DESCRIPTION OF THE COURSE

Name of the course Computer Vision	Code: MpCSTS01	Semester:3
Type of teaching: Lectures and tutorials	Lessons: L – 30 hours; T – 15 hours	Number of credits: 5

LECTURER:

Prof. d-r Petya Pavlova (FEA), Dep. CST, tel. 659 705,
e-mail: p_pavlova@tu-plovdiv.bg, Technical University of Sofia, branch Plovdiv

COURSE STATUS IN THE CURRICULUM: Compulsory education for the students of the "Computer systems and technologies" subject, department of Electronics and Control systems of the Technical University – Sofia, branch Plovdiv, degree of qualification "Master of science".

AIMS AND OBJECTIVES OF THE COURSE: After passing education the students have to obtain skills in area of achromatic and colour images processing, objects' features obtaining and systems for identification. During the labs each student must develop personal software for basic processing of the images

DESCRIPTION OF THE COURSE: Main topics: Methods and techniques for computer images derivation; different types of images and their features; Preliminary image processing – convolution and filtering, linear and non-linear filters, spatial filters, restrictions of applications. Mathematical morphology; Image segmentation; Object's features obtaining and normalizing; Principals of dynamic images processing; Analyze, clustering and minimization of the features' space. Systems and techniques for pattern recognition.

PREREQUISITES: Program languages, Digital signal processing

TEACHING METHODS: Lectures. Labs with programming using Visual C++ , OpenCV and initial shell of a software product, helpful for the personal product development

METHOD OF ASSESSMENT: Two tests on theory and some particular tasks solving. The final estimation is based on the tests results – 70% and laboratory work – 30%.

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:
1 Павлова П., Н. Шакев, Компютърно зрение, ТУ София филиал Пловдив, 2018 2.R. Gonzalez, R. Woods, Digital Image Processing, 3rd Ed., Prentice Hall, 2007. 3. У. Претт, Цифровая обработка изображений (пр. от англ.), т.1 и т.2, Москва, Мир, 1981. 4.Павлова П., Цифрова обработка на изображения (уч. пособие), Фондация физика, инженерство и медицина XXI, Пловдив 2005. 5.Ed. Al Bovik, Handbook of Image & Video Processing, sec. ed., Elsevier, 2005 6.Holst G., T. Lomheim, CMOS/ CCD sensors and cameras systems. Sec. ed. SPIE PRESS, 2011 7. Tekalp A., Digital Video Processing, Prentice Hall, 1995 8. Daugherty Geoff, Pattern Recognition and Identification, an introduction. Springer, 2013 g. 9.Farid H., Fundamentals of Image Processing**,** 2010 – e-book. 10.Fr. Shih, Image Processing and Pattern Recognition: Fundamentals and Techniques, John Wiley, 2010. 11.R. Kountchev, New Approaches in Intelligent Image Processing, WSEAS Press, 2013. 12. Ahad, Computer Vision and Action Recognition, A Guide for Image Processing and Computer Vision Community for Action Understanding, Atlantis Press, 2011

DESCRIPTION OF THE COURSE

Name of the subject: **Interface in a natural language**	Code: **MpCST02**	Semester: **3**
Type of training: Lectures Laboratory exercises	Lessons per semester: L - 30 LE - 15	Credits: **5**

LECTURER: Assoc. prof. PhD Dilyana Budakova, Technical University of Sofia – Plovdiv Branch

STATUTE OF THE SUBJECT IN THE CURRICULUM: Compulsory subject for the Master Degree course in „Computer systems and technologies“ in the Faculty of Electronics and Automation at the Technical University of Sofia, Plovdiv Branch.

AIMS OF THE SUBJECT: The subject aims at giving the students knowledge of non-formal methods for problems solving, of models for presenting knowledge as well as of methods of conclusion with the different models; it aims to acquaint the students with the ways of modeling and the application of intelligent virtual agents (IVA), which have recently developed as a new realistic emotional computer interface in a natural language; it also aims at giving the students the opportunity of making their own agent-assistants; the subject aims at acquainting the students with the basic and hybrid techniques for speech synthesis. An accent is put on realizing the new objectives in this area, namely, synthesizing expressive (emotional) speech. Algorithms of morphological and syntax analysis of a natural language are considered, together with algorithms of speech recognition and mathematical models for presentation in a natural language.

DESCRIPTION OF THE SUBJECT: Some of the basic topics to be considered are: Models for presenting knowledge and methods for conclusion with the different models (logical, network, production, frame). The students apply logical methods, create knowledge bases and solve problems by logical programming using Visual Prolog 7.0. The expert systems and Intelligent Agents are regarded as an example of Artificial Intelligence Systems (AIS), giving explanations of their solutions and communicating in a natural language with the user. SSML is considered, as well as the basic steps with TTS Processors for speech synthesis. Speech signals are investigated and speech is syntesized by means of the programme Praat; The programme system for building dialogue systems in a natural language in CSLU, developed by the University of Oregon, is used. The Natural Language Toolkit is used too. The student are introduced with the Windows Desktop Speech Technology and they used Assembly: System.Speech.dll; Namespace: System.Speech.Synthesis; Namespace: System.Speech.Recognition; in their developed programming systems. They used Visual Studio.NET, C# programming language and synthetic Bulgarian languages too.

PREREQUISITES: Programming and use of computers I, II, III, Component programming, Programming on the Internet, Computer graphics, Language processors.

METHODS OF TEACHING: Lectures, laboratory exercises on the main lecture topics, project on a chosen topic.

METHODS OF EXAMINATION AND ASSESSMENT: The mark is formed on an ongoing basis taking into account students performance during the laboratory exercises and the results from two written tests, comprising three questions on the lecture material.

