el-dear-god-workspace

October 5, 2024

0.1 Import Library

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
plt.style.use('default')
sns.set_style('white')

from scipy.stats import skew
from statsmodels.stats.outliers_influence import variance_inflation_factor
from sklearn.feature_selection import mutual_info_classif, SelectKBest
from sklearn.preprocessing import StandardScaler, OneHotEncoder, MinMaxScaler,␣
↪LabelEncoder
from imblearn.combine import SMOTEENN
# from sklearn.pipeline import Pipeline
# from sklearn.compose import ColumnTransformer
from sklearn.model_selection import train_test_split, GridSearchCV,␣
↪RandomizedSearchCV, cross_val_score, StratifiedKFold
from sklearn.metrics import accuracy_score, confusion_matrix,␣
↪classification_report, f1_score, precision_score, recall_score, roc_auc_score
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
```

0.2 Data Understanding

[2]:
```
path = '/content/ispu_dki_all.csv'

df = pd.read_csv(path)
df
```

[2]:

	tanggal	stasiun	pm10	pm25	so2	co	o3	no2	max	critical	categori
0	2010-01-01	DKI1 (Bunderan HI)	60.0	NaN	4.0	73.0	27.0	14.0	73.0	CO	SEDANG
1	2010-01-02	DKI1 (Bunderan HI)	32.0	NaN	2.0	16.0	33.0	9.0	33.0	O3	BAIK
2	2010-01-03	DKI1 (Bunderan HI)	27.0	NaN	2.0	19.0	20.0	9.0	27.0	PM10	BAIK
3	2010-01-04	DKI1 (Bunderan HI)	22.0	NaN	2.0	16.0	15.0	6.0	22.0	PM10	BAIK
4	2010-01-05	DKI1 (Bunderan HI)	25.0	NaN	2.0	17.0	15.0	8.0	25.0	PM10	BAIK
…	…	…	…	…	…	…	…	…	…	…	…
4621	2023-11-26	DKI1 (Bunderan HI)	55.0	75.0	43.0	15.0	15.0	25.0	75.0	PM25	SEDANG
4622	2023-11-27	DKI3 (Jagakarsa)	54.0	77.0	56.0	13.0	27.0	16.0	77.0	PM25	SEDANG
4623	2023-11-28	DKI1 (Bunderan HI)	62.0	96.0	45.0	15.0	29.0	34.0	96.0	PM25	SEDANG
4624	2023-11-29	DKI4 (Lubang Buaya)	71.0	105.0	30.0	19.0	22.0	14.0	105.0	PM25	TIDAK SEHAT
4625	2023-11-30	DKI1 (Bunderan HI)	38.0	67.0	43.0	12.0	34.0	34.0	67.0	PM25	SEDANG

[4626 rows x 11 columns]

[3]:
```
df['tanggal'] = pd.to_datetime(df['tanggal'])
```

[4]:
```
df = df[df.tanggal >= '2021-02-01']
df.reset_index(drop=True, inplace=True)
df
```

[4]:

	tanggal	stasiun	pm10	pm25	so2	co	o3	no2
0	2021-02-01	DKI5 (Kebon Jeruk)	73.0	126.0	38.0	26.0	46.0	34.0
1	2021-02-02	DKI3 (Jagakarsa)	53.0	70.0	40.0	14.0	55.0	25.0
2	2021-02-03	DKI3 (Jagakarsa)	32.0	53.0	40.0	11.0	42.0	19.0
3	2021-02-04	DKI5 (Kebon Jeruk)	36.0	59.0	40.0	14.0	47.0	24.0
4	2021-02-05	DKI3 (Jagakarsa)	29.0	51.0	40.0	14.0	45.0	35.0
..	…	…	…	…	…	…	…	…
718	2023-11-26	DKI1 (Bunderan HI)	55.0	75.0	43.0	15.0	15.0	25.0
719	2023-11-27	DKI3 (Jagakarsa)	54.0	77.0	56.0	13.0	27.0	16.0
720	2023-11-28	DKI1 (Bunderan HI)	62.0	96.0	45.0	15.0	29.0	34.0
721	2023-11-29	DKI4 (Lubang Buaya)	71.0	105.0	30.0	19.0	22.0	14.0
722	2023-11-30	DKI1 (Bunderan HI)	38.0	67.0	43.0	12.0	34.0	34.0

```
       max critical     categori
0    126.0     PM25  TIDAK SEHAT
1     70.0     PM25       SEDANG
2     53.0     PM25       SEDANG
3     59.0     PM25       SEDANG
4     51.0     PM25       SEDANG
..     …       …           …
718   75.0     PM25       SEDANG
719   77.0     PM25       SEDANG
720   96.0     PM25       SEDANG
721  105.0     PM25  TIDAK SEHAT
722   67.0     PM25       SEDANG

[723 rows x 11 columns]
```

[5]:
```
df.shape
```

[5]:
```
(723, 11)
```

[6]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 723 entries, 0 to 722
Data columns (total 11 columns):
 #   Column    Non-Null Count  Dtype
---  ------    --------------  -----
 0   tanggal   723 non-null    datetime64[ns]
 1   stasiun   723 non-null    object
 2   pm10      563 non-null    float64
 3   pm25      722 non-null    float64
 4   so2       717 non-null    float64
 5   co        716 non-null    float64
 6   o3        718 non-null    float64
 7   no2       715 non-null    float64
 8   max       723 non-null    float64
 9   critical  722 non-null    object
 10  categori  723 non-null    object
dtypes: datetime64[ns](1), float64(7), object(3)
memory usage: 62.3+ KB
```

[7]:
```
cats = [i for i in df.columns if df[i].dtype == 'O']

for i in cats:
  print(f'{i} : {df[i].unique()}')
```

```
stasiun : ['DKI5 (Kebon Jeruk)' 'DKI3 (Jagakarsa)' 'DKI2 (Kelapa Gading)'
 'DKI4 (Lubang Buaya)' 'DKI1 (Bunderan HI)']
critical : ['PM25' 'O3' 'PM10' 'SO2' nan]
```

```
categori : ['TIDAK SEHAT' 'SEDANG' 'BAIK' 'SANGAT TIDAK SEHAT' 'TIDAK ADA DATA']
```

[8]:
```python
for i in cats:
  print(f'{i} : {df[i].value_counts()}')
```

```
stasiun : stasiun
DKI4 (Lubang Buaya)     512
DKI3 (Jagakarsa)         91
DKI2 (Kelapa Gading)     67
DKI5 (Kebon Jeruk)       35
DKI1 (Bunderan HI)       18
Name: count, dtype: int64
critical : critical
PM25    664
O3       28
SO2      26
PM10      4
Name: count, dtype: int64
categori : categori
SEDANG                404
TIDAK SEHAT           306
BAIK                    9
SANGAT TIDAK SEHAT      3
TIDAK ADA DATA          1
Name: count, dtype: int64
```

[9]:
```python
modulus_categori = df['categori'].mode()[0]
#modulus_critical = df['critical'].mode()[0]

df['categori'] = df['categori'].replace(df['categori'].
  ↪value_counts()[df['categori'].value_counts() == 1].index, modulus_categori)
#df['critical'] = df['critical'].replace(df['critical'].
  ↪value_counts()[df['critical'].value_counts() == 1].index, modulus_critical)
df['categori'] = df['categori'].replace('SANGAT TIDAK SEHAT', 'TIDAK SEHAT')
```

[10]:
```python
duplicate_dates = df[df.duplicated(subset=['tanggal'], keep=False)]['tanggal']

if not duplicate_dates.empty:
  print("Tanggal yang duplikat:")
  print(duplicate_dates)
else:
  print("Tidak ada tanggal yang duplikat.")
```

```
Tidak ada tanggal yang duplikat.
```

[11]:
```python
df.describe()
```

[11]:
```
                             tanggal        pm10        pm25         so2  \
count                            723  563.000000  722.000000  717.000000
mean   2022-07-08 08:47:48.049792512   59.834813   94.422438   43.919107
min              2021-02-01 00:00:00    3.000000   23.000000   13.000000
25%              2021-07-31 12:00:00   51.000000   76.250000   34.000000
50%              2022-12-04 00:00:00   61.000000   94.000000   44.000000
75%              2023-06-02 12:00:00   69.000000  111.000000   53.000000
max              2023-11-30 00:00:00  179.000000  287.000000   89.000000
std                              NaN   17.242753   27.416654   11.888995

                co          o3         no2         max
count  716.000000  718.000000  715.000000  723.000000
mean    16.135475   36.711699   22.853147   95.408022
min      1.000000    6.000000    1.000000    0.000000
25%     11.000000   21.000000   15.000000   77.000000
50%     15.000000   33.000000   20.000000   95.000000
75%     20.000000   51.000000   30.000000  111.000000
max     54.000000  181.000000   65.000000  287.000000
std      7.169073   21.122124   10.952634   27.115088
```

[12]:
```
col_cats = ['critical', 'categori', 'stasiun']

df[col_cats].describe()
```

[12]:
```
       critical categori              stasiun
count       722      723                  723
unique        4        3                    5
top        PM25   SEDANG  DKI4 (Lubang Buaya)
freq        664      405                  512
```

0.3 Data Cleansing

[13]:
```
df.isnull().sum() * 100 / len(df)
```

[13]:
```
tanggal      0.000000
stasiun      0.000000
pm10        22.130014
pm25         0.138313
so2          0.829876
co           0.968188
o3           0.691563
no2          1.106501
max          0.000000
critical     0.138313
categori     0.000000
dtype: float64
```

[14]:
```
df['tahun'] = df['tanggal'].dt.year
for year in df['tahun'].unique():
  null_count = df[df['tahun'] == year]['pm25'].isnull().sum()
  print(f"Jumlah nilai null pada kolom pm25 di tahun {year}: {null_count}")
```

```
Jumlah nilai null pada kolom pm25 di tahun 2021: 0
Jumlah nilai null pada kolom pm25 di tahun 2022: 0
Jumlah nilai null pada kolom pm25 di tahun 2023: 1
```

[15]:
```
df['pm10'] = df['pm10'].interpolate(method='linear')
df['pm25'] = df['pm25'].interpolate(method='linear')
df['so2'] = df['so2'].interpolate(method='linear')
df['co'] = df['co'].interpolate(method='linear')
df['o3'] = df['o3'].interpolate(method='linear')
df['no2'] = df['no2'].interpolate(method='linear')
```

[16]:
```
df['critical'] = df['critical'].fillna(df['critical'].mode()[0])
```

[17]:
```
df.isnull().sum()
```

[17]:
```
tanggal     0
stasiun     0
pm10        0
pm25        0
so2         0
co          0
o3          0
no2         0
max         0
critical    0
categori    0
tahun       0
dtype: int64
```

[18]:
```
df.duplicated().sum()
```

[18]:
```
0
```

[19]:
```
df = df.iloc[:, :-1]
df.head()
```

[19]:

