MACHINE LEARNING MODEL DEPLOYMENT & MODEL TRACKING USING MLFLOW

BY GROUP 2

DATA SCIENCE B

OUR TEAM MEMBER

M. Kamal Jaza

M. Irvan Arfandi

Risma Ashali

Rizal Maulana K.

Shafira Aisyah

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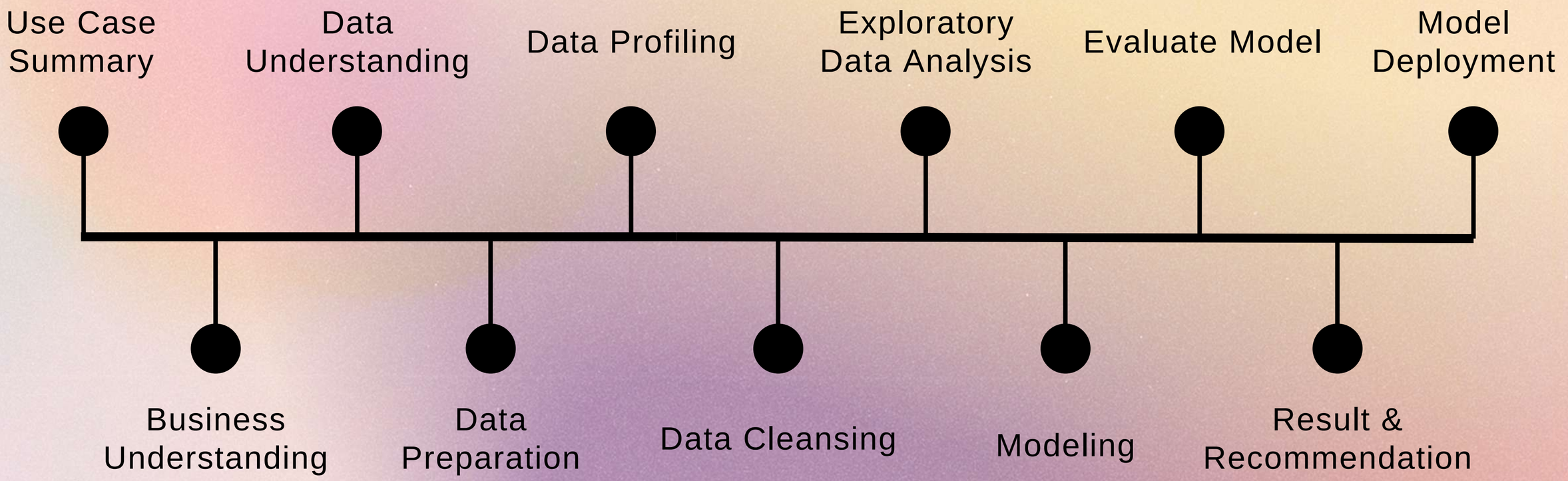
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USE CASE SUMMARY

USE CASE SUMMARY

Objective Statement

- To get insight how much sales based on tv advertising
- To get insight how much money is spent on advertising on TV
- To gain insight into the relationship between sales and TV marketing
- To predict sales based on TV advertising using Linear Regression
- To get insight about model deployment using MLflow

Challenges

There are no other variables as a comparison

Methodology/Analytic Technique

- Descriptive Analysis
- Graph Analysis
- Modeling using Linear Regression
- Model Deployment using MLflow

USE CASE SUMMARY

Business Benefit

- Knowing how much sales from tv advertising
- Knowing how sales predict results by placing ads on TV
- Helping business team optimize spent advertising costs

Expected Outcome

- Know how much sales based on TV advertising
- Know how much money is spent on advertising on TV
- Know about relationship between sales and TV marketing
- Know the results of sales prediction based on TV advertising using Linear Regression
- Know about creating model deployments using MLflow and the results

BUSINESS UNDERSTANDING

BUSINESS UNDERSTANDING

- TV Marketing is the method of demonstrating features of products and providing their information on television to attract viewers and encourage them to buy the shown products is called trade through television marketing.
- This case has some business question using the data:
  - How much company spent money on TV advertising?
  - How much money is spent on advertising on TV?
  - How about relationship between sales and TV marketing?
  - How about the results of sales prediction based on TV advertising using Linear Regression?
  - How to create a model deployment using MLflow?

