In [ ]:
```
import pandas as pd
import numpy as np
import operator
import matplotlib.pyplot as plt
```

In [ ]:
```
# reads a CSV file named iris data andnstores in Pandas DataFrame
data = pd.read_csv('iris.csv', header=None, names=['sepal_length', 'se
pal_width', 'petal_length', 'petal_width', 'class'])
print(data)
```

```
     sepal_length  sepal_width  petal_length  petal_width      class
0             5.1          3.5           1.4          0.2     Setosa
1             4.9          3.0           1.4          0.2     Setosa
2             4.7          3.2           1.3          0.2     Setosa
3             4.6          3.1           1.5          0.2     Setosa
4             5.0          3.6           1.4          0.2     Setosa
..            ...          ...           ...          ...        ...
145           6.7          3.0           5.2          2.3  Virginica
146           6.3          2.5           5.0          1.9  Virginica
147           6.5          3.0           5.2          2.0  Virginica
148           6.2          3.4           5.4          2.3  Virginica
149           5.9          3.0           5.1          1.8  Virginica

[150 rows x 5 columns]
```

In [ ]:
```
# generates a randomized array of integers from 0 to the number of row
s
indices = np.random.permutation(data.shape[0])

# calculating the index on which data will be divided
div = int(0.75 * len(indices))

# dividing the indexes into two array
development_id, test_id = indices[:div], indices[div:]

# using loc method of pandas dataframe which will select a particular
row and its all columns
# its just like splitting into training set and testing set

development_set, test_set = data.loc[development_id,:], data.loc[test_
id,:]
print("Development Set:\n", development_set, "\n\nTest Set:\n", test_s
et)
```

```
Development Set:
      sepal_length  sepal_width  petal_length  petal_width      clas
s
```

```
7              5.0          3.4           1.5          0.2     Setosa
41             4.5          2.3           1.3          0.3     Setosa
6              4.6          3.4           1.4          0.3     Setosa
1              4.9          3.0           1.4          0.2     Setosa
111            6.4          2.7           5.3          1.9  Virginica
..             ...          ...           ...          ...        ...
13             4.3          3.0           1.1          0.1     Setosa
26             5.0          3.4           1.6          0.4     Setosa
3              4.6          3.1           1.5          0.2     Setosa
35             5.0          3.2           1.2          0.2     Setosa
137            6.4          3.1           5.5          1.8  Virginica

[112 rows x 5 columns]

Test Set:
      sepal_length  sepal_width  petal_length  petal_width        cla
ss
5              5.4          3.9           1.7          0.4      Setos
a
66             5.6          3.0           4.5          1.5  Versicolo
r
141            6.9          3.1           5.1          2.3   Virginic
a
78             6.0          2.9           4.5          1.5  Versicolo
r
43             5.0          3.5           1.6          0.6      Setos
a
96             5.7          2.9           4.2          1.3  Versicolo
r
87             6.3          2.3           4.4          1.3  Versicolo
r
104            6.5          3.0           5.8          2.2   Virginic
a
49             5.0          3.3           1.4          0.2      Setos
a
122            7.7          2.8           6.7          2.0   Virginic
a
12             4.8          3.0           1.4          0.1      Setos
a
102            7.1          3.0           5.9          2.1   Virginic
a
17             5.1          3.5           1.4          0.3      Setos
a
92             5.8          2.6           4.0          1.2  Versicolo
r
121            5.6          2.8           4.9          2.0   Virginic
a
68             6.2          2.2           4.5          1.5  Versicolo
r
132            6.4          2.8           5.6          2.2   Virginic
```

a					
2	4.7	3.2	1.3	0.2	Setos
a					
42	4.4	3.2	1.3	0.2	Setos
a					
48	5.3	3.7	1.5	0.2	Setos
a					
81	5.5	2.4	3.7	1.0	Versicolo
r					
146	6.3	2.5	5.0	1.9	Virginic
a					
24	4.8	3.4	1.9	0.2	Setos
a					
98	5.1	2.5	3.0	1.1	Versicolo
r					
120	6.9	3.2	5.7	2.3	Virginic
a					
89	5.5	2.5	4.0	1.3	Versicolo
r					
142	5.8	2.7	5.1	1.9	Virginic
a					
147	6.5	3.0	5.2	2.0	Virginic
a					
112	6.8	3.0	5.5	2.1	Virginic
a					
11	4.8	3.4	1.6	0.2	Setos
a					
32	5.2	4.1	1.5	0.1	Setos
a					
46	5.1	3.8	1.6	0.2	Setos
a					
100	6.3	3.3	6.0	2.5	Virginic
a					
143	6.8	3.2	5.9	2.3	Virginic
a					
52	6.9	3.1	4.9	1.5	Versicolo
r					
69	5.6	2.5	3.9	1.1	Versicolo
r					
139	6.9	3.1	5.4	2.1	Virginic
a					
129	7.2	3.0	5.8	1.6	Virginic
a					

