Assignment 3

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```
from google.colab import drive
drive.mount('/content/drive')
```

```
Mounted at /content/drive
```

Pada assignment ini, kita akan meneliti data prediksi stroke dengan menggunakan algoritma Decision Tree dan Random Forest untuk melakukan prediksi penyakit stroke. Lalu melakukan Hyperparameter Tuning Pada model tersebut dan tentukan model mana yang terbaik berdasarkan matrik evaluasi yang digunakan.

Attribute Information

1. id: unique identifier
2. gender: "Male", "Female" or "Other"
3. age: age of the patient
4. hypertension: 0 if the patient doesn't have hypertension, 1 if the patient has hypertension
5. heart_disease: 0 if the patient doesn't have any heart diseases, 1 if the patient has a heart disease
6. ever_married: "No" or "Yes"
7. work_type: "children", "Govt_jov", "Never_worked", "Private" or "Self-employed"
8. Residence_type: "Rural" or "Urban"
9. avg_glucose_level: average glucose level in blood
10. bmi: body mass index
11. smoking_status: "formerly smoked", "never smoked", "smokes" or "Unknown"*
12. stroke: 1 if the patient had a stroke or 0 if not

*Note: "Unknown" in smoking_status means that the information is unavailable for this patient

Import Libraries

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

```
#preprocessing
from sklearn.model_selection import train_test_split
from imblearn.over_sampling import SMOTE
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split

#model ML
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
```

```
#evaluasi
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from sklearn.metrics import accuracy_score, classification_report
```

Data Loading

```
!mkdir ~/.kaggle
```

```
!cp '/content/kaggle.json' ~/.kaggle
!chmod 600 ~/.kaggle/kaggle.json
!kaggle datasets list
```

```
cp: cannot stat '/content/kaggle.json': No such file or directory
chmod: cannot access '/root/.kaggle/kaggle.json': No such file or directory
```

```
Traceback (most recent call last):
  File "/usr/local/bin/kaggle", line 5, in <module>
    from kaggle.cli import main
  File "/usr/local/lib/python3.10/dist-packages/kaggle/__init__.py", line 7, in <module>
    api.authenticate()
  File "/usr/local/lib/python3.10/dist-packages/kaggle/api/kaggle_api_extended.py", line 398, in authenticate
    raise IOError('Could not find {}. Make sure it\'s located in'
OSError: Could not find kaggle.json. Make sure it's located in /root/.kaggle. Or use the environment method.
```

```
!kaggle datasets download -d fedesoriano/stroke-prediction-dataset
```

```
Dataset URL: https://www.kaggle.com/datasets/fedesoriano/stroke-prediction-dataset
License(s): copyright-authors
Downloading stroke-prediction-dataset.zip to /content
  0% 0.00/67.4k [00:00<?, ?B/s]
100% 67.4k/67.4k [00:00<00:00, 46.9MB/s]
```

```
!unzip /content/stroke-prediction-dataset.zip
```

```
Archive:  /content/stroke-prediction-dataset.zip
  inflating: healthcare-dataset-stroke-data.csv
```

```
df= pd.read_csv('healthcare-dataset-stroke-data.csv')
df.shape
```

```
(5110, 12)
```

Assessing Data

[ ] ↳ *11 sel tersembunyi*

Cleaning Data

[ ] ↳ *4 sel tersembunyi*

EDA (Exploratory Data Analysis) & Visualization

```
df.describe(include="all")
```

	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glucose_level	bmi	sm
count	4909	4909.000000	4909.000000	4909.000000	4909	4909	4909	4909.000000	4909.000000	
unique	3	NaN	NaN	NaN	2	5	2	NaN	NaN	
top	Female	NaN	NaN	NaN	Yes	Private	Urban	NaN	NaN	
freq	2897	NaN	NaN	NaN	3204	2811	2490	NaN	NaN	
mean	NaN	42.865374	0.091872	0.049501	NaN	NaN	NaN	105.305150	28.893237	
std	NaN	22.555115	0.288875	0.216934	NaN	NaN	NaN	44.424341	7.854067	
min	NaN	0.080000	0.000000	0.000000	NaN	NaN	NaN	55.120000	10.300000	
25%	NaN	25.000000	0.000000	0.000000	NaN	NaN	NaN	77.070000	23.500000	
50%	NaN	44.000000	0.000000	0.000000	NaN	NaN	NaN	91.680000	28.100000	
75%	NaN	60.000000	0.000000	0.000000	NaN	NaN	NaN	113.570000	33.100000	
max	NaN	82.000000	1.000000	1.000000	NaN	NaN	NaN	271.740000	97.600000	

```
df.dtypes
```

```
gender               object
age                 float64
hypertension          int64
heart_disease         int64
ever_married         object
work_type            object
Residence_type       object
avg_glucose_level   float64
bmi                 float64
smoking_status       object
stroke                int64
dtype: object
```

Stroke Patients

