HSB
Hochschule Bremen
City University of Applied Sciences

Stochastic Signals and Systems

Questionnaire

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Chapter 1: Probability Theory

1) What are the different approaches for the definition of probability?
2) How is the conditional probability defined?
3) Please, specify the Bayes' and generalized Bayes Formula.
4) What is a random variable (discrete/continuous)?
5) How is the distribution/density function of a random variable defined?
6) Please, specify a few typical distributions/densities (discrete/continuous).
7) Explain the terms multivariate, marginal, conditional distribution/density and independence.
8) Point out, how the density function of a transformed random variable can be determined (univariate and multivariate)
9) How is the expectation operator defined (discrete/continuous)?
10) Please, specify typical applications of the expectation operator.
11) Explain the basics of the Mean Square Estimation Approach (nonlinear and linear).
12) What is known as orthogonality principle and what does it tell us?
13) Please, describe the different convergence concepts for sequences of random variables.
14) How are the different convergence concepts related to each other?
15) What do the laws of large numbers and the central limit theorems tell us?

Chapter 2: Stochastic Processes

1) What is a real/complex stochastic process (discrete and continuous time)?
2) How can one introduce a probabilistic description of stochastic processes?
3) Please, specify the typical moment functions of a real/complex stochastic process.
4) Indicate typical stochastic processes and their properties.
5) What is a stationary real/complex stochastic process (discrete and continuous time)?
6) Please, specify the typical moment functions of a real/complex stationary stochastic process.
7) Report on stochastic limiting operations taken in the mean square sense.
8) How is the spectral/cross spectral density function of real/complex stochastic processes (discrete and continuous time) defined?
9) Please, specify the spectral representation of linear filtered real/complex stochastic processes in terms of their spectral and cross spectral density functions.
10) How is an AR-, MA- and ARMA-Process defined?
11) Please, describe the derivation of the Yule-Walker Equation and state their properties for determining the coefficients of an AR-Process.
12) Explain the way how the coefficients of an MA-Process can be calculated.
13) Describe the characteristic properties of AR- and MA-Processes.
14) Indicate the procedure for determining the coefficients of an ARMA-Process.

Chapter 3: Parameter Estimation

1) What is the difference between an estimation function and an estimator?
2) Explain the terms Bias, Covariance and Mean Square Error?
3) Describe the idea behind the MVU, MMSE, consistency and asymptotic normality property of an estimator.
4) What is a sufficient statistic and how can the sufficiency be verified?
5) Explain the concept of a minimal sufficiency and complete sufficiency of a statistic.

6) What are the prepositions of the Rao-Blackwell and Lehmann-Scheffe Theorem?
7) When does a distribution form an exponential family?
8) Which property of an exponential family insures the completeness of the sufficient statistic?
8) Describe the procedure of least squares estimation (linear parameter model).
9) What is the preposition of the Gauss-Markov Theorem?
10) Please, state the statistical properties of least squares estimators.
11) Report on the definition of the Fisher Information Matrix, the preposition of the Cramer-Rao inequality and the asymptotic efficiency property of an estimator.
10) What is the heuristic idea behind the Maximum Likelihood Estimation principle?
11) Indicate some properties of Maximum Likelihood Estimation.
12) Explain the concept of Bayes Estimation?
13) State the solutions of non-linear and linear Minimum Mean Square Error Estimation.
14) What is the Minimum Mean Absolute Error Estimate for the single parameter case?
15) How can one determine the Maximum A Posteriori Estimates for the single and multiple parameter case.
16) Compare the results of Minimum Mean Square Error, Minimum Mean Absolute Error and Maximum A Posteriori Estimation for the single parameter case only.

Chapter 4: Signal Detection

1) Describe the typical steps required for constructing a hypotheses test?
2) When do we speak of a binary/multiple hypotheses test and simple/composite hypotheses?
3) Which function is used to describe a hypotheses test?
4) How is the power function defined?
5) What is known as type 1 and type 2 error?
6) How can one determine the probability of type 1 / type 2 error and the power of a test?
7) When is a test uniformly most powerful?
3) What is the proposition of the Neyman-Pearson-Theorem?
4) Which parameters are involved for calculating the receiver operating characteristic?
5) What do you know about Chernoff bounds?
6) Describe the idea underlying Bayes Hypotheses Testing.
7) How can a composite hypotheses test problem be mapped into a simple hypotheses test problem using Bayes Approach?
8) When do we speak about monotone likelihood ratios?
9) Do monotone likelihood ratios lead to uniformly most powerful tests?
10) Explain the notions single sided test, double sided test and unbiased test?
11) What is the intention by introducing the invariance principle?
12) When do we speak of linear hypotheses?
13) How can one test linear hypotheses by means of least squares estimation?
14) Please, state the definition of a Maximum Likelihood Ratio Test.
15) When do we apply a Maximum Likelihood Ratio Test?
15) Explain the steps required to derive the maximum likelihood ratio.
16) When should we consider non parametric tests?

Chapter 5: Spectrum Analysis

Chapter 6: Optimal Filtering

1) What is the goal of an Optimal Filter if the measured signal can be modelled as a known deterministic signal embedded in additive noise?
2) How is this particular Optimal Filter called?
3) Please specify the impulse response of a Matched Filter in case of additive white noise.
4) Does the matched filter distort the known deterministic signal?
5) Explain, why the matched filtering can be interpreted as a correlation operation.
6) What is the objective of an Optimal Filter if the measured signal consists of a stochastic signal of interest embedded in additive noise?
7) How is this particular Optimal Filter called?
8) Which Cost-function does the Wiener Filter minimize?
9) Which principle can be exploited to solve this minimization problem?
10) After exploiting the orthogonality principle which equation can be derived?
11) Which cases with respect to the impulse response have to be distinguished by solving the Wiener-Hopf equation?
12) Which three different application of a Wiener Filter are known in accordance with the instant of time an estimate has to be provided and the time interval the data have been observed?