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**Department
of
Computer Engineering
Laboratory Practice V (410254)
LAB MANUAL
Class: BE (2019 Pattern)
Prepared By: Mr. Sharad Jadhav**



SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE

410254: LABORATORY PRACTICE V

Teaching Scheme	Credit	Examination Scheme
PR: 2 Hours/Week	02	TW: 50 Marks Practical: 50 Marks

COURSE OUTCOMES (CO)

	After completion of the course, students will be able to
CO1	Analyse and measure performance of sequential and parallel algorithms.
CO2	Design and Implement solutions for multicore/Distributed/parallel environment.
CO3	Identify and apply the suitable algorithms to solve AI/ML problems.
CO4	Apply the technique of Deep Neural network for implementing Linear regression and classification.
CO5	Apply the technique of Convolution (CNN) for implementing Deep Learning models
CO6	Design and develop Recurrent Neural Network (RNN) for prediction.

410254: LABORATORY PRACTICE V

Course Objectives:

- To understand and implement searching and sorting algorithms.
- To learn the fundamentals of GPU Computing in the CUDA environment.
- To illustrate the concepts of Artificial Intelligence/Machine Learning (AI/ML).
- To understand Hardware acceleration.
- To implement different deep learning models.

Guidelines for Instructor's Manual

Laboratory Practice V is for practical hands on for core courses High Performance Computing and Data Learning. The instructor's manual is to be developed as a hands-on resource and as ready reference. The instructor's manual need to include prologue (about University/program/institute/

department/foreword/ preface etc), University syllabus, conduction and Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/ guidelines, references among others.

Guidelines for Student's Laboratory Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal may consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software and Hardware requirements, Date of Completion, Assessment grade/marks and assessor's sign, Theory-Concept in brief, Algorithm/Database design, test cases, conclusion/analysis). Program codes with sample output of all performed assignments are to be submitted as softcopy.

Guidelines for Laboratory /Term Work Assessment

Continuous assessment of laboratory work is to be done based on overall performance and lab assignments performance of student. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness reserving weightage for successful mini-project completion and related documentation.

Guidelines for Practical Examination

- Both internal and external examiners should jointly frame suitable problem statements for practical examination based on the term work completed.
- During practical assessment, the expert evaluator should give the maximum weightage to the satisfactory implementation of the problem statement.
- The supplementary and relevant questions may be asked at the time of evaluation to test the student's for advanced learning, understanding of the fundamentals, effective and efficient implementation.
- Encouraging efforts, transparent evaluation and fair approach of the evaluator will not create any uncertainty or doubt in the minds of the students. So adhering to these principles will consummate our team efforts to the promising boost to the student's academics.

Guidelines for Laboratory Conduction

- List of recommended programming assignments and sample mini-projects is provided for reference.
- Referring these, Course Teacher or Lab Instructor may frame the assignments/mini-project by understanding the prerequisites, technological aspects, utility and recent trends related to the respective courses.
- Preferably there should be multiple sets of assignments/mini-project and distribute among batches of students.
- Real world problems/application-based assignments/mini-projects create interest among learners serving as foundation for future research or startup of business projects.
- Mini-project can be completed in group of 2 to 3 students.
- Software Engineering approach with proper documentation is to be strictly followed.
- Use of open source software is to be encouraged.
- Instructor may also set one assignment or mini-project that is suitable to respective course beyond the scope of syllabus.

Operating System recommended: - 64-bit Open-source Linux or its derivative Programming

Languages: Object Oriented Languages C++/JAVA/PYTHON/R

Programming tools recommended: Front End: Java/Perl/PHP/Python/Ruby/.net,

Backend: MongoDB/MYSQL/Oracle, Database Connectivity: ODBC/JDBC

The CO-PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	1	-	2	1	-	-	-	-	-
CO2	1	2	1	-	-	1	-	-	-	-	-	1
CO3	-	1	1	1	1	-	-	-	-	-	-	-
CO4	3	3	3	-	--	-	-	-	-	-	-	-
CO5	3	3	3	3	-	-	-	-	-	-	-	-
CO6	3	3	3	3	--	-	-	-	-	-	-	-
CO7	3	3	3	3	-	-	-	-	-	-	-	-

List of Assignments

Group 1

410250: High Performance Computing

Sr.No	Any 4 Assignments and 1 Mini Project are Mandatory
1	Design and implement Parallel Breadth First Search and Depth First Search based on existing algorithms using OpenMP. Use a Tree or an undirected graph for BFS and DFS .
2	Write a program to implement Parallel Bubble Sort and Merge sort using OpenMP. Use existing algorithms and measure the performance of sequential and parallel algorithms.
3	Implement Min, Max, Sum and Average operations using Parallel Reduction.
4	Write a CUDA Program for : 1. Addition of two large vectors 2. Matrix Multiplication using CUDA C
5	Implement HPC application for AI/ML domain.
	1. Mini Project: Evaluate performance enhancement of parallel Quicksort Algorithm using MPI 2. Mini Project: Implement Huffman Encoding on GPU 3. Mini Project: Implement Parallelization of Database Query optimization 4. Mini Project: Implement Non-Serial Polyadic Dynamic Programming with GPU Parallelization

Group: 2.

410251 : Deep Learning

Any 3 Assignments and 1 Mini Project are Mandatory

1	Linear regression by using Deep Neural network: Implement Boston housing price prediction problem by Linear regression using Deep Neural network. Use Boston House price prediction dataset.
2	Classification using Deep neural network (Any One from the following) 1. Multiclass classification using Deep Neural Networks: Example: Use the OCR letter recognition dataset https://archive.ics.uci.edu/ml/datasets/letter+recognition 2. Binary classification using Deep Neural Networks Example: Classify movie reviews into positive" reviews and "negative" reviews, just based on the text content of the reviews. Use IMDB dataset
	Recurrent neural network (RNN) Use the Google stock prices dataset and design a time series analysis and prediction system using RNN.
	1. Mini Project: Human Face Recognition 2. Mini Project: Gender and Age Detection: predict if a person is a male or female and also their age 3. Mini Project: Colorizing Old B&W Images: color old black and white images to colorful images

Group: B Deep Learning

Assignment No.1

Title of the Assignment: Linear regression by using Deep Neural network: Implement Boston housing price. prediction problem by Linear regression using Deep Neural network. Use Boston House price prediction dataset.

Objective of the Assignment: Students should be able to perform Linear regression by using Deep Neural network on Boston House Dataset.

Prerequisite:

1. Basic of programming language
 2. Concept of Linear Regression
 3. Concept of Deep Neural Network
-

Contents for Theory:

1. What is Linear Regression
 2. Example of Linear Regression
 3. Concept of Deep Neural Network
 4. How Deep Neural Network Work
 5. Code Explanation with Output
-

What is Linear Regression?

Linear regression is a statistical approach that is commonly used to model the relationship between a dependent variable and one or more independent variables. It assumes a linear relationship between the variables and uses mathematical methods to estimate the coefficients that best fit the data. Deep neural networks are a type of machine learning algorithm that are modeled after the structure and function of the human brain. They consist of multiple layers of interconnected neurons that process data and learn from it to make predictions or classifications.

Linear regression using deep neural networks combines the principles of linear regression with the power of deep learning algorithms. In this approach, the input features are passed through one or more layers of neurons to extract features and then a linear regression model is applied to the output of the last layer to make predictions. The weights and biases of the neural network are adjusted during training to optimize the performance of the model.

This approach can be used for a variety of tasks, including predicting numerical values, such as stock prices or housing prices, and classifying data into categories, such as detecting whether an image contains a particular object or not. It is often used in fields such as finance, healthcare, and image recognition.

Example Of Linear Regression

A suitable example of linear regression using deep neural network would be predicting the price of a house based on various features such as the size of the house, the number of bedrooms, the location, and the age of the house.

In this example, the input features would be fed into a deep neural network, consisting of multiple layers of interconnected neurons. The first few layers of the network would learn to extract features from the input data, such as identifying patterns and correlations between the input features. The output of the last layer would then be passed through a linear regression model, which would use the learned features to predict the price of the house.

During training, the weights and biases of the neural network would be adjusted to minimize the difference between the predicted price and the actual price of the house. This process is known as gradient descent, and it involves iteratively adjusting the model's parameters until the optimal values are reached. Once the model is trained, it can be used to predict the price of a new house based on its features. This approach can be used in the real estate industry to provide accurate and reliable estimates of house prices, which can help both buyers and sellers make informed decisions.

Concept of Deep Neural Network-

A deep neural network is a type of machine learning algorithm that is modeled after the structure and function of the human brain. It consists of multiple layers of interconnected nodes, or artificial neurons, that process data and learn from it to make predictions or classifications. Each layer of the network performs a specific type of processing on the data, such as identifying patterns or correlations between features, and passes the results to the next layer. The layers closest to the input are known as the "input layer", while the layers closest to the output are known as the "output layer". The intermediate layers between the input and output layers are known as "hidden layers". These layers are responsible for extracting increasingly complex features from the input data, and can be deep (i.e., containing many hidden layers) or shallow (i.e., containing only a few hidden layers).

Deep neural networks are trained using a process known as backpropagation, which involves adjusting the weights and biases of the nodes based on the error between the predicted output

and the actual output. This process is repeated for multiple iterations until the model reaches an optimal level of accuracy.

Deep neural networks are used in a variety of applications, such as image and speech recognition, natural language processing, and recommendation systems. They are capable of learning from vast amounts of data and can automatically extract features from raw data, making them a powerful tool for solving complex problems in a wide range of domains.

How Deep Neural Network Work-

Boston House Price Prediction is a common example used to illustrate how a deep neural network can work for regression tasks. The goal of this task is to predict the price of a house in Boston based on various features such as the number of rooms, crime rate, and accessibility to public transportation. Here's how a deep neural network can work for Boston House Price Prediction:

1. **Data pre-processing:** The first step is to pre-process the data. This involves normalizing the input features to have a mean of 0 and a standard deviation of 1, which helps the network learn more efficiently. The dataset is then split into training and testing sets.
2. **Model architecture:** A deep neural network is then defined with multiple layers. The first layer is the input layer, which takes in the normalized features. This is followed by several hidden layers, which can be deep or shallow. The last layer is the output layer, which predicts the house price.
3. **Model training:** The model is then trained using the training set. During training, the weights and biases of the nodes are adjusted based on the error between the predicted output and the actual output. This is done using an optimization algorithm such as stochastic gradient descent.
4. **Model evaluation:** Once the model is trained, it is evaluated using the testing set. The performance of the model is measured using metrics such as mean squared error or mean absolute error.
5. **Model prediction:** Finally, the trained model can be used to make predictions on new data, such as predicting the price of a new house in Boston based on its features.
6. By using a deep neural network for Boston House Price Prediction, we can obtain accurate predictions based on a large set of input features. This approach is scalable and can be used for other regression tasks as well.