```
stroke_counttotal = df[['stroke']].value_counts().sum()
print('Total pasien yang terkena stroke', stroke_counttotal)
```

```
Total pasien yang terkena stroke 4909
```

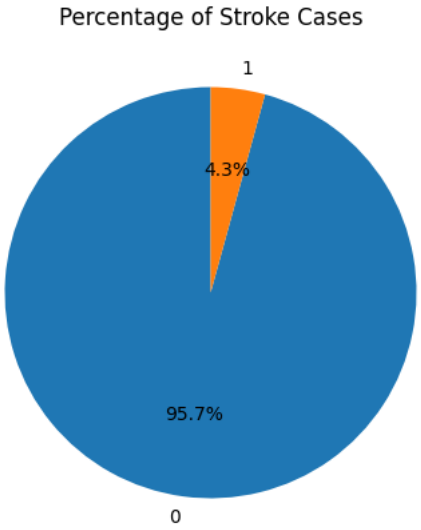
Menghitung persentasi penderita stroke

```
stroke_count = df['stroke'].value_counts().reset_index(name='count')
stroke_count.columns = ['stroke', 'count']
stroke_count['percentage'] = (stroke_count['count'] / stroke_count['count'].sum()) * 100
stroke_count
```

	stroke	count	percentage
0	0	4700	95.742514
1	1	209	4.257486

Next steps: View recommended plots

```
plt.figure(figsize=(5, 5))
plt.pie(stroke_count['percentage'], labels=stroke_count['stroke'], autopct='%1.1f%%', startangle=90)
plt.title('Percentage of Stroke Cases')
plt.show()
```



Dari 4909 pasien pada dataset, 4.3% merupakan penderita stroke dan 95.7% bukan penderita stroke

Categorical Features

Gender

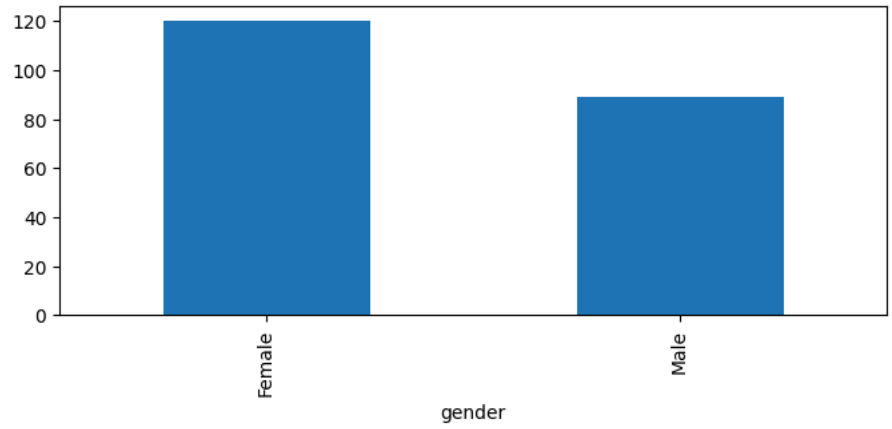
```
condition = (1)
stroke_patients = df[(df['stroke'] == 1)]
```

```
stroke_patients['gender'].value_counts()
```

```
gender
Female    120
Male       89
Name: count, dtype: int64
```

```
plt.figure(figsize=(8,3))
stroke_patients["gender"].value_counts().plot(kind = "bar")
```

```
<Axes: xlabel='gender'>
```



Dapat disimpulkan bahwa penderita penyakit stroke paling banyak merupakan wanita

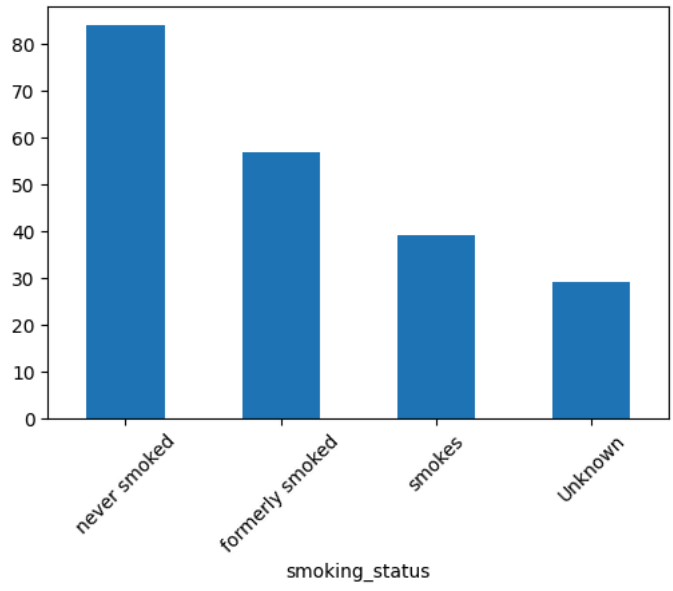
Smoke Status

