# Chapter – 9
# STATISTICS

Statistics deals with the collection, classification, presentation, analysis and interpretation of numeric data (quantitative data).

The simplest form of numerical data is a series of values of a certain variable. Such values can be given as individual numbers. Therefore, such data is called an individual series of raw data.

In such a series, some numbers could occur repeatedly. In such cases, it would be convenient to group these numbers. This grouping can be done in two ways. The numbers can be arranged in ascending (or descending) order and the number of times each number occurs (its frequency) can be specified. This results in a discrete series. Alternately, we may choose to ignore the actual number and record only the fact that it lies between certain limits. Such grouping results in a continuous series. The values between the limits are called intervals. For example, consider the marks obtained by the students of a class. This data has been represented in each of the ways below.

Individual series
60, 55, 70, 60, 70
65, 75, 65, 70, 55
58, 74, 67, 68, 73

Discrete series

| Frequency | 2 | 1 | 2 | 2 | 1 | 1 | 3 | 1 | 1 | 1 |
|-----------|----|----|----|----|----|----|----|----|----|----|
| Number | 55 | 58 | 60 | 65 | 67 | 68 | 70 | 73 | 74 | 75 |

Continuous series
We denote the marks obtained by the students as

| Intervals | Frequency |
|-----------|-----------|
| $x \leq 55$ | 2 |
| $55 < x \leq 60$ | 3 |
| $60 < x \leq 65$ | 2 |
| $65 < x \leq 70$ | 5 |
| $70 < x \leq 75$ | 3 |

Collection of data, especially on a large scale, is typically an expensive process and requires big teams of field workers. Therefore it needs careful planning. The primary consideration is the purpose for which the collected data will be used.

After data has been collected, classified and presented, it has to be analysed and interpreted. To analyse data, the important features of the data have to be identified and relations between quantities (variables) have to be studied. Two important features of any data are the central tendency and dispersion. Instead of thinking of all the numbers in a set, we would like to think of a typical number, the 'central' value. Two sets of numbers, which may have the same 'central' value, may differ in terms of the variation of all the numbers in the set, i.e. the extent to which the numbers 'disperse' from this central value.

Various quantitative measures can be defined to measure these two properties, ie central tendency and dispersion.

In this chapter, we shall limit ourselves to an individual series and study such properties.

## I. Measures of Central Tendencies

The measures we discuss here are
(A) Arithmetic Mean,
(B) Geometric Mean,
(C) Harmonic Mean,
(D) Median and
(5) Mode.

### 1. Arithmetic Mean (A.M.) ($\bar{x}$)

Given $x_1, x_2, \ldots\ldots\ldots, x_n$ (n individual items)

$$A.M. = \bar{x} = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

or $\bar{x} = \dfrac{\text{Sum of the observations}}{\text{The number of observations}}$

#### Examples

(i) The arithmetic mean of (5, 8, 9, 14, −16) is
$$= \frac{5 + 8 + 9 + 14 - 16}{5} = \frac{20}{5} = 4$$

(ii) The arithmetic mean of (3, 4, 5, 6, 7, 8, 9, 10) is
$$= \frac{3 + 4 + 5 + 6 + 7 + 8 + 9 + 10}{8} = \frac{52}{10} = 5.2$$

**Note:**
(a) The algebraic sum of deviations about the mean is 0 or $\Sigma(x - \bar{x}) = 0$.
(b) The arithmetic mean of two numbers a, b is $\dfrac{a + b}{2}$.
(c) If b = AM of (a, c), then a, b and c are in arithmetic progression.

### 2. Geometric Mean (G.M.)

Given $x_1, x_2, \ldots\ldots\ldots, x_n$ (n individual items all being positive)

$$G.M. = (x_1 \cdot x_2 \cdot \ldots\ldots, x_n)^{1/n}$$

or G.M. = $n^{th}$ root of the product of the numbers.

#### Examples

(i) The geometric mean of (10, 30, 90) is
$= (10 \times 30 \times 90)^{1/3}$
$= (10 \times 30 \times 3 \times 30)^{1/3}$
$= (30 \times 30 \times 30)^{1/3} = 30$

(ii) The geometric mean of (24, 20, 15, 45, 75) is
$= (8 \times 3 \times 5 \times 4 \times 3 \times 5 \times 3^2 \times 5 \times 3 \times 5^2)^{1/5}$
$= (2^9 \times 3^5 \times 5^5)^{1/5}$
$= 2 \times 3 \times 5 = 30$

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**Michael Sullivan,Abe Mizrahi**