LANGUAGE OF TEACHING: Bulgarian

RECOMMENDED LITERATURE:

1. Russell S., Norvig P., Artificial Intelligence A Modern Approach, Prentice Hall, Third Edition, 2010, ISBN-13 978-0-13-604259-4, ISBN-10 0-13-604259-7
2. Teahan W. J., Artificial Intelligence – Agent Behaviour I, 2010 William John Teahan & Ventus Publishing ApS, ISBN 978-87-7681-559-2
3. Winston P.H. Artificial intelligence, Third edition, 1992, MIT Press, ISBN-13: 978-0201533774, ISBN-10: 0201533774,
4. Nilsson N., Principles of Artificial Intelligence, Tioga, Palo Alto, California, 1980 (Нильсон Н., Принципъі искусственого интеллекга, Радио и связ, 1985)
5. Davis R., Lenat D., Knowledge-Based Systems in Artificial Intelligence, Mc-Grow-Hill, 1982.
6. International conference of Intelligent Virtual Agents papers. Publish in LNCS Springer 2006-2010.
7. M. Tatham, DEVELOPMENTS IN SPEECH SYNTHESIS, *Department of Language and Linguistics, University of Essex, UK*, Katherine Morton *Formerly University of Essex, UK*
8. A. Black K. Lenzo, Building Synthetic Voices For FestVox 2.1 Editio Copyright © 1999-2007
9. Speech Synthesis Markup Language (SSML) http://www.w3.org/TR/speech-synthesis/
10. University of Victoria, British Columbia, Canada, Linguistics Resurces - phonetic alphabet audio illustation http://web.uvic.ca/ling/resources/ipa/charts/IPAlab/IPAlab.htm

11. VoiceXML http://docs.voxeo.com/voicexml/2.0/home.htm
12. Oregon, Health & Science University, Center for spoken Language Understanding
13. P. Boersma D. Weenink, University of Amsterdam, Netherlands, Praat. http://www.fon.hum.uva.nl/praat/ University of Victoria, Department of Linguistics, S. Bird, Q. Wang – ръководство за изследване на речеви сигнали базирано на софтуера Praat.
14. The Stanford Natural Language Processing Group http://nlp.stanford.edu/research.shtml
15. Daniel Jurafsky and James H. Martin, SPEECH and LANGUAGE PROCESSING. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition Second Edition by
16. Centre for spoken language understanding (CSLU). http://cslu.cse.ogi.edu/tutordemos/
17. Нишева, М., Шишков Д., Изкуствен интелект, Интеграл, 1999.
18. Димитров Д., Никовски Д., Изкуствен интелект, ТУ-София, 1997.
19. Даковски, Л.Г., Д. Будакова, Ръководство по Изкуствен интелект. ТУ-София, 2009.
20. Чарняк, Ю., Макдърмод Д., Увод в изкуствения интелект, Софтех, 1997.
21. Sonya Bird, Qian Wang, LING 380: Acoustic Phonetics Lab Manual, Department of Linguistics University of Victoria
22. Natural Language Toolkit : http://www.nltk.org/
23. DEVELOPMENTS IN SPEECH SYNTHESIS Essex, UK Mark Tatham, Katherine Morton2 Published Online: 11 JAN 2006 Copyright © 2005 John Wiley & Sons, Ltd LNAI, Springer 2006-2010
24. Oregon, Health & Science University, Center for spoken Language Understanding (CSLU). http://cslu.cse.ogi.edu/tutordemos/
25. University of Amsterdam, Netherlands, Praat. http://www.fon.hum.uva.nl/praat/
26. Davis R., Lenat D., Knowledge-Based Systems in Artificial Intelligence, Mc-Grow-Hill, 1982.
27. Попов, Е.В. Искусственньій интеллект, Радио и связ, кн. 1: Системьі общения и Експертньіе системьі., 1990, кн. 2, Модели и методи, 1990.
28. Даковски Л.Г. под редакцията на Попчев, Изкуствен интелект – проблеми и приложения, Техника, София, 1990.

Web Addresses	
Natural Language Toolkit	http://www.nltk.org/
Columbia University in the sity of New York Natural Language Processing	https://www.coursera.org/course/nlangp
Praat	http://www.fon.hum.uva.nl/praat/
Center for spoken Language Understanding (CSLU).	http://cslu.cse.ogi.edu/tutordemos/
intelligent-virtual-agents-iva-2013	http://ispr.info/2012/12/06/call-13th-international-conference-on-intelligent-virtual-agents-iva-2013/
Gergana – SpeechLab2 BACL the Bulgarian Association for Computational Linguistics. Android	https://play.google.com/store/apps/details?id=org.bacl.android.speechlab2g&hl=bg
Daria - S2G + DARIA NUANCE VOICE	https://harposoftware.com/en/bulgarian/267-S2G-Daria-Nuance-Voice.html
Irina - Innoetics TTS Reader 1 Female Bulgarian Voice (IRINA)	
Ivan	Windows 10

DESCRIPTION OF THE COURSE

Name of the course **Distributed systems and Computer Communications**	Code: **MpCST03**	Semester: **3**
Type of teaching: Lectures and laboratory work	Lessons per semester: L – 30 hours; LW – 15 hours	Number of credits: **4**

LECTURER: Prof. PhD Grisha Spasov (FEA),Dep. CST, tel.: 659 724, email: gvs@tu-plovdiv.bg, Technical University of Sofia, branch Plovdiv

COURSE STATUS IN THE CURRICULUM: Eligible for the students specialty "Computer Systems and Technologies" M.Sc. programme of the Faculty of Electronics and Automatics, Technical University of Sofia, branch Plovdiv.

AIMS AND OBJECTIVES OF THE COURSE: At the end of the course the students are expected to have knowledge for basic principles for creating distributed systems and client-server applications, together with the architecture of Middleware for distributed systems.

DESCRIPTION OF THE COURSE: The main topics concern: Introduction to distributed systems. Hardware and software aspect of the client-server model. Communication protocols of the application layer. Middleware protocols and distributed applications –RPV, RMI, MQS. Distributed processes – client-server, threads, code migration, software agents. Naming in distributed systems- DNS, X.500. Synchronization of distributed work. Co-ordination and replication of resources. Co-ordination models. Replication models. Security policy in distributed systems. Encryption methods – PKI. KERBEROS, SESAME. Distributed object-based systems – CORBA, DCOM. Distributed file systems – NFS, AD. Distributed document-based systems – WWW, Lotus Notes. Distributed systems based on object co-ordination – JINI.

PREREQUISITES: From B.Sc. programme: Operating Systems, Computer Architectures, Programming Languages, Computer Networks.

TEACHING METHODS: Lectures, using slides and multimedia presentations, laboratory work, using demo-programs and case study.

METHOD OF ASSESSMENT: Written exam on the theory and defense of the case study. The final grade is constructed on the exam results (totally 60%), the case study (30%) and the laboratory work (10%).

INSTRUCTION LANGUAGE: Bulgarian.

