UTS Deep Learning - No 1

Nama: Farren Angelica Dinzani

NIM: 2702243546

Dataset: 1A

Link video:
https://drive.google.com/file/d/1JV4M9mNmjGevwa4qRj6FSAwViduDzjDr/vie
usp=sharing

EDA & PREPROCESSING

In [1]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from sklearn.preprocessing import LabelEncoder, StandardScaler, OneHotEncode
from sklearn.model_selection import train_test_split
from sklearn.impute import SimpleImputer

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

Read data

In [2]:
```
df = pd.read_parquet('dataset_1A.parquet')
df.head()
```

Out[2]:

	Month	Hour	DayOfWeek	Holiday	Temperature	Humidity	SquareFootage	Occupancy
0	8	3	Sunday	Yes	24.492063	59.969085	1403.454805	7
1	1	8	Wednesday	No	26.312114	51.408711	1220.547133	8
2	1	19	Sunday	Yes	20.516186	40.918500	1114.230124	8
3	7	3	Wednesday	Yes	20.879426	46.859237	1096.207227	7
4	10	17	Saturday	No	23.015216	48.998158	1999.982252	1

Informasi data

In [3]:
```
df.shape
```

Out[3]:
```
(1232, 12)
```

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1232 entries, 0 to 1231
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   Month              1232 non-null   object 
 1   Hour               1232 non-null   int64  
 2   DayOfWeek          1232 non-null   object 
 3   Holiday            1232 non-null   object 
 4   Temperature        1232 non-null   float64
 5   Humidity           1232 non-null   float64
 6   SquareFootage      1232 non-null   float64
 7   Occupancy          1232 non-null   int64  
 8   HVACUsage          1232 non-null   object 
 9   LightingUsage      1232 non-null   object 
 10  RenewableEnergy    1232 non-null   float64
 11  EnergyConsumption  1232 non-null   object 
dtypes: float64(4), int64(2), object(6)
memory usage: 115.6+ KB
```

- Dataset terdiri dari 12 kolom.
- Memua kolom memiliki nilai non-null yang cukup.
- Kolom EnergyConsumption yang perlu diubah menjadi tipe float.

In [ ]:
```
df['EnergyConsumption'] = pd.to_numeric(df['EnergyConsumption'], errors='coe
```

In [6]:
```
df['Month'].value_counts()
```

Out[6]:
```
1            189
4            119
10           115
3            100
12            99
6             95
11            93
8             90
7             88
5             84
9             83
2             64
Sep            7
July           4
September      2
Name: Month, dtype: int64
```

Pada kolom 'Month' terdapat data yang tidak sesuai dengan format yang diharapkan. Data tersebut adalah 'Sep', 'July', dan 'September'. Harus diubah menjadi '9', '7', dan '9' agar sesuai dengan format.

In [ ]:
```
df['Month'] = df['Month'].replace({'Sep': 9, 'July': 7, 'September': 9})
```

Ubah data type 'Month' menjadi int

In [8]:
```
df['Month'] = df['Month'].astype(int)
```

In [9]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1232 entries, 0 to 1231
Data columns (total 12 columns):
 #   Column             Non-Null Count  Dtype
---  ------             --------------  -----
 0   Month              1232 non-null   int64
 1   Hour               1232 non-null   int64
 2   DayOfWeek          1232 non-null   object
 3   Holiday            1232 non-null   object
 4   Temperature        1232 non-null   float64
 5   Humidity           1232 non-null   float64
 6   SquareFootage      1232 non-null   float64
 7   Occupancy          1232 non-null   int64
 8   HVACUsage          1232 non-null   object
 9   LightingUsage      1232 non-null   object
 10  RenewableEnergy    1232 non-null   float64
 11  EnergyConsumption  1229 non-null   float64
dtypes: float64(5), int64(3), object(4)
memory usage: 115.6+ KB
```

In [10]:
```
df.columns
```

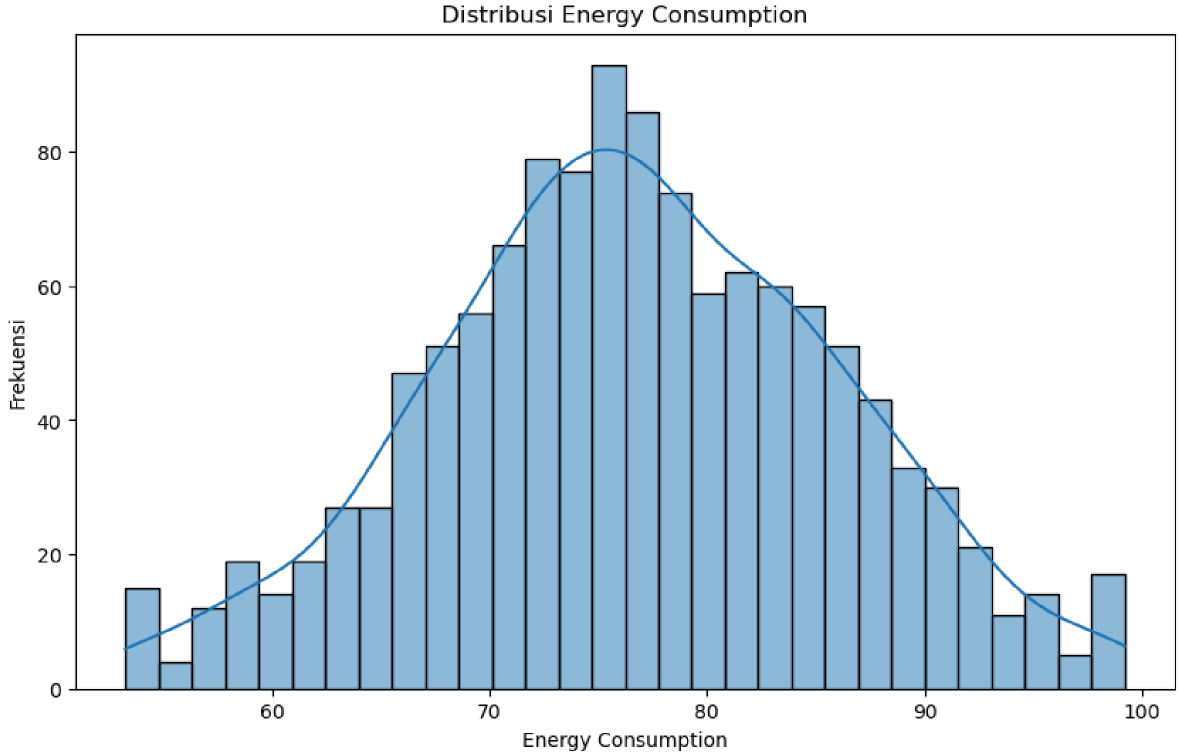
Out[10]:
```
Index(['Month', 'Hour', 'DayOfWeek', 'Holiday', 'Temperature', 'Humidity',
       'SquareFootage', 'Occupancy', 'HVACUsage', 'LightingUsage',
       'RenewableEnergy', 'EnergyConsumption'],
      dtype='object')
```