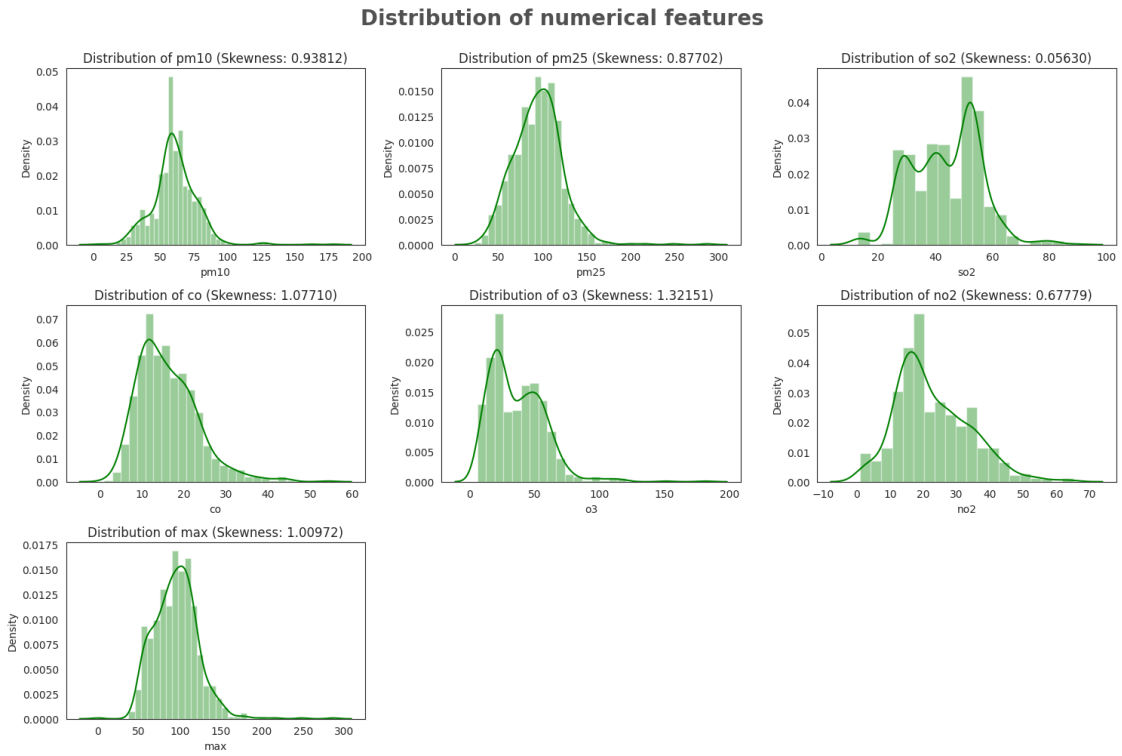
	tanggal	stasiun	pm10	pm25	so2	co	o3	no2	max	\
0	2021-02-01	DKI5 (Kebon Jeruk)	73.0	126.0	38.0	26.0	46.0	34.0	126.0	
1	2021-02-02	DKI3 (Jagakarsa)	53.0	70.0	40.0	14.0	55.0	25.0	70.0	
2	2021-02-03	DKI3 (Jagakarsa)	32.0	53.0	40.0	11.0	42.0	19.0	53.0	
3	2021-02-04	DKI5 (Kebon Jeruk)	36.0	59.0	40.0	14.0	47.0	24.0	59.0	
4	2021-02-05	DKI3 (Jagakarsa)	29.0	51.0	40.0	14.0	45.0	35.0	51.0	

```
  critical     categori
0     PM25  TIDAK SEHAT
1     PM25       SEDANG
2     PM25       SEDANG
3     PM25       SEDANG
4     PM25       SEDANG
```

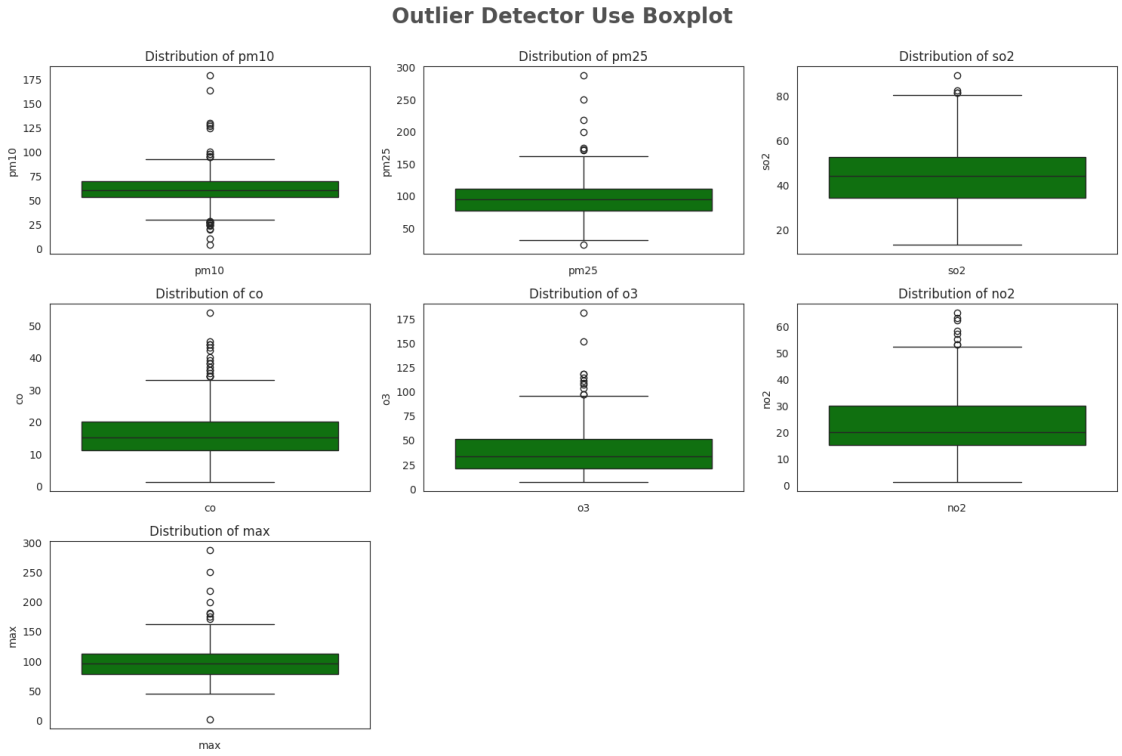
[20]:
```
df_eda = df.copy()

df_eda_num = df_eda.select_dtypes(include=np.number)
df_eda_cat = df_eda.select_dtypes(include='object')

df_eda_num.shape[1], df_eda_cat.shape[1]
```

[20]:
```
(7, 3)
```

[21]:
```
plt.figure(figsize=(15,10))
plt.suptitle('Distribution of numerical features', fontsize=20,␣
 ↪fontweight='bold', alpha=0.8, y=1.)

for i in range(0, len(df_eda_num.columns)):
  plt.subplot(3, 3, i+1)
  sns.distplot(x=df_eda_num[df_eda_num.columns[i]], color='g')
  plt.title(f'Distribution of {df_eda_num.columns[i]} (Skewness:␣
 ↪{skew(df_eda_num[df_eda_num.columns[i]]):.5f})')
  plt.xlabel(df_eda_num.columns[i])
  plt.tight_layout()
```



[22]:
```
plt.figure(figsize=(15, 10))
plt.suptitle('Outlier Detector Use Boxplot', fontsize=20, fontweight='bold',␣
 ↪alpha=0.8, y=1.)

for i in range(0, len(df_eda_num.columns)):
  plt.subplot(3, 3, i+1)
  sns.boxplot(y=df_eda_num[df_eda_num.columns[i]], color='g')
  plt.title(f"Distribution of {df_eda_num.columns[i]}")
  plt.xlabel(df_eda_num.columns[i])
  plt.tight_layout()
```



[23]:
```python
def check_outlier(df, col):
  Q1 = df[col].quantile(0.25)
  Q3 = df[col].quantile(0.75)
  IQR = Q3 - Q1

  lower_bound = Q1 - 1.5 * IQR
  upper_bound = Q3 + 1.5 * IQR

  outliers = df[(df[col] < lower_bound) | (df[col] > upper_bound)]

  return outliers

def remove_outlier(df, col):
  Q1 = df[col].quantile(0.25)
  Q3 = df[col].quantile(0.75)
  IQR = Q3 - Q1

  lower_bound = Q1 - 1.5 * IQR
  upper_bound = Q3 + 1.5 * IQR

  df_clean = df[(df[col] >= lower_bound) & (df[col] <= upper_bound)]

  return df_clean
```

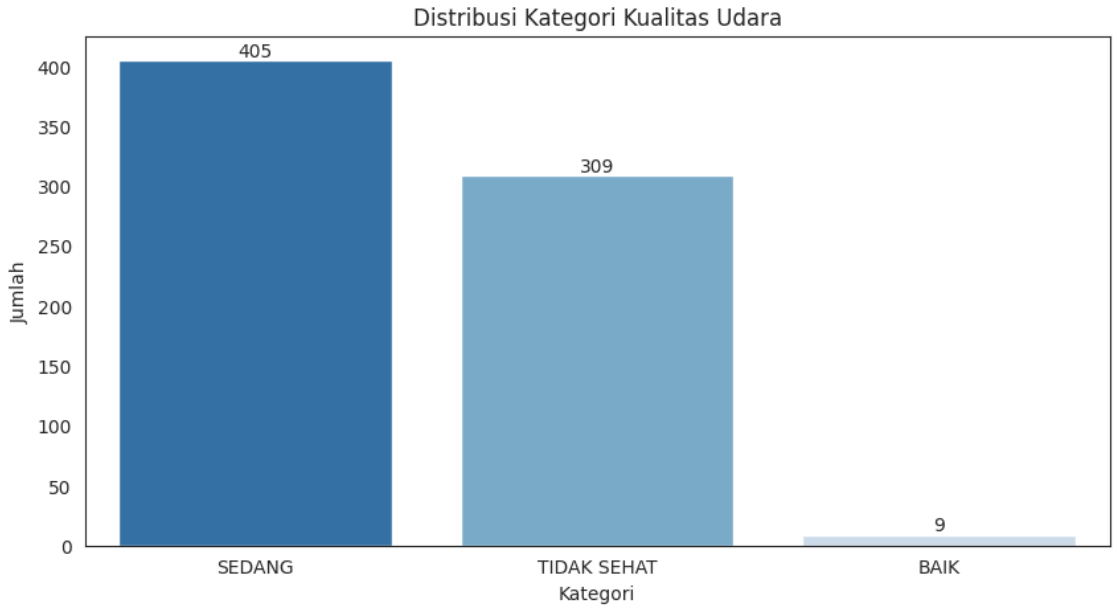
[24]:
```
def check_outliers_all_columns(df):
    numeric_columns = df.select_dtypes(include=['number']).columns
    outlier_counts = {}

    for col in numeric_columns:
        outliers = check_outlier(df, col)
        total_outliers = len(outliers)
        outlier_counts[col] = total_outliers

    for col, count in outlier_counts.items():
        print(f"Total outlier pada kolom {col}: {count}")


check_outliers_all_columns(df)
```

```
Total outlier pada kolom pm10: 28
Total outlier pada kolom pm25: 8
Total outlier pada kolom so2: 4
Total outlier pada kolom co: 18
Total outlier pada kolom o3: 11
Total outlier pada kolom no2: 8
Total outlier pada kolom max: 9
```

