

UNIVERSITY OF MUMBAI



DEPARTMENT OF COMPUTER SCIENCE

M.SC (Computer Science)

CERTIFICATE

Certified that the work entered in this journal was
done in the computer laboratory by the student

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First Year Sem 2

Semester during the year **2021-2022** in a Satisfactory
manner.

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Practical 1

AIM :- Implement Linear Regression (Diabetes Dataset)

THEORY : -

Logistic regression is a classification model in machine learning, extensively used in clinical analysis. It uses probabilistic estimations which helps in understanding the relationship between the dependent variable and one or more independent variables. Diabetes, being one of the most common diseases around the world, when detected early, may prevent the progression of the disease and avoid other complications. In this work, we design a prediction model, that predicts whether a patient has diabetes, based on certain diagnostic measurements included in the dataset, and explore various techniques to boost the performance and accuracy.

CODE / OUTPUT : -

```
# Import Dependencies

import numpy as np

import matplotlib.pyplot as plt

from sklearn import datasets, linear_model, metrics

from sklearn.model_selection import train_test_split

from sklearn.metrics import mean_squared_error, r2_score

import seaborn as sns


# Load the diabetes dataset

diabetes=datasets.load_diabetes()


# X - feature vectors

# y - Target values

X=diabetes.data

y=diabetes.target


# splitting X and y into training and testing sets

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.4,
```

```
random_state=1)
```

```
# Create linear regression object
```

```
lin_reg=linear_model.LinearRegression()
```

```
# Train the model using train and test data
```

```
lin_reg.fit(X_train,y_train)
```

```
Out[6]: LinearRegression()
```

```
# Predict values for X_test data
```

```
predicted = lin_reg.predict(X_test)
```

```
# Regression coefficients
```

```
print('\n Coefficients are:\n',lin_reg.coef_)
```

```
# Intercept
```

```
print('\nIntercept : ',lin_reg.intercept_)
```

```
# variance score: 1 means perfect prediction
```

```
print('Variance score: ',lin_reg.score(X_test, y_test))
```

```
Coefficients are:  
[ -59.73663337 -215.62170919  599.92621335  291.96724002 -829.65206295  
 544.63994617  164.85191153  224.2392528   768.94426062   70.84982207]  
  
Intercept : 152.89009028286725  
Variance score: 0.4160439011127657
```

```
# Mean Squared Error
```

```
print("Mean squared error: %.2f\n"
```

```
      % mean_squared_error(y_test, predicted))
```

```
# Original data of X_test
```

```
expected = y_test
```

```
Mean squared error: 2962.93
```

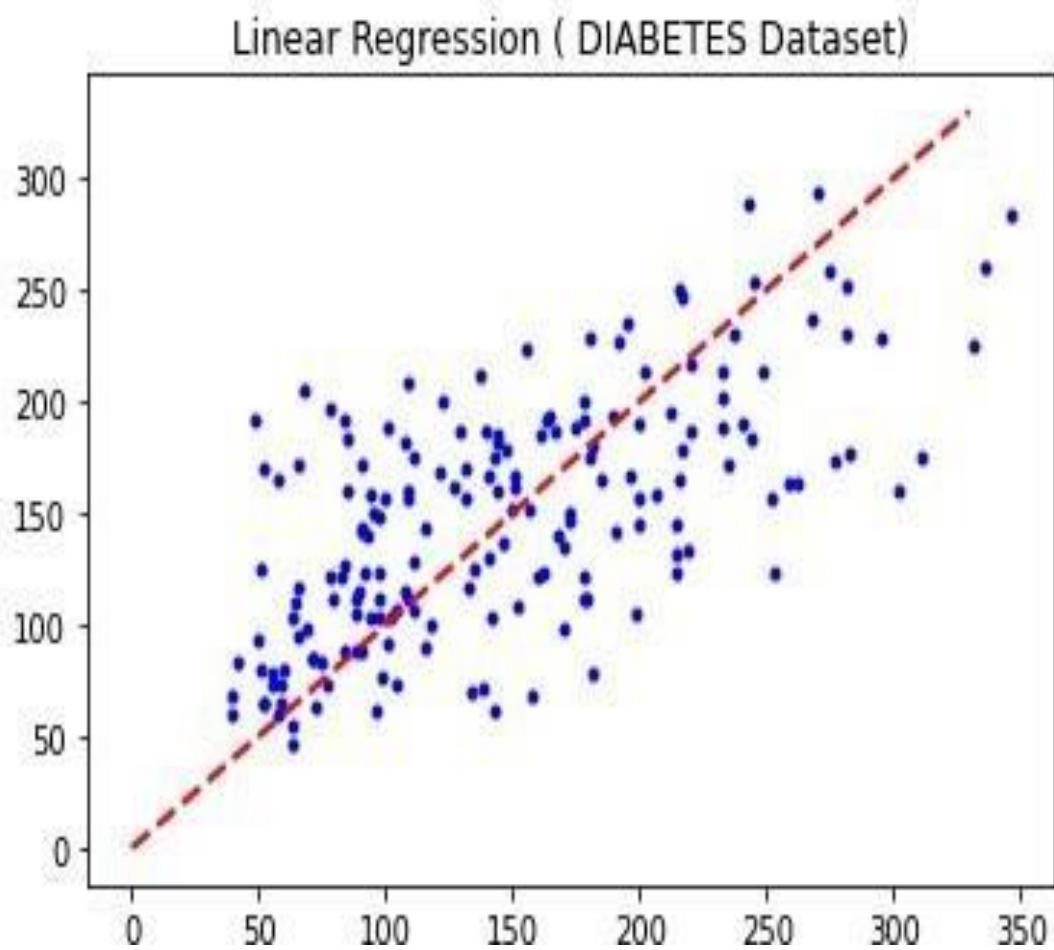
Plot a graph for expected and predicted values

```
plt.title('Linear Regression ( DIABETES Dataset)')
```

```
plt.scatter(expected,predicted,c='b',marker='.',s=36)
```

```
plt.plot(np.linspace(0, 330, 100),np.linspace(0, 330, 100), '--r', linewidth=2)
```

```
plt.show()
```



Practical 2

AIM :- Implement Logistic Regression (Iris Dataset)

THEORY: -

Logistic regression is a model that uses a logistic function to model a dependent variable. Like all regression analyses, the logistic regression is a predictive analysis. Logistic regression is used to describe data and to explain the relationship between one dependent variable and one or more nominal, ordinal, interval or ratio-level independent variables. It classifies an iris species as either (virginica, setosa, or versicolor) based off of the pedal length, pedal height, sepal length, and sepal height using a machine learning algorithm called Logistic Regression.

CODE / OUTPUT : -

```
import numpy as np

import matplotlib.pyplot as plt

from sklearn.linear_model import LogisticRegression
from sklearn import datasets

# import some data to play with
iris = datasets.load_iris()

X = iris.data[:, :2] # we only take the first two features.
Y = iris.target

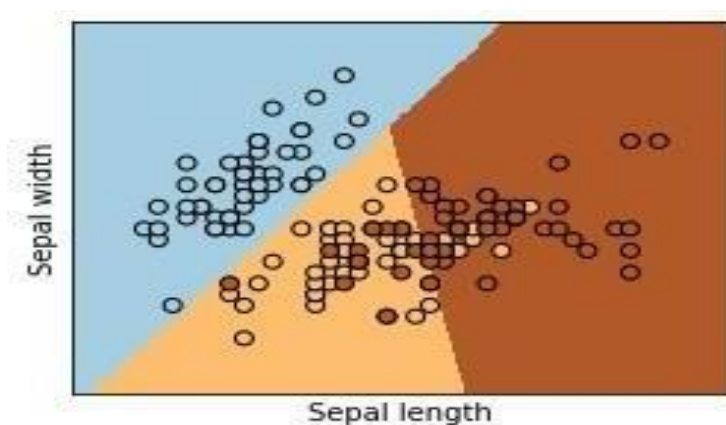
# Create an instance of Logistic Regression Classifier and fit the data.
logreg = LogisticRegression(C=1e5)
logreg.fit(X, Y)
```

```
Out[3]: LogisticRegression(C=100000.0)
```

```
# Plot the decision boundary. For that, we will assign a color to each
# point in the mesh [x_min, x_max][y_min, y_max].
x_min, x_max = X[:, 0].min() - 0.5, X[:, 0].max() + 0.5
y_min, y_max = X[:, 1].min() - 0.5, X[:, 1].max() + 0.5
h = 0.02 # step size in the mesh
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))
Z = logreg.predict(np.c_[xx.ravel(), yy.ravel()])

# Put the result into a color plot
Z = Z.reshape(xx.shape)
plt.figure(1, figsize=(4, 3))
plt.pcolormesh(xx, yy, Z, cmap=plt.cm.Paired)

# Plot also the training points
plt.scatter(X[:, 0], X[:, 1], c=Y, edgecolors="k", cmap=plt.cm.Paired)
plt.xlabel("Sepal length")
plt.ylabel("Sepal width")
plt.xlim(xx.min(), xx.max())
plt.ylim(yy.min(), yy.max())
plt.xticks(())
plt.yticks(())
plt.show()
```



Practical 3

AIM :- Implement Multinomial Logistic Regression (Iris Dataset)

THEORY :-

Multinomial logistic regression is a classification method that generalizes logistic regression to multiclass problems, i.e. with more than two possible discrete outcomes. That is, it is a model that is used to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables (which may be real-valued, binary-valued, categorical-valued, etc.).

CODE / OUTPUT : -

```
#Loading the libraries and the data

import numpy as np
import pandas as pd

from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn import preprocessing
from sklearn.metrics import accuracy_score
from sklearn.model_selection import cross_val_score
from sklearn.metrics import confusion_matrix

import matplotlib as mpl
import matplotlib.pyplot as plt
import statsmodels.api as sm

#for readable figures
pd.set_option('float_format', '{:f}'.format)

iris = pd.read_csv("./Iris_Data.csv")
iris.head()
```



```
Out[1]:
```

	sepal_length	sepal_width	petal_length	petal_width	species
0	5.100000	3.500000	1.400000	0.200000	Iris-setosa
1	4.900000	3.000000	1.400000	0.200000	Iris-setosa
2	4.700000	3.200000	1.300000	0.200000	Iris-setosa
3	4.600000	3.100000	1.500000	0.200000	Iris-setosa
4	5.000000	3.600000	1.400000	0.200000	Iris-setosa

```
x = iris.drop('species', axis=1)
```

```
y = iris['species']
```

```
trainX, testX, trainY, testY = train_test_split(x, y, test_size = 0.2)
```

```
#Fit the model
```

```
log_reg = LogisticRegression(solver='newton-cg', multi_class='multinomial')
```

```
log_reg.fit(trainX, trainY)
```

```
y_pred = log_reg.predict(testX)
```

```
# Model validation
```

```
# print the accuracy and error rate:
```

```
print('Accuracy: {:.2f}'.format(accuracy_score(testY, y_pred)))
```

```
print('Error rate: {:.2f}'.format(1 - accuracy_score(testY, y_pred)))
```

```
Accuracy: 1.00  
Error rate: 0.00
```

```
# look at the scores from cross validation:
```

```
clf = LogisticRegression(solver='newton-cg', multi_class='multinomial')
```

```
scores = cross_val_score(clf, trainX, trainY, cv=5)
```

```
scores
```

```
Out[5]: array([0.91666667, 1.          , 0.95833333, 0.91666667, 0.875      ])
```

```
print("Accuracy: %0.2f (+/- %0.2f)" % (scores.mean(), scores.std() * 2))
```

```
Accuracy: 0.93 (+/- 0.08)
```

#Look at the confusion matrix:

```
confusion_matrix = confusion_matrix(testY, y_pred)
```

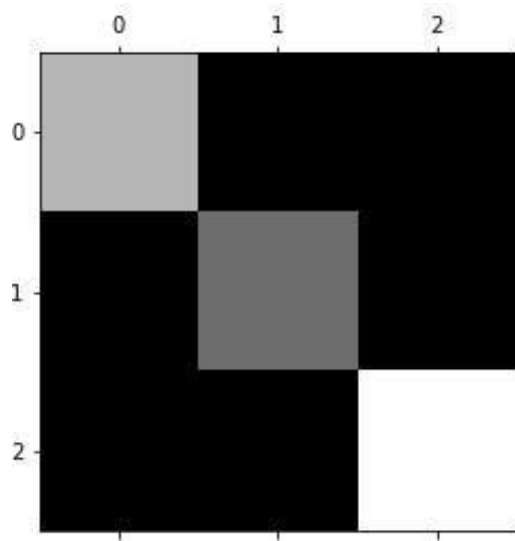
```
print(confusion_matrix)
```

```
[[10  0  0]
 [ 0  6  0]
 [ 0  0 14]]
```

