Intro to Linear Algebra

For Artificial Intelligence

By Orevaoghene Ahia

Objective and Outline

OBJECTIVE

- To attain a clear understanding of Linear Algebra that is applicable in Data Science and Artificial Intelligence.

OUTLINE

- Tensors, Scalars, Vector and Matrices
- Relevance in Data Science and Machine Learning or Artificial Intelligence

Class Discussion

Differentiate between Elementary Algebra and Linear Algebra

INTRODUCTION

Linear algebra is the branch of mathematics concerning linear equation such as $a_1x_1 + \cdots + a_nx_n = b$ and their representations through matrices and vector spaces. *(wikipedia.com)*

Linear algebra is the branch of mathematics concerning linear equation such as and their representations through matrices and vector spaces. *(wikipedia.com)*

Introduction

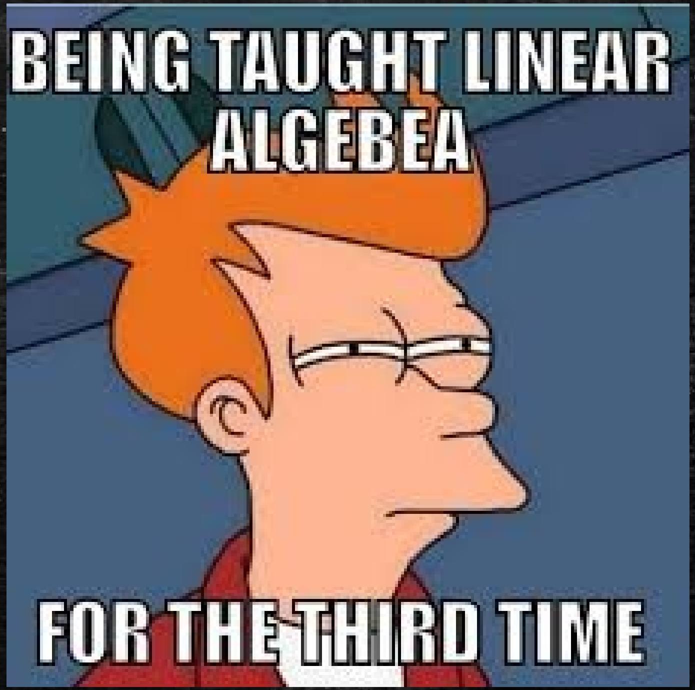
- Linear algebra is used in many fields of mathematics, natural sciences, computer science, and social science. Such as

- ❑ **Geometry**
- ❑ **Chemistry**
- ❑ **Coding theory**
- ❑ **Economics**
- ❑ **Genetics**
- ❑ **MACHINE LEARNING**

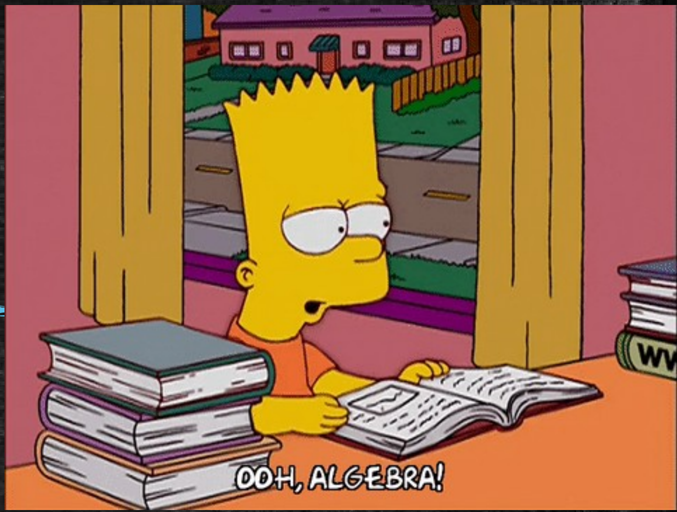
Introduction

Linear Algebra is a fundamental and important backbone of any machine learning algorithm. Hence it is important that we attain an in-depth understanding Linear Algebra as Data Science and Artificial Intelligence experts.

But why should we learn Linear Algebra?



