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

!pwd
```

```
Mounted at /content/gdrive
/content
```

```
%cd "/content/gdrive/MyDrive/7mo Semestre/Modulo 2"

!ls
```

```
/content/gdrive/MyDrive/7mo Semestre/Modulo 2
 brain_stroke.csv             'Neural Network.ipynb'   Valhalla23.csv
 mc-donalds-menu.csv           PlayDataset.csv
'Momento de Retro: Modulo 2'   Titanic
```

```
import pandas as pd
import numpy as np

import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

import missingno as msno
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import zero_one_loss
from sklearn.preprocessing import LabelEncoder
from mlxtend.plotting import plot_decision_regions
from sklearn.preprocessing import LabelEncoder

from sklearn.metrics import accuracy_score
from sklearn.metrics import f1_score
from sklearn.metrics import recall_score
from sklearn.metrics import precision_score
from sklearn import tree
from sklearn import metrics
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import validation_curve
from sklearn import datasets
```

```
def _draw_bootstrap_sample(rng, X, y):
    sample_indices = np.arange(X.shape[0])
    bootstrap_indices = rng.choice(
        sample_indices, size=sample_indices.shape[0], replace=True
    )
    return X[bootstrap_indices], y[bootstrap_indices]


def bias_variance_decomp(
    estimator,
    X_train,
    y_train,
    X_test,
    y_test,
    loss="0-1_loss",
    num_rounds=200,
    random_seed=None,
    **fit_params
):
    """
    estimator : object
        A classifier or regressor object or class implementing both a
        `fit` and `predict` method similar to the scikit-learn API.
    X_train : array-like, shape=(num_examples, num_features)
        A training dataset for drawing the bootstrap samples to carry
        out the bias-variance decomposition.
    y_train : array-like, shape=(num_examples)
        Targets (class labels, continuous values in case of regression)
        associated with the `X_train` examples.
    X_test : array-like, shape=(num_examples, num_features)
        The test dataset for computing the average loss, bias,
        and variance.
    y_test : array-like, shape=(num_examples)
        Targets (class labels, continuous values in case of regression)
        associated with the `X_test` examples.
    loss : str (default='0-1_loss')
        Loss function for performing the bias-variance decomposition.
        Currently allowed values are '0-1_loss' and 'mse'.
    num_rounds : int (default=200)
        Number of bootstrap rounds (sampling from the training set)
        for performing the bias-variance decomposition. Each bootstrap
        sample has the same size as the original training set.
    random_seed : int (default=None)
        Random seed for the bootstrap sampling used for the
        bias-variance decomposition.
    fit_params : additional parameters
        Additional parameters to be passed to the .fit() function of the
        estimator when it is fit to the bootstrap samples.
    Returns
    ----------
    avg_expected_loss, avg_bias, avg_var : returns the average expected
        average bias, and average bias (all floats), where the average
        is computed over the data points in the test set.
    Examples
    -----------
    For usage examples, please see
    http://rasbt.github.io/mlxtend/user_guide/evaluate/bias_variance_decomp/
    """
    supported = ["0-1_loss", "mse"]
    if loss not in supported:
        raise NotImplementedError("loss must be one of the following: %s" % supported)

    for ary in (X_train, y_train, X_test, y_test):
        if hasattr(ary, "loc"):
            raise ValueError(
                "The bias_variance_decomp does not "
                "support pandas DataFrames yet. "
                "Please check the inputs to "
                "X_train, y_train, X_test, y_test. "
                "If e.g., X_train is a pandas "
                "DataFrame, try passing it as NumPy array via "
                "X_train=X_train.values."
            )

    rng = np.random.RandomState(random_seed)

    if loss == "0-1_loss":
        dtype = np.int64
    elif loss == "mse":
        dtype = np.float64

    all_pred = np.zeros((num_rounds, y_test.shape[0]), dtype=dtype)

    for i in range(num_rounds):
        X_boot, y_boot = _draw_bootstrap_sample(rng, X_train, y_train)

        # Keras support
        if estimator.__class__.__name__ in ["Sequential", "Functional"]:

            # reset model
            for ix, layer in enumerate(estimator.layers):
                if hasattr(estimator.layers[ix], "kernel_initializer") and hasattr(
                    estimator.layers[ix], "bias_initializer"
                ):
                    weight_initializer = estimator.layers[ix].kernel_initializer
                    bias_initializer = estimator.layers[ix].bias_initializer

                    old_weights, old_biases = estimator.layers[ix].get_weights()

                    estimator.layers[ix].set_weights(
                        [
                            weight_initializer(shape=old_weights.shape),
                            bias_initializer(shape=len(old_biases)),
                        ]
                    )

            estimator.fit(X_boot, y_boot, **fit_params)
            pred = estimator.predict(X_test).reshape(1, -1)
        else:
            pred = estimator.fit(X_boot, y_boot, **fit_params).predict(X_test)
        all_pred[i] = pred