BIBLIOGRAPHY: 1. Maarten Van Steen, Andrews S. Tanenbaum. " Distributer Systems" Third edition, Maarten van Steen, 2017, ISBN: 978-90-815406-2-9; 2. Кристофър Стоун, Джо Уебър. " Java 2: Праграмиране за Интернет", 1999, LIO Book Publishing; 3. Jon C. Sanader. "Effective TCP/IP Programming", Addison-Wesley, 2000, ISBN 0201615894; 4. George Coulouris et al.." DISTRIBUTED SYSTEMS. Concepts and Design" Fifth Edition, Addison-Wesley, 2012, ISBN 13: 978-0-13-214301-1.

DESCRIPTION OF THE COURSE

Name of the course **GRID programming**	Code: **MpCST4.1**	Semester: **3**
Type of teaching: Lectures, laboratory work	Lessons per week: L – 30 hours; LW – **15** hours	Number of credits: **4**

LECTURER:

Assoc. Prof. Ph.D. Maria Marinova (FEA), Dept. CST – tel.: 659 727,
Technical University of Sofia, branch Plovdiv,
e-mail: m_marinova@tu-plovdiv.bg

COURSE STATUS IN THE CURRICULUM: Selective course for the students in MSc program in Computer systems and technologies.

AIMS AND OBJECTIVES OF THE COURSE: The aim of the course is to create knowledge about GRID *Architectures*: what is VO, CE and SE. The students will be learned about basic components of OGSA, components of gLite 3.0 middleware, SOA/SOAP и OGSA; WSDL и WSIL, OGSA-DAI.

DESCRIPTION OF THE COURSE: architecture of GRID; main terms like virtual organizations, computing elements and storage elements; encrypting algorithm – X.509, asynchronous and synchronous encrypting, fields of Grid computing; SOA and OGSA, modifying of web services in grid; WSDL и WSIL, OGSA-DAI; grid computing and computing and clouds difference and similarly; types of distributed systems, distributed programming: model client-server, socket, java RMI, DCOM and CORBA; Job Description Language using to start programs on the grid;

PREREQUISITES: Good fundamental knowledge in the courses Parallel Programming and High-Performance Computer Systems.

TEACHING METHODS: Lectures and laboratory work. For laboratory exercises students have grid certificate to access EU Grid Infrastructure. Programming on gLite middleware with JDL.

METHOD OF ASSESSMENT: Final mark is form like takes value of mark of test, laboratory work and course project.

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:
C. Prabhu, *Grid and Cluster Computing*, 2013, **K. Hwang,** *Distributed and Cloud Computing: From Parallel Processing to Internet of Things*, 2014, **F. Berman, G. Fox, A. Hey**, *Grid Computing. Making the Global Infrastructure a Reality*. (ed.). Wiley, 2003, **T. Erl, Z. Mahmood,** *Cloud Computing: Concepts, Technology and Architecture*, 2013, **B.Wilkinson,** *Grid Computing: Techniques and Applications*, 2009, **F.Magoules,** *Fundamentals of Grid Computing: Theory, Algorithms and Technologies*,2009, **Culler D., Singh J.,** *Parallel Computer Architecture: A Hardware/Software Approach*. Elsevier, 2009, **A. Kshemkalyani, M. Singhal,** *Distributed Computing: Principles, Algorithms, and Systems*, 2011

WWW addresses:

Global Grid Forum http://www.gridforum.org/
European Grid Infrastructure: http://www.egi.eu/
The Grid Computing Information Centre: http://www.gridcomputing.com
IITC-BAS, Грид Технологии и Приложения: http://gta.grid.bas.bg/index.php/bg/
LEGION: http://www.cs.virginia.edu/~legion/
http://www.cs.kent.edu/~farrell/grid06/reference/index.html
http://www.electro.fisica.unlp.edu.ar/eela/docs/gLite-3-UserGuide.pdf

DESCRIPTION OF THE COURSE

Name of the course: **Programming of modern heterogeneous architectures**	Code: **MpCST4.2**	Semester: **3**
Type of teaching: Lectures, laboratory work, course work	Lessons per week: **L – 30; LW – 15**	Number of credits: **4**

LECTURERS:
Assoc. Prof. PhD Maria Pl. Marinova, lecturer in TU-Sofia branch Plovdiv, Faculty of electronics and automatics, dept. Computer systems and technologies, tel.: 659727, e-mail: m_marinova@tu-plovdiv.bg,

COURSE STATUS IN THE CURRICULUM: Selective for students speciality Computer Systems and Technologies MEng programme of the Faculty of Electronics and Automation

AIMS AND OBJECTIVES OF THE COURSE: At the end of the course the students are expected to know the parallel languages as CUDA C, OpenCL and have knowledge to programming onto MIC processors.

DESCRIPTION OF THE COURSE:
Main topics: Parallel programming of heterogeneous computer architectures. Programming of the multi-GPU. Programming on Xeon Phi accelerators. Using of *warp* execution – warps-thread blocks, warp divergence, distribution of the resources, warp latency and synchronization.

PREREQUISITES: Parallel Programming, Operating Systems, Computer Architectures.

TEACHING METHODS: Lectures, using slides, case studies, laboratory and course work, work in teams, course work description preparation and defence.

METHOD OF ASSESSMENT: One test assessment at the end of the semester (50%), and defence of course work implemented during the laboratory exercises (50%).

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:
Lecture slides
Han J., Bharatkumar S., Learn CUDA Programming: A beginner's guide to GPU programming and parallel computing with CUDA 10.x and C/C++, 1st edition, 2020
Soyata T., GPU Parallel Program Development Using CUDA. 2020
Kirt D., Wen-mei W., Programming Massively Parallel Processors. A hands-on Approach. Third edition, 2018.
Reinders J., Jeffers J., High Performance Parallelism Pearls. Multicore and Many-core Programming Approaches Volume II – 2015.
Jeffers J., Reinders J., Sodani A., Intel Xeon Phi Processor High Performance Programming, 2016
CUDA Programming. A Developer's Guide to Parallel Computing with GPUs. Shane Cook. 2020

DESCRIPTION OF THE COURSE

Course title: **UML object-oriented design**	Code: **MpCST5.1**	Semester: **3**
Classes: Lectures, Laboratory work	Hours per week: L – **30,** LW - **15**	Credits: **5**

LECTURERS:
Assoc. Prof. PhD Ivaylo Atanassov (FEA) – tel.: 659 729, email: ivo_atan@tu-plovdiv.bg , Dobrinka Petrova, PhD (FEA), email: dpetrova@tu-plovdiv.bg
Technical University – Sofia, branch Plovdiv

POSITION IN THE CURRICULUM: Selective discipline for "Computer systems and technologies", faculty of "Electronics and automatics", Technical University – Sofia, branch Plovdiv, master degree.