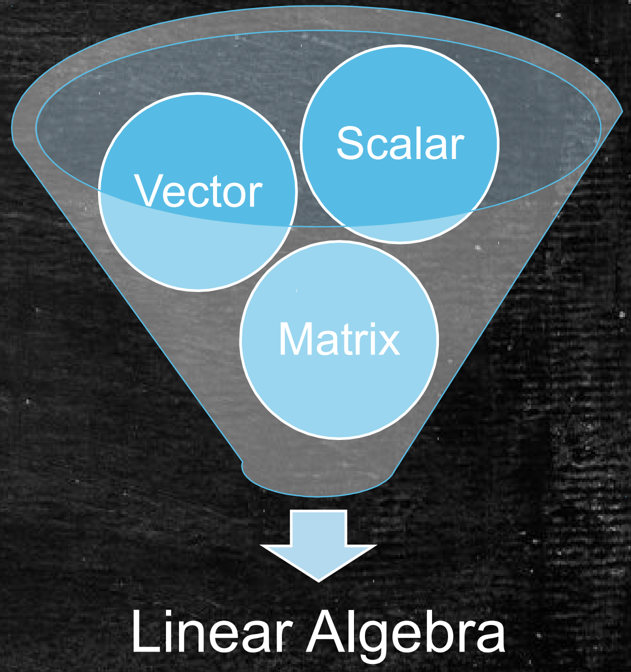
Introduction



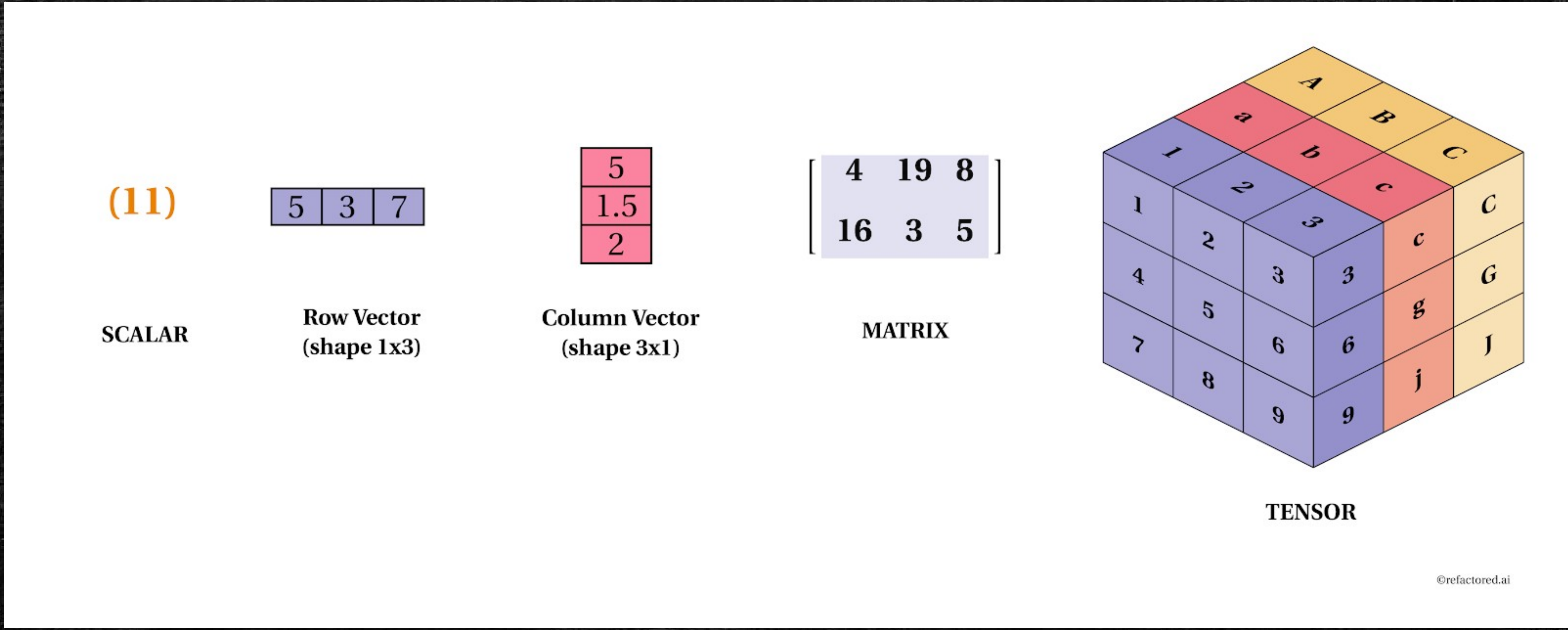
- Linear Algebra is a fundamental and important backbone of machine learning algorithms.
- Its concepts are a crucial prerequisite for understanding the theory behind Machine Learning, especially if you are working with Deep Learning Algorithms
- In order to be able to read and interpret statistics, you must learn the notation and operations of linear algebra.
- Algorithms written in standard 'for-loop' notation can be reformulated as matrix equations providing significant gains in computational efficiency.

Tensor Scalar Vector Matrix

- The two primary mathematical entities that are of interest in linear algebra are the **vector** and the **matrix**.
- They are examples of a more general entity known as a **tensor**. Tensors possess an *order* (or *rank*), which determines the number of dimensions in an array required to represent it.



Tensor Scalar Vector Matrix



Scalars

Any real number, or any quantity that can be measured using a single real number. *(http://www.mathwords.com)*

Scalar

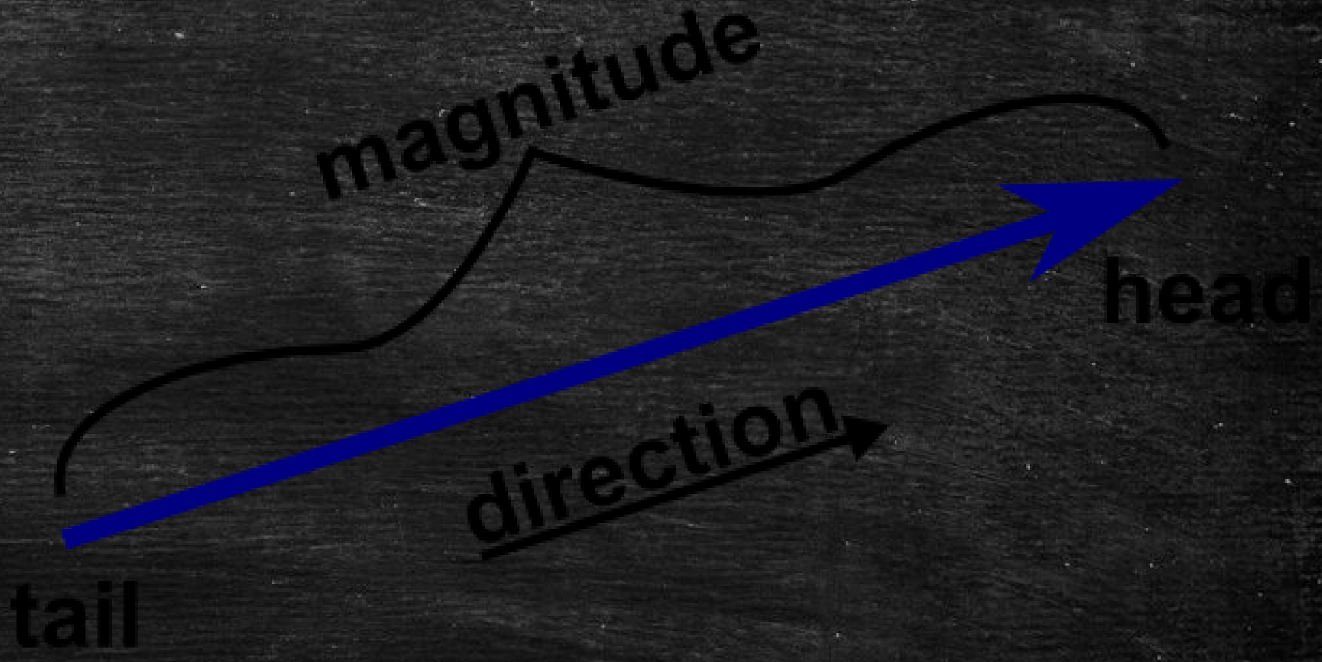
SCALAR

- A scalar is a variable that describes a single number
- Integers, rational numbers, real numbers etc.
- It is denoted with an italic font

$$i.e. \, a, n, x$$

SCALAR

- A scalar is a variable that describes a single number
- Integers, rational numbers, real numbers etc.
- It is denoted with an italic font



Vectors

A vector is an object that has both a magnitude and a direction.
A column of numbers