    if loss == "0-1_loss":
        main_predictions = np.apply_along_axis(
            lambda x: np.argmax(np.bincount(x)), axis=0, arr=all_pred
        )

        avg_expected_loss = np.apply_along_axis(
            lambda x: (x != y_test).mean(), axis=1, arr=all_pred
        ).mean()

        avg_bias = np.sum(main_predictions != y_test) / y_test.size

        var = np.zeros(pred.shape)

        for pred in all_pred:
            var += (pred != main_predictions).astype(np.int)
        var /= num_rounds

        avg_var = var.sum() / y_test.shape[0]

    else:
        avg_expected_loss = np.apply_along_axis(
            lambda x: ((x - y_test) ** 2).mean(), axis=1, arr=all_pred
        ).mean()

        main_predictions = np.mean(all_pred, axis=0)

        avg_bias = np.sum((main_predictions - y_test) ** 2) / y_test.size
        avg_var = np.sum((main_predictions - all_pred) ** 2) / all_pred.size

    return avg_expected_loss, avg_bias, avg_var
```

```
dset = pd.read_csv("brain_stroke.csv")
```

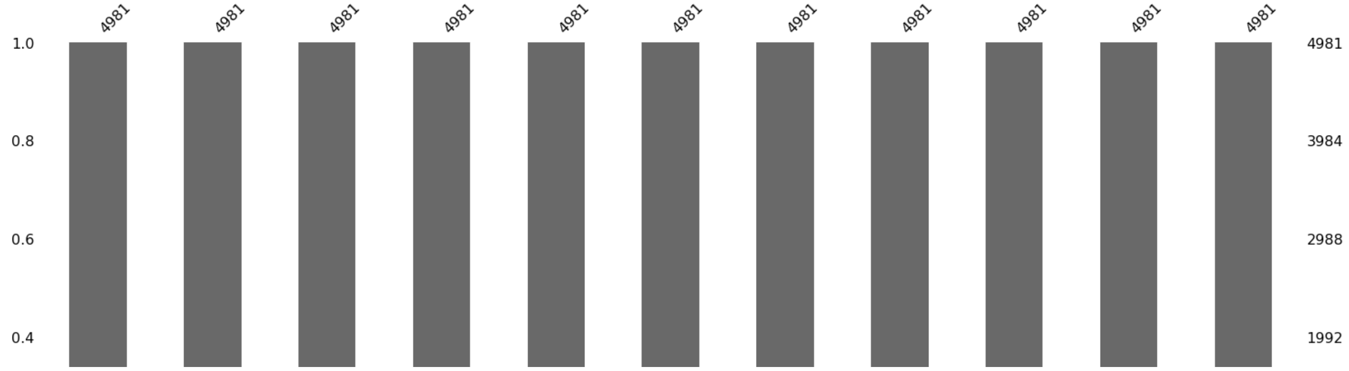
```
dset.head(5000)
```

1 to 25 of 4981 entries Filter

index	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glu
0	Male	67.0	0	1	Yes	Private	Urban	
1	Male	80.0	0	1	Yes	Private	Rural	
2	Female	49.0	0	0	Yes	Private	Urban	
3	Female	79.0	1	0	Yes	Self-employed	Rural	
4	Male	81.0	0	0	Yes	Private	Urban	
5	Male	74.0	1	1	Yes	Private	Rural	
6	Female	69.0	0	0	No	Private	Urban	
7	Female	78.0	0	0	Yes	Private	Urban	
8	Female	81.0	1	0	Yes	Private	Rural	
9	Female	61.0	0	1	Yes	Govt_job	Rural	
10	Female	54.0	0	0	Yes	Private	Urban	
11	Female	79.0	0	1	Yes	Private	Urban	
12	Female	50.0	1	0	Yes	Self-employed	Rural	
13	Male	64.0	0	1	Yes	Private	Urban	
14	Male	75.0	1	0	Yes	Private	Urban	
15	Female	60.0	0	0	No	Private	Urban	
16	Female	71.0	0	0	Yes	Govt_job	Rural	
17	Female	52.0	1	0	Yes	Self-employed	Urban	