```
stroke_patients["smoking_status"].value_counts()
```

```
smoking_status
never smoked       84
formerly smoked    57
smokes             39
Unknown            29
Name: count, dtype: int64
```

```
plt.figure(figsize=(6,4))
stroke_patients["smoking_status"].value_counts().plot(kind = "bar")
plt.xticks(rotation=45)
```

```
(array([0, 1, 2, 3]),
 [Text(0, 0, 'never smoked'),
  Text(1, 0, 'formerly smoked'),
  Text(2, 0, 'smokes'),
  Text(3, 0, 'Unknown')])
```



Dari pasien tersebut 57 orang diantaranya sebelumnya pernah merokok, 84 orang tidak merokok dan 39 merupakan perokok.

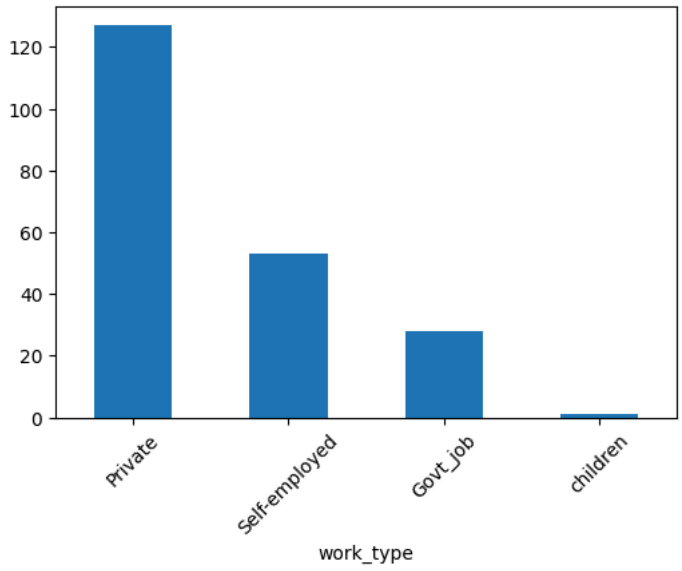
Work Status

```
stroke_patients["work_type"].value_counts()
```

```
work_type
Private          127
Self-employed     53
Govt_job          28
children           1
Name: count, dtype: int64
```

```
plt.figure(figsize=(6,4))
stroke_patients["work_type"].value_counts().plot(kind = "bar")
plt.xticks(rotation=45)
```

```
(array([0, 1, 2, 3]),
 [Text(0, 0, 'Private'),
  Text(1, 0, 'Self-employed'),
  Text(2, 0, 'Govt_job'),
  Text(3, 0, 'children')])
```



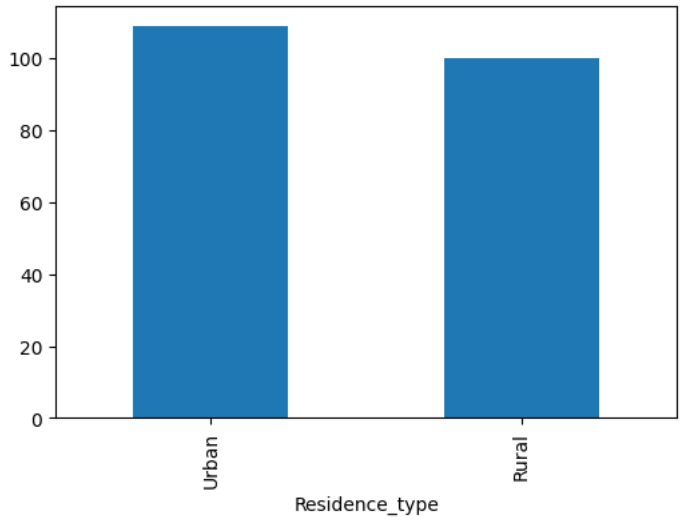
Dapat diketahui bahwa individu yang bekerja di sektor swasta/private lebih berpeluang terkena stroke yaitu lebih dari 120 orang.