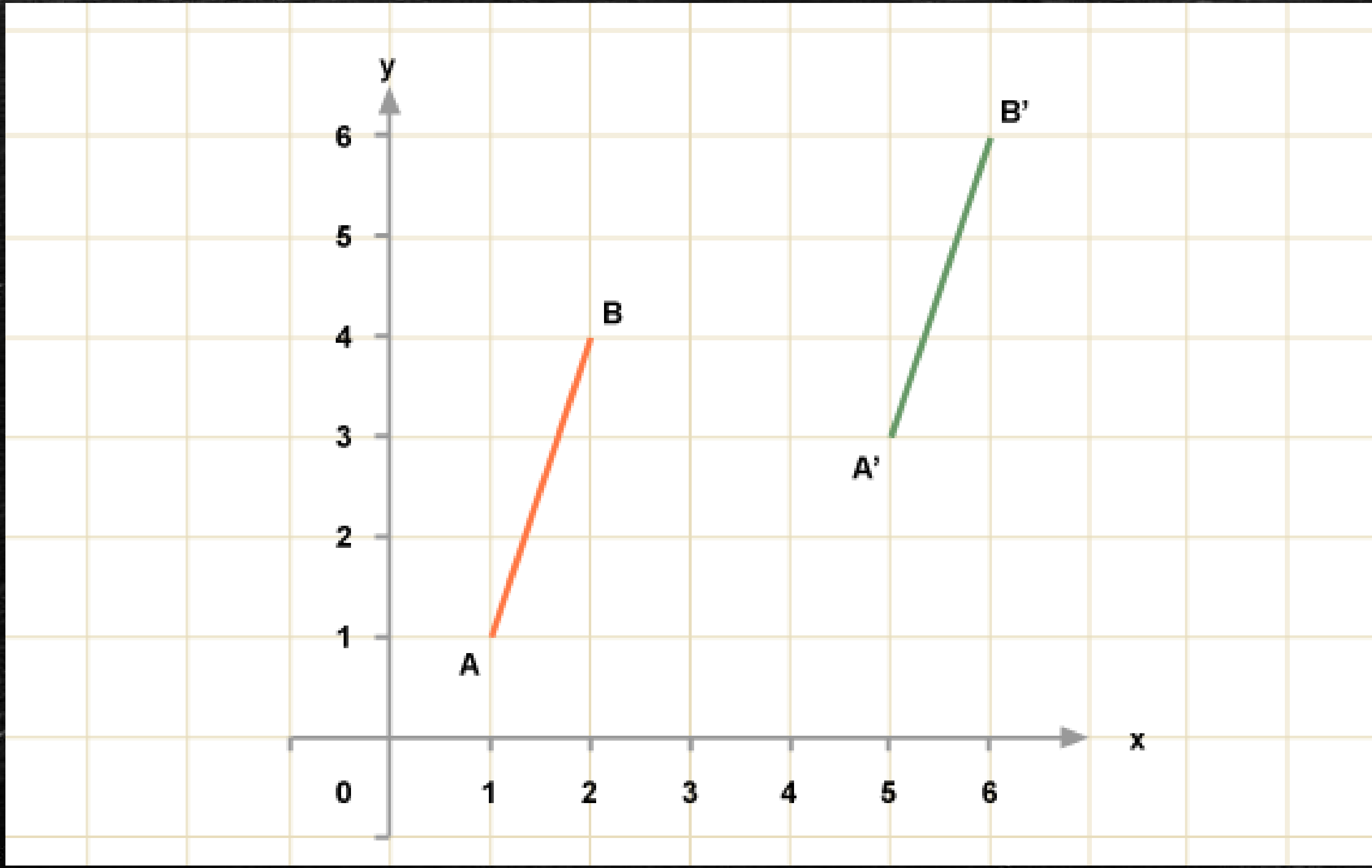
Vector

- A vector is a 1-d array of numbers.
- It can be real, binary or integers.
- A Vector has just a single index, which can point to a specific value within the Vector. For example, V2 refers to the second value within the Vector, which is X2 in the graph below.

$$\begin{bmatrix} x1 \\ x2 \\ x3 \end{bmatrix}$$

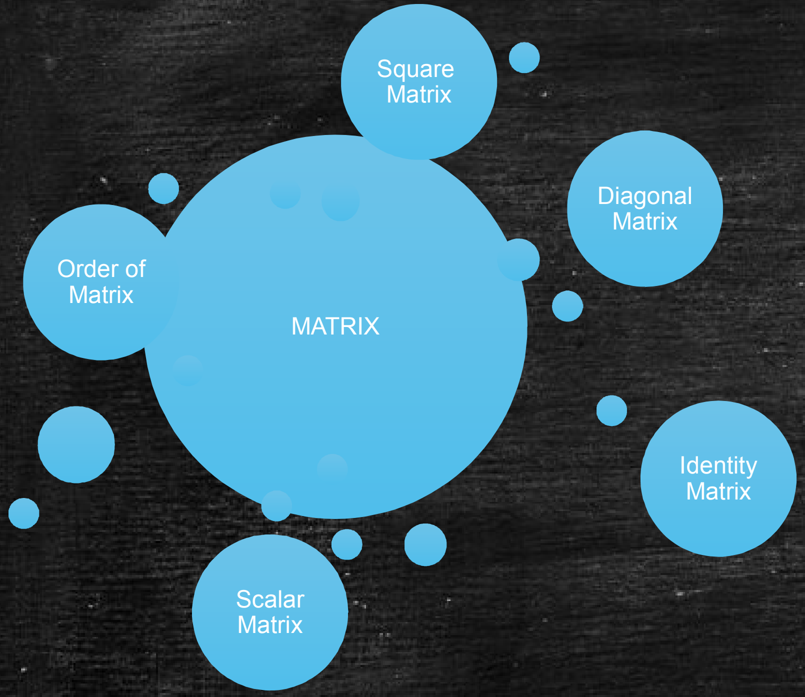
Vector

- We can also think of vectors as identifying points in space, with each element giving the coordinate along a different axis.



Vector

- VECTOR
- In machine learning vectors often represent ***feature vectors***, with their individual components specifying how important a particular feature is.
- Such features could include :
  - Relative importance of words in a text document
  - The intensity of a set of pixels in a two-dimensional image.
  - Historical price values for a cross-section of financial instruments
  - Classes to be re



Class Discussion

m x n is a conventional way of saying ____ and ____ in matrix.

Matrix

A **matrix** (plural: **matrices**) is a rectangular *array* of numbers, symbols, or expressions, arranged in *rows* and *columns*.