7. Boston House Price Prediction Dataset-

Boston House Price Prediction is a well-known dataset in machine learning and is often used to demonstrate regression analysis techniques. The dataset contains information about 506 houses in Boston, Massachusetts, USA. The goal is to predict the median value of owner-occupied homes in thousands of dollars.

The dataset includes 13 input features, which are:

CRIM: per capita crime rate by town

ZN: proportion of residential land zoned for lots over 25,000 sq.ft.

INDUS: proportion of non-retail business acres per town

CHAS: Charles River dummy variable (1 if tract bounds river; 0 otherwise)

NOX: nitric oxides concentration (parts per 10 million)

RM: average number of rooms per dwelling

AGE: proportion of owner-occupied units built prior to 1940

DIS: weighted distances to five Boston employment centers

RAD: index of accessibility to radial highways

TAX: full-value property-tax rate per \$10,000

PTRATIO: pupil-teacher ratio by town

B: $1000(B_k - 0.63)^2$ where B_k is the proportion of black people by town

LSTAT: % lower status of the population

The output variable is the median value of owner-occupied homes in thousands of dollars (MEDV). To predict the median value of owner-occupied homes, a regression model is trained on the dataset. The model can be a simple linear regression model or a more complex model, such as a deep neural network. After the model is trained, it can be used to predict the median value of owner-occupied homes based on the input features. The model's accuracy can be evaluated using metrics such as mean squared error or mean absolute error.

Boston House Price Prediction is an example of regression analysis and is often used to teach machine learning concepts. The dataset is also used in research to compare the performance of different regression models.

Source Code with Explanation-

```
#Importing the pandas for data processing and numpy for numerical computing
```

```
import numpy as np
```

```
import pandas as pd
```

```
# Importing the Boston Housing dataset from the sklearn
```

```
from sklearn.datasets import load_boston
```

```
boston = load_boston()
```

```
#Converting the data into pandas dataframe
```

```
data = pd.DataFrame(boston.data)
```

```
#First look at the data
```

```
data.head()
```

	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33

```
#Adding the feature names to the dataframe
```

```
data.columns = boston.feature_names
```

```
#Adding the target variable to the dataset
```

```
data['PRICE'] = boston.target
```

```
#Looking at the data with names and target variable
```

```
data.head(n=10)
```

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTAT	PRICE
0	0.00632	18.0	2.31	0.0	0.538	6.575	65.2	4.0900	1.0	296.0	15.3	396.90	4.98	24.0
1	0.02731	0.0	7.07	0.0	0.469	6.421	78.9	4.9671	2.0	242.0	17.8	396.90	9.14	21.6
2	0.02729	0.0	7.07	0.0	0.469	7.185	61.1	4.9671	2.0	242.0	17.8	392.83	4.03	34.7
3	0.03237	0.0	2.18	0.0	0.458	6.998	45.8	6.0622	3.0	222.0	18.7	394.63	2.94	33.4
4	0.06905	0.0	2.18	0.0	0.458	7.147	54.2	6.0622	3.0	222.0	18.7	396.90	5.33	36.2
5	0.02985	0.0	2.18	0.0	0.458	6.430	58.7	6.0622	3.0	222.0	18.7	394.12	5.21	28.7
6	0.08829	12.5	7.87	0.0	0.524	6.012	66.6	5.5605	5.0	311.0	15.2	395.60	12.43	22.9
7	0.14455	12.5	7.87	0.0	0.524	6.172	96.1	5.9505	5.0	311.0	15.2	396.90	19.15	27.1
8	0.21124	12.5	7.87	0.0	0.524	5.631	100.0	6.0821	5.0	311.0	15.2	386.63	29.93	16.5
9	0.17004	12.5	7.87	0.0	0.524	6.004	85.9	6.5921	5.0	311.0	15.2	386.71	17.10	18.9

```
#Shape of the data
```

```
print(data.shape)
```

```
#Checking the null values in the dataset
```

```
data.isnull().sum()
```

```
CRIM 0
```

```
ZN 0
```

```

INDUS 0
CHAS 0
NOX 0
RM 0
AGE 0
DIS 0
RAD 0
TAX 0
PTRATIO 0
B 0
LSTAT 0
PRICE 0
dtype: int64

```

#Checking the statistics of the data

```
data.describe()
```

This is sometimes very useful, for example if you look at the CRIM the max is 88.97 and 75% of the value is below 3.677083 and # mean is 3.613524 so it means the max values is actually an outlier or there are

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO
count	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000	506.000000
mean	3.613524	11.363636	11.136779	0.069170	0.554695	6.284634	68.574901	3.795043	9.549407	408.237154	18.455534
std	8.601545	23.322453	6.860353	0.253994	0.115878	0.702617	28.148861	2.105710	8.707259	168.537116	2.164946
min	0.006320	0.000000	0.460000	0.000000	0.385000	3.561000	2.900000	1.129600	1.000000	187.000000	12.600000
25%	0.082045	0.000000	5.190000	0.000000	0.449000	5.885500	45.025000	2.100175	4.000000	279.000000	17.400000
50%	0.256510	0.000000	9.690000	0.000000	0.538000	6.208500	77.500000	3.207450	5.000000	330.000000	19.050000
75%	3.677083	12.500000	18.100000	0.000000	0.624000	6.623500	94.075000	5.188425	24.000000	666.000000	20.200000
max	88.976200	100.000000	27.740000	1.000000	0.871000	8.780000	100.000000	12.126500	24.000000	711.000000	22.000000

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
```

```
RangeIndex: 506 entries, 0 to 505
```

```
Data columns (total 14 columns):
```

```
# Column Non-Null Count Dtype
```

```
-- -----
```

```
0 CRIM 506 non-null float64
```

```
1 ZN 506 non-null float64
```

```
2 INDUS 506 non-null float64
3 CHAS 506 non-null float64
4 NOX 506 non-null float64
5 RM 506 non-null float64
6 AGE 506 non-null float64
7 DIS 506 non-null float64
8 RAD 506 non-null float64
9 TAX 506 non-null float64
10 PTRATIO 506 non-null float64
11 B 506 non-null float64
12 LSTAT 506 non-null float64
13 PRICE 506 non-null float64
```

```
dtypes: float64(14)
```

```
memory usage: 55.5 KB
```

```
#checking the distribution of the target variable
```

```
import seaborn as sns
```

```
sns.distplot(data.PRICE)
```

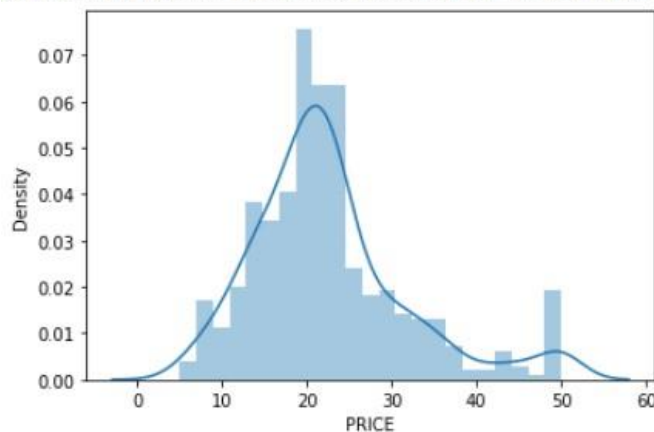
```
#The distribution seems normal, has not be the data normal we would have perform log transformation or took to square root of the data to make the data normal.
```

```
# Normal distribution is need for the machine learning for better predictibilty of the model
```

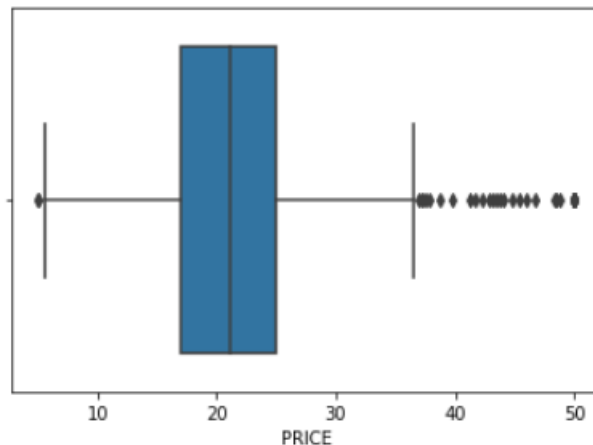
```
#Distribution using box plot
```

```
sns.boxplot(data.PRICE)
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f44d082c670>
```



```
<matplotlib.axes._subplots.AxesSubplot at 0x7f44d077ed60>
```



#Checking the correlation of the independent feature with the dependent feature

Correlation is a statistical technique that can show whether and how strongly pairs of variables are related. An intelligent correlation analysis can lead to a greater understanding of your data

#checking Correlation of the data

```
correlation = data.corr()
```

```
correlation.loc['PRICE']
```

```
CRIM -0.388305
```

```
ZN 0.360445
```

```
INDUS -0.483725
```

```
CHAS 0.175260
```

```
NOX -0.427321
```

```
RM 0.695360
```

```
AGE -0.376955
```

```
DIS 0.249929
```

```
RAD -0.381626
```

```
TAX -0.468536
```

```
PTRATIO -0.507787
```

```
B 0.333461
```

```
LSTAT -0.737663
```

```
PRICE 1.000000
```

```
Name: PRICE, dtype: float64
```

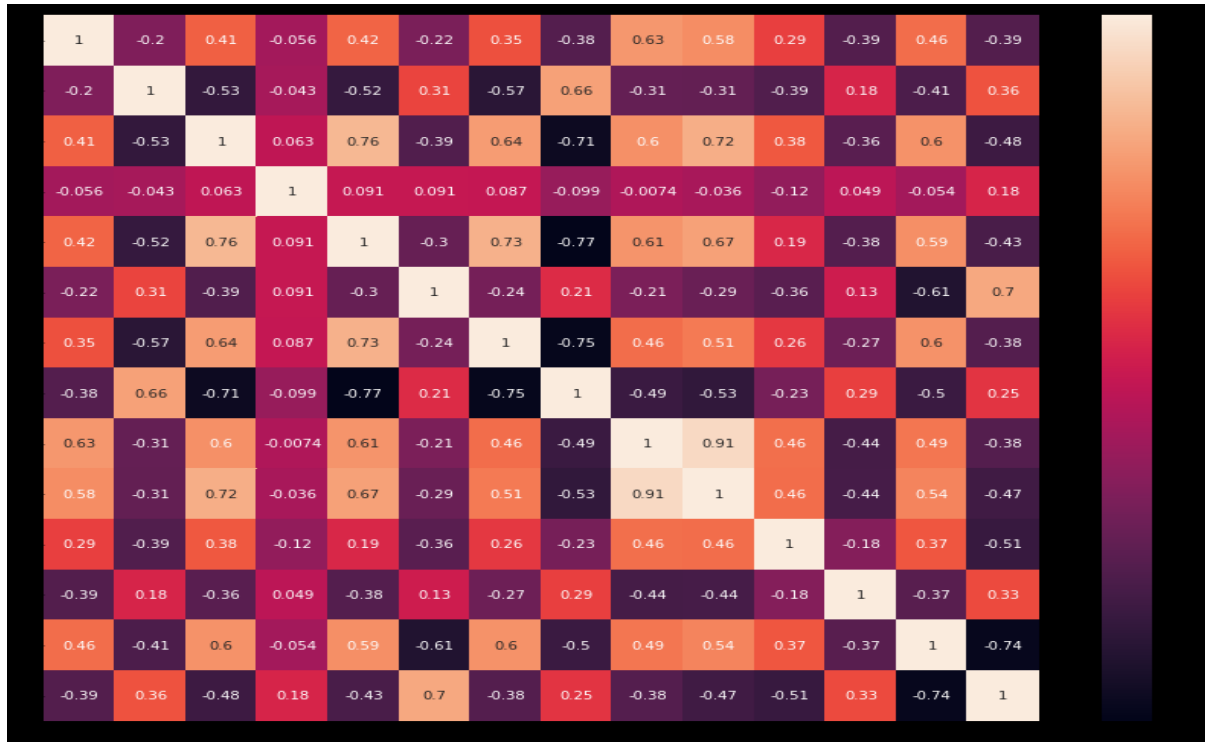
plotting the heatmap

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

