Advanced Mathematics

Course Description

Modern techniques to analyze data and derive predictions for future events are deeply rooted in mathematical techniques. This course builds a solid base to understand the concepts behind advanced algorithms used to process, analyze, and predict data and observations and enables students to follow future research, especially in the fields of data-intensive sciences. The course reviews differentiation and integration and then discusses partial differentiation, differentiation, vector algebra, and vector calculus. Matrix calculation and vector spaces are fundamental to many modern data processing algorithms and are discussed in detail. Calculations based on tensors are introduced. Common metrics are discussed from an informational, theoretical point of view.

Contents

1. Calculus
   1. Differentiation and Integration
   2. Partial Differentiation and Integration
   3. Vector Analysis
   4. Calculus of Variations
2. Integral Transformations
   1. Convolution
   2. Fourier Transformation
3. Vector Algebra
   1. Scalars and Vectors
   2. Addition and Subtraction of Vectors
   3. Multiplication of Vectors, Vector Product, and Scalar Product
4. Vector Calculus
   1. Integration of Vectors
   2. Differentiation of Vectors
   3. Scalar and Vector Fields
   4. Vector Operators
5. Matrices and Vector Spaces
   1. Basic Matrix Algebra
6. Determinant, Trace, Transpose, Complex, and Hermitian Conjugates
7. Eigenvectors and Eigenvalues
8. Diagonalization
9. Tensors
10. Information Theory
    1. MSE
11. Gini Index
12. Entropy, Shannon Entropy, and Kulback–Leibler Distance
13. Cross Entropy