SATBAYEV UNIVERSITY

«Approved by»

Seilova N.A. _____
signature of the Director of the Institute
«10» 01 2020y.

Юнусов Р. _____
signature of the head of the Department
«27» 12 2019y.

SYLLABUS
CSE 2252 Applied Information Theory
Semester: spring: 2019
2019/2020 Academic Year
3 credits (3/0/0)

Almaty, 2019

SATBAYEV UNIVERSITY
Institute of Cybernetics and information technology
Department of "Software Engineering"

Ravil I. Muhamedyev
Room#
ravil.muhamedyev@gmail.com

Personal Information About the Instructor	Time and place of Classes		Contact Information	
	Lessons	Office hours	Tel:	e-mail:
Professor	According to the schedule	According to the schedule	8 707 684 43 70	ravil.muhamedyev@gmail.com

Course Duration: 3 credits, 15 weeks, 45 class hours
Course Pre-Requisites: Basic knowledge of Programming, Probability Theory

Course Information

Course Description:

This course is about Information Theory that is theoretical basis of Information and Communication Technologies. Information Theory explains many key aspects of communication and data processing. The Theory considers the concepts of entropy, information, optimal coding methods, noise immunity coding techniques and signal models . Lately Information Theory successfully applied in tasks of machine learning and artificial intelligence.

The focus of this course is to explain the fundamental concepts of Information Theory and to illustrate their applications. The course provides some techniques for prototyping a software based on linear algebra and Information Theory. During the course students obtain the theoretical knowledge and practical skills in development of such type of software.

Course Objectives:

- Concept and types of information systems
- The concept of control as a science
- The concept of entropy, information and assessment methods
- Methods for quantitative assessment of information
- Theoretical and practical aspects of optimal (efficient) encoding
- Theoretical and practical aspects of noise immunity coding
- Models of signals, data transfer systems, modulation and demodulations, signal sampling
- Application of the theory of noise immunity coding in data processing systems

At the end of the semester, students are expected to be able to

- Understand what is an entropy and an information,
- Understand efficient coding methods,
- Understand noise immunity coding techniques
- Understand mathematical models of signals
- Identify when and why a certain methods of the signals and data processing should be used

Learning outcomes

I. Produce
Software for data processing based on Information Theory

II. Use
Information Theory methods to solve practical problems (coding, cryptography, data processing)

III. Knowledgeably Discuss
The basic concepts of data transmission, methods and algorithms of efficient coding, methods of noise immunity coding, models of signals, applications of information theory

Prerequisites:

- Basic knowledge of Programming, Probability, Algorithms and Data Structure, Mathematics

Literature required:

Basic

1. MacKay D. J. C. Information theory, inference and learning algorithms. – Cambridge university press, 2003.
2. Вернер М. Основы кодирования //М.: Техносфера. – 2006. - 288 с.
3. Cover T. M., Thomas J. A. Elements of information theory. – John Wiley & Sons, 2012.
4. Gray R. M. Entropy and information theory. – Springer Science & Business Media, 2011.

Additional

5. Shannon C. E. A mathematical theory of communication //ACM SIGMOBILE Mobile Computing and Communications Review. – 2001. – Т. 5. – №. 1. – С. 3-55.
6. Delgado-Bonal A., Martín-Torres J. Human vision is determined based on information theory //Scientific reports. – 2016. – Т. 6.
7. Jung T. I. et al. Applying information theory to neuronal networks: from theory to experiments //Entropy. – 2014. – Т. 16. – №. 11. – С. 5721-5737.
8. Ruddell B. L., Brunsell N. A., Stoy P. Applying information theory in the geosciences to quantify process uncertainty, feedback, scale //Eos, Transactions American Geophysical Union. – 2013. – Т. 94. – №. 5. – С. 56-56.
9. El Gamal A., Kim Y. H. Network information theory. – Cambridge university press, 2011.
10. Chaitin G. J. A theory of program size formally identical to information theory //Journal of the ACM (JACM). – 1975. – Т. 22. – №. 3. – С. 329-340.

