red-wine-quality-prediciton

February 3, 2024

[3]:
```
!pip install pandas
!pip install numpy
!pip install seaborn
!pip install matplotlib
```

```
Requirement already satisfied: pandas in d:\python 3.8\lib\site-packages (2.0.3)
Requirement already satisfied: python-dateutil>=2.8.2 in d:\python 3.8\lib\site-
packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in d:\python 3.8\lib\site-packages
(from pandas) (2024.1)
Requirement already satisfied: tzdata>=2022.1 in d:\python 3.8\lib\site-packages
(from pandas) (2023.4)
Requirement already satisfied: numpy>=1.20.3 in d:\python 3.8\lib\site-packages
(from pandas) (1.24.4)
Requirement already satisfied: six>=1.5 in d:\python 3.8\lib\site-packages (from
python-dateutil>=2.8.2->pandas) (1.16.0)
Requirement already satisfied: numpy in d:\python 3.8\lib\site-packages (1.24.4)
Collecting seaborn
  Using cached seaborn-0.13.2-py3-none-any.whl.metadata (5.4 kB)
Requirement already satisfied: numpy!=1.24.0,>=1.20 in d:\python 3.8\lib\site-
packages (from seaborn) (1.24.4)
Requirement already satisfied: pandas>=1.2 in d:\python 3.8\lib\site-packages
(from seaborn) (2.0.3)
Requirement already satisfied: matplotlib!=3.6.1,>=3.4 in d:\python
3.8\lib\site-packages (from seaborn) (3.7.4)
Requirement already satisfied: contourpy>=1.0.1 in d:\python 3.8\lib\site-
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (1.1.1)
Requirement already satisfied: cycler>=0.10 in d:\python 3.8\lib\site-packages
(from matplotlib!=3.6.1,>=3.4->seaborn) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in d:\python 3.8\lib\site-
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (4.47.2)
Requirement already satisfied: kiwisolver>=1.0.1 in d:\python 3.8\lib\site-
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (1.4.5)
Requirement already satisfied: packaging>=20.0 in d:\python 3.8\lib\site-
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (23.2)
Requirement already satisfied: pillow>=6.2.0 in d:\python 3.8\lib\site-packages
(from matplotlib!=3.6.1,>=3.4->seaborn) (10.2.0)
Requirement already satisfied: pyparsing>=2.3.1 in d:\python 3.8\lib\site-
```

```
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (3.1.1)
Requirement already satisfied: python-dateutil>=2.7 in d:\python 3.8\lib\site-
packages (from matplotlib!=3.6.1,>=3.4->seaborn) (2.8.2)
Requirement already satisfied: importlib-resources>=3.2.0 in d:\python
3.8\lib\site-packages (from matplotlib!=3.6.1,>=3.4->seaborn) (6.1.1)
Requirement already satisfied: pytz>=2020.1 in d:\python 3.8\lib\site-packages
(from pandas>=1.2->seaborn) (2024.1)
Requirement already satisfied: tzdata>=2022.1 in d:\python 3.8\lib\site-packages
(from pandas>=1.2->seaborn) (2023.4)
Requirement already satisfied: zipp>=3.1.0 in c:\users\hitesh
karthik\appdata\roaming\python\python38\site-packages (from importlib-
resources>=3.2.0->matplotlib!=3.6.1,>=3.4->seaborn) (3.17.0)
Requirement already satisfied: six>=1.5 in d:\python 3.8\lib\site-packages (from
python-dateutil>=2.7->matplotlib!=3.6.1,>=3.4->seaborn) (1.16.0)
Using cached seaborn-0.13.2-py3-none-any.whl (294 kB)
Installing collected packages: seaborn
Successfully installed seaborn-0.13.2
Requirement already satisfied: matplotlib in d:\python 3.8\lib\site-packages
(3.7.4)
Requirement already satisfied: contourpy>=1.0.1 in d:\python 3.8\lib\site-
packages (from matplotlib) (1.1.1)
Requirement already satisfied: cycler>=0.10 in d:\python 3.8\lib\site-packages
(from matplotlib) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in d:\python 3.8\lib\site-
packages (from matplotlib) (4.47.2)
Requirement already satisfied: kiwisolver>=1.0.1 in d:\python 3.8\lib\site-
packages (from matplotlib) (1.4.5)
Requirement already satisfied: numpy<2,>=1.20 in d:\python 3.8\lib\site-packages
(from matplotlib) (1.24.4)
Requirement already satisfied: packaging>=20.0 in d:\python 3.8\lib\site-
packages (from matplotlib) (23.2)
Requirement already satisfied: pillow>=6.2.0 in d:\python 3.8\lib\site-packages
(from matplotlib) (10.2.0)
Requirement already satisfied: pyparsing>=2.3.1 in d:\python 3.8\lib\site-
packages (from matplotlib) (3.1.1)
Requirement already satisfied: python-dateutil>=2.7 in d:\python 3.8\lib\site-
packages (from matplotlib) (2.8.2)
Requirement already satisfied: importlib-resources>=3.2.0 in d:\python
3.8\lib\site-packages (from matplotlib) (6.1.1)
Requirement already satisfied: zipp>=3.1.0 in c:\users\hitesh
karthik\appdata\roaming\python\python38\site-packages (from importlib-
resources>=3.2.0->matplotlib) (3.17.0)
Requirement already satisfied: six>=1.5 in d:\python 3.8\lib\site-packages (from
python-dateutil>=2.7->matplotlib) (1.16.0)
```

[4]:
```
import numpy as np
import matplotlib.pyplot as plt
```

```
import pandas as pd
import seaborn as sns
from warnings import filterwarnings
filterwarnings(action='ignore')
```

```
C:\Users\Hitesh Karthik\AppData\Local\Temp\ipykernel_27364\2861500716.py:3:
DeprecationWarning:
Pyarrow will become a required dependency of pandas in the next major release of
pandas (pandas 3.0),
(to allow more performant data types, such as the Arrow string type, and better
interoperability with other libraries)
but was not found to be installed on your system.
If this would cause problems for you,
please provide us feedback at https://github.com/pandas-dev/pandas/issues/54466

  import pandas as pd
```

****Loading Dataset****

[5]:
```
wine = pd.read_csv(r"C:\Users\Hitesh Karthik\OneDrive\Desktop\machine learning␣
↪projects\Red Wine Quality Predicition\winequality-red.csv")
wine.sample(25)
```

[5]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	\
197	11.5	0.300	0.60	2.00	0.067	
619	11.3	0.370	0.41	2.30	0.088	
1022	7.0	0.510	0.09	2.10	0.062	
525	10.4	0.640	0.24	2.80	0.105	
599	12.7	0.590	0.45	2.30	0.082	
80	6.2	0.450	0.20	1.60	0.069	
344	11.9	0.570	0.50	2.60	0.082	
860	7.2	0.620	0.06	2.70	0.077	
717	7.6	0.460	0.11	2.60	0.079	
116	8.3	0.540	0.28	1.90	0.077	
1276	8.5	0.400	0.40	6.30	0.050	
1596	6.3	0.510	0.13	2.30	0.076	
978	7.0	0.400	0.32	3.60	0.061	
46	7.7	0.935	0.43	2.20	0.114	
1443	6.9	0.580	0.20	1.75	0.058	
1466	7.3	0.480	0.32	2.10	0.062	
196	7.3	0.580	0.30	2.40	0.074	
659	7.1	0.840	0.02	4.40	0.096	
1406	8.2	0.240	0.34	5.10	0.062	
1431	7.6	0.430	0.31	2.10	0.069	
452	6.8	0.560	0.03	1.70	0.084	
542	9.3	0.715	0.24	2.10	0.070	
244	15.0	0.210	0.44	2.20	0.075	
1349	6.9	0.570	0.00	2.80	0.081	

```
56             10.2             0.420         0.57             3.40      0.070
```

```
      free sulfur dioxide  total sulfur dioxide  density    pH  sulphates  \
197                  12.0                  27.0  0.99810  3.11       0.97
619                   6.0                  16.0  0.99880  3.09       0.80
1022                  4.0                   9.0  0.99584  3.35       0.54
525                  29.0                  53.0  0.99980  3.24       0.67
599                  11.0                  22.0  1.00000  3.00       0.70
80                    3.0                  15.0  0.99580  3.41       0.56
344                   6.0                  32.0  1.00060  3.12       0.78
860                  15.0                  85.0  0.99746  3.51       0.54
717                  12.0                  49.0  0.99680  3.21       0.57
116                  11.0                  40.0  0.99780  3.39       0.61
1276                  3.0                  10.0  0.99566  3.28       0.56
1596                 29.0                  40.0  0.99574  3.42       0.75
978                   9.0                  29.0  0.99416  3.28       0.49
46                   22.0                 114.0  0.99700  3.25       0.73
1443                  8.0                  22.0  0.99322  3.38       0.49
1466                 31.0                  54.0  0.99728  3.30       0.65
196                  15.0                  55.0  0.99680  3.46       0.59
659                   5.0                  13.0  0.99700  3.41       0.57
1406                  8.0                  22.0  0.99740  3.22       0.94
1431                 13.0                  74.0  0.99580  3.26       0.54
452                  18.0                  35.0  0.99680  3.44       0.63
542                   5.0                  20.0  0.99660  3.12       0.59
244                  10.0                  24.0  1.00005  3.07       0.84
1349                 21.0                  41.0  0.99518  3.41       0.52
56                    4.0                  10.0  0.99710  3.04       0.63
```

```
      alcohol  quality
197      10.1        6
619       9.3        5
1022     10.5        5
525       9.9        5
599       9.3        6
80        9.2        5
344      10.7        6
860       9.5        5
717      10.0        5
116      10.0        6
1276     12.0        4
1596     11.0        6
978      11.3        7
46        9.2        5
1443     11.7        5
1466     10.0        7
196      10.2        5
```

```
659      11.0        4
1406     10.9        6
1431      9.9        6
452      10.0        6
542       9.9        5
244       9.2        7
1349     10.8        5
56        9.6        5
```

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1599 entries, 0 to 1598
Data columns (total 12 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   fixed acidity         1599 non-null   float64
 1   volatile acidity      1599 non-null   float64
 2   citric acid           1599 non-null   float64
 3   residual sugar        1599 non-null   float64
 4   chlorides             1599 non-null   float64
 5   free sulfur dioxide   1599 non-null   float64
 6   total sulfur dioxide  1599 non-null   float64
 7   density               1599 non-null   float64
 8   pH                    1599 non-null   float64
 9   sulphates             1599 non-null   float64
 10  alcohol               1599 non-null   float64
 11  quality               1599 non-null   int64
dtypes: float64(11), int64(1)
memory usage: 150.0 KB
```

1 Description

[7]:
```
wine.describe()
```

[7]:
```
       fixed acidity  volatile acidity  citric acid  residual sugar  \
count    1599.000000       1599.000000  1599.000000     1599.000000
mean        8.319637          0.527821     0.270976        2.538806
std         1.741096          0.179060     0.194801        1.409928
min         4.600000          0.120000     0.000000        0.900000
25%         7.100000          0.390000     0.090000        1.900000
50%         7.900000          0.520000     0.260000        2.200000
75%         9.200000          0.640000     0.420000        2.600000
max        15.900000          1.580000     1.000000       15.500000

         chlorides  free sulfur dioxide  total sulfur dioxide      density  \
```

```
count  1599.000000          1599.000000          1599.000000  1599.000000
mean      0.087467            15.874922            46.467792     0.996747
std       0.047065            10.460157            32.895324     0.001887
min       0.012000             1.000000             6.000000     0.990070
25%       0.070000             7.000000            22.000000     0.995600
50%       0.079000            14.000000            38.000000     0.996750
75%       0.090000            21.000000            62.000000     0.997835
max       0.611000            72.000000           289.000000     1.003690

                pH    sulphates      alcohol      quality
count  1599.000000  1599.000000  1599.000000  1599.000000
mean      3.311113     0.658149    10.422983     5.636023
std       0.154386     0.169507     1.065668     0.807569
min       2.740000     0.330000     8.400000     3.000000
25%       3.210000     0.550000     9.500000     5.000000
50%       3.310000     0.620000    10.200000     6.000000
75%       3.400000     0.730000    11.100000     6.000000
max       4.010000     2.000000    14.900000     8.000000
```

2 Finding Null Values

[8]:
```
wine.isnull().sum()
```

[8]:
```
fixed acidity           0
volatile acidity        0
citric acid             0
residual sugar          0
chlorides               0
free sulfur dioxide     0
total sulfur dioxide    0
density                 0
pH                      0
sulphates               0
alcohol                 0
quality                 0
dtype: int64
```

[9]:
```
wine.groupby('quality').mean()
```

[9]:
```
         fixed acidity  volatile acidity  citric acid  residual sugar  \
quality
3             8.360000          0.884500     0.171000        2.635000
4             7.779245          0.693962     0.174151        2.694340
5             8.167254          0.577041     0.243686        2.528855
6             8.347179          0.497484     0.273824        2.477194
7             8.872362          0.403920     0.375176        2.720603
```

