
Epoch 33: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.4337 - val_loss: 0.2678 - lr: 2.5000e-04
Epoch 34/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2778 - val_loss: 0.3277 - lr: 1.2500e-04
Epoch 35/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3023 - val_loss: 0.2631 - lr: 1.2500e-04
Epoch 36/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3036 - val_loss: 0.2530 - lr: 1.2500e-04
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2742 - val_loss: 0.2346 - lr: 1.2500e-04
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3181 - val_loss: 0.2372 - lr: 1.2500e-04
Epoch 39/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2927 - val_loss: 0.2520 - lr: 1.2500e-04
Epoch 40/1000
393/399 [============================>.] - ETA: 0s - loss: 0.3064
Epoch 40: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.3053 - val_loss: 0.2356 - lr: 1.2500e-04
Epoch 41/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2607 - val_loss: 0.2281 - lr: 6.2500e-05
Epoch 42/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2586 - val_loss: 0.2379 - lr: 6.2500e-05
Epoch 43/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2557 - val_loss: 0.2282 - lr: 6.2500e-05
Epoch 44/1000
391/399 [============================>.] - ETA: 0s - loss: 0.2433
Epoch 44: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2430 - val_loss: 0.2335 - lr: 6.2500e-05
Epoch 45/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2302 - val_loss: 0.2271 - lr: 3.1250e-05
Epoch 46/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2290 - val_loss: 0.2291 - lr: 3.1250e-05
Epoch 47/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2306 - val_loss: 0.2309 - lr: 3.1250e-05
Epoch 48/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2317 - val_loss: 0.2264 - lr: 3.1250e-05
Epoch 49/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2285 - val_loss: 0.2237 - lr: 3.1250e-05
Epoch 50/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2281 - val_loss: 0.2264 - lr: 3.1250e-05
Epoch 51/1000
```

```
399/399 [==============================] - 3s 7ms/step - loss: 0.2299 - val_loss: 0.2259 - lr: 3.1250e-05
Epoch 52/1000
399/399 [==============================] - ETA: 0s - loss: 0.2287
Epoch 52: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 3s 7ms/step - loss: 0.2287 - val_loss: 0.2283 - lr: 3.1250e-05
Epoch 53/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2196 - val_loss: 0.2243 - lr: 1.5625e-05
Epoch 54/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2207 - val_loss: 0.2217 - lr: 1.5625e-05
Epoch 55/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2196 - val_loss: 0.2231 - lr: 1.5625e-05
Epoch 56/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2213 - val_loss: 0.2247 - lr: 1.5625e-05
Epoch 57/1000
391/399 [============================>.] - ETA: 0s - loss: 0.2200
Epoch 57: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2199 - val_loss: 0.2267 - lr: 1.5625e-05
Epoch 58/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2168 - val_loss: 0.2236 - lr: 1.0000e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2155 - val_loss: 0.2262 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2160 - val_loss: 0.2205 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2154 - val_loss: 0.2223 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2163 - val_loss: 0.2274 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2144 - val_loss: 0.2201 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2151 - val_loss: 0.2205 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2156 - val_loss: 0.2257 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2142 - val_loss: 0.2230 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2142 - val_loss: 0.2207 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2139 - val_loss: 0.2230 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2146 - val_loss: 0.2313 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2148 - val_loss: 0.2212 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2142 - val_loss: 0.2223 - lr: 1.0000e-05
Epoch 72/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2143 - val_loss: 0.2215 - lr: 1.0000e-05
Epoch 73/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2143 - val_loss: 0.2211 - lr: 1.0000e-05
Epoch 74/1000
395/399 [============================>.] - ETA: 0s - loss: 0.2155Restoring model weights from the end of the best epoch: 63.
399/399 [==============================] - 2s 6ms/step - loss: 0.2153 - val_loss: 0.2277 - lr: 1.0000e-05
Epoch 74: early stopping
  93/3116 [..............................] - ETA: 5s
```

```
2022-10-26 13:09:15.701790: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 4s 2ms/step