AIMS OF THE COURSE: The "UML object-oriented design" course aims to give students knowledge and skills for object-oriented design and solving problems with the corresponding tools.

COURSE DESCRIPTION: Main topics: Object-oriented design – principles and basic terms. Class design. Inheritance and abstract classes. Elements, relationships, diagrams. Requirements modeling. Conceptual modeling. Class diagrams. Object diagrams. Behavior modeling. Sequence diagrams and states diagrams. Packages, components, components diagrams. Nodes and components, deployment diagrams..

PREREQUISITES: Programming of computers – part I, II, III, Programming languages, Object-oriented programming, Component programming.

TEACHING METHODS: Lectures, exercises on the main topics, solving assignments related to the system programming.

TESTING AND EVALUATION: The final mark is composed from the examination test.

COURSE LANGUAGE: Bulgarian

RECOMMENDED LITERATURE:
1. HORSTMANN, C., Object-Oriented Design and Patterns, John Wiley & Sons, Inc., 2006
2. OJO, A., E. Esteves, Object-Oriented Analysis and Design with UML - Training Course, e-Macao Report 19, 2005
3. SHALLOWAY, A., J. Trott, Design patterns explained – a new perspective on object-oriented design, Addison Wesley professional, 2004
4. PRIESTLEY, M., Practical object-oriented design with UML, McGrow Hill, 2003

DESCRIPTION OF THE COURSE

Name of the course **Internet Programming**	Code: **MpCST5.2**	Semester: **3**
Type of teaching: Lectures and laboratory work Course work	Lessons per semester: L – 30 hours; LW – 15 hours	Number of credits: **5**

LECTURER:

Assist. of Prof. Ph.D. Dobrinka Petrova (FEA) – tel.: 0320659 727,
email: dpetrova@tu-plovdiv.bg
Technical University of Sofia, Plovdiv Branch

COURSE STATUS IN THE CURRICULUM: Elective course for students in MSc program in Computer Systems and Technologies.

AIMS AND OBJECTIVES OF THE COURSE: At the end of the course the students are expected to have knowledge about main principles of creating Web and Internet applications, client-side and server-side scripting, database access technologies.

DESCRIPTION OF THE COURSE: The main topics concern: Client-server architecture; HTML5 and CSS; JavaScript programming, AJAX and Document Object Model (DOM); Model-View-Controller (MVC); Server-side programming – JSP, ASP.NET and PHP; Database connectivity; Regular expressions; Web 2.0 and 3.0 – wiki, blog, RSS, Web Services, Semantic Web.

PREREQUISITES: Good fundamental knowledge in Programming Languages, Programming Environments, XML Technologies, Computer Networks, Database Managements Systems.

TEACHING METHODS: Lectures, using slides, laboratory work on main topics with individual and group tasks, course project preparation and defence.

METHOD OF ASSESSMENT: Composite evaluation: continuous assessment (40%), essay or presentation on the theory (10%) and course project (50%).

INSTRUCTION LANGUAGE: Bulgarian.

BIBLIOGRAPHY:

1. J. Duckett, "Web Design with HTML, CSS, JavaScript and jQuery Set",Wiley, 2014, 1st Edition, ISBN: 9781118907443;
2. A. Lock. ASP.NET Core in Action, Manning Publications, 2018, 1st Edition, ISBN: 9781617294617;
3. R. Nixon, “Learning PHP, MySQL & JavaScript”, O'Reilly Media; 5th edition, 2018, ISBN: 978-1491978917;
4. M. Fitzgerald, "Introducing Regular Expressions," "O'Reilly Media, Inc.", 2012, ISBN:9781449392680;
5. E. Elliott, "Programming JavaScript Applications," O'Reilly Media Formats: Safari Books Online, Early Release Ebook, March 2014;
6. M.P. MATHA, "JSP and SERVLETS: A Comprehensive Study," PHI Learning Pvt. Ltd., 2013, ISBN: 9788120347458;
7. N. Gray, “Web Server Programming,” Wiley, 2003, ISBN: 0470850973.

DESCRIPTION OF THE COURSE

Name of the course: **Systems for remote monitoring and control of spacecrafts**	Code: **MpCST6.1**	Semester: **3**
Type of teaching: Lectures, laboratory work	Lessons per semester: L – 30 hours; LW – 15 hours	Number of credits: **4**

LECTURER:
Assoc. prof. Mitko Shopov, PhD, lecturer in TU-Sofia, Plovdiv branch, Faculty of Electronics and Automatics, Dept. CST – tel.: (032) 659 765 e-mail:mshopov@tu-plovdiv.bg
Hristo Indzhov, PhD, Section head, consultant, Telespazio-Vega, Darmstadt, Germany, e-mail: Hristo.Indzhov@telespazio-vega.de

COURSE STATUS IN THE CURRICULUM: Electable course for students in MSc program in Computer systems and technologies.
AIMS AND OBJECTIVES OF THE COURSE: t the end of the course the students are expected to have knowledge about architecture and organization of monitoring and control systems (MCS), their main information flows and the components that represent them. They will have beginner experience in development of components/modules for MCS based on the educational environment Simple MCS.

DESCRIPTION OF THE COURSE: The discipline is an introduction to monitoring and control systems (MCS) and their application in the space sector and space missions. The content of the course is based on an educational MCS (Simple MCS) developed with the help of Java and Spring Framework. Simple MCS introduces the telemetry chain, the telecommand chain and the components that build them. The main goal of the exercises is to implement missing functionalities in said components e.g. work with specific file formats (YAML), bitwise manipulations and object conversions, encoding and decoding of binary streams, synchronization in multi-threaded environment, storage and retrieval of data.

PREREQUISITES: Good fundamental knowledge in programming languages (including multithreading), programming environments, Computer networks, Database management systems.
TEACHING METHODS: Lectures with multimedia and web resources, laboratory works in main topics with individual and group tasks.