```
msno.bar(dset)
```

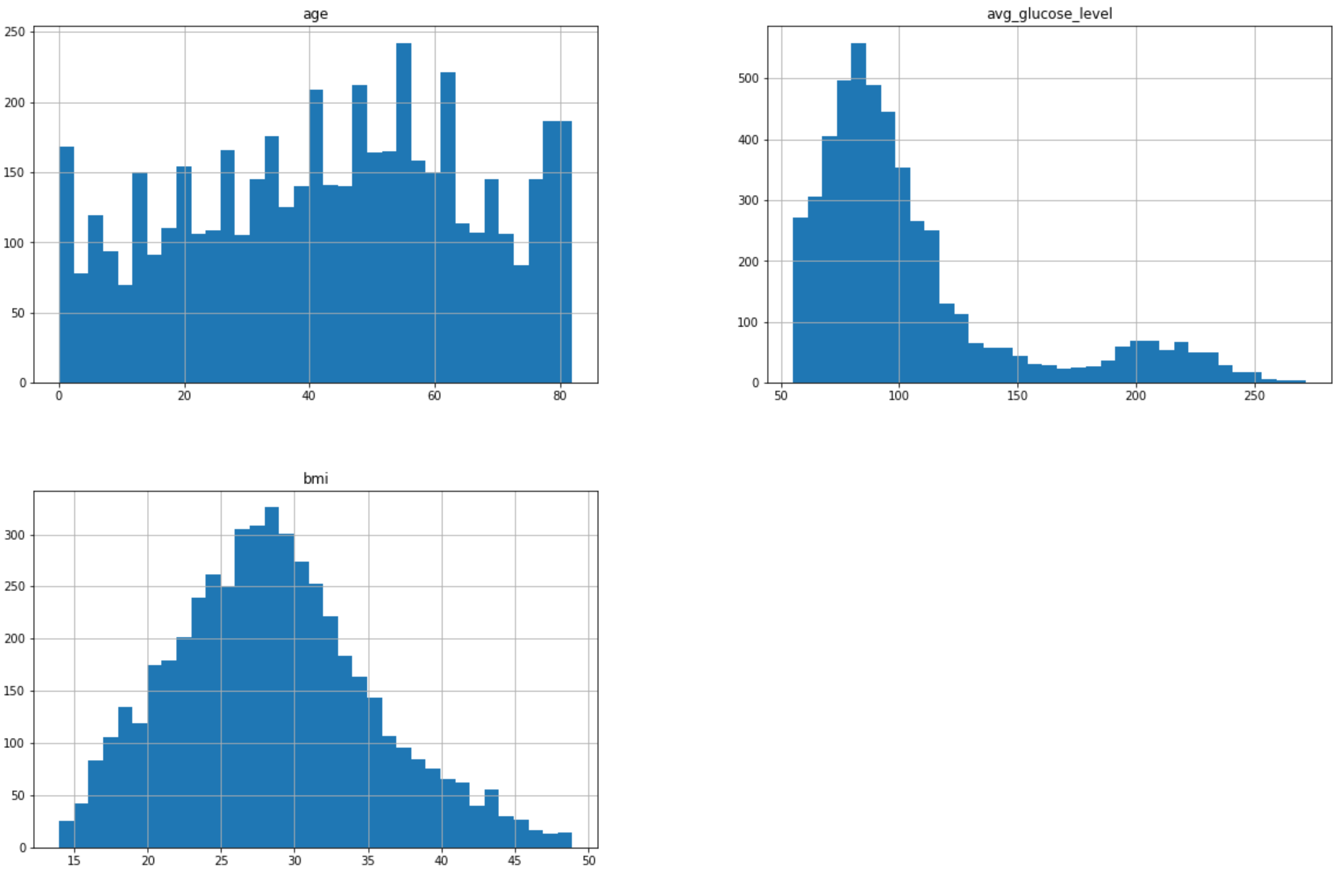
```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff43a6ca710>
```



```
dset.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4981 entries, 0 to 4980
Data columns (total 11 columns):
 #   Column             Non-Null Count  Dtype  
---  ------             --------------  -----  
 0   gender             4981 non-null   object 
 1   age                4981 non-null   float64
 2   hypertension       4981 non-null   int64  
 3   heart_disease      4981 non-null   int64  
 4   ever_married       4981 non-null   object 
 5   work_type          4981 non-null   object 
 6   Residence_type     4981 non-null   object 
 7   avg_glucose_level  4981 non-null   float64
 8   bmi                4981 non-null   float64
 9   smoking_status     4981 non-null   object 
 10  stroke             4981 non-null   int64  
dtypes: float64(3), int64(3), object(5)
memory usage: 428.2+ KB
```

```
h_dset = dset.drop(["hypertension","heart_disease","gender","ever_married","work_type","Resid

h_dset.hist(bins=35, figsize=(20,13))
plt.show()
```



```
print(f"Skewness: {dset['age'].skew()}")
print(f"Kurtosis: {dset['age'].kurt()}")
```

```
    Skewness: -0.14400119564600208
    Kurtosis: -0.9948387710574367
```

```
print(f"Skewness: {dset['bmi'].skew()}")
print(f"Kurtosis: {dset['bmi'].kurt()}")
```

```
    Skewness: 0.37155291522876177
    Kurtosis: -0.13832077359699424
```

```
print(f"Skewness: {dset['avg_glucose_level'].skew()}")
print(f"Kurtosis: {dset['avg_glucose_level'].kurt()}")
```