DATA UNDERSTANDING & DATA PREPARATION

DATA UNDERSTANDING & DATA PREPARATION

Data Understanding

- Data of TV Marketing
- This data have 2 columns and 200 rows
- Source Code : https://www.kaggle.com/datasets/leiadis/tvmarketing
- Data Dictionary :
  - TV : money spent on advertising via TV
  - Sales : number of sales

Data Preparation

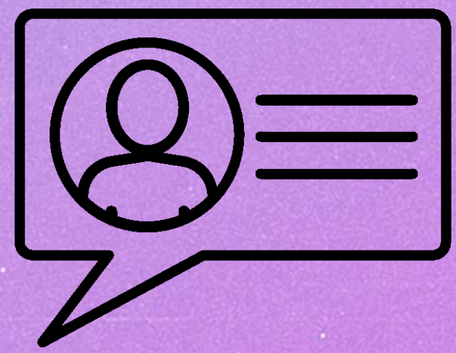
- Code Used:
  - Python Version: 3.7.15
  - Packages: Pandas, Numpy, Matplotlib, Seaborn, MLFlow, sklearn and Warnings

DATA PROFILING

DATA PROFILING

First of all, we will import package which will be used in processing this data, especially with Linear Regression modeling and model deployment using mlflow

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

from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_absolute_error
from sklearn.metrics import mean_absolute_percentage_error
from sklearn.metrics import r2_score
from sklearn.metrics import mean_squared_error

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



DATA PROFILING

Then define the tvmarketing dataset into the df variable and read it with the syntax above. After that, see a preview of the previously loaded dataset.

```
df = pd.read_csv('tvmarketing.csv')
df.head()
```

	TV	Sales
0	230.1	22.1
1	44.5	10.4
2	17.2	9.3
3	151.5	18.5
4	180.8	12.9

The table on the side is a display of the top 5 rows of the dataset to be used.

DATA PROFILING

We will display information from an existing dataset

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   TV      200 non-null    float64
 1   Sales   200 non-null    float64
dtypes: float64(2)
memory usage: 3.2 KB
```

The dataset has a total of 200 values and the data type is float

Then we will check whether there are missing values or not

```
df.isna().sum()
```

```
TV        0
Sales     0
dtype: int64
```

It can be seen that the dataset has no empty values.

DATA PROFILING

We will display basic statistical information from TV Marketing data such as percentile, mean, std ect.

```
df.describe().T
```

	count	mean	std	min	25%	50%	75%	max
TV	200.0	147.0425	85.854236	0.7	74.375	149.75	218.825	296.4
Sales	200.0	14.0225	5.217457	1.6	10.375	12.90	17.400	27.0

From the table above it is known that there are 200 rows with average money spent on advertising through TV is 147.04 and average sales is 14 ,02. Money spent on advertising least is 0.7 and most is 296.4. The least sale is 1.6 and the most is 27.

DATA CLEANSING

DATA CLEANSING

The TV Marketing dataset is clean because the data no longer has missing values and the data types are already appropriate.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype
---  ------  --------------  -----
 0   TV      200 non-null    float64
 1   Sales   200 non-null    float64
dtypes: float64(2)
memory usage: 3.2 KB
```

