Department of Computer Engineering

MET,BKC,Adgaon,Nashik

Group 1

Assignment No. 1

Title: Linear regression by using Deep Neural network:

Objective:

Students should be able to apply the technique of Deep Neural network for implementing Linear regression.

Problem Statement:

Implement Boston housing price prediction problem by Linear regression using Deep Neural network. Use Boston House price prediction dataset.

Software and Hardware Requirements:

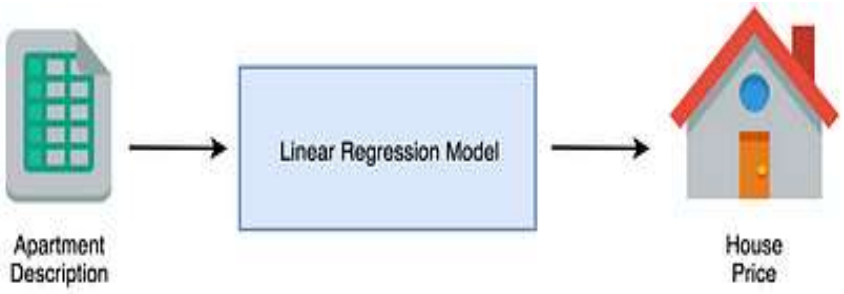
Theory:

Linear Regression is a machine learning algorithm based on **supervised learning**. It performs a **regression task**. Regression models a target prediction value based on independent variables. It is mostly used for finding out the relationship between variables and forecasting. Different regression models differ based on – the kind of relationship between dependent and independent variables they are considering, and the number of independent variables getting used. There are many names for a regression's dependent variable. It may be called an outcome variable, criterion variable, endogenous variable, or regressand. The independent variables can be called exogenous variables, predictor variables, or regressors.

Linear regression is used in many different fields, including finance, economics, and psychology, to understand and predict the behavior of a particular variable. For example, in finance, linear regression might be used to understand the relationship between a company's stock price and its earnings, or to predict the future value of a currency based on its past performance.

It's a **Supervised Learning algorithm** which goal is to **predict continuous, numerical values based on given data input**. From the geometrical perspective, each data sample is a point. Linear Regression tries to **find parameters of the linear function**, so the **distance between the all the points and the line is as small as possible**. Algorithm used for parameters update is called **Gradient Descent**.

For example, if we have a dataset consisting of apartments properties and their prices in some specific area, Linear Regression algorithm can be used to find a mathematical function which will try to estimate the value of different apartment (outside of the dataset), based on its attributes.



Deep Neural Network :

A deep neural network (DNN) is an ANN with multiple hidden layers between the input and output layers. The main purpose of a neural network is to receive a set of inputs, perform progressively complex calculations on them, and give output to solve real world problems like classification. We restrict ourselves to feed forward neural networks.

Neural networks are widely used in supervised learning and reinforcement learning problems. These networks are based on a set of layers connected to each other.

In deep learning, the number of hidden layers, mostly non-linear, can be large; say about 1000 layers. DL models produce much better results than normal ML networks.

A deep neural network is beneficial when you need to replace human labor with autonomous work without compromising its efficiency.

The deep neural network usage can find various applications in real life.

The American company Pony.ai is another example of how you can use DNN. They developed a system for AI cars that can work without a driver. It requires more than just a simple algorithm of actions, but a much deeper learning system, which should be able to recognize people, road signs and other markings like trees, and other important objects.

The famous company UbiTech creates AI robots. One of their creations is the Alpha 2 robot that can live in a family, speak with its members, search for information, write messages, and execute voice commands

The neural network needs to learn all the time to solve tasks in a more qualified manner or even to use various methods to provide a better result. When it gets new information in the system, it learns how to act accordingly to a new situation.

Learning becomes deeper when tasks you solve get harder. Deep neural network represents the type of machine learning when the system uses many layers of nodes to derive high-level functions from input information. It means transforming the data into a more creative and abstract component.

Visualising data

It is very important to always understand the structure of data. The more features there are, the harder it is. In this case, scatter plot is used to **display the relationship between target and training features**.

