Universitatea Națională de Știință și Tehnologie Politehnica București
Facultatea de Electronică, Telecomunicații și
Tehnologia Informației

COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Medical Electronics and Informatics

2. Date despre disciplină

2.1 Course name (ro) (en)				Metode avansate de prelucrare a semnalelor biomedicale Advanced Signal Processing Methods			
2.2 Course Lecturer				Prof. Dr. Georgeta-Mihaela NEAGU			
2.3 Instructor for practical activities				Prof. Dr. Georgeta-Mihaela NEAGU			
2.4 Year of studies	1	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M2.O.02-10		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	4	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	28
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					63
Tutoring					0
Examinations					6
Other activities (if any):					0

3.7 Total hours of individual study	69.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	To acquire the knowledge on advanced signal processing it is mandatory to attend/pass the following courses: · Digital Signal Processing · Signals, circuits, systems. Calculus and Algebra
4.2 Results of learning	Acquire the knowledge specific to the following courses: · mathematics · algorithms · object oriented programming · digital signal processing · estimation and decision programming (Matlab)

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	· The lectures will be presented using the videoprojector.
5.2 Seminary/ Laboratory/Project	· The lab will be run using the videoprojector and the computers having Matlab installed on. The labs are mandatory, as stipulated by the „Regulamentul studiilor universitare de licenţă” (Romanian version only) and „Regulamentul privind activitatea profesională a studenţilor” (Romanian version only).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

The course provides the advanced knowledge regarding the advanced (bio)signal processing: spectral analysis, adaptive filtering, time-frequency analysis, chaos theory, PCA, ICA, multivariate analysis. The students will learn how to handle any uni-/multi- dimensional signal processing problem, and will get the ability to extend their knowledge in signal processing and to solve any (bio)signal processing problem. The applications will impact the student ability to apply the advanced signal processing methods: spectral analysis, adaptive filtering, time-frequency analysis, chaos theory, PCA, ICA, multivariate analysis.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	• Demonstrate the ability to operate with basics of fundamental sciences, engineering and medical sciences, general and specialized knowledge, to solve problems specific to the advanced signal processing domain. • Have the ability to develop the HW/SW to support the advanced signal processing considered for the equipments used in medice for diagnose, therapy, reabilitation and inteligent prostheses. • Develp, implement, monitore and support the medical devices, equipments and technical systems that include BMIs. • Provide technical support and specialized assistance for/within the organisations concerning the reglementations, monitoring, use and control of the medical equipments and systems based on advanced signal processing. • Coordinate and implement (research) projects for medical equipments/technologies based on advanced signal processing. • Apply IT solution specific for advanced signal processing medical applications: data mining, advanced biosignal and medical image processing/analysis, medical data protection. • Coherently and corectly argue and analize the basic knowledge, based on the key concepts of the course and using the specific methodology. • Communicate, verbally and in written, in Romanian, using the vocabulary specific to the course domain. • Communicate, verbally and in written, in a foreign language (English), using the vocabulary specific to the course domain.
Transversal (General) Competences	• Identify the lifelong learning needs and efficiently use the informations sources and the communication and aided professional development resources (Internet, specialized SW, online courses, etc), both in Romanian and in a foreign language (English). • Address and responsably tack tasks in multisciplinary teams, assuming different positions/attributions. • Work within teams and efficients communicate with the colleagues to solve problems of a medium complexity. • Critical and independent evaluation: the students have the scientific ability to look for the necessary information and to present valuable conclusions/solutions. • Have the ability to analyse and synthesize: the students have the ability to present efficiently the acquired knowledge, applying the systematisation. • Respect the academic ethics: proper citation. • Apply emotional intelligence principles to emotionally and socially solve some situations regarding the real life/academic/professional tasks, showing self control and objectivity when deciding and under stress.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* **List** the most important information regarding the domain development. **Defines** domain specific concepts. **Describes/classify** domain specific concepts/processes/fenomena/structures. **Reveals domain specific consequences and relations.**
Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* **Select** and **group** relevant information. **Apply logically argued the domain specific principles.** **Efficently work within teams.** **Generate scientific documents.** **Experimentally verify the identified solutions.** **Solve** practical applications. **Correctly identify the causal relations**. **Analise and compare available domain solutions.** **Identify solutions** and **propose** solving plans/projects. **Formulate conclusions regarding the realzed experiments.** **Give arguments** when identifying solving solutions/steps.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* **Select** and analyze the appropriate literature. **Respect the academic ethics,** correctly citing the used literature. **Are open** to learn new concepts. **Collaborate** with the colleagues and the academic staff during the didactical activities. **Show authonomy** when organizing some applications, learning activities or when solving specific problems **Show social responsability** by geting involved in the academic social life. **Promote and contribute to the domain, offering new solutions,** to improve the quality of the social life. **Realistically identify the contribution of the engineering domain** to the social and economic life by offering reliable and sustenable solutions. **Apply professional ethics/deonthologyn when evaluating the technological impact of the domain specific proposed solutions,** considering the environmental impact. **Analize and take business opportunities** specific to the domain. **Demonstrate management skills** in real life situations (time administration, conflict elimination).

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

The teaching will include both knowledge presentation and interactive discussions, considering the learning preferences of the students and their learning needs; the direct and inderect exploration will be considered (experiments, demonstrations, modelling), and also active learning will be involved (exercises, problems solving, practical activities).

Power point presentations and specialized videos will be considered. Each course will summarize the information from the previous lectures, stressing especiallly the knowledge from the last course.