1it [03:11, 191.21s/it]
Model: "model_1"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 397)]             0

 dense_3 (Dense)             (None, 198)               78804

 dense_4 (Dense)             (None, 99)                19701

 dense_5 (Dense)             (None, 1)                 100

=================================================================
Total params: 98,605
Trainable params: 98,605
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
 10/399 [..............................] - ETA: 2s - loss: 379.0120
2022-10-26 13:09:27.443299: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
399/399 [==============================] - ETA: 0s - loss: 62.5336
2022-10-26 13:09:30.015212: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
399/399 [==============================] - 3s 7ms/step - loss: 62.5336 - val_loss: 25.0395 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 20.7031 - val_loss: 13.3592 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 2s 6ms/step - loss: 13.8686 - val_loss: 14.5686 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 2s 6ms/step - loss: 12.9809 - val_loss: 6.3854 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.4222 - val_loss: 7.5742 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.4006 - val_loss: 4.7529 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.2259 - val_loss: 5.3312 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.8789 - val_loss: 4.3545 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.0142 - val_loss: 3.1657 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.3477 - val_loss: 4.0384 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.5982 - val_loss: 2.6650 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.0956 - val_loss: 2.8792 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.5107 - val_loss: 5.0039 - lr: 0.0010
Epoch 14/1000
396/399 [============================>.] - ETA: 0s - loss: 2.8634
Epoch 14: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 2.8633 - val_loss: 2.8035 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.7871 - val_loss: 1.9520 - lr: 5.0000e-04
Epoch 16/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.5753 - val_loss: 1.4579 - lr: 5.0000e-04
Epoch 17/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.5369 - val_loss: 2.2359 - lr: 5.0000e-04
Epoch 18/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.1561 - val_loss: 1.8470 - lr: 5.0000e-04
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.6958 - val_loss: 1.1803 - lr: 5.0000e-04
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.1010 - val_loss: 1.6024 - lr: 5.0000e-04
Epoch 21/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.1125 - val_loss: 1.0103 - lr: 5.0000e-04
Epoch 22/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.0806 - val_loss: 0.5798 - lr: 5.0000e-04
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.1569 - val_loss: 0.8401 - lr: 5.0000e-04
Epoch 24/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.7736 - val_loss: 0.4282 - lr: 5.0000e-04
Epoch 25/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.2951 - val_loss: 0.7485 - lr: 5.0000e-04
Epoch 26/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.0901 - val_loss: 0.9989 - lr: 5.0000e-04
Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.6909 - val_loss: 0.3855 - lr: 5.0000e-04
```

```
Epoch 28/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.1248 - val_loss: 1.6406 - lr: 5.0000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.7109 - val_loss: 0.4085 - lr: 5.0000e-04
Epoch 30/1000
397/399 [============================>.] - ETA: 0s - loss: 1.0908
Epoch 30: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 1.0906 - val_loss: 1.2058 - lr: 5.0000e-04
Epoch 31/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3545 - val_loss: 0.2612 - lr: 2.5000e-04
Epoch 32/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3403 - val_loss: 0.3427 - lr: 2.5000e-04
Epoch 33/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4039 - val_loss: 0.2688 - lr: 2.5000e-04
Epoch 34/1000
399/399 [==============================] - ETA: 0s - loss: 0.3612
Epoch 34: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.3612 - val_loss: 0.4892 - lr: 2.5000e-04
Epoch 35/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2867 - val_loss: 0.2386 - lr: 1.2500e-04
Epoch 36/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2662 - val_loss: 0.2377 - lr: 1.2500e-04
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2808 - val_loss: 0.2434 - lr: 1.2500e-04
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2908 - val_loss: 0.2388 - lr: 1.2500e-04
Epoch 39/1000
394/399 [============================>.] - ETA: 0s - loss: 0.3056
Epoch 39: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.3051 - val_loss: 0.2441 - lr: 1.2500e-04
Epoch 40/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2424 - val_loss: 0.2408 - lr: 6.2500e-05
Epoch 41/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2427 - val_loss: 0.2353 - lr: 6.2500e-05
Epoch 42/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2383 - val_loss: 0.2378 - lr: 6.2500e-05
Epoch 43/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2384 - val_loss: 0.3318 - lr: 6.2500e-05
Epoch 44/1000
396/399 [============================>.] - ETA: 0s - loss: 0.2500
Epoch 44: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2499 - val_loss: 0.2494 - lr: 6.2500e-05
Epoch 45/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2310 - val_loss: 0.2295 - lr: 3.1250e-05
Epoch 46/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2299 - val_loss: 0.2559 - lr: 3.1250e-05
Epoch 47/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2280 - val_loss: 0.2259 - lr: 3.1250e-05
Epoch 48/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2302 - val_loss: 0.2230 - lr: 3.1250e-05
Epoch 49/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2286 - val_loss: 0.2298 - lr: 3.1250e-05
Epoch 50/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2273 - val_loss: 0.2227 - lr: 3.1250e-05
Epoch 51/1000
```