In [ ]:
```
# extracting the class labels for development and testing data
test_class = list(test_set.iloc[:,-1])
dev_class = list(development_set.iloc[:,-1])

# calculating mean and standard deviation for both development set and
testing set
mean_development_set = development_set.mean()
mean_test_set = test_set.mean()
std_development_set = development_set.std()
std_test_set = test_set.std()
```

```
<ipython-input-7-f2c127012c5f>:6: FutureWarning: Dropping of nuisanc
e columns in DataFrame reductions (with 'numeric_only=None') is depr
ecated; in a future version this will raise TypeError.  Select only
valid columns before calling the reduction.
  mean_development_set = development_set.mean()
<ipython-input-7-f2c127012c5f>:7: FutureWarning: Dropping of nuisanc
e columns in DataFrame reductions (with 'numeric_only=None') is depr
ecated; in a future version this will raise TypeError.  Select only
valid columns before calling the reduction.
  mean_test_set = test_set.mean()
<ipython-input-7-f2c127012c5f>:8: FutureWarning: Dropping of nuisanc
e columns in DataFrame reductions (with 'numeric_only=None') is depr
ecated; in a future version this will raise TypeError.  Select only
valid columns before calling the reduction.
  std_development_set = development_set.std()
<ipython-input-7-f2c127012c5f>:9: FutureWarning: Dropping of nuisanc
e columns in DataFrame reductions (with 'numeric_only=None') is depr
ecated; in a future version this will raise TypeError.  Select only
valid columns before calling the reduction.
  std_test_set = test_set.std()
```

In [ ]:
```
# finding Euclidean Distance
def euclideanDistance(data_1, data_2, data_len):
    dist = 0
    for i in range(data_len):
        dist = dist + np.square(data_1[i] - data_2[i])
    return np.sqrt(dist)

# Formula for Normalized Euclidean Distance
# d(p, q) = sqrt(sum(((pi - mu_i) / sigma_i - (qi - mu_i) / sigma_i) *
* 2))
# pi and qi are features of data_1 and data_2 and mu is mean and sigma
_i is standard deviation
def normalizedEuclideanDistance(data_1, data_2, data_len, data_mean, d
ata_std):
    n_dist = 0
    for i in range(data_len):
        n_dist = n_dist + (np.square(((data_1[i] - data_mean[i])/data_
```

```
std[i]) - ((data_2[i] - data_mean[i])/data_std[i])))
    return np.sqrt(n_dist)


def cosineSimilarity(data_1, data_2):
# computes the dot product of data_1 and data_2 without considering th
e last element of data_2.
    dot = np.dot(data_1, data_2[:-1])
    norm_data_1 = np.linalg.norm(data_1)
    norm_data_2 = np.linalg.norm(data_2[:-1])

# It computes the cosine similarity between data_1 and data_2, dividin
g dot by the product of the two Euclidean norms.
    cos = dot / (norm_data_1 * norm_data_2)
    return (1-cos)

# This function calculates the distance between the test instance and
all instances
# Then it finds the k nearest neighbors and returns the class

# For K-nearest neighbours
def knn(dataset, testInstance, k, dist_method, dataset_mean, dataset_s
td):
    distances = {}

    length = testInstance.shape[1]
    if dist_method == 'euclidean':
        for x in range(len(dataset)):
            dist_up = euclideanDistance(testInstance, dataset.iloc[x],
length)
            distances[x] = dist_up[0]
    elif dist_method == 'normalized_euclidean':
        for x in range(len(dataset)):
            dist_up = normalizedEuclideanDistance(testInstance, datase
t.iloc[x], length, dataset_mean, dataset_std)
            distances[x] = dist_up[0]
    elif dist_method == 'cosine':
        for x in range(len(dataset)):
            dist_up = cosineSimilarity(testInstance, dataset.iloc[x])
            distances[x] = dist_up[0]

    # Sort values based on distance
    sort_distances = sorted(distances.items(), key=operator.itemgetter
(1))
    neighbors = []
    # Extracting nearest k neighbors
    for x in range(k):
        neighbors.append(sort_distances[x][0])
    # Initializing counts for 'class' labels counts as 0
    counts = {"Iris-setosa" : 0, "Iris-versicolor" : 0, "Iris-virginic
```

```
a" : 0}
    # Computing the most frequent class
    for x in range(len(neighbors)):
        response = dataset.iloc[neighbors[x]][-1]
        if response in counts:
            counts[response] += 1
        else:
            counts[response] = 1
    # Sorting the class in reverse order to get the most frequest clas
s
    sort_counts = sorted(counts.items(), key=operator.itemgetter(1), r
everse=True)
    return(sort_counts[0][0])
```

