DS Workshop

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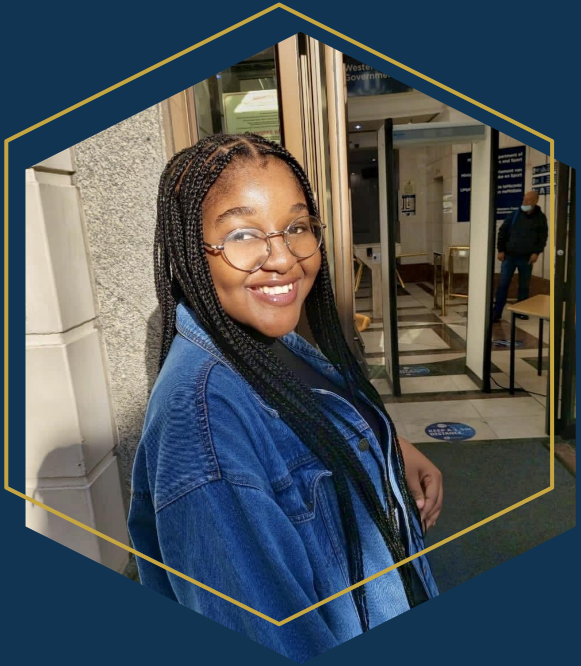
# Linear Algebra for Data Scientists

# Welcome

## Your Lecturer for this session



**Sanana Mwanawina**

# Workshop - Housekeeping

- The use of disrespectful language is prohibited in the questions, this is a supportive, learning environment - please engage accordingly.
- No question is daft or silly - **ask them!**
- There are Q/A sessions midway and at the end of the session, should you wish to ask any follow-up questions.
- You can also submit questions here: www.hyperiondev.com/support
- For all non-academic questions, please submit a query: www.hyperiondev.com/support
- Report a safeguarding incident: hyperiondev.com/safeguardreporting
- We would love your feedback on lectures and workshops: https://hyperionde.wufoo.com/forms/zsgv4m40ui4i0g/

# GitHub repo

Go to: github.com/HyperionDevBootcamps

Then click on the "**C4_DS_lecture_examples**" repository, do view or download the code.

# Objectives

1. Understand why we need to know Linear Algebra
2. Learn some linear operations
3. Understand what eigenvectors and eigenvalues are

# Why should we know about Linear Algebra

1. Foundational knowledge. It provides the necessary tools and notation for working with higher-level mathematical concepts used in Data Science
2. Crucial for understanding how machine learning algorithms work under the hood
3. Data manipulation using linear operations
4. Dimension reduction techniques
5. Deep Learning
6. Data visualisation

# Vectors & Matrices

- A vector is a mathematical object that represents magnitude and direction
- It is essentially a list of numbers.
- Matrix notation to represent vectors:

$$\mathbf{V} = \begin{pmatrix} v_1 \\ v_2 \\ v_3 \end{pmatrix}.$$

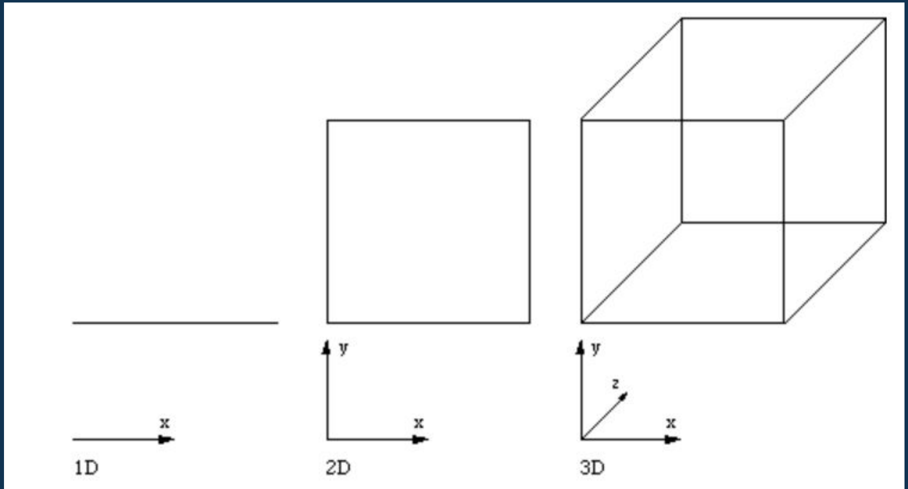
Column vector

$$\mathbf{V} = \begin{pmatrix} v_1 & v_2 & v_3 \end{pmatrix}.$$

Row vector

# Vectors & Matrices

- Dimensionality

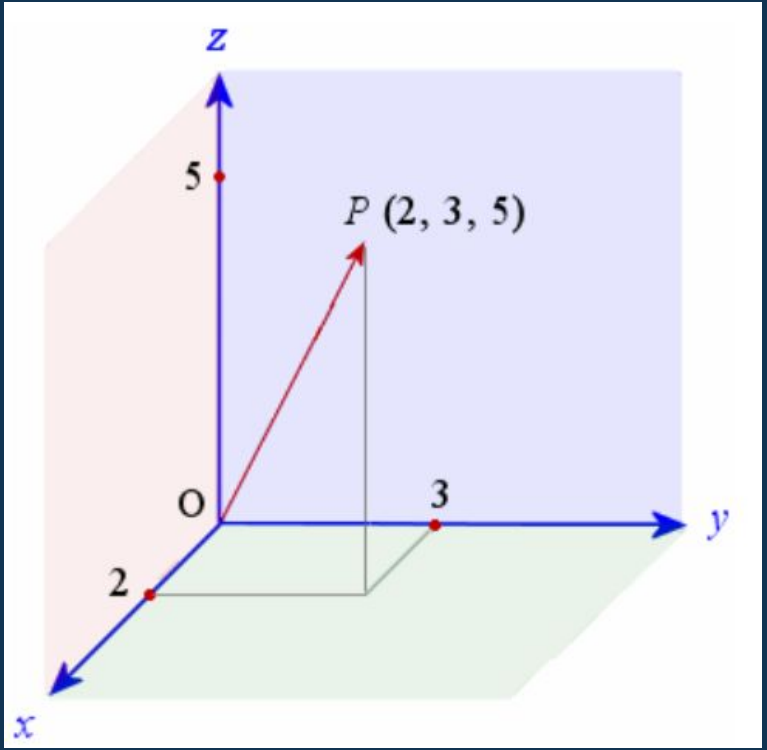


# Vectors & Matrices

- 1-vector
  V = (2)

- 2-vector
  V = (2, 3)

- 3-vector
  V = (2, 3, 5)



# Matrices & Vectors

- A matrix is an array of numbers or expressions that is arranged in rows and columns
- A multi-dimensional array

$$\mathbf{X} = \begin{pmatrix} x_{1,1} & x_{1,2} \\ x_{2,1} & x_{2,2} \\ x_{3,1} & x_{3,2} \end{pmatrix}.$$

# Linear Operations

- Addition and subtraction
  - Matrices have to compatible

$$A = \begin{bmatrix} 2 & 1 \\ 5 & 4 \end{bmatrix}$$

$$B = \begin{bmatrix} 2 & 0 \\ 7 & 3 \end{bmatrix}$$

$$A + B = \begin{bmatrix} 2 & 1 \\ 5 & 4 \end{bmatrix} + \begin{bmatrix} 2 & 0 \\ 7 & 3 \end{bmatrix}$$

$$= \begin{bmatrix} 4 & 1 \\ 12 & 7 \end{bmatrix}$$

# Linear Operations

- Scalar multiplication
  - A scalar is just a single number
  - You just need to multiply each matrix  element by the scalar

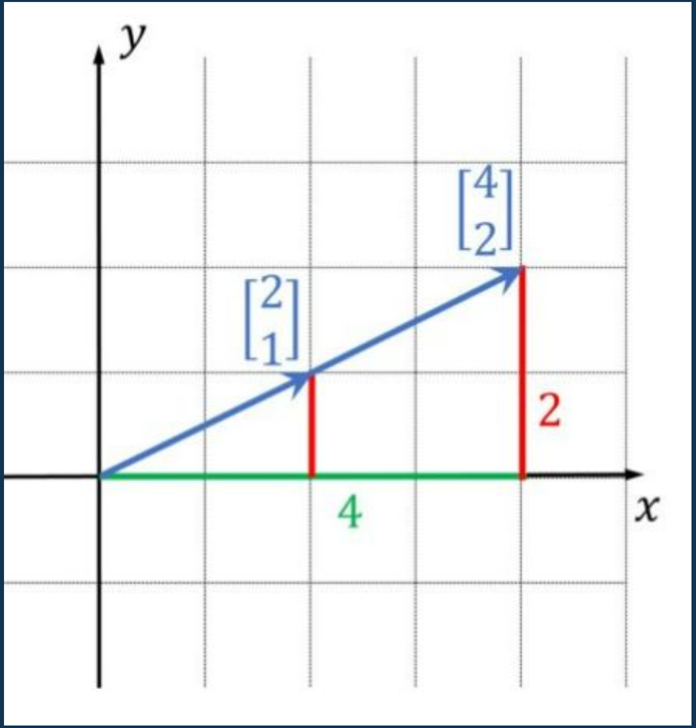
$$2\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} = \begin{bmatrix} 2(1) & 2(2) \\ 2(3) & 2(4) \end{bmatrix} = \begin{bmatrix} 2 & 4 \\ 6 & 8 \end{bmatrix}$$

# Linear Operations

Scaling:

$$2 \cdot \begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 2x \\ 2y \end{bmatrix}$$

$$2 \cdot \begin{bmatrix} 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 4 \\ 2 \end{bmatrix}$$



# Linear Operations

- Matrix multiplication
  - Matrices have to conformable
  - If matrix A is an $x$ x $y$ matrix then B must be a $y$ x $z$ matrix

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \\ a_{31} & a_{32} \end{bmatrix} \cdot \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}$$