```
    Skewness: 1.5875258856135788
    Kurtosis: 1.7526730761547773
```

```
h_dset.describe()
```

1 to 8 of 8 entries Filter

index	age	avg_glucose_level	bmi
count	4981.0	4981.0	4981.0
mean	43.41985946597069	105.94356153382854	28.498173057618956
std	22.6627550736985	45.07537280843004	6.79046362629275
min	0.08	55.12	14.0
25%	25.0	77.23	23.7
50%	45.0	91.85	28.1
75%	61.0	113.86	32.6

```
clean_cat = {"gender": {"Male":0, "Female": 1}, "ever_married": {"No":0,"Yes":1}, "work_type"

dset = dset.replace(clean_cat)

dset.head()
```

1 to 5 of 5 entries Filter

index	gender	age	hypertension	heart_disease	ever_married	work_type	Residence_type	avg_glu
0	0	67.0	0	1	1	0	1	
1	0	80.0	0	1	1	0	0	
2	1	49.0	0	0	1	0	1	
3	1	79.0	1	0	1	2	0	
4	0	81.0	0	0	1	0	1	

Show 25 per page

Like what you see? Visit the data table notebook to learn more about interactive tables.

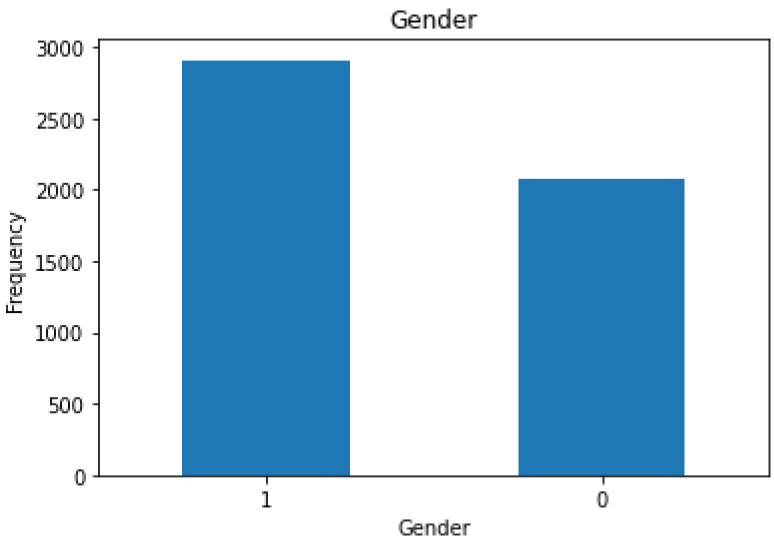
```
dset["gender"].value_counts()
```

```
1    2907
0    2074
Name: gender, dtype: int64
```

```
dset["gender"].value_counts(normalize = True)
```

```
1    0.583618
0    0.416382
Name: gender, dtype: float64
```

```
dset["gender"].value_counts().plot(kind="bar")
plt.title("Gender")
plt.xlabel("Values")
plt.xticks(rotation=0)
plt.ylabel("Frequency")
plt.show()
```



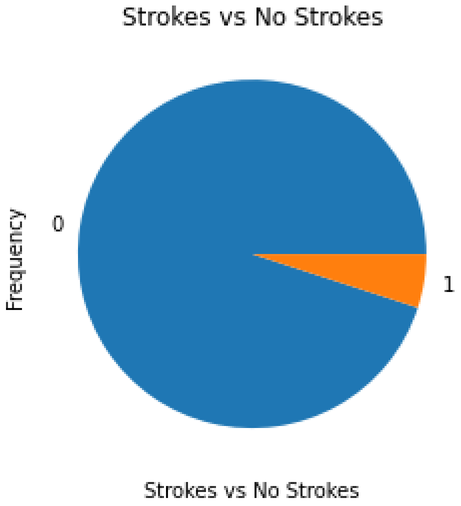
```
dset["stroke"].value_counts()
```

```
0    4733
1     248
Name: stroke, dtype: int64
```

```
dset["stroke"].value_counts(normalize = True)
```

```
0    0.950211
1    0.049789
Name: stroke, dtype: float64
```

```
dset["stroke"].value_counts().plot(kind="pie")
plt.title("Strokes vs No Strokes")
plt.xlabel("Values")
plt.xticks(rotation=0)
plt.ylabel("Frequency")
plt.show()
```



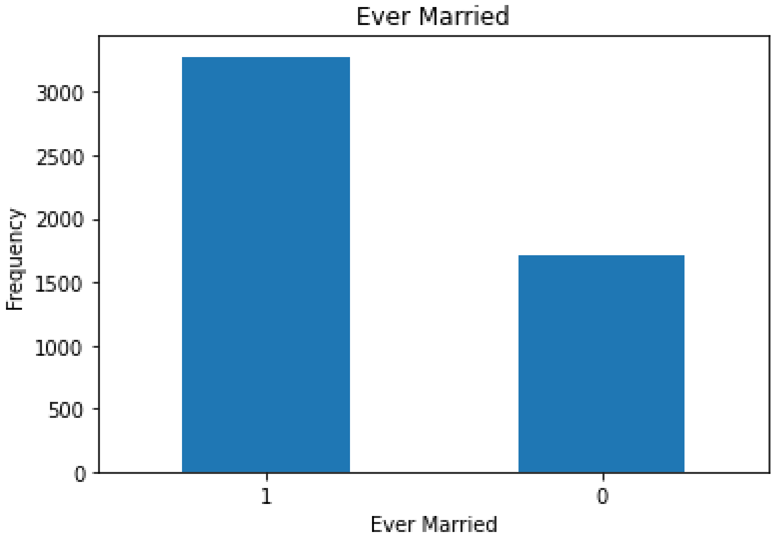
```
dset["ever_married"].value_counts()
```