METHOD OF ASSESSMENT: One assessment test at the end of semester (70%), and laboratory work (30%).
INSTRUCTION LANGUAGE: Bulgarian
BIBLIOGRAPHY:

29. European Cooperation for Space Standardization http://ecss.nl/
30. European Space Agency https://www.esa.int/ESA
31. European Ground Systems Common Core http://www.egscc.esa.int/
32. Cubesat http://www.cubesat.org/
33. Java https://docs.oracle.com/javase/tutorial/
34. Spring Framework https://spring.io/
35. Maven https://maven.apache.org/
36. GIT https://git-scm.com/

DESCRIPTION OF THE COURSE

Name of the course **Methods and devises for digital signal processing**	Code: **MpCST6.2**	Semester: **3**
Type of teaching: Lectures, Laboratory work	Lessons per week: L – 30 hours; LW – 15 hours	Number of credits: **4**

LECTURER:

Assoc. Prof. D-r Boyko Petrov, tel: 659760 e-mail: abpetrov@persecteam.com
TU-Sofia, branch Plovdiv

COURSE STATUS IN THE CURRICULUM: Selective subject for the students specialty "Computer Systems and Technologies" master dergee program of the Faculty of Electronics and Automatics, Technical University of Sofia, branch Plovdiv.

AIMS AND OBJECTIVES OF THE COURSE: The goal of the course is giving theoretical and practical knowledge in the areas of analyzes and syntheses of computer systems for digital processing of one dimensional and multi dimensional signals The main theoretical topics are related to development and realization of devices and systems for digital signal processing.

DESCRIPTION OF THE COURSE:. Main topics**:** development of linear digital filters, methods for spectral and correlative analyses of the signals, specialized techniques for signal processing, methods for one multidimensional signals compressing, architecture of specialized processors for digital signal processing. Practical topics: program realization of digital filters, using of computer libraries for spectral and correlative signal analyses of digital signal processors.

PREREQUISITES: Good programming skills with the C computer language. Good knowledge on mathematics.

TEACHING METHODS: Lectures, using slides and multimedia presentations, laboratory work with some particular tasks solving, course work.

METHOD OF ASSESSMENT: The final estimation is based on the exam results – 80% and laboratory work – 20%.

INSTRUCTION LANGUAGE: Bulgarian.

BIBLIOGRAPHY:

1. Макс, Ж., Методы и техника обработки сигналов при физических измерениях, М.: Мир, 1983, първа и втора част.
2. Ташев, Ив., Методи,устройства и системи за събиране и преобразуване на информация, Учебник за дистанционно обучение при ТУ София.
3. Прэтт У.: Цифровая обработка изображений, том 1 и 2, Москва,"Мир", 1982г.
4. Беноа Ерве, Цифрова телевизия – MPEG-1, MPEG-2. Принципи на системата DVB, София,2001г, "ЛИК"
5. http://www.analog.com/processors/sharc/
6. http://www.analog.com/processors/blackfin/index.html
7. http://www.cs.sfu.ca/CC/820/mark/material/refs.html

DESCRIPTION OF THE COURSE

Name of the course **Project**	Code: **MpCST07**	Semester: **3**
Type of teaching: Course project	Lessons per week: Self work	Number of credits: **2**

Student must select one of the subjects from the current semester and develop course project.

DESCRIPTION OF THE COURSE

Name of the course: **Distributed embedded systems**	Code: **MpCST08**	Semester: **4**
Type of teaching: Lectures, laboratory work, course work	Lessons per week: **L – 30; LW – 15**	Number of credits: **5**

LECTURERS:
Assoc. Prof. PhD Nikolay R. Kakanakov, lecturer in TU-Sofia branch Plovdiv, Faculty of electronics and automatics, dept. Computer systems and technologies, tel.: 659765, e-mail: kakanak@tu-plovdiv.bg

COURSE STATUS IN THE CURRICULUM: Compulsory for students speciality Computer Systems and Technologies MEng programme of the Faculty of Electronics and Automation

AIMS AND OBJECTIVES OF THE COURSE: At the end of the course the students are expected to know the techniques for design and implementation of application and systems programs for distributed embedded systems as well as communication protocols and architecture for data exchange in distributed embedded systems.

DESCRIPTION OF THE COURSE:
Main topics: Embedded systems programming. Development platforms and tools for DES. Designing DES. Application of Web technologies in DES. Real-time Operating Systems. Ethernet in real-time communication. Sensor networks. Distributed Embedded Systems security. Internet of Things and BigData. Analytical estimation of delays in controller networks.

PREREQUISITES: Microcontroller technologies, Microprocessors, Computer Periphery, Operating Systems, Programming, Computer Networks.

TEACHING METHODS: Lectures, using slides, case studies, laboratory and course work, work in teams, course work description preparation and defence.

METHOD OF ASSESSMENT: One test assessment at the end of the semester (50%), and defence of course work implemented during the laboratory exercises (50%).

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:
1. J. Axelson “Embedded Ethernet and Internet Complete”, Lakeview Research LLC, 2003, ISBN:1-931448-000;
2. Qing Li and Carolyn Yao, “Real-Time Concepts for Embedded Systems, “ CMP Books, 2003.
3. Topp, U., P. Müller, “Web based service for embedded devices”, Lecture Notes in Computer Science, Volume 2593 / 2003, pp. 141 – 153, ISSN: 0302-9743;
4. M. Barr, A. Massa, "Programming Embedded Systems," O'Reilly, 2006.;
5. G. Spasov, M. Shopov. V. Spasova, N. Kakanakov, “Tutorial for laboratory work in microprocessor systems”, Technical University of Sofia, 2013.
6. G. Spasov, N. Kakanakov, M. Shopov, “Tutorial for laboratory work in computer networks”, Technical University of Sofia, 2009.

DESCRIPTION OF THE COURSE

Name of the course **VLSI design**	Code: **MpCST09**	Semester: **4**
Type of teaching: Lectures and laboratory work	Lessons per semester: L – 30 hours; LW – 15 hours	Number of credits: **5**

LECTURER:

Assoc. Prof. PhD Atanas Kostadinov, Computer systems and Technologies Department, Technical University – Sofia, branch Plovdiv, Phone: + 359 32 659 726, email: kostadat@tu-plovdiv.bg.