# Linear Operations

Matrix multiplication (dot product):

$$\mathbf{A}\cdot\mathbf{B} = \begin{pmatrix} (a_{1,1}b_{1,1}+a_{1,2}b_{2,1}) & (a_{1,1}b_{1,2}+a_{1,2}b_{2,2}) & (a_{1,1}b_{1,3}+a_{1,2}b_{2,3}) \\ (a_{2,1}b_{1,1}+a_{2,2}b_{2,1}) & (a_{2,1}b_{1,2}+a_{2,2}b_{2,2}) & (a_{2,1}b_{1,3}+a_{2,2}b_{2,3}) \\ (a_{3,1}b_{1,1}+a_{3,2}b_{2,1}) & (a_{3,1}b_{1,2}+a_{3,2}b_{2,2}) & (a_{3,1}b_{1,3}+a_{3,2}b_{2,3}) \\ (a_{4,1}b_{1,1}+a_{4,2}b_{2,1}) & (a_{4,1}b_{1,2}+a_{4,2}b_{2,2}) & (a_{4,1}b_{1,3}+a_{4,2}b_{2,3}) \end{pmatrix}$$

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \times \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix} = \begin{bmatrix} 1\times5 + 2\times7 & 1\times6 + 2\times8 \\ 3\times5 + 4\times7 & 3\times6 + 4\times8 \end{bmatrix} = \begin{bmatrix} 5+14 & 6+16 \\ 15+28 & 18+32 \end{bmatrix} = \begin{bmatrix} 19 & 22 \\ 43 & 50 \end{bmatrix}$$

# Eigenvectors and eigenvalues

Why do we need to know about eigenvectors and eigenvalues?

1. They are used extensively in Machine Learning algorithms
2. Dimension reduction techniques
3. Understanding data variation

# Eigenvectors and eigenvalues

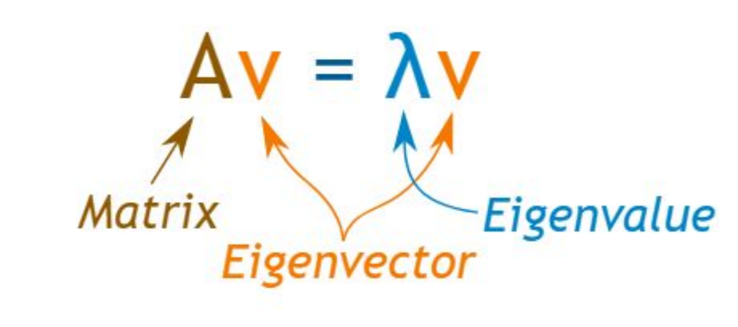
- If A is a square matrix, then a non-zero vector v is an eigenvector of A if

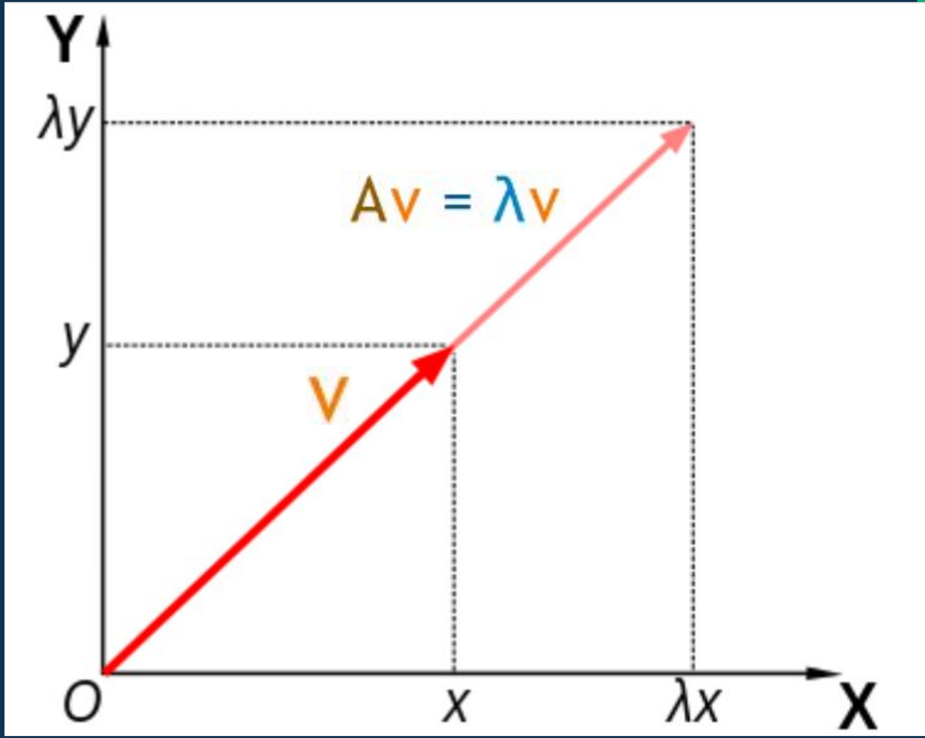
$$Av = \lambda v$$

For some scalar $\lambda$.

- The matrix-vector product gives the same value you would get from scaling the vector by some factor

# Eigenvectors and eigenvalues



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# Q & A Section

**Please use this time to ask any questions relating to the topic explained, should you have any**

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# Thank you for joining us