```
fig,axes = plt.subplots(figsize=(15,12))
```

```
sns.heatmap(correlation,square = True,annot = True)
```

By looking at the correlation plot LSTAT is negatively correlated with -0.75 and RM is positively correlated to the price and PTRATIO is correlated negatively with -0.51



Checking the scatter plot with the most correlated features

```
plt.figure(figsize = (20,5))
```

```
features = ['LSTAT','RM','PTRATIO']
```

```
for i, col in enumerate(features):
```

```
plt.subplot(1, len(features) , i+1)
```

```
x = data[col]
```

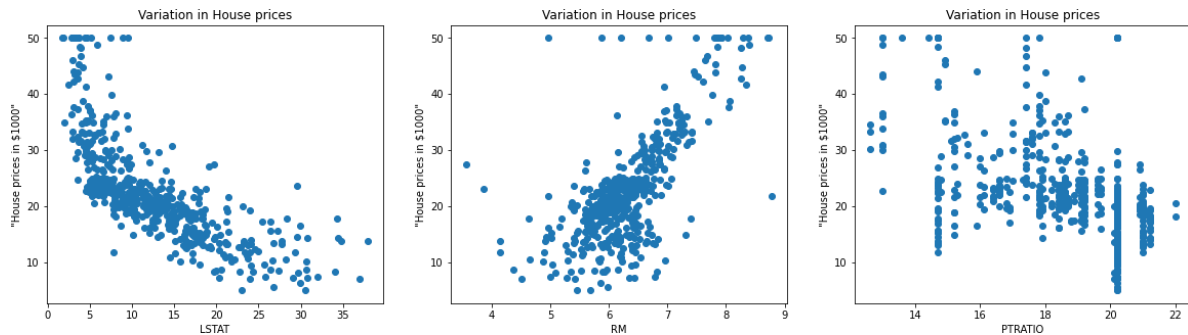
```
y = data.PRICE
```

```
plt.scatter(x, y, marker='o')
```

```
plt.title("Variation in House prices")
```

```
plt.xlabel(col)
```

```
plt.ylabel("House prices in $1000")
```



Splitting the dependent feature and independent feature

```
#X = data[['LSTAT','RM','PTRATIO']]
```

```
X = data.iloc[:, :-1]
```

```
y= data.PRICE
```

In order to provide a standardized input to our neural network, we need to perform the normalization of our dataset.

This can be seen as a step to reduce the differences in scale that may arise from the existent features.

We perform this normalization by subtracting the mean from our data and dividing it by the standard deviation.

One more time, this normalization should only be performed by using the mean and standard deviation from the training set,

in order to avoid any information leak from the test set.

```
mean = X_train.mean(axis=0)
```

```
std = X_train.std(axis=0)
```

```
X_train = (X_train - mean) / std
```

```
X_test = (X_test - mean) / std
```

#Linear Regression

```
from sklearn.linear_model import LinearRegression
```

```
regressor = LinearRegression()
```

#Fitting the model

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

Model Evaluation

#Prediction on the test dataset

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

Predicting RMSE the Test set results

```
from sklearn.metrics import mean_squared_error
```



```

rmse = (np.sqrt(mean_squared_error(y_test, y_pred)))
print(rmse)
from sklearn.metrics import r2_score
r2 = r2_score(y_test, y_pred)
print(r2)
# Neural Networks
#Scaling the dataset
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = sc.fit_transform(X_train)
X_test = sc.transform(X_test)
# Due to the small amount of presented data in this dataset, we must be careful to not create an
overly complex model,
# which could lead to overfitting our data. For this, we are going to adopt an architecture based
on two Dense layers,
# the first with 128 and the second with 64 neurons, both using a ReLU activation function.
# A dense layer with a linear activation will be used as output layer.
# In order to allow us to know if our model is properly learning, we will use a mean squared
error loss function and to report the performance of it we will adopt the mean average error
metric.
# By using the summary method from Keras, we can see that we have a total of 10,113
parameters, which is acceptable for us.
#Creating the neural network model
import keras
from keras.layers import Dense, Activation, Dropout
from keras.models import Sequential
model = Sequential()
model.add(Dense(128, activation = 'relu', input_dim = 13))
model.add(Dense(64, activation = 'relu'))
model.add(Dense(32, activation = 'relu'))
model.add(Dense(16, activation = 'relu'))
model.add(Dense(1))
#model.compile(optimizer='adam', loss='mse', metrics=['mae'])
model.compile(optimizer = 'adam', loss = 'mean_squared_error', metrics=['mae'])

```

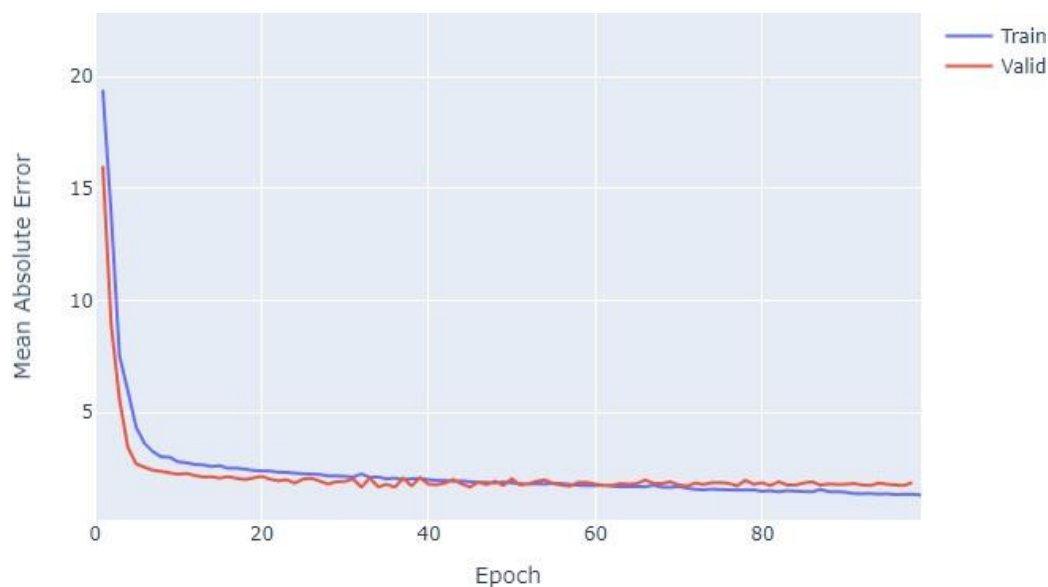
```

!pip install ann_visualizer
!pip install graphviz
from ann_visualizer.visualize import ann_viz;
#Build your model here
ann_viz(model, title="DEMO ANN");
history = model.fit(X_train, y_train, epochs=100, validation_split=0.05)
# By plotting both loss and mean average error, we can see that our model was capable of
learning patterns in our data without overfitting taking place (as shown by the validation set
curves)

from plotly.subplots import make_subplots
import plotly.graph_objects as go
fig = go.Figure()
fig.add_trace(go.Scattergl(y=history.history['loss'],name='Train'))
fig.add_trace(go.Scattergl(y=history.history['val_loss'],name='Valid'))
fig.update_layout(height=500, width=700,xaxis_title='Epoch',yaxis_title='Loss')
fig.show()

fig = go.Figure()
fig.add_trace(go.Scattergl(y=history.history['mae'],name='Train'))
fig.add_trace(go.Scattergl(y=history.history['val_mae'],name='Valid'))
fig.update_layout(height=500, width=700,xaxis_title='Epoch',yaxis_title='Mean Absolute
Error')
fig.show()

```



#Evaluation of the model

```
y_pred = model.predict(X_test)
mse_nn, mae_nn = model.evaluate(X_test, y_test)
print('Mean squared error on test data: ', mse_nn)
print('Mean absolute error on test data: ', mae_nn)
4/4 [=====] - 0s 4ms/step - loss: 10.5717 - mae: 2.2670
Mean squared error on test data: 10.571733474731445
Mean absolute error on test data: 2.2669904232025146
```

#Comparison with traditional approaches

#First let's try with a simple algorithm, the Linear Regression:

```
from sklearn.metrics import mean_absolute_error
lr_model = LinearRegression()
lr_model.fit(X_train, y_train)
y_pred_lr = lr_model.predict(X_test)
mse_lr = mean_squared_error(y_test, y_pred_lr)
mae_lr = mean_absolute_error(y_test, y_pred_lr)
print('Mean squared error on test data: ', mse_lr)
print('Mean absolute error on test data: ', mae_lr)
from sklearn.metrics import r2_score
r2 = r2_score(y_test, y_pred)
print(r2)
0.8812832788381159
```

Predicting RMSE the Test set results

```
from sklearn.metrics import mean_squared_error
rmse = (np.sqrt(mean_squared_error(y_test, y_pred)))
print(rmse)
3.320768607496587
```

Make predictions on new data