Matrix - Quick Exercise

Matrix A

$$\begin{bmatrix} 7 & 3 \\ 2 & 5 \\ 6 & 8 \\ 9 & 0 \end{bmatrix}$$

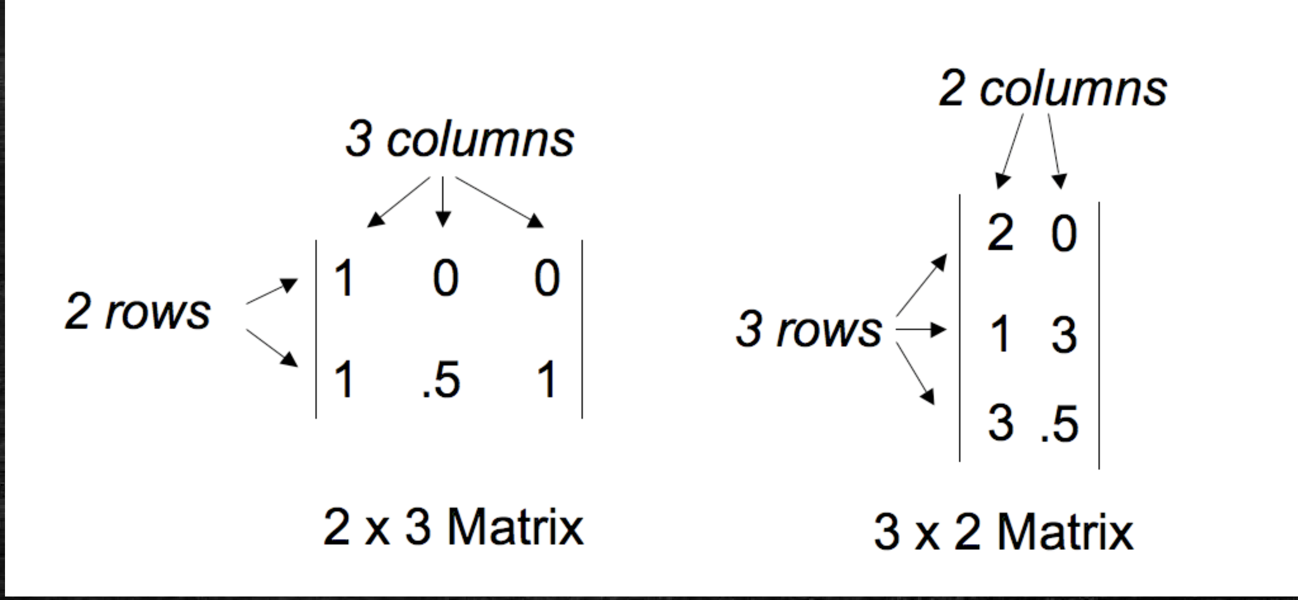
Matrix B

$$\begin{bmatrix} 7 & 4 & 9 \\ 8 & 1 & 5 \end{bmatrix}$$

Based on the previous class Exercise, can you identify the value of m and n in this matrix A and B?

Matrix


m-by-n matrix
a i,j
n columns
j changes
m rows
i changes
a 1,1 a 1,2 a 1,3
a 2,1 a 2,2 a 2,3
a 3,1 a 3,2 a 3,3


3 columns
2 rows
1 0 0
1 .5 1
2 x 3 Matrix
2 columns
3 rows
2 0
1 3
3 .5
3 x 2 Matrix

Matrix

- Some of you might wonder the relevance of matrix operations will be useful in the context of deep learning.
- But general and more broadly, linear algebra is the ‘language in which machine learning was written’. If we can understand the basics of the language, we'll be in a much better position to grasp the more complex ideas that form the backbone of neural network models in lectures.
- We will begin by looking at **matrix addition** and then consider **matrix multiplication**. These operations will eventually allow us to discuss a topic known as **matrix inversion**, which will form the foundation we need.

Matrix

Matrix Addition

Matrix – Matrix Addition

- Matrices can be added to scalars, vectors and other matrices.
- Each of these operations has a precise definition.
- These techniques are used frequently in machine learning and deep learning so it is worth familiarising yourself with them.

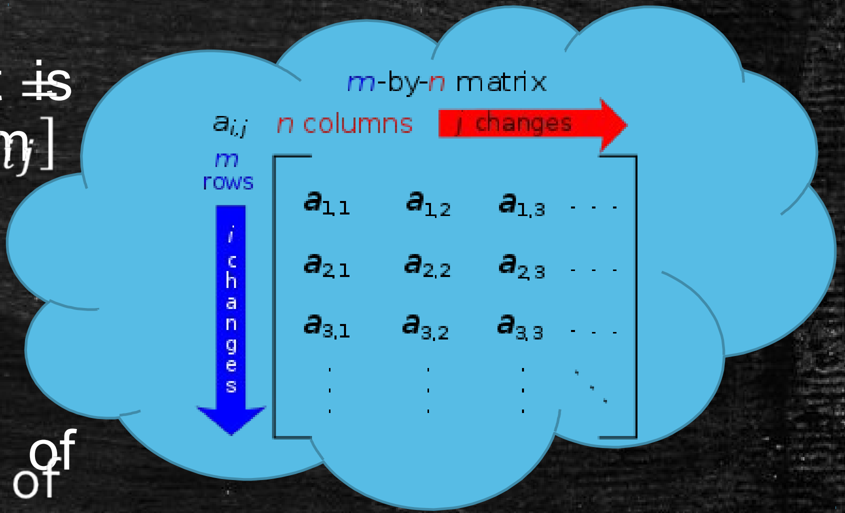
Matrix – Matrix Addition

Matrix-Matrix Addition

- Given two matrices of size m x n, $A = [a_{ij}]$ and $B = [b_{ij}]$, it is possible to obtain a solution, $C = [c_{ij}]$ which is a matrix sum
- i.e. $A + B = C$ where, $[a_{ij}] + [b_{ij}] = [c_{ij}]$

Note:

- C is constructed by element-wise summing of respective elements of A and B.
- The two matrix to be added must have equal size *(except in the case of broadcasting)*
- i.e. $(m \times n)_a + (m \times n)_b = (m \times n)_c$