```
8             8.566667          0.423333     0.391111        2.577778

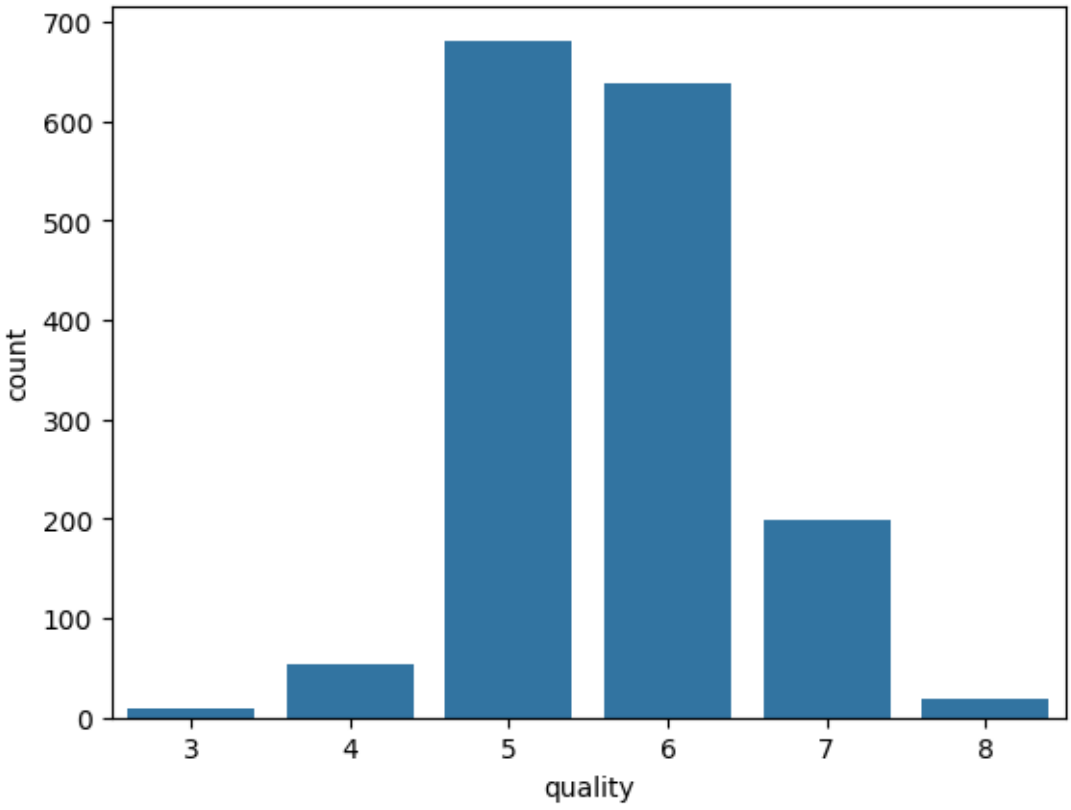
         chlorides  free sulfur dioxide  total sulfur dioxide   density  \
quality
3         0.122500            11.000000             24.900000  0.997464
4         0.090679            12.264151             36.245283  0.996542
5         0.092736            16.983847             56.513950  0.997104
6         0.084956            15.711599             40.869906  0.996615
7         0.076588            14.045226             35.020101  0.996104
8         0.068444            13.277778             33.444444  0.995212

                pH  sulphates    alcohol
quality
3         3.398000   0.570000   9.955000
4         3.381509   0.596415  10.265094
5         3.304949   0.620969   9.899706
6         3.318072   0.675329  10.629519
7         3.290754   0.741256  11.465913
8         3.267222   0.767778  12.094444
```

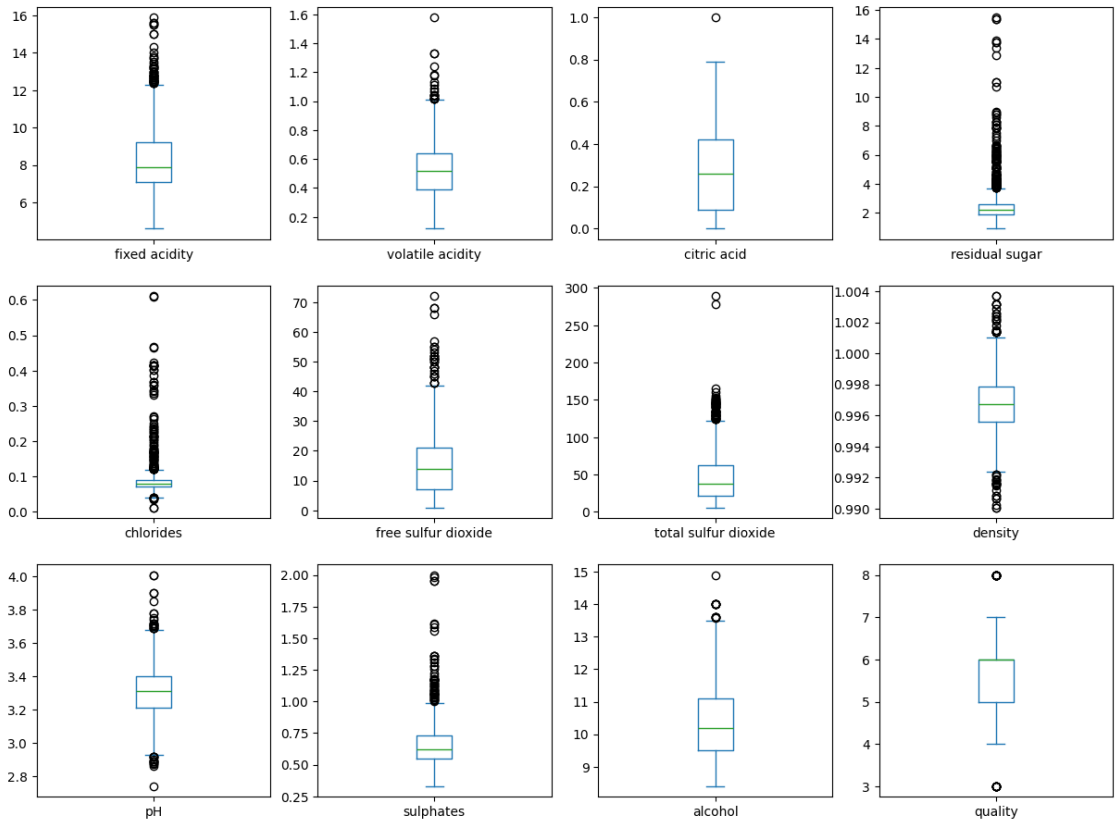
3 Data Analysis

4 Countplot:

[10]:
```
# Assuming 'wine' is your DataFrame
sns.countplot(data=wine, x='quality')
plt.show()
```

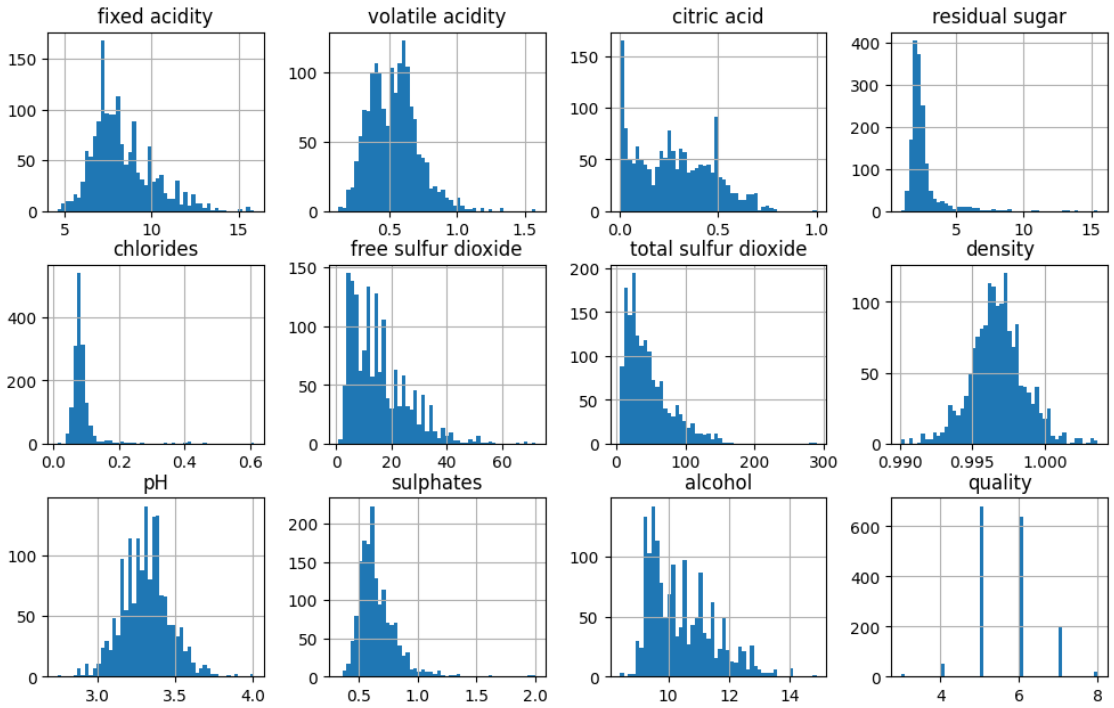


[11]:
```
# Assuming 'wine' is your DataFrame
wine.plot(kind='box', subplots=True, layout=(4, 4), sharex=False, figsize=(15,␣
↪15))
plt.show()
```



5 Histogram

[12]:
```
wine.hist(figsize=(12, 10), bins=50, layout=(4, 4))
plt.show()
```



6 Histplot

[13]:
```
fig, axes = plt.subplots(3, 4, figsize=(60, 40))