Prepare data (input & target)

In [ ]:
```
df_input=df[['Month', 'Hour', 'Holiday', 'Temperature', 'Humidity','SquareFo
df_target=df[['EnergyConsumption']]
```

Visualisasi distribusi kolom target: EnergyConsumption

In [ ]:
```
plt.figure(figsize=(10, 6))
sns.histplot(df['EnergyConsumption'], bins=30, kde=True)
plt.title('Distribusi Energy Consumption')
plt.xlabel('Energy Consumption')
plt.ylabel('Frekuensi')
plt.show()
```

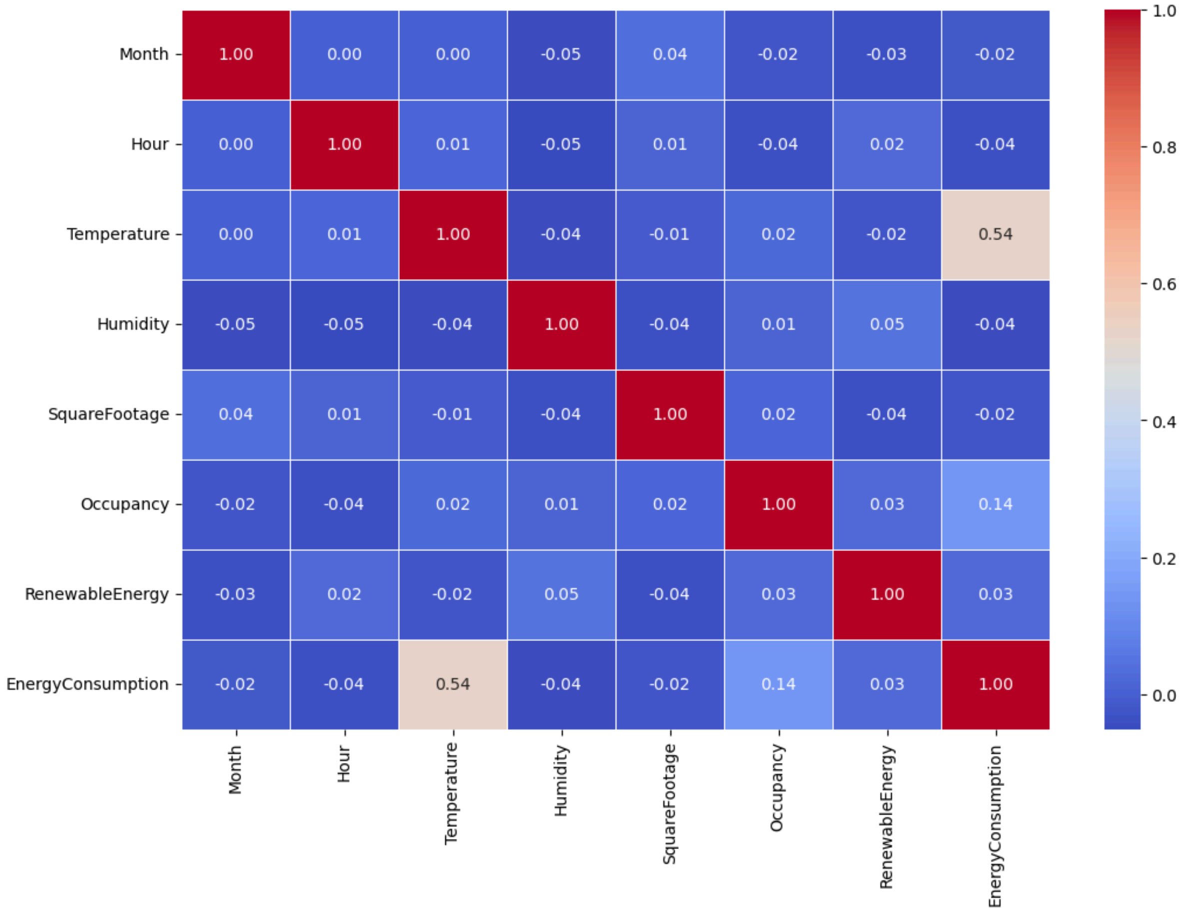


- Data terdistribusi hampir normal, dengan sebagian besar nilai EnergyConsumption berkisar antara 60 hingga 90.
- Menunjukkan bahwa sebagian besar gedung memiliki konsumsi energi yang serupa.