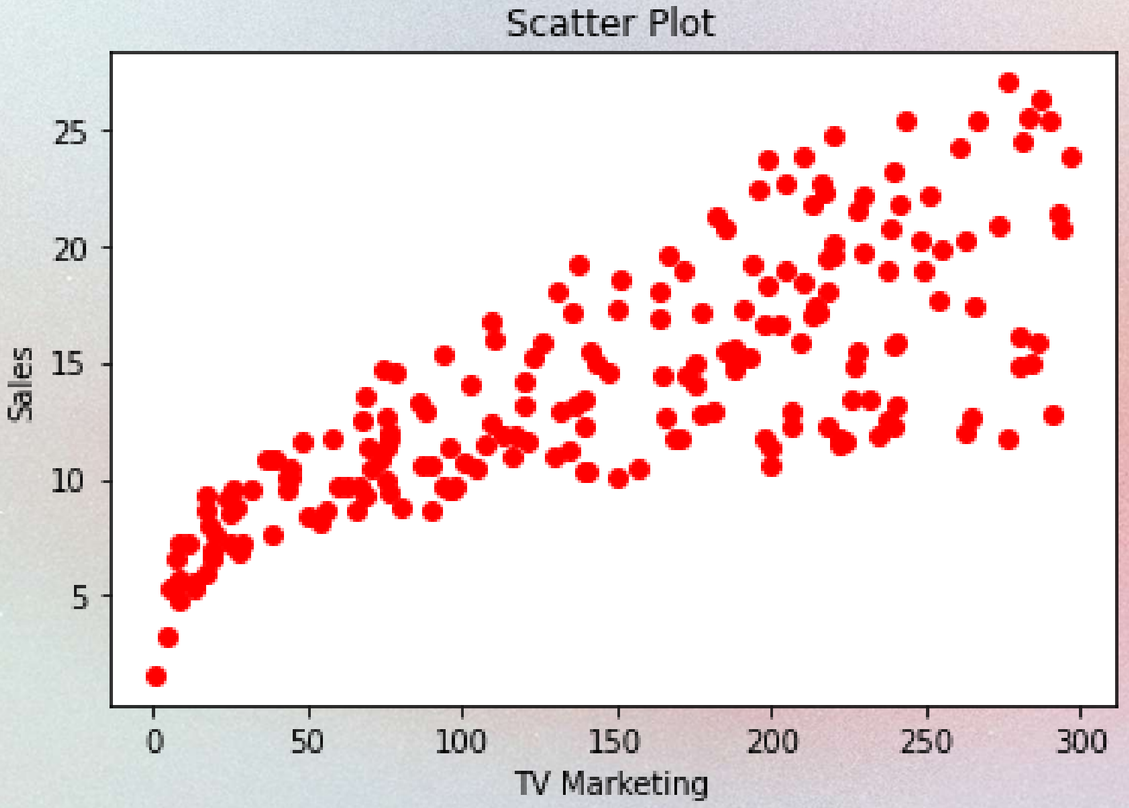
```
df.isna().sum()
```

```
TV        0
Sales     0
dtype: int64
```

EXPLORATORY DATA ANALYSIS

SCATTER PLOT

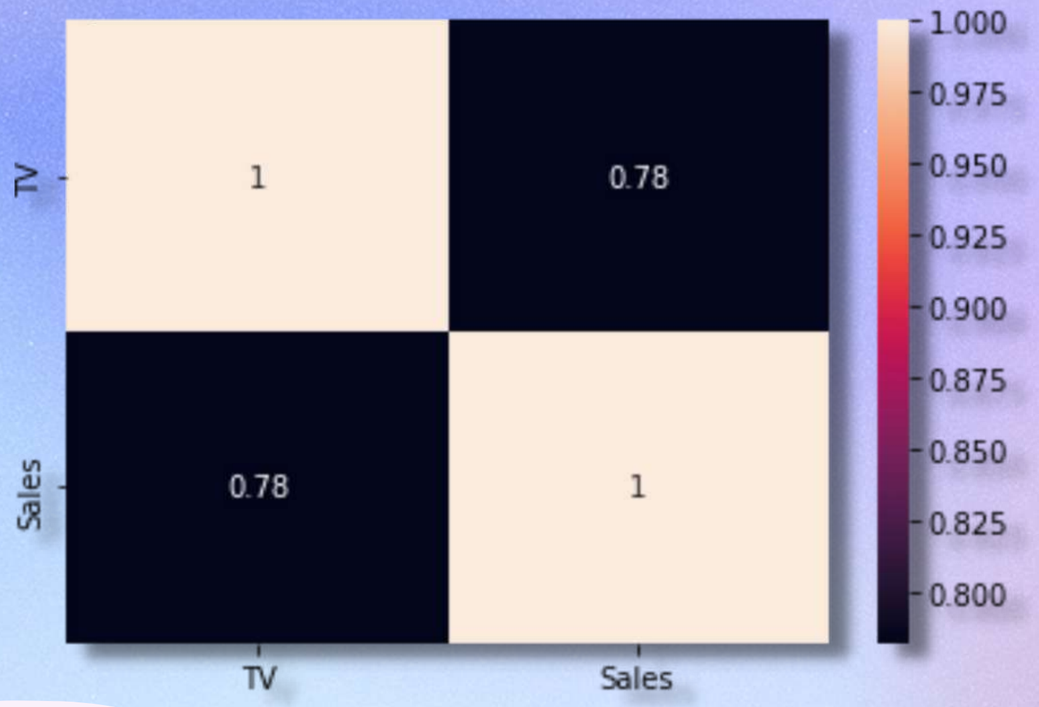
How about relationship between sales and TV marketing?