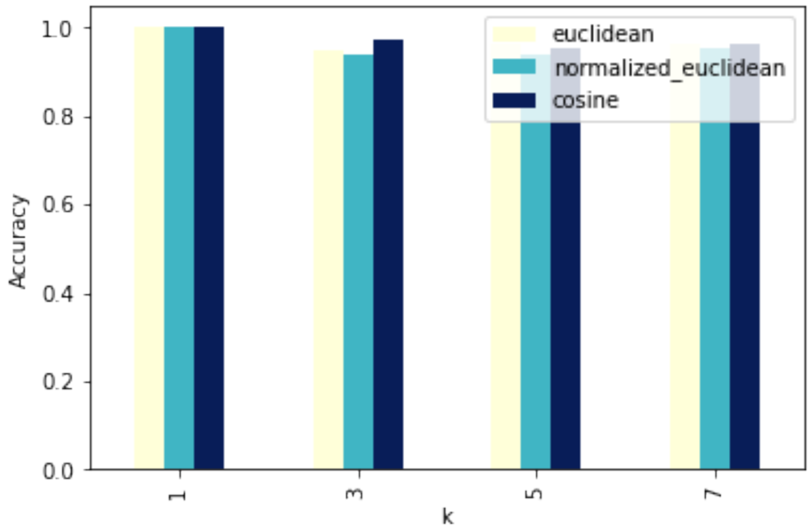
In [ ]:
```
# Now we implememt KNN algorithm on development set for various values
of K
# It iterates through each data point in the development set
# to determine its predicted class label based on the k nearest neighb
ors

row_list = []
for index, rows in development_set.iterrows():
    my_list =[rows.sepal_length, rows.sepal_width, rows.petal_length,
rows.petal_width]
    row_list.append([my_list])
# k values for the number of neighbors that need to be considered
k_n = [1, 3, 5, 7]
# Distance metrics
distance_methods = ['euclidean', 'normalized_euclidean', 'cosine']
# Performing kNN on the development set by iterating all of the develo
pment set data points and for each k and each distance metric
obs_k = {}
for dist_method in distance_methods:
    development_set_obs_k = {}
    for k in k_n:
        development_set_obs = []
        for i in range(len(row_list)):
          development_set_obs.append(knn(development_set, pd.DataFrame
(row_list[i]), k, dist_method, mean_development_set, std_development_s
et))
        development_set_obs_k[k] = development_set_obs
    # Nested Dictionary containing the observed class for each k and e
ach distance metric (obs_k of the form obs_k[dist_method][k])
    obs_k[dist_method] = development_set_obs_k
    print(dist_method.upper() + " distance method performed on the dat
aset for all k values!")
```

```
EUCLIDEAN distance method performed on the dataset for all k values!
NORMALIZED_EUCLIDEAN distance method performed on the dataset for al
l k values!
COSINE distance method performed on the dataset for all k values!
```

In [ ]:
```
accuracy = {}
for key in obs_k.keys():
    accuracy[key] = {}
    for k_value in obs_k[key].keys():
        #print('k = ', key)
        count = 0
        for i,j in zip(dev_class, obs_k[key][k_value]):
            if i == j:
                count = count + 1
            else:
                pass
        accuracy[key][k_value] = count/(len(dev_class))

# Storing the accuracy for each k and each distance metric into a data
frame
df_res = pd.DataFrame({'k': k_n})
for key in accuracy.keys():
    value = list(accuracy[key].values())
    df_res[key] = value
print(df_res)

# Plotting a Bar Chart for accuracy
draw = df_res.plot(x='k', y=['euclidean', 'normalized_euclidean', 'cos
ine'], kind="bar", colormap='YlGnBu')
draw.set(ylabel='Accuracy')

# Ignoring k=1 if the value of accuracy for k=1 is 100%, since this mo
stly implies overfitting
df_res.loc[df_res['k'] == 1.0, ['euclidean', 'normalized_euclidean', '
cosine']] = np.nan

# Fetching the best k value for using all hyper-parameters
# In case the accuracy is the same for different k and different dista
nce metric selecting the first of all the same
column_val = [c for c in df_res.columns if not c.startswith('k')]
col_max = df_res[column_val].max().idxmax()
best_dist_method = col_max
row_max = df_res[col_max].argmax()
best_k = int(df_res.iloc[row_max]['k'])
if df_res.isnull().values.any():
    print('\n\n\nBest k value is\033[1m', best_k, '\033[0mand best dis
tance metric is\033[1m', best_dist_method, '\033[0m. Ignoring k=1 if t
he value of accuracy for k=1 is 100%, since this mostly implies overfi
tting')
else:
    print('\n\n\nBest k value is\033[1m', best_k, '\033[0mand best dis
tance metric is\033[1m', best_dist_method, '\033[0m.')
```