Matrix – Matrix Addition

Matrix-Matrix Addition

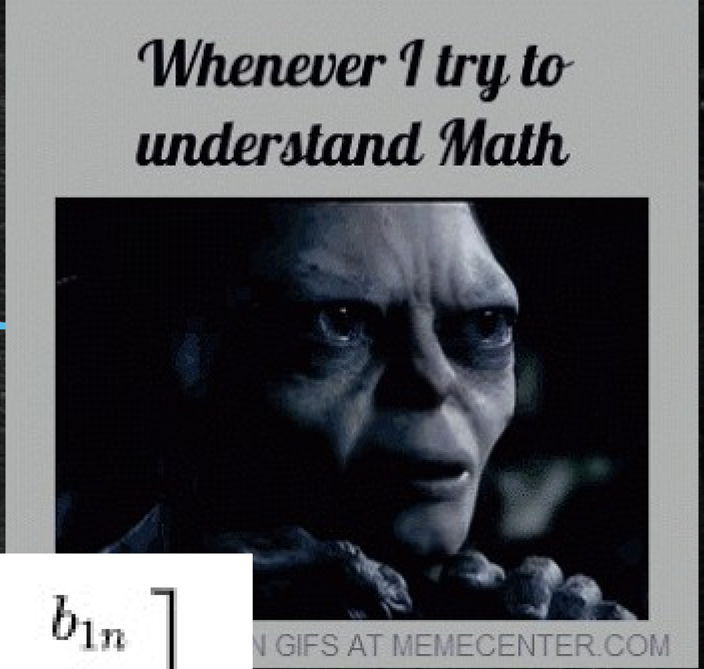
- Matrix-Matrix addition has a *COMMUTATIVE* nature.

$$\text{i.e. } A + B = B + A$$

- Matrix-Matrix addition has a *ASSOCIATIVE* nature.

$$\text{i.e. } A + (B + C) = (A + B) + C$$

Matrix – Matrix Addition



Matrix-Matrix Addition

$$\mathbf{A}+\mathbf{B}=\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} + \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ b_{m1} & b_{m2} & \cdots & b_{mn} \end{bmatrix}$$

$$= \begin{bmatrix} a_{11}+b_{11} & a_{12}+b_{12} & \cdots & a_{1n}+b_{1n} \\ a_{21}+b_{21} & a_{22}+b_{22} & \cdots & a_{2n}+b_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1}+b_{m1} & a_{m2}+b_{m2} & \cdots & a_{mn}+b_{mn} \end{bmatrix}$$

Matrix – Matrix Addition

Matrix-Matrix Addition

ADD

$$A + B = \begin{bmatrix} a_1 & a_2 \\ a_3 & a_4 \end{bmatrix} + \begin{bmatrix} b_1 & b_2 \\ b_3 & b_4 \end{bmatrix}$$

$$= \begin{bmatrix} a_1 + b_1 & a_2 + b_2 \\ a_3 + b_3 & a_4 + b_4 \end{bmatrix}$$

SUBTRACT

$$A - B = \begin{bmatrix} a_1 & a_2 \\ a_3 & a_4 \end{bmatrix} - \begin{bmatrix} b_1 & b_2 \\ b_3 & b_4 \end{bmatrix}$$

$$= \begin{bmatrix} a_1 - b_1 & a_2 - b_2 \\ a_3 - b_3 & a_4 - b_4 \end{bmatrix}$$

Matrix – Matrix Addition

Matrix-Matrix Addition

$$\begin{bmatrix} 1 & 3 \\ 1 & 0 \\ 1 & 2 \end{bmatrix} + \begin{bmatrix} 0 & 0 \\ 7 & 5 \\ 2 & 1 \end{bmatrix} =$$

$$X + Y = \begin{bmatrix} 3 & 5 & 2 & 4 \\ 7 & 6 & 8 & 4 \\ 5 & 1 & 3 & 8 \end{bmatrix} + \begin{bmatrix} 2 & 6 & 3 & 7 \\ 9 & 3 & 8 & 1 \\ 4 & 6 & 9 & 7 \end{bmatrix}$$

Class Exercise

- Try solving this 2 matrix problems with your hand.
- Try solving with some python code

Matrix – Matrix Addition

Matrix-Matrix Addition

$$\begin{bmatrix}1 & 3\\1 & 0\\1 & 2\end{bmatrix} + \begin{bmatrix}0 & 0\\7 & 5\\2 & 1\end{bmatrix} = \begin{bmatrix}1+0 & 3+0\\1+7 & 0+5\\1+2 & 2+1\end{bmatrix} = \begin{bmatrix}1 & 3\\8 & 5\\3 & 3\end{bmatrix}$$

$$X + Y = \begin{bmatrix}3 & 5 & 2 & 4\\7 & 6 & 8 & 4\\5 & 1 & 3 & 8\end{bmatrix} + \begin{bmatrix}2 & 6 & 3 & 7\\9 & 3 & 8 & 1\\4 & 6 & 9 & 7\end{bmatrix}$$

$$= \begin{bmatrix}3+2 & 5+6 & 2+3 & 4+7\\7+9 & 6+3 & 8+8 & 4+1\\5+4 & 1+6 & 3+9 & 8+7\end{bmatrix}$$

$$= \begin{bmatrix}5 & 11 & 5 & 11\\16 & 9 & 16 & 5\\9 & 7 & 12 & 15\end{bmatrix}$$

Solution

- If you got the answer, then you deserve some accolades.
- Why don't you try subtracting. Compare your answer with that of your neighbour

Matrix – Matrix Addition

Matrix-Scalar Addition

Matrix-Scalar Addition

- It is also possible to add scalar values x to a matrix of size m x n, $A = [a_{ij}]$ to produce $B = [b_{ij}]$

$$\text{i.e. } B = x + A$$

- Matrix-Scalar addition is also COMMUTATIVE and ASSOCIATIVE

$$\text{i.e. } A + (x + C) = (A + x) + C$$
$$A + x = x + A$$

Matrix – Matrix Addition

Broadcasting

- For certain applications in machine learning it is possible to define a shorthand notation known as **broadcasting**. But what is Broadcasting?
- Consider

Matrix Multiplication

Matrix – Matrix Multiplication

- Matrix addition might have been simple for most of us, However when it comes to multiplication of matrices the rules become more complex.
- One very important operation we should consider before hitting at matrix multiplication is **Matrix Transpose**

Matrix Transpose

- The transpose of a matrix $A = [a_{ij}]_{m \times n}$ of size $m \times n$ is denoted by A^T of size $n \times m$ and it is given element-wise.

$$A = [a_{ij}]_{m \times n} \qquad A^T = [a_{ji}]_{n \times m}$$

Change you spot what changed in A^T and A?

- Matrix addition might have been simple for most of us. However when it comes to multiplication of matrices the rules become more complex.
- One very important operation we should consider before hitting at matrix multiplication is **Matrix Transpose**

Matrix Transpose

- The transpose of a matrix of size $m \times n$ is denoted by of size and it is given element-wise.

Change you spot what changed in ?