```
399/399 [==============================] - 2s 6ms/step - loss: 0.2292 - val_loss: 0.2246 - lr: 3.1250e-05
Epoch 52/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2249 - val_loss: 0.2261 - lr: 3.1250e-05
Epoch 53/1000
399/399 [==============================] - ETA: 0s - loss: 0.2244
Epoch 53: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2244 - val_loss: 0.2349 - lr: 3.1250e-05
Epoch 54/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2217 - val_loss: 0.2229 - lr: 1.5625e-05
Epoch 55/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2197 - val_loss: 0.2262 - lr: 1.5625e-05
Epoch 56/1000
395/399 [============================>.] - ETA: 0s - loss: 0.2186
Epoch 56: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2187 - val_loss: 0.2290 - lr: 1.5625e-05
Epoch 57/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2174 - val_loss: 0.2203 - lr: 1.0000e-05
Epoch 58/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2158 - val_loss: 0.2203 - lr: 1.0000e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2169 - val_loss: 0.2207 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2159 - val_loss: 0.2193 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2160 - val_loss: 0.2191 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2171 - val_loss: 0.2230 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2151 - val_loss: 0.2218 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2156 - val_loss: 0.2212 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2146 - val_loss: 0.2213 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2160 - val_loss: 0.2207 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2157 - val_loss: 0.2240 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2146 - val_loss: 0.2237 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2160 - val_loss: 0.2201 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2142 - val_loss: 0.2206 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2141 - val_loss: 0.2236 - lr: 1.0000e-05
Epoch 72/1000
398/399 [============================>.] - ETA: 0s - loss: 0.2139Restoring model weights from the end of the best epoch: 61.
399/399 [==============================] - 2s 6ms/step - loss: 0.2140 - val_loss: 0.2215 - lr: 1.0000e-05
Epoch 72: early stopping
  94/3116 [..............................] - ETA: 4s
2022-10-26 13:12:20.246898: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 5s 2ms/step
2it [06:16, 187.55s/it]
```

```
Model: "model_2"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_3 (InputLayer)        [(None, 397)]             0

 dense_6 (Dense)             (None, 198)               78804

 dense_7 (Dense)             (None, 99)                19701

 dense_8 (Dense)             (None, 1)                 100

=================================================================
Total params: 98,605
Trainable params: 98,605
Non-trainable params: 0
_________________________________________________________________
Epoch 1/1000
  8/399 [..............................] - ETA: 2s - loss: 476.0985
2022-10-26 13:12:32.180265: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
399/399 [==============================] - ETA: 0s - loss: 76.4363
2022-10-26 13:12:35.190623: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
```

```
399/399 [==============================] - 3s 8ms/step - loss: 76.4363 - val_loss: 26.6507 - lr: 0.0010
Epoch 2/1000
399/399 [==============================] - 2s 6ms/step - loss: 21.8769 - val_loss: 13.9779 - lr: 0.0010
Epoch 3/1000
399/399 [==============================] - 2s 6ms/step - loss: 19.2746 - val_loss: 9.8844 - lr: 0.0010
Epoch 4/1000
399/399 [==============================] - 2s 6ms/step - loss: 10.2649 - val_loss: 10.0106 - lr: 0.0010
Epoch 5/1000
399/399 [==============================] - 2s 6ms/step - loss: 7.7060 - val_loss: 5.4153 - lr: 0.0010
Epoch 6/1000
399/399 [==============================] - 2s 6ms/step - loss: 5.6507 - val_loss: 4.2045 - lr: 0.0010
Epoch 7/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.7786 - val_loss: 4.5118 - lr: 0.0010
Epoch 8/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.0423 - val_loss: 3.6279 - lr: 0.0010
Epoch 9/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.7295 - val_loss: 4.7085 - lr: 0.0010
Epoch 10/1000
399/399 [==============================] - 2s 6ms/step - loss: 4.1805 - val_loss: 2.7694 - lr: 0.0010
Epoch 11/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.8336 - val_loss: 2.5705 - lr: 0.0010
Epoch 12/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.6143 - val_loss: 2.3021 - lr: 0.0010
Epoch 13/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.4804 - val_loss: 2.3131 - lr: 0.0010
Epoch 14/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.8192 - val_loss: 2.1401 - lr: 0.0010
Epoch 15/1000
399/399 [==============================] - 2s 6ms/step - loss: 2.3220 - val_loss: 2.3240 - lr: 0.0010
Epoch 16/1000
399/399 [==============================] - 3s 6ms/step - loss: 1.9474 - val_loss: 1.2404 - lr: 0.0010
Epoch 17/1000
399/399 [==============================] - 3s 7ms/step - loss: 1.4458 - val_loss: 0.9898 - lr: 0.0010
Epoch 18/1000
399/399 [==============================] - 3s 6ms/step - loss: 1.5416 - val_loss: 0.7147 - lr: 0.0010
Epoch 19/1000
399/399 [==============================] - 2s 6ms/step - loss: 1.0913 - val_loss: 0.3870 - lr: 0.0010
Epoch 20/1000
399/399 [==============================] - 2s 6ms/step - loss: 6.3731 - val_loss: 25.5094 - lr: 0.0010
Epoch 21/1000
399/399 [==============================] - 2s 6ms/step - loss: 3.6203 - val_loss: 1.5590 - lr: 0.0010
Epoch 22/1000
391/399 [============================>.] - ETA: 0s - loss: 1.9219
Epoch 22: ReduceLROnPlateau reducing learning rate to 0.0005000000237487257.
399/399 [==============================] - 2s 6ms/step - loss: 1.9005 - val_loss: 0.8366 - lr: 0.0010
Epoch 23/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.5407 - val_loss: 0.2452 - lr: 5.0000e-04
Epoch 24/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.3579 - val_loss: 0.3723 - lr: 5.0000e-04
Epoch 25/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.6677 - val_loss: 0.4600 - lr: 5.0000e-04
Epoch 26/1000
392/399 [============================>.] - ETA: 0s - loss: 0.4938
Epoch 26: ReduceLROnPlateau reducing learning rate to 0.0002500000118743628.
399/399 [==============================] - 2s 6ms/step - loss: 0.4924 - val_loss: 0.4931 - lr: 5.0000e-04
```