From the chart above, it can be seen that there is a strong relationship between TV advertising and sales. Based on scatterplot, the relationship between TV advertising and sales is **directly proportional**. As more money is spent on advertising on TV, sales will increase.

HEATMAP

How about relationship between sales and TV marketing?



From the heatmap above, it can be seen that there is a strong relationship between TV advertising and sales. This is because the correlation value between sales and tv marketing is **0.78** where it is **more than 0.5**.

LINEAR REGRESSION MODELLING

PREPROCESSING

```
X = df.drop(['Sales'], axis=1)
y = df['Sales']
```

Before modelling, we have to do **preprocessing modeling.** The variable Y to be used is the Sales variable so, for the variable X it can be defined for all variables except the Sales variable.

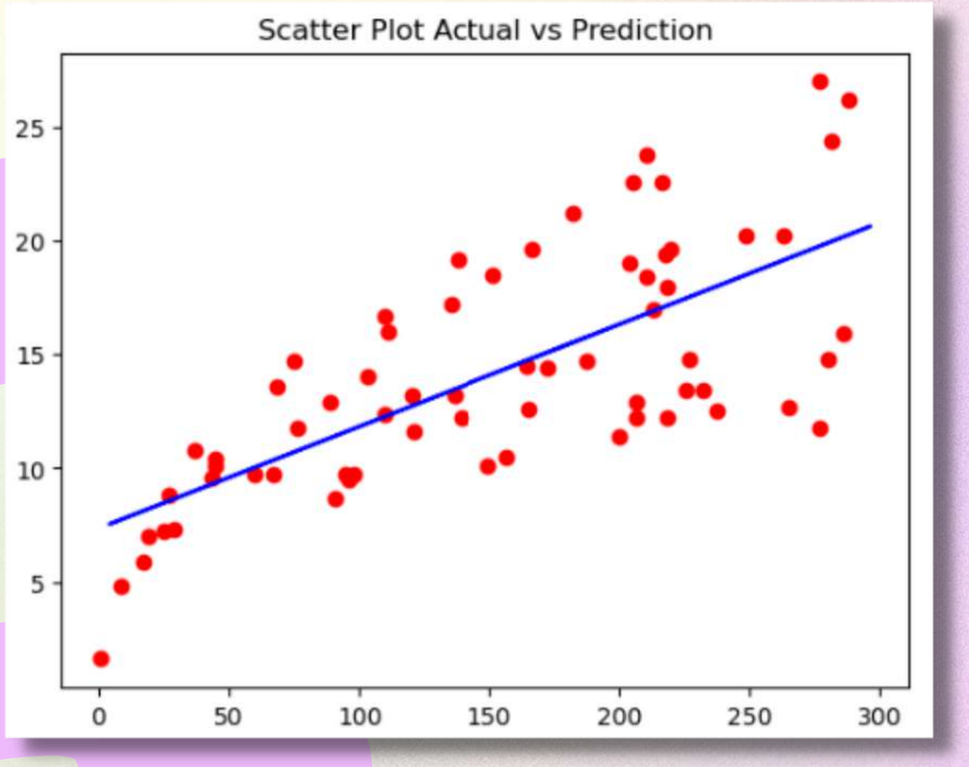
Splitting Traing & Test

```
X = df.drop(['Sales'], axis=1)
y = df['Sales']
```

it is necessary to **divide the dataset** into two parts, namely the part used for **data training and data testing** with the proportion of 1/3.

LINEAR REGRESSION MODELLING

Modeling with training data using a Linear Regression model.