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*Linear Algebra, Data Science, and Machine Learning* Jeff Calder,Peter J. Olver,2025-08-25 This text provides a mathematically rigorous introduction to modern methods of machine learning and data analysis at the advanced

undergraduate beginning graduate level The book is self contained and requires minimal mathematical prerequisites There is a strong focus on learning how and why algorithms work as well as developing facility with their practical applications Apart from basic calculus the underlying mathematics linear algebra optimization elementary probability graph theory and statistics is developed from scratch in a form best suited to the overall goals In particular the wide ranging linear algebra components are unique in their ordering and choice of topics emphasizing those parts of the theory and techniques that are used in contemporary machine learning and data analysis The book will provide a firm foundation to the reader whose goal is to work on applications of machine learning and or research into the further development of this highly active field of contemporary applied mathematics To introduce the reader to a broad range of machine learning algorithms and how they are used in real world applications the programming language Python is employed and offers a platform for many of the computational exercises Python notebooks complementing various topics in the book are available on a companion GitHub site specified in the Preface and can be easily accessed by scanning the QR codes or clicking on the links provided within the text Exercises appear at the end of each section including basic ones designed to test comprehension and computational skills while others range over proofs not supplied in the text practical computations additional theoretical results and further developments in the subject The Students Solutions Manual may be accessed from GitHub Instructors may apply for access to the Instructors Solutions Manual from the link supplied on the text s Springer website The book can be used in a junior or senior level course for students majoring in mathematics with a focus on applications as well as students from other disciplines who desire to learn the tools of modern applied linear algebra and optimization It may also be used as an introduction to fundamental techniques in data science and machine learning for advanced undergraduate and graduate students or researchers from other areas including statistics computer science engineering biology economics and finance and so on     *Statistics of Directional Data* K. V. Mardia,2014-07-03 Probability and Mathematical Statistics A Series of Monographs and Textbooks Statistics of Directional Data aims to provide a systematic account of statistical theory and methodology for observations which are directions The publication first elaborates on angular data and frequency distributions descriptive measures and basic concepts and theoretical models Discussions focus on moments and measures of location and dispersion distribution function corrections for grouping calculation of the mean direction and the circular variance interrelations between different units of angular measurement and diagrammatical representation The book then examines fundamental theorems and distribution theory point estimation and tests for samples from von Mises populations The text takes a look at non parametric tests distributions on spheres and inference problems on the sphere Topics include tests for axial data point estimation distribution theory moments and limiting distributions and tests of goodness of fit and tests of uniformity The publication is a dependable reference for researchers interested in probability and mathematical statistics     **A Course in Statistics with R** Prabhanjan N. Tattar,Suresh Ramaiah,B. G. Manjunath,2016-03-15 Integrates

the theory and applications of statistics using R A Course in Statistics with R has been written to bridge the gap between theory and applications and explain how mathematical expressions are converted into R programs The book has been primarily designed as a useful companion for a Masters student during each semester of the course but will also help applied statisticians in revisiting the underpinnings of the subject With this dual goal in mind the book begins with R basics and quickly covers visualization and exploratory analysis Probability and statistical inference inclusive of classical nonparametric and Bayesian schools is developed with definitions motivations mathematical expression and R programs in a way which will help the reader to understand the mathematical development as well as R implementation Linear regression models experimental designs multivariate analysis and categorical data analysis are treated in a way which makes effective use of visualization techniques and the related statistical techniques underlying them through practical applications and hence helps the reader to achieve a clear understanding of the associated statistical models Key features Integrates R basics with statistical concepts Provides graphical presentations inclusive of mathematical expressions Aids understanding of limit theorems of probability with and without the simulation approach Presents detailed algorithmic development of statistical models from scratch Includes practical applications with over 50 data sets **Mathematics of Big Data** Jeremy Kepner,Hayden Jananthan,2018-07-17 The first book to present the common mathematical foundations of big data analysis across a range of applications and technologies Today the volume velocity and variety of data are increasing rapidly across a range of fields including Internet search healthcare finance social media wireless devices and cybersecurity Indeed these data are growing at a rate beyond our capacity to analyze them The tools including spreadsheets databases matrices and graphs developed to address this challenge all reflect the need to store and operate on data as whole sets rather than as individual elements This book presents the common mathematical foundations of these data sets that apply across many applications and technologies Associative arrays unify and simplify data allowing readers to look past the differences among the various tools and leverage their mathematical similarities in order to solve the hardest big data challenges The book first introduces the concept of the associative array in practical terms presents the associative array manipulation system D4M Dynamic Distributed Dimensional Data Model and describes the application of associative arrays to graph analysis and machine learning It provides a mathematically rigorous definition of associative arrays and describes the properties of associative arrays that arise from this definition Finally the book shows how concepts of linearity can be extended to encompass associative arrays Mathematics of Big Data can be used as a textbook or reference by engineers scientists mathematicians computer scientists and software engineers who analyze big data *Demographic Methods across the Tree of Life* Roberto Salguero-Gomez,Marlène Gamelon,2021-08-31 Demography is everywhere in our lives from birth to death Indeed the universal currencies of survival development reproduction and recruitment shape the performance of all species from microbes to humans The number of techniques for demographic data acquisition and analyses across the entire tree of

