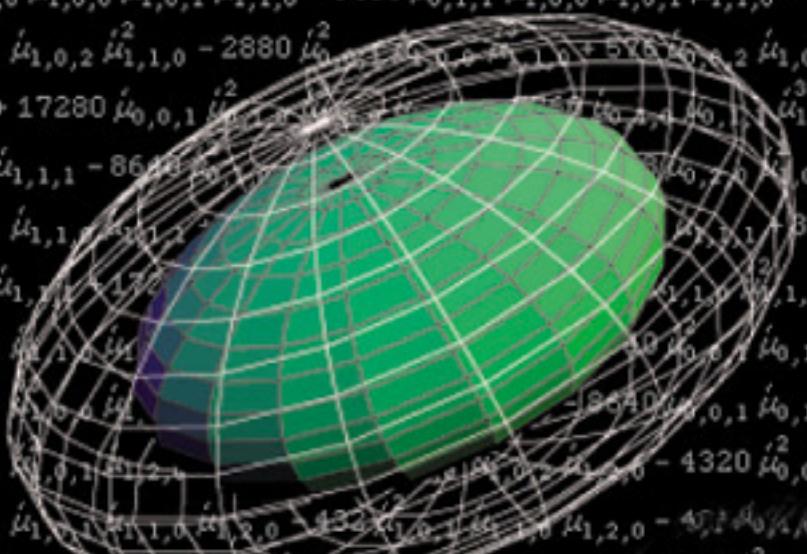


~~10320 $\mu_{0,0,1}^2 \mu_{0,1,0}^3 \mu_{1,0,0}^4 - 5040 \mu_{0,0,2} \mu_{0,1,0}^3 \mu_{1,0,0}^4 - 30240 \mu_{0,0,1} \mu_{0,1,1}^2 \mu_{1,0,0}^4 + 4320 \mu_{0,1,0}^2 \mu_{0,1,2} \mu_{1,0,0}^4 - 15120 \mu_{0,0,1} \mu_{0,1,0} \mu_{0,2,0} \mu_{1,0,0}^4 + 2160 \mu_{0,0,2} \mu_{0,1,0} \mu_{0,2,0} \mu_{1,0,0}^4 + 360 \mu_{0,1,2} \mu_{0,2,0} \mu_{1,0,0}^4 + 1320 \mu_{0,0,1} \mu_{0,1,0} \mu_{0,2,1} \mu_{1,0,0}^4 - 720 \mu_{0,1,1} \mu_{0,2,1} \mu_{1,0,0}^4 - 360 \mu_{0,1,0}$~~
SPRINGER TEXTS IN STATISTICS

MATHEMATICAL STATISTICS

with **Mathematica**



COLIN ROSE

MURRAY D. SMITH

Contents

Preface

xi

Chapter 1 Introduction

1.1	Mathematical Statistics with <i>Mathematica</i>	1
A	A New Approach	1
B	Design Philosophy	1
C	If You Are New to <i>Mathematica</i>	2
1.2	Installation, Registration and Password	3
A	Installation, Registration and Password	3
B	Loading mathStatica	5
C	Help	5
1.3	Core Functions	6
A	Getting Started	6
B	Working with Parameters	8
C	Discrete Random Variables	9
D	Multivariate Random Variables	11
E	Piecewise Distributions	13
1.4	Some Specialised Functions	15
1.5	Notation and Conventions	24
A	Introduction	24
B	Statistics Notation	25
C	<i>Mathematica</i> Notation	27

Chapter 2 Continuous Random Variables

2.1	Introduction	31
2.2	Measures of Location	35
A	Mean	35
B	Mode	36
C	Median and Quantiles	37
2.3	Measures of Dispersion	40
2.4	Moments and Generating Functions	45
A	Moments	45
B	The Moment Generating Function	46
C	The Characteristic Function	50
D	Properties of Characteristic Functions (and mgf's)	52

E	Stable Distributions	56
F	Cumulants and Probability Generating Functions	60
G	Moment Conversion Formulae	62
2.5	Conditioning, Truncation and Censoring	65
A	Conditional /Truncated Distributions	65
B	Conditional Expectations	66
C	Censored Distributions	68
D	Option Pricing	70
2.6	Pseudo-Random Number Generation	72
A	<i>Mathematica</i> 's Statistics Package	72
B	Inverse Method (Symbolic)	74
C	Inverse Method (Numerical)	75
D	Rejection Method	77
2.7	Exercises	80

Chapter 3 Discrete Random Variables

3.1	Introduction	81
3.2	Probability: ‘Throwing’ a Die	84
3.3	Common Discrete Distributions	89
A	The Bernoulli Distribution	89
B	The Binomial Distribution	91
C	The Poisson Distribution	95
D	The Geometric and Negative Binomial Distributions	98
E	The Hypergeometric Distribution	100
3.4	Mixing Distributions	102
A	Component-Mix Distributions	102
B	Parameter-Mix Distributions	105
3.5	Pseudo-Random Number Generation	109
A	Introducing DiscreteRNG	109
B	Implementation Notes	113
3.6	Exercises	115

Chapter 4 Distributions of Functions of Random Variables

4.1	Introduction	117
4.2	The Transformation Method	118
A	Univariate Cases	118
B	Multivariate Cases	123
C	Transformations That Are <i>Not</i> One-to-One; Manual Methods	127
4.3	The MGF Method	130
4.4	Products and Ratios of Random Variables	133
4.5	Sums and Differences of Random Variables	136
A	Applying the Transformation Method	136
B	Applying the MGF Method	141
4.6	Exercises	147