The lectures will contain images, plot and diagrams that facilitate information acquiring.

The course provides knowledge and practical activities that support students development by establishing optimal communication and collaboration steps and by discovery.

The active information listening and assertive communication skills will be considered, and the feedback will be implemented to include the needs of the students.

Team working activities will be also implemented.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Practical considerations regarding the sampling of continuous signals	2
2	Describing discrete systems with signal graphs and state variables	2
3	Multirate systems 3.1. Introduction 3.2. Decimation and interpolation 3.3. Filter design and analysis 3.4. Mirror filters 3.5. FIR interpolation	3
4	Time-frequency analysis 4.1. Short Time Fourier Transform 4.2. Wavelet Transform; noise cancelling using the Wavelet transform 4.3. Wigner-Ville Transform 4.4. Time-frequency analysis in biosignal processing	5
5	Wiener filtering 5.1. Orthogonality principles 5.2. IIR and FIR Wiener Filters 5.3. Linear prediction. Levinson-Durbin algorithm 5.4. Wiener filtering applications– noise cancelling from biosignals	4
6	Adaptive filtering 6.1. Gradient descent algorithm 6.2. LMS algorithm 6.3. Adaptive filtering applications– noise cancelling from biosignals	3

7	Statistical signal processing: spectrum estimation and modeling 7.1. Introduction 7.2. Estimators 7.3. Estimation of the autocorrelation 7.4. Nonparametric spectrum estimation 7.5. Parametric spectrum estimation	3
8	Multivariate analysis 8.1. Linear models applied in multivariate analysis (multidimensional autoregressive model; algorithms that estimates the AR coefficients) 8.2. Nonlinear multivariate models 8.3. Direct connectivity estimation in time, by applying the MVAR analysis 8.4. Direct connectivity estimation in frequency domain, by applying the MVAR analysis 8.5. Multivariate analysis applied in biosignal processing	6
	Total:	28

Bibliography:

1. Neagu Georgeta-Mihaela, Metode avansate de prelucrare a semnalelor, Note de curs si prezentari Power Point, disponibile în Moodle.
2. Ungureanu Georgeta Mihaela (2013): Analiza şi prelucrarea semnalelor: aplicaţii în ingineria biomedicală (Digital Signal Processing and Analysis: biomedical engineering applications), MATRIX ROM, ISBN 978-973-755-946-3 (253 pages) (recognized by CNCSIS).
3. Najmi, Amir-Homayoon, and Todd K. Moon. 2020. Advanced Signal Processing: A Concise Guide. 1st ed. New York: McGraw Hill. https://www.accessengineeringlibrary.com/content/book/9781260458930.
4. G. M. Ungureanu, Prelucrarea digitală a semnalelor, MATRIX ROM, 2008.
5. V. P. Tuzlukov, Signal processing noise, CRC Press, 2002.
6. S. Stergiopoulos, Advanced signal processing, CRC Press LLC, 2001.

LABORATORY

Crt. no.	Content	No. hours
1	Using the GUIDE tool of Matlab	2
2	Discrete signals and systems. Z transform, Inverse Z transform, DFT	2
3	FIR and IIR design	4
4	Multirate systems. Decimation. Interpolation.	2
5	Statistical signal processing. Spectrum estimation.	2
6	Multivariate analysis	2
	Total:	14

PROJECT

Crt. no.	Content	No. hours
1	Implementation of an advanced signal processingapplication (Brain Machine Interface) in teams of 2 students	14

	Total:	14

Bibliography:

1. Neagu Georgeta-Mihaela, Metode avansate de prelucrare a semnalelor, Note de curs si prezentari Power Point, disponibile în Moodle.
2. Ungureanu Georgeta Mihaela (2013): Analiza şi prelucrarea semnalelor: aplicaţii în ingineria biomedicală (Digital Signal Processing and Analysis: biomedical engineering applications), MATRIX ROM, ISBN 978-973-755-946-3 (253 pages) (recognized by CNCSIS).
3. Najmi, Amir-Homayoon, and Todd K. Moon. 2020. Advanced Signal Processing: A Concise Guide. 1st ed. New York: McGraw Hill. https://www.accessengineeringlibrary.com/content/book/9781260458930.
4. G. M. Ungureanu, Prelucrarea digitală a semnalelor, MATRIX ROM, 2008.
5. V. P. Tuzlukov, Signal processing noise, CRC Press, 2002.
6. S. Stergiopoulos, Advanced signal processing, CRC Press LLC, 2001.

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Proving the undestanding of the fundamental knowledge. Differential analysis of the theoretical methods/techniques.	written	25%
	Proving the ability to apply the theory when solving specific problems.	written	25%
11.5 Seminary/laboratory/project	Showing the ability to address an advanced signal processing problem	written/project	25%
	Having the ability to evaluate the results	written/project	25%
11.6 Passing conditions			
Graduation rules valid for the students enrolled at ETTI/UPB. Obtaining 50% of the evaluation mark.			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

The involved activities will allow the students to gain skills in solving problems and improving the available solutions in the advanced signal processing domain.

The course considers the current knowledge/ aspects/ phnomena addressed by the domain literature and personal research/presentations.

The proposed activities that covers the advanced signal processing domain impact the students skills to deal with every day situations, improving the socio-economic environment.

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	Prof. Dr. Georgeta-Mihaela NEAGU	Prof. Dr. Georgeta-Mihaela NEAGU

Date of department approval	Head of department Conf. Dr. Bogdan Cristian FLOREA
Date of approval in the Faculty Council	Dean Prof. Dr. Mihnea Udrea