	k	euclidean	normalized_euclidean	cosine
0	1	1.000000	1.000000	1.000000
1	3	0.946429	0.937500	0.973214
2	5	0.964286	0.937500	0.955357
3	7	0.964286	0.955357	0.964286

Best k value is **3** and best distance metric is **cosine** . Ignoring k=1 if the value of accuracy for k=1 is 100%, since this mostly implies overfitting



In [ ]:
```
print('\n\n\nBest k value is\033[1m', best_k, '\033[0mand best distance metric is\033[1m', best_dist_method, '\033[0m')
```

Best k value is **3** and best distance metric is **cosine**

In [ ]:
```
# Creating a list of list of all columns except 'class' by iterating t
hrough the development set
row_list_test = []
for index, rows in test_set.iterrows():
    my_list =[rows.sepal_length, rows.sepal_width, rows.petal_length,
rows.petal_width]
    row_list_test.append([my_list])
test_set_obs = []
for i in range(len(row_list_test)):
    test_set_obs.append(knn(test_set, pd.DataFrame(row_list_test[i]),
best_k, best_dist_method, mean_test_set, std_test_set))
#print(test_set_obs)

count = 0
for i,j in zip(test_class, test_set_obs):
    if i == j:
        count = count + 1
    else:
        pass
accuracy_test = count/(len(test_class))
print('Final Accuracy of the Test dataset is ', accuracy_test)
```

```
Final Accuracy of the Test dataset is  1.0
```

