KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI
Projekt współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego
UNIA EUROPEJSKA
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Course title	ECTS code
Information Theory	13.2.0422

Name of unit administrating study

Faculty of Mathematics, Physics and Informatics

Studies

faculty	field of study		
Faculty of Mathematics, Physics and Informatics	Quantum Information Technology	type	all
		form	all
		specialty	all
		specialization	all

Teaching staff

prof. UG, dr hab. Karol Horodecki; dr Michał Studziński; mgr Chithra Raj; mgr Otavio Dantas Molitor

Forms of classes, the realization and number of hours

Forms of classes

Auditorium classes, Lecture

The realization of activities

classroom instruction, online classes

Number of hours

Auditorium classes: 30 hours, Lecture: 30 hours

ECTS credits

5

The academic cycle

2022/2023 summer semester

Type of course

obligatory

Language of instruction

english

Teaching methods

- critical incident (case) analysis
- discussion
- multimedia-based lecture
- problem solving
- problem-focused lecture

Form and method of assessment and basic criteria for eveluation or examination requirements

Final evaluation

- Graded credit
- Examination

Assessment methods

- written exam (test)
- written exam (long written answer/problem solving)

The basic criteria for evaluation

Exercises:
90% of the final mark : 2 written colloquia during the semester.
10% of the final mark are due to activity of the student during classes.
Lecture:
3 groups of issues out of 15 covered in the lecture, described correctly in minimum 50%

Method of verifying required learning outcomes

Required courses and introductory requirements

A. Formal requirements

Completion of the course “probability theory” and/or statistical physics is required

B. Prerequisites

Basic knowledge of mathematics at high school level is required

Aims of education

The student will acquire basic knowledge in the field of application of the main concepts of information theory such as entropy, mutual information or relative entropy and their properties. He will also learn the capacities of communication channels and methods of estimating them. Acquiring this

knowledge will result in understanding of the possibilities and limitations of communication as well as will provide an introduction to other courses of quantum information theory. The student will be able to apply the knowledge learned in whatever context it can be used, including physics, statistics and cryptography

Course contents

The course contents includes presentation of the following concepts (lecture and exercises will be devoted to the same topics):
Shannon entropy function, its interpretation and properties,
Entropy functions of many variables, including conditional entropy, mutual information, relative entropy, conditional mutual information and their properties, including data processing inequality and the chain principle for conditional mutual information
"Asymptotic Equipartition Property" theorem, compression codes (including Huffman's), Lempel-Zif compression algorithm
Error correction codes (Huffman, CSS, other line codes)
The concept of typical and total typical sequences, Shannon's theorem on the capacity of a communication channel, random code technique
Capacities of selected communication channels (among others, broadcast channel, multiple access channel, erasure channel) and Slepian-Wolf theorem on joint coding
Interpretation of relative entropy in the context of betting
Kolmogorov complexity and Kraft and Mc Millan inequality
The use of IT in cryptography (secure key agreement) including the Csisar & Koerner theorem and the protocol increasing security by means of two-way communication by U. Maurer and non-increasing (so-called monotonous) security functions.
Application of IT in quantum communication: von-Neumann entropy versus Shannon entropy similarities and differences; quantum conditional entropy versus Shannon's conditional entropy - comparison.

Bibliography of literature

A. Literature required to pass the course
E. Shannon, W. Weaver “ The Mathematical Theory of Communication”
Thomas M. Cover, Joy A. Thomas “Elements of Information theory”
R. W. Yeung “A First Course in Information Theory”
chapters of M. Nielsen, I. Chuang „Quantum Information and Computation” concerning IT
B. Extracurricular readings
other chapters of M. Nielsen, I. Chuang „Quantum Information and Computation”

The learning outcomes (for the field of study and specialization)

K_W01 Student has extensive knowledge of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of science, world cognition and social development.
K_W02 Student has in-depth knowledge of advanced mathematics, mathematical and computer methods necessary to solve physical problems of medium complexity and advanced in the area of quantum information and its technological aspects.
W_W06 Student has knowledge of the current trends in the development of physics, in particular within the quantum information theory.
K_U01 Student can apply mathematical knowledge to formulating, analyzing and solving problems related to information theory

Knowledge

W01: Student can define basic notions including entropy, mutual information, code, channel capacity, relative entropy, Kolmogorov complexity etc. (K_W01)
W02 Student knows the proofs of the main facts such as Asymptotic Equipartition Property, Shanonn’s theorem etc., as well as knows basic methods such as compression algorithms (K_W02)

Skills

U01 Student is proving certain information-theoretic properties of a complex systems such as channels and their capacities, and is interpreting the results (K_U01)
U02 The student is able to apply introduced methods and concepts in various context of information theory including other fields (such as physics, statistics or cryptography) (K_U01)

Social competence

Contact

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