SYLLABUS

1. Data about the program of study

1.1	Institution	Technical University of Cluj-Napoca
1.2	Faculty	Electronics, Telecommunications and Information Technology
1.3	Department	Communications
1.4	Field of study	Electronics and Telecommunications Engineering
1.5	Cycle of study	Master of Science
1.6	Program of study/Qualification	Multimedia Technologies/ Telecommunications/ Master
1.7	Form of education	Full time
1.8	Subject code	TM-E09.00/ TC-E11.30

2. Data about the subject

2.1	Subject name					Machine Learning for Image Analysis					
2.2	Subject area					Electronics and Telecommunications Engineering					
2.3	Course responsible/lecturer					Associate Professor Mihaela GORDAN, PhD					
2.4	Teachers in charge of applications					Assistant Professor Camelia FLOREA, PhD					
2.5	Year of study	I	2.6	Semester	2	2.7	Assessment	E	2.8	Subject category	DA/DO

3. Estimated total time

Year/ Sem.	Subject name	No. of weeks	Course [hours/ week]	Applications [hours/ week]			Course [hours/ semester]	Applications [hours/ semester]			Indiv. study	TOTAL	Credits
				S	L	P		S	L	P			
I/2	Methods and Systems for Image Analysis and Interpretation	14	2	0	1	0	28	0	14	0	58	100	4

3.1	Number of hours per week	3	3.2	of which, course	2	3.3	applications	1
3.4	Total hours in the curriculum	42	3.5	of which, course	28	3.6	applications	14

Individual study	Hours
Manual, lecture material and notes, bibliography	10
Supplementary study in the library, online and in the field	15
Preparation for laboratory works, homework, reports, portfolios, essays	25
Tutoring	4
Exams and tests	2
Other activities	2

3.7	Total hours of individual study	58
3.8	Total hours per semester	100
3.9	Number of credit points	5

4. Pre-requisites (where appropriate)

4.1	Curriculum	Digital image processing; Information theory; Linear algebra
4.2	Competence	NO

5. Requirements (where appropriate)

5.1	For the course	NO
5.2	For the applications	Technical University of Cluj-Napoca

6. Specific competences

Professional competences	1. Demonstrate mastery knowledge and innovation/generalization abilities in the topics related to: - human visual system features correlated to the image analysis systems; - color image representation, enhancement and segmentation; - image analysis/object recognition through the means of supervised classification; - general image analysis and interpretation frameworks and their customization for practical applications; - supervised classification for pattern recognition in general; selection and combination of classifiers for object recognition/image analysis 2. Manage complex technical activities and projects, taking responsibility for decision-making in unpredictable work or study contexts, in application fields implying the use of color image analysis and interpretation, object recognition, supervised learning methods/supervised classification. 3. Demonstrate the cognitive and practical skills required to develop creative solutions to problems that involve image analysis and/or interpretation, image classification, object recognition – virtually in any application that can benefit from a computer vision component 4. Demonstrate specialized problem-solving skills required in research and innovation in order to develop new procedures and to integrate interdisciplinary knowledge into color image processing, analysis and interpretation systems adapted to new practical applications, to build data analysis and interpretation systems and to design and implement practical systems according to new user requirements (from fields other than engineering). 5. Manage and transform work or study contexts that are complex, unpredictable and require new strategic approaches, by applying and generalizing the knowledge and practice from the particular field of image analysis systems.
Cross competences	1. Exercise management and supervision in contexts of work or study activities where there is unpredictable change; review and develop performance of self and others; take responsibility for managing professional development of individuals and groups 2. Adaptation to new technologies, professional and personal development, by continuous education using printed documentation, specialized software and electronic documentation resources in both Romanian and English language 3. Take responsibility for contributing to professional knowledge and practice by research/innovation and publications