Chapter 5 Systems of Distributions

5.1	Introduction	149
5.2	The Pearson Family	149
A	Introduction	149
B	Fitting Pearson Densities	151
C	Pearson Types	157
D	Pearson Coefficients in Terms of Moments	159
E	Higher Order Pearson-Style Families	161
5.3	Johnson Transformations	164
A	Introduction	164
B	S_L System (Lognormal)	165
C	S_U System (Unbounded)	168
D	S_B System (Bounded)	173
5.4	Gram–Charlier Expansions	175
A	Definitions and Fitting	175
B	Hermite Polynomials; Gram–Charlier Coefficients	179
5.5	Non-Parametric Kernel Density Estimation	181
5.6	The Method of Moments	183
5.7	Exercises	185

Chapter 6 Multivariate Distributions

6.1	Introduction	187
A	Joint Density Functions	187
B	Non-Rectangular Domains	190
C	Probability and Prob	191
D	Marginal Distributions	195
E	Conditional Distributions	197
6.2	Expectations, Moments, Generating Functions	200
A	Expectations	200
B	Product Moments, Covariance and Correlation	200
C	Generating Functions	203
D	Moment Conversion Formulae	206
6.3	Independence and Dependence	210
A	Stochastic Independence	210
B	Copulae	211
6.4	The Multivariate Normal Distribution	216
A	The Bivariate Normal	216
B	The Trivariate Normal	226
C	CDF, Probability Calculations and Numerics	229
D	Random Number Generation for the Multivariate Normal	232
6.5	The Multivariate t and Multivariate Cauchy	236
6.6	Multinomial and Bivariate Poisson	238
A	The Multinomial Distribution	238
B	The Bivariate Poisson	243
6.7	Exercises	248

Chapter 7 Moments of Sampling Distributions

7.1	Introduction	251
	A Overview	251
	B Power Sums and Symmetric Functions	252
7.2	Unbiased Estimators of Population Moments	253
	A Unbiased Estimators of Raw Moments of the Population	253
	B h-statistics: Unbiased Estimators of Central Moments	253
	C k-statistics: Unbiased Estimators of Cumulants	256
	D Multivariate h- and k-statistics	259
7.3	Moments of Moments	261
	A Getting Started	261
	B Product Moments	266
	C Cumulants of k-statistics	267
7.4	Augmented Symmetries and Power Sums	272
	A Definitions and a Fundamental Expectation Result	272
	B Application 1: Understanding Unbiased Estimation	275
	C Application 2: Understanding Moments of Moments	275
7.5	Exercises	276

Chapter 8 Asymptotic Theory

8.1	Introduction	277
8.2	Convergence in Distribution	278
8.3	Asymptotic Distribution	282
8.4	Central Limit Theorem	286
8.5	Convergence in Probability	292
	A Introduction	292
	B Markov and Chebyshev Inequalities	295
	C Weak Law of Large Numbers	296
8.6	Exercises	298

Chapter 9 Statistical Decision Theory

9.1	Introduction	301
9.2	Loss and Risk	301
9.3	Mean Square Error as Risk	306
9.4	Order Statistics	311
	A Definition and OrderStat	311
	B Applications	318
9.5	Exercises	322

Chapter 10 Unbiased Parameter Estimation

10.1	Introduction	325
	A Overview	325
	B SuperD	326

10.2 Fisher Information	326
A Fisher Information	326
B Alternate Form	329
C Automating Computation: <i>FisherInformation</i>	330
D Multiple Parameters	331
E Sample Information	332
10.3 Best Unbiased Estimators	333
A The Cramér–Rao Lower Bound	333
B Best Unbiased Estimators	335
10.4 Sufficient Statistics	337
A Introduction	337
B The Factorisation Criterion	339
10.5 Minimum Variance Unbiased Estimation	341
A Introduction	341
B The Rao–Blackwell Theorem	342
C Completeness and MVUE	343
D Conclusion	346
10.6 Exercises	347

Chapter 11 Principles of Maximum Likelihood Estimation

11.1 Introduction	349
A Review	349
B SuperLog	350
11.2 The Likelihood Function	350
11.3 Maximum Likelihood Estimation	357
11.4 Properties of the ML Estimator	362
A Introduction	362
B Small Sample Properties	363
C Asymptotic Properties	365
D Regularity Conditions	367
E Invariance Property	369
11.5 Asymptotic Properties: Extensions	371
A More Than One Parameter	371
B Non-identically Distributed Samples	374
11.6 Exercises	377

Chapter 12 Maximum Likelihood Estimation in Practice

12.1 Introduction	379
12.2 <i>FindMaximum</i>	380
12.3 A Journey with <i>FindMaximum</i>	384
12.4 Asymptotic Inference	392
A Hypothesis Testing	392
B Standard Errors and <i>t</i> -statistics	395

12.5 Optimisation Algorithms	399
A Preliminaries	399
B Gradient Method Algorithms	401
12.6 The BFGS Algorithm	405
12.7 The Newton–Raphson Algorithm	412
12.8 Exercises	418

Appendix

A.1 Is That the Right Answer, Dr Faustus?	421
A.2 Working with Packages	425
A.3 Working with <code>=</code> , <code>→</code> , <code>==</code> and <code>:=</code>	426
A.4 Working with Lists	428
A.5 Working with Subscripts	429
A.6 Working with Matrices	433
A.7 Working with Vectors	438
A.8 Changes to Default Behaviour	443
A.9 Building Your Own mathStatica Function	446

Notes

447

References

463

Index

469