COURSE STATUS IN THE CURRICULUM: A compulsory subject for the Computer Systems and Technologies students admitted to the master program. Computer Systems and Technologies Department belongs to the Electronics and Automation Faculty (EAF). EAF is a part of the Technical University – Sofia, Plovdiv branch.

AIMS AND OBJECTIVES OF THE COURSE: The main goal of the above-mentioned subject is the receiving or refreshing of a basic knowledge for CPLDs (Complex Programmable Logic Devices), FPGAs (Field Programmable Gate Arrays) and VHDL (Very high speed integrated circuit Hardware Description Language). The main topics are connected to the CPLD, FPGA and VHDL. The acquired knowledge will open to the students the possibilities of using reconfigurable integrated circuits and VHDL in the digital and microprocessor devices and systems design. The objectives of this course are:

- Understand or refresh the concept of reconfigurable logic;
- Know and remember how different processor architectures are designed;
- Learn or refresh your knowledge how to use the VHDL in simulation and synthesis of a microprocessor and a simple computer;
- Be able to use CAD tools to design and simulate digital circuits.

DESCRIPTION OF THE COURSE: The main topics covered in this subject are: The basic terms used in VLSI (Very Large – Scale Integration) design. CMOS (Complementary Metal Oxide Semiconductor) logic gates. Behavioral, Structural and Dataflow descriptions of digital devices using VHDL; Simulation of the designed digital circuits using ModelSim. Work with Quartus II Web Edition/Quartus Prime Lite Edition and Vivado HL System Edition; Cyclone II FPGA Starter Development Board, DE2 (Development and education board) and Nexys4 DDR FPGA boards – basic electronic components and parameters; Fundamentals of different microprocessor architectures; Microprocessors datapath – design and test of simple datapath unit. Microprocessor control unit – implementing basic arithmetic and logic instructions; Verification of the designed computer system consisting of microprocessor and RAM (Random Access Memory) using SignalTap II embedded logic analyze; Optimization of implemented processor architecture using Quartus II Advisors; Different IP (Intellectual Property) microprocessor architectures described by HDLs (Hardware Description Languages); Synchronization and signal propagation in VLSI circuits; Multiple cores microprocessor architectures – short information; Multiprocessor systems – types, advantages and disadvantages.

PREREQUISITES: The prerequisite subject is BCS55 Reconfigurable logic.

TEACHING METHODS: The lectures presented the above material using slides and multimedia projector. In the laboratory exercises are applied CAD tools to design and simulate digital circuits described in VHDL as well as FPGA boards for their implementation.

METHOD OF ASSESSMENT: The written exam is in the form of a test. The final mark consists of written exam (80%), midterm exam (10%) and laboratory work (lab report grading - 10%).

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:

1. W. Dally, R. Harting, T. Aamodt, Digital Design Using VHDL: A Systems Approach 1st Edition, Cambridge University Press, 2016.
2. C. Unsalan and B. Tar, Digital system design with FPGA: Implementation using Verilog and VHDL 1st Edition, McGraw-Hill Education, 2017.
3. Modern digital design with EDA, VHDL and FPGA, Terasic Inc., 2015.
4. http://www.ee.ryerson.ca/~courses/coe328
5. https://www.intel.com/content/www/us/en/products/programmable.html
6. http://www.xilinx.com

DESCRIPTION OF THE COURSE

Name of the course **Algorithms in bioinformatics**	Code: Mp**CST10.1**	Semester: 4
Type of teaching: Lectures and tutorials	Lessons per semester: L – 30 hours; T – 15 hours	Number of credits: **5**

LECTURER:
Assoc. Prof. PhD Ivaylo Atanassov (FEA) – tel.: 659 729, email: ivo_atan@tu-plovdiv.bg , Technical University of Sofia, branch Plovdiv

COURSE STATUS IN THE CURRICULUM: Optional course for first year students in Computer Systems and Technologies, M.Sc. programme of the Faculty of Electronics and Automatics, Technical University of Sofia, branch Plovdiv.

AIMS AND OBJECTIVES OF THE COURSE: After course completion students should : know the goals of bioinformatics ; biological motivation concepts ; a set of methods and algorithms used in bionformatics and a set of bioinformatics databanks.

DESCRIPTION OF THE COURSE: Main topics : Molecular biology reminder. Sequence comparison algorithms. Markov models. Databases in bioinformatics. Gene detection. Genome mapping. Protein analysis.

PREREQUISITES: Discrete mathematics. Data structures. Sinthesis and analysis of algorithms. Combinatorial algorithms.

TEACHING METHODS: Lectures with multimedia presentations. Tutorials using demo software.

METHOD OF ASSESSMENT: Written tests on the theory.

INSTRUCTION LANGUAGE: Bulgarian.

BIBLIOGRAPHY: 1. Shamir R., Algorithms in molecular biology, 2002; 2. Online Courses in Bioinformatics and Molecular Biology, MIT ; 3. Tomova Sn., Biology digest (in Bulgarian), Sofia, Modula 1994; 4. Stoichev S., J.Genoff, Lecture scripts in bioinformatics, Plovdiv, 2004.

DESCRIPTION OF THE COURSE

Name of the course **Combinatorial Algorithms**	Code: **MpCST10.2**	Semester: **4**
Type of teaching: Lectures and laboratory work	Lessons per semester: L – 30 hours; LW – 15 hours	Number of credits: **5**

LECTURER:

Assist. of Prof. Ph.D. Dobrinka Petrova (FEA) – tel.: 0320659 727,
email: dpetrova@tu-plovdiv.bg
Technical University of Sofia, Plovdiv Branch

COURSE STATUS IN THE CURRICULUM: Elective course for students in MSc program in Computer Systems and Technologies.

AIMS AND OBJECTIVES OF THE COURSE: The aim of the course is to provide knowledge about the mathematics and basic methods and algorithms, used in Combinatorics and Graph Theory. Students gain skills to apply them for solving problems in different areas of Computer Science.

DESCRIPTION OF THE COURSE: The main topics concern: Permutations; Variations; Combinations; Sets, Partitioning; Graph – basics and representation; Graph Search; Extremal path algorithms; Euler Path and Cycle; Hamiltonian Path and Cycle; Topological Sorting; Planarity; Colorings; Matching; Isomorphism and Automorphism.