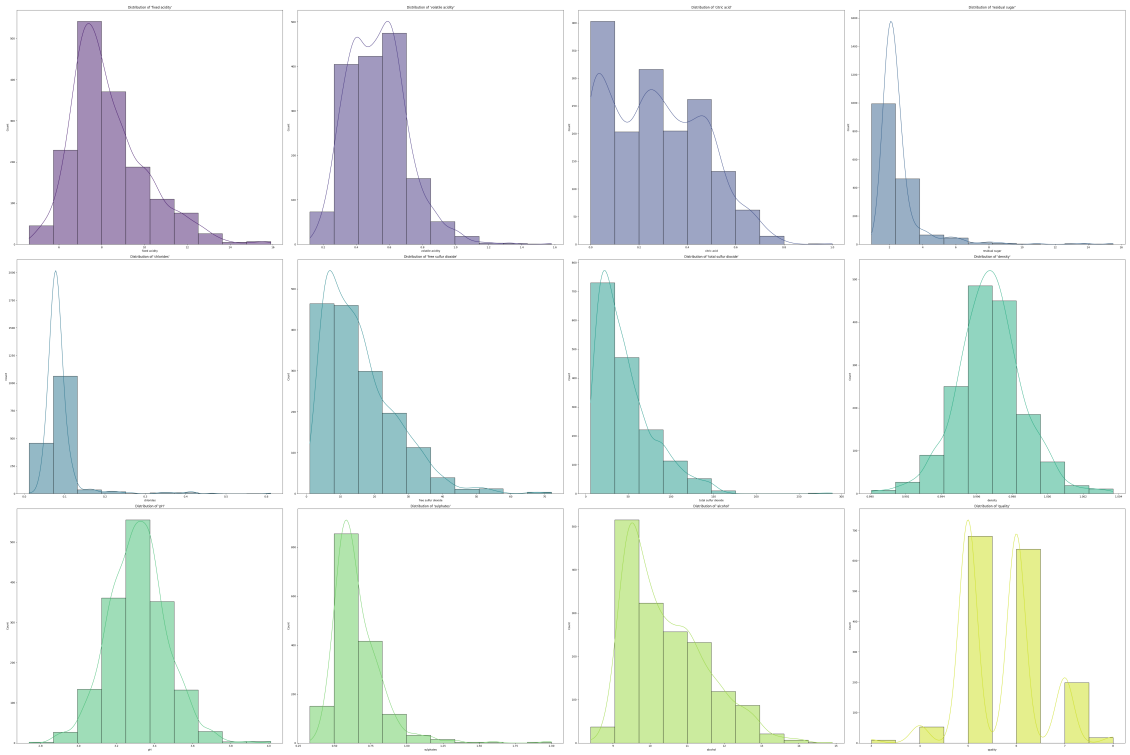
# List of features for iteration
features = ["fixed acidity", "volatile acidity", "citric acid", "residual␣
 ↪sugar",
            "chlorides", "free sulfur dioxide", "total sulfur dioxide",␣
 ↪"density",
            "pH", "sulphates", "alcohol", "quality"]

# Iterate over features and corresponding axes
for i, feature in enumerate(features):
    row, col = divmod(i, 4)

    # Set color dynamically based on the feature
    color = sns.color_palette("viridis", n_colors=len(features))[i]

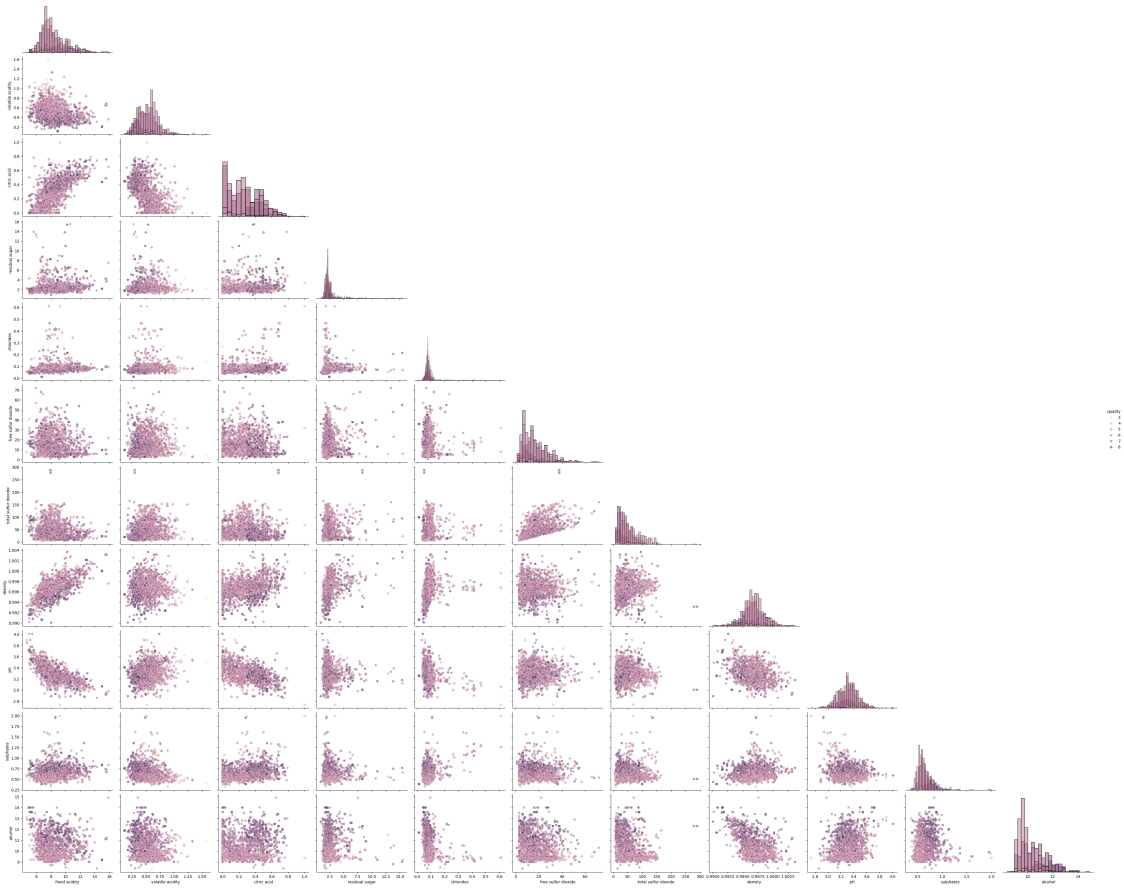
    # Create histograms
    sns.histplot(ax=axes[row, col], x=wine[feature], bins=10, kde=True,␣
 ↪cbar=True, color=color)
    axes[row, col].set(title=f"Distribution of '{feature}'")
```

```
plt.tight_layout()
plt.show()
```



7 Pairplot

[14]:
```
sns.pairplot(wine,
             diag_kind="hist",
             hue="quality",
             height=3,
             aspect=1.2,
             corner=True,
             markers=["o", "s", "D"],  # Specify markers for each quality level
             plot_kws={"alpha": 0.5}   # Adjust transparency for better␣
 ↪visibility
            );
```



8 Scatterplot

[15]:
```
fig, axes = plt.subplots(2, 3, figsize=(15, 10))
axes = axes.flatten()

# Relationship between 'residual_sugar' and 'quality'
sns.scatterplot(x="residual sugar", y="quality", hue="quality", data=wine,␣
 ↪ax=axes[0])
axes[0].set_title("Relationship: 'Residual Sugar' vs 'Quality'")

# Relationship between 'alcohol' and 'quality'
sns.scatterplot(x="alcohol", y="quality", hue="quality", data=wine, ax=axes[1])
axes[1].set_title("Relationship: 'Alcohol' vs 'Quality'")

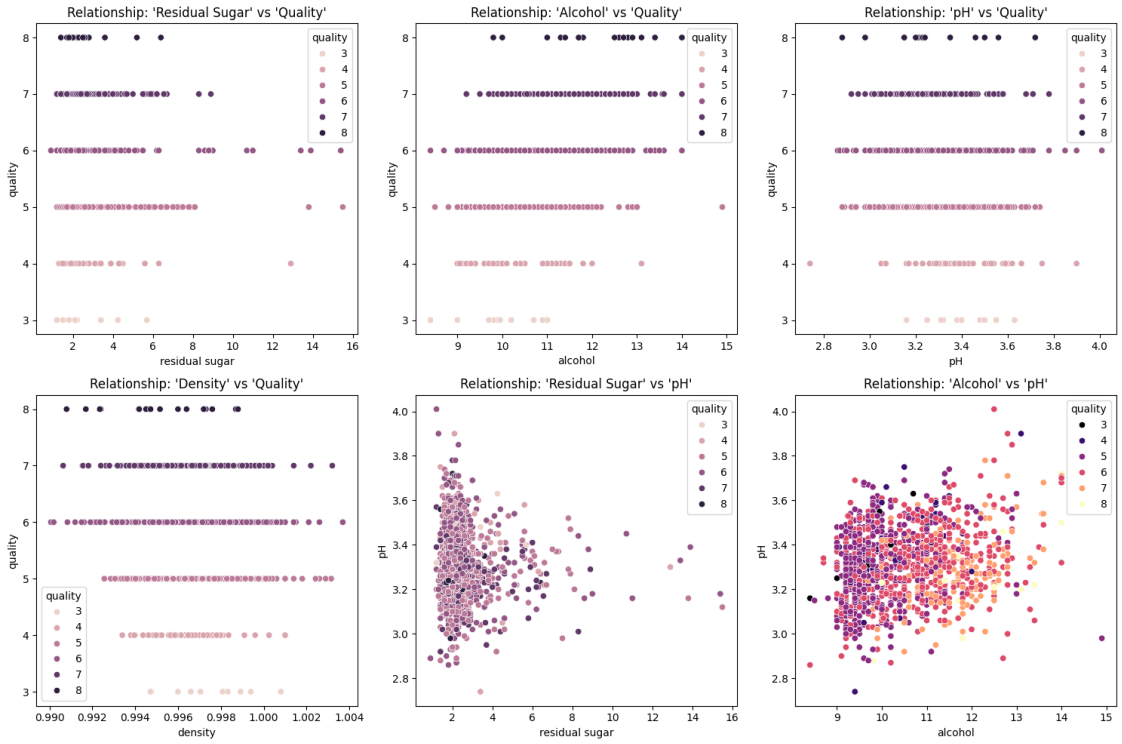
# Relationship between 'pH' and 'quality'
sns.scatterplot(x="pH", y="quality", hue="quality", data=wine, ax=axes[2])
axes[2].set_title("Relationship: 'pH' vs 'Quality'")
```

```
# Relationship between 'density' and 'quality'
sns.scatterplot(x="density", y="quality", hue="quality", data=wine, ax=axes[3])
axes[3].set_title("Relationship: 'Density' vs 'Quality'")

# Relationship between 'residual_sugar' and 'pH'
sns.scatterplot(x="residual sugar", y="pH", hue="quality", data=wine,␣
 ↪ax=axes[4])
axes[4].set_title("Relationship: 'Residual Sugar' vs 'pH'")

# Relationship between 'alcohol' and 'pH'
sns.scatterplot(x="alcohol", y="pH", hue="quality", palette="magma", data=wine,␣
 ↪ax=axes[5])
axes[5].set_title("Relationship: 'Alcohol' vs 'pH'")