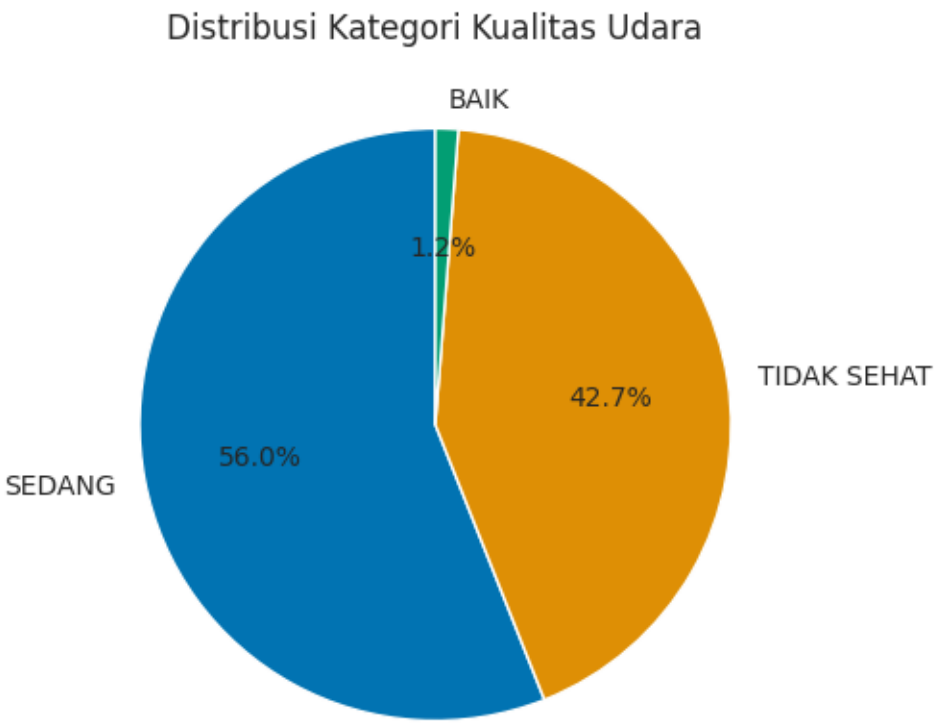
[25]:
```
# def remove_outliers_all_columns(df):
#     numeric_columns = df.select_dtypes(include=['number']).columns

#     df_clean = df.copy()
#     for col in numeric_columns:
#         df_clean = remove_outlier(df_clean, col)

#     return df_clean

# df_clean = remove_outliers_all_columns(df)
# check_outliers_all_columns(df_clean)
```

0.4 Eksploratory Data Analysis (EDA)

[26]:
```
plt.figure(figsize=(10, 5))
ax = sns.countplot(x='categori', data=df, order=df['categori'].value_counts().
  ↪index, palette='Blues_r')
for container in ax.containers:
  ax.bar_label(container, size=10, label_type='edge')
plt.title('Distribusi Kategori Kualitas Udara')
plt.xlabel('Kategori')
plt.ylabel('Jumlah')
plt.show()
```



[27]:
```
plt.figure(figsize=(10, 5))
plt.pie(df['categori'].value_counts(), labels=df['categori'].value_counts().
  ↪index, autopct='%1.1f%%', startangle=90, colors=sns.
  ↪color_palette('colorblind'))
plt.title('Distribusi Kategori Kualitas Udara')
plt.show()
```



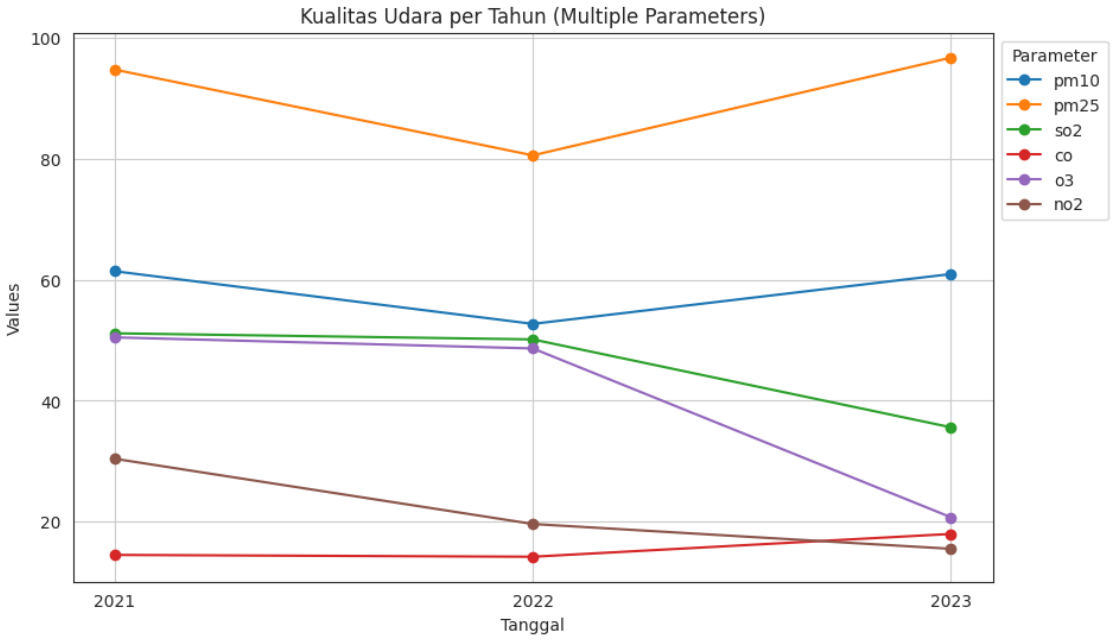
[28]:
```
df_timeseries = df.drop(columns=['stasiun', 'critical', 'categori'], axis=1)
df_timeseries.set_index('tanggal', inplace=True)
df_timeseries.head()
```

[28]:

tanggal	pm10	pm25	so2	co	o3	no2	max
2021-02-01	73.0	126.0	38.0	26.0	46.0	34.0	126.0
2021-02-02	53.0	70.0	40.0	14.0	55.0	25.0	70.0
2021-02-03	32.0	53.0	40.0	11.0	42.0	19.0	53.0
2021-02-04	36.0	59.0	40.0	14.0	47.0	24.0	59.0
2021-02-05	29.0	51.0	40.0	14.0	45.0	35.0	51.0

[29]:
```
def aggregate_data(df, value_cols, freq='Y'):
    df_aggregated = df.resample(freq).mean()[value_cols].reset_index()
    return df_aggregated

def plot_time_series_multi(df, date_col, value_cols, title='Time Series Plot'):
    plt.figure(figsize=(10, 6))

    for col in value_cols:
        plt.plot(df[date_col], df[col], marker='o', label=col)
```

```
    plt.title(title)
    plt.xlabel('Tanggal')
    plt.ylabel('Values')
    plt.grid(True)
    plt.legend(title='Parameter', bbox_to_anchor=(1, 1), loc='upper left')
    plt.xticks(df[date_col], df[date_col].dt.year)
    plt.show()

list_senyawa = ['pm10', 'pm25', 'so2', 'co', 'o3', 'no2']
aggregated_data_y = aggregate_data(df_timeseries, list_senyawa, freq='Y')

plot_time_series_multi(aggregated_data_y, 'tanggal', list_senyawa,␣
 ↪title='Kualitas Udara per Tahun (Multiple Parameters)')
```



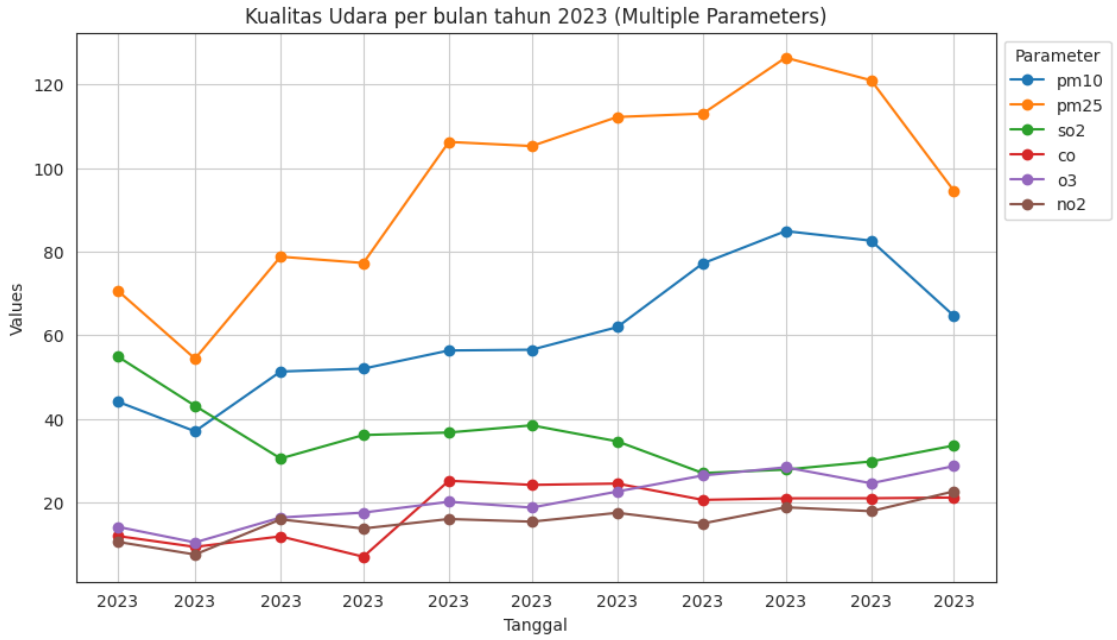
[30]:
```
df_timeseries_2 = df_timeseries.copy()
df_timeseries_2.reset_index(inplace=True)

df_timeseries_day = df_timeseries_2[df_timeseries_2['tanggal'] >= '2023-01-01']
df_timeseries_day.set_index('tanggal', inplace=True)
df_timeseries_day
```

[30]:

tanggal	pm10	pm25	so2	co	o3	no2	max
2023-01-01	44.0	61.0	56.0	16.0	20.0	19.0	61.0
2023-01-02	34.0	43.0	59.0	15.0	21.0	19.0	59.0

```
2023-01-03  28.0   34.0  57.0  13.0  21.0  16.0   57.0
2023-01-04  31.0   49.0  60.0  17.0  21.0  26.0   60.0
2023-01-05  40.0   59.0  53.0  10.0  18.0   7.0   59.0
…            …      …     …     …     …     …      …
2023-11-26  55.0   75.0  43.0  15.0  15.0  25.0   75.0
2023-11-27  54.0   77.0  56.0  13.0  27.0  16.0   77.0
2023-11-28  62.0   96.0  45.0  15.0  29.0  34.0   96.0
2023-11-29  71.0  105.0  30.0  19.0  22.0  14.0  105.0
2023-11-30  38.0   67.0  43.0  12.0  34.0  34.0   67.0

[334 rows x 7 columns]
```

[31]:
```
aggregated_data_m = aggregate_data(df_timeseries_day, list_senyawa, freq='M')

plot_time_series_multi(aggregated_data_m, 'tanggal', list_senyawa,␣
 ↪title='Kualitas Udara per bulan tahun 2023 (Multiple Parameters)')
```



[32]:
```
df.groupby('stasiun')[list_senyawa].agg('mean').round(2)
```

[32]:

stasiun	pm10	pm25	so2	co	o3	no2
DKI1 (Bunderan HI)	55.36	82.72	44.22	14.92	28.47	30.72
DKI2 (Kelapa Gading)	52.03	73.96	51.54	15.75	59.36	26.15
DKI3 (Jagakarsa)	49.34	72.90	44.09	11.35	29.97	15.86
DKI4 (Lubang Buaya)	63.77	101.60	42.59	16.93	34.14	22.59
DKI5 (Kebon Jeruk)	60.83	92.74	47.49	17.69	50.29	31.80