PREREQUISITES: Good fundamental knowledge in Synthesis and Analysis of Algorithms, Discrete Mathematics, Mathematics and Programming.

TEACHING METHODS: Lectures, using slides, laboratory work on main topics with individual and group tasks.

METHOD OF ASSESSMENT: Composite evaluation: assessment test at the end of semester (60%) and laboratory work (40%).

INSTRUCTION LANGUAGE: Bulgarian.

BIBLIOGRAPHY:

1. Наков Пр., П. Добриков. Програмиране = ++ Алгоритми; София, 2005.
2. Harris J. M., J. L. Hirst, M. Mossinghoff. Combinatorics and Graph Theory, Second edition, Springer, 2008.
3. M. Bona. A Walk Through Combinatorics: An Introduction to Enumeration and Graph Theory, Third Edition, World Scientific Publishing Co, 2011.
4. R. J. Wilson, Introduction to Graph Theory, 5th edition, Prentice Hall, 2010.
5. B. Bollobás, Modern Graph Theory, Graduate Texts in Mathematics 184, Springer-Verlag, 1998.
6. Kreher D. L. and Stinson D. G. Combinatorial Algorithms, CRC Press, 1998.

DESCRIPTION OF THE COURSE

Name of the subject **Learning and self-learning in programming**	Code: **MpCST10.3**	Semester: **4**
Type of training: Lectures and Laboratory work	Lessons per semester L – **30,** LW – **15**	Credits: **5**

LECTURER: Assoc. Professor PhD Dilyana Budakova
Technical University of Sofia, Plovdiv Branch

STATUTE OF THE SUBJECT IN THE CURRICULUM: Optional subject for the Master of Science degree course in „Computer systems and technologies“ in the Faculty of Electronics and Automation at the Technical University of Sofia, Plovdiv Branch.

AIMS OF THE SUBJECT: **The aim of the subject** is to introduce the students into the theory and practice of learning and self-learning in computer systems. At the end of their training the students are expected to be able to design systems, capable of learning and self-learning by choosing the most appropriate method in dependence on the task they have assigned to themselves. The students will be able to realize systems, learning from their experience and capable of deriving the only correct model of a notion or a situation (provided such a model exists) and able to predic whether an event is going to happen or not as well as to give instructions how the event could be avoided; the systems will be capable of finding out the most important charactersitics while considering an unfamiliar process or event, as well as of explaining the cause and result relationships that have lead to a particular event etc. Building systems of this kind will be economically beneficial for the society.

DESCRIPTION OF THE SUBJECT: Some of the main topics to be discussed are: learning by analyzing differences, learning by explaining experience, learning by correcting mistakes, learning by recording cases, learning by managing multiple models, learning by building identification trees, learning by training neural nets, learning by training perceptrons, learning by training approximation nets, deep learning, learning by simulating evolution, learning while recognizing objects, learning while creating descriptions of images, learning under the conditions of language restrictions. Special accent is placed on the peculiarities in the structure of the learning systems and typical examples of their use are discussed. Conditional probability, Bayes rule, Bayesian networks, Probabilistic Graphical Models, Markov models, Hidden Markov Models, Evaluation, Decoding, Learning, Reinforcement learning, Q-learning, Imitation learning.

PREREQUISITES: Programming and use of computers I, II, III, Component programming, Interface in a natural language.

METHODS OF TEACHING: Lectures, laboratory exercises on the main lecture topics, project on a chosen topic

METHODS OF EXAMINATION AND ASSESSMENT: The mark is formed mainly on the basis of the examination though students performance during the laboratory exercises is also taken into account, as well as their results from the written test. The examination comprises three questions on the lecture material.

LANGUAGE OF TEACHING: Bulgarian

RECOMMENDED LITERATURE:

1. Sutton S. Richard, Barto A. Andrew, Reinforcement Learning: An Introduction, Second Edition, (2017), The MIT Press, Cambridge, Massachusetts, London, England.
2. Russell S., Norvig P., Artificial Intelligence A Modern Approach, Prentice Hall, Third Edition, (2010), ISBN-13 978-0-13-604259-4, ISBN-10 0-13-604259-7
3. Teahan W. J., Artificial Intelligence – Agent Behaviour I, (2010) William John Teahan & Ventus Publishing ApS, ISBN 978-87-7681-559-2
4. Winston P.H. Artificial intelligence, Third edition, (1992), MIT Press, ISBN-13: 978-0201533774, ISBN-10: 0201533774,
5. Michael Nielsen, http://neuralnetworksanddeeplearning.com/chap6.html
6. Andrew Ng, http://www.andrewng.org/research/;
7. Machine Learning – Stanford University https://www.youtube.com/playlist?list=PLLssT5z_DsK-h9vYZkQkYNWcItqhlRJLN
8. Mugleton, S., Inductive Logic Programming, Academic Pressq 1992
9. Агре, Г., З. Марков, Д. Дочев, Увод в машинното самообучение, Софтех, София, 2001
10. Vosniadou S., A. Ortony (eds), Similarity and Analogical Reasoning, Cambridge University Press, 1988.

11. Helman, D. H., (ed.), Analogical Reasoning, Reidel, Dordrecht, 1988
12. Thayse, A. (ed.), From Natural Language Processing to Logic for Expert Systems, John Wiley and Sons, 1992
13. Cohen, P.R., E.A. Feagenbaum (eds.), The Handbook of Artificial Intelligence, Los Angeles, William Kaufmann, 1982.
14. Schaal, S (1999). Is imitation learning the route to humanoid robots? Trends in Cognitive Sciences 3:233-242. Computer Science and Neuroscience, HNB-103, University of Southern California, Los Angeles, CA 90089-2520 Kawato Dynamic Brain Project (ERATO/JST), 2-2 Hikaridai, Seika-cho, Soraku-gun, 619-02 Kyoto, Japan