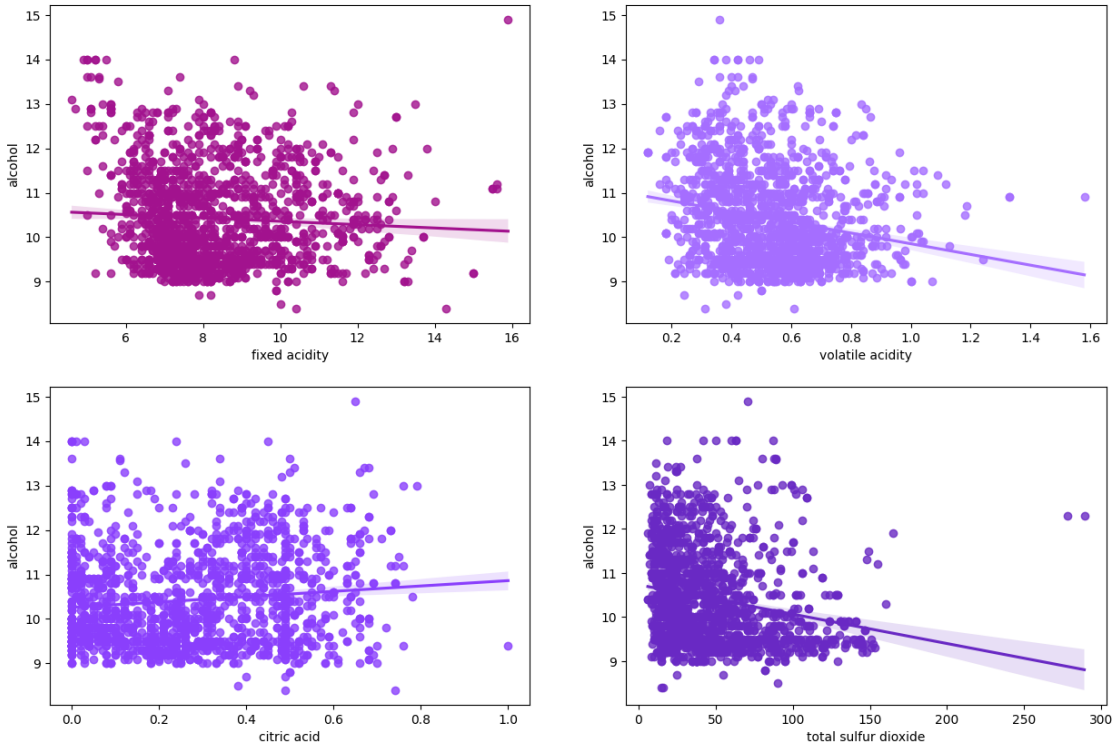
plt.tight_layout()
plt.show()
```



9 Regplot

[16]:
```
fig, axes = plt.subplots(2, 2, figsize = (15, 10))
axes = axes.flatten()

sns.regplot(ax = axes[0], x = "fixed acidity", y = "alcohol", data = wine,␣
 ↪color = "#A2128E");
sns.regplot(ax = axes[1], x = "volatile acidity", y = "alcohol", data = wine,␣
 ↪color = "#A56EFF");
sns.regplot(ax = axes[2], x = "citric acid", y = "alcohol", data = wine, color␣
 ↪= "#8A3FFC");
sns.regplot(ax = axes[3], x = "total sulfur dioxide", y = "alcohol", data =␣
 ↪wine, color = "#6929C4");
```



10 Hexagonal Binned Plot

[17]:
```
fig, ([ax0, ax1], [ax2, ax3]) = plt.subplots(nrows = 2, ncols = 2, figsize =␣
 ↪(17, 10))

hb = ax0.hexbin(wine["sulphates"], wine["quality"], gridsize = 30, cmap =␣
 ↪'Purples_r')
ax0.set_title("Hexagon binning")
```

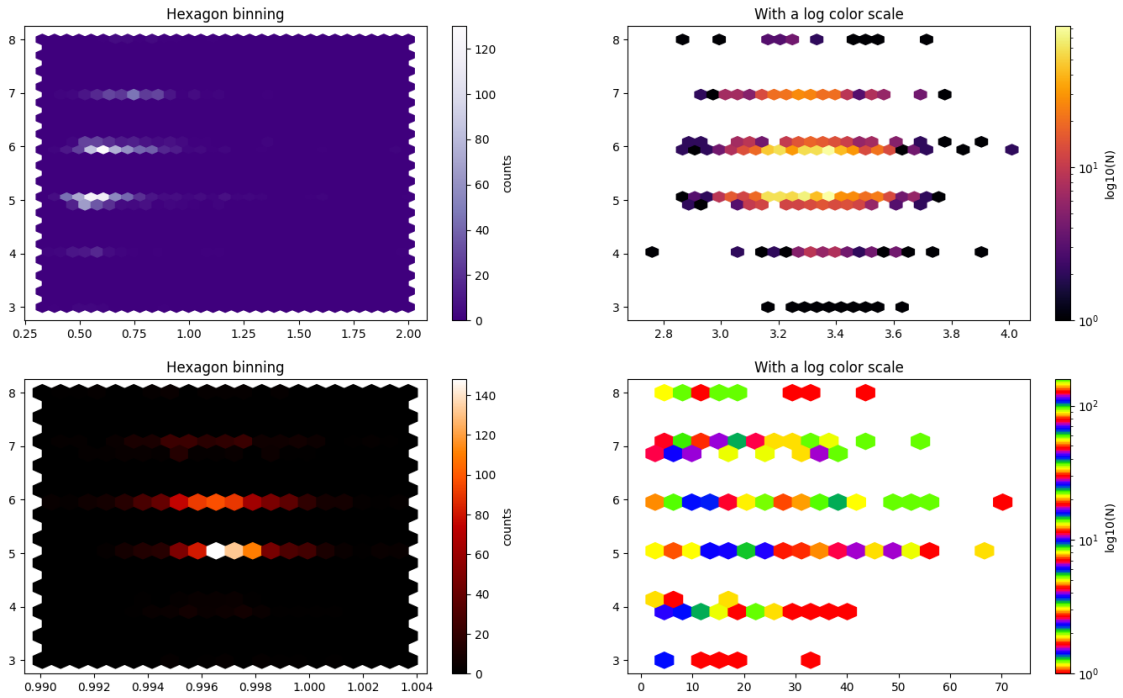
```
cb = fig.colorbar(hb, ax = ax0, label = 'counts')


hb = ax1.hexbin(wine["pH"], wine["quality"], gridsize = 30, bins = 'log', cmap␣
 ↪= 'inferno')
ax1.set_title("With a log color scale")
cb = fig.colorbar(hb, ax = ax1, label = 'log10(N)')


hb = ax2.hexbin(wine["density"], wine["quality"], gridsize = 20, cmap =␣
 ↪'gist_heat')
ax2.set_title("Hexagon binning")
cb = fig.colorbar(hb, ax = ax2, label = 'counts')

hb = ax3.hexbin(wine["free sulfur dioxide"], wine["quality"], gridsize = 20,␣
 ↪bins = 'log',
                cmap = 'prism')
ax3.set_title("With a log color scale")
cb = fig.colorbar(hb, ax = ax3, label = 'log10(N)')

plt.show()
```



11 Visualization with Plotly Express

11.0.1 Overview

Reference: https://plotly.com/python/plotly-express/

The plotly.express module contains functions that can create entire figures at once, and is referred to as Plotly Express or PX. Plotly Express is a built-in part of the plotly library, and is the recommended starting point for creating most common figures. Every Plotly Express function uses graph objects internally and returns a plotly.graph_objects.Figure instance. Throughout the plotly documentation, you will find the Plotly Express way of building figures at the top of any applicable page, followed by a section on how to use graph objects to build similar figures. Any figure created in a single function call with Plotly Express could be created using graph objects alone, but with between 5 and 100 times more code.

Plotly Express provides more than 30 functions for creating different types of figures. The API for these functions was carefully designed to be as consistent and easy to learn as possible, making it easy to switch from a scatter plot to a bar chart to a histogram to a sunburst chart throughout a data exploration session.

[18]:
```
purple = ['#491D8B', '#6929C4', '#8A3FFC', '#A56EFF',
          '#BE95FF', '#CA96EC', '#A163CF', '#29066B',
          '#7D3AC1', '#AF4BCE', '#DB4CB2', '#EB548C',
          '#EC96E0', '#A2128E', '#E8D9F3', '#641811']

sns.palplot(purple, size = 2)
```

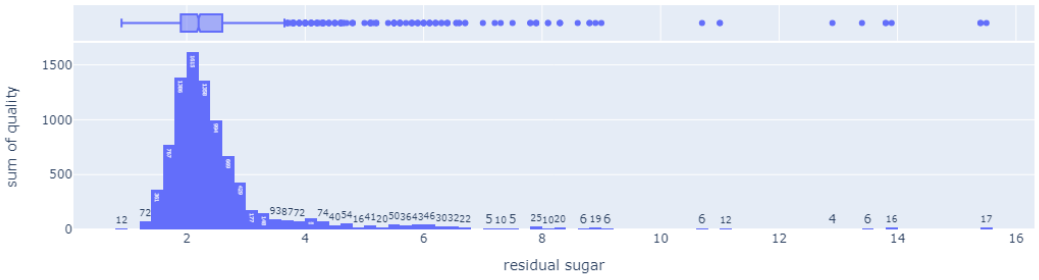
[19]:
```
!pip install plotly pandas
```

```
Requirement already satisfied: plotly in d:\python 3.8\lib\site-packages
(5.18.0)
Requirement already satisfied: pandas in d:\python 3.8\lib\site-packages (2.0.3)
Requirement already satisfied: tenacity>=6.2.0 in d:\python 3.8\lib\site-
packages (from plotly) (8.2.3)
Requirement already satisfied: packaging in d:\python 3.8\lib\site-packages
(from plotly) (23.2)
Requirement already satisfied: python-dateutil>=2.8.2 in d:\python 3.8\lib\site-
packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in d:\python 3.8\lib\site-packages
(from pandas) (2024.1)
Requirement already satisfied: tzdata>=2022.1 in d:\python 3.8\lib\site-packages
(from pandas) (2023.4)
Requirement already satisfied: numpy>=1.20.3 in d:\python 3.8\lib\site-packages
(from pandas) (1.24.4)
```

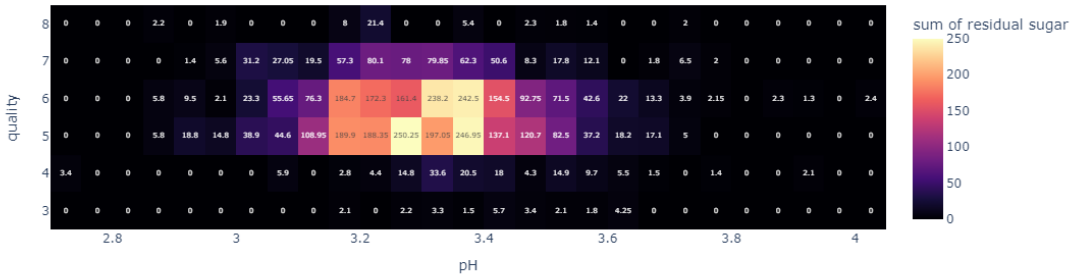
```
Requirement already satisfied: six>=1.5 in d:\python 3.8\lib\site-packages (from
python-dateutil>=2.8.2->pandas) (1.16.0)
```

[20]:
```
import plotly.express as px
import pandas as pd
```

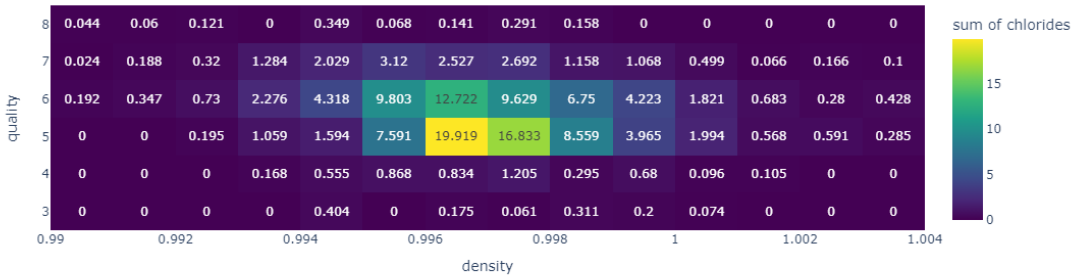
[21]:
```
fig = px.histogram(wine, x = "residual sugar", y = "quality", marginal = "box",
                   color = None, text_auto = True, hover_data  = wine.columns)
fig.show()
```



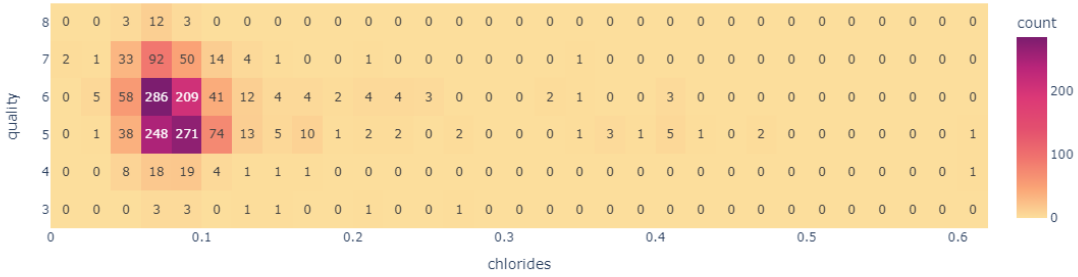
[22]:
```
fig = px.density_heatmap(wine, x = "pH", y = "quality", z = "residual sugar",
                         color_continuous_scale = "magma", text_auto = True)
fig.show()
```



[23]:
```
fig = px.density_heatmap(wine, x = "density", y = "quality", z = "chlorides",
                         color_continuous_scale = "Viridis", text_auto = True)
fig.show()
```



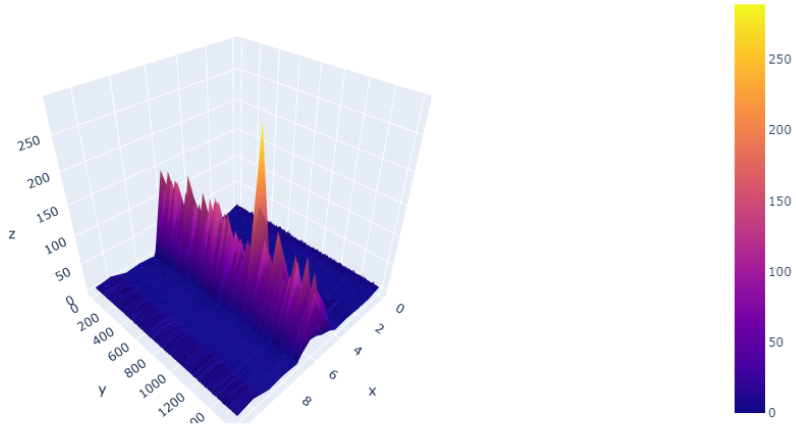
[24]:
```
fig = px.density_heatmap(wine, x = "chlorides", y = "quality", text_auto = True,
                         color_continuous_scale = "sunsetdark")
fig.show()
```



[25]:
```
import plotly.graph_objects as go
```

[26]:
```
data = wine
fig = go.Figure(data = [go.Surface(z = data.values)])
fig.update_layout(autosize = True, width = 600, height = 600)