If you have many variables, it makes sense to plot the confusion matrix:

```
plt.matshow(confusion_matrix, cmap=plt.cm.gray)
```

```
plt.show()
```



#Calculated probabilities

#get the probabilities of the predicted classes

probability = log_reg.predict_proba(testX)

probability

```
Out[9]: array([[9.77177267e-01, 2.28226180e-02, 1.15291342e-07],
 [3.15508406e-04, 3.08742123e-01, 6.90942369e-01],
 [4.05833517e-06, 2.02355204e-02, 9.79760421e-01],
 [9.65833217e-01, 3.41664723e-02, 3.11152866e-07],
 [7.62413496e-03, 8.48073124e-01, 1.44302741e-01],
 [6.28488743e-05, 1.26754242e-01, 8.73182909e-01],
 [1.45813299e-06, 2.85751813e-02, 9.71423361e-01],
 [9.85612953e-01, 1.43870021e-02, 4.50510430e-08],
 [9.58087024e-05, 2.37604349e-01, 7.62299843e-01],
 [1.48077079e-07, 9.67116139e-03, 9.90328691e-01],
 [7.36532150e-04, 4.38827401e-01, 5.60436066e-01],
 [9.83925007e-01, 1.60749399e-02, 5.31322483e-08],
 [6.16083666e-04, 2.60226818e-01, 7.39157098e-01],
 [4.96184418e-06, 4.20074265e-02, 9.57987612e-01],
 [8.94595259e-08, 1.03011426e-02, 9.89698768e-01],
 [2.85615469e-02, 9.14889387e-01, 5.65490659e-02],
 [1.96617408e-05, 2.40582944e-02, 9.75922044e-01],
 [9.86409941e-01, 1.35900230e-02, 3.60773562e-08],
 [9.38044534e-01, 6.19551257e-02, 3.40320864e-07],
 [9.86999674e-01, 1.30002738e-02, 5.20347448e-08],
 [2.18962552e-05, 5.42286793e-02, 9.45749424e-01],
 [9.70345579e-01, 2.96543110e-02, 1.09581545e-07],
 [1.07061610e-02, 7.63582236e-01, 2.25711603e-01],
 [5.96119296e-03, 8.04958103e-01, 1.89080704e-01],
 [1.98090631e-04, 1.94208015e-01, 8.05593894e-01],
 [9.82592389e-01, 1.74075552e-02, 5.59265185e-08],
 [9.43324589e-01, 5.66750800e-02, 3.31517288e-07],
 [1.74083427e-02, 9.50815074e-01, 3.17765834e-02],
 [1.53811428e-02, 9.09184838e-01, 7.54340190e-02],
 [7.13182512e-06, 1.86770785e-02, 9.81315790e-01]])
```

#Each column here represents a class. The class with the highest probability is the output of the predicted class. Here we can see that the length of the probability data is the same as the length of the test data.

```
print(probability.shape[0])
```

```
print(testX.shape[0])
```

```
30
30
```

#Output into shape and a readable format

```
df = pd.DataFrame(log_reg.predict_proba(testX), columns=log_reg.classes_)
```

```
df.head()
```

#with the .classes_ function we get the order of the classes that Python gave.

```
Out[11]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica
0	0.977177	0.022823	0.000000
1	0.000316	0.308742	0.690942
2	0.000004	0.020236	0.979760
3	0.965833	0.034166	0.000000
4	0.007624	0.848073	0.144303

#sum of the probabilities must always be 1

```
df['sum'] = df.sum(axis=1)
```

```
df.head()
```

```
Out[12]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum
0	0.977177	0.022823	0.000000	1.000000
1	0.000316	0.308742	0.690942	1.000000
2	0.000004	0.020236	0.979760	1.000000
3	0.965833	0.034166	0.000000	1.000000
4	0.007624	0.848073	0.144303	1.000000

add the predicted classes...

```
df['predicted_class'] = y_pred
```

```
df.head()
```

```
Out[13]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class
0	0.977177	0.022823	0.000000	1.000000	Iris-setosa
1	0.000316	0.308742	0.690942	1.000000	Iris-virginica
2	0.000004	0.020236	0.979760	1.000000	Iris-virginica
3	0.965833	0.034166	0.000000	1.000000	Iris-setosa
4	0.007624	0.848073	0.144303	1.000000	Iris-versicolor

#Actual classes:

```
df['actual_class'] = testY.to_frame().reset_index().drop(columns='index')
```

```
df.head()
```

```
Out[14]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class	actual_class
0	0.977177	0.022823	0.000000	1.000000	Iris-setosa	Iris-setosa
1	0.000316	0.308742	0.690942	1.000000	Iris-virginica	Iris-virginica
2	0.000004	0.020236	0.979760	1.000000	Iris-virginica	Iris-virginica
3	0.965833	0.034166	0.000000	1.000000	Iris-setosa	Iris-setosa
4	0.007624	0.848073	0.144303	1.000000	Iris-versicolor	Iris-versicolor

#Do a plausibility check whether the classes were predicted correctly.

```
le = preprocessing.LabelEncoder()
```

```
df['label_pred'] = le.fit_transform(df['predicted_class'])
```

```
df['label_actual'] = le.fit_transform(df['actual_class'])
```

```
df.head()
```

```
Out[15]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class	actual_class	label_pred	label_actual
0	0.977177	0.022823	0.000000	1.000000	Iris-setosa	Iris-setosa	0	0
1	0.000316	0.308742	0.690942	1.000000	Iris-virginica	Iris-virginica	2	2
2	0.000004	0.020236	0.979760	1.000000	Iris-virginica	Iris-virginica	2	2
3	0.965833	0.034166	0.000000	1.000000	Iris-setosa	Iris-setosa	0	0
4	0.007624	0.848073	0.144303	1.000000	Iris-versicolor	Iris-versicolor	1	1

#See that the two variables (predicted_class & actual_class) were coded the same and can therefore be continued properly.

```
targets = df['predicted_class']
```

```
integerEncoded = le.fit_transform(targets)
```

```
integerMapping=dict(zip(targets,integerEncoded))
```

```
integerMapping
```

```
Out[17]: {'Iris-setosa': 0, 'Iris-virginica': 2, 'Iris-versicolor': 1}
```

```
targets = df['actual_class']
```

```
integerEncoded = le.fit_transform(targets)
```

```
integerMapping=dict(zip(targets,integerEncoded))
```

```
integerMapping
```

```
Out[18]: {'Iris-setosa': 0, 'Iris-virginica': 2, 'Iris-versicolor': 1}
```

Plausibility check whether the classes were predicted correctly. If the result of subtraction is 0, it was a correct estimate of the model.

```
df['check'] = df['label_actual'] - df['label_pred']
```

```
df.head(7)
```

```
Out[20]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class	actual_class	label_pred	label_actual	check
0	0.977177	0.022823	0.000000	1.000000	Iris-setosa	Iris-setosa	0	0	0
1	0.000316	0.308742	0.690942	1.000000	Iris-virginica	Iris-virginica	2	2	0
2	0.000004	0.020236	0.979760	1.000000	Iris-virginica	Iris-virginica	2	2	0
3	0.965833	0.034166	0.000000	1.000000	Iris-setosa	Iris-setosa	0	0	0
4	0.007624	0.848073	0.144303	1.000000	Iris-versicolor	Iris-versicolor	1	1	0
5	0.000063	0.126754	0.873183	1.000000	Iris-virginica	Iris-virginica	2	2	0
6	0.000001	0.028575	0.971423	1.000000	Iris-virginica	Iris-virginica	2	2	0

#For better orientation, we give the observations descriptive names and delete unnecessary columns.

```
df['correct_prediction?'] = np.where(df['check'] == 0, 'True', 'False')
```

```
df = df.drop(['label_pred', 'label_actual', 'check'], axis=1)
```

```
df.head()
```

```
Out[21]:
```

	Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class	actual_class	correct_prediction?
0	0.977177	0.022823	0.000000	1.000000	Iris-setosa	Iris-setosa	True
1	0.000316	0.308742	0.690942	1.000000	Iris-virginica	Iris-virginica	True
2	0.000004	0.020236	0.979760	1.000000	Iris-virginica	Iris-virginica	True
3	0.965833	0.034166	0.000000	1.000000	Iris-setosa	Iris-setosa	True
4	0.007624	0.848073	0.144303	1.000000	Iris-versicolor	Iris-versicolor	True

#Use the generated "values" to manually calculate the accuracy again.

```
true_predictions = df[(df["correct_prediction?"] == 'True')].shape[0]
false_predictions = df[(df["correct_prediction?"] == 'False')].shape[0]
total = df["correct_prediction?"].shape[0]
print('manual calculated Accuracy is:', (true_predictions / total * 100))
```

```
manual calculated Accuracy is: 100.0
```

#take finally a look at the probabilities of the mispredicted classes

```
wrong_pred = df[(df["correct_prediction?"] == 'False')]
wrong_pred
```

```
Out[23]:
```

Iris-setosa	Iris-versicolor	Iris-virginica	sum	predicted_class	actual_class	correct_prediction?
-------------	-----------------	----------------	-----	-----------------	--------------	---------------------

#Multinomial Logit with the statsmodel library

#To get the p-values of the model created above we have to use the statsmodel library again.

```
x = iris.drop('species', axis=1)
y = iris['species']
x = sm.add_constant(x, prepend = False)
mnlogit_mod = sm.MNLogit(y, x)
mnlogit_fit = mnlogit_mod.fit()
print (mnlogit_fit.summary())
```

Warning: Maximum number of iterations has been exceeded.

Current function value: 0.039662

Iterations: 35

MNLogit Regression Results

```
=====
Dep. Variable:      species  No. Observations:      150
Model:              MNLogit  Df Residuals:          140
Method:             MLE     Df Model:              8
Date:              Fri, 13 May 2022  Pseudo R-squ.:      0.9639
Time:              20:17:46   Log-Likelihood:    -5.9493
converged:          False    LL-Null:          -164.79
Covariance Type:    nonrobust  LLR p-value:      7.055e-64
=====

species=Iris-versicolor   coef   std err      z    P>|z|    [0.025    0.975]
-----
sepal_length             -0.4880  2.54e+04  -1.92e-05  1.000   -4.98e+04  4.98e+04
sepal_width              -13.9801  4.06e+04  -0.000     1.000   -7.96e+04  7.96e+04
petal_length             14.4645  1.61e+04   0.001     0.999   -3.16e+04  3.16e+04
petal_width              11.0469  2.62e+04   0.000     1.000   -5.14e+04  5.14e+04
const                    -4.3766  6.94e+04  -6.31e-05  1.000   -1.36e+05  1.36e+05
=====

species=Iris-virginica   coef   std err      z    P>|z|    [0.025    0.975]
-----
sepal_length             -2.9532  2.54e+04  -0.000     1.000   -4.98e+04  4.98e+04
sepal_width              -20.6610  4.06e+04  -0.001     1.000   -7.96e+04  7.96e+04
petal_length             23.8939  1.61e+04   0.001     0.999   -3.16e+04  3.16e+04
petal_width              29.3330  2.62e+04   0.001     0.999   -5.14e+04  5.14e+04
const                    -47.0144  6.94e+04  -0.001     0.999   -1.36e+05  1.36e+05
=====
```

```
c:\users\harsh\appdata\local\programs\python\python38\lib\site-packages\statsmodels\base\model.py:604: ConvergenceWarning: Maximum Likelihood optimization failed to converge. Check mle_retvals
warnings.warn("Maximum Likelihood optimization failed to "
```


Practical 4

AIM :- Implement SVM Classifier (Iris Dataset)

THEORY :-

Support Vector Machine(SVM) is a supervised machine learning algorithm used for both classification and regression. Though we say regression problems as well its best suited for classification. The objective of SVM algorithm is to find a hyperplane in an N-dimensional space that distinctly classifies the data points. The dimension of the hyperplane depends upon the number of features. If the number of input features is two, then the hyperplane is just a line. If the number of input features is three, then the hyperplane becomes a 2-D plane. It becomes difficult to imagine when the number of features exceeds three.

