COURSE DESCRIPTION CARD - SYLLABUS

Course name
Signal compression and coding [N2AiR1-SW>KiKS]

Course

Field of study
Automatic Control and Robotics

Year/Semester
1/1

Area of study (specialization)
Vision Systems

Profile of study
general academic

Level of study
second-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
20

Laboratory classes
0

Other
0

Tutorials
20

Projects/seminars
0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Knowledge: The student starting this course should have basic knowledge of algebra and discrete mathematics. Skills: Should have the ability to solve basic problems in digital signal processing and the ability to obtain information from indicated sources. The student should also understand the need to expand his competences. Social competences: In addition, the student should exhibit qualities such as honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture and respect for other people.

Course objective

1. Provide students with basic knowledge of compression and coding algorithms in the field of multimedia signals. 2. Developing students' skills in solving problems related to the selection of appropriate techniques of compression, encryption and correction of data in ICT systems. 3. Shaping in students the importance of knowledge of standards and recommendations related to data processing in data compression and signal coding systems.

Course-related learning outcomes

Knowledge

1. has extended and deepened knowledge of selected areas of mathematics necessary to formulate and solve complex tasks in the field of information theory and signal processing - [K2_W1]
2. has an ordered, theoretically founded, detailed knowledge of the methods of analysis and design of control systems - [K2_W7]
3. knows and understands the principles of operation of algorithms that compress image data in a lossless and lossy way - [-]
Skills
1. The student can use advanced methods of signal processing and analysis, including video signal and extract information from analyzed signals - [K2_U11]
2. is able to estimate the effectiveness of archiving programs - [-]
3. can use up-to-date data encryption algorithms - [-]
4. can define sources of errors during transmission and indicate methods of protection against their influence - [-]
Social competences
1. The student is aware of the need for a professional approach to technical issues, scrupulous reading of the documentation and environmental conditions in which the devices and their components may function - [K2_K4]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:
Formative assessment:
a) in the scope of lectures:
based on answers to questions about the material discussed in previous lectures
b) in the scope of tutorials:
on the basis of the assessment of knowledge and understanding of the current issues presented in the course.
Summative assessment:
a) a) in the field of lectures, verification of the assumed learning outcomes is carried out by:
i. assessment of the knowledge and skills demonstrated in the problem-based written exam (the student may use didactic materials); The exam consists of 8 test questions and 3 tasks, with a total of 20 points for the correct answers. Rating scale: 0 ... 10 points. - unsatisfactory, 11 ... 12 points - satisfactory, 13 ... 14 points - sufficient plus, 15 ... 16 points - good, 17 ... 18 points - good plus, 19 ... 20 points - very good,
ii. discussion of the exam results,
b) in the field of tutorials, verification of the assumed learning outcomes is carried out by:
i. assessment of the student's preparation for individual classes,
ii. continuous assessment, during each class (oral answers) - rewarding the increase in the ability to use the learned rules and methods,
iii. assessment of self-solved tasks (partially during the classes and also after their completion),
iv. assessment of knowledge and skills related to solving tasks through 2 tests per semester.
Obtaining additional points for activity during classes, in particular for:
i. discuss of additional aspects of the issue,
ii. effectiveness of applying the acquired knowledge while solving a given problem,
iii. comments related to the improvement of teaching materials,
iv. indicating students' perceptive difficulties enabling ongoing improvement of the didactic process.

Programme content

The program includes lossless and lossy compression algorithms, quantization processes, data encryption operations, redundant coding in transmission systems.