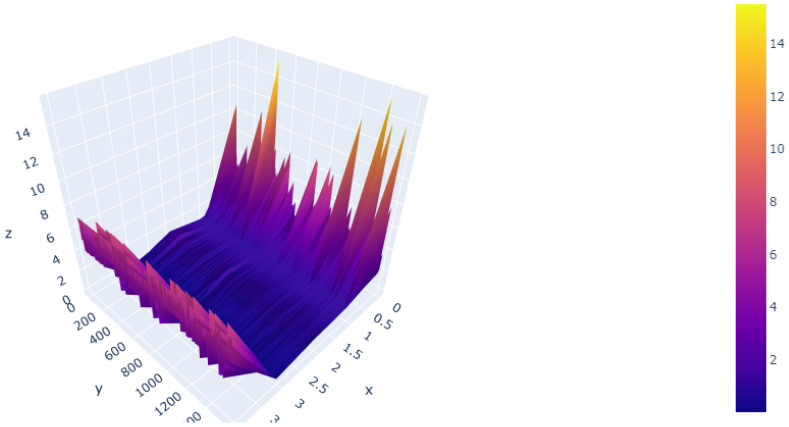
fig.show()
```



[27]:
```
data = wine[["residual sugar", "density", "sulphates", "chlorides", "quality"]]

fig = go.Figure(data = [go.Surface(z = data.values)])
fig.update_layout(autosize = True, width = 600, height = 600)

fig.show()
```



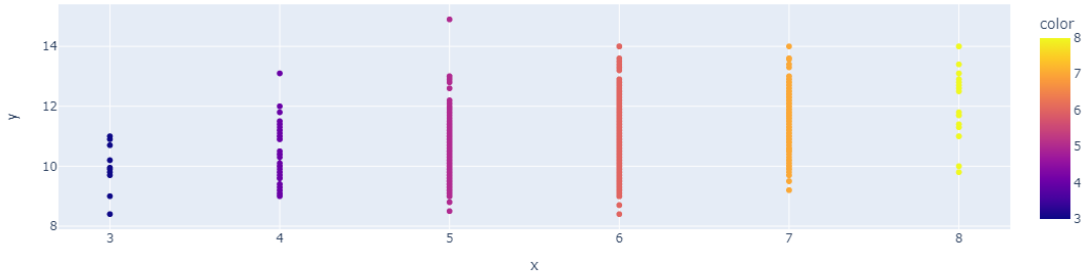
[39]:
```
!pip install plotly
import plotly.io as pio
```

```
Requirement already satisfied: plotly in d:\python 3.8\lib\site-packages
(5.18.0)
Requirement already satisfied: tenacity>=6.2.0 in d:\python 3.8\lib\site-
packages (from plotly) (8.2.3)
Requirement already satisfied: packaging in d:\python 3.8\lib\site-packages
(from plotly) (23.2)
```

[42]:
```
import plotly.express as px

subject = wine["quality"]
score = wine["alcohol"]

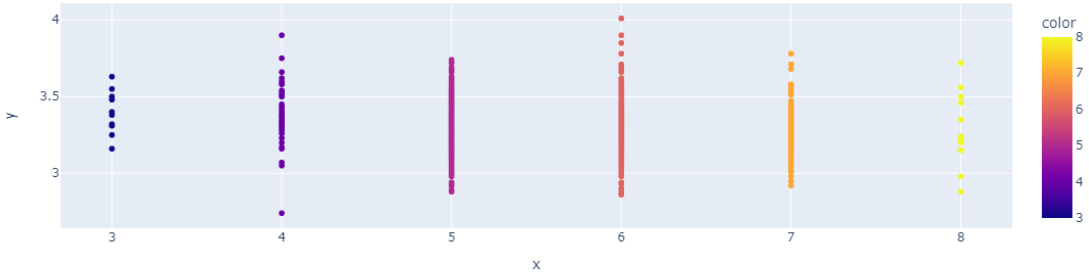
fig = px.scatter(x=subject, y=score, color=subject)
fig.show()
```



[43]:
```
import plotly.express as px

subject = wine["quality"]
score = wine["pH"]

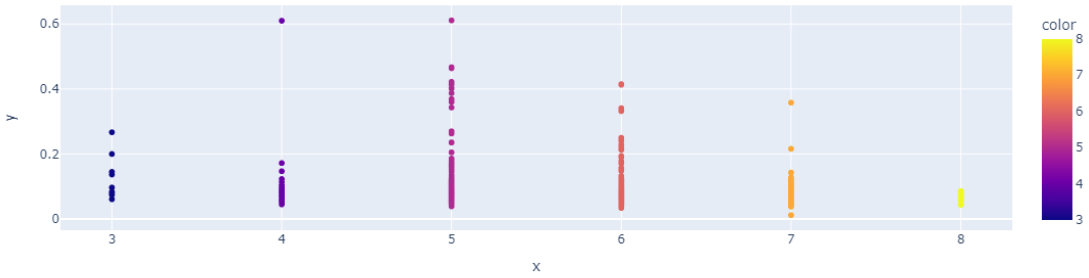
fig = px.scatter(x=subject, y=score, color=subject)
fig.show()
```



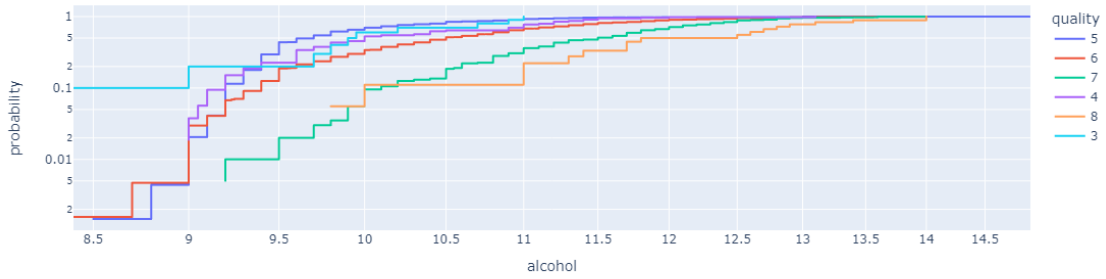
[44]:
```
import plotly.express as px

subject = wine["quality"]
score = wine["chlorides"]