```
stroke_patients["Residence_type"].value_counts()
```

```
Residence_type
Urban    109
Rural    100
Name: count, dtype: int64
```

```
plt.figure(figsize=(6,4))
stroke_patients["Residence_type"].value_counts().plot(kind = "bar")
```

```
<Axes: xlabel='Residence_type'>
```



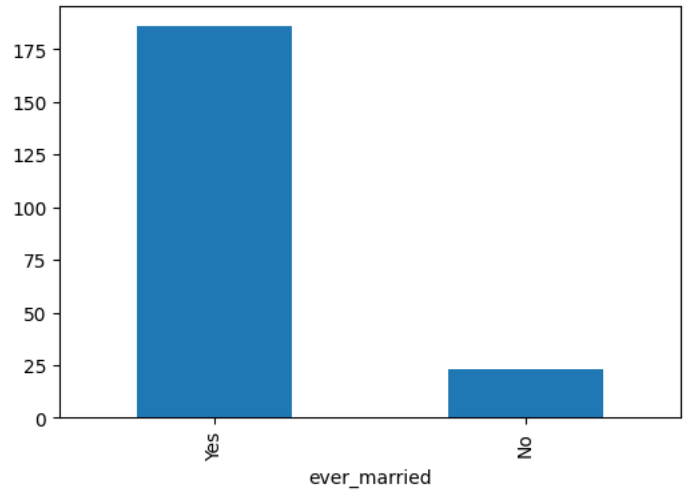
Terlihat setara antara penduduk perkotaan dan pedesaan

```
stroke_patients["ever_married"].value_counts()
```

```
ever_married
Yes    186
No      23
Name: count, dtype: int64
```

```
plt.figure(figsize=(6,4))
stroke_patients["ever_married"].value_counts().plot(kind = "bar")
```

```
<Axes: xlabel='ever_married'>
```



Individu yang sudah menikah lebih mendominasi daripada yang belum

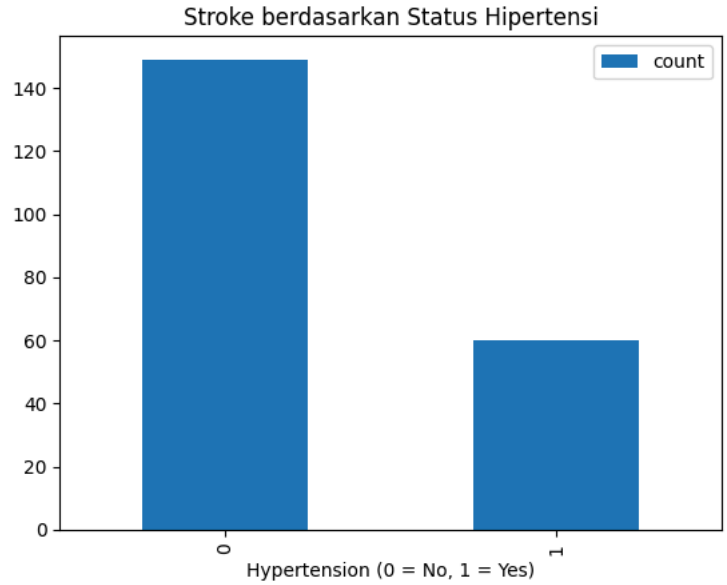
Hypertension

```
stroke_patients["hypertension"].value_counts()
```

```
hypertension
0    149
1     60
Name: count, dtype: int64
```

```
stroke_patients["hypertension"].value_counts().plot(kind = "bar")
plt.title('Stroke berdasarkan Status Hipertensi')
plt.xlabel('Hypertension (0 = No, 1 = Yes)')
plt.legend(loc='upper right', bbox_to_anchor=(1, 1))
```

```
<matplotlib.legend.Legend at 0x7f917f507310>
```



Dapat dilihat dari 209 pasien stroke 60 pasien merupakan penderita hipertensi.

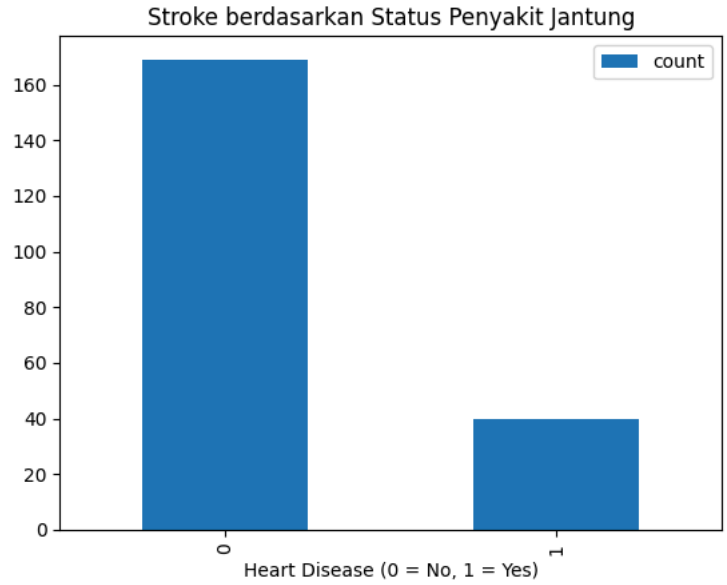
Heart Disease

