Syllabus

Probability and Statistics EST0002

I. COURSE FEATURES

Program: Mathematics, Chemistry, Physics, Engineering, Computer Science		
Prerequisites: none		
Duration: 72 hours	Academic year: 2024/1	
Instructors: Prof. Fernando Deeke Sasse		
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II. SUMMARY

Exploratory data analysis. Probability. Discrete and continuous random variables. Discrete and continuous probability distributions. Joint probability distributions. Parameter estimation. Hypothesis testing. Regression and correlation. Sampling notions.

III. TOPICS

1. Scientific method and scientific thinking
2. Types of data collection
3. Mechanistic and empirical models
4. Probability and probabilistic models
5. Sample spaces and events
6. Randomized experiments
7. Counting techniques
8. Binomial distribution
9. Geometric binomial distribution
10. Negative binomial distribution
11. Hypergeometric distribution
12. Poisson distribution
13. Geometric distribution
14. Formal and frequentist definition of probability
15. Addition rules
16. Conditional probability
17. Multiplication rules and total probability
18. Independent events
19. Bayes' theorem
20. Random variables
21. Discrete random variables
22. Discrete probability distributions and mass probability functions
23. Cumulative distribution functions
24. Mean and variance of a discrete random variable
25. Descriptive statistics: introduction
26. Stem-and-leaf diagrams
27. Bar diagrams
28. Histograms
29. Box plots
30. Time series

31. Scatter plots
32. Probability plots
33. Continuous random variables
34. Probability density functions and probability distributions
35. Cumulative distribution functions
36. Mean and variance of a continuous random variable
37. Continuous uniform distribution
38. Normal distribution
39. Normal approximation for binomial and Poisson distributions.
40. Exponential distribution
41. Gamma distribution
42. Weibull distribution
43. Lognormal distribution
44. Beta distribution
45. Erlang distribution
46. Point estimation of parameters
47. Estimation of parameters and sampling distributions
48. Sampling distributions and central limit theorem
49. Unbiased estimators
50. Variance of an estimator
51. Standard error
52. Standard bootstrap error
53. Mean squared error of an estimator.
54. Estimation methods: moments, maximum likelihood.
55. Bayesian parameter estimation.
56. Sampling distributions
57. Statistical intervals for a single sample
58. Confidence interval for the mean of a normal distribution, with known variance
59. Confidence interval for the mean of a normal distribution, with unknown variance and the t- distribution
60. Confidence interval for the variance and standard deviation of the normal distribution
61. Confidence interval for a large sample of a proportion of a population
62. Rules for constructing a confidence interval
63. Bootstrap confidence interval
64. Tolerance and prediction intervals
65. Hypothesis testing for a single sample: introduction
66. Unilateral and bilateral tests
67. P-value in hypothesis testing
68. Connection between hypothesis tests and confidence intervals
69. General procedure for testing hypotheses
70. Tests of the mean of a normal distribution with known variance
71. Tests of the mean of a normal distribution with unknown variance
72. Tests of the variance and standard deviation of a normal distribution
73. Tests on a proportion of the population
74. Type II error and choice of sample size
75. Goodness of fit
76. Contingency tables

77. Simple linear regression
78. Least squares estimators
79. Hypothesis testing in linear regression
80. Confidence intervals in the parameters of the linear regression line
81. Gradient descent method
82. Prediction of new observations
83. Adequacy of the regression model
84. Residual analysis
85. Coefficient of determination
86. Correlation.
87. Regression on transformed variables
88. Logistic regression

IV. LEARNING METHODOLOGY

Students must have active role during classes, presenting problems, solving problems.

V. GRADING

Assignments: 20%

Midterm exam: 20%

Final exam: 60%

IV. BIBLIOGRAPHY

1. MONTGOMERY, Douglas C.; RUNGER, George C. Applied statistics and probability for engineers. 5th ed. Hoboken: Wiley, 2011. 768 p
2. NETER, John; WASSERMAN, William. Applied linear statistical models: regression, analysis of variance, and experimental designs, 3rd ed. Boston: Irwin, c1990. 1181p.
3. LAWSON, John. Basic experimental strategies and data analysis for science and engineering. Boca Raton: CRC Press, Taylor & Francis Group, [2017] 1 online resource.
4. PEARL, Judea; GLYMOUR, Madelyn; JEWELL, Nicholas P. Causal inference in statistics: a primer. Chichester, West Sussex, United Kingdom: J. Wiley & Sons, 2016. xvii, 136 p.
5. EVERITT, Brian. Chance Rules: an informal guide to probability, risk and statistics. New York, NY: Springer New York: Springer New York, 2008. VI, 142 p
6. Downey, Allen B. Think Bayes: Bayesian Statistics in Python ,2nd ed., O'Reilly, 2021, https://allendowney.github.io/ThinkBayes2/