CODE / OUTPUT : -

```
import numpy as np
import matplotlib.pyplot as plt
from sklearn import svm, datasets

def make_meshgrid(x, y, h=0.02):
    """Create a mesh of points to plot in

    Parameters
    -----
    x: data to base x-axis meshgrid on
    y: data to base y-axis meshgrid on
    h: stepsize for meshgrid, optional

    Returns
    -----
    xx, yy : ndarray
    """
    x_min, x_max = x.min() - 1, x.max() + 1
```

```
y_min, y_max = y.min() - 1, y.max() + 1  
xx, yy = np.meshgrid(np.arange(x_min, x_max, h), np.arange(y_min, y_max, h))  
return xx, yy
```

```
def plot_contours(ax, clf, xx, yy, **params):  
    """Plot the decision boundaries for a classifier.
```

Parameters

ax: matplotlib axes object

clf: a classifier

xx: meshgrid ndarray

yy: meshgrid ndarray

params: dictionary of params to pass to contourf, optional

"""

```
Z = clf.predict(np.c_[xx.ravel(), yy.ravel()])  
Z = Z.reshape(xx.shape)  
out = ax.contourf(xx, yy, Z, **params)  
return out
```

```
# import some data to play with
```

```
iris = datasets.load_iris()
```

```
# Take the first two features. We could avoid this by using a two-dim dataset
```

```
X = iris.data[:, :2]
```

```
y = iris.target
```

```
# we create an instance of SVM and fit out data. We do not scale our
```

```
# data since we want to plot the support vectors
```

```
C = 1.0 # SVM regularization parameter
```

```
models = (
```

```
    svm.SVC(kernel="linear", C=C),
```

```
    svm.LinearSVC(C=C, max_iter=10000),
```

```
    svm.SVC(kernel="rbf", gamma=0.7, C=C),
```

```
    svm.SVC(kernel="poly", degree=3, gamma="auto", C=C),
```

```
)
```

```
models = (clf.fit(X, y) for clf in models)
```

```
# title for the plots
```

```
titles = (
```

```
    "SVC with linear kernel",
```

```
    "LinearSVC (linear kernel)",
```

```
    "SVC with RBF kernel",
```

```
    "SVC with polynomial (degree 3) kernel",
```

```
)
```

```
# Set-up 2x2 grid for plotting.
```

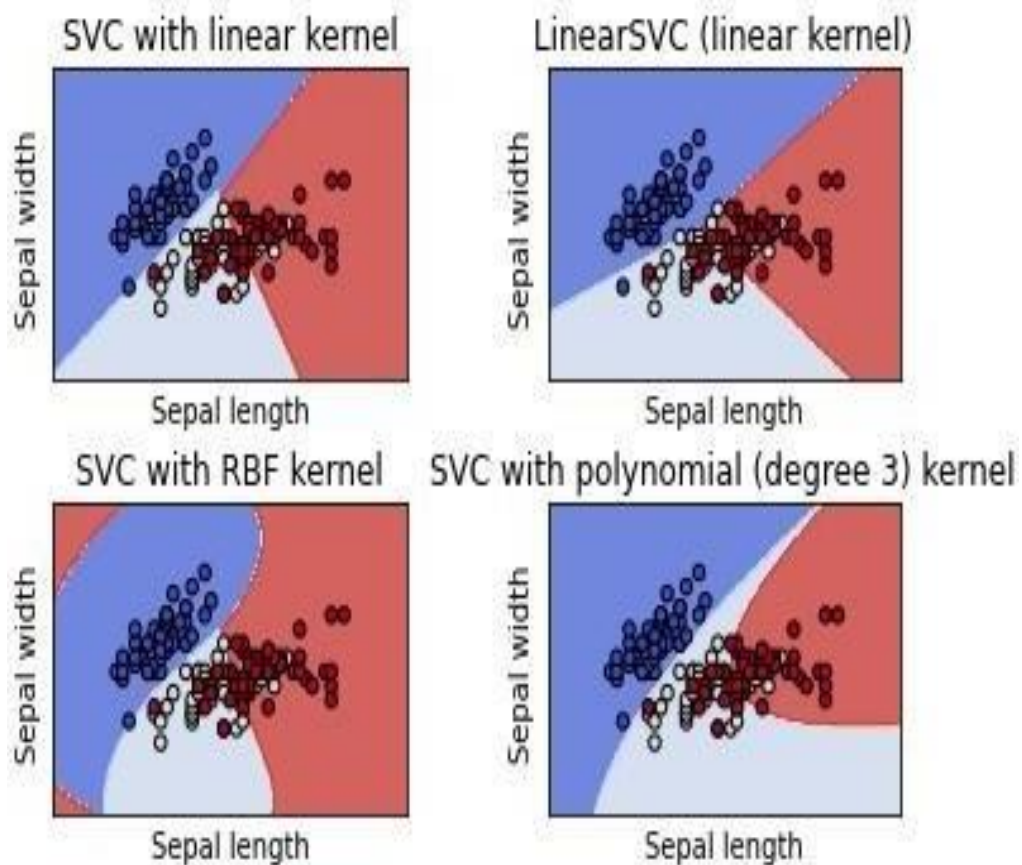
```
fig, sub = plt.subplots(2, 2)
```

```
plt.subplots_adjust(wspace=0.4, hspace=0.4)
```

```
X0, X1 = X[:, 0], X[:, 1]
```

```
xx, yy = make_meshgrid(X0, X1)
```

```
for clf, title, ax in zip(models, titles, sub.flatten()):  
    plot_contours(ax, clf, xx, yy, cmap=plt.cm.coolwarm, alpha=0.8)  
    ax.scatter(X0, X1, c=y, cmap=plt.cm.coolwarm, s=20, edgecolors="k")  
    ax.set_xlim(xx.min(), xx.max())  
    ax.set_ylim(yy.min(), yy.max())  
    ax.set_xlabel("Sepal length")  
    ax.set_ylabel("Sepal width")  
    ax.set_xticks()  
    ax.set_yticks()  
    ax.set_title(title)  
plt.show()
```



Practical 5

AIM :- Train and fine-tune a Decision Tree for the Moons Dataset

THEORY : -

A Decision tree is a flowchart-like structure in which each internal node represents a test on a feature (e.g. whether a coin flip comes up heads or tails) , each leaf node represents a class label (decision taken after computing all features) and branches represent conjunctions of features that lead to those class

Libraries : numpy is used for scientific computing with Python. It is one of the fundamental packages you will use. Matplotlib library is used in Python for plotting graphs. The datasets package is the place from where you will import the make moons dataset. Sklearn library is used for scientific computing. It has many features related to classification, regression and clustering algorithms including support vector machines.

CODE / OUTPUT : -

```
# GridSearchCV to fine-tune a Decision Tree Classifier
```

```
import numpy as np
```

```
import matplotlib.pyplot as plt
```

```
#Visualization
```

```
# This function will help in visualization of our dataset.
```

```
def plot_dataset(X, y, axes):
```

```
    plt.figure(figsize=(10,6))
```

```
    plt.plot(X[:, 0][y==0], X[:, 1][y==0], "bs",alpha = 0.5)
```

```
    plt.plot(X[:, 0][y==1], X[:, 1][y==1], "g^",alpha = 0.2)
```

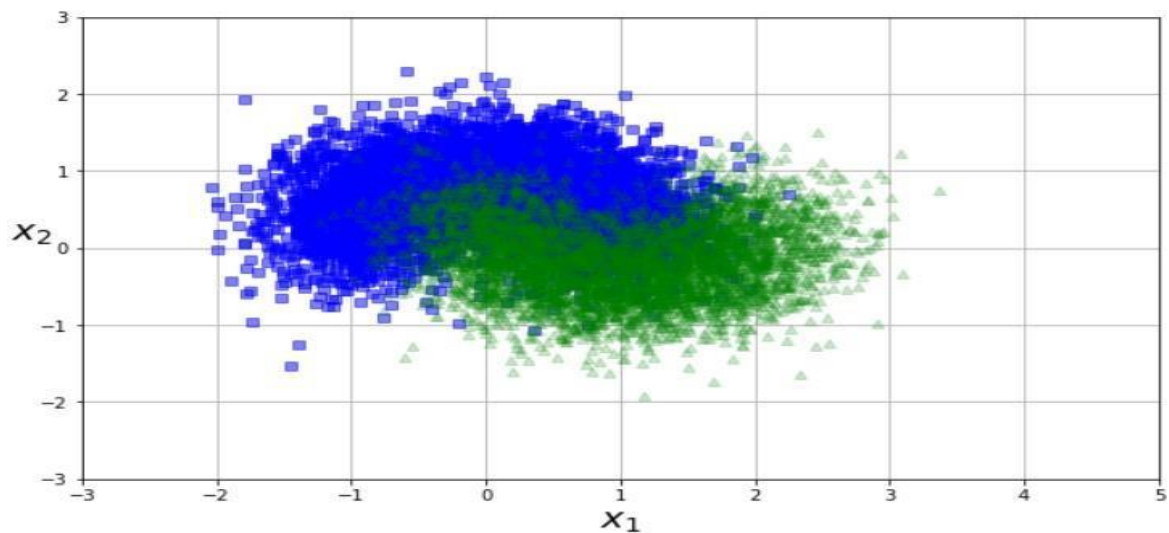
```
    plt.axis(axes)
```

```
    plt.grid(True, which='both')
```

```
    plt.xlabel(r"$x_1$", fontsize=20)
```

```
    plt.ylabel(r"$x_2$", fontsize=20, rotation=0)
```

```
from sklearn.datasets import make_moons
X, y = make_moons(n_samples=10000, noise=0.4, random_state=21)
plot_dataset(X, y, [-3, 5, -3, 3])
```



```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2)

from sklearn.tree import DecisionTreeClassifier
tree_clf = DecisionTreeClassifier()

from sklearn.model_selection import GridSearchCV
parameter = {
    'criterion': ["gini", "entropy"],
    'max_leaf_nodes': list(range(2, 50)),
    'min_samples_split': [2, 3, 4]
}

clf = GridSearchCV(tree_clf, parameter, cv = 5, scoring = "accuracy", return_train_score=True, n_jobs=-1)

clf.fit(X_train, y_train)
```

```
Out[9]: GridSearchCV(cv=5, estimator=DecisionTreeClassifier(), n_jobs=-1,
                    param_grid={'criterion': ['gini', 'entropy'],
                                'max_leaf_nodes': [2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
                                                    13, 14, 15, 16, 17, 18, 19, 20, 21,
                                                    22, 23, 24, 25, 26, 27, 28, 29, 30,
                                                    31, ...],
                                'min_samples_split': [2, 3, 4]},
                    return_train_score=True, scoring='accuracy')
```

Getting the best parameter:

clf.best_params_

```
Out[10]: {'criterion': 'entropy', 'max_leaf_nodes': 29, 'min_samples_split': 2}
```