0.5 Feature Engineering

[33]:
```
df2 = df.copy()
df2.reset_index(drop=True, inplace=True)
#df2.drop(columns=['tanggal'], inplace=True)
df2['year'] = df2['tanggal'].dt.year
df2['month'] = df2['tanggal'].dt.month
df2['day'] = df2['tanggal'].dt.day
df2
```

[33]:

	tanggal	stasiun	pm10	pm25	so2	co	o3	no2	max	critical	categori	year	month	day
0	2021-02-01	DKI5 (Kebon Jeruk)	73.0	126.0	38.0	26.0	46.0	34.0	126.0	PM25	TIDAK SEHAT	2021	2	1
1	2021-02-02	DKI3 (Jagakarsa)	53.0	70.0	40.0	14.0	55.0	25.0	70.0	PM25	SEDANG	2021	2	2
2	2021-02-03	DKI3 (Jagakarsa)	32.0	53.0	40.0	11.0	42.0	19.0	53.0	PM25	SEDANG	2021	2	3
3	2021-02-04	DKI5 (Kebon Jeruk)	36.0	59.0	40.0	14.0	47.0	24.0	59.0	PM25	SEDANG	2021	2	4
4	2021-02-05	DKI3 (Jagakarsa)	29.0	51.0	40.0	14.0	45.0	35.0	51.0	PM25	SEDANG	2021	2	5
..	…	…	…	…	…	…	…	…	…	…	…	…	…	…
718	2023-11-26	DKI1 (Bunderan HI)	55.0	75.0	43.0	15.0	15.0	25.0	75.0	PM25	SEDANG	2023	11	26
719	2023-11-27	DKI3 (Jagakarsa)	54.0	77.0	56.0	13.0	27.0	16.0	77.0	PM25	SEDANG	2023	11	27
720	2023-11-28	DKI1 (Bunderan HI)	62.0	96.0	45.0	15.0	29.0	34.0	96.0	PM25	SEDANG	2023	11	28
721	2023-11-29	DKI4 (Lubang Buaya)	71.0	105.0	30.0	19.0	22.0	14.0	105.0	PM25	TIDAK SEHAT	2023	11	29
722	2023-11-30	DKI1 (Bunderan HI)	38.0	67.0	43.0	12.0	34.0	34.0	67.0	PM25	SEDANG	2023	11	30

[723 rows x 14 columns]

[34]:
```
df2.drop(columns=['tanggal'], inplace=True)
```

[35]:
```
df2.categori.unique()
```

[35]:
```
array(['TIDAK SEHAT', 'SEDANG', 'BAIK'], dtype=object)
```

[36]:
```
le = LabelEncoder()

df2['categori'] = le.fit_transform(df2['categori'])
```

```
df2.categori.unique()
```

[36]:
```
array([2, 1, 0])
```

[37]:
```
le.classes_
```

[37]:
```
array(['BAIK', 'SEDANG', 'TIDAK SEHAT'], dtype=object)
```

[38]:
```
df2.categori.head()
```

[38]:
```
0    2
1    1
2    1
3    1
4    1
Name: categori, dtype: int64
```

[39]:
```
df2.stasiun.unique(), df2.critical.unique()
```

[39]:
```
(array(['DKI5 (Kebon Jeruk)', 'DKI3 (Jagakarsa)', 'DKI2 (Kelapa Gading)',
        'DKI4 (Lubang Buaya)', 'DKI1 (Bunderan HI)'], dtype=object),
 array(['PM25', 'O3', 'PM10', 'SO2'], dtype=object))
```

[40]:
```
ohe = OneHotEncoder(drop='first')

col_ohe = ['stasiun', 'critical']

for i in col_ohe:
  ohe.fit(df2[[i]])
  df_ohe = pd.DataFrame(ohe.transform(df2[[i]]).toarray(), columns=ohe.
 ↪get_feature_names_out([i]))
  df2 = pd.concat([df2, df_ohe], axis=1)

df2
```

[40]:

	stasiun	pm10	pm25	so2	co	o3	no2	max	critical	\
0	DKI5 (Kebon Jeruk)	73.0	126.0	38.0	26.0	46.0	34.0	126.0	PM25	
1	DKI3 (Jagakarsa)	53.0	70.0	40.0	14.0	55.0	25.0	70.0	PM25	
2	DKI3 (Jagakarsa)	32.0	53.0	40.0	11.0	42.0	19.0	53.0	PM25	
3	DKI5 (Kebon Jeruk)	36.0	59.0	40.0	14.0	47.0	24.0	59.0	PM25	
4	DKI3 (Jagakarsa)	29.0	51.0	40.0	14.0	45.0	35.0	51.0	PM25	
..	…	…	…	…	…	…	…	…	…	
718	DKI1 (Bunderan HI)	55.0	75.0	43.0	15.0	15.0	25.0	75.0	PM25	
719	DKI3 (Jagakarsa)	54.0	77.0	56.0	13.0	27.0	16.0	77.0	PM25	
720	DKI1 (Bunderan HI)	62.0	96.0	45.0	15.0	29.0	34.0	96.0	PM25	
721	DKI4 (Lubang Buaya)	71.0	105.0	30.0	19.0	22.0	14.0	105.0	PM25	
722	DKI1 (Bunderan HI)	38.0	67.0	43.0	12.0	34.0	34.0	67.0	PM25	

```
     categori  year  month  day  stasiun_DKI2 (Kelapa Gading)  \
0           2  2021      2    1                           0.0
1           1  2021      2    2                           0.0
2           1  2021      2    3                           0.0
3           1  2021      2    4                           0.0
4           1  2021      2    5                           0.0
..        …   …    …  …                                  …
718         1  2023     11   26                           0.0
719         1  2023     11   27                           0.0
720         1  2023     11   28                           0.0
721         2  2023     11   29                           0.0
722         1  2023     11   30                           0.0

     stasiun_DKI3 (Jagakarsa)  stasiun_DKI4 (Lubang Buaya)  \
0                         0.0                          0.0
1                         1.0                          0.0
2                         1.0                          0.0
3                         0.0                          0.0
4                         1.0                          0.0
..                        …                          …
718                       0.0                          0.0
719                       1.0                          0.0
720                       0.0                          0.0
721                       0.0                          1.0
722                       0.0                          0.0

     stasiun_DKI5 (Kebon Jeruk)  critical_PM10  critical_PM25  critical_SO2
0                           1.0            0.0            1.0           0.0
1                           0.0            0.0            1.0           0.0
2                           0.0            0.0            1.0           0.0
3                           1.0            0.0            1.0           0.0
4                           0.0            0.0            1.0           0.0
..                          …              …              …           …
718                         0.0            0.0            1.0           0.0
719                         0.0            0.0            1.0           0.0
720                         0.0            0.0            1.0           0.0
721                         0.0            0.0            1.0           0.0
722                         0.0            0.0            1.0           0.0

[723 rows x 20 columns]
```

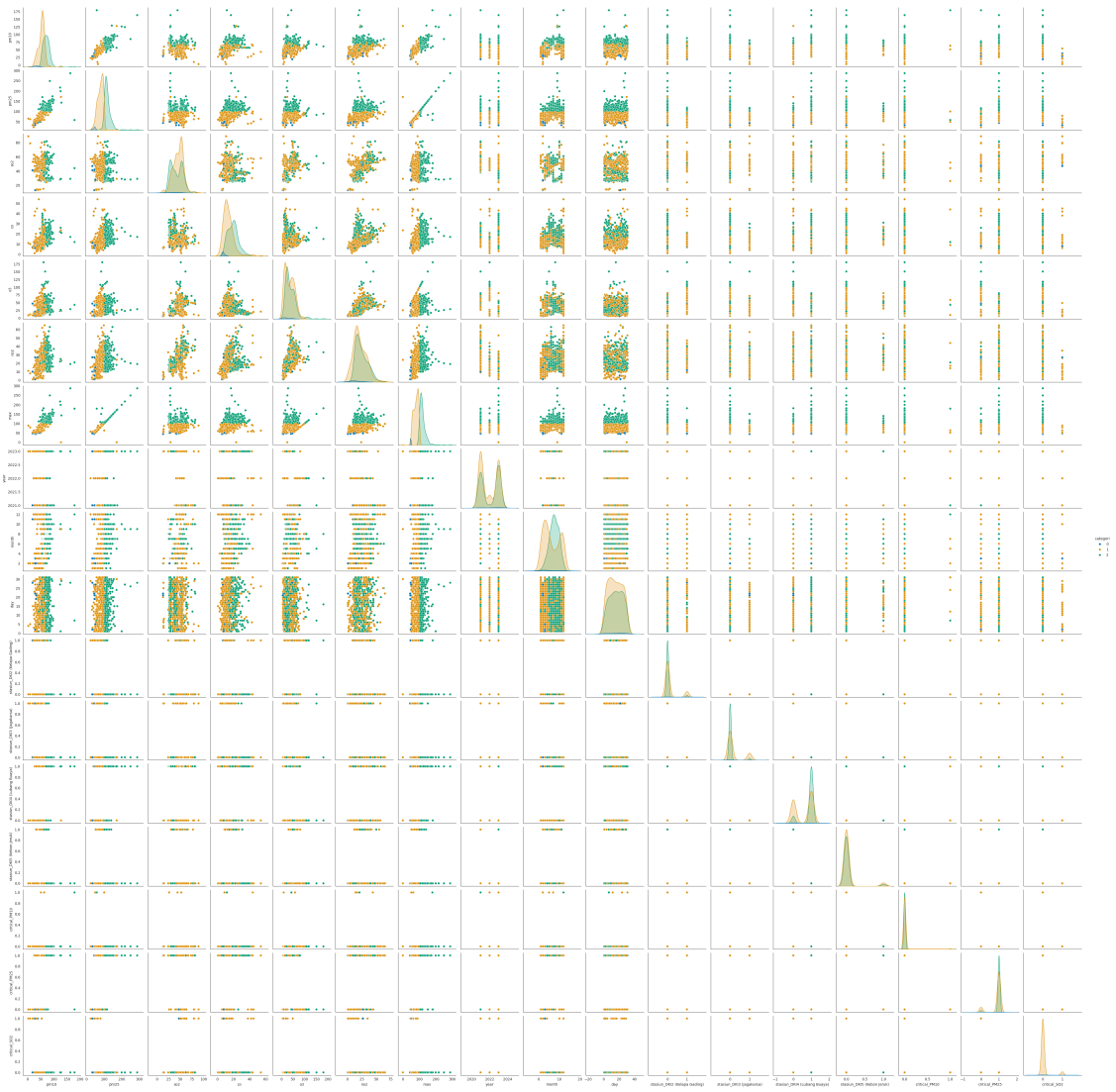
[41]:
```
df2.drop(columns=col_ohe, inplace=True)
df2.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 723 entries, 0 to 722
```

```
Data columns (total 18 columns):
 #   Column                          Non-Null Count  Dtype
---  ------                          --------------  -----
 0   pm10                            723 non-null    float64
 1   pm25                            723 non-null    float64
 2   so2                             723 non-null    float64
 3   co                              723 non-null    float64
 4   o3                              723 non-null    float64
 5   no2                             723 non-null    float64
 6   max                             723 non-null    float64
 7   categori                        723 non-null    int64
 8   year                            723 non-null    int32
 9   month                           723 non-null    int32
 10  day                             723 non-null    int32
 11  stasiun_DKI2 (Kelapa Gading)    723 non-null    float64
 12  stasiun_DKI3 (Jagakarsa)        723 non-null    float64
 13  stasiun_DKI4 (Lubang Buaya)     723 non-null    float64
 14  stasiun_DKI5 (Kebon Jeruk)      723 non-null    float64
 15  critical_PM10                   723 non-null    float64
 16  critical_PM25                   723 non-null    float64
 17  critical_SO2                    723 non-null    float64
dtypes: float64(14), int32(3), int64(1)
memory usage: 93.3 KB
```

