

Syllabus ECE 4345

1. Review of Probability
 - 1.1.1. Definitions of probability
 - 1.1.2. Classical definition
 - 1.1.2.1. Bertrand's paradox
 - 1.1.2.2. The Monte Hall problem
 - 1.1.2.3. Monte Hall problem #2
 - 1.1.3. Relative frequency definition
 - 1.1.4. Monte Carlo simulation
 - 1.1.4.1. Compute π by throwing darts
 - 1.1.4.2. Buffon's needle
 - 1.1.5. Classical definition
 - 1.1.5.1. Axioms
- 1.2. Fundamentals
 - 1.2.1. Independence & mutually exclusive events
 - 1.2.2. Conditional probability
 - 1.2.3. Universal set partition
 - 1.2.4. Theorem of total probability
 - 1.2.5. Bayes theorem
- 1.3. Random variables
 - 1.3.1. Definition
 - 1.3.2. Cumulative distribution functions
 - 1.3.2.1. Properties
 - 1.3.2.2. Probabilities from CDF's
 - 1.3.3. Probability density functions
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 - 1.3.3.2. Properties
 - 1.3.3.3. Histograms
 - 1.3.3.4. Conditional PDF's and CDF's
 - 1.3.4. Discrete random variables
 - 1.3.5. Mixed random variables
 - 1.3.6. Common random variable pdf's
 - 1.3.6.1. Bernoulli
 - 1.3.6.2. Binomial
 - 1.3.6.3. Geometric
 - 1.3.6.4. Negative binomial
 - 1.3.6.5. Poisson
 - 1.3.6.6. Uniform
 - 1.3.6.6.1. Discrete
 - 1.3.6.6.2. Continuous

- 1.3.6.7. Gaussian (normal)
 - 1.3.6.7.1. Erf function
 - 1.3.6.7.2. Variations
 - 1.3.6.8. Exponential
 - 1.3.6.8.1. The ageless exponential
 - 1.3.6.9. Cauchy
 - 1.3.6.10. Laplace
 - 1.3.6.11. Gamma
 - 1.3.6.12. Other
2. Transformation of a random variable
 - 2.1. Effects of nonlinearities
 - 2.1.1. Strictly increasing
 - 2.1.2. $Y = g(X)$
 - 2.1.2.1. Uniqueness
 - 2.1.3. Synthesis & Inversion
 - 2.2. Expected Values
 - 2.3. Central tendency and dispersion measures
 - 2.4. Moments
 - 2.4.1. Mean & variance
 - 2.5. Characteristic functions
 - 2.5.1. Properties
 - 2.5.2. Pdf convolution
 - 2.5.3. Second characteristic functions
 - 2.5.4. Moment generating functions
 - 2.5.5. Probability generating functions
 - 2.5.6. Examples
 - 2.5.6.1. Bernoulli
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 - 2.5.6.3. Geometric
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 - 2.5.6.5. Poisson
 - 2.5.6.6. Uniform
 - 2.5.6.7. Gaussian
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 - 2.5.6.10. Gamma
 - 2.5.7. Tail inequalities
 - 2.5.7.1. Markov's inequality
 - 2.5.7.2. Chebyshev inequality
 - 2.5.7.3. The Chernoff bound
 3. Information & entropy (ADD)
 - 3.1. Defining information