Visualisasi korelasi antar fitur

In [ ]:
```
plt.figure(figsize=(12, 8))
correlation_matrix = df.corr()
sns.heatmap(correlation_matrix, annot=True, fmt=".2f", cmap="coolwarm", line
```

Out[ ]: <Axes: >



- Temperature memiliki korelasi yang cukup kuat dengan EnergyConsumption.
- Masuk akal karena suhu ruangan dapat mempengaruhi penggunaan energi untuk pendinginan atau pemanasan.

Data splitting

Menjadi train, val, dan test dengan proporsi 70:10:20

In [ ]:
```
X_train, X_temp, y_train, y_temp = train_test_split(df_input, df_target, tes
X_val, X_test, y_val, y_test = train_test_split(X_temp, y_temp, test_size=0.
```

Cek missing value

In [ ]:
```
print(X_train.isnull().sum())
```

```
Month             0
Hour              0
Holiday           0
Temperature       0
Humidity          0
SquareFootage     0
Occupancy         0
HVACUsage         0
LightingUsage     0
RenewableEnergy   0
dtype: int64
```

Tidak ada missing value

In [16]:
```
X_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 862 entries, 2 to 1126
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
---  ------           --------------  -----  
 0   Month            862 non-null    int64  
 1   Hour             862 non-null    int64  
 2   Holiday          862 non-null    object 
 3   Temperature      862 non-null    float64
 4   Humidity         862 non-null    float64
 5   SquareFootage    862 non-null    float64
 6   Occupancy        862 non-null    int64  
 7   HVACUsage        862 non-null    object 
 8   LightingUsage    862 non-null    object 
 9   RenewableEnergy  862 non-null    float64
dtypes: float64(4), int64(3), object(3)
memory usage: 74.1+ KB
```

Encoding

Kolom Holiday, HVACUsage, dan LightingUsage adalah variabel kategorikal dengan nilai Yes/No atau On/Off yang perlu diubah menjadi 1/0 untuk dapat digunakan dalam model.

In [ ]:
```
X_train['Holiday'] = X_train['Holiday'].map({'Yes': 1, 'No': 0})
X_test['Holiday'] = X_test['Holiday'].map({'Yes': 1, 'No': 0})
X_val['Holiday'] = X_val['Holiday'].map({'Yes': 1, 'No': 0})

X_train['HVACUsage'] = X_train['HVACUsage'].map({'On': 1, 'Off': 0})
X_test['HVACUsage'] = X_test['HVACUsage'].map({'On': 1, 'Off': 0})
X_val['HVACUsage'] = X_val['HVACUsage'].map({'On': 1, 'Off': 0})

X_train['LightingUsage'] = X_train['LightingUsage'].map({'On': 1, 'Off': 0}
X_test['LightingUsage'] = X_test['LightingUsage'].map({'On': 1, 'Off': 0})
X_val['LightingUsage'] = X_val['LightingUsage'].map({'On': 1, 'Off': 0})
```

cek NaN

In [ ]:
```
print(np.any(np.isnan(X_train)))
print(np.any(np.isnan(y_train)))

print(np.any(np.isnan(X_test)))
print(np.any(np.isnan(y_test)))

print(np.any(np.isnan(X_val)))
print(np.any(np.isnan(y_val)))
```

```
False
True
False
False
False
False
```

Terdapat NaN pada y_train, dan lakukan fillna untuk mengisi nilai NaN dengan mean.

In [ ]:
```
y_train = y_train.fillna(y_train.mean())
```

Standard Scaling

In [ ]:
```
standard_scaler = StandardScaler()

X_train_standardized = standard_scaler.fit_transform(X_train)
X_val_standardized = standard_scaler.transform(X_val)
X_test_standardized = standard_scaler.transform(X_test)
```

Cek data sebelum melakukan model

In [108…
```
X_test.head()
```

Out[108]:

	Month	Hour	Holiday	Temperature	Humidity	SquareFootage	Occupancy	HVACUs
1219	8	12	1	20.126991	51.408470	1492.203415	7	
355	2	1	1	26.823037	39.000664	1998.439525	3	
415	3	15	0	29.998671	43.798996	1404.058579	3	
310	2	5	1	28.295123	42.784629	1141.161725	1	
344	11	15	1	27.558304	35.324520	1206.614730	1	

In [23]:
```
import tensorflow as tf

# Mendapatkan daftar perangkat fisik GPU
physical_devices = tf.config.list_physical_devices('GPU')

# Nonaktifkan GPU dengan menyembunyikan GPU
if len(physical_devices) > 0:
    tf.config.set_visible_devices([], 'GPU')
```

SEQUENTIAL MODEL

Dalam model ini, setiap lapisan (layer) tersambung secara berurutan dari lapisan input hingga lapisan output.

Pembuatan model Sequential

- Input layer: Jumlah fitur = 10
- Hidden layer: Jumlah neuron untuk setiap layer adalah 20, karena input memiliki 10 fitur
- Output layer: Memiliki 1 neuron karena kita melakukan regresi, di mana kita ingin memprediksi EnergyConsumption, yang merupakan nilai kontinu.
- Compile model: Fungsi loss yang digunakan adalah mean_squared_error (MSE), ideal untuk regresi.