```
stroke_patients["heart_disease"].value_counts()
```

```
heart_disease
0    169
1     40
Name: count, dtype: int64
```

```
stroke_patients["heart_disease"].value_counts().plot(kind = "bar")
plt.title('Stroke berdasarkan Status Penyakit Jantung')
plt.xlabel('Heart Disease (0 = No, 1 = Yes)')
plt.legend(loc='upper right', bbox_to_anchor=(1, 1))
```

```
<matplotlib.legend.Legend at 0x7f917f3a5b10>
```



Dari 209 pasien stroke, 40 orang merupakan penderita penyakit jantung dan 169 orang tidak

Numerical Features

Age

```
stroke_patients["age"].value_counts()
```

```
age
80.0    16
78.0    16
81.0    14
79.0    13
57.0    10
82.0     9
68.0     9
63.0     7
77.0     7
74.0     7
70.0     6
59.0     6
54.0     6
69.0     6
71.0     5
76.0     5
72.0     5
60.0     4
61.0     4
73.0     4
58.0     4
66.0     3
45.0     3
56.0     3
51.0     3
67.0     3
39.0     3
75.0     3
49.0     3
50.0     3
52.0     2
65.0     2
64.0     2
48.0     2
53.0     2
55.0     2
43.0     1
47.0     1
38.0     1
46.0     1
32.0     1
42.0     1
```

```
14.0     1
Name: count, dtype: int64
```

Terlihat beberapa rentang usia, pasien yang berusia 78 atau 80 lebih rentan terkena stroke. KIta akan membagi rentang usia menjadi 4 kelompok dan memvisualisasikannya agar mudah dimengerti.

```
age_range = [0, 24, 45, 60, 80, 100]

stroke_patients['age_group'] = pd.cut(stroke_patients['age'], bins=age_range, labels=['0 to 24', '25 to 44', '45 to 59', '69 to 79', '8

age_group = stroke_patients.groupby(['age_group']).size().reset_index(name = 'count')
age_group
```

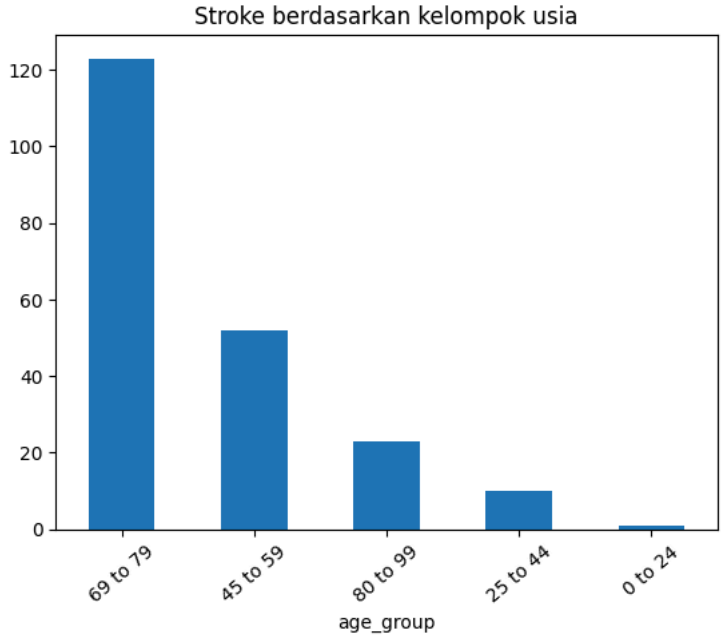
```
<ipython-input-36-dec98c4665f1>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  stroke_patients['age_group'] = pd.cut(stroke_patients['age'], bins=age_range, labels=['0 to 24', '25 to 44', '45 to 59', '69 to 7
```

	age_group	count
0	0 to 24	1
1	25 to 44	10
2	45 to 59	52
3	69 to 79	123
4	80 to 99	23

Next steps: View recommended plots

```
stroke_patients["age_group"].value_counts().plot(kind = "bar")
plt.title('Stroke berdasarkan kelompok usia')
plt.xticks(rotation=40)
```

```
(array([0, 1, 2, 3, 4]),
 [Text(0, 0, '69 to 79'),
  Text(1, 0, '45 to 59'),
  Text(2, 0, '80 to 99'),
  Text(3, 0, '25 to 44'),
  Text(4, 0, '0 to 24')])
```



Dapat dilihat bahwa pasien yang berusia 69 sampai 79 tahun lebih rentan terkena stroke.

Average Glucose Level

```
stroke_patients["avg_glucose_level"].value_counts()
```

```
avg_glucose_level
228.69    1
```

```
131.41    1
195.71    1
74.02     1
203.87    1
         ..
226.98    1
72.81     1
68.02     1
68.56     1
78.81     1
Name: count, Length: 209, dtype: int64
```

Menurut National Institutes of Health (NIH), berikut merupakan kisaran kadar gula darah.

- 99 mg/dL, kadar gula darah normal
- 100-125 mg/dL, berarti pradiabetes
- 126 mg/dL atau lebih tinggi, merupakan diabetes