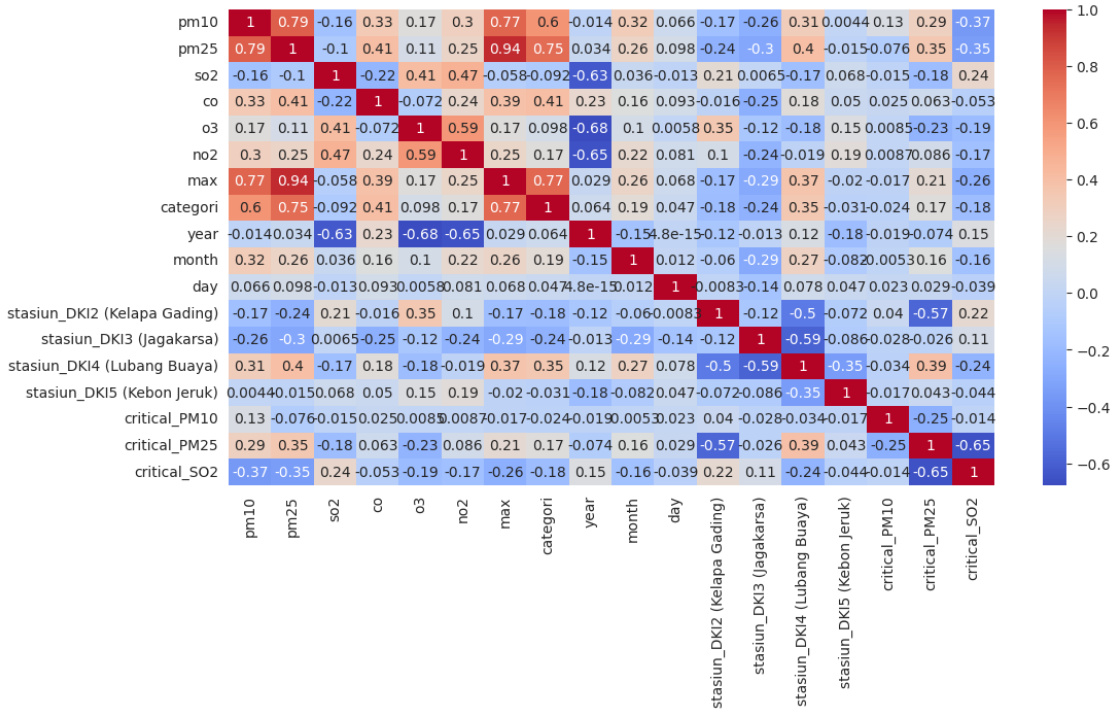
[42]:
```
sns.pairplot(df2, hue='categori', palette='colorblind')
```

[42]:
```
<seaborn.axisgrid.PairGrid at 0x79ee7ee521d0>
```



[43]:
```
plt.figure(figsize=(12, 6))
sns.heatmap(df2.corr(), annot=True, cmap='coolwarm')
```

[43]: <Axes: >



0.6 Model Selection

[44]:
```
X = df2.drop(columns=['categori'], axis=1)
y = df2['categori']
```

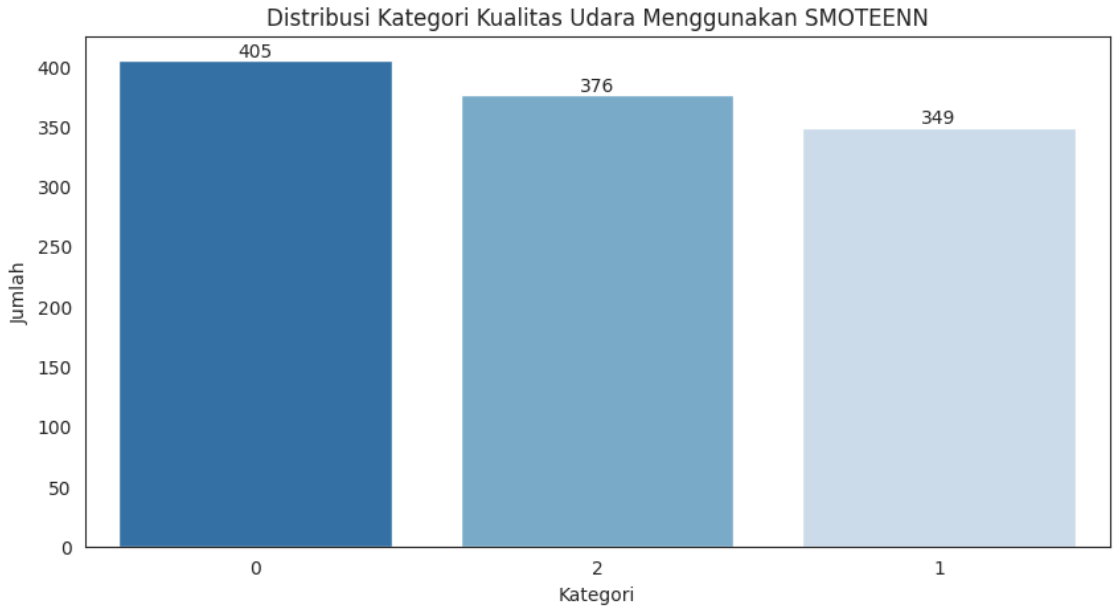
[45]:
```
df2.categori.value_counts()
```

[45]:
```
categori
1    405
2    309
0      9
Name: count, dtype: int64
```

[46]:
```
sme = SMOTEENN(sampling_strategy='auto', random_state=24)
X_res, y_res = sme.fit_resample(X, y)
y_res.value_counts()
```

[46]:
```
categori
0    405
2    376
1    349
Name: count, dtype: int64
```

[47]:
```
plt.figure(figsize=(10, 5))
ax = sns.countplot(x=y_res, order=y_res.value_counts().index, palette='Blues_r')
for container in ax.containers:
  ax.bar_label(container, size=10, label_type='edge')
plt.title('Distribusi Kategori Kualitas Udara Menggunakan SMOTEENN')
plt.xlabel('Kategori')
plt.ylabel('Jumlah')
plt.show()
```



[48]:
```
X_train, X_test, y_train, y_test = train_test_split(X_res, y_res, test_size=0.
  ↪2, random_state=42, stratify=y_res)
```

[49]:
```
X_train.columns
```

[49]:
```
Index(['pm10', 'pm25', 'so2', 'co', 'o3', 'no2', 'max', 'year', 'month', 'day',
       'stasiun_DKI2 (Kelapa Gading)', 'stasiun_DKI3 (Jagakarsa)',
       'stasiun_DKI4 (Lubang Buaya)', 'stasiun_DKI5 (Kebon Jeruk)',
       'critical_PM10', 'critical_PM25', 'critical_SO2'],
      dtype='object')
```

[50]:
```
vif = pd.DataFrame()
vif['Features'] = X_train.columns
vif['VIF'] = [variance_inflation_factor(X_train.values, i) for i in␣
  ↪range(X_train.shape[1])]
vif
```

[50]:

	Features	VIF
0	pm10	62.443400
1	pm25	395.779359
2	so2	31.974594
3	co	9.807979
4	o3	12.413079
5	no2	17.045695
6	max	447.326002
7	year	100.177781
8	month	6.215770
9	day	5.608160
10	stasiun_DKI2 (Kelapa Gading)	6.093118
11	stasiun_DKI3 (Jagakarsa)	6.561093
12	stasiun_DKI4 (Lubang Buaya)	27.743750
13	stasiun_DKI5 (Kebon Jeruk)	2.454893
14	critical_PM10	1.410984
15	critical_PM25	54.112393
16	critical_SO2	8.919659

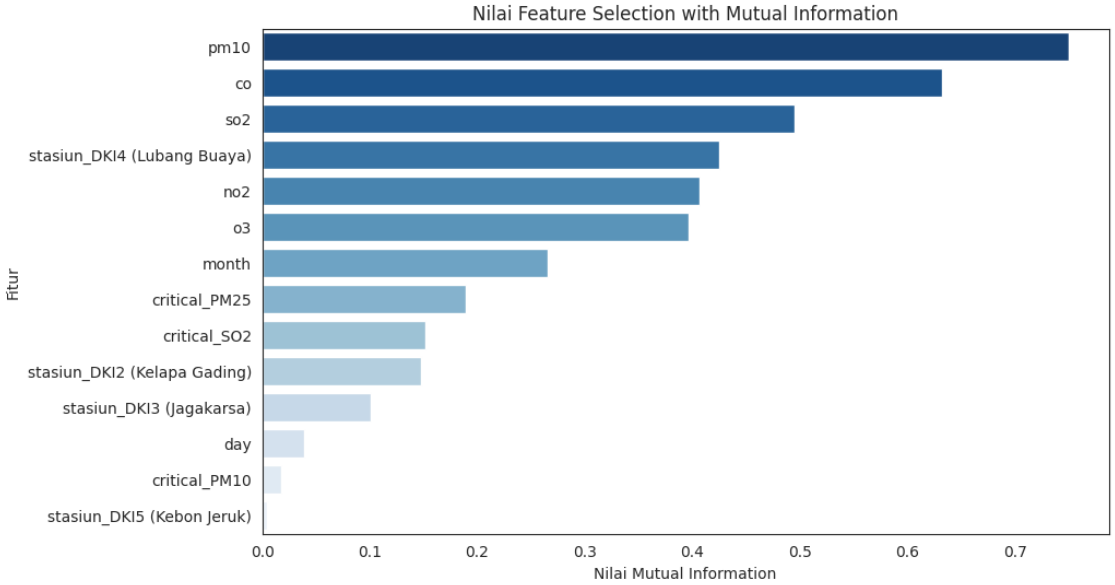
[51]:
```
col_high_vif = ['max', 'pm25', 'year']

X_train.drop(columns=col_high_vif, inplace=True)
X_test.drop(columns=col_high_vif, inplace=True)
```

[52]:
```
mutual_info = mutual_info_classif(X_train, y_train)
mutual_info = pd.Series(mutual_info)
mutual_info.index = X_train.columns
mutual_info.sort_values(ascending=False)
```

[52]:
```
pm10                           0.749941
co                             0.632169
so2                            0.495090
stasiun_DKI4 (Lubang Buaya)    0.424748
no2                            0.406863
o3                             0.396490
month                          0.265607
critical_PM25                  0.189266
critical_SO2                   0.151790
stasiun_DKI2 (Kelapa Gading)   0.147192
stasiun_DKI3 (Jagakarsa)       0.100925
day                            0.038630
critical_PM10                  0.017768
stasiun_DKI5 (Kebon Jeruk)     0.004442
dtype: float64
```

[53]:
```
plt.figure(figsize=(10, 6))
```

```
sns.barplot(x=mutual_info, y=mutual_info.index, orient='h', palette='Blues_r',␣
 ↪order=mutual_info.sort_values(ascending=False).index)
plt.xlabel('Nilai Mutual Information')
plt.ylabel('Fitur')
plt.title('Nilai Feature Selection with Mutual Information')
plt.show()
```



[54]:
```
sel_ten_cols = SelectKBest(mutual_info_classif, k=10)
sel_ten_cols.fit(X_train, y_train)
selected_columns = X_train.columns[sel_ten_cols.get_support()]
X_train = X_train[selected_columns]
X_test = X_test[selected_columns]
```