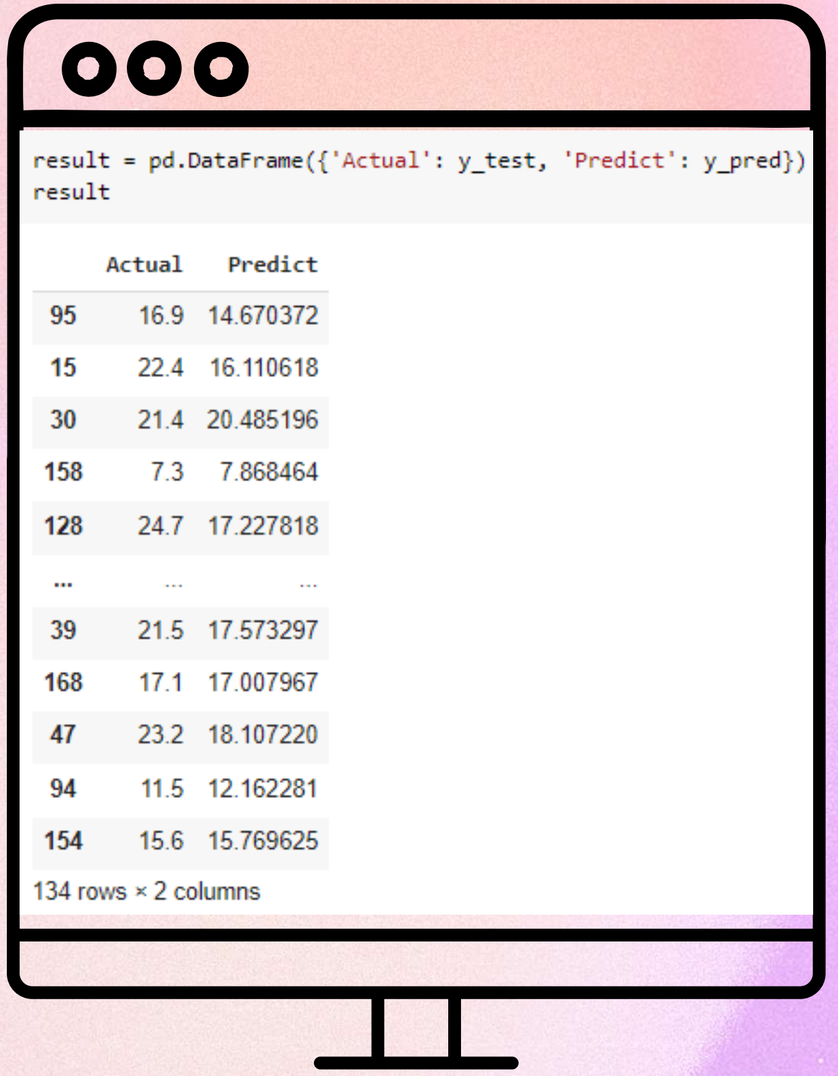


Note: blue line is y_predict

Based on the scatter plot, it can be seen that the modeled train data tends to **approach the linear line** which is the result of the prediction. This means that the data and the predicted results are not much different so it can be said that **the data follows a linear regression model.**

EVALUATE MODEL

In the last stage, we will evaluate the model using MAE, MAPE, R-Square, and RMSE to see if the model formed is good enough.



```
result = pd.DataFrame({'Actual': y_test, 'Predict': y_pred})
result
```

	Actual	Predict
95	16.9	14.670372
15	22.4	16.110618
30	21.4	20.485196
158	7.3	7.868464
128	24.7	17.227818
...	...	...
39	21.5	17.573297
168	17.1	17.007967
47	23.2	18.107220
94	11.5	12.162281
154	15.6	15.769625

134 rows × 2 columns

EVALUATE MODEL

MAE is the average of the absolute difference between the actual value and the predicted value

```
mean_absolute_error(y_test, y_pred)
```

```
2.3813679825552074
```

Based on the evaluation of the model using MAE, a fairly small value was obtained and close to 0, which is 2,381. This means that the formed model is good for prediction.

MAPE (Mean Absolute Percentage Error) is the mean absolute percentage difference between the actual and the predicted value.

```
[ ]  mean_absolute_percentage_error(y_test, y_pred)
```

```
0.18279457728279747
```

Based on the evaluation of the model using MAPE, a value of 0.18 or 18% is obtained, where this figure is below 20%. This means that the model formed has good forecasting results.

R square is a number ranging from 0 to 1 which indicates the magnitude of the combination of independent variables together affecting the value of the dependent variable

```
[ ]  r2_score(y_test,y_pred)
```

```
0.6569436980049992
```

Based on the evaluation of the model using R-Square, a value of 0.65 or 65% is obtained. This means that TV advertising has an effect of 65% on sales while the remaining 35% is influenced by other unknown factors.

Root Mean Square Error (RMSE) is the sum of the squared errors or the difference between the actual value and the predetermined predicted value.

```
[ ]  rmse = np.sqrt(mean_squared_error(y_test,y_pred))
     rmse
```

```
3.060418770219597
```

Based on the evaluation of the model using the RMSE, a fairly small value was obtained and close to 0, which is 3.06. This means that the model is good enough to make predictions.