#look at the training results:

cvres = clf.cv_results_

for mean_score, params in zip(cvres["mean_train_score"], cvres["params"]):

print(mean_score, params)

```
0.774 {'criterion': 'gini', 'max_leaf_nodes': 2, 'min_samples_split': 2}
0.774 {'criterion': 'gini', 'max_leaf_nodes': 2, 'min_samples_split': 3}
0.774 {'criterion': 'gini', 'max_leaf_nodes': 2, 'min_samples_split': 4}
0.821875 {'criterion': 'gini', 'max_leaf_nodes': 3, 'min_samples_split': 2}
0.821875 {'criterion': 'gini', 'max_leaf_nodes': 3, 'min_samples_split': 3}
0.821875 {'criterion': 'gini', 'max_leaf_nodes': 3, 'min_samples_split': 4}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 4, 'min_samples_split': 2}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 4, 'min_samples_split': 3}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 4, 'min_samples_split': 4}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 5, 'min_samples_split': 2}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 5, 'min_samples_split': 3}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 5, 'min_samples_split': 4}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 6, 'min_samples_split': 2}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 6, 'min_samples_split': 3}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 6, 'min_samples_split': 4}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 7, 'min_samples_split': 2}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 7, 'min_samples_split': 3}
0.8566874999999999 {'criterion': 'gini', 'max_leaf_nodes': 7, 'min_samples_split': 4}
0.85765625 {'criterion': 'gini', 'max_leaf_nodes': 8, 'min_samples_split': 2}
0.85765625 {'criterion': 'gini', 'max_leaf_nodes': 8, 'min_samples_split': 3}
0.85765625 {'criterion': 'gini', 'max_leaf_nodes': 8, 'min_samples_split': 4}
0.85778125 {'criterion': 'gini', 'max_leaf_nodes': 9, 'min_samples_split': 2}
0.85778125 {'criterion': 'gini', 'max_leaf_nodes': 9, 'min_samples_split': 3}
0.85778125 {'criterion': 'gini', 'max_leaf_nodes': 9, 'min_samples_split': 4}
0.8592187499999999 {'criterion': 'gini', 'max_leaf_nodes': 10, 'min_samples_split': 2}
0.8592187499999999 {'criterion': 'gini', 'max_leaf_nodes': 10, 'min_samples_split': 3}
0.8592187499999999 {'criterion': 'gini', 'max_leaf_nodes': 10, 'min_samples_split': 4}
0.86071875 {'criterion': 'gini', 'max_leaf_nodes': 11, 'min_samples_split': 2}
0.86071875 {'criterion': 'gini', 'max_leaf_nodes': 11, 'min_samples_split': 3}
0.86071875 {'criterion': 'gini', 'max_leaf_nodes': 11, 'min_samples_split': 4}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 12, 'min_samples_split': 2}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 12, 'min_samples_split': 3}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 12, 'min_samples_split': 4}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 13, 'min_samples_split': 2}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 13, 'min_samples_split': 3}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 13, 'min_samples_split': 4}
0.8615625 {'criterion': 'gini', 'max_leaf_nodes': 14, 'min_samples_split': 2}
```


[illegible]

[illegible]

[illegible]


```
0.8689375 {'criterion': 'entropy', 'max_leaf_nodes': 31, 'min_samples_split': 2}
0.8689375 {'criterion': 'entropy', 'max_leaf_nodes': 31, 'min_samples_split': 3}
0.8689375 {'criterion': 'entropy', 'max_leaf_nodes': 31, 'min_samples_split': 4}
0.869125 {'criterion': 'entropy', 'max_leaf_nodes': 32, 'min_samples_split': 2}
0.869125 {'criterion': 'entropy', 'max_leaf_nodes': 32, 'min_samples_split': 3}
0.869125 {'criterion': 'entropy', 'max_leaf_nodes': 32, 'min_samples_split': 4}
0.8692500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 33, 'min_samples_split': 2}
0.8692500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 33, 'min_samples_split': 3}
0.8692500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 33, 'min_samples_split': 4}
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0.86934375 {'criterion': 'entropy', 'max_leaf_nodes': 34, 'min_samples_split': 3}
0.86934375 {'criterion': 'entropy', 'max_leaf_nodes': 34, 'min_samples_split': 4}
0.8694375000000001 {'criterion': 'entropy', 'max_leaf_nodes': 35, 'min_samples_split': 2}
0.8694375000000001 {'criterion': 'entropy', 'max_leaf_nodes': 35, 'min_samples_split': 3}
0.8694375000000001 {'criterion': 'entropy', 'max_leaf_nodes': 35, 'min_samples_split': 4}
0.8699375 {'criterion': 'entropy', 'max_leaf_nodes': 36, 'min_samples_split': 2}
0.8699375 {'criterion': 'entropy', 'max_leaf_nodes': 36, 'min_samples_split': 3}
0.8699375 {'criterion': 'entropy', 'max_leaf_nodes': 36, 'min_samples_split': 4}
0.8701874999999999 {'criterion': 'entropy', 'max_leaf_nodes': 37, 'min_samples_split': 2}
0.8701874999999999 {'criterion': 'entropy', 'max_leaf_nodes': 37, 'min_samples_split': 3}
0.8701874999999999 {'criterion': 'entropy', 'max_leaf_nodes': 37, 'min_samples_split': 4}
0.87034375 {'criterion': 'entropy', 'max_leaf_nodes': 38, 'min_samples_split': 2}
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0.87034375 {'criterion': 'entropy', 'max_leaf_nodes': 38, 'min_samples_split': 4}
0.87053125 {'criterion': 'entropy', 'max_leaf_nodes': 39, 'min_samples_split': 2}
0.87053125 {'criterion': 'entropy', 'max_leaf_nodes': 39, 'min_samples_split': 3}
0.87053125 {'criterion': 'entropy', 'max_leaf_nodes': 39, 'min_samples_split': 4}
0.8706250000000001 {'criterion': 'entropy', 'max_leaf_nodes': 40, 'min_samples_split': 2}
0.8706250000000001 {'criterion': 'entropy', 'max_leaf_nodes': 40, 'min_samples_split': 3}
0.8706250000000001 {'criterion': 'entropy', 'max_leaf_nodes': 40, 'min_samples_split': 4}
0.87109375 {'criterion': 'entropy', 'max_leaf_nodes': 41, 'min_samples_split': 2}
0.87109375 {'criterion': 'entropy', 'max_leaf_nodes': 41, 'min_samples_split': 3}
0.87109375 {'criterion': 'entropy', 'max_leaf_nodes': 41, 'min_samples_split': 4}
0.87121875 {'criterion': 'entropy', 'max_leaf_nodes': 42, 'min_samples_split': 2}
```

```
0.87121875 {'criterion': 'entropy', 'max_leaf_nodes': 42, 'min_samples_split': 3}
0.87121875 {'criterion': 'entropy', 'max_leaf_nodes': 42, 'min_samples_split': 4}
0.8713437500000001 {'criterion': 'entropy', 'max_leaf_nodes': 43, 'min_samples_split': 2}
0.8713437500000001 {'criterion': 'entropy', 'max_leaf_nodes': 43, 'min_samples_split': 3}
0.8713437500000001 {'criterion': 'entropy', 'max_leaf_nodes': 43, 'min_samples_split': 4}
0.87165625 {'criterion': 'entropy', 'max_leaf_nodes': 44, 'min_samples_split': 2}
0.87165625 {'criterion': 'entropy', 'max_leaf_nodes': 44, 'min_samples_split': 3}
0.87165625 {'criterion': 'entropy', 'max_leaf_nodes': 44, 'min_samples_split': 4}
0.8717187500000001 {'criterion': 'entropy', 'max_leaf_nodes': 45, 'min_samples_split': 2}
0.8717187500000001 {'criterion': 'entropy', 'max_leaf_nodes': 45, 'min_samples_split': 3}
0.8717187500000001 {'criterion': 'entropy', 'max_leaf_nodes': 45, 'min_samples_split': 4}
0.8717500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 46, 'min_samples_split': 2}
0.8717500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 46, 'min_samples_split': 3}
0.8717500000000001 {'criterion': 'entropy', 'max_leaf_nodes': 46, 'min_samples_split': 4}
0.8719062500000001 {'criterion': 'entropy', 'max_leaf_nodes': 47, 'min_samples_split': 2}
0.8719062500000001 {'criterion': 'entropy', 'max_leaf_nodes': 47, 'min_samples_split': 3}
0.8719062500000001 {'criterion': 'entropy', 'max_leaf_nodes': 47, 'min_samples_split': 4}
0.87234375 {'criterion': 'entropy', 'max_leaf_nodes': 48, 'min_samples_split': 2}

0.87234375 {'criterion': 'entropy', 'max_leaf_nodes': 48, 'min_samples_split': 3}
0.87234375 {'criterion': 'entropy', 'max_leaf_nodes': 48, 'min_samples_split': 4}
0.87240625 {'criterion': 'entropy', 'max_leaf_nodes': 49, 'min_samples_split': 2}
0.87240625 {'criterion': 'entropy', 'max_leaf_nodes': 49, 'min_samples_split': 3}
0.87240625 {'criterion': 'entropy', 'max_leaf_nodes': 49, 'min_samples_split': 4}
```

#Getting the training score

```
clf.score(X_train, y_train)
```

```
Out[12]: 0.867
```

```
from sklearn.metrics import confusion_matrix
```

```
pred = clf.predict(X_train)
```

```
confusion_matrix(y_train, pred)
```

```
Out[13]: array([[3547, 469],
                [ 595, 3389]], dtype=int64)
```

#from the confusion matrix let's get our precision and recall, which are better metrics.

```
from sklearn.metrics import precision_score, recall_score
```

```
pre = precision_score(y_train, pred)
```

```
re = recall_score(y_train, pred)
```

```
print(f"Precision: {pre} Recall:{re}")
```

```
Precision: 0.8784344219803006 Recall:0.8506526104417671
```

#we have a higher precision than recall but lets combine the two metrics into F1 score.

```
from sklearn.metrics import f1_score
```

```
f1_score(y_train, pred)
```

```
Out[15]: 0.8643203264473348
```

#Getting the testing score

```
clf.score(X_test, y_test)
```

```
Out[16]: 0.8625
```


Practical 6

AIM :- Train an SVM regressor on the California Housing Dataset

THEORY : -

SVM regressor : Support Vector Regression is a supervised learning algorithm that is used to predict discrete values. Support Vector Regression uses the same principle as the SVMs. The basic idea behind SVR is to find the best fit line. In SVR, the best fit line is the hyperplane that has the maximum number of points

California Housing Dataset : The data contains information from the 1990 California census ,it does provide an accessible introductory dataset for teaching people about the basics of machine learning.

CODE / OUTPUT : -

```
# IMPORT LIBRARIES
```

```
import pandas as pd
```

```
import numpy as np
```

```
import matplotlib.pyplot as plt
```

```
import seaborn as sns
```

```
test=pd.read_csv("./california_housing_test.csv")
```

```
train=pd.read_csv("./california_housing_train.csv")
```

```
train.head()
```

Out[3]:

	longitude	latitude	housing_median_age	total_rooms	total_bedrooms	population	households	median_income	median_house_value
0	-122.00	37.55	27	6103	1249	3026	1134	4.1591	332400
1	-122.07	37.93	25	7201	1521	3264	1433	3.7433	252100
2	-118.02	33.90	34	2678	511	1540	497	4.4954	202900
3	-121.79	39.73	8	5690	1189	2887	1077	3.0625	116300
4	-120.90	39.93	23	2679	546	1424	529	2.8812	81900

test.tail()

Out[4]:

	Unnamed: 0	longitude	latitude	housing_median_age	total_rooms	total_bedrooms	population	households	median_income
3397	3398	-118.33	34.09	36	654	186	416	138	3.6953
3398	3399	-117.88	34.09	29	3416	790	2223	728	3.5109
3399	3400	-118.32	34.26	32	3690	791	1804	715	4.4875
3400	3401	-118.12	33.80	35	1835	435	774	418	2.7092
3401	3402	-118.19	33.78	42	1021	300	533	187	1.8036

print(train.info())

print(test.info())