```
stroke_patients['avg_glucose_level'] = stroke_patients['avg_glucose_level'].astype(int)
gluco_range = [0, 99, 125, float('inf')]
stroke_patients['gluco_group'] = pd.cut(stroke_patients['avg_glucose_level'], bins=gluco_range, labels=['0 to 99', '100 to 125', '126 a
gluco_group = stroke_patients.groupby(['gluco_group']).size().reset_index(name = 'count')
gluco_group
```

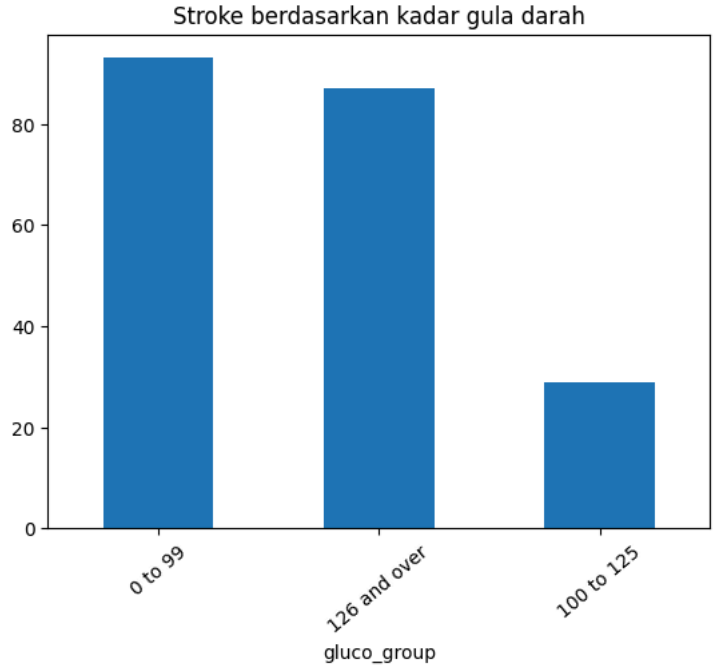
```
<ipython-input-39-4fef5e199b90>:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  stroke_patients['avg_glucose_level'] = stroke_patients['avg_glucose_level'].astype(int)
<ipython-input-39-4fef5e199b90>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  stroke_patients['gluco_group'] = pd.cut(stroke_patients['avg_glucose_level'], bins=gluco_range, labels=['0 to 99', '100 to 125',
```

	gluco_group	count
0	0 to 99	93
1	100 to 125	29
2	126 and over	87

Next steps: View recommended plots

```
stroke_patients["gluco_group"].value_counts().plot(kind = "bar")
plt.title('Stroke berdasarkan kadar gula darah')
plt.xticks(rotation=40)
```

```
(array([0, 1, 2]),
 [Text(0, 0, '0 to 99'), Text(1, 0, '126 and over'), Text(2, 0, '100 to 125')])
```



Dapat dilihat bahwa 93 pasien memiliki kadar gula darah normal. 87 pasien memiliki diabetes.

BMI

- 0 - 18.4: Underweight
- 18.5 - 24.9: Normal
- 25.0 - 29.9: Overweight
- 30 or more: Obesitas

```
bmi_range = [0, 18.5, 25.0, 30.0, float('inf')]
labels = ['0 to 18.4', '18.5 to 24.9', '25.0 to 29.9', '30.0 and more']
stroke_patients['bmi'] = pd.cut(stroke_patients['bmi'], bins=bmi_range, labels=labels)
bmi_group = stroke_patients.groupby('bmi').size().reset_index(name='count')
bmi_group
```

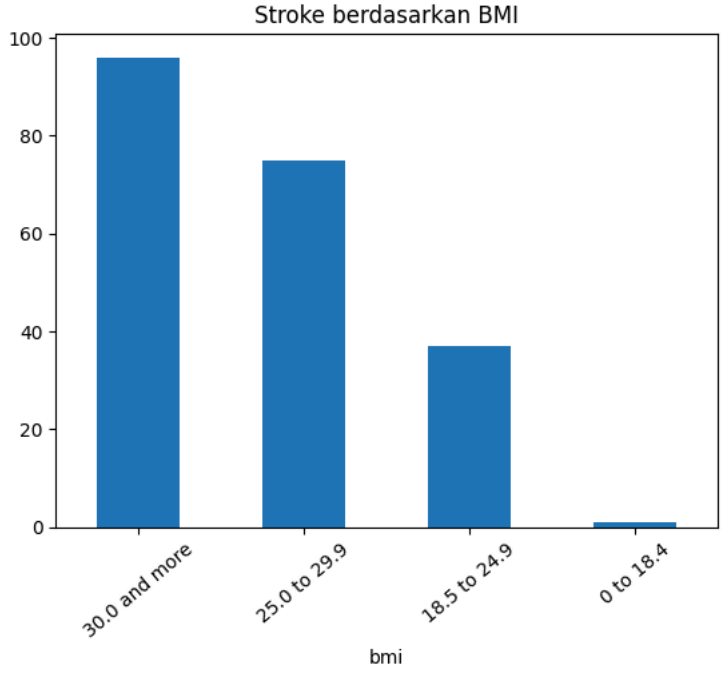
```
<ipython-input-41-18da8eaf5e63>:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus
  stroke_patients['bmi'] = pd.cut(stroke_patients['bmi'], bins=bmi_range, labels=labels)
```

	bmi	count
0	0 to 18.4	1
1	18.5 to 24.9	37
2	25.0 to 29.9	75
3	30.0 and more	96

Next steps: View recommended plots