ML FLOW CODE & ML FLOW UI

ML FLOW CODE

```
# Data Profiling
# Import Package

import os
import sys

import pandas as pd
import numpy as np
from sklearn.linear_model import LinearRegression
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error, mean_absolute_error, mean_absolute_percentage_error, r2_score
import warnings
warnings.filterwarnings('ignore')

from urllib.parse import urlparse
import mlflow
import mlflow.sklearn

import logging

logging.basicConfig(level=logging.WARN)
logger = logging.getLogger(__name__)

if __name__ == "main":
    warnings.filterwarnings("ignore")
    np.random.seed(40)
```

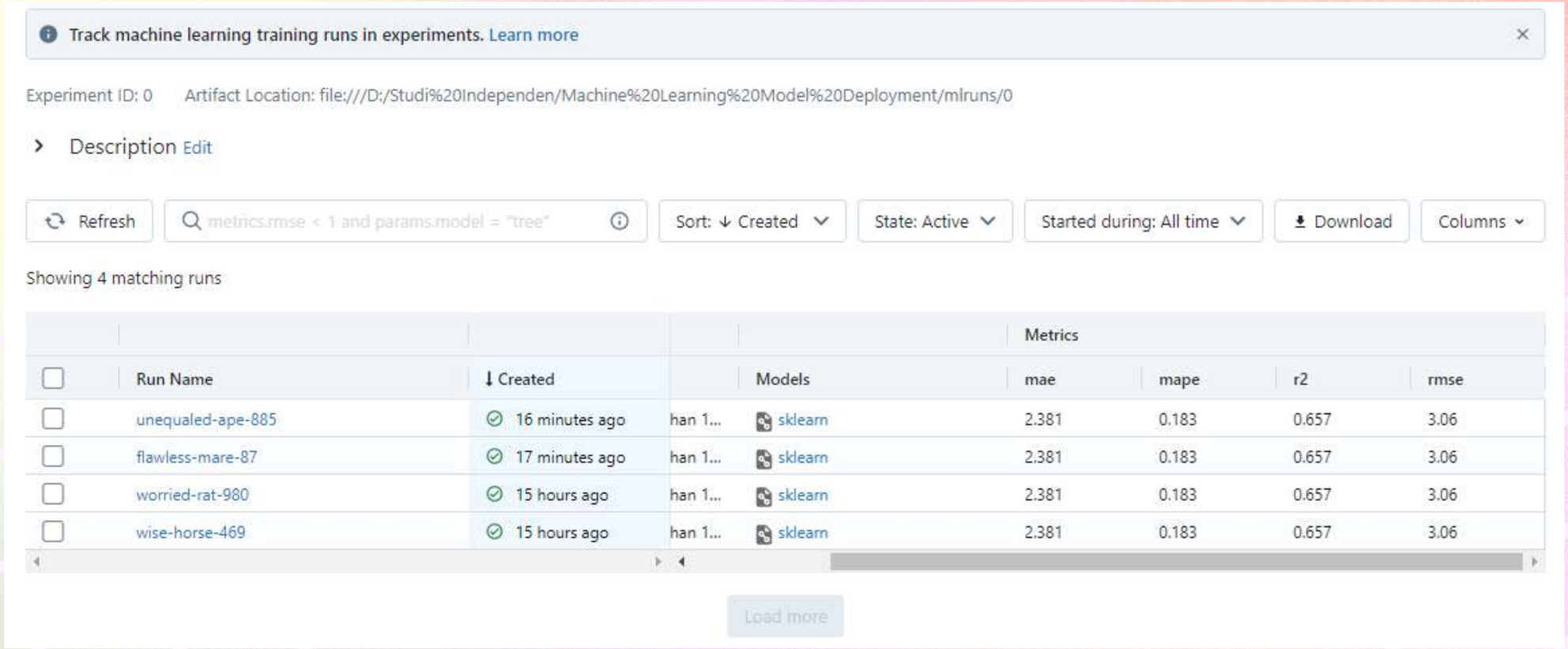
ML FLOW CODE

```
#Load Dataset
df = pd.read_csv('tvmarketing.csv')

#Preprocessing Modeling
X = df.drop(['Sales'], axis=1)
y = df['Sales']

#Splitting Training and Test Set
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size = 1/3, random_state = 42)

# Eval Metrics
def eval_metrics(actual, pred):
    rmse = np.sqrt(mean_squared_error(actual, pred))
    mae = mean_absolute_error(actual, pred)
    mape = mean_absolute_percentage_error(actual, pred)
    r2 = r2_score(actual, pred)
    return rmse, mae, mape, r2
```

