SYLLABUS

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Electronics, Telecommunications and information Technology
1.3 Department	Communications
1.4 Field of study	Electronic Engineering, Telecommunications and Information Technologies
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Telecommunications Technologies and Systems/ Engineer Applied Electronics/Engineer
1.7 Form of education	Full time
1.8 Subject code	TST-E50.20/EA-E51

2. Data about the subject

2.1 Subject name	Digital Image Processing						
2.2 Subject area	Theoretical area Methodological area Analytic area						
2.3 Course responsible	Assoc.Prof. Mihaela GORDAN, Ph.D – Mihaela.Gordan@com.utcluj.ro						
2.4 Teacher in charge with seminar / laboratory / project	Assist.Prof. Camelia FLOREA, Ph.D – Camelia.Florea@com.utcluj.ro						
2.5 Year of study	IV	2.6 Semester	7	2.7 Assessment	V	2.8 Subject category	DS/DO

3. Estimated total time

3.1 Number of hours per week	4	of which: 3.2 course	2	3.3 project / laboratory	2
3.4 To Total hours in the curriculum	56	of which: 3.5 course	28	3.6 project / laboratory	28

Distribution of time	hours
Manual, lecture material and notes, bibliography	10
Supplementary study in the library, online specialized platforms and in the field	10
Preparation for seminars / laboratories, homework, reports, portfolios and essays	14
Tutoring	5
Exams and tests	5
Other activities:	0

3.7 Total hours of individual study	44
3.8 Total hours per semester	100
3.9 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 curriculum	Linear Algebra; Signals and Systems; Computer Programming
4.2 competence	Basic programming skills; basic use of image image manipulation programs

5. Requirements (where appropriate)

5.1. for the course	
5.2. for the seminars / laboratories / projects	

6. Specific competences

Professional competences	**C4. Design, implementation and operation of data, voice, video and multimedia services. This is based on the understanding and the application of fundamental concepts in telecommunications and transmission of information** C4.2 Solving practical problems using general knowledge about the multimedia techniques – in particular: select, develop and implement software algorithms for: ▪ image down-sampling/up-sampling, brightness quantization as required for the transmission and storage of digital images in a communication system; ▪ image enhancement, e.g. contrast enhancement, image de-blurring, noise removal, to overcome the practical problems occurring during the acquisition and transmission of digital images in a communication system; ▪ image analysis, coding and compression for different applications – e.g. environment surveillance, security, medical imaging, virtual reality C4.3 Explanation and interpretation of the main requirements and specific approaches to data, voice, video and multimedia transmissions – for the particular case of digital images and video, with emphasize on: ▪ image/video coding and compression (explanation of the concept of redundancy; transform-based image/video coding and compression; image/video quantization); image/video semantic content description through image analysis **C5. Selecting, installing, configuring and operating fixed or mobile telecommunications equipment. Equipping a site with usual telecommunications networks** C5.2 Explain and interpret the technologies and basic protocols for the integrated fix and mobile telecommunications systems – with an emphasize on the video acquisition, transmission, storage and enhancement/basic processing components
Transversal competences	N/A

7. Discipline objectives (as results from the key competences gained)

7.1 General objective	Developing professional competences regarding the acquisition, processing, analysis, compression and transmission of digital images, from the point of view of understanding the theoretical fundamentals and of their integration in practical applications
7.2 Specific objectives	1. Understanding the basic concepts regarding the acquisition, processing (specific for communications systems: image enhancement, noise suppression, image restoration), compression and analysis of digital images (for machine vision applications) 2. Developing skills and abilities to design and implement image processing algorithms, image compression algorithms and image analysis/object recognition algorithms 3. Developing skills and abilities to integrate basic image processing,

	analysis and compression algorithms in practical applications specific to multimedia communications systems 4. Developing skills and abilities needed to implement and verify the performance of digital imaging systems

8. Contents

8.1 Lecture (syllabus)	Teaching methods	Notes
1. Course description. General notions regarding the processing, analysis and coding/compression of digital images. Mathematical representation of grey scale and color digital images.	Presentation; explanation; demonstration; debates; conversation; learning through discovery	
2. Image acquisition. Image sampling/down-sampling: the sampling theorem in the 2-D space, the Nyquist rates, the alias effect. Image reconstruction from its samples / image up-sampling.		
3. Brightness/color quantization: general process; uniform quantization; optimal (MMSE) quantization; visual quantization.		
4. Transform-based digital image representation. Unitary separable two-dimensional image transforms. Properties and applications. Applications of transform-based image representation: compression and coding; image denoising; image analysis/object recognition.		
5. Two-dimensional unitary sinusoidal image transforms (DFT, DCT); two-dimensional unitary rectangular image transforms (Walsh, Haar).		
6. Applications of transform-based image representation: compression and coding; performance of transform based image compression. Image denoising in the transform domain.		
7. Histogram statistics of digital images. Grey scale transformations for image enhancement; contrast enhancement algorithms.		
8. Spatial image filtering for image enhancement: low-pass spatial filtering and image denoising; unsharp masking; high-pass and band-pass spatial filtering. Applications of image enhancement in communication systems and medical imaging systems.		
9. Digital image analysis: structure of an image analysis system; key components of an image analysis system. Image features classification; categories of hand crafted features; feature extraction; feature selection.		
10. Edge based image features; edge detection. Edge linking; boundary extraction. Texture representation; texture descriptors.		
11. Digital image segmentation. Region-based and contour-based image segmentation methods. Image segmentation in the feature space; spatially constrained image segmentation.		