Matrix – Matrix Multiplication

Matrix Transpose - Example

$$\boldsymbol{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \end{bmatrix}, \quad \boldsymbol{A}^T = \begin{bmatrix} a_{11} & a_{21} \\ a_{12} & a_{22} \\ a_{13} & a_{23} \end{bmatrix}$$

$$\boldsymbol{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}, \quad \boldsymbol{x}^T = \begin{bmatrix} x_1 & x_2 & x_3 \end{bmatrix}$$

Matrix – Matrix Multiplication

Matrix Transpose – Quick Quiz

- $A^{TT} = A$ *true or false*
- $x^T = x \quad where\ 'x'\ is\ a\ scalar$ *true or false*
- Is there a reflecting effect on the matrix along the line of diagonal elements? i.e. a_{ii} *(hint: try transposing a 3 x 3 matrix and watch the diagonals) what do you notice?*

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

Matrix-Matrix Multiplication

- The reason why matrix multiplication is a complex operation compared to matrix addition is because it doesn't involve multiplying the matrices element-wise.

- Instead, a more complex procedure is utilised, for each element, involving an entire row of one matrix and an entire column of the other.

- The reason why matrix multiplication is a complex operation compared to matrix addition is because it doesn't involve multiplying the matrices element-wise.

- Instead, a more complex procedure is utilised, for each element, involving an entire row of one matrix and an entire column of the other.

Note:

Note:

- Given a matrix $A = [a_{ij}]_{m \times n}$ and a matrix $B = [b_{ij}]_{n \times p}$ the matrix product $C = AB = [c_{ij}]_{m \times p}$

- Given a matrix and a matrix the matrix product

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

- From the previous discussion, can you determine the dimension of the product of *AB?*

$$\boldsymbol{A} = \begin{bmatrix} 2 & 5 & 1 \\ 7 & 3 & 6 \end{bmatrix}, \quad \boldsymbol{B} = \begin{bmatrix} 1 & 8 \\ 9 & 4 \\ 3 & 5 \end{bmatrix}$$

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

- How about the product *BA*?

Lets treat matrix multiplication before answering this questions.

$$\boldsymbol{A} = \begin{bmatrix} 2 & 5 & 1 \\ 7 & 3 & 6 \end{bmatrix}, \quad \boldsymbol{B} = \begin{bmatrix} 1 & 8 \\ 9 & 4 \\ 3 & 5 \end{bmatrix}$$

Matrix – Matrix Multiplication

Do you Understand?

Matrix-Matrix Multiplication

- How do we do multiply two 2 x 2 matrix ?

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} ? & ? \\ ? & ? \end{bmatrix}$$

- As a smart G, let me just jump to the answer.

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

- How do we do multiply two 2 x 2 matrix ?

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} ? & ? \\ ? & ? \end{bmatrix}$$

- As a smart G, let me just jump to the answer.

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

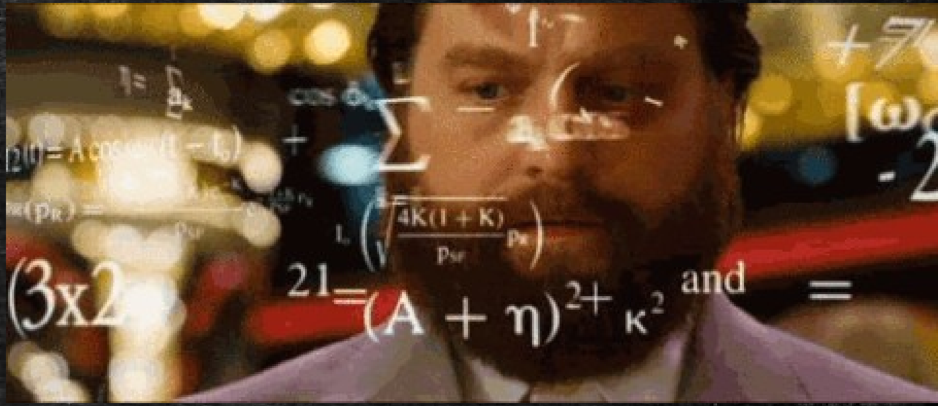
Matrix – Matrix Multiplication

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$



Matrix-Matrix Multiplication

Following shows you how each of the elements in resulting matrix are calculated.

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

- If it is not clear to you yet on how each of the elements in the resulting matrix came, take a look at the following arrows. I hope it got clearer to you.

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \bullet \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{bmatrix}$$

Matrix – Matrix Multiplication

Welcome Back
Lets solve the
matrix
multiplication

Matrix-Matrix Multiplication

- From the previous discussion, can you determine the dimension of the product of *AB?*

$$\boldsymbol{A} = \begin{bmatrix} 2 & 5 & 1 \\ 7 & 3 & 6 \end{bmatrix}, \quad \boldsymbol{B} = \begin{bmatrix} 1 & 8 \\ 9 & 4 \\ 3 & 5 \end{bmatrix}$$

Matrix – Matrix Multiplication

Matrix-Matrix Multiplication

- How about the product *BA?*

$$\boldsymbol{A} = \begin{bmatrix} 2 & 5 & 1 \\ 7 & 3 & 6 \end{bmatrix}, \quad \boldsymbol{B} = \begin{bmatrix} 1 & 8 \\ 9 & 4 \\ 3 & 5 \end{bmatrix}$$

How about this one?

Matrix – Matrix Multiplication

SOLUTION

Matrix-Matrix Multiplication

$$\boldsymbol{AB} = \begin{bmatrix} 2\cdot 1 + 5\cdot 9 + 1\cdot 3 & 2\cdot 8 + 5\cdot 4 + 1\cdot 5 \\ 7\cdot 1 + 3\cdot 9 + 6\cdot 3 & 7\cdot 8 + 3\cdot 4 + 6\cdot 5 \end{bmatrix} = \begin{bmatrix} 50 & 41 \\ 52 & 98 \end{bmatrix}$$

$$\boldsymbol{BA} = \begin{bmatrix} 1\cdot 2 + 8\cdot 7 & 1\cdot 5 + 8\cdot 3 & 1\cdot 1 + 8\cdot 6 \\ 9\cdot 2 + 4\cdot 7 & 9\cdot 5 + 4\cdot 3 & 9\cdot 1 + 4\cdot 6 \\ 3\cdot 2 + 5\cdot 7 & 3\cdot 5 + 5\cdot 3 & 3\cdot 1 + 5\cdot 6 \end{bmatrix} = \begin{bmatrix} 58 & 29 & 49 \\ 46 & 57 & 33 \\ 41 & 30 & 33 \end{bmatrix}$$

Matrix – Matrix Multiplication

Matrix-Scalar Multiplication

- Scalar-matrix multiplication is simpler than matrix-matrix multiplication. Given a matrix $A = [a_{ij}]_{m\times n}$ and a scalar $\lambda \in R$ the scalar-matrix product λA is calculated by multiplying every element of A by λ such that $A = [\lambda a_{ij}]_{m\times n}$

$$\lambda(A + B) = \lambda A + \lambda B$$

Class Exercise?