```
import sklearn
new_data = sklearn.preprocessing.StandardScaler().fit_transform([[0.1, 10.0,
5.0, 0, 0.4, 6.0, 50, 6.0, 1, 400, 20, 300, 10]])
prediction = model.predict(new_data)
print("Predicted house price:", prediction)
1/1 [=====] - 0s 70ms/step
```

Predicted house price: [[11.104753]]

`#new_data=sklearn.preprocessing.StandardScaler().fit_transform([[0.1, 10.0, 5.0, 0, 0.4, 6.0, 50, 6.0, 1, 400, 20, 300, 10]]))` is a line of code that standardizes the input features of a new data point.

In this specific case, we have a new data point represented as a list of 13 numeric values ([0.1, 10.0, 5.0, 0, 0.4, 6.0, 50, 6.0, 1, 400, 20, 300, 10]) that represents the values for the 13 features of the Boston House Price dataset.

The `StandardScaler()` function from the `sklearn.preprocessing` module is used to standardize the data. Standardization scales each feature to have zero mean and unit variance, which is a common preprocessing step in machine learning to ensure that all features contribute equally to the model. The `fit_transform()` method is used to fit the scaler to the data and apply the standardization transformation. The result is a new data point with standardized feature values.

Conclusion- In this way we can Predict the Boston House Price using Deep Neural Network.

Assignment Question

1. What is Linear Regression?
2. What is a Deep Neural Network?
3. What is the concept of standardization?
4. Why split data into train and test?
5. Write Down Application of Deep Neural Network?

Group B Deep Learning

Assignment No: 2A

Title of the Assignment: Binary classification using Deep Neural Networks Example: Classify movie reviews into positive" reviews and "negative" reviews, just based on the text content of the reviews. Use IMDB dataset

Objective of the Assignment: Students should be able to Classify movie reviews into positive reviews and "negative reviews on IMDB Dataset.

Prerequisite:

1. Basic of programming language
 2. Concept of Classification
 3. Concept of Deep Neural Network
-

Contents for Theory:

1. What is Classification
 2. Example of Classification
 3. How Deep Neural Network Work on Classification
 4. Code Explanation with Output
-

What is Classification?

Classification is a type of supervised learning in machine learning that involves categorizing data into predefined classes or categories based on a set of features or characteristics. It is used to predict the class of new, unseen data based on the patterns learned from the labeled training data.

In classification, a model is trained on a labeled dataset, where each data point has a known class label. The model learns to associate the input features with the corresponding class labels and can then be used to classify new, unseen data.

For example, we can use classification to identify whether an email is spam or not based on its content and metadata, to predict whether a patient has a disease based on their medical records and symptoms, or to classify images into different categories based on their visual features.

Classification algorithms can vary in complexity, ranging from simple models such as decision trees and k-nearest neighbours to more complex models such as support vector machines and

neural networks. The choice of algorithm depends on the nature of the data, the size of the dataset, and the desired level of accuracy and interpretability.

Classification is a common task in deep neural networks, where the goal is to predict the class of an input based on its features. Here's an example of how classification can be performed in a deep neural network using the popular MNIST dataset of handwritten digits.

The MNIST dataset contains 60,000 training images and 10,000 testing images of handwritten digits from 0 to 9. Each image is a grayscale 28x28 pixel image, and the task is to classify each image into one of the 10 classes corresponding to the 10 digits.

We can use a convolutional neural network (CNN) to classify the MNIST dataset. A CNN is a type of deep neural network that is commonly used for image classification tasks.

How Deep Neural Network Work on Classification-

Deep neural networks are commonly used for classification tasks because they can automatically learn to extract relevant features from raw input data and map them to the correct output class. The basic architecture of a deep neural network for classification consists of three main parts: an input layer, one or more hidden layers, and an output layer. The input layer receives the raw input data, which is usually preprocessed to a fixed size and format. The hidden layers are composed of neurons that apply linear transformations and nonlinear activations to the input features to extract relevant patterns and representations. Finally, the output layer produces the predicted class labels, usually as a probability distribution over the possible classes.

During training, the deep neural network learns to adjust its weights and biases in each layer to minimize the difference between the predicted output and the true labels. This is typically done by optimizing a loss function that measures the discrepancy between the predicted and true labels, using techniques such as gradient descent or stochastic gradient descent.

One of the key advantages of deep neural networks for classification is their ability to learn hierarchical representations of the input data. In a deep neural network with multiple hidden layers, each layer learns to capture more complex and abstract features than the previous layer, by building on the representations learned by the earlier layers. This hierarchical structure allows deep neural networks to learn highly discriminative features that can separate different classes of input data, even when the data is highly complex or noisy.

Overall, the effectiveness of deep neural networks for classification depends on the choice of architecture, hyperparameters, and training procedure, as well as the quality and quantity of the training data. When trained properly, deep neural networks can achieve state-of-the-art

performance on a wide range of classification tasks, from image recognition to natural language processing.

IMDB Dataset-The IMDB dataset is a large collection of movie reviews collected from the IMDB website, which is a popular source of user-generated movie ratings and reviews. The dataset consists of 50,000 movie reviews, split into 25,000 reviews for training and 25,000 reviews for testing.

Each review is represented as a sequence of words, where each word is represented by an integer index

based on its frequency in the dataset. The labels for each review are binary, with 0 indicating a negative

review and 1 indicating a positive review.

The IMDB dataset is commonly used as a benchmark for sentiment analysis and text classification tasks, where the goal is to classify the movie reviews as either positive or negative based on their text content. The dataset is challenging because the reviews are often highly subjective and can contain complex language and nuances of meaning, making it difficult for traditional machine learning approaches to accurately classify them.

Deep learning approaches, such as deep neural networks, have achieved state-of-the-art performance on the IMDB dataset by automatically learning to extract relevant features from the raw text data and map them to the correct output class. The IMDB dataset is widely used in research and education for natural language processing and machine learning, as it provides a rich source of labelled text data for training and testing deep learning models.

Source Code and Output-

The IMDB sentiment classification dataset consists of 50,000 movie reviews from IMDB users that are labeled as either positive (1) or negative (0).

The reviews are pre-processed and each one is encoded as a sequence of word indexes in the form of integers.

The words within the reviews are indexed by their overall frequency within the dataset. For example, the integer “2” encodes the second most frequent word in the data.

The 50,000 reviews are split into 25,000 for training and 25,000 for testing.

Text Process word by word at different timestamp (You may use RNN LSTM GRU)

convert input text to vector represent input text

DOMAIN: Digital content and entertainment industry

CONTEXT: The objective of this project is to build a text classification model that analyses the customer's sentiments based on their reviews in the IMDB database. The model uses a

complex deep learning model to build an embedding layer followed by a classification algorithm to analyse the sentiment of the customers.

DATA DESCRIPTION: The Dataset of 50,000 movie reviews from IMDB, labelled by sentiment (positive/negative).

Reviews have been preprocessed, and each review is encoded as a sequence of word indexes (integers).

For convenience, the words are indexed by their frequency in the dataset, meaning the word that has index 1 is the most frequent word.

Use the first 20 words from each review to speed up training, using a max vocabulary size of 10,000.

As a convention, "0" does not stand for a specific word, but instead is used to encode any unknown word.

PROJECT OBJECTIVE: Build a sequential NLP classifier which can use input text parameters to determine the customer sentiments.

```
import numpy as np
```

```
import pandas as pd
```

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

```
#loading imdb data with most frequent 10000 words
```

```
from keras.datasets import imdb
```

```
(X_train, y_train), (X_test, y_test) = imdb.load_data(num_words=10000) # you may take top 10,000
```

```
word frequently used review of movies other are discarded
```

```
#consolidating data for EDA Exploratory data analysis (EDA) is used by data scientists to analyze and investigate data sets and summarize their main characteristics
```

```
data = np.concatenate((X_train, X_test), axis=0) # axis 0 is first running vertically downwards across
```

```
rows (axis 0), axis 1 is second running horizontally across columns (axis 1),
```

```
label = np.concatenate((y_train, y_test), axis=0)
```

```
X_train.shape
```

```
(25000,)
```

```
X_test.shape
```

```
(25000,)
```

```
y_train.shape
```

```
(25000,)
```



```

y_test.shape
(25000,)

print("Review is ",X_train[0])
# series of no converted word to vocabulary associated with index
print("Review is ",y_train[0])
Review is [1, 194, 1153, 194, 8255, 78, 228, 5, 6, 1463, 4369, 5012, 134, 26, 4, 715, 8, 118,
1634, 14, 394, 20, 13, 119, 954, 189, 102, 5, 207, 110, 3103, 21, 14, 69, 188, 8, 30, 23, 7, 4,
249, 126, 93, 4, 114, 9, 2300, 1523, 5, 647, 4, 116, 9, 35, 8163, 4, 229, 9, 340, 1322, 4, 118, 9,
4, 130, 4901, 19, 4, 1002, 5, 89, 29, 952, 46, 37, 4, 455, 9, 45, 43, 38, 1543, 1905, 398, 4, 1649,
26, 6853, 5, 163, 11, 3215, 2, 4, 1153, 9, 194, 775, 7, 8255, 2, 349, 2637, 148, 605, 2, 8003,
15, 123, 125, 68, 2, 6853, 15, 349, 165, 4362, 98, 5, 4, 228, 9, 43, 2, 1157, 15, 299, 120, 5, 120,
174, 11, 220, 175, 136, 50, 9, 4373, 228, 8255, 5, 2, 656, 245, 2350, 5, 4, 9837, 131, 152, 491,
18, 2, 32, 7464, 1212, 14, 9, 6, 371, 78, 22, 625, 64, 1382, 9, 8, 168, 145, 23, 4, 1690, 15, 16,
4, 1355, 5, 28, 6, 52, 154, 462, 33, 89, 78, 285, 16, 145, 95]
Review is 0
vocab=imdb.get_word_index() # Retrieve the word index file mapping words to indices
print(vocab)
{'fawn': 34701, 'tsukino': 52006, 'hunnery': 52007, 'sonja': 16816, 'vani': 63951, 'woods': 1408,
'spiders':
16115,
y_train
array([1, 0, 0, ..., 0, 1, 0])
y_test
array([0, 1, 1, ..., 0, 0, 0])
# Function to perform relevant sequence adding on the data
# Now it is time to prepare our data. We will vectorize every review and fill it with zeros so
that it contains exactly 10000 numbers.
# That means we fill every review that is shorter than 500 with zeros.
# We do this because the biggest review is nearly that long and every input for our neural
network needs
to have the same size.
# We also transform the targets into floats.
# sequences is name of method the review less than 10000 we perform padding overthere
# binary vectorization code:

```

```

# VECTORIZE as one cannot feed integers into a NN
# Encoding the integer sequences into a binary matrix - one hot encoder basically
# From integers representing words, at various lengths - to a normalized one hot encoded tensor
(matrix) of 10k columns
def vectorize(sequences, dimension = 10000)
: # We will vectorize every review and fill it with zeros so that it contains exactly 10,000
numbers.# Create an all-zero matrix of shape (len(sequences), dimension)
results = np.zeros((len(sequences), dimension))
for i, sequence in enumerate(sequences):
results[i, sequence] = 1
return results

# Now we split our data into a training and a testing set.
# The training set will contain reviews and the testing set
# # Set a VALIDATION set
test_x = data[:10000]
test_y = label[:10000]
train_x = data[10000:]
train_y = label[10000:]
test_x.shape
(10000,)
test_y.shape
(10000,)
train_x.shape
(40000,)
train_y.shape
(40000,)
print("Categories:", np.unique(label))
print("Number of unique words:", len(np.unique(np.hstack(data))))
SNJB's Late Sau. K.B. Jain College Of Engineering
# The hstack() function is used to stack arrays in sequence horizontally (column wise).
Categories: [0 1]
Number of unique words: 9998
length = [len(i) for i in data]
print("Average Review length:", np.mean(length))

```

```
print("Standard Deviation:", round(np.std(length)))
```

The whole dataset contains 9998 unique words and the average review length is 234 words, with a standard deviation of 173 words.

Average Review length: 234.75892

Standard Deviation: 173

If you look at the data you will realize it has been already pre-processed.

All words have been mapped to integers and the integers represent the words sorted by their frequency.

This is very common in text analysis to represent a dataset like this.

So 4 represents the 4th most used word,

5 the 5th most used word and so on...

The integer 1 is reserved for the start marker,

the integer 2 for an unknown word and 0 for padding.

Let's look at a single training example:

```
print("Label:", label[0])
```

Label: 1

```
print("Label:", label[1])
```

Label: 0

```
print(data[0])
```

Retrieves a dict mapping words to their index in the IMDB dataset.