[55]:
```
X_train.shape[1], X_test.shape[1]
```

[55]:
```
(10, 10)
```

[56]:
```
models = {
    'Logistic Regression': LogisticRegression(),
    'Random Forest': RandomForestClassifier(),
    'K-Nearest Neighbors': KNeighborsClassifier(),
    'Decision Tree': DecisionTreeClassifier(),
    'Support Vector Machine': SVC()
}

for i in range(len(list(models))):
  model = list(models.values())[i]
```

```
model.fit(X_train, y_train)

y_train_pred = model.predict(X_train)
y_test_pred = model.predict(X_test)

model_train_accuracy = accuracy_score(y_train, y_train_pred)
model_train_f1 = f1_score(y_train, y_train_pred, average='weighted')
model_train_recall = recall_score(y_train, y_train_pred, average='weighted')
model_train_precision = precision_score(y_train, y_train_pred,␣
↪average='weighted')
#model_train_roc_auc = roc_auc_score(y_train, y_train_pred,␣
↪average='weighted', multi_class='ovr')

model_test_accuracy = accuracy_score(y_test, y_test_pred)
model_test_f1 = f1_score(y_test, y_test_pred, average='weighted')
model_test_recall = recall_score(y_test, y_test_pred, average='weighted')
model_test_precision = precision_score(y_test, y_test_pred,␣
↪average='weighted')
#model_test_roc_auc = roc_auc_score(y_test, y_test_pred, average='weighted',␣
↪multi_class='ovr')

print(list(models.keys())[i])

print('Model performance for Training set')
print("- Accuracy: {:.4f}".format(model_train_accuracy))
print('- F1 Score: {:.4f}'.format(model_train_f1))

print('- Recall: {:.4f}'.format(model_train_recall))
print('- Precision: {:.4f}'.format(model_train_precision))
#print('- ROC AUC Score: {:.4f}'.format(model_train_roc_auc))



print('----------------------------------')


print('Model performance for Test set')
print('- Accuracy: {:.4f}'.format(model_test_accuracy))
print('- F1 Score: {:.4f}'.format(model_test_f1))

print('- Recall: {:.4f}'.format(model_test_recall))
print('- Precision: {:.4f}'.format(model_test_precision))
#print('- ROC AUC Score: {:.4f}'.format(model_test_roc_auc))



print('='*35)
```

```
  print('\n')
```

```
Logistic Regression
Model performance for Training set
- Accuracy: 0.8573
- F1 Score: 0.8513
- Recall: 0.8573
- Precision: 0.8588
----------------------------------
Model performance for Test set
- Accuracy: 0.8584
- F1 Score: 0.8552
- Recall: 0.8584
- Precision: 0.8560
==================================


Random Forest
Model performance for Training set
- Accuracy: 1.0000
- F1 Score: 1.0000
- Recall: 1.0000
- Precision: 1.0000
----------------------------------
Model performance for Test set
- Accuracy: 0.9513
- F1 Score: 0.9515
- Recall: 0.9513
- Precision: 0.9520
==================================


K-Nearest Neighbors
Model performance for Training set
- Accuracy: 0.9392
- F1 Score: 0.9384
- Recall: 0.9392
- Precision: 0.9402
----------------------------------
Model performance for Test set
- Accuracy: 0.9381
- F1 Score: 0.9371
- Recall: 0.9381
- Precision: 0.9411
==================================
```

```
Decision Tree
Model performance for Training set
- Accuracy: 1.0000
- F1 Score: 1.0000
- Recall: 1.0000
- Precision: 1.0000
----------------------------------
Model performance for Test set
- Accuracy: 0.9071
- F1 Score: 0.9078
- Recall: 0.9071
- Precision: 0.9094
==================================


Support Vector Machine
Model performance for Training set
- Accuracy: 0.8938
- F1 Score: 0.8905
- Recall: 0.8938
- Precision: 0.8945
----------------------------------
Model performance for Test set
- Accuracy: 0.9115
- F1 Score: 0.9089
- Recall: 0.9115
- Precision: 0.9128
==================================
```

[57]:
```python
rfc_params = {
    'max_depth': [5, 10, 15, None],
    'min_samples_split': [2, 4, 6, 8, 10],
    'min_samples_leaf': [1, 2, 4, 6, 8, 10],
    'n_estimators': [100, 200, 300]
}

dtr_params = {
    'max_depth': [5, 10, 15, None],
    'min_samples_split': [2, 4, 6, 8, 10],
    'min_samples_leaf': [1, 2, 4, 6, 8, 10]
}

lr_params = {
    'C': [0.001, 0.01, 0.1, 1, 10, 100],
    'penalty': ['l1', 'l2'],
```

```
    'solver': ['liblinear', 'saga']
}

knn_params = {
    'n_neighbors': [3, 5, 7, 9],
    'weights': ['uniform', 'distance'],
    'p': [1, 2]
}

svc_params = {
    'C': [0.001, 0.01, 0.1, 1, 10, 100],
    'kernel': ['linear', 'poly', 'rbf', 'sigmoid'],
    'gamma': ['scale', 'auto']
}
```

[58]:
```
random_cv_models = [
    ('Lr', LogisticRegression(), lr_params),
    ('Rfc', RandomForestClassifier(), rfc_params),
    ('Knn', KNeighborsClassifier(), knn_params),
    ('Dtr', DecisionTreeClassifier(), dtr_params),
    ('Svc', SVC(), svc_params)
]
random_cv_models
```

[58]:
```
[('Lr',
  LogisticRegression(),
  {'C': [0.001, 0.01, 0.1, 1, 10, 100],
   'penalty': ['l1', 'l2'],
   'solver': ['liblinear', 'saga']}),
 ('Rfc',
  RandomForestClassifier(),
  {'max_depth': [5, 10, 15, None],
   'min_samples_split': [2, 4, 6, 8, 10],
   'min_samples_leaf': [1, 2, 4, 6, 8, 10],
   'n_estimators': [100, 200, 300]}),
 ('Knn',
  KNeighborsClassifier(),
  {'n_neighbors': [3, 5, 7, 9],
   'weights': ['uniform', 'distance'],
   'p': [1, 2]}),
 ('Dtr',
  DecisionTreeClassifier(),
  {'max_depth': [5, 10, 15, None],
   'min_samples_split': [2, 4, 6, 8, 10],
   'min_samples_leaf': [1, 2, 4, 6, 8, 10]}),
 ('Svc',
  SVC(),
```

```
  {'C': [0.001, 0.01, 0.1, 1, 10, 100],
   'kernel': ['linear', 'poly', 'rbf', 'sigmoid'],
   'gamma': ['scale', 'auto']})]
```

[59]:
```
model_params = {}

for name, model, params in random_cv_models:
  random = RandomizedSearchCV(estimator=model,
                              param_distributions=params,
                              cv=3,
                              n_iter=10,
                              scoring='accuracy',
                              n_jobs=-1,
                              verbose=2)
  random.fit(X_train, y_train)
  model_params[name] = random.best_params_


for model_name in model_params:
  print(f'------------- Best Params for {model_name} ---------------')
  print(model_params[model_name])
```

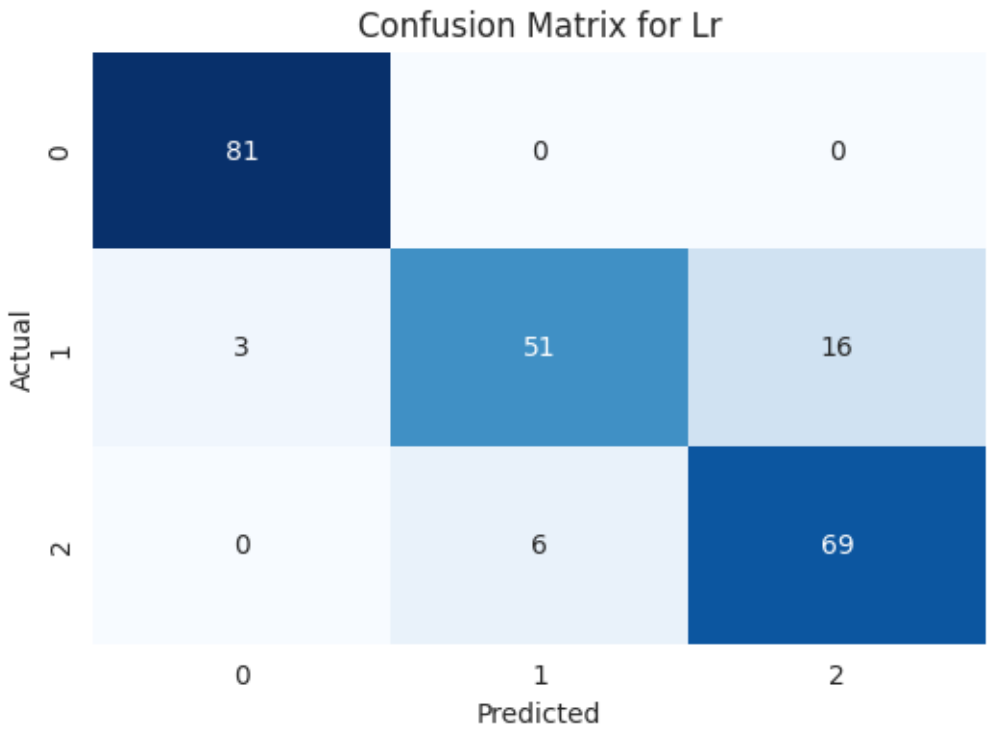
```
Fitting 3 folds for each of 10 candidates, totalling 30 fits
Fitting 3 folds for each of 10 candidates, totalling 30 fits
Fitting 3 folds for each of 10 candidates, totalling 30 fits
Fitting 3 folds for each of 10 candidates, totalling 30 fits
Fitting 3 folds for each of 10 candidates, totalling 30 fits
------------- Best Params for Lr ---------------
{'solver': 'liblinear', 'penalty': 'l1', 'C': 100}
------------- Best Params for Rfc ---------------
{'n_estimators': 300, 'min_samples_split': 10, 'min_samples_leaf': 1,
'max_depth': 15}
------------- Best Params for Knn ---------------
{'weights': 'distance', 'p': 1, 'n_neighbors': 3}
------------- Best Params for Dtr ---------------
{'min_samples_split': 2, 'min_samples_leaf': 4, 'max_depth': 10}
------------- Best Params for Svc ---------------
{'kernel': 'linear', 'gamma': 'auto', 'C': 100}
```

[60]:
```
models_params_grid = {
    'Lr': LogisticRegression(),
    'Rfc': RandomForestClassifier(),
    'Knn': KNeighborsClassifier(),
    'Dtr': DecisionTreeClassifier(),
    'Svc': SVC()
}
```