University of Stanford Machine Learning	https://www.coursera.org/course/ml
University of Toronto Neural Networks for Machine learning	https://www.coursera.org/course/neuralnets
The paper Visualizing and Understanding Convolutional Networks by Matthew Zeiler and Rob Fergus (2013).	Visualizing and Understanding Convolutional Networks https://arxiv.org/abs/1311.2901 Cornell University Library.
Gabor filters	https://en.wikipedia.org/wiki/Gabor_filter
Deep learning - machine learning library Theano	http://deeplearning.net/software/theano/
James Bergstra, Olivier Breuleux, Frederic Bastien, Pascal Lamblin, Ravzan Pascanu, Guillaume Desjardins, Joseph Turian, David Warde-Farley, and Yoshua Bengio (2010).	Theano: A CPU and GPU Math Expression Compiler in Python, http://www.iro.umontreal.ca/~lisa/pointeurs/theano_scipy2010.pdf
GPUs have thousands of cores to process parallel workloads efficiently	http://www.nvidia.com/object/what-is-gpu-computing.html#sthash.7KDbJoy0.dpuf
Reinforcement Learning	http://incompleteideas.net/sutton/book/ebook/node7.html
Bayesian Networks witout Tears Eugene Charniak	
Daphne Koller Probabilistic Graphical Models	https://www.youtube.com/playlist?list=PLLssT5z_DsK-h9vYZkQkYNWcItqhlRJLN
Andrew Ng Baidu.avi	http://www.andrewng.org/research/
Webots:	http://www.cyberbotics.com/webots.php .
Maya J. Mataric, Chad Jenkins, Marcelo Kallmann, et.al. Robot learning from human demonstration, University of Southern California, Interaction Lab / Robotics Research Lab, Center for Robotics and Embedded Systems (CRES), USC Robotics Research Lab, DARPA, MARS PI Meeting 9/2003	http://slideplayer.com/slide/5080365/
software library **dmpbbo**:	https://github.com/stulp/dmpbbo .
The Pepper learn how to make “bilboquet”	https://www.youtube.com/watch?v=jkaRO8J_1XI

DESCRIPTION OF THE COURSE

Name of the course **Mathematical methods for digital signal processing**	Code:: **FaMpEE03;** **FaMpCST02;** **FaMpAICE202**	Semester: **4**
Type of teaching: Lectures and Laboratoty work	Semester hours: L – 20 hours, LW – 20 hour	Number of credits: **3**

LECTURER:

Assoc. Prof. PhD B. K. Pachedjieva (FEA) – tel.: 659 708; e-mail: pachedjieva@tu-plovdiv.bg

Technical University of Sofia, branch Plovdiv

COURSE STATUS IN THE CURRICULUM: Optional course for the students in Master's programs in "Electrical Engineering", "Computer Systems and Technologies" and "Automatics, Information and Control Engineering"

AIMS AND OBJECTIVES OF THE COURSE: The aim of the course is to provide theoretical knowledge and practical skills using mathematical methods for digital processing and in particular Probabilistic and statistic methods at solving most important theoretical and practical problems in electronics – in particular statistical treatment of experimental data.

DESCRIPTION OF THE COURSE: The main topics concern: Probabilities; Random variables; System from random variables; Deterministic connections between Random variables; Statistical treatment experimental date; Random Processes; Stationary Random Processes; Markov Random Processes; Elements of the theory telegraphic systems; Transforming random processes in electronics units.

PREREQUISITES:. Good fundamental knowledge in the courses: Higher mathematics, Theoretical electrical engineering, Signals and systems.

TEACHING METHODS: Lectures, and laboratory work.

METHOD OF ASSESSMENT: Two two-hour assessments at mid and end of semester.

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:
1. Vencel E. S., L. A. Ovcharov. The theory of probability and its engineering applications. Moscow, Science press, 1988. 2. Gmurman V. E. The theory of probabilities and mathematical statistics. Moscow, Higher school press, 2002.
3. Gmurman V. E. Manual to the decision of tasks on the theory of probabilities and mathematical statistics Moscow, Higher school press, 2003. 4. Srinath M. D. Introduction to statistical signal processing with applications. Prentice-Hall, New Jersey, 1996. 5. Alberto Leon-Garcia. Probability and Random Processing for Electrical Engineering, Addison–Wesley, 1994. 6. Ferdinandov E. S., B. K. Pachedjieva. Probabilistic and statistic methods in communications. Sofia, Siela, 2005.

DESCRIPTION OF THE COURSE

Name of the course **Time series forecasting**	Code: FaMpEE01	Semester: 1
Type of teaching: Lectures, Laboratory work	Lessons: L– 20 hours; LW– 20 hours	Number of credits: **3**

LECTURERS: eng. Alexander Angelov, e-mail: aangelov82@abv.bg;
ESO EAD, RDS-South, Plovdiv

COURSE STATUS IN THE CURRICULUM: Facultative course for the students specialty “Electrical Engineering”, “Automatics, Information and Control Engineering” and ”Computer systems and technologies” at the Faculty of Electronics and Automation in TU-Sofia, Plovdiv Branch, Master's degree.

AIMS AND OBJECTIVES OF THE COURSE: After the successful completion of the course students must know the basic methods for forecasting time series and be able to apply them in data analysis.

DESCRIPTION OF THE COURSE: In the learning process, students are introduced to different methods for predicting time series - conventional (regression and autocorrelation methods, smoothing methods, etc.) and modern, based on artificial intelligence (neural networks, etc.). Algorithms for analysis of the initial data, selection of a suitable mathematical model and methods for determining the parameters of the model are considered. The course deals with applied examples and tasks, focused mainly on engineering applications for modelling and making forecasts based on the compiled models. Algorithms for quantitative assessment of the accuracy of the applied models are studied.

PREREQUISITES: Knowledge of the basics of mathematics is required.

TEACHING METHODS: Multimedia presentations are used in the lectures. Students have pre-accessed the presentations and can supplement them with explanations from the teacher. Laboratory exercises include specific tasks using computers and data processing software..

METHOD OF ASSESSMENT: Two examines during the semester (80%), Laboratory work (20%).

INSTRUCTION LANGUAGE: Bulgarian

BIBLIOGRAPHY:

1.Вучков, И., С. Стоянов. Математическо моделиране и оптимизация на технологични обекти. Техника, София, 1980, 1986

2. Цочев, В., Д. Дамгалиев, Н. Козарев, Н. Манолов. Ръководство по методи за експериментални изследвания и оптимизация. МАРТИЛЕН, София, 1994.

3. Вучков, И., С. Стоянов, Н.Козарев, В.Цочев. Ръководство за лабораторни упражнения по статистически методи.Издателство “Нови знания”, София, 2002

4. R.H. Shumway, D. S. Stoffer. Time Series Analysis and Its Applications, Springer Texts in Statistics, 3rd ed.