```
Epoch 27/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3015 - val_loss: 1.0920 - lr: 2.5000e-04
Epoch 28/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3837 - val_loss: 0.2505 - lr: 2.5000e-04
Epoch 29/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.4019 - val_loss: 0.2436 - lr: 2.5000e-04
Epoch 30/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.3036 - val_loss: 0.2443 - lr: 2.5000e-04
Epoch 31/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2853 - val_loss: 0.7139 - lr: 2.5000e-04
Epoch 32/1000
395/399 [============================>.] - ETA: 0s - loss: 0.4095
Epoch 32: ReduceLROnPlateau reducing learning rate to 0.0001250000059371814.
399/399 [==============================] - 2s 6ms/step - loss: 0.4085 - val_loss: 0.3570 - lr: 2.5000e-04
Epoch 33/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2660 - val_loss: 0.2335 - lr: 1.2500e-04
Epoch 34/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2439 - val_loss: 0.2413 - lr: 1.2500e-04
Epoch 35/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2680 - val_loss: 0.2481 - lr: 1.2500e-04
Epoch 36/1000
395/399 [============================>.] - ETA: 0s - loss: 0.2592
Epoch 36: ReduceLROnPlateau reducing learning rate to 6.25000029685907e-05.
399/399 [==============================] - 2s 6ms/step - loss: 0.2591 - val_loss: 0.3293 - lr: 1.2500e-04
Epoch 37/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2337 - val_loss: 0.2347 - lr: 6.2500e-05
Epoch 38/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2354 - val_loss: 0.2345 - lr: 6.2500e-05
Epoch 39/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2355 - val_loss: 0.2277 - lr: 6.2500e-05
Epoch 40/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2423 - val_loss: 0.2334 - lr: 6.2500e-05
Epoch 41/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2307 - val_loss: 0.5223 - lr: 6.2500e-05
Epoch 42/1000
398/399 [============================>.] - ETA: 0s - loss: 0.2359
Epoch 42: ReduceLROnPlateau reducing learning rate to 3.125000148429535e-05.
399/399 [==============================] - 3s 6ms/step - loss: 0.2359 - val_loss: 0.2551 - lr: 6.2500e-05
Epoch 43/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2234 - val_loss: 0.2234 - lr: 3.1250e-05
Epoch 44/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2235 - val_loss: 0.2269 - lr: 3.1250e-05
Epoch 45/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2256 - val_loss: 0.2262 - lr: 3.1250e-05
Epoch 46/1000
394/399 [============================>.] - ETA: 0s - loss: 0.2210
Epoch 46: ReduceLROnPlateau reducing learning rate to 1.5625000742147677e-05.
399/399 [==============================] - 3s 6ms/step - loss: 0.2209 - val_loss: 0.2303 - lr: 3.1250e-05
Epoch 47/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2191 - val_loss: 0.2210 - lr: 1.5625e-05
Epoch 48/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2163 - val_loss: 0.2208 - lr: 1.5625e-05
Epoch 49/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2154 - val_loss: 0.2275 - lr: 1.5625e-05
Epoch 50/1000
```