What if we have λ and μ scalars, multiplying a matrix A?

$$(\lambda + \mu)A = ?$$

$$\lambda(\mu A) = ?$$

Matrix – Matrix Multiplication

Matrix-Scalar Multiplication

- The second result states that if you add two scalars together and then multiply the result by a matrix it gives the same answer as if you individually multiplied the matrix separately by each scalar and added the result.
- The third result states that the order of scalar multiplication does not matter. If you multiply the matrix by one scalar, and then multiply the result by another scalar it gives the same answer as if you first multiplied both scalars together and then by the matrix.
- All of these results follow from the simple rules of scalar multiplication and addition.

Matrix

Terms related to Matrix

- **Order of matrix** – If a matrix has 3 rows and 4 columns, order of the matrix is 3*4 i.e. row*column.
- **Square matrix** – The matrix in which the number of rows is equal to the number of columns.
- **Diagonal matrix** – A matrix with all the non-diagonal elements equal to 0 is called a diagonal matrix.
- **Upper triangular matrix** – Square matrix with all the elements below diagonal equal to 0.

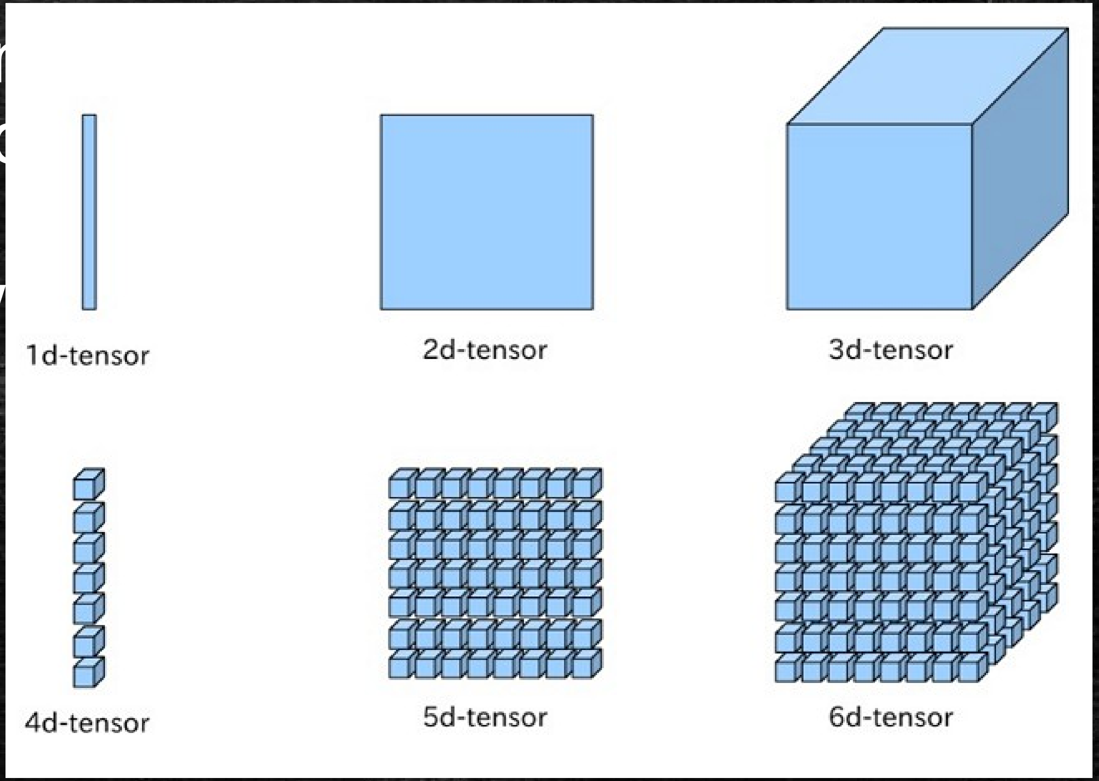
Matrix

- **Lower triangular matrix** – Square matrix with all the elements above the diagonal equal to 0.
- **Scalar matrix** – Square matrix with all the diagonal elements equal to some constant k.
- **Identity matrix** – Square matrix with all the diagonal elements equal to 1 and all the non-diagonal elements equal to 0.
- **Column matrix** – The matrix which consists of only 1 column. Sometimes, it is used to represent a vector.
- **Row matrix** – A matrix consisting only of row.
- **Trace** – It is the sum of all the diagonal elements of a square matrix

Tensors

Tensor

- **Tensors** possess an order (or rank), which determines the number of dimensions in an array required to represent it.
- In machine learning, and deep learning in particular, a 3rd-order tensor can be used describe the intensity values of multiple channels (red, green and blue) from a tw dimensional image.