Depending on what is necessary to show, some other types of visualization (e.g. box plot) and techniques could be useful (e.g. clustering). Here, a **linear dependency between features can be observed** — with the increase of values on axis x, values on the y-axis are linearly increasing or decreasing accordingly. It's great because if that was not the case (e.g. relationship would be exponential), then it would be hard to fit a line through all the points and different algorithm should be considered.

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 preprocessing: The first step is to preprocess 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.

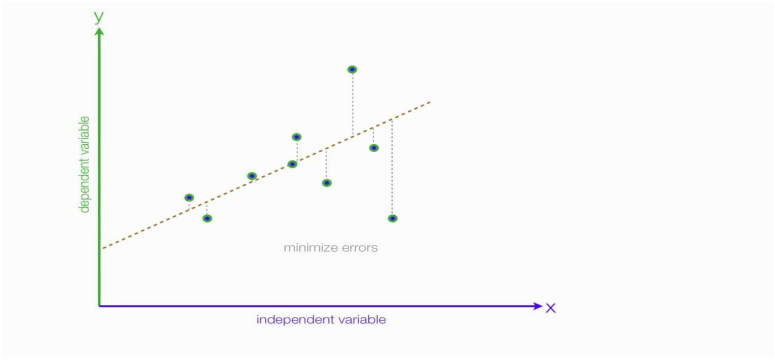
3. Model training: The model is then trained using the training set. During training, the weights and biases of the nodes are adjusted based on the error between the predicted output and the actual output. This is done using an optimization algorithm such as stochastic gradient descent.

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.

The objective of Linear Regression is to find a line that minimizes the prediction error of all the data points.



- The Mean absolute error represents the average of the absolute difference between the actual and predicted values in the dataset. It measures the average of the residuals in the dataset.

$$MAE = \frac{1}{N}\sum_{i=1}^{N} |y_i - \hat{y}|$$

Where,

$\hat{y}$ – *predicted value of y*

$\bar{y}$ – *mean value of y*

- Mean Squared Error represents the average of the squared difference between the original and predicted values in the data set. It measures the variance of the residuals.

$$MSE = \frac{1}{N}\sum_{i=1}^{N} (y_i - \hat{y})^2$$

- Root Mean Squared Error is the square root of Mean Squared error. It measures the standard deviation of residuals.

$$RMSE = \sqrt{MSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} (y_i - \hat{y})^2}$$

- The coefficient of determination or R-squared represents the proportion of the variance in the dependent variable which is explained by the linear regression model. It is a scale-free score i.e. irrespective of the values being small or large, the value of R square will be less than one.

$$R^2 = 1 - \frac{\sum (y_i - \hat{y})^2}{\sum (y_i - \bar{y})^2}$$

Boston Datatset: The Boston Housing dataset contains information about various houses in Boston through different parameters. Each record in the database describes a Boston suburb or town. The data was drawn from the Boston Standard Metropolitan Statistical Area (SMSA) in 1970. This data was originally a part of UCI Machine Learning Repository and has been removed now.

There are 506 samples and 13 feature variables in this dataset. The objective is to predict the value of prices of the house using the given features

The attributes are defined as follows (taken from the UCI Machine Learning Repository1):

1. CRIM: per capita crime rate by town
2. ZN: proportion of residential land zoned for lots over 25,000 sq.ft.
3. INDUS: proportion of non-retail business acres per town
4. CHAS: Charles River dummy variable (= 1 if tract bounds river; 0 otherwise)
5. NOX: nitric oxides concentration (parts per 10 million)
6. RM: average number of rooms per dwelling
7. AGE: proportion of owner-occupied units built prior to 1940
8. DIS: weighted distances to five Boston employment centers
9. RAD: index of accessibility to radial highways
10. TAX: full-value property-tax rate per $10,000
11. PTRATIO: pupil-teacher ratio by town
12. B: 1000(Bk−0.63)2 where Bk is the proportion of blacks by town
13. LSTAT: % lower status of the population
14. MEDV: Median value of owner-occupied homes in $1000s

Conclusion: In this way we learn to implement Boston housing price prediction problem by Linear regression using Deep Neural network.

Assignment Question

1. What is neural Network?
2. What is deep learning?
3. Differentiate between Linear regression and Logistic Regression.
4. What is an example of a simple linear regression question?
5. What is limitation and purpose of linear regression model?