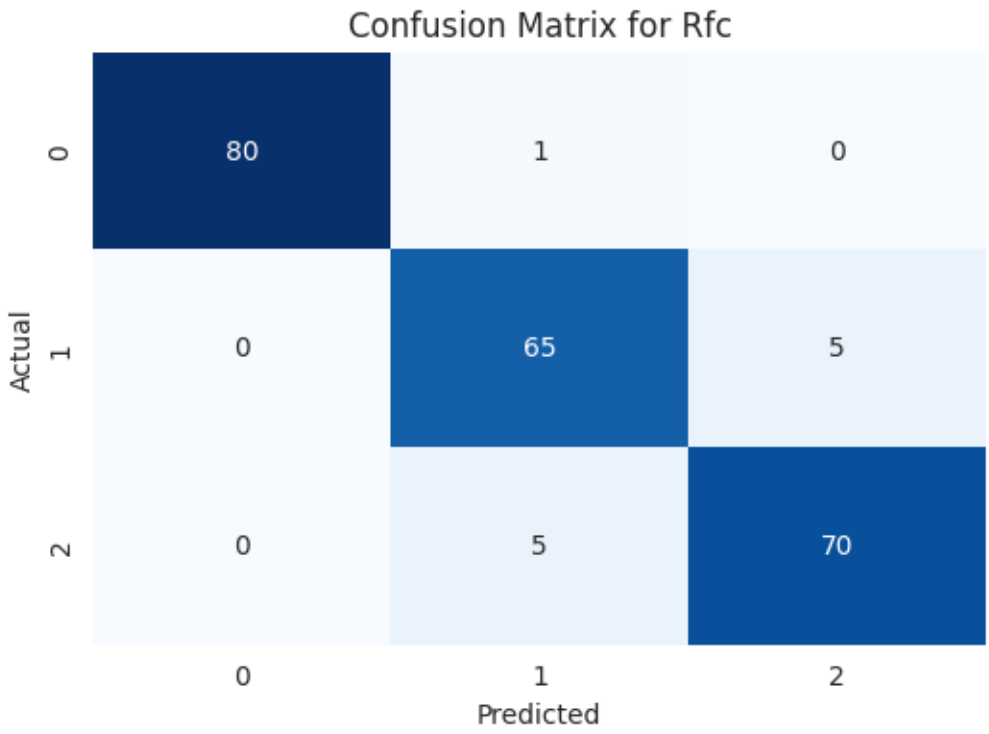
```
fitted_models = {}
for i in range(len(list(models_params_grid))):
  model_name = list(models_params_grid.keys())[i]
  model = list(models_params_grid.values())[i]

  model.set_params(**model_params[model_name])
  model.fit(X_train, y_train)
  fitted_models[model_name] = model

  y_train_pred = model.predict(X_train)
  y_test_pred = model.predict(X_test)

  train_accuracy = accuracy_score(y_train, y_train_pred)
  train_f1 = f1_score(y_train, y_train_pred, average='weighted')
  train_recall = recall_score(y_train, y_train_pred, average='weighted')
  train_precision = precision_score(y_train, y_train_pred, average='weighted')

  test_accuracy = accuracy_score(y_test, y_test_pred)
  test_f1 = f1_score(y_test, y_test_pred, average='weighted')
  test_recall = recall_score(y_test, y_test_pred, average='weighted')
  test_precision = precision_score(y_test, y_test_pred, average='weighted')

  print(f'------------- {model_name} ---------------')
  print(f'Training Accuracy: {train_accuracy:.4f}')
  print('- F1 Score: {:.4f}'.format(train_f1))
  print('- Recall: {:.4f}'.format(train_recall))
  print('- Precision: {:.4f}'.format(train_precision))

  print('----------------------------------')

  print(f'Test Accuracy: {test_accuracy:.4f}')
  print('- F1 Score: {:.4f}'.format(test_f1))
  print('- Recall: {:.4f}'.format(test_recall))
  print('- Precision: {:.4f}'.format(test_precision))

  print('----------------------------------')

  print(f'Classification Report:')
  print(classification_report(y_test, y_test_pred))

  cm = confusion_matrix(y_test, y_test_pred)

  plt.figure(figsize=(6,4))
  sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', cbar=False)
  plt.title(f'Confusion Matrix for {model_name}')
  plt.ylabel('Actual')
  plt.xlabel('Predicted')
```

```
  plt.show()

  print('='*50)
```

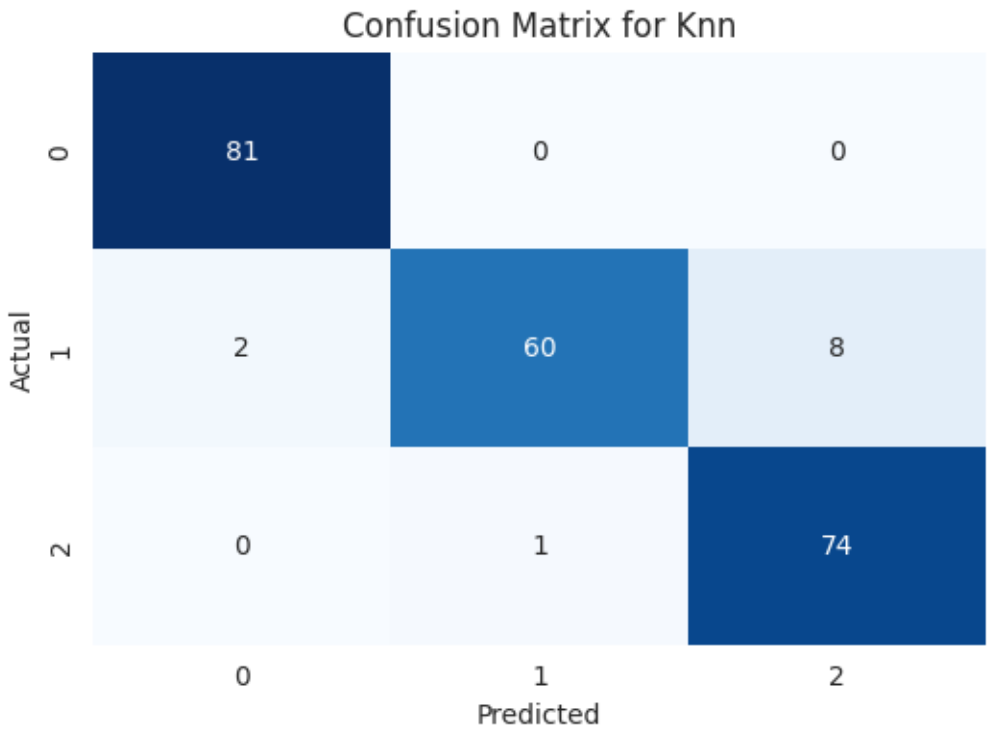
```
------------ Lr ---------------
Training Accuracy: 0.8971
- F1 Score: 0.8938
- Recall: 0.8971
- Precision: 0.9032
----------------------------------
Test Accuracy: 0.8894
- F1 Score: 0.8869
- Recall: 0.8894
- Precision: 0.8921
----------------------------------
Classification Report:
              precision    recall  f1-score   support

           0       0.96      1.00      0.98        81
           1       0.89      0.73      0.80        70
           2       0.81      0.92      0.86        75

    accuracy                           0.89       226
   macro avg       0.89      0.88      0.88       226
weighted avg       0.89      0.89      0.89       226
```



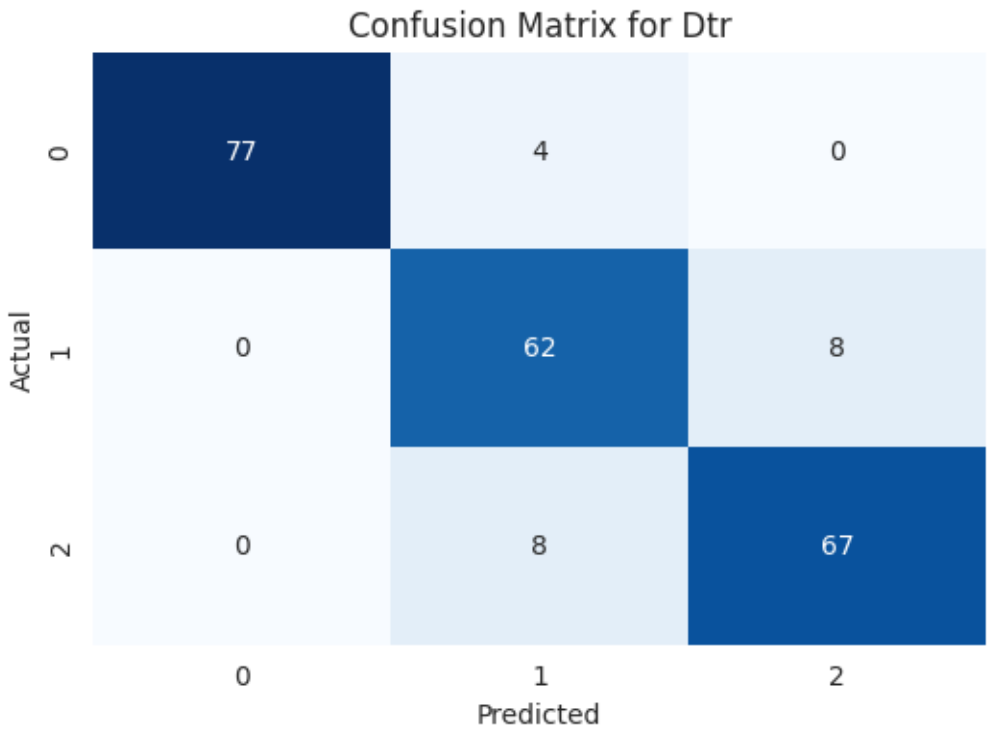
```
==================================================
------------ Rfc ---------------
Training Accuracy: 0.9801
- F1 Score: 0.9801
- Recall: 0.9801
- Precision: 0.9802
---------------------------------
Test Accuracy: 0.9513
- F1 Score: 0.9515
- Recall: 0.9513
- Precision: 0.9517
---------------------------------
Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.99      0.99        81
           1       0.92      0.93      0.92        70
           2       0.93      0.93      0.93        75

    accuracy                           0.95       226
   macro avg       0.95      0.95      0.95       226
weighted avg       0.95      0.95      0.95       226
```



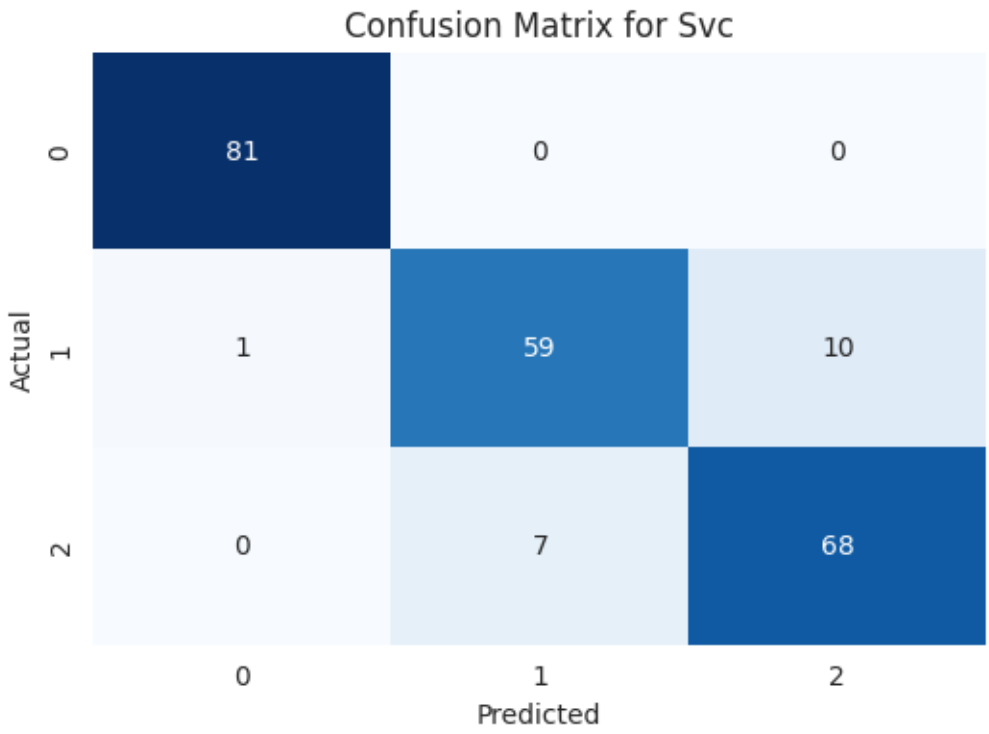
```
==================================================
------------ Knn ---------------
Training Accuracy: 1.0000
- F1 Score: 1.0000
- Recall: 1.0000
- Precision: 1.0000
---------------------------------
Test Accuracy: 0.9513
- F1 Score: 0.9506
- Recall: 0.9513
- Precision: 0.9539
---------------------------------
Classification Report:
              precision    recall  f1-score   support

           0       0.98      1.00      0.99        81
           1       0.98      0.86      0.92        70
           2       0.90      0.99      0.94        75

    accuracy                           0.95       226
   macro avg       0.95      0.95      0.95       226
weighted avg       0.95      0.95      0.95       226
```



```
================================================
------------ Dtr ---------------
Training Accuracy: 0.9679
- F1 Score: 0.9680
- Recall: 0.9679
- Precision: 0.9682
---------------------------------
Test Accuracy: 0.9115
- F1 Score: 0.9125
- Recall: 0.9115
- Precision: 0.9144
---------------------------------
Classification Report:
              precision    recall  f1-score   support

           0       1.00      0.95      0.97        81
           1       0.84      0.89      0.86        70
           2       0.89      0.89      0.89        75

    accuracy                           0.91       226
   macro avg       0.91      0.91      0.91       226
weighted avg       0.91      0.91      0.91       226
```