In [ ]:
```
import keras
from tensorflow.keras.models import Sequential
from tensorflow.keras import layers, Input, Model
import tensorflow as tf

input_dim = X_train.shape[1]

model_sequential = Sequential()

model_sequential.add(tf.keras.Input(shape=(input_dim,)))
```

```
model_sequential.add(layers.Dense(2 * input_dim, activation='relu'))
model_sequential.add(layers.Dense(2 * input_dim, activation='relu'))

model_sequential.add(layers.Dense(1))

model_sequential.compile(optimizer='adam', loss='mean_squared_error',
                          metrics=['mae', 'mape', tf.keras.metrics.RootMeanS

model_sequential.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Para
dense (Dense)	(None, 20)	
dense_1 (Dense)	(None, 20)	
dense_2 (Dense)	(None, 1)	

Total params: 661 (2.58 KB)

Trainable params: 661 (2.58 KB)

Non-trainable params: 0 (0.00 B)

Training: Model dilatih menggunakan 15 epoch.

In [ ]:
```
model_sequential.fit(X_train, y_train, epochs=15, validation_data=(X_val, y_
```

```
Epoch 1/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - loss: 61.7545 - mae: 6.2082 - map
e: 8.2447 - root_mean_squared_error: 7.8521 - val_loss: 85.4363 - val_mae:
7.6835 - val_mape: 10.1452 - val_root_mean_squared_error: 9.2432
Epoch 2/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 65.4547 - mae: 6.3566 - map
e: 8.4657 - root_mean_squared_error: 8.0886 - val_loss: 90.0275 - val_mae:
7.9099 - val_mape: 10.3797 - val_root_mean_squared_error: 9.4883
Epoch 3/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 68.3369 - mae: 6.5088 - map
e: 8.5728 - root_mean_squared_error: 8.2646 - val_loss: 75.2581 - val_mae:
6.5077 - val_mape: 9.1421 - val_root_mean_squared_error: 8.6751
Epoch 4/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 69.7819 - mae: 6.5294 - map
e: 8.7844 - root_mean_squared_error: 8.3510 - val_loss: 73.7685 - val_mae:
6.8928 - val_mape: 9.3496 - val_root_mean_squared_error: 8.5889
Epoch 5/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 61.5166 - mae: 6.3112 - map
e: 8.4263 - root_mean_squared_error: 7.8409 - val_loss: 72.8996 - val_mae:
6.7872 - val_mape: 9.2489 - val_root_mean_squared_error: 8.5381
Epoch 6/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 63.2037 - mae: 6.4156 - map
e: 8.5357 - root_mean_squared_error: 7.9429 - val_loss: 76.2150 - val_mae:
6.5231 - val_mape: 9.1875 - val_root_mean_squared_error: 8.7301
Epoch 7/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 70.2456 - mae: 6.6787 - map
e: 9.0003 - root_mean_squared_error: 8.3802 - val_loss: 76.0833 - val_mae:
7.1066 - val_mape: 9.5585 - val_root_mean_squared_error: 8.7226
Epoch 8/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 66.8895 - mae: 6.6280 - map
e: 8.7517 - root_mean_squared_error: 8.1770 - val_loss: 76.8982 - val_mae:
7.1688 - val_mape: 9.6198 - val_root_mean_squared_error: 8.7692
Epoch 9/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 62.1864 - mae: 6.3153 - map
e: 8.4618 - root_mean_squared_error: 7.8813 - val_loss: 72.0271 - val_mae:
6.5605 - val_mape: 9.0662 - val_root_mean_squared_error: 8.4869
Epoch 10/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 61.1945 - mae: 6.1599 - map
e: 8.2370 - root_mean_squared_error: 7.8028 - val_loss: 77.4493 - val_mae:
7.2085 - val_mape: 9.6609 - val_root_mean_squared_error: 8.8005
Epoch 11/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 67.2476 - mae: 6.4562 - map
e: 8.5270 - root_mean_squared_error: 8.1993 - val_loss: 72.0824 - val_mae:
6.5429 - val_mape: 9.0601 - val_root_mean_squared_error: 8.4901
Epoch 12/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 67.4649 - mae: 6.4994 - map
e: 8.7797 - root_mean_squared_error: 8.2021 - val_loss: 75.9357 - val_mae:
6.5116 - val_mape: 9.1648 - val_root_mean_squared_error: 8.7141
Epoch 13/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 74.9500 - mae: 6.9464 - map
e: 9.2348 - root_mean_squared_error: 8.6511 - val_loss: 73.9596 - val_mae:
6.5101 - val_mape: 9.1131 - val_root_mean_squared_error: 8.6000
Epoch 14/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 69.6439 - mae: 6.6325 - map
e: 8.9266 - root_mean_squared_error: 8.3440 - val_loss: 77.9204 - val_mae:
7.2403 - val_mape: 9.6944 - val_root_mean_squared_error: 8.8273
Epoch 15/15
27/27 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step - loss: 63.9658 - mae: 6.4420 - map
e: 8.5346 - root_mean_squared_error: 7.9923 - val_loss: 71.8889 - val_mae:
6.5792 - val_mape: 9.0749 - val_root_mean_squared_error: 8.4787
```

Out[ ]:
```
<keras.src.callbacks.history.History at 0x2d2c18850>
```

FUNCTIONAL MODEL

Lebih fleksibel dibandingkan Sequential Model. Functional memungkinkan pembuatan model yang lebih kompleks dengan berbagai input, output, dan koneksi yang lebih rumit.

Pembuatan model Functional

- Input layer: Jumlah fitur = 10
- Hidden layer: Jumlah neuron untuk setiap layer adalah 20, karena input memiliki 10 fitur
- Output layer: Memiliki 1 neuron karena kita melakukan regresi, di mana kita ingin memprediksi EnergyConsumption, yang merupakan nilai kontinu.
- Compile model: Fungsi loss yang digunakan adalah mean_squared_error (MSE), ideal untuk regresi.

In [ ]:

```
from tensorflow.keras import layers, Input, Model

inputs = Input(shape=(input_dim,))

x = layers.Dense(2 * input_dim, activation='relu')(inputs)
x = layers.Dense(2 * input_dim, activation='relu')(x)

outputs = layers.Dense(1)(x)  # Output layer (regresi)

model_functional = Model(inputs=inputs, outputs=outputs)

model_functional.compile(optimizer='adam', loss='mean_squared_error',
                         metrics=['mae', 'mape', tf.keras.metrics.RootMeanS

print("Functional Model Summary:")
model_functional.summary()
```

```
Functional Model Summary:
```

Model: "functional_3"

Layer (type)	Output Shape	Para
input_layer_1 (InputLayer)	(None, 10)	
dense_3 (Dense)	(None, 20)	
dense_4 (Dense)	(None, 20)	
dense_5 (Dense)	(None, 1)	

Total params: 661 (2.58 KB)
Trainable params: 661 (2.58 KB)
Non-trainable params: 0 (0.00 B)

Training: Model dilatih menggunakan 15 epoch.

In [ ]:

```
model_functional.fit(X_train, y_train, epochs=15, validation_data=(X_val, y_
```

```
Epoch 1/15
27/27 - 0s - 4ms/step - loss: 72.3171 - mae: 6.9013 - mape: 9.1790 - root_m
ean_squared_error: 8.5039 - val_loss: 73.0154 - val_mae: 6.6162 - val_mape:
9.1384 - val_root_mean_squared_error: 8.5449
Epoch 2/15
27/27 - 0s - 3ms/step - loss: 73.3371 - mae: 6.8222 - mape: 9.0588 - root_m
ean_squared_error: 8.5637 - val_loss: 77.4449 - val_mae: 7.1628 - val_mape:
9.6364 - val_root_mean_squared_error: 8.8003
Epoch 3/15
27/27 - 0s - 3ms/step - loss: 67.1327 - mae: 6.4978 - mape: 8.6627 - root_m
ean_squared_error: 8.1935 - val_loss: 74.3012 - val_mae: 6.5541 - val_mape:
9.1479 - val_root_mean_squared_error: 8.6198
Epoch 4/15
27/27 - 0s - 3ms/step - loss: 66.4327 - mae: 6.4879 - mape: 8.6473 - root_m
ean_squared_error: 8.1506 - val_loss: 74.0580 - val_mae: 6.8401 - val_mape:
9.3212 - val_root_mean_squared_error: 8.6057
Epoch 5/15
27/27 - 0s - 3ms/step - loss: 71.4347 - mae: 6.7012 - mape: 8.9125 - root_m
ean_squared_error: 8.4519 - val_loss: 74.7921 - val_mae: 6.9241 - val_mape:
9.3999 - val_root_mean_squared_error: 8.6482
Epoch 6/15
27/27 - 0s - 3ms/step - loss: 68.2584 - mae: 6.5547 - mape: 8.6917 - root_m
ean_squared_error: 8.2619 - val_loss: 73.0159 - val_mae: 6.6657 - val_mape:
9.1734 - val_root_mean_squared_error: 8.5449
Epoch 7/15
27/27 - 0s - 3ms/step - loss: 79.8708 - mae: 7.0246 - mape: 9.3411 - root_m
ean_squared_error: 8.9370 - val_loss: 90.9948 - val_mae: 7.9256 - val_mape:
10.4097 - val_root_mean_squared_error: 9.5391
Epoch 8/15
27/27 - 0s - 3ms/step - loss: 77.6849 - mae: 7.0689 - mape: 9.4095 - root_m
ean_squared_error: 8.8139 - val_loss: 88.8695 - val_mae: 7.8216 - val_mape:
10.3017 - val_root_mean_squared_error: 9.4271
Epoch 9/15
27/27 - 0s - 3ms/step - loss: 74.4918 - mae: 6.9592 - mape: 9.2541 - root_m
ean_squared_error: 8.6309 - val_loss: 79.4793 - val_mae: 7.3051 - val_mape:
9.7764 - val_root_mean_squared_error: 8.9151
Epoch 10/15
27/27 - 0s - 3ms/step - loss: 66.9765 - mae: 6.5214 - mape: 8.6914 - root_m
ean_squared_error: 8.1839 - val_loss: 74.2450 - val_mae: 6.8601 - val_mape:
9.3406 - val_root_mean_squared_error: 8.6166
Epoch 11/15
27/27 - 0s - 3ms/step - loss: 67.0780 - mae: 6.5162 - mape: 8.6833 - root_m
ean_squared_error: 8.1901 - val_loss: 72.9884 - val_mae: 6.6516 - val_mape:
9.1614 - val_root_mean_squared_error: 8.5433
Epoch 12/15
27/27 - 0s - 3ms/step - loss: 70.3250 - mae: 6.6899 - mape: 8.9025 - root_m
ean_squared_error: 8.3860 - val_loss: 73.7768 - val_mae: 6.5607 - val_mape:
9.1340 - val_root_mean_squared_error: 8.5893
Epoch 13/15
27/27 - 0s - 3ms/step - loss: 69.2405 - mae: 6.5967 - mape: 8.7707 - root_m
ean_squared_error: 8.3211 - val_loss: 77.5449 - val_mae: 7.1711 - val_mape:
9.6444 - val_root_mean_squared_error: 8.8060
Epoch 14/15
27/27 - 0s - 3ms/step - loss: 73.3149 - mae: 6.7915 - mape: 9.0519 - root_m
ean_squared_error: 8.5624 - val_loss: 92.4336 - val_mae: 7.9924 - val_mape:
10.4810 - val_root_mean_squared_error: 9.6142
Epoch 15/15
27/27 - 0s - 3ms/step - loss: 67.8459 - mae: 6.5494 - mape: 8.7061 - root_m
ean_squared_error: 8.2369 - val_loss: 73.1494 - val_mae: 6.7027 - val_mape:
9.2019 - val_root_mean_squared_error: 8.5527
```

Out[ ]:

```
<keras.src.callbacks.history.History at 0x2d4d08ed0>
```

MODIFIKASI SEQUENTIAL MODEL

1. Input layer: sesuai dengan jumlah fitur input = 10
2. Hidden layer pertama:
   - menambah jumlah neuron menjadi tiga kali lipat dimensi input untuk meningkatkan kapasitas model.
   - Leaky ReLU mencegah masalah "dying neurons" dengan memberikan nilai kecil untuk nilai negatif (alpha=0.3).
   - Batch Normalization untuk membantu model belajar lebih cepat dan stabil.
   - Menggunakan Dropout sebesar 30% untuk mencegah overfitting.
3. Hidden layer kedua: Neuron lebih banyak lagi, konfigurasi sama.
4. Hidden layer ketiga: 2x jumlah neuron dari dimensi input.
5. Output layer: 1 neuron, karena kita melakukan tugas regresi untuk memprediksi nilai kontinu dari EnergyConsumption.

In [ ]:

```
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, BatchNormalization, Leal
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import EarlyStopping
import tensorflow as tf

model_sequential_modif = Sequential()

# Input layer
model_sequential_modif.add(tf.keras.Input(shape=(X_train.shape[1],)))

# Hidden layer pertama
model_sequential_modif.add(Dense(3 * X_train.shape[1]))
model_sequential_modif.add(LeakyReLU(alpha=0.3))
model_sequential_modif.add(BatchNormalization())
model_sequential_modif.add(Dropout(0.3))

# Hidden layer kedua
model_sequential_modif.add(Dense(3 * X_train.shape[1]))
model_sequential_modif.add(LeakyReLU(alpha=0.3))
model_sequential_modif.add(BatchNormalization())
model_sequential_modif.add(Dropout(0.3))

# Hidden layer ketiga
model_sequential_modif.add(Dense(2 * X_train.shape[1]))
model_sequential_modif.add(LeakyReLU(alpha=0.3))
model_sequential_modif.add(BatchNormalization())
model_sequential_modif.add(Dropout(0.3))

# Output layer
model_sequential_modif.add(Dense(1))

optimizer = Adam(learning_rate=0.0005)

model_sequential_modif.compile(optimizer=optimizer, loss='mean_squared_erro
                               metrics=[tf.keras.metrics.RootMeanSquaredEr

model_sequential_modif.summary()
```

Model: "sequential_1"

Layer (type)	Output Shape	Para
dense_6 (Dense)	(None, 30)	
leaky_re_lu (LeakyReLU)	(None, 30)	
batch_normalization (BatchNormalization)	(None, 30)	
dropout (Dropout)	(None, 30)	
dense_7 (Dense)	(None, 30)	
leaky_re_lu_1 (LeakyReLU)	(None, 30)	
batch_normalization_1 (BatchNormalization)	(None, 30)	
dropout_1 (Dropout)	(None, 30)	
dense_8 (Dense)	(None, 20)	
leaky_re_lu_2 (LeakyReLU)	(None, 20)	
batch_normalization_2 (BatchNormalization)	(None, 20)	
dropout_2 (Dropout)	(None, 20)	
dense_9 (Dense)	(None, 1)	

Total params: 2,221 (8.68 KB)
Trainable params: 2,061 (8.05 KB)
Non-trainable params: 160 (640.00 B)

- Early stopping: Menghentikan training jika tidak ada perbaikan pada val_loss dalam 5 epoch berturut-turut.
- Training: Dilatih selama 50 epoch, dengan validation data untuk memantau overfitting. Early stopping memastikan bahwa pelatihan berhenti saat model mulai mengalami overfitting.

In [ ]:
```
early_stopping = EarlyStopping(monitor='val_loss', patience=5, restore_best_

model_sequential_modif.fit(X_train, y_train, epochs=50, verbose=2, validati
```

```
Epoch 1/50
27/27 - 0s - 4ms/step - loss: 181.4971 - mae: 10.6602 - mape: 14.0420 - roo
t_mean_squared_error: 13.4721 - val_loss: 69.4552 - val_mae: 6.5999 - val_m
ape: 9.0207 - val_root_mean_squared_error: 8.3340
Epoch 2/50
27/27 - 0s - 3ms/step - loss: 195.4977 - mae: 11.2098 - mape: 14.8383 - roo
t_mean_squared_error: 13.9820 - val_loss: 69.0139 - val_mae: 6.5700 - val_m
ape: 8.9823 - val_root_mean_squared_error: 8.3075
Epoch 3/50
27/27 - 0s - 3ms/step - loss: 197.6206 - mae: 11.2334 - mape: 14.8261 - roo
t_mean_squared_error: 14.0578 - val_loss: 72.7347 - val_mae: 6.5698 - val_m
ape: 9.0922 - val_root_mean_squared_error: 8.5285
Epoch 4/50
27/27 - 0s - 3ms/step - loss: 198.1405 - mae: 11.1424 - mape: 14.6385 - roo
t_mean_squared_error: 14.0762 - val_loss: 72.2332 - val_mae: 6.5568 - val_m
ape: 9.0599 - val_root_mean_squared_error: 8.4990
Epoch 5/50
27/27 - 0s - 3ms/step - loss: 217.8742 - mae: 11.5849 - mape: 15.2590 - roo
t_mean_squared_error: 14.7606 - val_loss: 73.9926 - val_mae: 6.9924 - val_m
ape: 9.3582 - val_root_mean_squared_error: 8.6019
Epoch 6/50
27/27 - 0s - 3ms/step - loss: 204.9069 - mae: 11.3801 - mape: 14.9843 - roo
t_mean_squared_error: 14.3146 - val_loss: 77.0719 - val_mae: 7.2365 - val_m
ape: 9.5728 - val_root_mean_squared_error: 8.7791
Epoch 7/50
27/27 - 0s - 3ms/step - loss: 194.1683 - mae: 11.3432 - mape: 14.9572 - roo
t_mean_squared_error: 13.9344 - val_loss: 72.1202 - val_mae: 6.8550 - val_m
ape: 9.2419 - val_root_mean_squared_error: 8.4924
```

Out[ ]:
```
<keras.src.callbacks.history.History at 0x2db0d98d0>
```

MODIFIKASI FUNCTIONAL MODEL

1. Input layer: disesuaikan dengan dimensi input.
2. Hidden layer pertama:
   - Leaky ReLU untuk meningkatkan kapasitas model dan mencegah "dying neurons".
   - Batch Normalization dan Dropout untuk membantu pelatihan dan mencegah overfitting.
3. Hidden layer kedua: Neuron lebih banyak untuk menjaga generalisasi model.
4. Hidden layer ketiga: Neuron lebih banyak dan menerapkan Leaky ReLU, Batch Normalization, dan Dropout untuk layer tambahan.
5. Output layer: tetap 1 neuron karena kita melakukan regresi.

In [ ]:
```
from tensorflow.keras import Input, Model
from tensorflow.keras.layers import Dense, Dropout, LeakyReLU, BatchNormali
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.callbacks import EarlyStopping

inputs = Input(shape=(X_train.shape[1],))