Morphological image filtering/analysis.		
12. Object descriptors: contour descriptors; shape descriptors; geometrical descriptors; statistical moment features for object recognition.		
13. Basic concepts regarding image and video coding and compression. Losless vs. lossy video compression. Video coding principles.		
14. Topics review and synthesis. Preparation for the final verification.		

Bibliography

1. A. Vlaicu, Prelucrarea numerică a imaginilor, Editura Albastră, Cluj-Napoca, 1997, 393 pagini, ISBN 973-9215-41-6
2. M. Gordan, Sisteme de analiză a imaginilor digitale folosind clasificatoare maşini cu vectori suport, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2006, ISBN 973-686-867-2
3. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing (3rd Edition), Prentice Hall, 2008
4. M. Sonka, V. Hlavac, R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson Learning, 2007

On-line:

Powerpoint slides – lectures presentations:

5. http://ctmtc.utcluj.ro:8080/sites/pni/pni/Course/Forms/AllItems.aspx

Sample exercises and solutions:

6. http://ctmtc.utcluj.ro:8080/sites/pni/pni/Exercises/Forms/AllItems.aspx

8.2 Laboratory	Teaching methods	Notes
1. Introduction to IMAQ Vision. Structure of the image processing applications in LabView	Guide students to implement software applications in LabView, verify through experiments the applications, ellaborate laboratory reports and discuss the results	
2. The discrete Fourier transform; image filtering in the transform domain		
3. Image enhancement through grey scale transformations		
4. Spatial filtering for image enhancement: noise removal (low pass spatial filtering)		
5. Edge detection		
6. Binary image morphology		
7. Final lab assessment; make-up missed lab sessions.		

8.2 Project	Teaching methods	Notes
1. Presentation of the projects topics. Presentation of the implementation requirements general to all projects and particular to each topic. Work plan specification. Discussion about the presentation of the results	Group debate; exercise; presentation-debate; algorithmic; case study; project; experiment; problematization method	
2. The study phase. Presentation of theoretical reports describing the algorithms selected for implementation. Discussions and questions.		
3. The design phase. Presentation of the block diagram of the application. Discussions, questions, suggestions		
4. The implementation of the components of the application. Verification on test data. Presentation of the preliminary results. Discussion of the encountered difficulties and finding ways to solve them		
5. Final application implementation phase – linking the		

components into the end-user application. Functional verification of the application on test data. Discussion of the encountered difficulties and finding ways to solve them		
6. Generation of the set of test images and videos. Experiments to obtain the results. Evaluation of the application performance and comparison to the target results/state of the art. Editing the written documentation of the project.		
7. Theoretical and practical presentation of the project. Evaluation/grading of the project.		

Bibliography

1. http://ctmtc.utcluj.ro:8080/sites/pni/pni/Laboratory/Forms/AllItems.aspx
2. M. Gordan, Sisteme de analiză a imaginilor digitale folosind clasificatoare maşini cu vectori suport, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2006, ISBN 973-686-867-2
3. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing (3rd Edition), Prentice Hall, 2008
4. M. Sonka, V. Hlavac, R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson Learning, 2007
5. http://ctmtc.utcluj.ro:8080/sites/pni/pni/Materiale/Forms/AllItems.aspx

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The discipline content and the acquired skills are in agreement with the expectations of the professional organizations and the employers in the field, where the students carry out the internship stages and/or occupy a job (in the field of computer vision, digital imaging, multimedia systems engineering, multimedia communications, computer graphics), and the expectations of the national organization for quality assurance (ARACIS).

10. Evaluation

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	The level of acquired theoretical knowledge and practical skills	Written test (theoretical questions and numerical exercises)	60%
10.5 Laboratory	The level of acquired knowledge and abilities	Laboratory reports	15%
10.6 Project	The level of acquired knowledge and practical skills	Project evaluation (theoretical presentation, software implementation, results)	25%
10.6 Minimum standard of performance			

Qualitative level:

Minimal knowledge:

- ✓ Know the basic concepts specific to the acquisition, representation and processing of a digital image.
- ✓ Understand the role and applications of most common image enhancement algorithms.
- ✓ Know the difference between grey scale transformations, spatial operations and transform domain operations
- ✓ Understand the application of image transforms to image data compression
- ✓ Know the basic concepts involved in image analysis systems

- ✓ Know the most frequent feature extractors in computer vision systems

Minimal competences:

- ✓ To be able to define (conceptually) the notions mentioned above.
- ✓ To be able to solve numerical exercises applying the algorithms listed above
- ✓ To be able to recognize the image processing algorithm applied, based on the input image and the output result.

Quantitative level:

- ✓ Do all the laboratory works
- ✓ Finish the project
- ✓ The grade for the written test should be at least 4.5.
- ✓ The grade for the laboratory reports should be at least 5.

Date of filling in:	**Responsible**	**Title Surname NAME**	**Signature**
13.09.2022	Course	Assoc. Prof. Mihaela GORDAN, Ph.D	
	Applications	Assist. Prof. Camelia FLOREA, Ph.D	

Date of approval in the Council of the Communications Department 13.09.2022	Head of Communications Department Prof. Virgil DOBROTA, Ph.D.
Date of approval in the Council of the Faculty of Electronics, Telecommunications and Information Technology 21.09.2022	Dean Prof. Ovidiu POP, Ph.D.