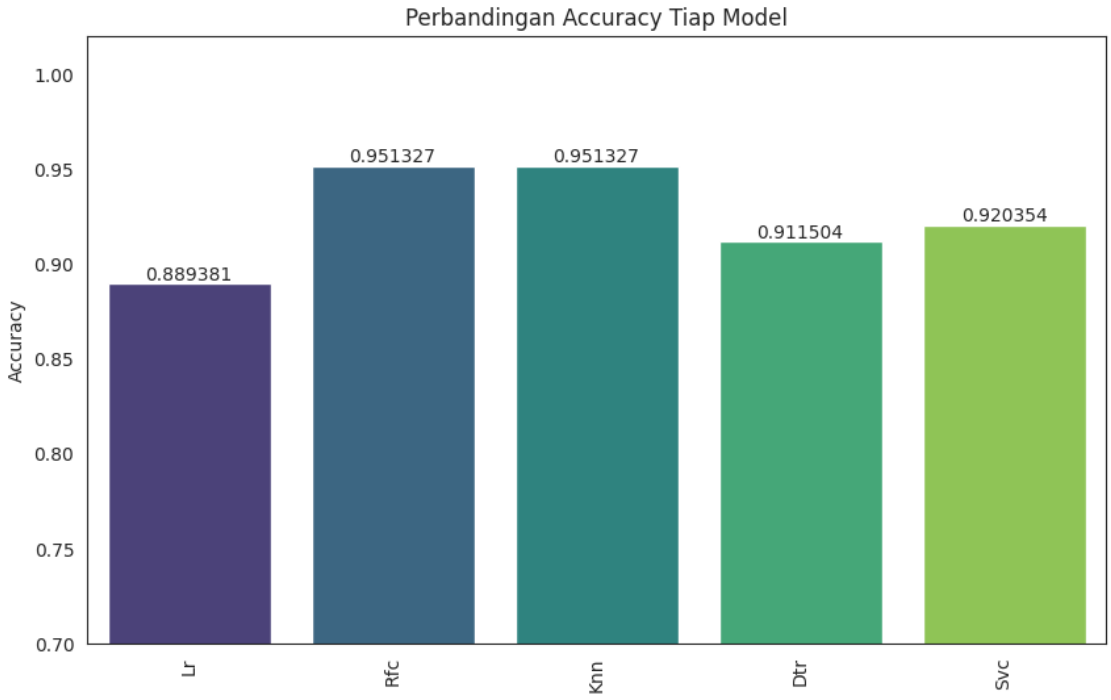


```
==================================================
------------ Svc ---------------
Training Accuracy: 0.9204
- F1 Score: 0.9193
- Recall: 0.9204
- Precision: 0.9209
---------------------------------
Test Accuracy: 0.9204
- F1 Score: 0.9199
- Recall: 0.9204
- Precision: 0.9202
---------------------------------
Classification Report:
              precision    recall  f1-score   support

           0       0.99      1.00      0.99        81
           1       0.89      0.84      0.87        70
           2       0.87      0.91      0.89        75

    accuracy                           0.92       226
   macro avg       0.92      0.92      0.92       226
weighted avg       0.92      0.92      0.92       226
```



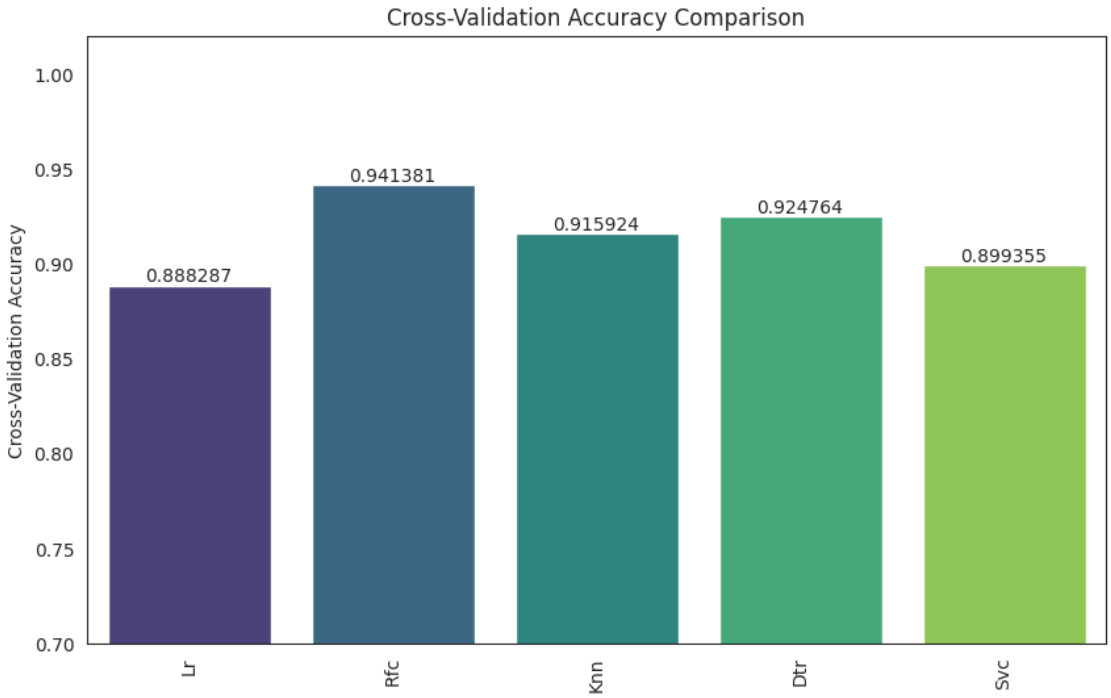
==========

[61]:
```
models = ['Lr', 'Rfc', 'Knn', 'Dtr', 'Svc']

accuracy = []
for model_name in models:
    model = fitted_models[model_name]
    y_test_pred = model.predict(X_test)
    acc = accuracy_score(y_test, y_test_pred)
    accuracy.append(acc)


plt.figure(figsize=(10, 6))
ax = sns.barplot(x=models, y=accuracy, palette='viridis')
for container in ax.containers:
  ax.bar_label(container, size=10, label_type='edge')
plt.xticks(rotation=90)
plt.ylim(0.7, 1.02)
plt.ylabel('Accuracy')
plt.title('Perbandingan Accuracy Tiap Model')
plt.show()
```



[62]:
```
skf = StratifiedKFold(n_splits=5, shuffle=True, random_state=42)

models = ['Lr', 'Rfc', 'Knn', 'Dtr', 'Svc']

cv_scores = {}
for model_name in models:
    model = fitted_models[model_name]
    scores = cross_val_score(model, X_train, y_train, cv=skf,␣
 ↪scoring='accuracy')

    cv_scores[model_name] = scores.mean()

    print(f'Cross-Validation Accuracy Scores for {model_name}: {scores}')
    print(f'Mean Accuracy for {model_name}: {scores.mean():.4f}')
    print('-' * 50)

plt.figure(figsize=(10, 6))
ax = sns.barplot(x=list(cv_scores.keys()), y=list(cv_scores.values()),␣
 ↪palette='viridis')
for container in ax.containers:
  ax.bar_label(container, size=10, label_type='edge')
plt.xticks(rotation=90)
plt.ylim(0.7, 1.02)
plt.ylabel('Cross-Validation Accuracy')
plt.title('Cross-Validation Accuracy Comparison')
plt.show()
```

```
Cross-Validation Accuracy Scores for Lr: [0.88950276 0.88950276 0.86740331
0.89502762 0.9       ]
Mean Accuracy for Lr: 0.8883
--------------------------------------------------
Cross-Validation Accuracy Scores for Rfc: [0.92265193 0.96132597 0.93370166
0.93922652 0.95      ]
Mean Accuracy for Rfc: 0.9414
--------------------------------------------------
Cross-Validation Accuracy Scores for Knn: [0.91712707 0.91712707 0.90607735
0.9281768  0.91111111]
Mean Accuracy for Knn: 0.9159
--------------------------------------------------
Cross-Validation Accuracy Scores for Dtr: [0.93922652 0.93922652 0.91160221
0.92265193 0.91111111]
Mean Accuracy for Dtr: 0.9248
--------------------------------------------------
Cross-Validation Accuracy Scores for Svc: [0.90607735 0.8839779  0.90055249
0.88950276 0.91666667]
Mean Accuracy for Svc: 0.8994
--------------------------------------------------
```



0.7 Testing

[63]:
```
X_train.columns
```

[63]:
```
Index(['pm10', 'so2', 'co', 'o3', 'no2', 'month',
       'stasiun_DKI2 (Kelapa Gading)', 'stasiun_DKI4 (Lubang Buaya)',
       'critical_PM25', 'critical_SO2'],
      dtype='object')
```

[64]:
```
# test_df = pd.DataFrame({
#     'pm10': [31.467642],
#     'pm25': [44.508593],
#     'so2': [41.0],
#     'co': [7.0],
#     'o3': [42.204753],
#     'no2': [11.918099],
#     'max': [45.081901]
# })

# rfc_model = fitted_models['Rfc']
# rfc_prediction = rfc_model.predict(test_df)
# print('Prediction for test data:', rfc_prediction[0])
```

[65]:
```
X_train[:1]
```

[65]:
```
     pm10   so2    co    o3   no2  month  stasiun_DKI2 (Kelapa Gading)  \
792  66.0  52.0  17.0  51.0  43.0      6                           0.0

     stasiun_DKI4 (Lubang Buaya)  critical_PM25  critical_SO2
792                          1.0            1.0           0.0
```

[66]:
```
y_train[:1]
```

[66]:
```
792    2
Name: categori, dtype: int64
```

[67]:
```
le.classes_
```

[67]:
```
array(['BAIK', 'SEDANG', 'TIDAK SEHAT'], dtype=object)
```