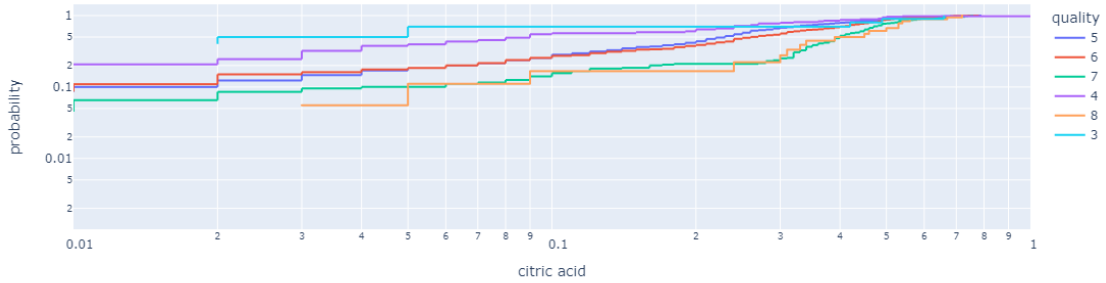
fig = px.scatter(x=subject, y=score, color=subject)
fig.show()
```



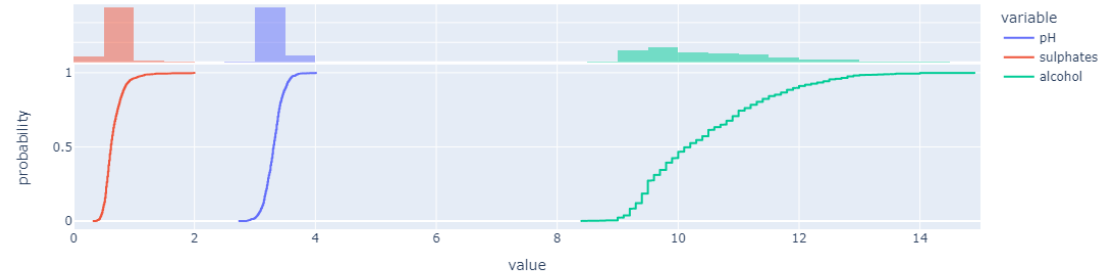
[36]:
```
fig = px.ecdf(wine, x = "alcohol", log_x = True, log_y = True, color =␣
 ↪"quality")
fig.show()
```



[37]:
```
fig = px.ecdf(wine, x = "citric acid", log_x = True, log_y = True, color =␣
↪"quality")
fig.show()
```



[38]:
```
fig = px.ecdf(wine, x = ["pH", "sulphates", "alcohol"],
              marginal = "histogram", markers = False)
fig.show()
```



5.8 |Heatmap and Correlation

11.0.2 Correlation and Causation

Reference: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/statistical+language+-+correlation+and+causation

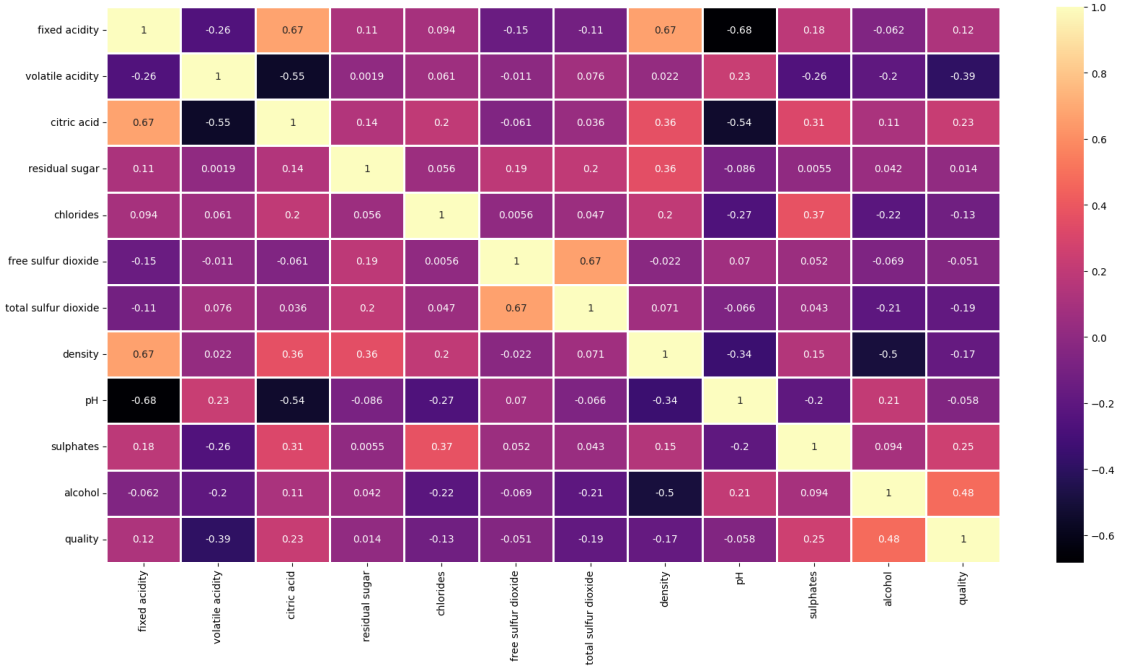
Two or more variables considered to be related, in a statistical context, if their values change so that as the value of one variable increases or decreases so does the value of the other variable (although it may be in the opposite direction). For example, for the two variables "hours worked" and "income earned" there is a relationship between the two if the increase in hours worked is associated with an increase in income earned. If we consider the two variables "price" and "purchasing power", as the price of goods increases a person's ability to buy these goods decreases (assuming a constant income).

Correlation is a statistical measure (expressed as a number) that describes the size and direction of a relationship between two or more variables. A correlation between variables, however, does not automatically mean that the change in one variable is the cause of the change in the values of the other variable.

Causation indicates that one event is the result of the occurrence of the other event; i.e. there is a causal relationship between the two events. This is also referred to as cause and effect.

Theoretically, the difference between the two types of relationships are easy to identify — an action or occurrence can cause another (e.g. smoking causes an increase in the risk of developing lung cancer), or it can correlate with another (e.g. smoking is correlated with alcoholism, but it does not cause alcoholism). In practice, however, it remains difficult to clearly establish cause and effect, compared with establishing correlation.

[46]:
```
plt.figure(figsize = [20, 10], facecolor = 'white')
sns.heatmap(wine.corr(), annot = True, linewidths = 2, cmap = "magma");
```



Correlation

IMPORTANT NOTE! There is 'multicollinearity' problem

Here we see that there is relatively high (0.67, positive) correlation between 'free sulfur dioxide' and 'total_sulfur_dioxide' variables. There is relatively high (-0.68, negative) correlation between "pH" and "fixed_acidity" variables. And there is about 0.5 correlation between some of other variables. That's why we must consider when build Machine Learning models.

[48]:
```
list = (wine[["alcohol","density"]].corr(), wine[["fixed acidity","pH"]].corr(),
        wine[["citric acid","pH"]].corr(), wine[["fixed acidity","density"]].
 ↪corr(),
        wine[["free sulfur dioxide","total sulfur dioxide"]].corr())
for corr in list:
    print(corr, "\n\n")
```

```
         alcohol  density
alcohol  1.00000 -0.49618
density -0.49618  1.00000


               fixed acidity        pH
fixed acidity       1.000000 -0.682978
pH                 -0.682978  1.000000


             citric acid        pH
citric acid     1.000000 -0.541904
pH             -0.541904  1.000000


               fixed acidity   density
fixed acidity       1.000000  0.668047
density             0.668047  1.000000


                     free sulfur dioxide  total sulfur dioxide
free sulfur dioxide             1.000000              0.667666
total sulfur dioxide            0.667666              1.000000
```

In the code blocks below we will look at the Pearson correlation coefficient between some variables

[49]:
```
!pip install scipy pandas
```

```
Requirement already satisfied: scipy in d:\python 3.8\lib\site-packages (1.10.1)
```

```
Requirement already satisfied: pandas in d:\python 3.8\lib\site-packages (2.0.3)
Requirement already satisfied: numpy<1.27.0,>=1.19.5 in d:\python 3.8\lib\site-
packages (from scipy) (1.24.4)
Requirement already satisfied: python-dateutil>=2.8.2 in d:\python 3.8\lib\site-
packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in d:\python 3.8\lib\site-packages
(from pandas) (2024.1)
Requirement already satisfied: tzdata>=2022.1 in d:\python 3.8\lib\site-packages
(from pandas) (2023.4)
Requirement already satisfied: six>=1.5 in d:\python 3.8\lib\site-packages (from
python-dateutil>=2.8.2->pandas) (1.16.0)
```

[50]:
```
import scipy.stats as st
```

[51]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["alcohol"],
                                                      wine["density"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.4961797702417019,
pvalue=3.9388353399870764e-100)
```

[52]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["free sulfur␣
↪dioxide"],
                                                      wine["total sulfur␣
↪dioxide"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=0.6676664504810215,
pvalue=6.404722954681174e-207)
```

[53]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["fixed acidity"],
                                                      wine["pH"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.6829781945685319,
pvalue=4.063034039841015e-220)
```

[54]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["citric acid"],
                                                      wine["pH"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.5419041447395099,
pvalue=1.007201325911255e-122)
```

[55]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["fixed acidity"],
                                                      wine["density"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=0.6680472921189741,
pvalue=3.0747470608584777e-207)
```

12 Feature Selection

[56]:
```
wine.sample(5)
```

[56]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	\
500	7.8	0.52	0.25	1.9	0.081	
1099	8.6	0.52	0.38	1.5	0.096	
24	6.9	0.40	0.14	2.4	0.085	
365	10.0	0.42	0.50	3.4	0.107	
18	7.4	0.59	0.08	4.4	0.086	

	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	\
500	14.0	38.0	0.99840	3.43	0.65	
1099	5.0	18.0	0.99666	3.20	0.52	
24	21.0	40.0	0.99680	3.43	0.63	
365	7.0	21.0	0.99790	3.26	0.93	
18	6.0	29.0	0.99740	3.38	0.50	

	alcohol	quality
500	9.0	6
1099	9.4	5
24	9.7	6
365	11.8	6
18	9.0	4

[57]:
```
wine['quality'].unique()
```

[57]:
```
array([5, 6, 7, 4, 8, 3], dtype=int64)
```

[58]:
```
# If wine quality is 7 or above then will consider as good quality wine
wine['goodquality'] = [1 if x >= 7 else 0 for x in wine['quality']]
wine.sample(5)
```

[58]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	\
1198	7.7	0.260	0.26	2.0	0.052	
109	8.1	0.785	0.52	2.0	0.122	
487	10.2	0.645	0.36	1.8	0.053	
1565	6.7	0.670	0.02	1.9	0.061	
625	6.8	0.690	0.00	5.6	0.124	

	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	\
1198	19.0	77.0	0.99510	3.15	0.79	
109	37.0	153.0	0.99690	3.21	0.69	
487	5.0	14.0	0.99820	3.17	0.42	
1565	26.0	42.0	0.99489	3.39	0.82	
625	21.0	58.0	0.99970	3.46	0.72	

```
      alcohol  quality  goodquality
1198     10.9        6            0
109       9.3        5            0
487      10.0        6            0
1565     10.9        6            0
625      10.2        5            0
```

[59]:
```
# See total number of good vs bad wines samples
wine['goodquality'].value_counts()
```

[59]:
```
goodquality
0    1382
1     217
Name: count, dtype: int64
```

[60]:
```
# Separate depedent and indepedent variables
X = wine.drop(['quality','goodquality'], axis = 1)
Y = wine['goodquality']
```

[61]:
```
X
```

[61]:
```
      fixed acidity  volatile acidity  citric acid  residual sugar  chlorides  \
0               7.4             0.700         0.00             1.9      0.076
1               7.8             0.880         0.00             2.6      0.098
2               7.8             0.760         0.04             2.3      0.092
3              11.2             0.280         0.56             1.9      0.075
4               7.4             0.700         0.00             1.9      0.076
…               …                 …            …                …        …
1594            6.2             0.600         0.08             2.0      0.090
1595            5.9             0.550         0.10             2.2      0.062
1596            6.3             0.510         0.13             2.3      0.076
1597            5.9             0.645         0.12             2.0      0.075
1598            6.0             0.310         0.47             3.6      0.067

      free sulfur dioxide  total sulfur dioxide  density    pH  sulphates  \
0                    11.0                  34.0  0.99780  3.51       0.56
1                    25.0                  67.0  0.99680  3.20       0.68
2                    15.0                  54.0  0.99700  3.26       0.65
3                    17.0                  60.0  0.99800  3.16       0.58
4                    11.0                  34.0  0.99780  3.51       0.56
…                     …                     …        …     …          …
1594                 32.0                  44.0  0.99490  3.45       0.58
1595                 39.0                  51.0  0.99512  3.52       0.76
1596                 29.0                  40.0  0.99574  3.42       0.75
1597                 32.0                  44.0  0.99547  3.57       0.71
1598                 18.0                  42.0  0.99549  3.39       0.66
```

```
      alcohol
0         9.4
1         9.8
2         9.8
3         9.8
4         9.4
…         …
1594     10.5
1595     11.2
1596     11.0
1597     10.2
1598     11.0

[1599 rows x 11 columns]
```

[62]:
```
print(Y)
```

```
0       0
1       0
2       0
3       0
4       0
       ..
1594    0
1595    0
1596    0
1597    0
1598    0
Name: goodquality, Length: 1599, dtype: int64
```

13 Feature Importance

[63]:
```
from sklearn.ensemble import ExtraTreesClassifier
classifiern = ExtraTreesClassifier()
classifiern.fit(X,Y)
score = classifiern.feature_importances_
print(score)
```

```
[0.07504659 0.10451426 0.09082463 0.07550917 0.06635143 0.06800035
 0.08268497 0.08175961 0.0680887  0.10957794 0.17764234]
```

14 Splitting Dataset

[64]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X,Y,test_size=0.
 ↪3,random_state=7)
```

15 Result

[65]:
```
model_res=pd.DataFrame(columns=['Model', 'Score'])
```

16 LogisticRegression:

[66]:
```
from sklearn.linear_model import LogisticRegression
model = LogisticRegression()
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score,confusion_matrix
# accuracy_score(Y_test,Y_pred)
model_res.loc[len(model_res)] = ['LogisticRegression',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

[66]:

	Model	Score
0	LogisticRegression	0.872917

17 Using KNN:

[67]:
```
from sklearn.neighbors import KNeighborsClassifier
model = KNeighborsClassifier(n_neighbors=3)
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
model_res.loc[len(model_res)] = ['KNeighborsClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

[67]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917

Using SVC:

[68]:
```
from sklearn.svm import SVC
model = SVC()
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['SVC', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.86875
```

[68]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750

18 Using Decision Tree:

[69]:
```
from sklearn.tree import DecisionTreeClassifier
model = DecisionTreeClassifier(criterion='entropy',random_state=7)
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['DecisionTreeClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8645833333333334
```

[69]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583

19 Using GaussianNB:

[70]:
```
from sklearn.naive_bayes import GaussianNB
model3 = GaussianNB()
model3.fit(X_train,Y_train)
y_pred = model3.predict(X_test)
```

```
from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['GaussianNB', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8333333333333334
```

[70]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333

20 Using Random Forest:

[71]:
```
from sklearn.ensemble import RandomForestClassifier
model2 = RandomForestClassifier(random_state=1)
model2.fit(X_train, Y_train)
y_pred = model2.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['RandomForestClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.89375
```

[71]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333
5	RandomForestClassifier	0.893750

21 Using Xgboost:

[72]:
```
import xgboost as xgb
model5 = xgb.XGBClassifier(random_state=1)
model5.fit(X_train, Y_train)
y_pred = model5.predict(X_test)

from sklearn.metrics import accuracy_score
```

```
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['XGBClassifier', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8895833333333333
```

[72]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333
5	RandomForestClassifier	0.893750
6	XGBClassifier	0.889583

[73]:
```
model_res = model_res.sort_values(by='Score', ascending=False)
model_res
```

[73]:

	Model	Score
5	RandomForestClassifier	0.893750
6	XGBClassifier	0.889583
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333

[47]:
```
subject = wine["quality"]
score = wine["alcohol"]

data = [dict(x = subject, y = score, mode = "markers", type = "scatter",
             transforms = [dict(type = "groupby", groups = subject)])]

fig_dict = dict(data = data)
pio.show(fig_dict, validate = False)
```

[48]:
```
subject = wine["quality"]
score = wine["pH"]

data = [dict(x = subject, y = score, mode = "markers", type = "scatter",
             transforms = [dict(type = "groupby", groups = subject)])]

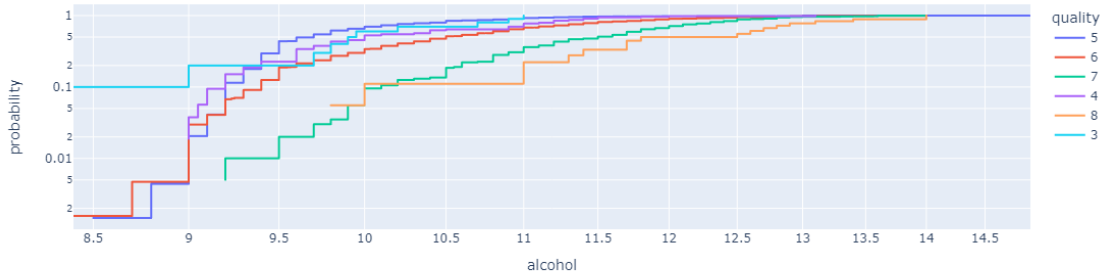
fig_dict = dict(data = data)
pio.show(fig_dict, validate = False)
```

[49]:
```
subject = wine["quality"]
score = wine["chlorides"]
```

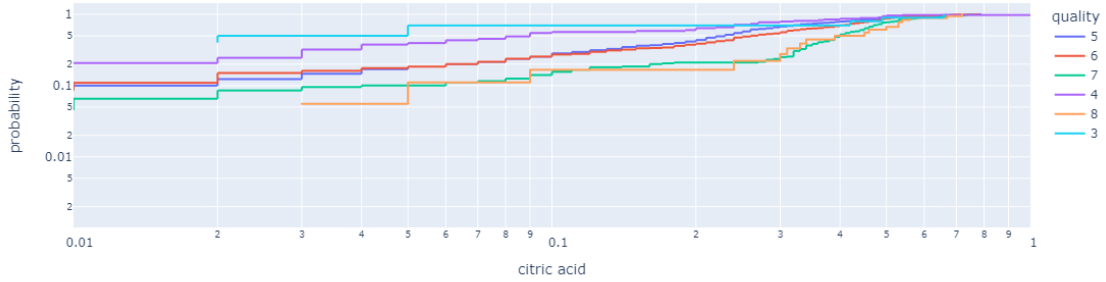
```
data = [dict(x = subject, y = score, mode = "markers", type = "scatter",
             transforms = [dict(type = "groupby", groups = subject)])]

fig_dict = dict(data = data)
pio.show(fig_dict, validate = False)
```

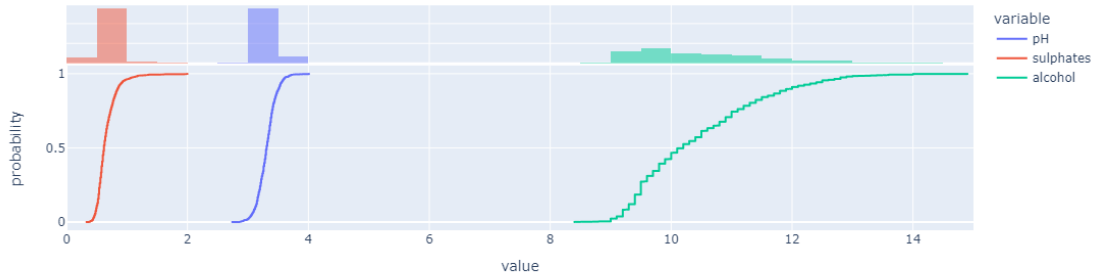
[51]:
```
fig = px.ecdf(wine, x = "alcohol", log_x = True, log_y = True, color =␣
 ↪"quality")
fig.show()
```



[52]:
```
fig = px.ecdf(wine, x = "citric acid", log_x = True, log_y = True, color =␣
 ↪"quality")
fig.show()
```



[53]:
```
fig = px.ecdf(wine, x = ["pH", "sulphates", "alcohol"],
              marginal = "histogram", markers = False)
fig.show()
```



22 Heatmap and Correlation

22.0.1 Correlation and Causation

Reference: https://www.abs.gov.au/websitedbs/D3310114.nsf/home/statistical+language+-+correlation+and+causation

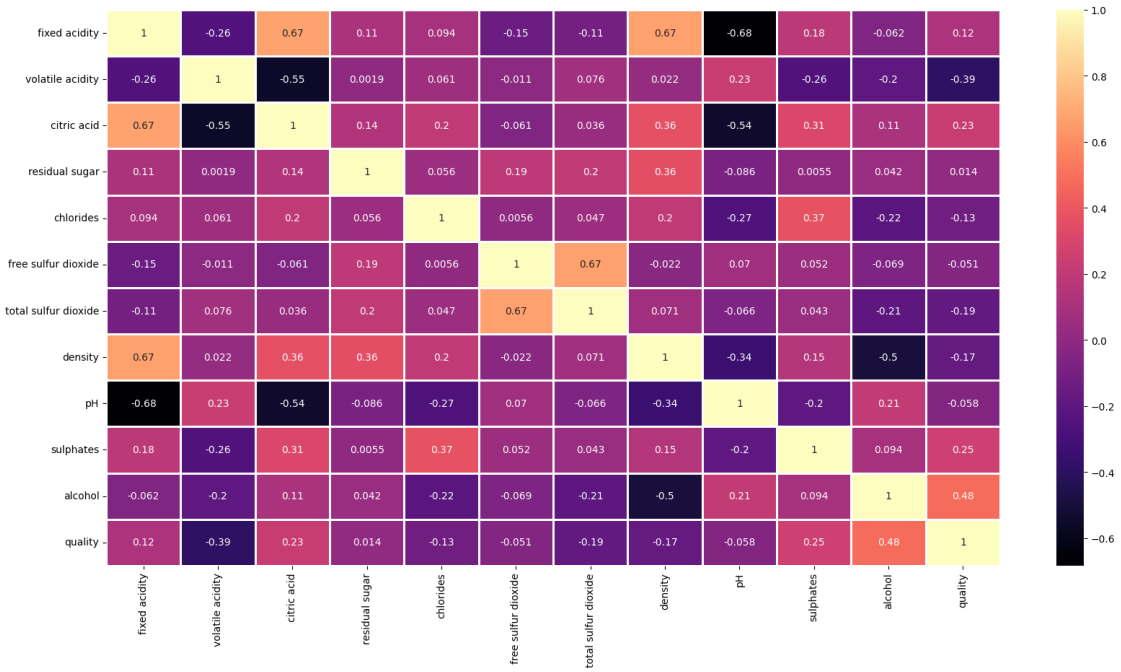
Two or more variables considered to be related, in a statistical context, if their values change so that as the value of one variable increases or decreases so does the value of the other variable (although it may be in the opposite direction). For example, for the two variables "hours worked" and "income earned" there is a relationship between the two if the increase in hours worked is associated with an increase in income earned. If we consider the two variables "price" and "purchasing power", as the price of goods increases a person's ability to buy these goods decreases (assuming a constant income).

Correlation is a statistical measure (expressed as a number) that describes the size and direction of a relationship between two or more variables. A correlation between variables, however, does not automatically mean that the change in one variable is the cause of the change in the values of the other variable.

Causation indicates that one event is the result of the occurrence of the other event; i.e. there is a causal relationship between the two events. This is also referred to as cause and effect.

Theoretically, the difference between the two types of relationships are easy to identify — an action or occurrence can cause another (e.g. smoking causes an increase in the risk of developing lung cancer), or it can correlate with another (e.g. smoking is correlated with alcoholism, but it does not cause alcoholism). In practice, however, it remains difficult to clearly establish cause and effect, compared with establishing correlation.

[55]:
```
plt.figure(figsize = [20, 10], facecolor = 'white')
sns.heatmap(wine.corr(), annot = True, linewidths = 2, cmap = "magma");
```



Correlation

IMPORTANT NOTE! There is 'multicollinearity' problem

Here we see that there is relatively high (0.67, positive) correlation between 'free sulfur dioxide' and 'total_sulfur_dioxide' variables. There is relatively high (-0.68, negative) correlation between "pH" and "fixed_acidity" variables. And there is about 0.5 correlation between some of other variables. That's why we must consider when build Machine Learning models.

[57]:
```
list = (wine[["alcohol","density"]].corr(), wine[["fixed acidity","pH"]].corr(),
        wine[["citric acid","pH"]].corr(), wine[["fixed acidity","density"]].
 ↪corr(),
        wine[["free sulfur dioxide","total sulfur dioxide"]].corr())
for corr in list:
    print(corr, "\n\n")
```

```
         alcohol   density
alcohol  1.00000 -0.49618
density -0.49618  1.00000


               fixed acidity        pH
fixed acidity       1.000000 -0.682978
pH                 -0.682978  1.000000


             citric acid        pH
```

```
citric acid     1.000000 -0.541904
pH             -0.541904  1.000000
```

```
               fixed acidity   density
fixed acidity       1.000000  0.668047
density             0.668047  1.000000
```

```
                      free sulfur dioxide  total sulfur dioxide
free sulfur dioxide              1.000000              0.667666
total sulfur dioxide             0.667666              1.000000
```

In the code blocks below we will look at the Pearson correlation coefficient between some variables

[59]:
```
!pip install scipy pandas
```

```
Requirement already satisfied: scipy in c:\python\lib\site-packages (1.12.0)
Requirement already satisfied: pandas in c:\python\lib\site-packages (2.2.0)
Requirement already satisfied: numpy<1.29.0,>=1.22.4 in c:\python\lib\site-
packages (from scipy) (1.26.3)
Requirement already satisfied: python-dateutil>=2.8.2 in c:\python\lib\site-
packages (from pandas) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in c:\python\lib\site-packages (from
pandas) (2023.4)
Requirement already satisfied: tzdata>=2022.7 in c:\python\lib\site-packages
(from pandas) (2023.4)
Requirement already satisfied: six>=1.5 in c:\python\lib\site-packages (from
python-dateutil>=2.8.2->pandas) (1.16.0)