- 3.1.1. Bits & flips
- 3.1.2. 20 questions
- 3.2. Entropy
 - 3.2.1. Binary entropy function
 - 3.2.2. Uniform entropy
 - 3.2.2.1. Maximum entropy
 - 3.2.3. Geometric entropy
 - 3.2.4. Relative entropy
 - 3.2.5. 20 questions revisited
 - 3.2.5.1. Optimal questioning
- 4. Joint 2D random variables (AE)
 - 4.1. Joint CDF's
 - 4.1.1. Marginal CDF's
 - 4.1.2. Properties of the CDF
 - 4.2. Joint PDF's
 - 4.2.1. Marginal PDF's
 - 4.2.2. Properties
 - 4.2.3. Relation to histograms
 - 4.3. Maxwell's flash of genius
 - 4.4. More CDF properties
 - 4.4.1. Inequality
 - 4.4.2. Min and max
 - 4.5. Discrete pdf's
 - 4.5.1. Point masses
 - 4.5.2. Multidimensional Dirac deltas
 - 4.5.3. Of the lattice type
 - 4.5.4. Line masses
 - 4.6. Conditional joint pdf's
- 5. Multiple random variables (AF)
 - 5.1. CDF's
 - 5.2. PDF's
 - 5.2.1. Marginals
 - 5.2.2. Conditional PDF's
 - 5.2.3. Independence
 - 5.3. Expectation
 - 5.4. Characteristic functions
 - 5.4.1. Random variable sum
 - 5.5. Functions of several random variables
 - 5.5.1. Leibnitz's Rule
 - 5.5.2. A single function of n random variables
 - 5.5.2.1. Sum of two RV's
 - 5.5.2.2. Product of two RV's

- 5.5.2.3. Quotient
- 5.6. Expectation
 - 5.6.1. Two methods
 - 5.6.2. Joint methods
 - 5.6.3. Correlation
 - 5.6.4. Joint Gaussian RV's
 - 5.6.4.1. Covariance matrix
- 5.7. Evaluating expectation
- 5.8. Correlation
- 5.9. Joint Gaussian RV's
- 5.10. Functions of n random variables (AG)
 - 5.10.1. Transformation Jacobian
 - 5.10.2. Uniform angle Gaussian radius example
 - 5.10.3. Use of auxiliary functions
- 6. Sums of RV's (AH)
 - 6.1. Mean and variance
 - 6.2. Characteristic function
 - 6.3. Average (Sample means)
 - 6.4. Mean & variance
 - 6.4.1. Law of large numbers
 - 6.5. Loose confidence intervals
 - 6.6. Sample variance
 - 6.7. A gambling sequence (Ala)
 - 6.8. Stochastic resonance (Alb)
 - 6.9. The central limit theorem (AJ)
 - 6.10. Confidence intervals (AK)
- 7. Stochastic process fundamentals (AL)
 - 7.1. Definition by distribution
 - 7.2. Quantization and discrete time
 - 7.3. Independent increments
 - 7.3.1. Weiner processes
 - 7.3.2. Markov processes
 - 7.4. First and second order statistics
 - 7.4.1. Autocorrelation
 - 7.4.2. Autocovariance
 - 7.4.3. Correlation coefficient
 - 7.4.4. i.i.d. random processes
 - 7.5. Ensemble averages
 - 7.6. Example stochastic processes (AN)
 - 7.6.1. Gaussian
 - 7.6.2. The flip theorem
 - 7.6.3. Multiple stochastic processes

- 7.6.4. Sum processes
- 7.6.5. Autocovariance
- 7.6.6. Poisson random processes
 - 7.6.6.1. Telegraph signal
 - 7.6.6.2. Poisson points
 - 7.6.6.3. Shot noise
- 7.6.7. Wiener processes
 - 7.6.7.1. Modelling stock prices
- 8. Stationarity (AO)
 - 8.1. Strict
 - 8.2. Wide sense
 - 8.2.1. Average power
 - 8.2.2. Autocorrelation Properties
 - 8.3. Cyclostationary processes
 - 8.4. Gaussian random processes
 - 8.4.1. SSS vs. WSS
- 9. Ergodicity (AP)
 - 9.1. Mean ergodicity
 - 9.2. Autocorrelation ergodicity
- 10. Processing of random signals (AQ)
 - 10.1. Power spectral density
 - 10.1.1. Properties
 - 10.2. Of discrete random processes
 - 10.3. White noise
 - 10.3.1. Discrete & Continuous
- 11. Filtering stochastic processes (RA)
 - 11.1. Linear & LTI filtering
 - 11.1.1. LTI filtering
 - 11.1.2. Nonstationary
 - 11.1.3. Stochastic differential equations
 - 11.2. Filtering WSS stochastic processes
 - 11.3. Power spectral density characterization
 - 11.3.1. Positivity proof
 - 11.3.2. Derivatives
 - 11.3.3. ARMA