Relevance of Matrices to Machine Learning

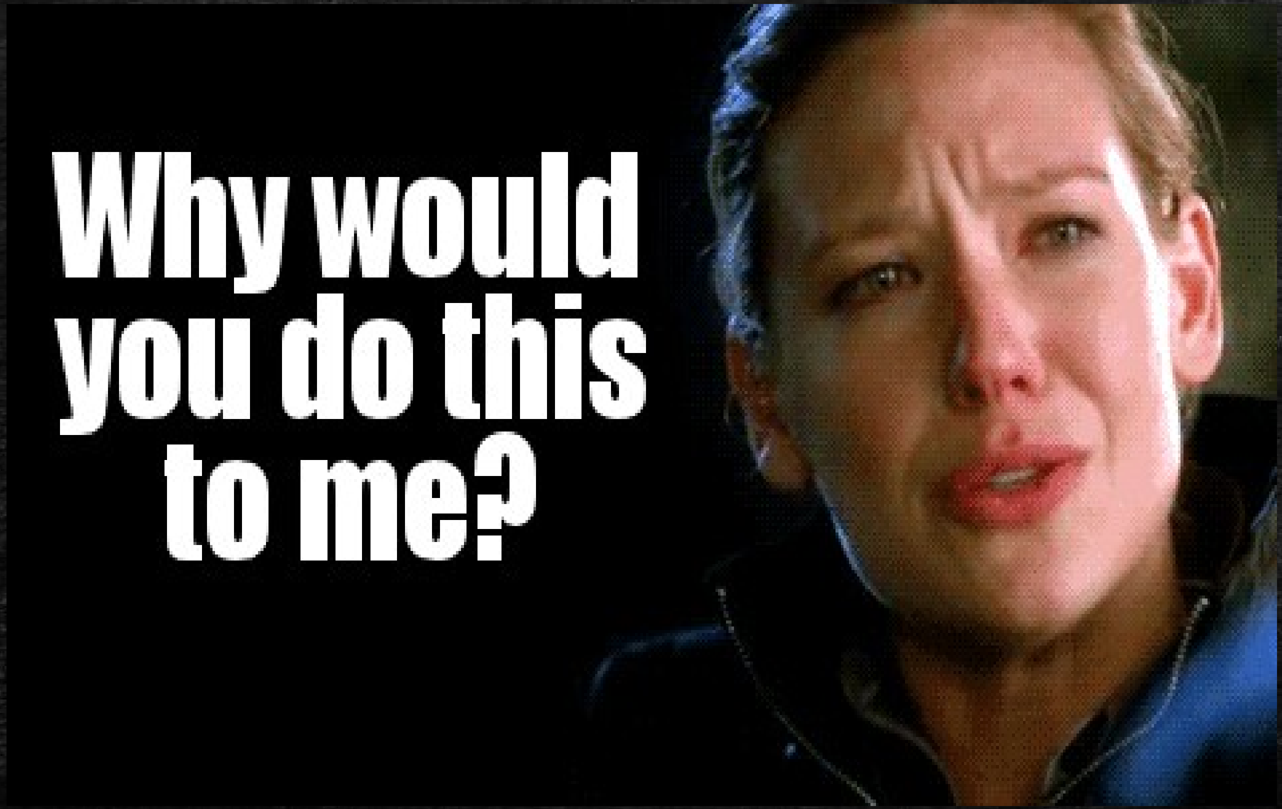
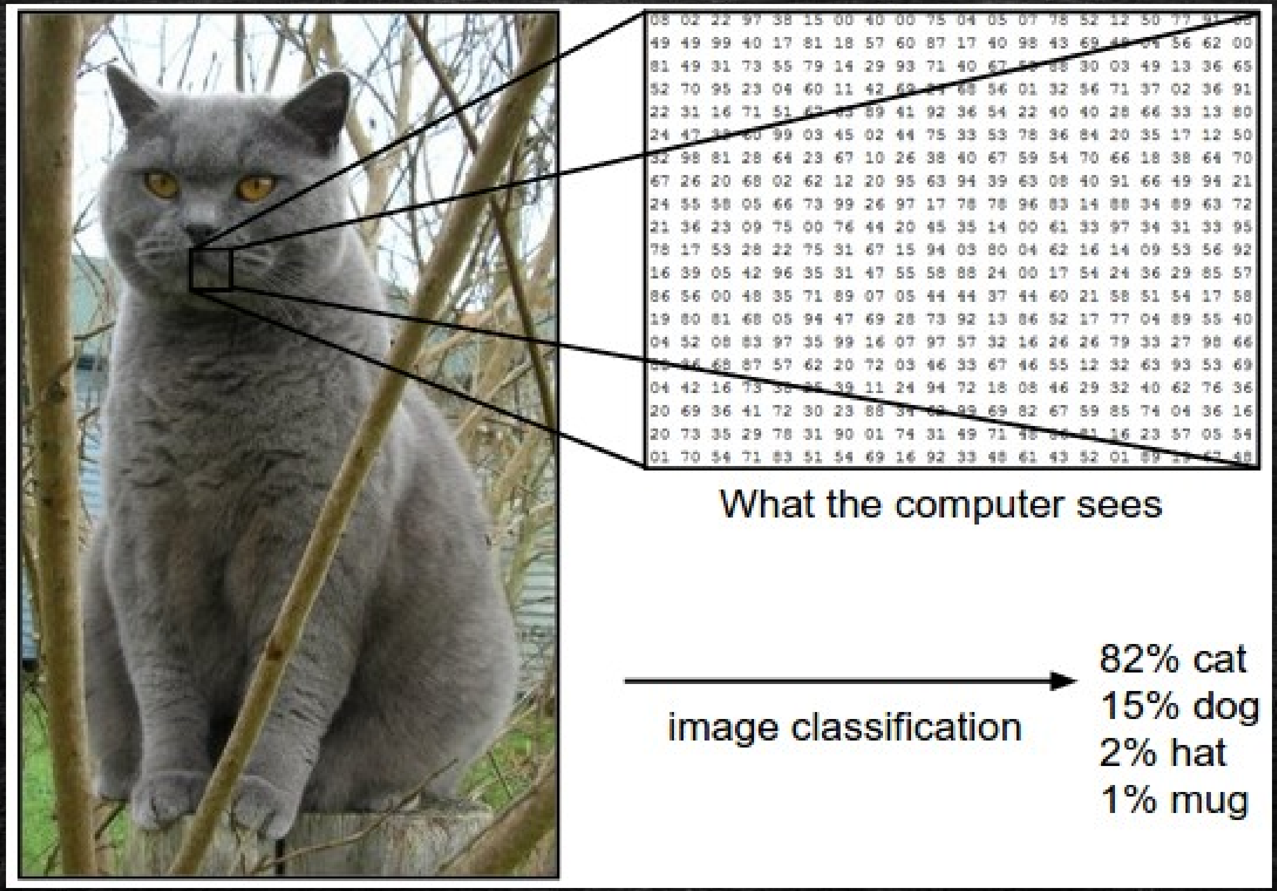


Image Processing

- It is very easy for our brains to recognize images.
- But making a computer recognize images is not an easy task, and is an active area of research in Machine Learning and Computer Science in general.
- So how can an image such as above with multiple attributes like colour be stored in a computer?
- This is achieved by storing the pixel intensities in a construct called **Matrix.** Then, this matrix can be processed to identify colours etc.
- So any operation which you want to perform on this image would likely use Linear Algebra and matrices at the back end.

Image Classification



XGBOOST

- If you are somewhat familiar with the Data Science domain, you might have heard about the word “XGBOOST”
- It is an algorithm employed most frequently by winners of Data Science Competitions.
- It stores the numeric data in the form of **Matrix** to give predictions.
- This enables XGBOOST to process data faster and provide more accurate results. Moreover, not just XGBOOST but various other algorithms use Matrices to store and process data.

Natural Language Processing

- Another active area of research in Machine Learning is dealing with text and the most common techniques employed are Bag of Words, Term Document Matrix etc.
- All these techniques in a very similar manner store counts(or something similar) of words in documents and store this frequency count in a Matrix form to perform tasks like Semantic analysis, Language translation, Language generation etc.

- So, now we understand the importance of Linear Algebra in machine learning.
- We have seen image, text or any data, in general, employing matrices to store and process data. This should be motivation enough to familiarize ourselves with it.


gif-finder.com