Handbook

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Contents

Part I
Math

1 Linear Algebra

1.1 Matrix Operations

The **addition** and subtraction of matrices happens element-wise. Take two 2×2 matrices A and B:

$$A + B = \begin{pmatrix} a_{11} + b_{11} & a_{12} + b_{12} \\ a_{21} + b_{21} & a_{22} + b_{22} \end{pmatrix} \tag{1}$$

The multiplication operation is known as the **dot product**.

$$A \cdot B = \begin{pmatrix} a_{11}b_{11} + a_{12}b_{21} & a_{11}b_{12} + a_{12}b_{22} \\ a_{21}b_{11} + a_{22}b_{21} & a_{21}b_{12} + a_{22}b_{22} \end{pmatrix} \tag{2}$$

The division operation does not exist for matrices. There is no inverse operation to the dot product. Note that matrix multiplication is *not commutative*. Multiplication is carried out right to left.

$$ABC = A(BC)$$

The equivalent concept to "dividing away" on two sides of an equation is to right-multiply an inverse.

$$B = ADC$$

The **transpose** of a matrix is flipped along its diagonal. Where the matrix is not square, this diagonal is imagined. For example given the 2×3 matrix C:

$$\begin{pmatrix} c_{11} & c_{12} & c_{13} \\ c_{21} & c_{22} & c_{23} \end{pmatrix}^T = \begin{pmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \\ c_{13} & c_{23} \end{pmatrix} \tag{3}$$

1.2 Inverse

The **inverse** of a matrix should satisfy $AA^{-1} = I$. The inverse is also the reciprocal of its determinant.

$$A^{-1} = \frac{1}{|A|} \tag{4}$$

For any $n \times n$ matrix, the inverse can also be found via Gauss-Jordan elimination. When the LHS is reduced to I, the RHS is the inverse of A.

$$\left(\begin{array}{ccc|ccc} a_{11} & a_{12} & a_{13} & 1 & 0 & 0 \\ a_{21} & a_{22} & a_{23} & 0 & 1 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 1 \end{array}\right) \tag{5}$$

1.3 Determinant

1.4 Cross Proudct

The **cross product** is a new operation to matrices. For a 2×2 matrix, the cross product is the same as its determinant.

$$A \times B = \det A - \det B = a_{11}a_{22} - a_{12}a_{21} - (bb - bb) \tag{6}$$

The cross product is more meaningful for matrices 3×3 or bigger.

$$A \times B = i() + j() + k() \tag{7}$$

1.5 Square Matrices

A **diagonal matrix** is a square matrix which is comprised of non-zero values along the diagonal and zeros everywhere else. The **identity matrix** is a square matrix with 1's on the diagonal.

$$I = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \ddots & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \tag{8}$$

1.6 Eigenvalues and Eigenvectors

2 Calculus

2.1 Derivative and integral foundations

2.2 Multivariable Topics

3 Probability

3.1 Probabilitly foundations

3.2 Markov Chains

3.3 Renewal Processes

Part II
Computer Science

4 Object Oriented Programming

This section will mostly be covered in Java, with analogies drawn to Python. This section will cover:

- Scope and encapsulation
- Polymorphism

4.1 Java foundations

```
class MyClass{
    private int x = 123;

    public MyClass(int a) {
        ...
    }
}
```

wtf? hello

4.2 Scope & Encapsulation

5 Data Structures & Algorithms

6 Machine Learning

Part III

Finance

7 Fixed Income