```
1    3280
0    1701
Name: ever_married, dtype: int64
```

```
dset["ever_married"].value_counts(normalize = True)
```

```
1    0.658502
0    0.341498
Name: ever_married, dtype: float64
```

```
dset["ever_married"].value_counts().plot(kind="bar")
plt.title("Ever Married")
plt.xlabel("Values")
plt.xticks(rotation=0)
plt.ylabel("Frequency")
plt.show()
```



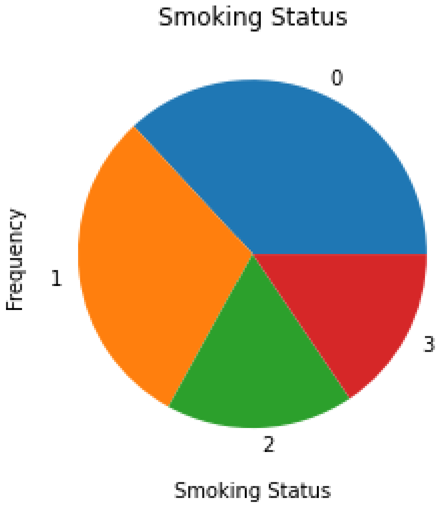
```
dset["smoking_status"].value_counts()
```

```
0    1838
1    1500
2     867
3     776
Name: smoking_status, dtype: int64
```

```
dset["smoking_status"].value_counts(normalize = True)
```

```
0    0.369002
1    0.301144
2    0.174061
3    0.155792
Name: smoking_status, dtype: float64
```

```
dset["smoking_status"].value_counts().plot(kind="pie")
plt.title("Smoking Status")
plt.xlabel("Values")
plt.xticks(rotation=0)
plt.ylabel("Frequency")
plt.show()
```



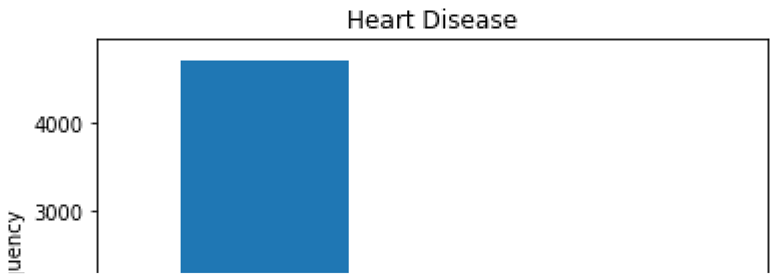
```
dset["heart_disease"].value_counts()
```