Course topics

The lecture program includes the following topics:
1. Introduction - data encoding purposes, data types, the concept of compression, compression efficiency, types of compression; a brief history of compression techniques; the concept of entropy, databases with test data, intuitive techniques, algorithms in programs for lossless data archiving.
2. Series length encoding (RLE) - the idea of series length encoding, RLE for text, RLE for images, RLE for RGB representation, conditional RLE encoding for images, BinHex format, MTF (move-to-front) encoding,

PCX and PCX encoding BMP, encoding in fax machines.
3. Statistical techniques - the idea of statistical techniques, definition of information, amount of information, Kolmogorov complexity, variable length codes, prefix codes. The Golomb-Rice codes and the Shannon-Fano codes.
4. Huffman codes - Huffman code length, canonical Huffman codes, decoding of canonical codes, determining the length of canonical codes, implementing the determination of the length of the codes. Adaptive Huffman encoder and examples of simplified adaptation schemes, TIFF format.
5. Arithmetic coding - fractional and integer realization.
6. Basic techniques of dictionary coding - LZ77, LZ78, LZW, LZX algorithms.
7. Modifications of dictionary coding - VCDIFF, LZFG, LZRW1, LZMW, LZAP, LZY, Burrows-Wheeler transform, prediction with partial match.
8. Uniform scalar quantization, non-uniform scalar quantization, adaptive quantization, vector quantization, Linde-Buz-Gray algorithm, applications of quantization in identification processes.
9. Transformer coding, Discrete Cosine Transform (DCT), JPEG standard.
10. Motion picture compression, motion estimation, MPEG standards.
11. Data encryption techniques - data protection methods, the concept of cryptography and cryptanalysis, encryption system, encryption system evaluation criteria, shifted ciphers, product substitution ciphers, homophonic substitution ciphers, polyalphabetic substitution ciphers, polygam substitution ciphers, Playfair cipher.
12. Advanced encryption techniques - cascade cipher, Enigma machine operation, DES (data encryption standard), Rijndael / AES cipher, open-key cryptographic system, Merkle-Hellman algorithm, ElGamal algorithm, RSA algorithm, electronic signature.
13. Error correction - generation of check digits, errors during digital transmission, repeat code, linear block codes, cyclic codes.
14. Operation of convolutional encoders - convolutional encoder, Viterbi algorithm, applications of convolutional encoders.
15. Summary.
The program of auditorium exercises covers the following issues:
1. Determining checksums.
2. RLE series length encoding (run-length encoding).
3. Unary coding (start-step-stop).
4. Coding and decoding of Golomba codes.
5. Determination of Shannon-Fano and Huffman codes.
6. Compression in graphic formats BMP, PNG, GIF, TIFF.
7. Arithmetic coding and decoding.
8. Dictionary coding and decoding - LZ77, LZSS, LZ78, LZW, LZMW, LZAP. Burrows-Wheeler transform.
9. Uniform and non-uniform scalar quantization, Lloyd-Max algorithm.
10. Vector quantization, LBG algorithm.
11. Lossy compression of JPEG images.
12. Motion estimation in video sequences, elements of MPEG standards.
13. Substitution and transposition encryption, elements of DES and AES algorithms.
14. Cryptographic systems with a public key.
15. Data correction - block and cyclic codes, convolutional coding and decoding with the use of the Viterbi algorithm, cyclic redundancy code.

Teaching methods

1. Lecture: multimedia presentation illustrated with examples given on the board, computer simulations using Matlab / Simulink and CrypTool software
2. Tutorials: solving problems, case studies, analysis of computer simulations

Bibliography

Basic
1. Kompresja danych - podstawy, metody bezstratne, kodery obrazów, Przelaskowski A., Wydawnictwo BTC, Warszawa, 2005
2. Wprowadzenie do kompresji danych, Drozdek A., WNT, Warszawa, 1999
3. Wprowadzenie do kodowania, Kwiatkowski W., BEL Studio, Warszawa, 2010
4. Kody korekcyjne i kryptografia, Mochnacki W., Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 2000

5. Zaawansowane techniki kompresji obrazów i sekwencji wizyjnych, Wydawnictwo Politechniki Poznańskiej, 1998
Additional
1. Cyfrowe przetwarzanie sygnałów - praktyczny poradnik dla inżynierów i naukowców, Smith S., Wydawnictwo BTC, Warszawa, 2007
2. Cyfrowe przetwarzanie sygnałów - metody, algorytmy, zastosowania, Stranneby D., Wydawnictwo BTC, Warszawa, 2004
3. Data compression - the complete reference, Salomon D., Springer, 2004

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	40	1,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	60	2,50