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MAT 1034 INTRODUCTION TO PROBABILITY
Chapter 4: Multivariate Probability Distribution

1.   Joint Probability Distributions

Our study of random variables and their probability distributions in the preceding chapters is restricted to one–dimensional sample spaces, where we recorded outcomes of an experiment as values assumed by a single random variable. There will be situations, however, where we may find it desirable to record the simultaneous outcomes of several variables. For example:

1.   We might measure the amount of precipitate P and volume V of gas released from a controlled chemical experiment, giving rise to a two–dimensional sample space consisting of the outcomes (p, v).

2.   We might be interested in the hardness H and tensile strength T of cold–drawn copper, resulting in the outcomes (h, t).

3.   In a study to determine the likelihood of success in college based on high school data, we might use a three-dimensional sample space and record for each individual his or her aptitude test score, high school class rank, and grade-point average at the end of freshman year in college.

If X and Y are two discrete random variables, the probability distribution for their simultaneous occurrence can be represented by a function with values $f(x, y)$ for any pair of values (x, y) within the range of the random variables X and Y. This function is referred to as the joint probability distribution of X and Y.

Hence, in the discrete case,

$$f(x, y) = P(X = x, Y = y)$$

that is, the values $f(x, y)$ give the probability that outcomes x and y occur at the same time.

Definition 1.1
The function $f(x, y)$ is a joint probability distribution or probability mass function of the discrete random variables X and Y if

1. $f(x, y) \geq 0$ for all (x, y)

2. $\sum_x \sum_y f(x, y) = 1$

3. $P(X = x, Y = y) = f(x, y)$

For any region A in the xy plane, $P\left[(X, Y) \in A\right] = \sum \sum_A f(x, y)$

Chapter 4 Multivariate Probability And Statistics

Dirk P. Kroese,Thomas Taimre,Zdravko I. Botev

Chapter 4 Multivariate Probability And Statistics:

Handbook of Monte Carlo Methods Dirk P. Kroese,Thomas Taimre,Zdravko I. Botev,2013-06-06 A comprehensive overview of Monte Carlo simulation that explores the latest topics techniques and real world applications More and more of today s numerical problems found in engineering and finance are solved through Monte Carlo methods The heightened popularity of these methods and their continuing development makes it important for researchers to have a comprehensive understanding of the Monte Carlo approach Handbook of Monte Carlo Methods provides the theory algorithms and applications that helps provide a thorough understanding of the emerging dynamics of this rapidly growing field The authors begin with a discussion of fundamentals such as how to generate random numbers on a computer Subsequent chapters discuss key Monte Carlo topics and methods including Random variable and stochastic process generation Markov chain Monte Carlo featuring key algorithms such as the Metropolis Hastings method the Gibbs sampler and hit and run Discrete event simulation Techniques for the statistical analysis of simulation data including the delta method steady state estimation and kernel density estimation Variance reduction including importance sampling latin hypercube sampling and conditional Monte Carlo Estimation of derivatives and sensitivity analysis Advanced topics including cross entropy rare events kernel density estimation quasi Monte Carlo particle systems and randomized optimization The presented theoretical concepts are illustrated with worked examples that use MATLAB a related Web site houses the MATLAB code allowing readers to work hands on with the material and also features the author s own lecture notes on Monte Carlo methods Detailed appendices provide background material on probability theory stochastic processes and mathematical statistics as well as the key optimization concepts and techniques that are relevant to Monte Carlo simulation Handbook of Monte Carlo Methods is an excellent reference for applied statisticians and practitioners working in the fields of engineering and finance who use or would like to learn how to use Monte Carlo in their research It is also a suitable supplement for courses on Monte Carlo methods and computational statistics at the upper undergraduate and graduate levels *Data Assimilation for the Geosciences* Steven J. Fletcher,2022-11-16 Data Assimilation for the Geosciences From Theory to Application Second Edition brings together all of the mathematical and statistical background knowledge needed to formulate data assimilation systems into one place It includes practical exercises enabling readers to apply theory in both a theoretical formulation as well as teach them how to code the theory with toy problems to verify their understanding It also demonstrates how data assimilation systems are implemented in larger scale fluid dynamical problems related to land surface the atmosphere ocean and other geophysical situations The second edition of Data Assimilation for the Geosciences has been revised with up to date research that is going on in data assimilation as well as how to apply the techniques The new edition features an introduction of how machine learning and artificial intelligence are interfacing and aiding data assimilation In addition to appealing to students and researchers across the geosciences this now also appeals to new students and scientists in the

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intelligent A comprehensive overview of site characterization information is also presented with a focus on its availability coverage value to decision making and challenges The remaining 13 chapters cover databases of soil and rock properties and the application of these databases to rock socket behavior rock classification settlement on soft marine clays permeability of fine grained soils and liquefaction among others The databases were compiled from studies undertaken in many countries including Austria Australia Brazil Canada China France Finland Germany India Iran Japan Korea Malaysia Mexico New Zealand Norway Singapore Sweden Thailand the United Kingdom and the United States This volume on site characterization is a companion to the volume on geotechnical structures Databases for Data Centric Geotechnics represents the most diverse and comprehensive assembly of database research in a single publication consisting of two volumes to date It follows from Model Uncertainties for Foundation Design also published by CRC Press and suits specialist geotechnical engineers researchers and graduate students   *Graphical Exploratory Data Analysis* S. H. C. DuToit,A. G. W. Steyn,R. H. Stumpf,2012-12-06 Portraying data graphically certainly contributes toward a clearer and more penetrative understanding of data and also makes sophisticated statistical data analyses more marketable This realization has emerged from many years of experience in teaching students in research and especially from engaging in statistical consulting work in a variety of subject fields Consequently we were somewhat surprised to discover that a comprehen sive yet simple presentation of graphical exploratory techniques for the data analyst was not available Generally books on the subject were either too incomplete stopping at a histogram or pie chart or were too technical and specialized and not linked to readily available computer programs Many of these graphical techniques have furthermore only recently appeared in statis tical journals and are thus not easily accessible to the statistically unsophis ticated data analyst This book therefore attempts to give a sound overview of most of the well known and widely used methods of analyzing and portraying data graph ically Throughout the book the emphasis is on exploratory techniques Real izing the futility of presenting these methods without the necessary computer programs to actually perform them we endeavored to provide working com puter programs in almost every case Graphic representations are illustrated throughout by making use of real life data Two such data sets are frequently used throughout the text In realizing the aims set out above we avoided intricate theoretical derivations and explanations but we nevertheless are convinced that this book will be of inestimable value even to a trained statistician   **An Introduction to Mathematical Statistics** H. D. Brunk,1965 Details the other revolutions during 1776 including the reaction of the native residents of San Francisco in the wake of the first European settlement there and the devastation of the Aleutian Islands by the Russians hunt for sea otters   **Water-resources Engineering** David A. Chin,2006 This in depth review of water resources engineering essentials focuses on both fundamentals and design applications Emphasis on fundamentals encourages readers understanding of basic equations in water resources engineering and the background that is necessary to develop innovative solutions to complex problems Comprehensive design applications illustrate the practical application of

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