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 13598 entries, 0 to 13597
Data columns (total 9 columns):
#   Column                Non-Null Count  Dtype
---  -
0   longitude              13598 non-null  float64
1   latitude               13598 non-null  float64
2   housing_median_age     13598 non-null  int64
3   total_rooms            13598 non-null  int64
4   total_bedrooms        13598 non-null  int64
5   population             13598 non-null  int64
6   households             13598 non-null  int64
7   median_income          13598 non-null  float64
8   median_house_value     13598 non-null  int64
dtypes: float64(3), int64(6)
memory usage: 956.2 KB
None
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3402 entries, 0 to 3401
Data columns (total 9 columns):
#   Column                Non-Null Count  Dtype
---  -
0   Unnamed: 0            3402 non-null  int64
1   longitude              3402 non-null  float64
2   latitude               3402 non-null  float64
3   housing_median_age     3402 non-null  int64
4   total_rooms            3402 non-null  int64
5   total_bedrooms        3402 non-null  int64
6   population             3402 non-null  int64
7   households             3402 non-null  int64
8   median_income          3402 non-null  float64
dtypes: float64(3), int64(6)
memory usage: 239.3 KB
None
```

n_train = train.shape[0]

n_test = test.shape[0]

y = train['median_house_value'].values

data = pd.concat((train, test)).reset_index(drop = True)

data.drop(['longitude','latitude'], axis=1, inplace = True)

#VISUALISING THE DATA

#Visualise the data

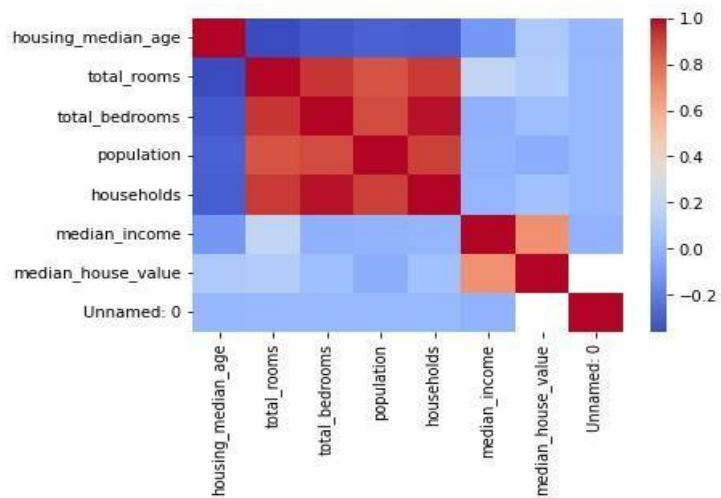
```
plt.figure()
```

```
sns.heatmap(data.corr(), cmap='coolwarm')
```

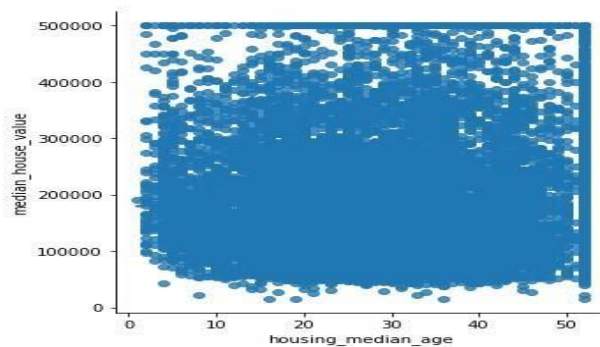
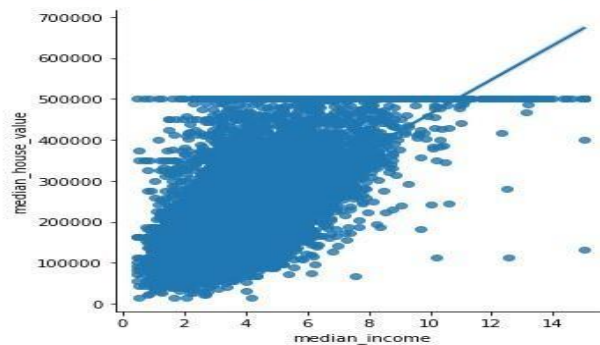
```
plt.show()
```

```
sns.lmplot(x='median_income', y='median_house_value', data=train)
```

```
sns.lmplot(x='housing_median_age', y='median_house_value', data=train)
```



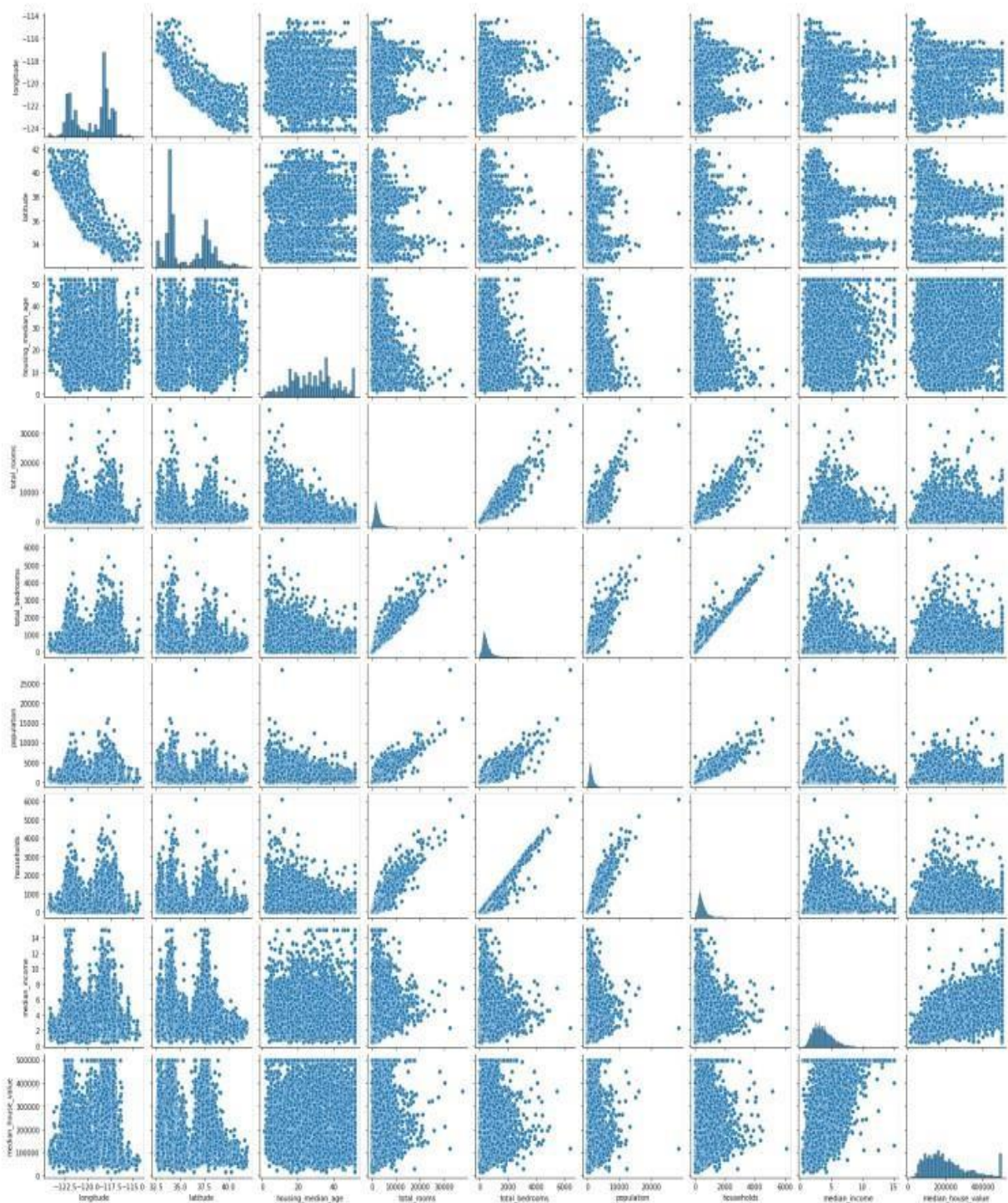
```
Out[7]: <seaborn.axisgrid.FacetGrid at 0x1cf0d13ea00>
```




```
sns.pairplot(train, palette='rainbow')
```

Out[8]:

<seaborn.axisgrid.PairGrid at 0x1cf0d38d430>



#FEATURE ENGINEERING

#Feature engineering is the process of using domain knowledge to extract features from raw data via data mining techniques.

#Select appropriate features

```
data = data[['total_rooms', 'total_bedrooms', 'housing_median_age', 'median_income', 'population', 'households']]
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 17000 entries, 0 to 16999
Data columns (total 6 columns):
#   Column                Non-Null Count  Dtype
---  ---
0   total_rooms            17000 non-null  int64
1   total_bedrooms         17000 non-null  int64
2   housing_median_age     17000 non-null  int64
3   median_income          17000 non-null  float64
4   population             17000 non-null  int64
5   households             17000 non-null  int64
dtypes: float64(1), int64(5)
memory usage: 797.0 KB
```

```
data['total_rooms'] = data['total_rooms'].fillna(data['total_rooms'].mean())
```

```
data['total_bedrooms'] = data['total_bedrooms'].fillna(data['total_bedrooms'].mean())
```

```
data['housing_median_age'] =
data['housing_median_age'].fillna(data['housing_median_age'].mean())
```

```
data['median_income'] = data['median_income'].fillna(data['median_income'].mean())
```

```
data['population'] = data['population'].fillna(data['population'].mean())
```

```
data['households'] = data['households'].fillna(data['households'].mean())
```

```
train = data[:n_train]
test = data[n_train:]
```

```
#FITTING THE MODEL
```

```
#Split the dataset into training and testing data
```

```
from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(train, y, test_size = 0.2)
```

```
y_train = y_train.reshape(-1,1)
```

```
y_test = y_test.reshape(-1,1)
```

```
from sklearn.preprocessing import StandardScaler
```

```
sc_X = StandardScaler()
```

```
sc_y = StandardScaler()
```

```
X_train = sc_X.fit_transform(X_train)
```

```
X_test = sc_X.fit_transform(X_test)
```

```
y_train = sc_y.fit_transform(y_train)
```

```
y_test = sc_y.fit_transform(y_test)
```

```
# Fit the model over the training data
```

```
from sklearn.svm import SVR
```

```
regressor = SVR(kernel = 'rbf')
```

```
regressor.fit(X_train, y_train)
```

```
c:\users\harsh\appdata\local\programs\python\python38\lib\site-packages\sklearn\utils\validation.py:993: DataConversionWarning:
A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples, ), for example using ravel().
y = column_or_1d(y, warn=True)
```

```
Out[14]: SVR()
```

```
y_pred = regressor.predict(X_test)
```

```
y_pred = y_pred.reshape(1,-1)
```

```
y_pred = sc_y.inverse_transform(y_pred)
```

```
y_pred
```

```
Out[15]: array([[179219.93127152, 134049.46739203, 287742.07026065, ...,
                164907.28374701, 90330.41746274, 254711.02129636]])
```

```
df = pd.DataFrame({'Real Values':sc_y.inverse_transform(y_test.reshape(1,-1)).ravel(),'Predicted
Values':y_pred.ravel()})
```

```
df
```

```
Out[17]:
```

	Real Values	Predicted Values
0	227900.0	179219.931272
1	81100.0	134049.467392
2	247100.0	287742.070261
3	446200.0	437493.815678
4	135200.0	131255.773320
...
2715	122500.0	104581.879284
2716	421000.0	353816.134198
2717	500001.0	164907.283747
2718	94300.0	90330.417463
2719	188900.0	254711.021296

2720 rows × 2 columns

Practical 8

AIM :- Implement MLP for classification of handwritten digits (MNIST Dataset)

THEORY : -

MLP : A multilayer perceptron (MLP) is a feedforward artificial neural network that generates a set of outputs from a set of inputs. An MLP is characterized by several layers of input nodes connected as a directed graph between the input and output layers. MLP uses backpropagation for training the network.

The MNIST database (Modified National Institute of Standards and Technology database) is a large database of handwritten digits that is commonly used for training various image processing systems. The database is widely used for training and testing in the field of machine learning. It was created by "re-mixing" the samples from NIST's original datasets. The MNIST database contains 60,000 training images and 10,000 testing images. Half of the training set and half of the test set were taken from NIST's training dataset, while the other half of the training set and the other half of the test set were taken from NIST's testing dataset. The original creators of the database keep a list of some of the methods tested on it. In their original paper, they use a support-vector machine to get an error rate of 0.8%.

CODE / OUTPUT : -

```
#import libraries
import tensorflow as tf
from keras.utils import np_utils
from keras.datasets import mnist
import seaborn as sns
from keras.initializers import RandomNormal
%matplotlib notebook

import matplotlib.pyplot as plt
import numpy as np
import time
```


#function for updating plots for each epoch and error

```
def plt_dynamic (x,vy, ty, ax, colors=['b']):
```

```
    ax.plot (x, vy, 'b',label='Validation Loss')
```

```
    ax.plot(x,vy, 'r',label='Trin Loss')
```

```
    plt.legend()
```

```
    plt.grid()
```

```
#fig.canvas.draw()
```

#train and test data

```
(X_train,y_train),(X_test,y_test)=mnist.load_data()
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/mnist.npz  
11493376/11490434 [=====] - 2s 0us/step  
11501568/11490434 [=====] - 2s 0us/step
```