[notice] A new release of pip is available: 23.2.1 -> 23.3.2
[notice] To update, run: python.exe -m pip install --upgrade pip
```

[60]:
```
import scipy.stats as st
```

[62]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["alcohol"],
                                                      wine["density"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.4961797702417019,
pvalue=3.9388353399870764e-100)
```

[64]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["free sulfur␣
↪dioxide"],
                                                      wine["total sulfur␣
↪dioxide"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=0.6676664504810215,
pvalue=6.404722954681174e-207)
```

[65]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["fixed acidity"],
                                                      wine["pH"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.6829781945685319,
pvalue=4.063034039841015e-220)
```

[66]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["citric acid"],
                                                      wine["pH"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=-0.5419041447395099,
pvalue=1.007201325911255e-122)
```

[67]:
```
print("Pearson correlation coefficient:", st.pearsonr(wine["fixed acidity"],
                                                      wine["density"]))
```

```
Pearson correlation coefficient: PearsonRResult(statistic=0.6680472921189741,
pvalue=3.074747060858477 7e-207)
```

23 Feature Selection

[68]:
```
wine.sample(5)
```

[68]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	\
593	9.9	0.490	0.58	3.50	0.094	
65	7.2	0.725	0.05	4.65	0.086	
688	7.7	0.660	0.04	1.60	0.039	
363	12.5	0.460	0.63	2.00	0.071	
959	8.0	0.590	0.05	2.00	0.089	

	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	\
593	9.0	43.0	1.00040	3.29	0.58	
65	4.0	11.0	0.99620	3.41	0.39	
688	4.0	9.0	0.99620	3.40	0.47	
363	6.0	15.0	0.99880	2.99	0.87	
959	12.0	32.0	0.99735	3.36	0.61	

	alcohol	quality
593	9.0	5
65	10.9	5
688	9.4	5
363	10.2	5
959	10.0	5

[69]:
```
wine['quality'].unique()
```

[69]:
```
array([5, 6, 7, 4, 8, 3], dtype=int64)
```

[70]:
```
# If wine quality is 7 or above then will consider as good quality wine
wine['goodquality'] = [1 if x >= 7 else 0 for x in wine['quality']]
wine.sample(5)
```

[70]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality	goodquality
773	7.9	0.400	0.29	1.80	0.157	1.0	44.0	0.99730	3.30	0.92	9.5	6	0
588	5.0	0.420	0.24	2.00	0.060	19.0	50.0	0.99170	3.72	0.74	14.0	8	1
554	15.5	0.645	0.49	4.20	0.095	10.0	23.0	1.00315	2.92	0.74	11.1	5	0
462	11.0	0.260	0.68	2.55	0.085	10.0	25.0	0.99700	3.18	0.61	11.8	5	0
269	11.5	0.180	0.51	4.00	0.104	4.0	23.0	0.99960	3.28	0.97	10.1	6	0

[71]:
```
# See total number of good vs bad wines samples
wine['goodquality'].value_counts()
```

[71]:
```
goodquality
0    1382
1     217
Name: count, dtype: int64
```

[72]:
```
# Separate depedent and indepedent variables
X = wine.drop(['quality','goodquality'], axis = 1)
Y = wine['goodquality']
```

[73]:
```
X
```

[73]:

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.56	9.4
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.99680	3.20	0.68	9.8
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.99700	3.26	0.65	9.8
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.99800	3.16	0.58	9.8
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.56	9.4

```
…              …                 …            …                …         …
1594            6.2             0.600         0.08             2.0      0.090
1595            5.9             0.550         0.10             2.2      0.062
1596            6.3             0.510         0.13             2.3      0.076
1597            5.9             0.645         0.12             2.0      0.075
1598            6.0             0.310         0.47             3.6      0.067

      free sulfur dioxide  total sulfur dioxide  density    pH  sulphates  \
0                    11.0                  34.0  0.99780  3.51       0.56
1                    25.0                  67.0  0.99680  3.20       0.68
2                    15.0                  54.0  0.99700  3.26       0.65
3                    17.0                  60.0  0.99800  3.16       0.58
4                    11.0                  34.0  0.99780  3.51       0.56
…                     …                     …       …   …         …
1594                 32.0                  44.0  0.99490  3.45       0.58
1595                 39.0                  51.0  0.99512  3.52       0.76
1596                 29.0                  40.0  0.99574  3.42       0.75
1597                 32.0                  44.0  0.99547  3.57       0.71
1598                 18.0                  42.0  0.99549  3.39       0.66

      alcohol
0         9.4
1         9.8
2         9.8
3         9.8
4         9.4
…         …
1594     10.5
1595     11.2
1596     11.0
1597     10.2
1598     11.0

[1599 rows x 11 columns]
```

[74]:
```
print(Y)
```

```
0       0
1       0
2       0
3       0
4       0
       ..
1594    0
1595    0
1596    0
1597    0
```

```
1598    0
Name: goodquality, Length: 1599, dtype: int64
```

24 Feature Importance

[75]:
```
from sklearn.ensemble import ExtraTreesClassifier
classifiern = ExtraTreesClassifier()
classifiern.fit(X,Y)
score = classifiern.feature_importances_
print(score)
```

```
[0.07141731 0.09966626 0.09740041 0.07393926 0.07001599 0.0703833
 0.08189362 0.08701146 0.06695778 0.10889258 0.17242203]
```

25 Splitting Dataset

[76]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, Y_train, Y_test = train_test_split(X,Y,test_size=0.
↪3,random_state=7)
```

26 Result

[83]:
```
model_res=pd.DataFrame(columns=['Model', 'Score'])
```

27 LogisticRegression:

[84]:
```
from sklearn.linear_model import LogisticRegression
model = LogisticRegression()
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score,confusion_matrix
# accuracy_score(Y_test,Y_pred)
model_res.loc[len(model_res)] = ['LogisticRegression',␣
↪accuracy_score(Y_test,y_pred)]
model_res
```

[84]:

	Model	Score
0	LogisticRegression	0.872917

28 Using KNN:

[85]:
```
from sklearn.neighbors import KNeighborsClassifier
model = KNeighborsClassifier(n_neighbors=3)
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
model_res.loc[len(model_res)] = ['KNeighborsClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

[85]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917

29 Using SVC

[86]:
```
from sklearn.svm import SVC
model = SVC()
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['SVC', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.86875
```

[86]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750

30 Using Decision Tree:

[87]:
```
from sklearn.tree import DecisionTreeClassifier
model = DecisionTreeClassifier(criterion='entropy',random_state=7)
model.fit(X_train,Y_train)
y_pred = model.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
```

```
model_res.loc[len(model_res)] = ['DecisionTreeClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8645833333333334
```

[87]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583

31 Using GaussianNB:

[88]:
```
from sklearn.naive_bayes import GaussianNB
model3 = GaussianNB()
model3.fit(X_train,Y_train)
y_pred = model3.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['GaussianNB', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8333333333333334
```

[88]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333

32 Using Random Forest:

[89]:
```
from sklearn.ensemble import RandomForestClassifier
model2 = RandomForestClassifier(random_state=1)
model2.fit(X_train, Y_train)
y_pred = model2.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['RandomForestClassifier',␣
 ↪accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.89375
```

[89]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333
5	RandomForestClassifier	0.893750

[90]:
```
!pip install xgboost
```

```
Collecting xgboost
  Obtaining dependency information for xgboost from https://files.pythonhosted.o
rg/packages/24/ec/ad387100fa3cc2b9b81af0829b5ecfe75ec5bb19dd7c19d4fea06fb81802/x
gboost-2.0.3-py3-none-win_amd64.whl.metadata
  Downloading xgboost-2.0.3-py3-none-win_amd64.whl.metadata (2.0 kB)
Requirement already satisfied: numpy in c:\python\lib\site-packages (from
xgboost) (1.26.3)
Requirement already satisfied: scipy in c:\python\lib\site-packages (from
xgboost) (1.12.0)
Downloading xgboost-2.0.3-py3-none-win_amd64.whl (99.8 MB)
   ---------------------------------------- 0.0/99.8 MB ? eta -:--:--
   ---------------------------------------- 0.0/99.8 MB ? eta -:--:--
   ---------------------------------------- 0.0/99.8 MB 660.6 kB/s eta 0:02:31
   ---------------------------------------- 0.1/99.8 MB 1.1 MB/s eta 0:01:35
   ---------------------------------------- 0.1/99.8 MB 950.9 kB/s eta 0:01:45
   ---------------------------------------- 0.2/99.8 MB 1.5 MB/s eta 0:01:06
   ---------------------------------------- 0.2/99.8 MB 1.5 MB/s eta 0:01:06
   ---------------------------------------- 0.3/99.8 MB 1.3 MB/s eta 0:01:18
   ---------------------------------------- 0.4/99.8 MB 1.3 MB/s eta 0:01:14
   ---------------------------------------- 0.5/99.8 MB 1.3 MB/s eta 0:01:14
   ---------------------------------------- 0.5/99.8 MB 1.3 MB/s eta 0:01:19
   ---------------------------------------- 0.5/99.8 MB 1.3 MB/s eta 0:01:19
   ---------------------------------------- 0.7/99.8 MB 1.3 MB/s eta 0:01:15
   ---------------------------------------- 0.7/99.8 MB 1.3 MB/s eta 0:01:17
   ---------------------------------------- 0.8/99.8 MB 1.3 MB/s eta 0:01:16
   ---------------------------------------- 0.9/99.8 MB 1.3 MB/s eta 0:01:14
   ---------------------------------------- 1.0/99.8 MB 1.4 MB/s eta 0:01:11
   ---------------------------------------- 1.1/99.8 MB 1.4 MB/s eta 0:01:10
   ---------------------------------------- 1.1/99.8 MB 1.4 MB/s eta 0:01:10
   ---------------------------------------- 1.2/99.8 MB 1.5 MB/s eta 0:01:08
    --------------------------------------- 1.3/99.8 MB 1.4 MB/s eta 0:01:08
    --------------------------------------- 1.4/99.8 MB 1.5 MB/s eta 0:01:08
    --------------------------------------- 1.4/99.8 MB 1.5 MB/s eta 0:01:07
    --------------------------------------- 1.5/99.8 MB 1.5 MB/s eta 0:01:07
    --------------------------------------- 1.6/99.8 MB 1.5 MB/s eta 0:01:05
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```
Installing collected packages: xgboost
Successfully installed xgboost-2.0.3


[notice] A new release of pip is available: 23.2.1 -> 23.3.2
[notice] To update, run: python.exe -m pip install --upgrade pip
```

33 Using Xgboost:

[91]:
```
import xgboost as xgb
model5 = xgb.XGBClassifier(random_state=1)
model5.fit(X_train, Y_train)
y_pred = model5.predict(X_test)

from sklearn.metrics import accuracy_score
print("Accuracy Score:",accuracy_score(Y_test,y_pred))
model_res.loc[len(model_res)] = ['XGBClassifier', accuracy_score(Y_test,y_pred)]
model_res
```

```
Accuracy Score: 0.8895833333333333
```

[91]:

	Model	Score
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333
5	RandomForestClassifier	0.893750
6	XGBClassifier	0.889583

[94]:
```
model_res = model_res.sort_values(by='Score', ascending=False)
model_res
```

[94]:

	Model	Score
5	RandomForestClassifier	0.893750
6	XGBClassifier	0.889583
0	LogisticRegression	0.872917
1	KNeighborsClassifier	0.872917
2	SVC	0.868750
3	DecisionTreeClassifier	0.864583
4	GaussianNB	0.833333