life microbes fungi plants and animals has drastically increased in recent decades These developments have been partially facilitated by the advent of technologies such as GIS and drones as well as analytical methods including Bayesian statistics and high throughput molecular analyses However despite the universality of demography and the significant research potential that could emerge from unifying i questions across taxa ii data collection protocols and iii analytical tools demographic methods to date have remained taxonomically siloed and methodologically disintegrated This is the first book to attempt a truly unified approach to demography and population ecology in order to address a wide range of questions in ecology evolution and conservation biology across the entire spectrum of life This novel book provides the reader with the fundamentals of data collection model construction analyses and interpretation across a wide repertoire of demographic techniques and protocols It introduces the novice demographer to a broad range of demographic methods including abundance based models life tables matrix population models integral projection models integrated population models individual based models and more Through the careful integration of data collection methods analytical approaches and applications clearly guided throughout with fully reproducible R scripts the book provides an up to date and authoritative overview of the most popular and effective demographic tools Demographic Methods across the Tree of Life is aimed at graduate students and professional researchers in the fields of demography ecology animal behaviour genetics evolutionary biology mathematical biology and wildlife management **A Mathematics Course for Political and Social Research** Will H. Moore,David A. Siegel,2013-07-24 Political science and sociology increasingly rely on mathematical modeling and sophisticated data analysis and many graduate programs in these fields now require students to take a math camp or a semester long or yearlong course to acquire the necessary skills Available textbooks are written for mathematics or economics majors and fail to convey to students of political science and sociology the reasons for learning often abstract mathematical concepts A Mathematics Course for Political and Social Research fills this gap providing both a primer for math novices in the social sciences and a handy reference for seasoned researchers The book begins with the fundamental building blocks of mathematics and basic algebra then goes on to cover essential subjects such as calculus in one and more than one variable including optimization constrained optimization and implicit functions linear algebra including Markov chains and eigenvectors and probability It describes the intermediate steps most other textbooks leave out features numerous exercises throughout and grounds all concepts by illustrating their use and importance in political science and sociology Uniquely designed and ideal for students and researchers in political science and sociology Uses practical examples from political science and sociology Features Why Do I Care sections that explain why concepts are useful Includes numerous exercises Complete online solutions manual available only to professors email david siegel at duke edu subject line Solution Set Selected solutions available online to students **Analysis of Variance, Design, and Regression** Ronald Christensen,2018-09-03 Analysis of Variance Design and Regression Linear Modeling for Unbalanced Data Second Edition

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projects and solutions to selected exercises As much as possible data sets and matrix entries are included in the files thus reducing the amount of manual data entry required *Symbolic Mathematics for Chemists* Fred Senese,2018-11-05 An essential guide to using Maxima a popular open source symbolic mathematics engine to solve problems build models analyze data and explore fundamental concepts Symbolic Mathematics for Chemists offers students of chemistry a guide to Maxima a popular open source symbolic mathematics engine that can be used to solve problems build models analyze data and explore fundamental chemistry concepts The author a noted expert in the field focuses on the analysis of experimental data obtained in a laboratory setting and the fitting of data and modeling experiments The text contains a wide variety of illustrative examples and applications in physical chemistry quantitative analysis and instrumental techniques Designed as a practical resource the book is organized around a series of worksheets that are provided in a companion website Each worksheet has clearly defined goals and learning objectives and a detailed abstract that provides motivation and context for the material This important resource Offers an text that shows how to use popular symbolic mathematics engines to solve problems Includes a series of worksheet that are prepared in Maxima Contains step by step instructions written in clear terms and includes illustrative examples to enhance critical thinking creative problem solving and the ability to connect concepts in chemistry Offers hints and case studies that help to master the basics while proficient users are offered more advanced avenues for exploration Written for advanced undergraduate and graduate students in chemistry and instructors looking to enhance their lecture or lab course with symbolic mathematics materials Symbolic Mathematics for Chemists A Guide for Maxima Users is an essential resource for solving and exploring quantitative problems in chemistry *Fundamental Mathematical Concepts for Machine Learning in Science* Umberto Michelucci,2024-05-16 This book is for individuals with a scientific background who aspire to apply machine learning within various natural science disciplines such as physics chemistry biology medicine psychology and many more It elucidates core mathematical concepts in an accessible and straightforward manner maintaining rigorous mathematical integrity For readers more versed in mathematics the book includes advanced sections that are not prerequisites for the initial reading It ensures concepts are clearly defined and theorems are proven where it s pertinent Machine learning transcends the mere implementation and training of algorithms it encompasses the broader challenges of constructing robust datasets model validation addressing imbalanced datasets and fine tuning hyperparameters These topics are thoroughly examined within the text along with the theoretical foundations underlying these methods Rather than concentrating on particular algorithms this book focuses on the comprehensive concepts and theories essential for their application It stands as an indispensable resource for any scientist keen on integrating machine learning effectively into their research Numerous texts delve into the technical execution of machine learning algorithms often overlooking the foundational concepts vital for fully grasping these methods This leads to a gap in using these algorithms effectively across diverse disciplines For instance a firm grasp of calculus is imperative to

comprehend the training processes of algorithms and neural networks while linear algebra is essential for the application and efficient training of various algorithms including neural networks Absent a solid mathematical base machine learning applications may be at best cursory or at worst fundamentally flawed This book lays the foundation for a comprehensive understanding of machine learning algorithms and approaches

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