```
X_train=X_train.reshape(X_train.shape [0], X_train.shape [1]*X_train.shape[2])
```

```
X_test=X_test.reshape(X_test.shape [0],X_test.shape [1]*X_test.shape [2])
```

```
#print('Number of Training Examples:', X_train. shape [0], 'and each image is of shape (%d,%d)'  
%(X_train.shape[1]*X_train.shape[2]))
```

```
#print('Number of Test Examples:', X_test.shape[0], 'and each image is of shape (%d,%d)'  
%(X_test.shape[1],X_test.shape[2]))
```

```
print('Number of Training Examples:',X_train.shape [0], 'and each image is of shape (%d)'  
%(X_train.shape[1]))
```

```
print('Number of Test Examples:',X_test.shape [0], 'and each image is of shape (%d)'  
%(X_test.shape[1]))
```

```
Number of Training Examples: 60000 and each image is of shape (784)  
Number of Test Examples: 10000 and each image is of shape (784)
```

```
# example of data point
```

```
print(X_train[0])
```

[illegible]

```
# normalize the data
```

```
X_train=X_train/255
```

```
X_test=X_test/255
```

```
# example of data after normalization
```

```
print(X_train[0])
```

0.32156863	0.21960784	0.15294118	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.07058824	0.85882353	0.99215686
0.99215686	0.99215686	0.99215686	0.99215686	0.77647059	0.71372549
0.96862745	0.94509804	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.31372549	0.61176471	0.41960784	0.99215686
0.99215686	0.80392157	0.04313725	0.	0.16862745	0.60392157
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.05490196	0.00392157	0.60392157	0.99215686	0.35294118
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.54509804	0.99215686	0.74509804	0.00784314	0.

40

0.	0.	0.	0.	0.15294118	0.58039216
0.89803922	0.99215686	0.99215686	0.99215686	0.98039216	0.71372549
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.09411765	0.44705882	0.86666667	0.99215686	0.99215686	0.99215686
0.99215686	0.78823529	0.30588235	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.09019608	0.25882353	0.83529412	0.99215686
0.99215686	0.99215686	0.99215686	0.77647059	0.31764706	0.00784314
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.07058824	0.67058824
0.85882353	0.99215686	0.99215686	0.99215686	0.99215686	0.76470588
0.31372549	0.03529412	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

[illegible]

```
print('Class label of first image:',y_train[0])
```

```
# convert this into 10 decimal vector

Y_train=np_utils.to_categorical(y_train,10)
Y_test=np_utils.to_categorical(y_test,10)
print('After converting the output into a vector:',Y_train[0])

Class label of first image: 5
After converting the output into a vector: [0. 0. 0. 0. 0. 1. 0. 0. 0. 0.]

# build softmax classifier

from keras.models import Sequential

from keras.layers import Dense, Activation

#model=Sequential([Dense(32, input_shape=(784,)),
#Activation('relu'),Dense(10),Activation('softmax')])

#model parameters
output_dim=10
input_dim=X_train.shape[1]
batch_size=128
nb_epoch=20

#start building model
#from keras.layers import Activation, Dense
model=Sequential()
#model.add(Dense(64))
#model.add(Activation('tanh'))
model.add(Dense(output_dim,input_dim=input_dim, activation='softmax'))

print(X_train.shape)
print(Y_train.shape)
print(X_test.shape)
print(Y_test.shape)
```

```
(60000, 784)  
(60000, 10)  
(10000, 784)  
(10000, 10)
```

Configure the learning process

```
model.compile(optimizer='sgd', loss='categorical_crossentropy', metrics=['accuracy'])
```

train using fit()

```
history = model.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch, verbose=1,  
validation_data=(X_test, Y_test))
```

```
Epoch 1/20
469/469 [=====] - 2s 2ms/step - loss: 1.2983 - accuracy: 0.6842 - val_loss: 0.8128 - val_accuracy: 0.8332
Epoch 2/20
469/469 [=====] - 1s 2ms/step - loss: 0.7107 - accuracy: 0.8410 - val_loss: 0.6071 - val_accuracy: 0.8626
Epoch 3/20
469/469 [=====] - 1s 2ms/step - loss: 0.5890 - accuracy: 0.8600 - val_loss: 0.5256 - val_accuracy: 0.8736
Epoch 4/20
469/469 [=====] - 1s 2ms/step - loss: 0.5271 - accuracy: 0.8692 - val_loss: 0.4799 - val_accuracy: 0.8812
Epoch 5/20
469/469 [=====] - 1s 2ms/step - loss: 0.4894 - accuracy: 0.8754 - val_loss: 0.4500 - val_accuracy: 0.8873
Epoch 6/20
469/469 [=====] - 1s 3ms/step - loss: 0.4634 - accuracy: 0.8797 - val_loss: 0.4286 - val_accuracy: 0.8908
Epoch 7/20
469/469 [=====] - 1s 2ms/step - loss: 0.4441 - accuracy: 0.8828 - val_loss: 0.4125 - val_accuracy: 0.8925
Epoch 8/20
469/469 [=====] - 1s 2ms/step - loss: 0.4292 - accuracy: 0.8858 - val_loss: 0.3998 - val_accuracy: 0.8953
Epoch 9/20
469/469 [=====] - 1s 2ms/step - loss: 0.4170 - accuracy: 0.8885 - val_loss: 0.3894 - val_accuracy: 0.8974
Epoch 10/20
469/469 [=====] - 1s 2ms/step - loss: 0.4070 - accuracy: 0.8907 - val_loss: 0.3809 - val_accuracy: 0.8977
Epoch 11/20
469/469 [=====] - 1s 2ms/step - loss: 0.3985 - accuracy: 0.8923 - val_loss: 0.3735 - val_accuracy: 0.8998
Epoch 12/20
469/469 [=====] - 1s 2ms/step - loss: 0.3911 - accuracy: 0.8938 - val_loss: 0.3674 - val_accuracy: 0.9015
Epoch 13/20
469/469 [=====] - 1s 2ms/step - loss: 0.3847 - accuracy: 0.8951 - val_loss: 0.3617 - val_accuracy: 0.9015
Epoch 14/20
469/469 [=====] - 1s 2ms/step - loss: 0.3790 - accuracy: 0.8962 - val_loss: 0.3565 - val_accuracy: 0.9021
Epoch 15/20
469/469 [=====] - 1s 2ms/step - loss: 0.3740 - accuracy: 0.8976 - val_loss: 0.3521 - val_accuracy: 0.9037
Epoch 16/20
469/469 [=====] - 1s 2ms/step - loss: 0.3694 - accuracy: 0.8991 - val_loss: 0.3483 - val_accuracy: 0.9049
Epoch 17/20
469/469 [=====] - 1s 2ms/step - loss: 0.3652 - accuracy: 0.8994 - val_loss: 0.3449 - val_accuracy: 0.9060
Epoch 18/20
469/469 [=====] - 1s 2ms/step - loss: 0.3614 - accuracy: 0.9006 - val_loss: 0.3416 - val_accuracy: 0.9077
Epoch 19/20
469/469 [=====] - 1s 2ms/step - loss: 0.3580 - accuracy: 0.9015 - val_loss: 0.3384 - val_accuracy: 0.9080
Epoch 20/20
469/469 [=====] - 1s 2ms/step - loss: 0.3548 - accuracy: 0.9021 - val_loss: 0.3355 - val_accuracy: 0.9084
```

```
score=model.evaluate(X_test,Y_test, verbose=0)
```

```
print('Test Score',score [0])
```

```
print('Test Accuracy',score[1])
```

```
'''fig,ax=plt.subplot(1,1)
```

```
ax.set_xlabel('epoch');
```

```
ax.set_ylabel('Categorical Crossentropy Loss')
```

```
#List the epoc numbers
```

```
x=list(range(1, nb_epoch+1))
```

```
vy=history.history['val loss']
```

```
ty=history.history['loss']
```

```
plt_dynamic (x,uy,ty,ax)
```

```
'''
```

```
Test Score 0.3355453610420227
```

```
Test Accuracy 0.9083999991416931
```

```
Out[26]: "fig,ax=plt.subplot(1,1)\nax.set_xlabel('epoch')\nax.set_ylabel('Categorical Crossentropy Loss')\n\n#List the epoc numbers\nx=\nlist(range(1, nb_epoch+1))\n\nvy=history.history['val loss']\nty=history.history['loss']\n\nplt_dynamic (x,uy,ty,ax)\n\n"
```

```
# multilayer perceptron
```

```
model_sigmoid=Sequential()
```

```
model_sigmoid.add(Dense(512,activation='sigmoid', input_shape=(input_dim,)))
```

```
model_sigmoid.add(Dense(128, activation='sigmoid'))
```

```
model_sigmoid.add(Dense(output_dim,activation='softmax'))
```

```
model_sigmoid.summary()
```

```
Model: "sequential_2"
```

Layer (type)	Output Shape	Param #
dense_1 (Dense)	(None, 512)	401920
dense_2 (Dense)	(None, 128)	65664
dense_3 (Dense)	(None, 10)	1290

```
=====  
Total params: 468,874
```

```
Trainable params: 468,874
```

```
Non-trainable params: 0
```

```
model_sigmoid.compile(optimizer='sgd', loss='categorical_crossentropy', metrics=['accuracy'])
```



```
history = model_sigmoid.fit(X_train, Y_train, batch_size=batch_size, epochs=nb_epoch, verbose=1,
validation_data=(X_test, Y_test))
```

```
Epoch 1/20
469/469 [=====] - 6s 11ms/step - loss: 2.2703 - accuracy: 0.2298 - val_loss: 2.2228 - val_accuracy: 0.
2836
Epoch 2/20
469/469 [=====] - 5s 10ms/step - loss: 2.1768 - accuracy: 0.4245 - val_loss: 2.1195 - val_accuracy: 0.
5768
Epoch 3/20
469/469 [=====] - 4s 9ms/step - loss: 2.0574 - accuracy: 0.5416 - val_loss: 1.9786 - val_accuracy: 0.5
896
Epoch 4/20
469/469 [=====] - 4s 9ms/step - loss: 1.8930 - accuracy: 0.6181 - val_loss: 1.7855 - val_accuracy: 0.6
382
Epoch 5/20
469/469 [=====] - 4s 9ms/step - loss: 1.6886 - accuracy: 0.6687 - val_loss: 1.5656 - val_accuracy: 0.6
840
Epoch 6/20
469/469 [=====] - 4s 9ms/step - loss: 1.4694 - accuracy: 0.7106 - val_loss: 1.3458 - val_accuracy: 0.7
406
Epoch 7/20
469/469 [=====] - 5s 10ms/step - loss: 1.2648 - accuracy: 0.7435 - val_loss: 1.1567 - val_accuracy: 0.
7628
Epoch 8/20
469/469 [=====] - 4s 9ms/step - loss: 1.0956 - accuracy: 0.7682 - val_loss: 1.0080 - val_accuracy: 0.7
882
Epoch 9/20
469/469 [=====] - 5s 10ms/step - loss: 0.9648 - accuracy: 0.7881 - val_loss: 0.8957 - val_accuracy: 0.
7998
Epoch 10/20
469/469 [=====] - 5s 10ms/step - loss: 0.8649 - accuracy: 0.8032 - val_loss: 0.8075 - val_accuracy: 0.
8191
Epoch 11/20
469/469 [=====] - 4s 9ms/step - loss: 0.7871 - accuracy: 0.8158 - val_loss: 0.7395 - val_accuracy: 0.8
271
Epoch 12/20
469/469 [=====] - 5s 10ms/step - loss: 0.7250 - accuracy: 0.8268 - val_loss: 0.6827 - val_accuracy: 0.
8386
Epoch 13/20
469/469 [=====] - 4s 10ms/step - loss: 0.6746 - accuracy: 0.8355 - val_loss: 0.6371 - val_accuracy: 0.
8472
Epoch 14/20
469/469 [=====] - 4s 9ms/step - loss: 0.6329 - accuracy: 0.8435 - val_loss: 0.5993 - val_accuracy: 0.8
521
Epoch 15/20
469/469 [=====] - 4s 9ms/step - loss: 0.5979 - accuracy: 0.8494 - val_loss: 0.5674 - val_accuracy: 0.8
596
Epoch 16/20
469/469 [=====] - 4s 9ms/step - loss: 0.5684 - accuracy: 0.8561 - val_loss: 0.5394 - val_accuracy: 0.8
633
Epoch 17/20
469/469 [=====] - 4s 9ms/step - loss: 0.5432 - accuracy: 0.8605 - val_loss: 0.5168 - val_accuracy: 0.8
685
Epoch 18/20
469/469 [=====] - 5s 10ms/step - loss: 0.5215 - accuracy: 0.8649 - val_loss: 0.4964 - val_accuracy: 0.
8731
Epoch 19/20
469/469 [=====] - 4s 9ms/step - loss: 0.5025 - accuracy: 0.8687 - val_loss: 0.4786 - val_accuracy: 0.8
765
Epoch 20/20
469/469 [=====] - 4s 9ms/step - loss: 0.4860 - accuracy: 0.8716 - val_loss: 0.4634 - val_accuracy: 0.8
793
```