# Hidden layer pertama
x = Dense(3 * X_train.shape[1])(inputs)
x = LeakyReLU(alpha=0.3)(x)
x = BatchNormalization()(x)
x = Dropout(0.3)(x)
```

```
# Hidden layer kedua
x = Dense(3 * X_train.shape[1])(x)
x = LeakyReLU(alpha=0.3)(x)
x = BatchNormalization()(x)
x = Dropout(0.3)(x)

# Hidden layer ketiga
x = Dense(2 * X_train.shape[1])(x)
x = LeakyReLU(alpha=0.3)(x)
x = BatchNormalization()(x)
x = Dropout(0.3)(x)

# Output layer
outputs = Dense(1)(x)

model_functional_modif = Model(inputs=inputs, outputs=outputs)

optimizer = Adam(learning_rate=0.0005)  # Learning rate lebih rendah

model_functional_modif.compile(optimizer=optimizer, loss='mean_squared_erro
                                metrics=[tf.keras.metrics.RootMeanSquaredEr

model_functional_modif.summary()
```

Model: "functional_17"

Layer (type)	Output Shape	Para
input_layer_3 (InputLayer)	(None, 10)	
dense_10 (Dense)	(None, 30)	
leaky_re_lu_3 (LeakyReLU)	(None, 30)	
batch_normalization_3 (BatchNormalization)	(None, 30)	
dropout_3 (Dropout)	(None, 30)	
dense_11 (Dense)	(None, 30)	
leaky_re_lu_4 (LeakyReLU)	(None, 30)	
batch_normalization_4 (BatchNormalization)	(None, 30)	
dropout_4 (Dropout)	(None, 30)	
dense_12 (Dense)	(None, 20)	
leaky_re_lu_5 (LeakyReLU)	(None, 20)	
batch_normalization_5 (BatchNormalization)	(None, 20)	
dropout_5 (Dropout)	(None, 20)	
dense_13 (Dense)	(None, 1)	

Total params: 2,221 (8.68 KB)

Trainable params: 2,061 (8.05 KB)

Non-trainable params: 160 (640.00 B)

Model dilatih selama 50 epoch dengan early stopping dan validation data untuk memantau performa.

In [ ]:
```
early_stopping = EarlyStopping(monitor='val_loss', patience=5, restore_best_

model_functional_modif.fit(X_train, y_train, epochs=50, verbose=2, validati
```

```
Epoch 1/50
27/27 - 0s - 4ms/step - loss: 195.3911 - mae: 10.9776 - mape: 14.4857 - roo
t_mean_squared_error: 13.9782 - val_loss: 77.2608 - val_mae: 7.2373 - val_m
ape: 9.5553 - val_root_mean_squared_error: 8.7898
Epoch 2/50
27/27 - 0s - 3ms/step - loss: 193.9443 - mae: 11.1688 - mape: 14.7077 - roo
t_mean_squared_error: 13.9264 - val_loss: 112.9375 - val_mae: 8.9133 - val_
mape: 11.3218 - val_root_mean_squared_error: 10.6272
Epoch 3/50
27/27 - 0s - 3ms/step - loss: 205.4549 - mae: 11.4398 - mape: 15.1007 - roo
t_mean_squared_error: 14.3337 - val_loss: 71.8089 - val_mae: 6.6250 - val_m
ape: 9.0282 - val_root_mean_squared_error: 8.4740
Epoch 4/50
27/27 - 0s - 3ms/step - loss: 194.7201 - mae: 10.9918 - mape: 14.5293 - roo
t_mean_squared_error: 13.9542 - val_loss: 75.7124 - val_mae: 7.0928 - val_m
ape: 9.4203 - val_root_mean_squared_error: 8.7013
Epoch 5/50
27/27 - 0s - 3ms/step - loss: 194.6088 - mae: 10.9449 - mape: 14.3597 - roo
t_mean_squared_error: 13.9502 - val_loss: 91.6898 - val_mae: 8.0257 - val_m
ape: 10.3717 - val_root_mean_squared_error: 9.5755
Epoch 6/50
27/27 - 0s - 3ms/step - loss: 186.6893 - mae: 10.9832 - mape: 14.4922 - roo
t_mean_squared_error: 13.6634 - val_loss: 72.5401 - val_mae: 6.6850 - val_m
ape: 9.1311 - val_root_mean_squared_error: 8.5170
Epoch 7/50
27/27 - 0s - 3ms/step - loss: 211.4969 - mae: 11.5716 - mape: 15.2949 - roo
t_mean_squared_error: 14.5429 - val_loss: 74.1374 - val_mae: 6.8945 - val_m
ape: 9.2877 - val_root_mean_squared_error: 8.6103
Epoch 8/50
27/27 - 0s - 3ms/step - loss: 197.5047 - mae: 11.1061 - mape: 14.6413 - roo
t_mean_squared_error: 14.0536 - val_loss: 74.8698 - val_mae: 6.9946 - val_m
ape: 9.3507 - val_root_mean_squared_error: 8.6527
```

Out[ ]: <keras.src.callbacks.history.History at 0x2d88d8310>

EVALUASI 4 MODEL

In [ ]:
```
from sklearn.metrics import mean_squared_error, mean_absolute_error, r2_sco