```
index = imdb.get_word_index() # word to index
```

Create inverted index from a dictionary with document ids as keys and a list of terms as values for each document

```
reverse_index = dict([(value, key) for (key, value) in index.items()]) # id to word
```

```
decoded = " ".join( [reverse_index.get(i - 3, "#") for i in data[0]] )
```

The indices are offset by 3 because 0, 1 and 2 are reserved indices for "padding", "start of sequence" and "unknown".

```
print(decoded)
```

this film was just brilliant casting location scenery story direction everyone's really suited the part they played and you could just imagine being there robert # is an amazing actor and now the same being director # father came from the same scottish island as myself so i loved the fact there was a real connection with this film the witty remarks throughout the film

#Adding sequence to data

Vectorization is the process of converting textual data into numerical vectors and is a process that is usually applied once the text is cleaned.

```
data = vectorize(data)
label = np.array(label).astype("float32")
labelDF=pd.DataFrame({'label':label})
sns.countplot(x='label', data=labelDF)
```

Creating train and test data set

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(data,label, test_size=0.20, random_state=1)
X_train.shape
(40000, 10000)
X_test.shape
(10000, 10000)
```

Let's create sequential model

```
from keras.utils import to_categorical
from keras import models
from keras import layers
model = models.Sequential()
```

Input - Layer

Note that we set the input-shape to 10,000 at the input-layer because our reviews are 10,000 integers long.

The input-layer takes 10,000 as input and outputs it with a shape of 50.

```
model.add(layers.Dense(50, activation = "relu", input_shape=(10000, )))
```

Hidden - Layers

Please note you should always use a dropout rate between 20% and 50%. # here in our case 0.3 means 30% dropout we are using dropout to prevent overfitting.

By the way, if you want you can build a sentiment analysis without LSTMs, then you simply need to replace it by a flatten layer:

```
model.add(layers.Dropout(0.3, noise_shape=None, seed=None))
```

```
model.add(layers.Dense(50, activation = "relu"))
```

```
model.add(layers.Dropout(0.2, noise_shape=None, seed=None))
```

```
model.add(layers.Dense(50, activation = "relu"))
```

Output- Layer

```
model.add(layers.Dense(1, activation = "sigmoid"))
```

```
model.summary()
```

Model: "sequential"

Layer (type)	Output Shape	Param #
--------------	--------------	---------

dense (Dense)	(None, 50)	500050
---------------	------------	--------

dropout (Dropout)	(None, 50)	0
-------------------	------------	---

dense_1 (Dense)	(None, 50)	2550
-----------------	------------	------

dropout_1 (Dropout)	(None, 50)	0
---------------------	------------	---

dense_2 (Dense)	(None, 50)	2550
-----------------	------------	------

dense_3 (Dense)	(None, 1)	51
-----------------	-----------	----

Total params: 505,201

Trainable params: 505,201

Non-trainable params: 0

#For early stopping

Stop training when a monitored metric has stopped improving.

monitor: Quantity to be monitored.

patience: Number of epochs with no improvement after which training will be stopped.

```
import tensorflow as tf
```

```
callback = tf.keras.callbacks.EarlyStopping(monitor='loss', patience=3)
```

We use the “adam” optimizer, an algorithm that changes the weights and biases during training.

We also choose binary-crossentropy as loss (because we deal with binary classification) and accuracy as our evaluation metric.

```
model.compile(
```

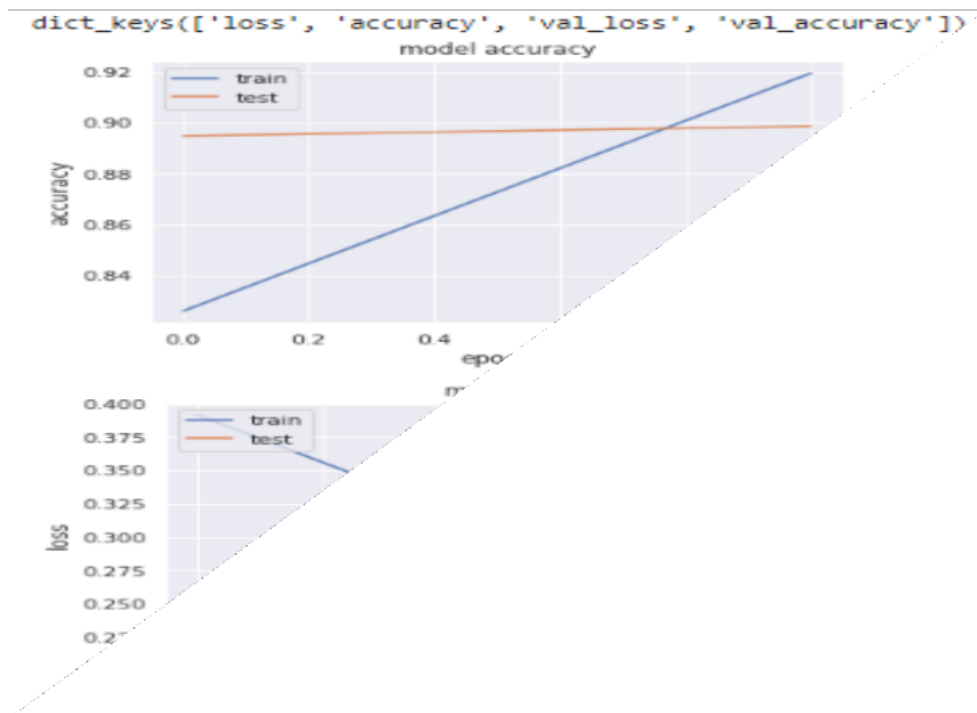
```

optimizer = "adam",
loss = "binary_crossentropy",
metrics = ["accuracy"]
)

from sklearn.model_selection import train_test_split
results = model.fit( X_train, y_train, epochs= 2, batch_size = 500, validation_data = (X_test,
y_test), callbacks=[callback])
# Let's check mean accuracy of our model
print(np.mean(results.history["val_accuracy"]))
# Evaluate the model
score = model.evaluate(X_test, y_test, batch_size=500)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
20/20 [=====] - 1s 24ms/step - loss: 0.2511 - accuracy:
0.8986
Test loss: 0.25108325481414795
Test accuracy: 0.8985999822616577
#Let's plot training history of our model.
# list all data in history
print(results.history.keys())
# Summarize history for accuracy
plt.plot(results.history['accuracy'])
plt.plot(results.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc='upper left')
plt.show()
# summarize history for loss
plt.plot(results.history['loss'])
plt.plot(results.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')

```

```
plt.legend(['train', 'test'], loc='upper left')  
plt.show()
```



Conclusion- In this way we can Classify the Movie Reviews by using DNN.

Assignment Question

1. What is Binary Classification?
2. What is binary Cross Entropy?
3. What is Validation Split?
4. What is the Epoch Cycle?
5. What is Adam Optimizer?

Group B Deep Learning

Assignment No: 2B

Title of the Assignment: Multiclass classification using Deep Neural Networks: Example: Use the OCR letter recognition dataset <https://archive.ics.uci.edu/ml/datasets/letter+recognition>

Objective of the Assignment: Students should be able to solve Multiclass classification using Deep Neural Networks Solve

Prerequisite:

1. Basic of programming language
 2. Concept of Multi Classification
 3. Concept of Deep Neural Network
-

Contents for Theory:

1. What is Multi-Classification
 2. Example of Multi-Classification
 3. How Deep Neural Network Work on Multi-Classification
 4. Code Explanation with Output
-

What is multiclass classification?

Multi Classification, also known as multiclass classification or multiclass classification problem, is a type of classification problem where the goal is to assign input data to one of three or more classes or categories. In other words, instead of binary classification, where the goal is to assign input data to one of two classes (e.g., positive or negative), multiclass classification involves assigning input data to one of several possible classes or categories (e.g., animal species, types of products, etc.).

In multiclass classification, each input sample is associated with a single class label, and the goal of the model is to learn a function that can accurately predict the correct class label for new, unseen input data. Multiclass classification can be approached using a variety of machine learning algorithms, including decision trees, support vector machines, and deep neural networks. Some examples of multiclass classification problems include image classification, where the goal is to classify images into one of several categories (e.g., animals, vehicles, buildings), and text classification, where the goal is to classify text documents into one of several categories (e.g., news topics, sentiment analysis).

Example of multiclass classification-

Here are a few examples of multiclass classification problems:

Image classification: The goal is to classify images into one of several categories. For example, an image classification model might be trained to classify images of animals into categories such as cats, dogs, and birds.

Text classification: The goal is to classify text documents into one of several categories. For example, a text classification model might be trained to classify news articles into categories such as politics, sports, and entertainment.

Disease diagnosis: The goal is to diagnose patients with one of several diseases based on their symptoms and medical history. For example, a disease diagnosis model might be trained to classify patients into categories such as diabetes, cancer, and heart disease.

Speech recognition: The goal is to transcribe spoken words into text. A speech recognition model might be trained to recognize spoken words in several languages or dialects.

Credit risk analysis: The goal is to classify loan applicants into categories such as low risk, medium risk, and high risk. A credit risk analysis model might be trained to classify loan applicants based on their credit score, income, and other factors. In all of these examples, the goal is to assign input data to one of several possible classes or categories.

Multiclass classification is a common task in machine learning and can be approached using a variety of algorithms, including decision trees, support vector machines, and deep neural networks.

