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230367 - QIT - Quantum Information Theory

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2019
Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 2,5 Teaching languages: English

Teaching staff

Coordinator: Rodriguez Fonollosa, Javier

Others: Pagès Zamora, Alba
Rodriguez Fonollosa, Javier

Prior skills

Basic knowledge of linear algebra, probability and random variables.

Degree competences to which the subject contributes

Specific:
CE1. 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.

Teaching methodology

- Lectures.
- Problems solved individually or in groups by the student.

Learning objectives of the subject

This subject combines two of the most important branches of science of the 20th century, the quantum theory developed in the 1920s and 1930s by scientists such as Planck, Einstein, Bohr, Heisenberg, Schrödinger, Pauli, Dirac and von Neumann, and the information theory, born after the work of Shannon in 1948. The basic postulates of quantum systems as well as their mathematical model will be presented. The concept of entropy and channel will also be generalized to establish the capacity of the quantum channels to transmit information, thus extending the emblematic Shannon theorem to the quantum context.

Study load

Total learning time: 62h 30m	Hours large group:	20h	32.00%
	Self study:	42h 30m	68.00%

Content

Introduction.	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m

Description:
a) The EPR paper and course outline.
b) Quantum states: the Bloch sphere, spectral decomposition, reversible evolution, measurement and the Born rule, the Stern-Gerlach experiment and measurement based on POVM.
c) Composite quantum systems: Kronecker product description, the no-cloning theorem, separable and entangled states,
the Schmidt decomposition, partial trace, purification, entanglement as a resource and the violation of the CHSH inequality.

Quantum protocols and channels	Learning time: 18h 45m Theory classes: 6h Self study : 12h 45m

Description:
a) Quantum protocols: Entanglement distribution, super-dense coding and quantum teleportation.
b) Quantum channels: Axiomatic definition, the Choi-Kraus theorem and the Choi rank, unitary and isometric channels,
examples of quantum channels.
c) The Classical-to-Classical channel, the Classical-to-Quantum channel, the Quantum-to-Classical channel.
d) Entanglement-breaking channels.
e) Purification of Quantum channels.

Quantum entropy and information	Learning time: 12h 30m Theory classes: 4h Self study : 8h 30m

Description:
a) Quantum entropy and joint entropy.
b) Conditional quantum entropy and coherent information.
c) Quantum mutual information and conditional quantum mutual information.
d) Quantum relative entropy.
e) Quantum typicality and conditional typicality.

Classical Communication.	Learning time: 12h 30m Theory classes: 4h Self study : 8h 30m
Description: a) Accessible information. b) The information of quantum channels. c) The HSW theorem. d) Capacity examples.	

Qualification system

- Attendance is mandatory.
- Participation in class (20%)
- Problems and/or group or individual presentation (80%)

Regulations for carrying out activities

There is no final exam.

Bibliography

Basic:

Wilde, M.M. Quantum information theory. Second edition. Cambridge, UK: Cambridge University Press, 2017. ISBN 9781107176164.

Complementary:

Nielsen, M.A.; Chuang, I.L. Quantum computation and quantum information. 10th anniversary ed. Cambridge, UK: Cambridge University Press, 2010. ISBN 9781107002173.