```
w_after = model_sigmoid.get_weights()
```

```
h1_w = w_after[0].flatten().reshape(-1,1)
```

```
h2_w = w_after[2].flatten().reshape(-1,1)
```

```
out_w = w_after[4].flatten().reshape(-1,1)
```

```
fig = plt.figure()
```

```
plt.title("Weight matrices after model trained")
```

```
plt.subplot(1, 3, 1)
```

```
plt.title("Trained model Weights")
```

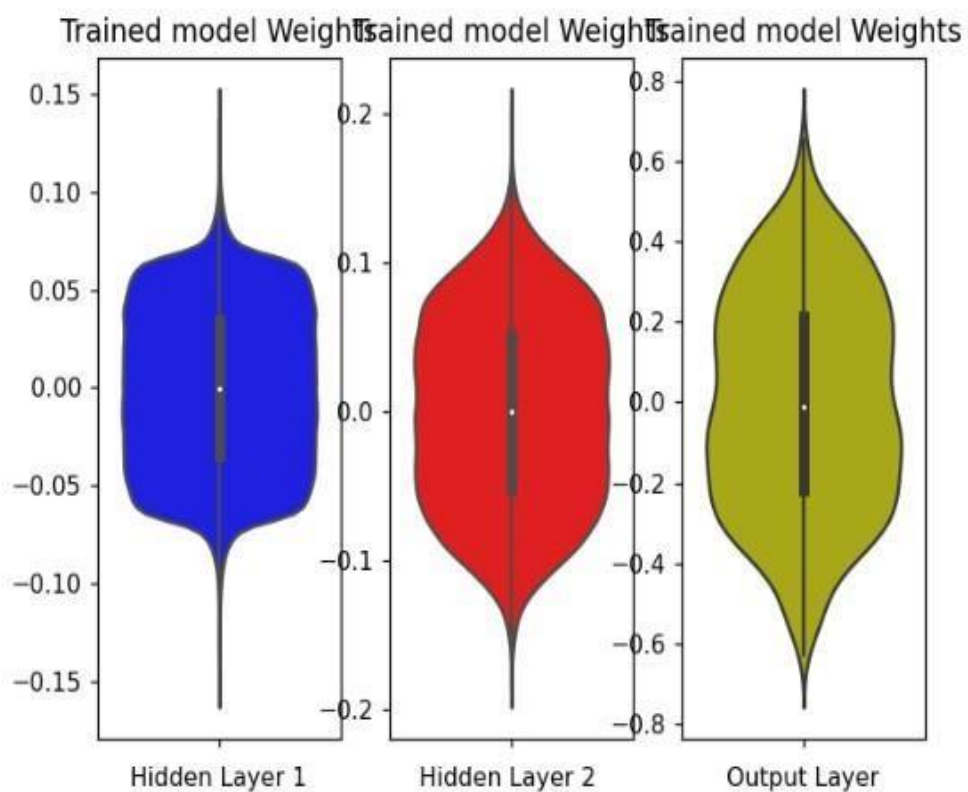
```
ax = sns.violinplot(y=h1_w, color='b')
```

```
plt.xlabel('Hidden Layer 1')
```

```
plt.subplot(1, 3, 2)
plt.title("Trained model Weights")
ax = sns.violinplot(y=h2_w, color='r')
plt.xlabel('Hidden Layer 2 ')
```

```
plt.subplot(1, 3, 3)
plt.title("Trained model Weights")
ax = sns.violinplot(y=out_w,color='y')
plt.xlabel('Output Layer')
plt.show()
```

IPython.core.display.Javascript object>



Practical 9

AIM :- Classification of images of clothing using TensorFlow (Fashion MNIST Dataset)

THEORY :-

A convolution multiplies a matrix of pixels with a filter matrix or 'kernel' and sums up the multiplication values. Then the convolution slides over to the next pixel and repeats the same process until all the image pixels have been covered.

CODE / OUTPUT : -

```
# Classification using Tensor flow on MNIST cloth dataset
```

```
#import libraries
```

```
import tensorflow as tf
```

```
# access the dataset
```

```
fashion_mnist=tf.keras.datasets.fashion_mnist
```

```
(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data( )
```

```
# print the training and test dataset
```

```
train_images.shape
```

```
Out[3]: (60000, 28, 28)
```

```
train_images [0]
```

```

Out[4]: array([[ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0, 13, 73,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0, 36, 136, 127, 62, 54,  0,  0,  0,  0,  0,  0,  0,  0,
  0, 3],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
  0, 102, 204, 176, 134, 144, 123, 23,  0,  0,  0,  0,  0,  0,
 10, 6],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
 0, 155, 236, 207, 178, 107, 156, 161, 109, 64, 23, 77, 130,
 72, 15],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
 69, 207, 223, 218, 216, 216, 163, 127, 121, 122, 146, 141, 88,
172, 66],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
200, 232, 232, 233, 229, 223, 223, 215, 213, 164, 127, 123, 196,
229, 8],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
183, 225, 216, 223, 228, 235, 227, 224, 222, 224, 221, 223, 245,
173, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
193, 228, 218, 213, 198, 180, 212, 210, 211, 213, 223, 220, 243,
202, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
219, 220, 212, 218, 192, 169, 227, 208, 218, 224, 212, 226, 197,
209, 52],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
244, 222, 220, 218, 203, 198, 221, 215, 213, 222, 220, 245, 119,
167, 56],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
236, 228, 230, 228, 240, 232, 213, 218, 223, 234, 217, 217, 209,
92, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
226, 217, 223, 222, 219, 222, 221, 216, 223, 229, 215, 218, 255,
77, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
207, 213, 221, 218, 208, 211, 218, 224, 223, 219, 215, 224, 244,
159, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
226, 200, 205, 211, 230, 224, 234, 176, 188, 250, 248, 233, 238,
215, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
159, 245, 193, 206, 223, 255, 221, 234, 221, 211, 220, 232,
246, 0],
 [ 3, 202, 228, 224, 221, 211, 211, 214, 205, 205, 205, 220, 240,
80, 150, 255, 229, 221, 188, 154, 191, 210, 204, 209, 222, 228,
98, 233, 198, 210, 222, 229, 229, 234, 249, 220, 194, 215, 217,
241, 65, 73, 106, 117, 168, 219, 221, 215, 217, 223, 223, 224,
229, 29],
 [ 75, 204, 212, 204, 193, 205, 211, 225, 216, 185, 197, 206, 198,
213, 240, 195, 227, 245, 239, 223, 218, 212, 209, 222, 220, 221,
230, 67],
 [ 48, 203, 183, 194, 213, 197, 185, 190, 194, 192, 202, 214, 219,
221, 220, 236, 225, 216, 199, 206, 186, 181, 177, 172, 181, 205,
206, 115],
 [ 0, 122, 219, 193, 179, 171, 183, 196, 204, 210, 213, 207, 211,
210, 200, 196, 194, 191, 195, 191, 198, 192, 176, 156, 167, 177,
210, 92],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
188, 193, 198, 204, 209, 210, 210, 211, 188, 188, 194, 192, 216,
170, 0],
 [ 2,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
221, 220, 193, 191, 179, 182, 182, 181, 176, 166, 168, 99, 58,
0, 0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0],
 [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
0,  0], dtype=uint8)

```

train_labels

```
Out[5]: array([9, 0, 0, ..., 3, 0, 5], dtype=uint8)
```

test_images.shape

```
Out[6]: (10000, 28, 28)
```

test_labels.shape

```
Out[7]: (10000,)
```

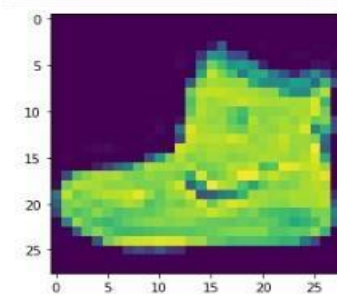
visualization of training data

import matplotlib.pyplot as plt

plot the first train_image

plt.imshow(train_images[0])

plt.show()



plot multiple images and its label

```
class_names = ['T-shirt/ top' , 'Trouser' , ' Pullover' , 'Dress ' , 'Coat ' , 'Sandal' , ' Shirt ' ,  
'Sneaker','Bag','Ankle boot']
```

plt.figure(figsize=(15,15))

for i in range(25):

plt.subplot(5,5,i+1)

plt.imshow(train_images[i])

plt.xlabel(class_names[train_labels[i]])

plt.xticks([])

plt.yticks([])

pass

plt.show()



scale images to a range of 0 to 1

train_images=train_images/255.0

test_images=test_images/255.0

see the train_image[0] after scaling

train_images[0]

```

0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.00392157, 0.      , 0.      ,
0.05098039, 0.28627451, 0.      , 0.      , 0.00392157,
0.01568627, 0.      , 0.      , 0.      , 0.      ,
0.00392157, 0.00392157, 0.      , ], 0.      ,
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.01176471, 0.      , 0.      ,
0.      , 0.      , 0.24313725, 0.21176471, 0.      ,
0.53333333, 0.49803922, 0.00392157, 0.01176471, 0.01568627,
0.      , 0.      , 0.01176471],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.02352941, 0.      , 0.4      ,
0.8      , 0.69019608, 0.5254902 , 0.56470588, 0.48235294,
0.09019608, 0.      , 0.      , 0.      , 0.      ,
0.04705882, 0.03921569, 0.      , ], 0.      ,

```

```

[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.60784314,
0.9254902 , 0.81176471, 0.69803922, 0.41960784, 0.61176471,
0.63137255, 0.42745098, 0.25098039, 0.09019608, 0.30196078,
0.50980392, 0.28235294, 0.05882353],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.00392157, 0.      , 0.27058824, 0.81176471,
0.8745098 , 0.85490196, 0.84705882, 0.84705882, 0.63921569,
0.49803922, 0.4745098 , 0.47843137, 0.57254902, 0.55294118,
0.34509804, 0.6745098 , 0.25882353],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.00392157,
0.00392157, 0.00392157, 0.      , 0.78431373, 0.90980392,
0.90980392, 0.91372549, 0.89803922, 0.8745098 , 0.8745098 ,
0.84313725, 0.83529412, 0.64313725, 0.49803922, 0.48235294,
0.76862745, 0.89803922, 0.      , ],

```

```

[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.71764706, 0.88235294,
0.84705882, 0.8745098 , 0.89411765, 0.92156863, 0.89019608,
0.87843137, 0.87058824, 0.87843137, 0.86666667, 0.8745098 ,
0.96078431, 0.67843137, 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.75686275, 0.89411765,
0.85490196, 0.83529412, 0.77647059, 0.70588235, 0.83137255,
0.82352941, 0.82745098, 0.83529412, 0.8745098 , 0.8627451 ,
0.95294118, 0.79215686, 0.      , ],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.00392157,
0.01176471, 0.      , 0.04705882, 0.85882353, 0.8627451 ,
0.83137255, 0.85490196, 0.75294118, 0.6627451 , 0.89019608,
0.81568627, 0.85490196, 0.87843137, 0.83137255, 0.88627451,
0.77254902, 0.81960784, 0.20392157],

```

