Content

Course Code	Course Name	Semester	Theory	Practice	Lab	Credit	ECTS
ISI 514	Advanced Statistical Modeling	1	3	0	0	3	6

Prerequisites	
Admission Requirements	

Language of Instruction	English
Course Type	Elective
Course Level	Masters Degree
Objective	The aim of this course is to enable students to learn and apply advanced methods in the field of statistical modeling. Students will delve deeper into the concepts of probability and sampling, learn the generation of random variables, exploratory data analysis, and use Monte Carlo methods for inferential statistics. In addition, they will gain extensive knowledge and skills on data partitioning, probability density estimation, supervised and unsupervised learning techniques, and parametric and nonparametric models.
Content	Probability Concepts, Sampling Concepts, Generating Random Variables, Exploratory Data Analysis, Finding Structure, Monte Carlo Methods for Inferential Statistics, Data Partitioning, Probability Density Estimation, Supervised Learning, Unsupervised Learning, Parametric and Nonparametric Models.
References	• M.H. DeGroot and M.J. Schervish, “Probability and Statistics”, Pearson, 4th Edition, 2012. • D.S. Moore, G.P. McCabe and B.A. Craig, “Introduction to the Practice of Statistics”, MacMillan, 10th Edition, 2021. • S.M. Ross, “Simulation”, Academic Press, 6th Edition, 2023. • W.L. Martinez, A.R. Martinez and J. Solka, “Exploratory Data Analysis with MATLAB”, Taylor & Francis, 2017. • T. Hastie, R. Tibshirani and J. Friedman, “The Elements of Statistical Learning: Data Mining, Inference, and Prediction”, Springer, Second Edition, 2009. • P. Glasserman, “Monte Carlo Methods in Financial Engineering”, Springer, 2003. • B. Efron and R.J. Tibshirani, “An Introduction to the Bootstrap”, Chapman & Hall, 1993. • C.M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006. • R.O. Duda, P.E. Hart and D.G. Stork, “Pattern Classification”, Wiley, 2nd Edition, 2001. • J. Han, M. Kamber and J. Pei, “Data Mining: Concepts and Techniques”, Morgan Kaufmann, 3rd Edition, 2011. • N.R. Draper and H. Smith, “Applied Regression Analysis”, Wiley-Interscience, 3rd edition, 1998.

Theory Topics

Week	Weekly Contents
1	Probability Concepts (Probability, Conditional Probability and Independence, Expectation, Common Distributions)
2	Sampling Concepts (Sampling Terminology and Concepts, Sampling Distributions, Parameter Estimation, Empirical Distribution Function)
3	Generating Random Variables (General Techniques for Generating Random Variables, Generating Continuous and Discrete Random Variables)
4	Exploratory Data Analysis (Exploring Univariate, Bivariate, Trivariate and Multi-Dimensional Data)
5	Finding Structure (Projecting Data, Principal Component Analysis, Projection Pursuit EDA, Independent Component Analysis, Nonlinear Dimensionality Reduction)
6	Monte Carlo Methods for Inferential Statistics (Classical Inferential Statistics, Monte Carlo Methods for Inferential Statistics, Bootstrap Methods)
7	Data Partitioning (Cross-Validation, Jackknife, Better Bootstrap Confidence Intervals, Jackknife-After-Bootstrap)
8	Probability Density Estimation (Histograms, Kernel Density Estimation, Finite Mixtures)
9	Midterm Exam
10	Supervised Learning (Bayes Decision Theory, Evaluating the Classifier, Classification Trees, Combining Classifiers, Nearest Neighbor Classifier, Support Vector Machines)
11	Unsupervised Learning (Measures of Distance, Hierarchical Clustering, K-Means Clustering, Model-Based Clustering, Assessing Cluster Results)

Week	Weekly Contents
12	Parametric and Nonparametric Models (Spline Regression Models, Logistic Regression, Generalized Linear Models, Model Selection and Regularization)
13	Parametric and Nonparametric Models (Partial Least Squares Regression, Some Smoothing Methods, Kernel Methods, Smoothing Splines)
14	Parametric and Nonparametric Models (Nonparametric Regression, Regression Trees, Additive Models, Multivariate Adaptive Regression Splines)