```
0    4706
1     275
Name: heart_disease, dtype: int64
```

```
dset["heart_disease"].value_counts(normalize = True)
```

```
0    0.94479
1    0.05521
Name: heart_disease, dtype: float64
```

```
dset["heart_disease"].value_counts().plot(kind="bar")
plt.title("Heart Disease")
plt.xlabel("Values")
plt.xticks(rotation=0)
plt.ylabel("Frequency")
plt.show()
```

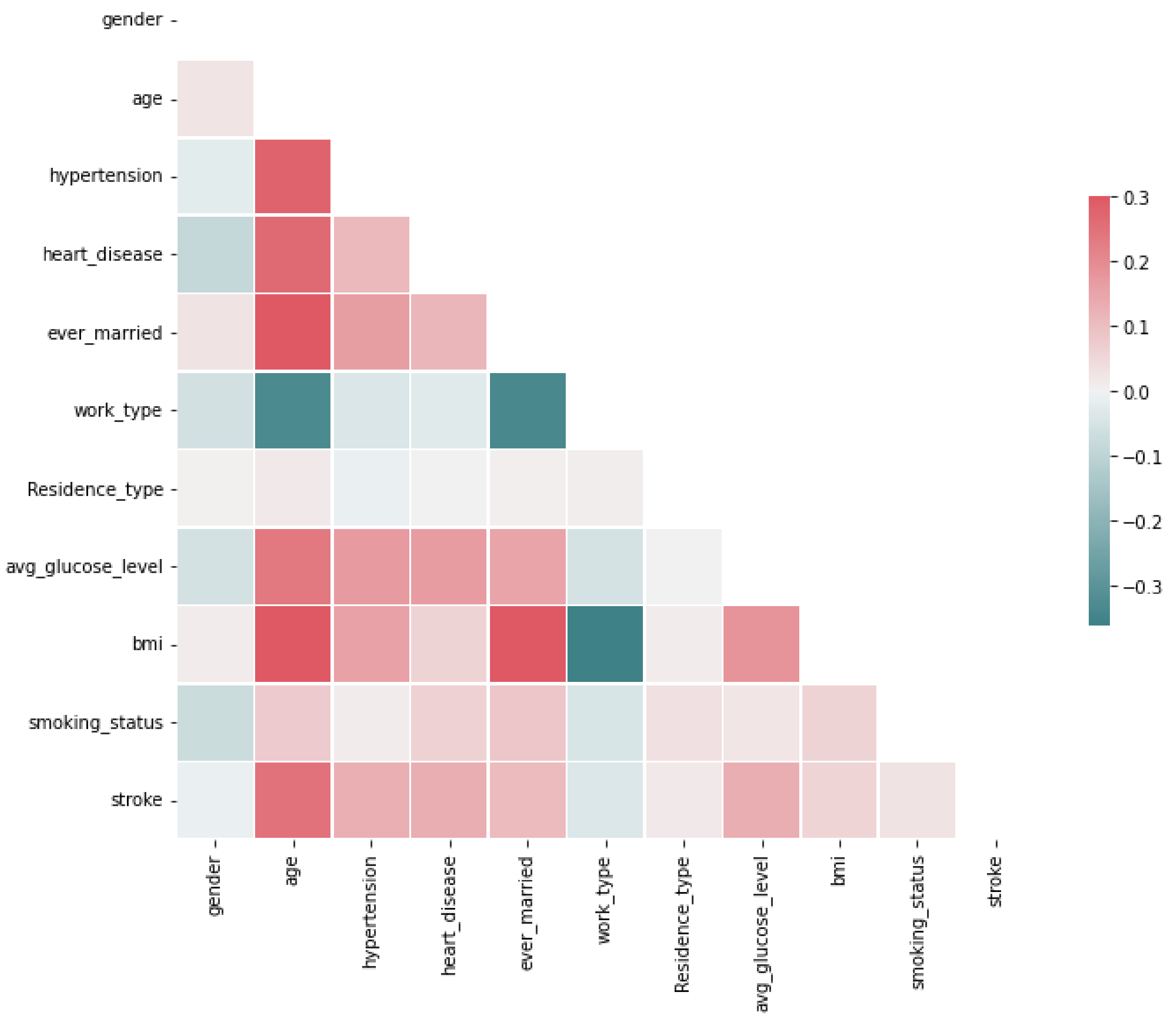


```
cor = dset.corr()
cor
```

	gender	age	hypertension	heart_disease	ever_married	work_t
gender	1.000000	0.026538	-0.021485	-0.086476	0.028971	-0.058
age	0.026538	1.000000	0.278120	0.264852	0.677137	-0.330
hypertension	-0.021485	0.278120	1.000000	0.111974	0.164534	-0.040
heart_disease	-0.086476	0.264852	0.111974	1.000000	0.114765	-0.027
ever_married	0.028971	0.677137	0.164534	0.114765	1.000000	-0.336
work_type	-0.058015	-0.330243	-0.040547	-0.027299	-0.336418	1.000
Residence_type	0.004301	0.017155	-0.004755	0.002125	0.008191	0.008
avg_glucose_level	-0.055796	0.236763	0.170028	0.166847	0.150724	-0.052
bmi	0.012093	0.373703	0.158762	0.060926	0.371690	-0.360
smoking_status	-0.070968	0.075962	0.011498	0.063801	0.085733	-0.043
stroke	-0.008870	0.246478	0.131965	0.134610	0.108398	-0.035

```
# Generate a mask for the upper triangle
mask = np.triu(np.ones_like(cor, dtype=bool))

# Set up the matplotlib figure
f, ax = plt.subplots(figsize=(11, 9))

# Generate a custom diverging colormap
cmap = sns.diverging_palette(200, 10, as_cmap=True)

# Draw the heatmap with the mask and correct aspect ratio
sns.heatmap(cor, mask=mask, cmap=cmap, vmax=.3, center=0,
            square=True, linewidths=.5, cbar_kws={"shrink": .5})
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7ff4374ad510>
```



```
X = dset.drop(["stroke"], axis = 1)
Y = dset["stroke"]

#X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.33, random_state=42)


data = dset.values
X, y = data[:, :-1], data[:, -1]
le=LabelEncoder()
y=le.fit_transform(y)


X_train, X_test, y_train, y_test = train_test_split(X, y,
                                                    test_size=0.3,
                                                    random_state=123,
                                                    shuffle=True,
                                                    stratify=y)
```

