Linear algebra

⇒ Linear algebra is a branch of mathematics that focuses on study of vectors, vector spaces (linear spaces), linear transformations and system of linear equations.

⇒ Linear algebra provides a framework for understanding the properties and operations of these mathematical objects which can be represented as matrices and vectors.

⇒ Foundational concepts of linear algebra used in ML, DL, NLP and Image processing are scalars, vectors, matrices, mathematical operations on matrices, linear transformations, eigen values, eigen vectors etc.

(*) APPLICATIONS OF LINEAR ALGEBRA:-

(i) Data representation and manipulation

Suppose we have a house price dataset which contains area, no. of rooms, location and price data.

If we want to train a model to predict house price:-

$$\text{Independent features}\left\{\begin{array}{l}\text{Area}\\ \text{No. of rooms}\\ \text{Location}\end{array}\right\} \rightarrow \boxed{\text{model}} \rightarrow \text{Price}\ \Big\}\ \text{output feature}$$

This data is represented to the model in the form of vectors. From this vector data, the model can quantify the relationship between different features. We use concepts like co-variance and co-relation while quantifying which will be covered in statistics.

Vectors can be represented in the form of dimensions.

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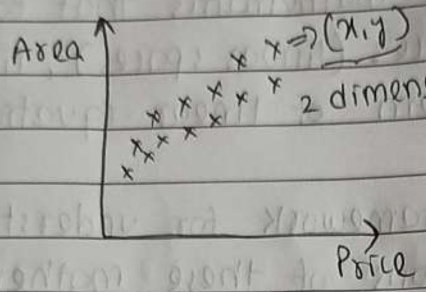
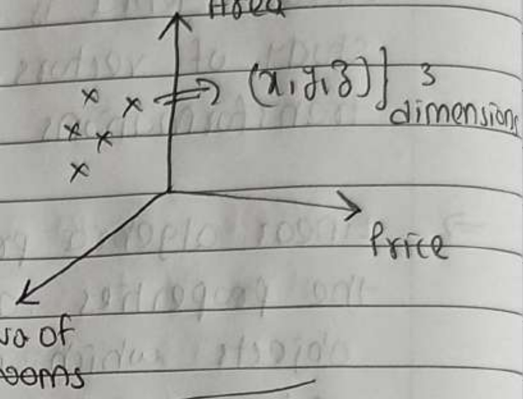
2-dimensional vector



vector is represented in 2 dimensions

$(x,y) \Rightarrow$ (Price, Area)

3-dimensional vector



vector is represented in 3 dimensions

$(x,y,z) \Rightarrow$ (Area, No. of rooms, Price)

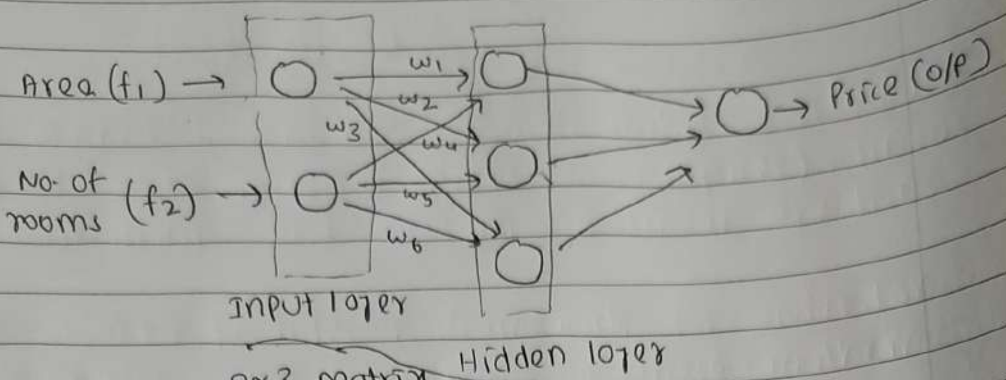
Linear algebra works well with higher dimensional data. For example, if we have 500 features, it will be represented as a vector with 500 dimensions. using techniques like dimensionality reduction, we can convert it into a 2 dimensional vector. This is the power of linear algebra

(2) Machine Learning and Artificial Intelligence

→ For model training, we rely on linear algebra because we perform multiple matrix operations and use linear equations

→ The dimensionality reduction is performed using PCA algorithm that uses eigen values and eigen vectors for converting higher dimensional data to lower dimensional data.

→ In neural networks, we have a concept called as forward propogation and backward propogation.



2x3 matrix

$$\begin{bmatrix} f_1 \\ f_2 \end{bmatrix} \begin{bmatrix} w_1 & w_2 & w_3 \\ w_4 & w_5 & w_6 \end{bmatrix} \Bigg\} \text{ matrix multiplication}$$

After matrix multiplication, we also add bias to every neuron. so, we also perform matrix addition. These are applications of linear algebra.
we use chain of derivatives during back propogation to update weights. so, it is an application of derivative in differential calculus.

③ <u>computer graphics</u>
Images are represented in 3 dimensions (R, G, B). If we want to apply transformations on image like scaling, rotating or making it black and white, we must perform matrix operations. Linear algebra can be used to tranform images or reducing dimensions of images.

④ <u>optimization</u>
we can solve equations using linear algebra.
<u>Ex</u>:- In linear regression, the equation of line will be $y = mx + c$. we use linear algebra to find best suited values of m and c. (we find the best fit line).