W	Topic	H	Labs	Hl	Practice
1	Signals, data, methods and information. Dialectical unity of data and methods in the information process. Information and Control.	1	Probability	2	
2	Information theory. Data transmission systems. Applications. Entropy. Examples. Properties of entropy.	1	Entropy	2	
3	Some reminders of linear algebra, Python, and Octave \ Matlab. Diversity of information and information systems	1	Task_L03-Linear algebra in numpy&Python	2	
4	Python tools for data science[1]. Natural language redundancy. Some examples of entropy calculation. Reading files, etc.	1	Task_L04-Linear algebra in numpy&Python[2]	2	
5	Аксиомы энтропии и информации. Теорема кодирования источников. Код Шеннона-Фано	1	ML_Ang_lab01.1_Python Basics with Numpy	2	
6	Huffman algorithm.	1	Task07_HuffmanAlgorithm.docx	2	
7	Example of programming. Project part 1.	1		2	
8	Mutual and conditional information. Conditional entropy. Joint entropy. Application: naive Bayes classifier[3]	1	ML_lab04_NaiveBayesClassifier	2	
	Midterm1				mt_ti_questions.doc
9	Binary symmetric Channel. General principles of redundancy. Noise immunity coding. Hamming codes.	1	Project.Part02. Huffman algorithm	2	
10	Noise immunity coding. Polinomial representation	1	Project.Part03. Decode back into text	2	
11	Noise immunity coding .Cyclic codes	1	Project.Part04. Hamming code	2	
12	Transmission channels and connection lines. Analog and digital signals. Analog-to-digital conversion.Determination of sampling frequency, Kotelnikov-Nyquist theorem. Quantization and companding. Modulation-demodulation, Spectre of signals.	1	Project.Part05. Add errors	2	
13	Application:maximum-entropy classification (MaxEnt) or the log-linear classifier	1	Project.Part06. Fix errors and decode Hamming code.	2	
14	Application: Clustering using Hamming distance, ART1[4]	1	Logistic regression (ML_lab03_logistic regression)	2	
15	Final review	1		2	
			15	30	

LABORATORY WORKS, **TASKS** for teachers supervised independent study of students (TSIS)

Week	Tasks	Cost (in	Project	Cost (in

[1] numpy, Reading files, counting characters
[2] Lectures_1_4_tasks_key.doc
[3] Module 4

[4] ART1 - алгоритм поиска с минимизацией Хеммингового расстояния

		points)		points)
1				
2	Task1	1		
3	Task2-Entropy	1		
4	Task3-Entropy2	3		
5	Task4-Applying of linear algebra	2	Project.Part01	
6	Task6-Shannon-Fano Algorithm	2		6
7	Task7-HuffmanAlgorithm	2	Entropy in classification. Logistic regression.	
	Midterm tasks	4		
8		3	Project.Part02. Huffman algorithm	6
9	Task8-ConditionalEntropy			
10		2	Project.Part03. Decode back into text	8
11			Project.Part04. Hamming code	8
12			Project.Part05. Add errors	6
13			Project.Part06. Fix errors and decode Hamming code.	6
14			Logistic regression (ML_lab03_logistic regression)	
15				

TASKS for student's independent study (SIS)

Week	SIS	Cost (in points)
1		3
2		3
3		3
4		3
5		8

COURSE ASSESSMENT PARAMETERS

Type of activity	Final scores
Attendance /participation	5%
Laboratory works: Tasks & Project	51%
Midterm	4%
Final exam	40%
Total	**100%**

No	Assessment criteria	Weeks															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16-17
1.	Attendance / participation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	5%
2.	Laboratory works	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15%
3.	SIS			*					*							*	12%
4.	TSIS								*							*	8%
5.	Mid-term test								*							*	20%
6.	Final examination															*	40%
	Total																**100%**

Lectures are conducted in the form of supervising of SIS on understanding of theory of given course, that is why students supplied with handouts uploaded into the intranet. Activity on lectures is required and is one of the constituent of final score. Mandatory requirement is preparation to each lesson.

Laboratories are organized in the form of research using special equipment. The preparation to the laboratories is provided in the form of solving of typical problems according to the lectures topics, which within experiments with laboratory equipment is one of the most important tools of understanding of modeling and simulation.

Grading policy:

Intermediate attestations (on 8th and 15th week) join topics of all lectures, laboratories, SIS-I, II, TSIS and materials for reading discussed to the time of attestation. Maximum number of points within attendance, activity, SIS, TSIS and laboratories for each attestation is 40 points.

Final exam joins and generalizes all course materials, is conducted in the complex form with quiz and problem. Final exam duration is 100 min. Maximum number of points is 40. At the end of the semester you receive overall total grade (summarized index of your work during semester) according to conventional SU grade scale.

ACADEMIC POLICY

Associate professor of Computer **Students are required:**

- to be respectful to the teacher and other students;
- to switch off mobile phones during classes;
- not to cheat. Plagiarized papers shall not be graded;
- to meet the deadlines;
- to come to classes prepared and actively participate in classroom work;
- to enter the room before the teacher starts the lesson;
- to attend all classes. No make-up tests are allowed unless there is a valid reason for missing them;
- to follow academic policy regarding **W, AW, I, F** grades.

Students are encouraged to

- consult the teacher on any issues related to the course;
- make up within a week's time for the works undone for a valid reason without any grade deductions;
- make any proposals on improvement of the academic process;
- track down their continuous rating throughout the semester.

Department of Software Engineering

Lecturer *R.I.Muxamediev*

Minutes # 7 of Department of Software Engineering, «27» 12 2019y.