```
clf_dt = DecisionTreeClassifier(random_state=123)
clf_dt.fit(X_train,y_train)
y_pred=clf_dt.predict(X_test)

avg_expected_loss, avg_bias, avg_var = bias_variance_decomp(clf_dt, X_train, y_train, X_test,
                                                            loss='0-1_loss',random_seed=123)


print("Accuracy:", accuracy_score(y_test,y_pred))
print("F1 Score:", f1_score(y_test,y_pred))
print("Recall:", recall_score(y_test,y_pred))
print("Precision:",precision_score(y_test,y_pred))
print("Confusion Matrix:\n",confusion_matrix(y_test,y_pred))
print('Average expected loss: %.3f' % avg_expected_loss)
print('Average bias: %.3f' % avg_bias)
print('Average variance: %.3f' % avg_var)
print('Sklearn 0-1 loss: %.3f' % zero_one_loss(y_test,y_pred))
```

```
Accuracy: 0.9117056856187291
F1 Score: 0.17500000000000002
Recall: 0.1891891891891892
Precision: 0.16279069767441862
Confusion Matrix:
 [[1349   72]
 [  60   14]]
Average expected loss: 0.094
Average bias: 0.055
Average variance: 0.060
Sklearn 0-1 loss: 0.088
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:127: DeprecationWarning: `r
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/relea
```

```
clf_dt.fit(X_train, y_train)
train_predictions = clf_dt.predict(X_train)
test_predictions = clf_dt.predict(X_test)
train_acc = accuracy_score(y_train, train_predictions)
test_acc = accuracy_score(y_test, test_predictions)
print('train acc', train_acc)
print('test acc', test_acc)
```

```
train acc 1.0
test acc 0.9117056856187291
```

```
### Después Pruning ###
clf_dt_prnd = DecisionTreeClassifier(criterion='gini', max_depth=3, random_state=123)
clf_dt_prnd.fit(X_train,y_train)
y_pred=clf_dt_prnd.predict(X_test)

avg_expected_loss, avg_bias, avg_var = bias_variance_decomp(
        clf_dt_prnd, X_train, y_train, X_test, y_test,
        loss='0-1_loss',
        random_seed=123)


print('Average expected loss--After pruning: %.3f' % avg_expected_loss)
print('Average bias--After pruning: %.3f' % avg_bias)
print('Average variance--After pruning: %.3f' % avg_var)
print('Sklearn 0-1 loss--After pruning: %.3f' % zero_one_loss(y_test,y_pred))
```

```
Accuracy: 0.9478260869565217
F1 Score: 0.0
Recall: 0.0
Precision: 0.0
Average expected loss--After pruning: 0.053
Average bias--After pruning: 0.049
Average variance--After pruning: 0.005
Sklearn 0-1 loss--After pruning: 0.052
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:127: DeprecationWarning: `r
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/relea
```

```
clf_dt_prnd.fit(X_train, y_train)
train_predictions = clf_dt_prnd.predict(X_train)
test_predictions = clf_dt_prnd.predict(X_test)
train_acc = accuracy_score(y_train, train_predictions)
test_acc = accuracy_score(y_test, test_predictions)
print('train acc', train_acc)
print('test acc', test_acc)
```

```
train acc 0.9515203671830178
test acc 0.9478260869565217
```

```
clf_dt_prnd = DecisionTreeClassifier(criterion='entropy', max_depth=3, random_state=123)
clf_dt_prnd.fit(X_train,y_train)
y_pred=clf_dt_prnd.predict(X_test)

avg_expected_loss, avg_bias, avg_var = bias_variance_decomp(
        clf_dt_prnd, X_train, y_train, X_test, y_test,
        loss='0-1_loss',
        random_seed=123)


print('Average expected loss--After pruning: %.3f' % avg_expected_loss)
print('Average bias--After pruning: %.3f' % avg_bias)
print('Average variance--After pruning: %.3f' % avg_var)
print('Sklearn 0-1 loss--After pruning: %.3f' % zero_one_loss(y_test,y_pred))
```

```
Accuracy: 0.9505016722408027
F1 Score: 0.0
Recall: 0.0
Precision: 0.0
Average expected loss--After pruning: 0.051
Average bias--After pruning: 0.049
Average variance--After pruning: 0.002
Sklearn 0-1 loss--After pruning: 0.049
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:127: DeprecationWarning: `r
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/relea
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: Undefine
  _warn_prf(average, modifier, msg_start, len(result))
```

```
clf_dt_prnd.fit(X_train, y_train)
train_predictions = clf_dt_prnd.predict(X_train)
test_predictions = clf_dt_prnd.predict(X_test)
train_acc = accuracy_score(y_train, train_predictions)
test_acc = accuracy_score(y_test, test_predictions)
print('train acc', train_acc)
print('test acc', test_acc)
```