```

[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.      ,
0.02352941, 0.      , 0.38823529, 0.95686275, 0.87058824,
0.8627451 , 0.85490196, 0.79607843, 0.77647059, 0.86666667,
0.84313725, 0.83529412, 0.87058824, 0.8627451 , 0.96078431,
0.46666667, 0.65490196, 0.21960784],
[0.      , 0.      , 0.      , 0.      , 0.      ,
0.      , 0.      , 0.      , 0.      , 0.01568627,
0.      , 0.      , 0.21568627, 0.9254902 , 0.89411765,
0.90196078, 0.89411765, 0.94117647, 0.90980392, 0.83529412,
0.85490196, 0.8745098 , 0.91764706, 0.85098039, 0.85098039,
0.81960784, 0.36078431, 0.      , ],
[0.      , 0.      , 0.00392157, 0.01568627, 0.02352941,
0.02745098, 0.00784314, 0.      , 0.      , 0.      ,
0.      , 0.      , 0.92941176, 0.88627451, 0.85098039,
0.8745098 , 0.87058824, 0.85882353, 0.87058824, 0.86666667,
0.84705882, 0.8745098 , 0.89803922, 0.84313725, 0.85490196,

```

1.		0.30196078,	0.],
[0.		0.01176471,	0.		, 0.
0.		0.	0.		0.24313725,
0.56862745,	0.8		0.89411765,	0.81176471,	0.83529412,
0.86666667,	0.85490196,	0.81568627,	0.82745098,	0.85490196,	
0.87843137,	0.8745098	0.85882353,	0.84313725,	0.87843137,	
0.95686275,	0.62352941,	0.],	
[0.		0.	0.		0.07058824,
0.17254902,	0.32156863,	0.41960784,	0.74117647,	0.89411765,	
0.8627451	0.87058824,	0.85098039,	0.88627451,	0.78431373,	
0.80392157,	0.82745098,	0.90196078,	0.87843137,	0.91764706,	
0.69019608,	0.7372549	0.98039216,	0.97254902,	0.91372549,	
0.93333333,	0.84313725,	0.],	
[0.		0.22352941,	0.73333333,	0.81568627,	0.87843137,
0.86666667,	0.87843137,	0.81568627,	0.8		0.83921569,
0.81568627,	0.81960784,	0.78431373,	0.62352941,	0.96078431,	
0.75686275,	0.80784314,	0.8745098	1.	1.	
0.86666667,	0.91764706,	0.86666667,	0.82745098,	0.8627451	
0.90980392,	0.96470588,	0.],	
[0.01176471,	0.79215686,	0.89411765,	0.87843137,	0.86666667,	
0.82745098,	0.82745098,	0.83921569,	0.80392157,	0.80392157,	
0.80392157,	0.8627451	0.94117647,	0.31372549,	0.58823529,	
1.		0.89803922,	0.86666667,	0.7372549	0.60392157,
0.74901961,	0.82352941,	0.8	0.81960784,	0.87058824,	
0.89411765,	0.88235294,	0.],	
[0.38431373,	0.91372549,	0.77647059,	0.82352941,	0.87058824,	
0.89803922,	0.89803922,	0.91764706,	0.97647059,	0.8627451	
0.76078431,	0.84313725,	0.85098039,	0.94509804,	0.25490196,	
0.28627451,	0.41568627,	0.45882353,	0.65882353,	0.85882353,	
0.86666667,	0.84313725,	0.85098039,	0.8745098	0.8745098	
0.87843137,	0.89803922,	0.11372549],			
[0.29411765,	0.8	0.83137255,	0.8	0.75686275,	
0.80392157,	0.82745098,	0.88235294,	0.84705882,	0.7254902	
0.77254902,	0.80784314,	0.77647059,	0.83529412,	0.94117647,	
0.76470588,	0.89019608,	0.96078431,	0.9372549	0.8745098	
0.85490196,	0.83137255,	0.81960784,	0.87058824,	0.8627451	
0.86666667,	0.90196078,	0.2627451],		
[0.18823529,	0.79607843,	0.71764706,	0.76078431,	0.83529412,	
0.77254902,	0.7254902	0.74509804,	0.76078431,	0.75294118,	
0.79215686,	0.83921569,	0.85882353,	0.86666667,	0.8627451	
0.9254902	0.88235294,	0.84705882,	0.78039216,	0.80784314,	
0.72941176,	0.70980392,	0.69411765,	0.6745098	0.70980392,	
0.80392157,	0.80784314,	0.45098039],			
[0.	0.47843137,	0.85882353,	0.75686275,	0.70196078,	
0.67058824,	0.71764706,	0.76862745,	0.8	0.82352941,	
0.83529412,	0.81176471,	0.82745098,	0.82352941,	0.78431373,	
0.76862745,	0.76078431,	0.74901961,	0.76470588,	0.74901961,	
0.77647059,	0.75294118,	0.69019608,	0.61176471,	0.65490196,	
0.69411765,	0.82352941,	0.36078431],			
[0.	0.	0.29019608,	0.74117647,	0.83137255,	
0.74901961,	0.68627451,	0.6745098	0.68627451,	0.70980392,	
0.7254902	0.7372549	0.74117647,	0.7372549	0.75686275,	
0.77647059,	0.8	0.81960784,	0.82352941,	0.82352941,	
0.82745098,	0.7372549	0.7372549	0.76078431,	0.75294118,	
0.84705882,	0.66666667,	0.],	
[0.00784314,	0.	0.	0.	0.25882353,	
0.78431373,	0.87058824,	0.92941176,	0.9372549	0.94901961,	
0.96470588,	0.95294118,	0.95686275,	0.86666667,	0.8627451	
0.75686275,	0.74901961,	0.70196078,	0.71372549,	0.71372549,	
0.70980392,	0.69019608,	0.65098039,	0.65882353,	0.38823529,	
0.22745098,	0.	0.],	
[0.	0.	0.	0.	0.	
0.	0.	0.15686275,	0.23921569,	0.17254902,	
0.28235294,	0.16078431,	0.1372549	0.	0.	
0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	
[0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	
0.	0.	0.	0.	0.	

[illegible]

```
# create model
```

```
model=tf.keras.Sequential()
```

```
model.add(tf.keras.layers.Flatten(input_shape=(28,28)))
```

```
model.add (tf.keras.layers.Dense(128,activation='relu'))
```

```
model.add(tf.keras.layers.Dense(10))
```

```
model.compile(optimizer= 'adam' ,
```

```
loss=tf.keras.losses.SparseCategoricalCrossentropy(from_logits=True),
```

```
metrics=['accuracy'])
```

```
# model summary
```

```
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
flatten (Flatten)	(None, 784)	0
dense (Dense)	(None, 128)	100480
dense_1 (Dense)	(None, 10)	1290

```
=====
Total params: 101,770
Trainable params: 101,770
Non-trainable params: 0
```

Train the Model

```
history=model.fit(train_images,train_labels,epochs=10)
```

```
Epoch 1/10
1875/1875 [=====] - 7s 3ms/step - loss: 0.5013 - accuracy: 0.8233
Epoch 2/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.3744 - accuracy: 0.8660
Epoch 3/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.3352 - accuracy: 0.8777
Epoch 4/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.3113 - accuracy: 0.8861
Epoch 5/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.2937 - accuracy: 0.8915
Epoch 6/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.2798 - accuracy: 0.8969
Epoch 7/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.2678 - accuracy: 0.9002
Epoch 8/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.2582 - accuracy: 0.9028
Epoch 9/10
1875/1875 [=====] - 6s 3ms/step - loss: 0.2475 - accuracy: 0.9076
Epoch 10/10
1875/1875 [=====] - 7s 4ms/step - loss: 0.2390 - accuracy: 0.9108
```

```
loss=history.history['loss']
```

```
acc=history.history['accuracy']
```

```
epochs_range=range(10)
```

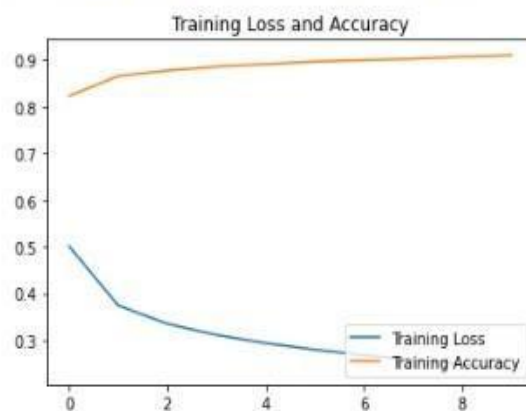
```
plt.plot(epochs_range,loss,label= 'Training Loss')
```

```
plt.plot(epochs_range,acc,label= 'Training Accuracy')
```

```
plt.legend(loc='lower right')
```

```
plt.title('Training Loss and Accuracy')
```

```
Out[16]: Text(0.5, 1.0, 'Training Loss and Accuracy')
```



Evaluate the accuracy

```
test_loss, test_acc=model.evaluate(test_images, test_labels, verbose=2)
```

```
print( '\Test accuracy: ', test_acc)
```

```
313/313 - 1s - loss: 0.3398 - accuracy: 0.8820 - 818ms/epoch - 3ms/step
\Test accuracy: 0.8820000290870667
```

Predict

```
probability_model=tf.keras.Sequential([model,tf.keras.layers.Softmax()])
```

```
predictions=probability_model.predict(test_images)
```

```
predictions[0]
```

```
Out[18]: array([3.8962352e-07, 1.4807861e-07, 1.2840245e-06, 9.7617547e-10,
 8.7510152e-06, 2.5299708e-03, 1.3094771e-06, 6.3346457e-03,
 3.1729502e-07, 9.9112320e-01], dtype=float32)
```

view prediction

```
import numpy as np
```

```
np.argmax(predictions[0])
```

```
Out[19]: 9
```

#verify predictions

```
def plot_image(i, predictions_array, true_label, img) :
```

```
    true_label, img=true_label [i] , img[i]
```

```
    plt.grid(False)
```

```
    plt.xticks([])
```

```
    plt.yticks([])
```

```
    plt.imshow(img)
```

```
    predicted_label = np.argmax(predictions_array)
```

```
    if predicted_label == true_label:
```

```
        color = 'blue'
```

```
    else:
```

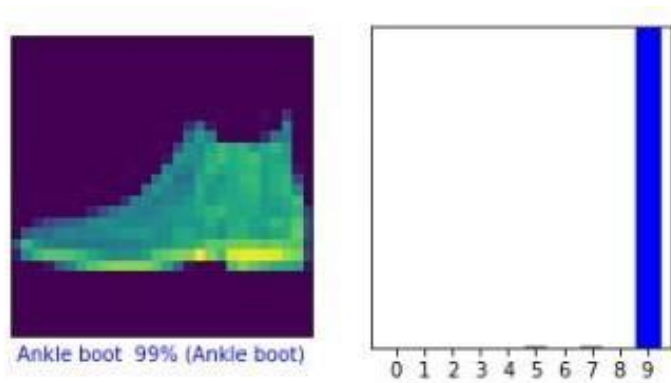
```
        color = 'red'
```

```
plt.xlabel("{} {:.2f}% {}".format(class_names[predicted_label],
                                   100*np.max(predictions_array),
                                   class_names[true_label]),
          color=color)

pass

def plot_value_array(i, predictions_array, true_label):
    true_label = true_label[i]
    plt.grid(False)
    plt.xticks(range(10))
    plt.yticks([])
    thisplot = plt.bar(range(10), predictions_array, color="#777777")
    plt.ylim([0,1])
    predicted_label = np.argmax(predictions_array)
    thisplot[predicted_label].set_color('red')
    thisplot[true_label].set_color('blue')
    pass

# Verify the 0th image prediction
i=0
plt.figure(figsize=(6,3))
plt.subplot(1,2,1)
plot_image(i,predictions[i],test_labels,test_images)
plt.subplot(1,2,2)
plot_value_array(i,predictions[i],test_labels)
plt.show()
```



```
# plot images with their predictions
num_rows = 5
num_cols = 3
num_images = num_rows * num_cols
plt.figure(figsize=(10,10))
for i in range(num_images):
    plt.subplot(num_rows, 2 * num_cols, 2 * i + 1)
    plot_image(i, predictions[i], test_labels, test_images)
    plt.subplot(num_rows, 2 * num_cols, 2 * i + 2)
    plot_value_array(i, predictions[i], test_labels)
plt.tight_layout()
plt.show()
```