```
399/399 [==============================] - 3s 6ms/step - loss: 0.2189 - val_loss: 0.2269 - lr: 1.5625e-05
Epoch 51/1000
399/399 [==============================] - ETA: 0s - loss: 0.2157
Epoch 51: ReduceLROnPlateau reducing learning rate to 1e-05.
399/399 [==============================] - 3s 7ms/step - loss: 0.2157 - val_loss: 0.2310 - lr: 1.5625e-05
Epoch 52/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2149 - val_loss: 0.2197 - lr: 1.0000e-05
Epoch 53/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2145 - val_loss: 0.2217 - lr: 1.0000e-05
Epoch 54/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2146 - val_loss: 0.2220 - lr: 1.0000e-05
Epoch 55/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2153 - val_loss: 0.2231 - lr: 1.0000e-05
Epoch 56/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2139 - val_loss: 0.2200 - lr: 1.0000e-05
Epoch 57/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2136 - val_loss: 0.2204 - lr: 1.0000e-05
Epoch 58/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2157 - val_loss: 0.2189 - lr: 1.0000e-05
Epoch 59/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2138 - val_loss: 0.2214 - lr: 1.0000e-05
Epoch 60/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2135 - val_loss: 0.2201 - lr: 1.0000e-05
Epoch 61/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2145 - val_loss: 0.2209 - lr: 1.0000e-05
Epoch 62/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2130 - val_loss: 0.2191 - lr: 1.0000e-05
Epoch 63/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2129 - val_loss: 0.2195 - lr: 1.0000e-05
Epoch 64/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2126 - val_loss: 0.2199 - lr: 1.0000e-05
Epoch 65/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2128 - val_loss: 0.2200 - lr: 1.0000e-05
Epoch 66/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2132 - val_loss: 0.2188 - lr: 1.0000e-05
Epoch 67/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2132 - val_loss: 0.2196 - lr: 1.0000e-05
Epoch 68/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2122 - val_loss: 0.2199 - lr: 1.0000e-05
Epoch 69/1000
399/399 [==============================] - 3s 7ms/step - loss: 0.2122 - val_loss: 0.2306 - lr: 1.0000e-05
Epoch 70/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2131 - val_loss: 0.2203 - lr: 1.0000e-05
Epoch 71/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2123 - val_loss: 0.2193 - lr: 1.0000e-05
Epoch 72/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2122 - val_loss: 0.2210 - lr: 1.0000e-05
Epoch 73/1000
399/399 [==============================] - 3s 6ms/step - loss: 0.2122 - val_loss: 0.2208 - lr: 1.0000e-05
Epoch 74/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2121 - val_loss: 0.2198 - lr: 1.0000e-05
Epoch 75/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2110 - val_loss: 0.2213 - lr: 1.0000e-05
Epoch 76/1000
399/399 [==============================] - 2s 6ms/step - loss: 0.2115 - val_loss: 0.2194 - lr: 1.0000e-05
```

```
Epoch 77/1000
393/399 [============================>.] - ETA: 0s - loss: 0.2118Restoring model weights from the end of the best epoch: 66.
399/399 [==============================] - 2s 6ms/step - loss: 0.2117 - val_loss: 0.2228 - lr: 1.0000e-05
Epoch 77: early stopping
  90/3116 [..............................] - ETA: 5s
2022-10-26 13:15:41.403152: I tensorflow/core/grappler/optimizers/custom_graph_optimizer_registry.cc:113] Plugin optimizer for device_type GPU is enabled.
3116/3116 [==============================] - 5s 2ms/step
2671/2671 [==============================] - 4s 2ms/step
3it [09:36, 192.19s/it]
```

In [ ]:
```
print(mlp_test_predict_mean.shape, mlp_train_predict.shape)
```

```
(85444, 1) (299050, 1)
```

Stacking

In [ ]:
```
new_X_train = np.concatenate((xgb_train_predict, cnn_train_predict, mlp_train_predict), axis=1)
new_X_test = np.concatenate((xgb_test_predict_mean, cnn_test_predict_mean, mlp_test_predict_mean), axis=1)

print(new_X_train.shape, new_X_test.shape)
```

```
(299050, 3) (85444, 3)
```

Meta-learner fitiing

In [ ]:
```
final_model = LinearRegression()
final_model.fit(new_X_train, y_train)
y_pred_final = final_model.predict(new_X_test)
```

Prediction & Evaluation

In [ ]:
```
y_pred_final
```

```
array([0.00354443, 0.00222816, 0.0026082 , ..., 0.00584544, 0.00279357,
       0.00383644])
```

In [ ]:
```
np_rmspe(y_test, y_pred_final)
```

```
0.23700999742395124
```

끝