UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH

Last update: 08-03-2016

230630 - STP - Stochastic Processes

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2016
Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 2,5 Teaching languages: English

Teaching staff

Coordinator: JAUME RIBA

Degree competences to which the subject contributes

Specific:

1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

Transversal:

2. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
3. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
4. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Teaching methodology

- Lectures
- Application classes
- Group work (distance)
- Individual work (distance)
- Exercises
- Short answer test (Control) (Mid Term Exam)
- Extended answer test (Final Exam)

Learning objectives of the subject

Learning objectives of the subject:

The aim of this course is to revisit the fundamental concepts and introduction of advanced concepts of the theory of stochastic processes, that is, models for systems that evolve un- predictably in time, from a unified and formal perspective, with a general application framework, and with emphasis on those aspects most related with the field of signal processing and communications.
Stochastic Processes constitute a very broad topic that can be approached with different angles, some are more mathematical oriented and some are more application oriented. This means that only some aspects (a small sample) will be covered in the course. Anyway, it is intended to be of great help either for students interested in getting a solid introductory background as a basis for other courses in the masters, and/or for students interested in a more in-depth theory to improve their understanding of the mathematical language used by the scientific community to describe those phenomena which are probabilistic in nature.

In general, the emphasis is put in those concepts more related with the areas of signal processing and communications, moving a little from the direct application and going in further depth. Less emphasis is put on those pure mathematic concepts or in those that are too much specialized. However, in-depth pure mathematics are required sometimes even for applications, and this is always a trade-off that the course tries to respect, balancing theory and intuition as much as possible.

Learning results of the subject:

- Ability to model signals and phenomena in a probabilistic manner.
- Ability to optimize system performance in statistical terms.
- Ability to use analytical tools that are useful in the study of stochastic models that appear in various engineering fields.
- Ability to predict system performance using statistical reasoning, and test it using numerical methods.
- Ability to apply the theory to specific engineering applications.

Study load

Total learning time: 62h 30m	Hours large group:	26h	41.60%
	Self study:	36h 30m	58.40%

Content

1. Radom Variables	Learning time: 56h Theory classes: 16h Guided activities: 2h Self study : 38h

Description:
- Probability review Flow control
- One random variable. Density, Distribution, Moments and Characteristic Function. Geometric interpretation of the expectation.
- Two random variables. Independence, ortogonality, uncorrelation.
- Upper bounds on tail probabilities. Markov's, Chebychev and Chernoff bounds
- Sequences of random variables. Convergence types. The sample mean. Law of large numbers. Central limit theorem
- Random vectors. Autocorreelation matrix and eigenbasis. Karhunen Loeve transform. Optimal spatial filters. Canonical Correlation Analysis. Multivariate Gaussian density
- Non linear transformations of zero-mean Gaussian random variables (Price's theorem)
- A geometric vision of random variables. Random variables as vectors in a Hilbert Space. Extension to complex random variables. Circularity.
- On Wirtinger Calculus and Lagrange Multipppliers)

2. Random Processes	Learning time: 69h Theory classes: 23h Guided activities: 2h Self study : 44h

Description:
- Definition of random processes and review of deterministic signals.
- Statistical description of random processes: mean, autocorrelation and properties
  - Wide-Sense Stationary random processes. Time averages of random processes and ergodic theorems. Stochastic Fourier Series and Karhunen-Loeve expansion. Response of widely LTI systems to WSS processes. Response to non-linear memory-less systems to Gaussian random processes. Power Spectral Density (PSD) and Einstein-Wiener-Khinchine theorem for WSS rp's. Cross spectral density and spectral coherence. Base Band representation of bandpass WSS processes. WSS representation of non-WSS processesVector processes and spectral matrix
- Pure and almost Cyclostationary random processes
  - Time averages, cyclic autocorrelation and cyclic spectrum.
  - Response to linear systems to cyclostationary processes.
- Optimum linear and quadratic systems.
- A geometric perspective for random processes.
- Introduction to Poisson, Wiener and Markov processes

0. Required background (at introductory level)

Degree competences to which the content contributes:

Description:
- Linear algebra and real analysis.
- Probability and random variables (probability density function, expectation, moments).
- Deterministic Signals and Linear Time-Invariant systems (convolution, energy, mean power).
- Fourier analysis (frequency response, Fourier series and Fourier transform).

Planning of activities

EXERCISES

Description:
Weekly exercises assignments (individual work).

PROJECTS

Description:
- Description: midterm project assignment (working groups of two persons).
- Description: final project assignment (working group of two persons).

SHORT ANSWER TEST (CONTROL):

Description:
Individual Midterm written exam.

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Description:
Individual Final written exam.

Qualification system

Final examination: from 50% to 100%
Partial examinations and controls: from 0% to 50%
Exercises: from 0% to 50%
Individual assessments: from 0% to 25%
Group assessments: from 0% to 50%
The final grade is the maximum between the Final Exam mark and the weighted former mark.

230630 - STP - Stochastic Processes

Bibliography

Basic:

Leon-García, A. Probability, statistics, and random processes for electrical engineering. 3rd ed. Upper Saddle River, NJ: Pearson Education, 2009. ISBN 9780137155606.

Oppenheim, A.V.; Schafer, R.W. Digital signal processing. London: Prentice-Hall International, 1975. ISBN 0132141078.

Papoulis, A.; Pillai, S.U. Probability, random variables, and stochastic processes. 3rd ed. Boston: McGraw-Hill, 2002. ISBN 9780073660110.

Peebles; P.Z. Probability, random, variables, and random signal principles. 4th ed. New York: McGraw-Hill, 2001. ISBN 0073660078.

Proakis, J.G.; Salehi, M. Digital communications. 5th ed. Boston: McGraw-Hill, 2008. ISBN 9780072957167.

Gardner, W.A. (ed.). Cyclostationarity in communications and signal processing. New York: IEEE Press, 1994. ISBN 0780310233.

Gardner, W.A. Statistical spectral analysis: a nonprobabilistic theory. Englewood Cliffs, NJ: Prentice-Hall, 1988. ISBN 0138445729.

Complementary:

Picinbono, B. Random signals and systems. Englewood Cliffs, NJ: Prentice-Hall, 1993. ISBN 0137522703.

Gardner, W.A. Introduction to random processes: with applications to signals and systems. 2nd ed. New York: McGraw-Hill, 1990. ISBN 0070228558.