ML FLOW CODE

```
# modeling

with mlflow.start_run():
        lr = LinearRegression()
        lr.fit(X_train, y_train)

        y_pred = lr.predict(X_test)

        (rmse, mae, mape, r2) = eval_metrics(y_test, y_pred)

        print("  RMSE: %s" % rmse)
        print("  MAE: %s" % mae)
        print("  MAPE: %s" % mape)
        print("  R2: %s" % r2)
        mlflow.log_metric("rmse", rmse)
        mlflow.log_metric("mae", mae)
        mlflow.log_metric("mape", mape)
        mlflow.log_metric("r2", r2)


        tracking_url_type_store = urlparse(mlflow.get_tracking_uri()).scheme

        if tracking_url_type_store != "file":
            mlflow.sklearn.log_model(lr, "model", registered_model_name="Linear Regression")
        else:
            mlflow.sklearn.log_model(lr, "model")
```

ML FLOW UI


Track machine learning training runs in experiments. Learn more
Experiment ID: 0
Artifact Location: file:///D:/Studi%20Independen/Machine%20Learning%20Model%20Deployment/mlruns/0
Description Edit
Refresh
metrics.rmse < 1 and params.model = "tree"
Sort: Created
State: Active
Started during: All time
Download
Columns
Showing 4 matching runs
Metrics
Run Name
Created
Models
mae
mape
r2
rmse
unequaled-ape-885
16 minutes ago
han 1...
sklearn
2.381
0.183
0.657
3.06
flawless-mare-87
17 minutes ago
han 1...
sklearn
2.381
0.183
0.657
3.06
worried-rat-980
15 hours ago
han 1...
sklearn
2.381
0.183
0.657
3.06
wise-horse-469
15 hours ago
han 1...
sklearn
2.381
0.183
0.657
3.06
Load more

RESULT & RECOMMENDATION

RESULT

- Based on the scatterplot, the relationship between TV advertising and sales is directly proportional. The more advertising on TV, the sales are also increasing.
- Based on the heatmap graph, it can be seen that there is a strong relationship between TV advertising and sales.
- The correlation value on the heatmap obtained is 0.78 where the figure is above 0.5.
- Based on the evaluation of the model using MAE, a fairly small value is obtained, it is 2,381. This means that the model formed is good for predictions.
- Based on the evaluation of the model using MAPE, a value of 0.18 or 18% is obtained, where this figure is below 20%. This means that the model formed has good forecasting results.
- Based on the evaluation of the model using R-Square, a value of 0.65 or 65% is obtained. This means that TV advertising has an effect of 65% on sales while the remaining 35% is influenced by other unknown factors.
- Based on the evaluation of the model using the RMSE, a fairly small value is obtained, namely 3.06. This means that the model is good enough to make predictions.

RECOMMENDATION

- In research other predictor variables can be added so that it is possible to get a better model.
- Companies must optimize the costs spent on advertising through TV because there are some sales are not necessarily high when the money spent on advertising is high.
- We can increase sales by advertising products through social media, news, etc

MODEL DEPLOYMENT

DEPLOYMENT

Deployment is a step to integrate the model machine learning into an existing production environment which can take in an input and return an output that can be used in making practical business decisions.

To Deploy the machine learning model, our team using MLflow Library

MLFLOW LIBRARY

MLflow is a platform to streamline machine learning development, including tracking experiments, packaging code into reproducible runs, and sharing and deploying models.

MLflow's current components are:

- MLflow Tracking: An API to log parameters, code, and results in machine learning experiments and compare them using an interactive UI.
- MLflow Projects: A code packaging format for reproducible runs using Conda and Docker, so you can share your ML code with others.
- MLflow Models: A model packaging format and tools that let you easily deploy the same model (from any ML library) to batch and real-time scoring on platforms such as Docker, Apache Spark, Azure ML and AWS SageMaker.
- MLflow Model Registry: A centralized model store, set of APIs, and UI, to collaboratively manage the full lifecycle of MLflow Models.
-

Result:

- Based on the model deployment, we can track model evaluations based on RMSE, MAE, MAPE, and R-Square in mlflow UI

mlflow™

THANK YOU FOR READING!