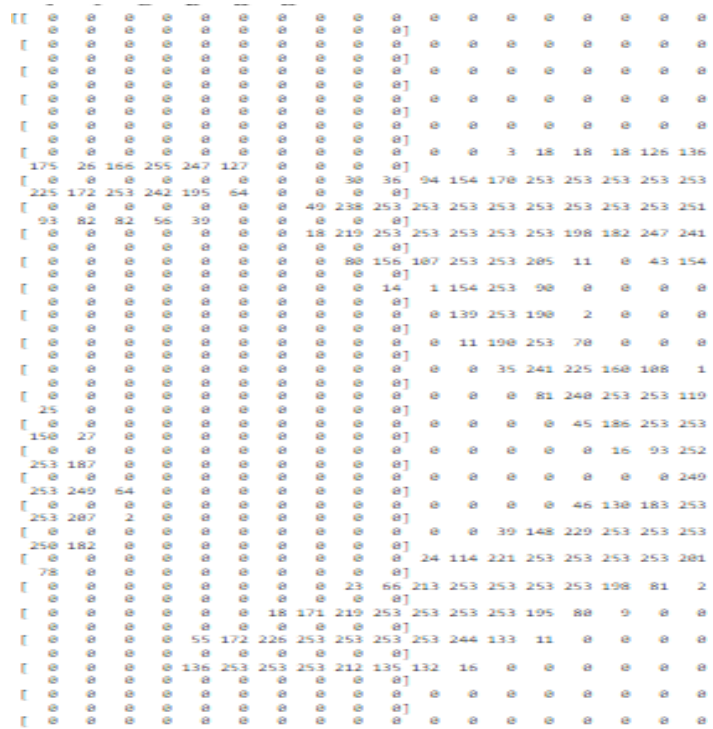
Source Code and Output

```
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout
from tensorflow.keras.optimizers import RMSprop
from tensorflow.keras.datasets import mnist
import matplotlib.pyplot as plt
from sklearn import metrics

# Load the OCR dataset
# The MNIST dataset is a built-in dataset provided by Keras.
# It consists of 70,000 28x28 grayscale images, each of which displays a single handwritten digit from 0 to 9.
# The training set consists of 60,000 images, while the test set has 10,000 images.
```

```
(x_train, y_train), (x_test, y_test) = mnist.load_data()

# X_train and X_test are our array of images while y_train and y_test are our array of labels
# for each image.
# The first tuple contains the training set features (X_train) and the training set labels (y_train).
# The second tuple contains the testing set features (X_test) and the testing set labels (y_test).
# For example, if the image shows a handwritten 7, then the label will be the integer 7.
plt.imshow(x_train[0], cmap='gray') # imshow() function which simply displays an image.
plt.show() # cmap is responsible for mapping a specific colormap to the values found in the
# array that you passed as the first argument.
# This is because of the format that all the images in the dataset have:
# 1. All the images are grayscale, meaning they only contain black, white and grey.
# 2. The images are 28 pixels by 28 pixels in size (28x28).
print(x_train[0])
# image data is just an array of digits. You can almost make out a 5 from the pattern of the
# digits in the array.
# Array of 28 values
# a grayscale pixel is stored as a digit between 0 and 255 where 0 is black, 255 is white and
# values in between are different shades of gray.
# Therefore, each value in the [28][28] array tells the computer which color to put in that
# position when.
```



```
# Reshape the data to fit the model
```

```
print("y_train shape", y_train.shape)
```

```
print("y_test shape", y_test.shape)
```

x_train and x_test have 3 dimensional shapes because they have a width and height (28x28 pixels) for each element.

The pixel value varies between 0 to 255.

(10000, 28, 28) Testing data that consists of grayscale images. It has the shape (10000, 28, 28) and the dtype of uint8. The pixel value varies between 0 to 255.

(10000,) Testing labels that consist of integers from 0-9 with dtype uint8. It has the shape (10000,).

```

X_train shape (60000, 28, 28)
y_train shape (60000,)
X_test shape (10000, 28, 28)
y_test shape (10000,)
# X: Training data of shape (n_samples, n_features)
# y: Training label values of shape (n_samples, n_labels)
# 2D array of height and width, 28 pixels by 28 pixels will just become 784 pixels (28 squared).
# Remember that X_train has 60,000 elements, each with 784 total pixels so will become
shape (60000, 784).
# Whereas X_test has 10,000 elements, each with each with 784 total pixels so will become
shape (10000, 784).
x_train = x_train.reshape(60000, 784)
x_test = x_test.reshape(10000, 784)
x_train = x_train.astype('float32') # use 32-bit precision when training a neural network, so at
one point the training data will have to be converted to 32 bit floats. Since the dataset fits easily
in RAM, we might as well convert to float immediately.
x_test = x_test.astype('float32')
x_train /= 255 # Each image has Intensity from 0 to 255
x_test /= 255
# Regarding the division by 255, this is the maximum value of a byte (the input feature's type
before the conversion to float32),
# so this will ensure that the input features are scaled between 0.0 and 1.0.
# Convert class vectors to binary class matrices
num_classes = 10
y_train = np.eye(num_classes)[y_train] # Return a 2-D array with ones on the diagonal and
zeros elsewhere.
y_test = np.eye(num_classes)[y_test] # f your particular categories is present then it mark as 1
else 0 in remain row # Define the model architecture
model = Sequential()
model.add(Dense(512, activation='relu', input_shape=(784,)))
# Input consist of 784 Neuron ie 784 input, 512 in the hidden layer
model.add (Dropout(0.2)) # DROP OUT RATIO 20%
model.add(Dense(512, activation='relu'))
#returns a sequence of another vectors of dimension 512

```

```

model.add(Dropout(0.2))
model.add(Dense(num_classes, activation='softmax')) # 10 neurons ie output node in the
output layer.
# Compile the model
model.compile(loss='categorical_crossentropy', # for a multi-class classification problem
optimizer=RMSprop(),
metrics=['accuracy'])
# Train the model
batch_size = 128
# batch_size argument is passed to the layer to define a batch size for the inputs.
epochs = 20
history = model.fit(x_train, y_train,
batch_size=batch_size,
epochs=epochs,
verbose=1, # verbose=1 will show you an animated progress bar eg. [=====]
validation_data=(x_test, y_test)) # Using validation_data means you are providing the training
set and validation set yourself, # 60000image/128=469 batch each # Evaluate the model
score = model.evaluate(x_test, y_test, verbose=0)
print('Test loss:', score[0])
print('Test accuracy:', score[1])
Test loss: 0.08541901409626007
Test accuracy: 0.9851999878883362

```

Conclusion- In this way we can do Multi classification using DNN.

Assignment Question

1. What is Batch Size?
2. What is Dropout?
3. What is RMSprop?
4. What is the Softmax Function?
5. What is the Relu Function?

Group B Deep Learning

Assignment No: 3B

Title of the Assignment: Use MNIST Fashion Dataset and create a classifier to classify fashion clothing into categories.

Objective of the Assignment: Students should be able to Use MNIST Fashion Dataset and create a classifier to classify fashion clothing into categories.

Prerequisite:

1. Basic of programming language
 2. Concept of Classification
 3. Concept of Deep Neural Network
-

Contents for Theory:

1. What is Classification
 2. Example of Classification
 3. What is CNN?
 4. How Deep Neural Network Work on Classification
 5. Code Explanation with Output
-

What is Classification?

Classification is a type of supervised learning in machine learning that involves categorizing data into predefined classes or categories based on a set of features or characteristics. It is used to predict the class of new, unseen data based on the patterns learned from the labeled training data. In classification, a model is trained on a labeled dataset, where each data point has a known class label. The model learns to associate the input features with the corresponding class labels and can then be used to classify new, unseen data.

For example, we can use classification to identify whether an email is spam or not based on its content and metadata, to predict whether a patient has a disease based on their medical records and symptoms, or to classify images into different categories based on their visual features.

Classification algorithms can vary in complexity, ranging from simple models such as decision trees and k-nearest neighbours to more complex models such as support vector machines and neural networks. The choice of algorithm depends on the nature of the data, the size of the dataset, and the desired level of accuracy and interpretability.

Example- Classification is a common task in deep neural networks, where the goal is to predict the class of an input based on its features. Here's an example of how classification can be performed in a deep neural network using the popular MNIST dataset of handwritten digits. The MNIST dataset contains 60,000 training images and 10,000 testing images of handwritten digits from 0 to 9. Each image is a grayscale 28x28 pixel image, and the task is to classify each image into one of the 10 classes corresponding to the 10 digits. We can use a convolutional neural network (CNN) to classify the MNIST dataset. A CNN is a type of deep neural network that is commonly used for image classification tasks.

What us CNN

Convolutional Neural Networks (CNNs) are commonly used for image classification tasks, and they are designed to automatically learn and extract features from input images. Let's consider an example of using a CNN to classify images of handwritten digits. In a typical CNN architecture for image classification, there are several layers, including convolutional layers, pooling layers, and fully connected layers.

Here's a diagram of a simple CNN architecture for the digit classification task: The input to the network is an image of size 28x28 pixels, and the output is a probability distribution over the 10 possible digits (0 to 9). The convolutional layers in the CNN apply filters to the input image, looking for specific patterns and features. Each filter produces a feature map that highlights areas of the image that match the filter. The filters are learned during training, so the network can automatically learn which features are most relevant for the classification task.

The pooling layers in the CNN down sample the feature maps, reducing the spatial dimensions of the data. This helps to reduce the number of parameters in the network, while also making the features more robust to small variations in the input image.

The fully connected layers in the CNN take the flattened output from the last pooling layer and perform a classification task by outputting a probability distribution over the 10 possible digits. During training, the network learns the optimal values of the filters and parameters by minimizing a loss function. This is typically done using stochastic gradient descent or a similar optimization algorithm. Once trained, the network can be used to classify new images by passing them through the network and computing the output probability distribution.

Overall, CNNs are powerful tools for image recognition tasks and have been used successfully in many applications, including object detection, face recognition, and medical image analysis.

CNNs have a wide range of applications in various fields, some of which are:

Image classification: CNNs are commonly used for image classification tasks, such as identifying objects in images and recognizing faces.

Object detection: CNNs can be used for object detection in images and videos, which involves identifying the location of objects in an image and drawing bounding boxes around them.

Semantic segmentation: CNNs can be used for semantic segmentation, which involves partitioning an image into segments and assigning each segment a semantic label (e.g., "road", "sky", "building").

Natural language processing: CNNs can be used for natural language processing tasks, such as sentiment analysis and text classification.

Medical imaging: CNNs are used in medical imaging for tasks such as diagnosing diseases from X-rays and identifying tumors from MRI scans.

Autonomous vehicles: CNNs are used in autonomous vehicles for tasks such as object detection and lane detection.