# Evaluasi untuk Sequential Model (Original)
y_pred_sequential = model_sequential.predict(X_test)
mse_sequential = mean_squared_error(y_test, y_pred_sequential)
mae_sequential = mean_absolute_error(y_test, y_pred_sequential)
r2_sequential = r2_score(y_test, y_pred_sequential)

# Evaluasi untuk Functional Model (Original)
y_pred_functional = model_functional.predict(X_test)
mse_functional = mean_squared_error(y_test, y_pred_functional)
mae_functional = mean_absolute_error(y_test, y_pred_functional)
r2_functional = r2_score(y_test, y_pred_functional)

# Evaluasi untuk Sequential Model (Modified)
y_pred_sequential_modif = model_sequential_modif.predict(X_test)
mse_sequential_modif = mean_squared_error(y_test, y_pred_sequential_modif)
```

```
mae_sequential_modif = mean_absolute_error(y_test, y_pred_sequential_modif)
r2_sequential_modif = r2_score(y_test, y_pred_sequential_modif)

# Evaluasi untuk Functional Model (Modified)
y_pred_functional_modif = model_functional_modif.predict(X_test)
mse_functional_modif = mean_squared_error(y_test, y_pred_functional_modif)
mae_functional_modif = mean_absolute_error(y_test, y_pred_functional_modif)
r2_functional_modif = r2_score(y_test, y_pred_functional_modif)



# Menampilkan hasil evaluasi
print("Evaluasi Model:")

# Evaluasi Original Sequential Model
print("\nOriginal Sequential Model:")
print(f"MSE: {mse_sequential}, MAE: {mae_sequential}, R²: {r2_sequential}")

# Evaluasi Original Functional Model
print("\nOriginal Functional Model:")
print(f"MSE: {mse_functional}, MAE: {mae_functional}, R²: {r2_functional}")

# Evaluasi Modified Sequential Model
print("\nModified Sequential Model:")
print(f"MSE: {mse_sequential_modif}, MAE: {mae_sequential_modif}, R²: {r2_se

# Evaluasi Modified Functional Model
print("\nModified Functional Model:")
print(f"MSE: {mse_functional_modif}, MAE: {mae_functional_modif}, R²: {r2_fu
```

```
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step
WARNING:tensorflow:5 out of the last 17 calls to <function TensorFlowTraine
r.make_predict_function.<locals>.one_step_on_data_distributed at 0x2daa5804
0> triggered tf.function retracing. Tracing is expensive and the excessive
number of tracings could be due to (1) creating @tf.function repeatedly in
a loop, (2) passing tensors with different shapes, (3) passing Python objec
ts instead of tensors. For (1), please define your @tf.function outside of
the loop. For (2), @tf.function has reduce_retracing=True option that can a
void unnecessary retracing. For (3), please refer to https://www.tensorflo
w.org/guide/function#controlling_retracing and https://www.tensorflow.org/a
pi_docs/python/tf/function for  more details.
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
WARNING:tensorflow:5 out of the last 17 calls to <function TensorFlowTraine
r.make_predict_function.<locals>.one_step_on_data_distributed at 0x2daa5a2a
0> triggered tf.function retracing. Tracing is expensive and the excessive
number of tracings could be due to (1) creating @tf.function repeatedly in
a loop, (2) passing tensors with different shapes, (3) passing Python objec
ts instead of tensors. For (1), please define your @tf.function outside of
the loop. For (2), @tf.function has reduce_retracing=True option that can a
void unnecessary retracing. For (3), please refer to https://www.tensorflo
w.org/guide/function#controlling_retracing and https://www.tensorflow.org/a
pi_docs/python/tf/function for  more details.
8/8 ━━━━━━━━━━━━━━━━━━━━ 0s 9ms/step
Evaluasi Model:

Original Sequential Model:
MSE: 61.860305743374, MAE: 6.252115019364708, R²: 0.1754854133067154

Original Functional Model:
MSE: 62.45223043036776, MAE: 6.266800704254569, R²: 0.16759585419792467

Modified Sequential Model:
MSE: 57.56914201211439, MAE: 5.9893836617507645, R²: 0.23268084821113644

Modified Functional Model:
MSE: 57.59351134368601, MAE: 5.957974902223641, R²: 0.23235603783221392
```

Evaluasi Model dan Analisis

1. Original Sequential Model: MSE: 61.86, MAE: 6.25, R^2: 0.175

   Analisis: Model ini memiliki kesalahan prediksi yang tinggi dengan R^2 rendah, hanya menjelaskan 17.5% variasi dalam data.

2. Original Functional Model: MSE: 62.45, MAE: 6.27, R^2: 0.168

   Analisis: Performa hampir identik dengan Sequential Model. R^2 lebih rendah, yang menunjukkan bahwa model ini sedikit lebih buruk dalam menjelaskan variasi target.

3. Modified Sequential Model: MSE: 57.57, MAE: 5.99, R^2: 0.233

   Analisis: Modifikasi menunjukkan peningkatan signifikan dalam mengurangi kesalahan dan meningkatkan R^2 menjadi 23.3%, lebih baik dibandingkan model original.

4. Modified Functional Model: MSE: 57.59, MAE: 5.96, R^2: 0.232

   Analisis: Hasilnya sangat mirip dengan Modified Sequential Model, dengan sedikit perbedaan di MSE dan R^2.

Kesimpulan:

```
- Modified Sequential Model adalah yang paling optimal dengan
MSE lebih rendah dan R² lebih tinggi dibandingkan model
original dan Functional Model.

- Modifikasi dengan Leaky ReLU, Batch Normalization, dan
Dropout meningkatkan kinerja model secara keseluruhan.
```