

Course Number and Title: 431: Probability and Statistical Methods

Quarter Taught: Fall 2011

Course Instructor: Abraham H. Haddad

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I. Course description:

Data analysis and representation; probability models; conditional probability and independence; reliability of systems and networks; binomial, Poisson, and geometric distributions; data relationships; correlation; inference with confidence; significance tests; network simulation and analysis; model of a switch; queuing models; performance analysis of network protocols; ALOHA; Ethernet.

II. Required text and/or other materials:

Montgomery & Runger, "Applied Statistics and Probability for Engineers", 5th Edition, John Wiley, 2011

Moore, McCabe & Craig, "Introduction to the Practice of Statistics", 6th Edition, Freeman, 2009

III. Reference text and/or other materials:

Class notes will be available online no later than the Thursday before class day.

www.eecs.northwestern.edu/~ahaddad/d31/

IV. Required prerequisites or knowledge base:

Algebra; sinusoidal, logarithmic, and exponential functions.

V. Rationale for inclusion in the IT program - relationship to other IT program courses:

It is a fundamental course that provides the basic understanding required to evaluate network and communication systems. It is a prerequisite to the wireless course, and to most technical network courses. It also has business applications in making decisions based on statistical data and average performance measures, rather than on worst-case scenarios. It is also applicable to data mining and business intelligence.

VI. Course goals:

To provide basic understanding of probabilistic and statistical methods and the knowledge of the application of such methods to the evaluation and analysis of communication systems and networks as well as application to other business models based on statistical data.

VII. Course Objectives: "As a result of this course students will be able to:

- a) Perform basic analysis of data using statistical methods;
- b) Perform simple inference of system parameters from measured data;

- c) Perform simple performance analysis of network or switch models;
- d) Analyze the reliability of interconnected systems;
- e) Perform a significance test to verify assumptions based on measured data;
- f) Make decisions based on statistical data;

VIII. Course topics/content (detailed - by week)

Week 1: Introduction to Random Experiments; Histograms & Distributions; Data Analysis and Representation: Displaying Distributions; Describing Distributions; Median, Quartiles; Mean, Variance, Standard Deviation

Week 2: Probability Models: Basic Rules; Conditional Probability & Independence; Failures, Error Rates; Reliability of Systems & Networks; Bayes' Rule

Week 3: Random Variables: Distributions & densities; Means & Variances; Examples: Uniform and Normal Distributions;

Week 4: Examples (cont.): Binomial and Geometric Distributions; Channel Error Rates; Poisson Distribution; Network & switch models

Week 5: Continuous Distributions & Densities; Exponential and Related models; Network Simulation and load models; Model of a switch: Queuing systems

Week 6: Data Relationships: Scatter diagrams and two-way tables; Linear Curve Fitting (Regression); **Midterm**

Week 7: Correlation; Mixed Variables Cases; Correlation and Causation; Sampling and Randomness; Law of Large Numbers and Central Limit Theorem; Bayes' Formula

Week 8: Introduction to Inference; Sample Mean, Binomial and Counts; Normal Approximation; Estimation and Confidence Intervals

Week 9: Significance Testing and Applications; Type I and II errors; Significance level and power of the test

Week 10: Network performance models; ALOHA, Ethernet; Flow Control in Networks Performance Evaluation

IX. Teaching methods:

Lectures using blackboard with notes available on the web

X. Type of homework, projects, exams, etc. required:

Weekly homework (may be group-based); one one-hour midterm in class (open books); one take-home final (several hours)

XI. Grading criteria:

10% Homework, 40% Midterm, 50% Final

Weekly Reading Assignments

Please note that in the following reading assignments, **A** represents the Moore et. al. text, and **B** represents the Montgomery & Runger text. The math level in book **B** may be beyond the scope of the course, so you need to proceed with care. However, the examples are more relevant and more extensive. Eight weeks cover the material on probability and statistics that is needed to evaluate network performance and communication systems topics, which are covered in the remaining two weeks. One of these weeks is in the middle of the course, and the other is at the end.

Week 1 (Sept. 17, 11): A 1.1-1.2; A 4.1-4.2; B1.1-1.4; B2.1-2.3; B6.3-6.5

Week 2 (Sept. 24, 11): A 4.2; A4.5; B2.4-2.7

Week 3 (Oct. 01, 11): A1.3; A4.3-4.4; B2.8-3.6; B4.6-4.7

Week 4 (Oct. 15, 11): B3.9; B4.1-4.10

Week 5 (Oct. 22, 11): Notes

Week 6 (Oct. 29, 11): A2.1-2.2; B11.1-11.2

Week 7 (Nov. 05, 11): A2.3-2.6; A3; B4.6-4.7; B6.3-6.5

Week 8 (Nov. 12, 11): A5.1-5.2; A6.1; B7.2; B8.1-8.2

Week 9 (Nov. 19, 11): A6.2-6.4; B9.1-9.2

Week 10 (Dec. 03, 11): Notes

COMMENTS

1. The material will stress examples and applications related to communications and information technology problems with emphasis on networks.
2. The level of coverage and the topics covered depend on the progress in class and on the background of the students.
3. The sections from the textbooks and the actual schedule are subject to change, as we progress through the material.
4. Those with prior wide exposure to probability and statistics may wish to have additional reading and would be offered the opportunity to carry out a project in addition to the exams and homework.
5. The material in the textbooks is very extensive and can serve to teach a one-year course in probability and statistics and applications to networks. However, this richness of material provides opportunities for the students with prior background to go into more depth under the instructor's guidance.
6. Updates and notes will be provided via a web page which is also accessible from the MSIT Home Page.

Instructor profile: professional and teaching experience

A. H. Haddad received the Ph.D. degrees in electrical engineering from Princeton University in 1966. He served on the EE faculty of UIUC and Georgia Tech. He also served as Program Director for Systems Theory and Operations Research at the National Science Foundation. On September 1, 1988 he joined Northwestern University as Henry and Isabelle Dever Professor of EECS and served as Chairman of the Department from 1988 to 1998. As of September 1, 1998 he has served as Director of the MSIT program at Northwestern. He served as Interim Chairman of the ECE Department during 2001-02 and 2004-05. He has extensive professional activities, including a term as President of the IEEE Control Systems Society in 1992, as Secretary of the American Automatic Control Council from 1990 to 2003 and as a member of the IFAC Executive Board from 1996 to 2005 and as member of the IFAC Council from 2005 to 2011. He is a Fellow of IFAC, IEEE, and AAAS, and a recipient of the IEEE Centennial Medal in 1984 and of the IEEE Third Millennium Medal in 2000.