Video analysis: CNNs can be used for tasks such as video classification, action recognition, and video captioning.

Overall, CNNs are a powerful tool for a wide range of applications, and they have been used successfully in many areas of research and industry.

How Deep Neural Network Work on Classification using CNN

Deep neural networks using CNNs work on classification tasks by learning to automatically extract features from input images and using those features to make predictions. Here's how it works:

Input layer: The input layer of the network takes in the image data as input.

Convolutional layers: The convolutional layers apply filters to the input images to extract relevant features. Each filter produces a feature map that highlights areas of the image that match the filter.

Activation functions: An activation function is applied to the output of each convolutional layer to introduce non-linearity into the network.

Pooling layers: The pooling layers down sample the feature maps to reduce the spatial dimensions of the data.

Dropout layer: Dropout is used to prevent overfitting by randomly dropping out a percentage of the neurons in the network during training.

Fully connected layers: The fully connected layers take the flattened output from the last pooling layer and perform a classification task by outputting a probability distribution over the possible classes.

Softmax activation function: The softmax activation function is applied to the output of the last fully connected layer to produce a probability distribution over the possible classes.

Loss function: A loss function is used to compute the difference between the predicted probabilities and the actual labels.

Optimization: An optimization algorithm, such as stochastic gradient descent, is used to minimize the loss function by adjusting the values of the network parameters.

Training: The network is trained on a large dataset of labeled images, adjusting the values of the parameters to minimize the loss function.

Prediction: Once trained, the network can be used to classify new images by passing them through the network and computing the output probability distribution.

MNIST Dataset-

The MNIST Fashion dataset is a collection of 70,000 grayscale images of 28x28 pixels, representing 10 different categories of clothing and accessories. The categories include T-shirts/tops, trousers, pullovers, dresses, coats, sandals, shirts, sneakers, bags, and ankle boots. The dataset is often used as a benchmark for testing image classification algorithms, and it is considered a more challenging version of the original MNIST dataset which contains handwritten digits. The MNIST Fashion dataset was released by Zalando Research in 2017 and has since become a popular dataset in the machine learning community.

The MNIST Fashion dataset is a collection of 70,000 grayscale images of 28x28 pixels each. These images represent 10 different categories of clothing and accessories, with each category containing 7,000 images.

The categories are as follows:

T-shirt/tops , Trousers ,Pullover ,Dresses ,Coats, Sandals, Shirts Sneakers, Bags

Ankle boots The images were obtained from Zalando's online store and are pre-processed to be normalized and centered. The training set contains 60,000 images, while the test set contains 10,000 images. The goal of the dataset is to accurately classify the images into their respective categories. The MNIST Fashion dataset is often used as a benchmark for testing image classification algorithms, and it is considered a more challenging version of the original MNIST dataset which contains handwritten digits. The dataset is widely used in the machine learning community for research and educational purposes.

Here are the general steps to perform Convolutional Neural Network (CNN) on the MNIST Fashion dataset:

- Import the necessary libraries, including TensorFlow, Keras, NumPy, and Matplotlib.
- Load the dataset using Keras' built-in function, `keras.datasets.fashion_mnist.load_data()`. This will provide the training and testing sets, which will be used to train and evaluate the CNN.
- Pre-process the data by normalizing the pixel values between 0 and 1, and reshaping the images to be of size (28, 28, 1) for compatibility with the CNN.
- Define the CNN architecture, including the number and size of filters, activation functions, and pooling layers. This can vary based on the specific problem being addressed.
- Compile the model by specifying the loss function, optimizer, and evaluation metrics. Common choices include categorical cross-entropy, Adam optimizer, and accuracy metric.
- Train the CNN on the training set using the `fit()` function, specifying the number of epochs and batch size.
- Evaluate the performance of the model on the testing set using the `evaluate()` function. This will provide metrics such as accuracy and loss on the test set.
- Use the trained model to make predictions on new images, if desired, using the `predict()` function.

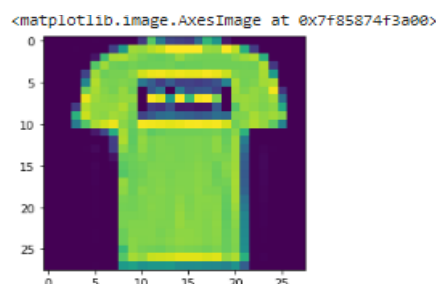
Source Code with Output

```
import tensorflow as tf
import matplotlib.pyplot as plt
from tensorflow import keras
import numpy as np

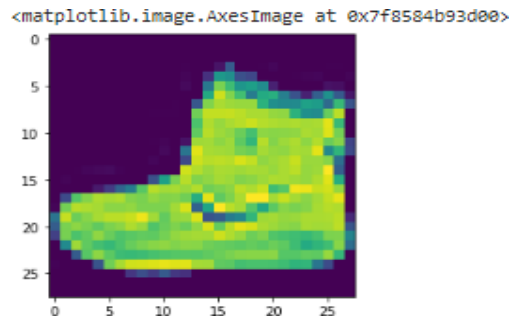
(x_train, y_train), (x_test, y_test) = keras.datasets.fashion_mnist.load_data()

# There are 10 image classes in this dataset and each class has a mapping corresponding to the
following labels: #0 T-shirt/top    #1 Trouser    #2 pullover    #3 Dress    #4 Coat    #5
sandals    #6 shirt    #7 sneaker    #8 bag    #9 ankle boot

plt.imshow(x_train[1])
```



```
plt.imshow(x_train[0])
```



Next, we will preprocess the data by scaling the pixel values to be between 0 and 1, and then reshaping the images to be 28x28 pixels.

```
x_train = x_train.astype('float32') / 255.0
```

```
x_test = x_test.astype('float32') / 255.0
```

```
x_train = x_train.reshape(-1, 28, 28, 1)
```

```
x_test = x_test.reshape(-1, 28, 28, 1)
```

28, 28 comes from width, height, 1 comes from the number of channels

-1 means that the length in that dimension is inferred.

This is done based on the constraint that the number of elements in an ndarray or Tensor when reshaped must remain the same.

each image is a row vector (784 elements) and there are lots of such rows (let it be n, so there are 784n elements). So TensorFlow can infer that -1 is n.

converting the training_images array to 4 dimensional array with sizes 60000, 28, 28, 1 for 0th to 3rd dimension.

```
x_train.shape
```

```
(60000, 28, 28)
```

```
x_test.shape
```

```
(10000, 28, 28, 1)
```

```
y_train.shape
```

```
(60000,)
```

```
y_test.shape
```

```
(10000,)
```

We will use a convolutional neural network (CNN) to classify the fashion items.

The CNN will consist of multiple convolutional layers followed by max pooling,

dropout, and dense layers. Here is the code for the model:

```
model = keras.Sequential([
```

```
keras.layers.Conv2D(32, (3,3), activation='relu', input_shape=(28,28,1)),
```

```

# 32 filters (default), randomly initialized
# 3*3 is Size of Filter
# 28,28,1 size of Input Image
# No zero-padding: every output 2 pixels less in every dimension
# in Parameter shown 320 is value of weights: (3x3 filter weights + 32 bias) * 32 filters
#  $32*3*3=288(\text{Total})+32(\text{bias})= 320$ 
keras.layers.MaxPooling2D((2,2)),
# It shown 13 * 13 size image with 32 channel or filter or depth.
keras.layers.Dropout(0.25),
# Reduce Overfitting of Training sample drop out 25% Neuron
keras.layers.Conv2D(64, (3,3), activation='relu'),
# Deeper layers use 64 filters
# 3*3 is Size of Filter
# Observe how the input image on 28x28x1 is transformed to a 3x3x64 feature map
#  $13(\text{Size})-3(\text{Filter Size})+1(\text{bias})=11$  Size for Width and Height with 64 Depth or filter or channel
# in Parameter shown 18496 is value of weights: (3x3 filter weights + 64 bias) * 64 filters
#  $64*3*3=576+1=577*32 + 32(\text{bias})=18496$ 
keras.layers.MaxPooling2D((2,2)),
# It shown 5 * 5 size image with 64 channel or filter or depth.
keras.layers.Dropout(0.25),
keras.layers.Conv2D(128, (3,3), activation='relu'),
# Deeper layers use 128 filters
# 3*3 is Size of Filter
# Observe how the input image on 28x28x1 is transformed to a 3x3x128 feature map
# It show  $5(\text{Size})-3(\text{Filter Size})+1(\text{bias})=3$  Size for Width and Height with 64 Depth or filter or channel
#  $128*3*3=1152+1=1153*64 + 64(\text{bias})= 73856$ 
# To classify the images, we still need a Dense and Softmax layer.
# We need to flatten the 3x3x128 feature map to a vector of size 1152
keras.layers.Flatten(),
keras.layers.Dense(128, activation='relu'),
# 128 Size of Node in Dense Layer
#  $1152*128 = 147584$ 

```

```

keras.layers.Dropout(0.25),
keras.layers.Dense(10, activation='softmax')
# 10 Size of Node another Dense Layer
# 128*10+10 bias= 1290])
model.summary()
Model: "sequential"
Layer (type) Output Shape Param #
=====
conv2d (Conv2D) (None, 26, 26, 32) 320 max_pooling2d (MaxPooling2D (None, 13, 13, 32)
0 ) dropout (Dropout) (None, 13, 13, 32) 0
conv2d_1 (Conv2D) (None, 11, 11, 64) 18496
max_pooling2d_1 (MaxPooling (None, 5, 5, 64) 02D)
dropout_1 (Dropout) (None, 5, 5, 64) 0
conv2d_2 (Conv2D) (None, 3, 3, 128) 73856
flatten (Flatten) (None, 1152) 0
dense (Dense) (None, 128) 147584
dropout_2 (Dropout) (None, 128) 0
dense_1 (Dense) (None, 10) 1290
=====
Total params: 241,546
Trainable params: 241,546
Non-trainable params: 0
# Compile and Train the Model
# After defining the model, we will compile it and train it on the training data.
model.compile(optimizer='adam',loss='sparse_categorical_crossentropy', etrics=['accuracy'])
history = model.fit(x_train, y_train, epochs=10, validation_data=(x_test, y_test))
# 1875 is a number of batches. By default batches contain 32 samles.60000 / 32 = 1875
# Finally, we will evaluate the performance of the model on the test data.
test_loss, test_acc = model.evaluate(x_test, y_test)
print('Test accuracy:', test_acc)
313/313 [=====] - 3s 10ms/step - loss: 0.2606 - accuracy:
0.9031
Test accuracy: 0.9031000137329102

```

Conclusion- In this way we can Classify fashion clothing into categories using CNN.

Assignment Question

1. What is MNIST dataset for classification?
2. How many classes are in the MNIST dataset?
3. What is 784 in MNIST dataset?
4. How many epochs are there in MNIST?
5. What are the hardest digits in MNIST?

