

EE364: Introduction to Probability and Statistics For Electrical Engineering and Computer Science

Introduction to concepts of randomness and uncertainty: probability, random variables, and statistics. Applications may be from digital communications, signal processing, automatic control, computer engineering, computer science. *Prerequisite:* MATH 225 or MATH 245 or EE 241 (this is being relaxed).

Syllabus

Introduction

- Use of words that convey uncertainty in our daily language
- Some examples of interesting situations that we are bound to encounter in which probability plays a central role
- Probability versus statistics
- Role of probability and statistics in engineering
- Are probability and statistics confined to engineering?
- What mathematics is used in probability and statistics?
- Examples of courses in EE that make heavy use of probability
- Are there kinds of uncertainty that can't be modeled using probability?
- What this course is about
- Where does this course stand in relation to the broad fields of probability and statistics?
- Web-resources
- Textbook for the course
- Homework policies

Probability

- Experiment
- Sample space
- Events
 - HANDOUT: Experiment, Sample Space and Events
- Role of set theory
- Counting sample points
 - Multiplication rules
 - Permutations (lineups)
 - Combinations (committees)
 - Using multiplication rules, permutations and combinations together
 - Final remarks
 - HANDOUT: *Double Counting*
- Probability of an event
- Additive rules
 - HANDOUT: *Basic Pairs of Complementary Events*

- Conditional probability and independent events
 - Conditional probability
 - Independence
- Multiplicative rules
 - HANDOUT: *Symmetries*
- Theorem of total probability
- Bayes' Rule
- Important Handout
 - HANDOUT: *Challenges to Solving Probability Problems*

Random Variables and Probability Distributions

- Concepts of a random variable
- Discrete probability distributions
- Continuous probability distributions
 - Probability density function
 - Notation
 - The event $X = x$
 - The event $X \approx x$
 - Warning
 - Properties of a distribution function
 - Final comment
- Joint probability distributions
 - Joint density function
 - The event $X \approx x$ and $Y \approx y$
 - Discrete random variables
- Marginal densities
 - Joint versus marginal densities
 - HANDOUT: *Joint Probabilities and Marginal Probabilities for the Example*
- Conditional densities
- Statistical independence

Mathematical Expectation

- Mean of a random variable
- Variance and covariance
 - Variance
 - Covariance
 - Correlation coefficient
- Means and variances of linear combinations of random variables
- Some interesting inequalities
 - Markov's inequality
 - Chebychev's inequality

Some Discrete Probability Distributions

- Motivation
- Probability questions for discrete random variables
 - HANDOUT: *Probability Questions for Discrete Random Variables*
- Binomial distribution
 - Bernoulli process
 - Binomial random variable and distribution
 - Aside: Method of Indicators
- Some other distributions
 - HANDOUT: *Discrete Probability Distributions*
- Poisson distribution
- Some examples of when to use a Poisson distribution or a Binomial distribution
 - Application of Poisson to number of successes in Bernoulli trials
 - Application of the Poisson to number of arrivals in a time period

Some Continuous Probability Distributions

- Motivation
- Continuous uniform distribution
- Normal distribution
- Normal approximation to the Binomial
- Gamma and exponential distributions
 - Exponential distribution
 - The Poisson versus the exponential
 - Gamma distribution
- Other distributions

Functions of Random Variables

- Functions of one random variable
 - Distribution function method
 - Density function method
- Non-one-to-one transformations
 - HANDOUT: *PDFs for Non-One-To-One transformations of one Random Variable*
- Functions of more than one random variable
 - The density of the sum of two arbitrary independent random variables
 - The sum of independent Normals
- The Characteristic Function (Moment generating function) (May not be covered)

Statistics

Some terminology

- Some statistical queries
- Some important statistics

- The sample mean and the Central Limit Theorem
 - The sample variance
 - Other situations
- Interval estimation: confidence intervals
 - Confidence intervals for estimating the mean when σ is known
 - Confidence intervals for estimating the mean when σ is unknown
 - Other cases
- Hypothesis testing
 - Statistical decisions
 - Statistical hypotheses: null hypothesis
 - Test of hypotheses and significance
 - Type-I and type-II errors
 - Level of significance
 - Tests involving the Normal distribution
 - Tests concerning a single mean when the variance is known
 - Relationship to confidence interval estimation
 - Other cases
- Simple linear regression (May be covered)
 - Relationship between variables
 - Curve fitting
 - Equations of approximating curves
 - The method of least squares
 - Remarks
 - Example