```
train acc 0.9500860585197934
test acc 0.9505016722408027
```

```
clf_RF = RandomForestClassifier(max_depth=2, random_state=0)
clf_RF.fit(X_train,y_train)
y_pred=clf_RF.predict(X_test)

avg_expected_loss, avg_bias, avg_var = bias_variance_decomp(
        clf_RF, X_train, y_train, X_test, y_test,
        loss='0-1_loss',
        random_seed=123)
```

```
print('Average expected loss: %.3f' % avg_expected_loss)
print('Average bias: %.3f' % avg_bias)
print('Average variance: %.3f' % avg_var)
print('Sklearn 0-1 loss: %.3f' % zero_one_loss(y_test,y_pred))
```

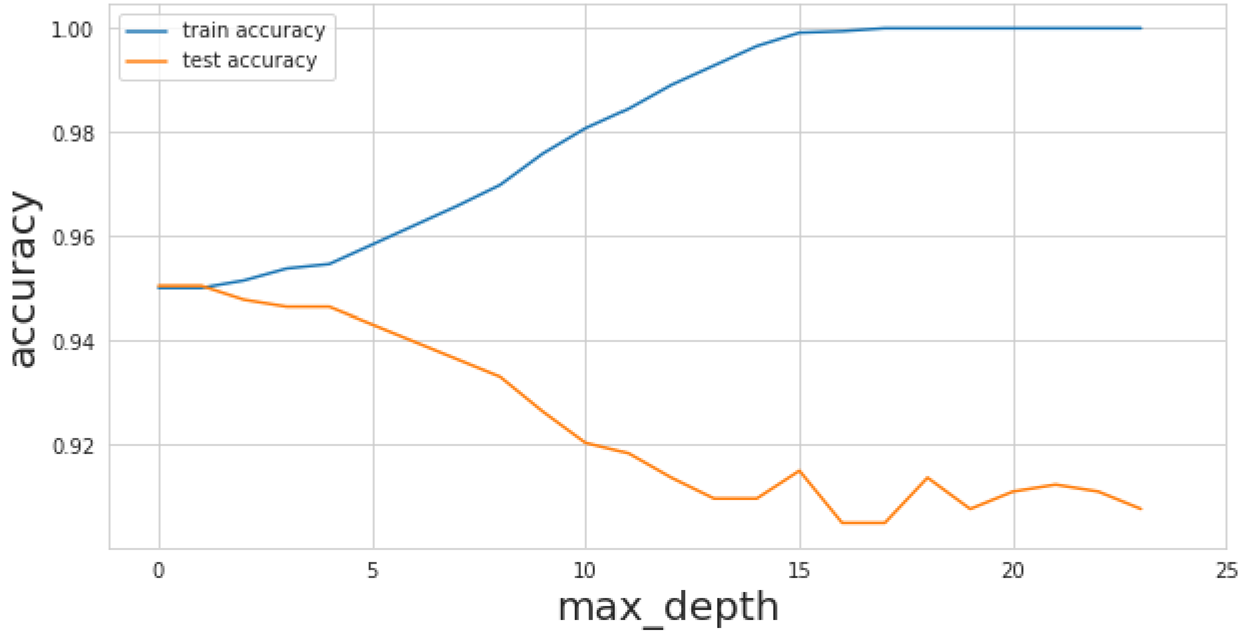
```
Accuracy: 0.9505016722408027
F1 Score: 0.0
Recall: 0.0
Precision: 0.0
Average expected loss: 0.049
Average bias: 0.049
Average variance: 0.000
Sklearn 0-1 loss: 0.049
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:127: DeprecationWarning: `r
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/relea
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1318: Undefine
  _warn_prf(average, modifier, msg_start, len(result))
```

```
clf_RF.fit(X_train, y_train)
train_predictions = clf_RF.predict(X_train)
test_predictions = clf_RF.predict(X_test)
train_acc = accuracy_score(y_train, train_predictions)
test_acc = accuracy_score(y_test, test_predictions)
print('train acc', train_acc)
print('test acc', test_acc)
```

```
train acc 0.9500860585197934
test acc 0.9505016722408027
```

```
train_accuracies = []
test_accuracies = []

for depth in range(1,25):
  tree_model = DecisionTreeClassifier(max_depth=depth)
  tree_model.fit(X_train, y_train)

  train_predictions = tree_model.predict(X_train)
  test_predictions = tree_model.predict(X_test)

  train_accuracy = metrics.accuracy_score(y_train, train_predictions)
  test_accuracy = metrics.accuracy_score(y_test,test_predictions)

  train_accuracies.append(train_accuracy)
  test_accuracies.append(test_accuracy)



plt.figure(figsize=(10,5))
sns.set_style("whitegrid")
plt.plot(train_accuracies, label = "train accuracy")
plt.plot(test_accuracies, label = "test accuracy")
plt.legend(loc = "upper left")
plt.xticks(range(0,26,5))
plt.xlabel("max_depth",size = 20)
plt.ylabel("accuracy",size = 20)
plt.show
```

```
<function matplotlib.pyplot.show(*args, **kw)>
```



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