Mini Project -1

Title - Implement Human Face Recognition

Project title: "Celebrity Face Recognition"

Objective: To build a deep neural network model that can recognize the identities of celebrities in the "CelebA" dataset.

Theory - Human face recognition using deep neural networks involves building a neural network model that can take an image of a human face as input and accurately recognize the person in the image. Here is a sample code using TensorFlow to implement a basic face recognition system using a deep neural network:

Human face recognition using deep neural networks (DNNs) involves training a neural network to identify and distinguish between different faces. The process typically involves the following steps:

Data collection: A large dataset of face images is collected, including images of different individuals and under different lighting and pose conditions.

Data preprocessing: The face images are preprocessed to remove noise, align the faces, and normalize the illumination.

Feature extraction: The preprocessed face images are then fed into a deep neural network to extract high-level features that capture the important characteristics of a face. The neural network typically consists of several layers of convolutional and pooling operations, followed by fully connected layers that produce a feature vector.

Training: The extracted features are then used to train the neural network to distinguish between different faces. This is typically done using a supervised learning approach, where the network is trained on a labelled dataset of face images and their corresponding identities.

Testing: After the neural network has been trained, it can be tested on a separate dataset to evaluate its performance. This typically involves measuring the accuracy of the network in correctly identifying the individuals in the test dataset.

Deployment: Once the neural network has been trained and tested, it can be deployed in a real-world application for face recognition. This typically involves capturing a face image, preprocessing it, and then feeding it into the neural network to obtain a feature vector. The feature vector is then compared to a database of known faces to determine the identity of the individual in the image. Overall, human face recognition using DNNs is a complex process that requires a large amount of data, sophisticated neural network architectures, and careful preprocessing and training. However, with the increasing availability of large datasets and

powerful computing resources, DNN-based face recognition systems have become increasingly accurate and effective in real-world applications.

Example- One example of human face recognition using DNNs is the FaceNet algorithm, which was developed by researchers at Google in 2015. FaceNet is a deep neural network that is trained to directly optimize the embedding of face images into a high-dimensional feature space, where distances between faces correspond to their similarity.

The FaceNet architecture consists of a deep convolutional neural network that takes a raw face image as input and produces a 128-dimensional feature vector as output. The network is trained on a large dataset of face images with labels that correspond to different individuals.

During training, the FaceNet network is optimized to minimize the distance between the feature vectors of images that depict the same person and maximize the distance between feature vectors of images that depict different people. This is done using a loss function called the triplet loss, which compares the distance between the feature vectors of an anchor image, a positive image (of the same person as the anchor), and a negative image (of a different person). The goal is to minimize the distance between the anchor and positive images while maximizing the distance between the anchor and negative images.

After training, the FaceNet network can be used for face recognition by capturing a face image, preprocessing it, and then feeding it into the network to obtain a 128-dimensional feature vector. This feature vector is then compared to a database of known faces by computing the Euclidean distance between the feature vector and the feature vectors of the faces in the database. The closest matching face in the database is then returned as the recognized identity. Overall, FaceNet is an example of a DNN-based face recognition system that has achieved high accuracy and robustness in real-world applications. It has been used in a variety of applications, including security systems, access control, and social media tagging.

```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import
import Dense, Flatten, Conv2D, MaxPooling2D, Dropout
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import cv2
```



```

# Define constants
img_height = 128
img_width = 128
batch_size = 32
epochs = 10
num_classes = 10

# Load the "CelebA" dataset
df = pd.read_csv('list_attr_celeba.csv')
df = df.sample(frac=1).reset_index(drop=True) # shuffle the dataset
df['image_id'] = df['image_id'].apply(lambda x: x[:-4]) # remove file extension from image IDs
df_train = df[:int(len(df)*0.8)] # 80% for training
df_val = df[int(len(df)*0.8):int(len(df)*0.9)] # 10% for validation
df_test = df[int(len(df)*0.9):] # 10% for testing

# Define data generators for training, validation, and testing sets
train_datagen = ImageDataGenerator(rescale=1./255)
val_datagen = ImageDataGenerator(rescale=1./255)
test_datagen = ImageDataGenerator(rescale=1./255)
train_generator = train_datagen.flow_from_dataframe(
    dataframe=df_train,directory='img_align_celeba',
    x_col='image_id',y_col='Smiling',target_size=(img_height, img_width),
    batch_size=batch_size, class_mode='binary')
val_generator = val_datagen.flow_from_dataframe(
    dataframe=df_val,
    directory='img_align_celeba',
    x_col='image_id',
    y_col='Smiling',
    target_size=(img_height, img_width),
    batch_size=batch_size, class_mode='binary')
test_generator = test_datagen.flow_from_dataframe( dataframe=df_test,
    directory='img_align_celeba', x_col='image_id', y_col='Smiling', target_size=(img_height,
    img_width), batch_size=batch_size, class_mode='binary')

```

```

# Define the neural network model
model = Sequential([Conv2D(32, (3,3), activation='relu', input_shape=(img_height,
img_width, 3)),MaxPooling2D((2,2)), Conv2D(64, (3,3), activation='relu'),
MaxPooling2D((2,2)), Conv2D(128, (3,3), activation='relu'), MaxPooling2D((2,2)),
Conv2D(128, (3,3), activation='relu'), MaxPooling2D((2,2)), Flatten(), Dropout(0.5),
Dense(512, activation='relu'), Dense(num_classes, activation='sigmoid')])

# Compile the model
model.compile(optimizer='adam',
loss='binary_crossentropy',
metrics=['accuracy'])

# Train the model
history = model.fit(train_generator, epochs=epochs, validation_data=val_generator)

# Evaluate the model on the test set
loss, accuracy = model.evaluate(test_generator)
print ("Test accuracy:", accuracy)

# Predict the smiling attribute of a sample image
img = cv2.imread('sample_image.jpg')
img = cv2.resize(img, (img_height, img_width))
img = np.expand_dims(img, axis=0)

```

Conclusion- In this way Human Face Recognition Implemented.

Assignment Question

1. What do you mean by Exploratory Analysis?
2. What do you mean by Correlation Matrix?
3. What is Conv2D used for?

Deep Learning Mini Project -2

Title - Implement Gender and Age Detection: predict if a person is a male or female and also their age

Project title: "Gender and Age Detection on UTK Face dataset

Objective: To build a deep neural network model that can recognize Gender and Age Detection on UTK Face dataset

Theory -

Collect and prepare the dataset: In this case, we can use the "UTKFace" dataset which contains images of faces with their corresponding gender and age labels. We need to preprocess the data, like resizing the images to a uniform size, shuffling the dataset, and limit the age to a certain value (like 100 years).

Split the dataset: Split the dataset into training, validation, and testing sets. The usual split ratio is 80%, 10%, and 10%, respectively.

Define data generators: Define data generators for training, validation, and testing sets using the "ImageDataGenerator" class in Keras. This class provides data augmentation techniques that can improve the model's performance, such as rotation, zoom, and horizontal flip.

Define the neural network model: Define a convolutional neural network (CNN) model that takes the face images as input and outputs two values - the probability of being male and the predicted age. The model can have multiple convolutional and pooling layers followed by some dense layers.

Compile the model: Compile the model with appropriate loss and metrics for each output (gender and age). In this case, we can use binary cross-entropy loss for gender and mean squared error (MSE) for age.

Train the model: Train the model using the fit method of the model object. We need to pass the data generators for the training and validation sets, as well as the number of epochs and batch size.

Evaluate the model: Evaluate the model's performance on the testing set using the evaluate method of the model object. This will give us the accuracy and mean absolute error (MAE) of the model.

Predict the gender and age of a sample image: Load a sample image and preprocess it. We can use the "cv2" library to read the image, resize it to the same size as the training images,

and normalize it. Then, we can use the "predict" method of the model object to get the predicted gender and age.

Source Code

```
Import tensorflow as tf
from tensorflow.keras.models
import Sequential
from tensorflow.keras.layers import Dense, Flatten, Conv2D, MaxPooling2D, Dropout
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import cv2

# Define constants
img_height = 128
img_width = 128
batch_size = 32
epochs = 10

# Load the "UTKFace" dataset df
= pd.read_csv('UTKFace.csv')
df['age'] = df['age'].apply(lambda x: min(x, 100)) # limit age to 100
df = df.sample(frac=1).reset_index(drop=True) # shuffle the dataset
df['image_path'] = 'UTKFace/' + df['image_path']
df_train = df[:int(len(df)*0.8)] # 80% for training
df_val = df[int(len(df)*0.8):int(len(df)*0.9)] # 10% for validation
df_test = df[int(len(df)*0.9):] # 10% for testing

# Define data generators for training, validation, and testing sets
train_datagen = ImageDataGenerator(rescale=1./255)
val_datagen = ImageDataGenerator(rescale=1./255)
test_datagen = ImageDataGenerator(rescale=1./255)
train_generator = train_datagen.flow_from_dataframe(
dataframe=df_train,
x_col='image_path',
y_col=['male', 'age'],
target_size=(img_height, img_width),
```

```

batch_size=batch_size,
class_mode='raw')
val_generator = val_datagen.flow_from_dataframe(
dataframe=df_val,
x_col='image_path',
y_col=['male', 'age'],
target_size=(img_height, img_width),
batch_size=batch_size,
class_mode='raw')
test_generator = test_datagen.flow_from_dataframe(
dataframe=df_test,
x_col='image_path',
y_col=['male', 'age'],
target_size=(img_height, img_width),
batch_size=batch_size,
class_mode='raw')
# Define the neural network model
model = Sequential([
Conv2D(32, (3,3), activation='relu', input_shape=(img_height, img_width, 3)),
MaxPooling2D((2,2)),
Conv2D(64, (3,3), activation='relu'),
MaxPooling2D((2,2)),
Conv2D(128, (3,3), activation='relu'),
MaxPooling2D((2,2)),
Conv2D(128, (3,3), activation='relu'),
MaxPooling2D((2,2)),
Flatten(),
Dropout(0.5),
Dense(512, activation='relu'),
Dense(2)
])
# Compile the model
model.compile(optimizer='adam', loss={'dense_1': 'binary_crossentropy', 'dense_2': 'mse'},
metrics={'dense_1': 'accuracy', 'dense_2': 'mae'})

```

```
# Train the model
history = model.fit(train_generator, epochs=epochs, validation_data=val_generator)
# Evaluate the model on the test set
loss, accuracy, mae = model.evaluate(test_generator)
print("Test accuracy:", accuracy)
print("Test MAE:", mae)
# Predict the gender and age of a sample image
img = cv2.imread('sample_image.jpg')
img
```

Conclusion- In this way Gender Age Detection Implemented.

Assignment Question

1. What do you mean Mean Squared Error (MSE)?
2. What do you mean by Mean Absolute error (MAE)?
3. What are data generators?