A-Z Linear Algebra & Calculus for AI & Data Science

Module 01: Vectors, Matrices & Linear Transformations

- Basic Properties: Notation, Terminologies, Sets, Subsets, Scalars, Vectors, and Matrices
- Vector Spaces & Basis (Subspaces, Linear Independence, Dimension)
- Introduction to Norms
- Column Space, Row Space, Null Space
- Matrix Operations: Addition, Subtraction, Multiplication
- Rank, Trace, Transpose Matrix
- Identity, Diagonal, Sparse & Dense Matrix
- Determinant, Orthogonal, Singular, Non-singular Matrix
- Inverse Matrix, Alternative to Matrix Division
- Covariance and Symmetric Matrices
- Positive-Negative Definite Matrix, Positive Semi-Definite
- Basic Logarithmic Properties
- Linear Transformations, Kernel & Range
- Change of Basis & Similarity Transformations
- Gram Matrix (Used in Kernel Methods)
- Eigenvalues & Eigenvectors
- Matrix Reduction: Cramer's Rule, Gaussian Elimination

Module 02: Differential Calculus for Machine Learning

- Basics of Differentiation
- Differentiation Rules: Power, Constant, Exponential, Product, Quotient, Chain Rule
- 1st & 2nd Order Partial Derivatives
- Convex vs. Non-Convex Functions
- Gradient Descent Concepts for Optimization
- Hessian Matrix & Its Role in Optimization

Module 03: Integral Calculus for Machine Learning

- Indefinite Integral, Definite Integral
- Continuous Integral Form of MSE, MAE, RMSE
- Probability Density Function (PDF)
- Cumulative Distribution Function (CDF)
- Expectation (Mean), Variance
- Sigmoid Function
- Shannon Entropy
- KL Divergence

Module 04: Regression Analysis & Correlation Analysis

- Correlation vs. Causation vs. Covariance
- Pearson Correlation / Types of correlations
- Covariance and Its Interpretation
- Simple & Multiple Linear Regression
- MSE, MAE, and RMSE
- R-Squared for Model Evaluation
- Distance Metrics: Euclidean Distance (L2 norm), Manhattan Distance (L1 norm), Minkowski Distance, Mahalanobis Distance, Chebyshev Distance, Cosine Similarity, Hamming Distance, and Jaccard Distance

Module 05: More About Regression in Machine Learning

- Polynomial Regression
- Real Problems & Solutions with High-Dimensional Data
- L1 (Lasso) Regularization
- L2 (Ridge) Regularization
- Elastic Net (L1 & L2)

Module 06: Matrix Factorization & Dimensionality Reduction

- Determinants & Rank of a Matrix
- Singular Value Decomposition (SVD)
- Low-Rank Approximation using SVD
- Moore-Penrose Pseudoinverse
- PCA for High-Dimensional Data
- t-SNE for Visualization

Module 07: Advanced Matrix Operations & Decompositions

- QR Decomposition & LU Decomposition
- Cholesky Decomposition for Positive Definite Matrices
- Adjoint & Pseudoinverse of a Matrix
- Norms: L1, L2, Frobenius, Spectral Norms

Module 08: Tensor Algebra for Deep Learning

- Tensors vs. Matrices
- Tensor Operations & Contractions
- Eigenvalues & Singular Values for Tensors
- Application of Tensor Algebra in Neural Networks

Special Module: Probabilistic Models and Bayesian Methods

- Bayes' Theorem & Conditional Probability
- Bayesian Inference: Prior, Likelihood, Posterior
- Probability Distribution for Discrete & Continuous Data
- Markov Chains & Monte Carlo Methods (MCMC)
- Hidden Markov Models (HMMs)
- Variational Inference
- Baysian Neural Network
- Baysian GANs

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