```
stroke_patients["bmi"].value_counts().plot(kind = "bar")
plt.title('Stroke berdasarkan BMI')
plt.xticks(rotation=40)
```

```
(array([0, 1, 2, 3]),
 [Text(0, 0, '30.0 and more'),
  Text(1, 0, '25.0 to 29.9'),
  Text(2, 0, '18.5 to 24.9'),
  Text(3, 0, '0 to 18.4')])
```



Dapat dilihat bahwa 96 pasien stroke memiliki BMI 30 atau lebih yang diketegorikan sebagai obesitas.

Data Preprocessing

Feature Engineering

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 4909 entries, 0 to 5109
Data columns (total 11 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   gender             4909 non-null   object 
 1   age                4909 non-null   float64
 2   hypertension       4909 non-null   int64  
 3   heart_disease      4909 non-null   int64  
 4   ever_married       4909 non-null   object 
 5   work_type          4909 non-null   object 
 6   Residence_type     4909 non-null   object 
 7   avg_glucose_level  4909 non-null   float64
 8   bmi                4909 non-null   float64
 9   smoking_status     4909 non-null   object 
 10  stroke             4909 non-null   int64  
dtypes: float64(3), int64(3), object(5)
memory usage: 460.2+ KB
```

Pemberian label pada kolom gender, ever_married, dan Residence_type

```
df['gender'].replace(['Male', 'Female', 'Other'],[0, 1, 1], inplace=True)
```

```
df['ever_married'].replace(['Yes', 'No'],[0, 1], inplace=True)
```

```
df['Residence_type'].replace(['Rural', 'Urban'],[0, 1], inplace=True)
```

```
df.head()
```

	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glucose_level	bmi	smoking_status	strok
0	0	67.0	0	1	0	Private	1	228.69	36.6	formerly smoked	
2	0	80.0	0	1	0	Private	0	105.92	32.5	never smoked	
3	1	49.0	0	0	0	Private	1	171.23	34.4	smokes	
4	1	79.0	1	0	0	Self-employed	0	174.12	24.0	never smoked	

Next steps: View recommended plots

OneHotEncoding

```
one_hot_encoded = df[['smoking_status','work_type']]
one_hot_encoded=pd.get_dummies(one_hot_encoded)
df.drop(columns=['smoking_status','work_type'],inplace=True)
```

```
df_encoded = pd.concat([df, one_hot_encoded], axis=1)
```

```
df_encoded.head()
```

	gender	age	hypertension	heart_disease	ever_married	Residence_type	avg_glucose_level	bmi	stroke	smoking_status_Unknown
0	0	67.0	0	1	0	1	228.69	36.6	1	False
2	0	80.0	0	1	0	0	105.92	32.5	1	False
3	1	49.0	0	0	0	1	171.23	34.4	1	False
4	1	79.0	1	0	0	0	174.12	24.0	1	False
5	0	81.0	0	0	0	1	186.21	29.0	1	False

Next steps: View recommended plots

Data Split

```
# feature & target
X = df_encoded.drop("stroke", axis=1)
y = df_encoded["stroke"]

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.25, random_state=42)
X_train, X_val, y_train, y_val = train_test_split(X_train, y_train, test_size=0.25, random_state=42)
```

Oversampling

```
smote = SMOTE(random_state=42)
X_train_smote, y_train_smote = smote.fit_resample(X_train, y_train)
```

Scaler

```
scaler = StandardScaler()
X_train_scaled = scaler.fit_transform(X_train_smote)
X_val_scaled = scaler.transform(X_val)
X_test_scaled = scaler.transform(X_test)
```