In [ ]:
```
! jupyter nbconvert --to html KNN+ConfusionMatrix+Iris_Data_set+Colab-
.ipynb
```

```
[NbConvertApp] WARNING | pattern 'KNN+ConfusionMatrix+Iris_Data_set+
Colab-.ipynb' matched no files
This application is used to convert notebook files (*.ipynb)
        to various other formats.

        WARNING: THE COMMANDLINE INTERFACE MAY CHANGE IN FUTURE RELE
ASES.

Options
=======
The options below are convenience aliases to configurable class-opti
ons,
as listed in the "Equivalent to" description-line of the aliases.
To see all configurable class-options for some <cmd>, use:
    <cmd> --help-all

--debug
    set log level to logging.DEBUG (maximize logging output)
    Equivalent to: [--Application.log_level=10]
--show-config
    Show the application's configuration (human-readable format)
    Equivalent to: [--Application.show_config=True]
```

```
--show-config-json
    Show the application's configuration (json format)
    Equivalent to: [--Application.show_config_json=True]
--generate-config
    generate default config file
    Equivalent to: [--JupyterApp.generate_config=True]
-y
    Answer yes to any questions instead of prompting.
    Equivalent to: [--JupyterApp.answer_yes=True]
--execute
    Execute the notebook prior to export.
    Equivalent to: [--ExecutePreprocessor.enabled=True]
--allow-errors
    Continue notebook execution even if one of the cells throws an e
rror and include the error message in the cell output (the default b
ehaviour is to abort conversion). This flag is only relevant if '--e
xecute' was specified, too.
    Equivalent to: [--ExecutePreprocessor.allow_errors=True]
--stdin
    read a single notebook file from stdin. Write the resulting note
book with default basename 'notebook.*'
    Equivalent to: [--NbConvertApp.from_stdin=True]
--stdout
    Write notebook output to stdout instead of files.
    Equivalent to: [--NbConvertApp.writer_class=StdoutWriter]
--inplace
    Run nbconvert in place, overwriting the existing notebook (only
            relevant when converting to notebook format)
    Equivalent to: [--NbConvertApp.use_output_suffix=False --NbConve
rtApp.export_format=notebook --FilesWriter.build_directory=]
--clear-output
    Clear output of current file and save in place,
            overwriting the existing notebook.
    Equivalent to: [--NbConvertApp.use_output_suffix=False --NbConve
rtApp.export_format=notebook --FilesWriter.build_directory= --ClearO
utputPreprocessor.enabled=True]
--no-prompt
    Exclude input and output prompts from converted document.
    Equivalent to: [--TemplateExporter.exclude_input_prompt=True --T
emplateExporter.exclude_output_prompt=True]
--no-input
    Exclude input cells and output prompts from converted document.
            This mode is ideal for generating code-free reports.
    Equivalent to: [--TemplateExporter.exclude_output_prompt=True --
TemplateExporter.exclude_input=True]
--log-level=<Enum>
    Set the log level by value or name.
    Choices: any of [0, 10, 20, 30, 40, 50, 'DEBUG', 'INFO', 'WARN',
'ERROR', 'CRITICAL']
    Default: 30
```

```
    Equivalent to: [--Application.log_level]
--config=<Unicode>
    Full path of a config file.
    Default: ''
    Equivalent to: [--JupyterApp.config_file]
--to=<Unicode>
    The export format to be used, either one of the built-in formats
            ['asciidoc', 'custom', 'html', 'latex', 'markdown', 'not
ebook', 'pdf', 'python', 'rst', 'script', 'slides']
            or a dotted object name that represents the import path
for an
            `Exporter` class
    Default: 'html'
    Equivalent to: [--NbConvertApp.export_format]
--template=<Unicode>
    Name of the template file to use
    Default: ''
    Equivalent to: [--TemplateExporter.template_file]
--writer=<DottedObjectName>
    Writer class used to write the
                                        results of the conversion
    Default: 'FilesWriter'
    Equivalent to: [--NbConvertApp.writer_class]
--post=<DottedOrNone>
    PostProcessor class used to write the
                                        results of the conversion
    Default: ''
    Equivalent to: [--NbConvertApp.postprocessor_class]
--output=<Unicode>
    overwrite base name use for output files.
                can only be used when converting one notebook at a t
ime.
    Default: ''
    Equivalent to: [--NbConvertApp.output_base]
--output-dir=<Unicode>
    Directory to write output(s) to. Defaults
                                  to output to the directory of each
notebook. To recover
                                  previous default behaviour (output
ting to the current
                                  working directory) use . as the fl
ag value.
    Default: ''
    Equivalent to: [--FilesWriter.build_directory]
--reveal-prefix=<Unicode>
    The URL prefix for reveal.js (version 3.x).
            This defaults to the reveal CDN, but can be any url poin
ting to a copy
            of reveal.js.
            For speaker notes to work, this must be a relative path
```

```
to a local
            copy of reveal.js: e.g., "reveal.js".
            If a relative path is given, it must be a subdirectory o
f the
            current directory (from which the server is run).
            See the usage documentation
            (https://nbconvert.readthedocs.io/en/latest/usage.html#r
eveal-js-html-slideshow)
            for more details.
    Default: ''
    Equivalent to: [--SlidesExporter.reveal_url_prefix]
--nbformat=<Enum>
    The nbformat version to write.
            Use this to downgrade notebooks.
    Choices: any of [1, 2, 3, 4]
    Default: 4
    Equivalent to: [--NotebookExporter.nbformat_version]

Examples
--------

    The simplest way to use nbconvert is

            > jupyter nbconvert mynotebook.ipynb

            which will convert mynotebook.ipynb to the default forma
t (probably HTML).

            You can specify the export format with `--to`.
            Options include ['asciidoc', 'custom', 'html', 'latex',
'markdown', 'notebook', 'pdf', 'python', 'rst', 'script', 'slides'].

            > jupyter nbconvert --to latex mynotebook.ipynb

            Both HTML and LaTeX support multiple output templates. L
aTeX includes
            'base', 'article' and 'report'.  HTML includes 'basic' a
nd 'full'. You
            can specify the flavor of the format used.

            > jupyter nbconvert --to html --template basic mynoteboo
k.ipynb

            You can also pipe the output to stdout, rather than a fi
le

            > jupyter nbconvert mynotebook.ipynb --stdout

            PDF is generated via latex
```

```
            > jupyter nbconvert mynotebook.ipynb --to pdf

            You can get (and serve) a Reveal.js-powered slideshow

            > jupyter nbconvert myslides.ipynb --to slides --post se
rve

            Multiple notebooks can be given at the command line in a
couple of
            different ways:

            > jupyter nbconvert notebook*.ipynb
            > jupyter nbconvert notebook1.ipynb notebook2.ipynb

            or you can specify the notebooks list in a config file,
containing::

                c.NbConvertApp.notebooks = ["my_notebook.ipynb"]

            > jupyter nbconvert --config mycfg.py

To see all available configurables, use `--help-all`.
```