Modeling

Decision Tree

```
# Training Model
dt = DecisionTreeClassifier(random_state=42)
dt.fit(X_train, y_train)
```

```
DecisionTreeClassifier(random_state=42)
```

```
# Evaluasi Model
predictions = dt.predict(X_test)
accuracy = accuracy_score(y_test, predictions)
print("Accuracy:", accuracy)
```

```
Accuracy: 0.9161237785016286
```

```
y_pred_train = dt.predict(X_train)
accuracy_train = accuracy_score(y_train, y_pred_train)
print("Accuracy:", accuracy_train)
```

```
Accuracy: 1.0
```

```
# Classification Report
print("Classification Repor data test:")
print(classification_report(y_test, predictions))
```

```
Classification Repor data test:
              precision    recall  f1-score   support

           0       0.95      0.96      0.96      1165
           1       0.14      0.13      0.13        63

    accuracy                           0.92      1228
   macro avg       0.55      0.54      0.55      1228
weighted avg       0.91      0.92      0.91      1228
```

Random Forest

```
# Random Forest
rf = RandomForestClassifier(random_state=42)
rf.fit(X_train, y_train)
```

```
RandomForestClassifier(random_state=42)
```

```
# Evaluasi Model
predictions = rf.predict(X_test)
accuracy = accuracy_score(y_test, predictions)
print("Accuracy:", accuracy)
```

```
Accuracy: 0.9486970684039088
```

```
y_pred_train = rf.predict(X_train)
accuracy_train = accuracy_score(y_train, y_pred_train)
print("Accuracy:", accuracy_train)
```

```
Accuracy: 1.0
```

```
# Classification Report
print("Classification Repor data test:")
print(classification_report(y_test, predictions))
```

```
Classification Repor data test:
              precision    recall  f1-score   support

           0       0.95      1.00      0.97      1165
           1       0.50      0.03      0.06        63

    accuracy                           0.95      1228
   macro avg       0.73      0.52      0.52      1228
weighted avg       0.93      0.95      0.93      1228
```

Hyperparameter Tunning

```
param_grid = {
    'criterion': ['gini', 'entropy'],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}

# Perform GridSearchCV with verbose output
grid_search = GridSearchCV(dt, param_grid, cv=5, verbose=1)
grid_search = GridSearchCV(rf, param_grid, cv=5, verbose=1)
grid_search.fit(X_val_scaled, y_val)

# Print best parameters and best score
print("Best Parameters:", grid_search.best_params_)
print("Best Score:", grid_search.best_score_)
```

```
Fitting 5 folds for each of 72 candidates, totalling 360 fits
Best Parameters: {'criterion': 'gini', 'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 2}
Best Score: 0.9619976498237369
```

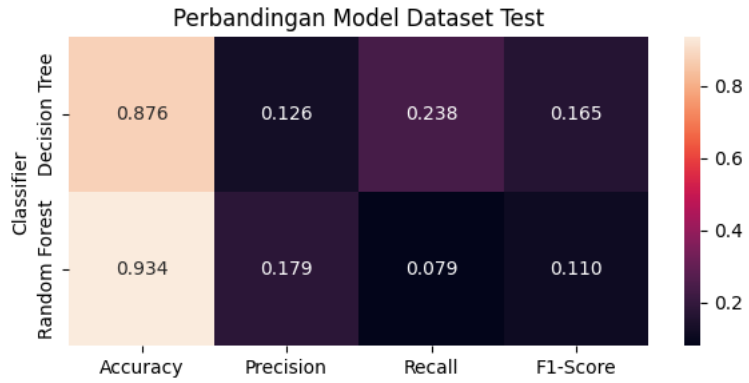
Model Comparison

```
classifiers = [
    ("Random Forest", RandomForestClassifier(n_estimators=50,max_depth=None,min_samples_split=5,min_samples_leaf=1,max_features='auto',
    ("Decision Tree", DecisionTreeClassifier(criterion='entropy',max_depth=10,min_samples_split=10,min_samples_leaf=2,random_state=42))
]

results = []
for name, clf in classifiers:
    clf.fit(X_train_scaled, y_train_smote)
    y_pred = clf.predict(X_test_scaled)

    accuracy = accuracy_score(y_test, y_pred)
    precision = precision_score(y_test, y_pred)
    recall = recall_score(y_test, y_pred)
    f1 = f1_score(y_test, y_pred)

    results.append([name, accuracy, precision, recall, f1])
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/ensemble/_forest.py:424: FutureWarning: `max_features='auto'` has been deprecated i
  warn(
```

```
results_df = pd.DataFrame(results, columns=["Classifier", "Accuracy", "Precision", "Recall", "F1-Score"])

results_df = results_df.sort_values(by="F1-Score", ascending=False)

# heatmap
plt.figure(figsize=(7, 3))
sns.heatmap(results_df.set_index("Classifier"), annot=True, fmt=".3f",  xticklabels=["Accuracy", "Precision", "Recall", "F1-Score"])
plt.title("Perbandingan Model Dataset Test")
```

```
Text(0.5, 1.0, 'Perbandingan Model Dataset Test')
```



Jika dilihat dari akurasinya, random forest adalah model yang lebih baik.