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

7.1	General objectives	Developing master level professional competences in the topics of color image representation, enhancement and segmentation, image analysis/object recognition through the means of supervised classification, general image analysis and interpretation frameworks and their customization for practical applications, selection and combination of various feature extraction methods and classifiers for object recognition/image analysis
7.2	Specific objectives	1. Acquire mastery knowledge and develop generalization abilities related to the mathematical modeling and implementation of the

		visual human perception mechanisms into practical image analysis and interpretation systems 2. Acquire mastery knowledge and develop innovation abilities in respect to color image representation, use of color spaces, color image enhancement and segmentation methods and to their employment into practical image analysis systems 3. Developing mastery skills and abilities to generalize the theoretical concepts behind supervised classification and to apply them for the particular case of digital image analysis, in particular application fields

8. Contents

8.1. Lecture (syllabus)		Teaching methods	Notes
1	Introduction to image analysis systems. Basis concepts, preliminary notions, practical applications.	Presentation; explanation; demonstration; debates; conversation; learning through discovery	Video-projector; interactive teaching style: alternation of multimedia teaching tools with the classical teaching tools (whiteboard); use of applets during teaching, to illustrate the operation of the methods/algorithms discussed
2	Human vision models and machine vision. Psychophysics of the human vision. Representation of the digital images. Color spaces: properties; perceptual color spaces; linear and non-linear transformations of the RGB color space.		
3	Color image preprocessing: color image enhancement; color image de-noising; processing in the RGB color space; processing in other color spaces.		
4	General structure of an image analysis and interpretation system. Main concepts; functional blocks. Region of interest definition. Feature extraction; common types of features in digital image analysis systems		
5	Feature selection: feature selection algorithms; feature quality/feature relevance assessment methodologies.		
6	Color image segmentation – basic algorithms. Unsupervised data clustering algorithms and their application for image segmentation in the feature space: k-means, fuzzy c-means		
7	Classifier-based object recognition. Basic concepts of data classification. General framework of digital image analysis based on classifiers.		
8	Similarity-based classifiers: k-NN and fuzzy K-NN.		
9	Probabilistic classifiers. Bayes rule. The Bayesian classifier.		
10	Optimization based classifiers. The binary (two-class) LDA classifier. Fisher optimization criterion in LDA classifier. Specific applications to image analysis.		
11	Multi-class LDA. Aplications to feature space dimensionality reduction for image analysis problems.		
12	Binary support vector machine (SVM) classifiers: principle; linear SVMs; the optimal separating hyperplane principle. Non-linear SVMs. Soft margin SVM classifiers. Probabilistic SVM classifiers. Multi-class SVM classifiers. Applications in digital image analysis and interpretation – practical cases/case studies.		
13	Artificial neural networks (ANN). Basic ANN architectures for object recognition from digital images.		
14	Convolutional neural networks (CNN) – solutions for image analysis without explicit feature extraction.		
8.2. Applications (lab)		Teaching methods	Notes
1	Presentation of the lab policy, lab sessions and lab assessment criteria. Color spaces and color image enhancement strategies in different color spaces. Color-based image segmentation – color histogram based methods.	Group debates; experiments; learning through discovery; case study; exercises; learning through	Use of computers, LabView software and the IMAQ Vision
2	Color image segmentation as pixel clustering in the feature space using k-means and fuzzy c-means. Bayesian classifier for color based image segmentation.		
3	Shape-based object recognition with statistical moments features and		

	k-NN classifiers.		
4	Single-object image classification and labeling using the binary LDA classifier.		
5	Single-object image classification and labeling using binary SVM classifiers (linear and non-linear).		
6	Multi-object image analysis using convolutional neural networks (CNN)		
7	Final lab assessment; make-up missed lab sessions.		

Bibliography

1. M.Gordan, Sisteme de analiză a imaginilor digitale folosind clasificatoare maşini cu vectori suport, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2006
2. A. Vlaicu, Prelucrarea numerică a imaginilor, Editura Albastră, Cluj-Napoca, 1997
3. Milan Sonka, V. Hlavac, R. Boyle, Image Processing, Analysis, and Machine Vision (3rd Edition), Thomson Learning, Apr 2007
4. R.C. Gonzalez, R.E. Woods, Digital Image Processing (3rd Edition), Prentice Hall, 2008
5. S.E.Umbaugh, Computer Imaging:Digital Image Analysis & Processing, CRC Press, 2005
6. R. O. Duda, P. E. Hart, D. G. Stork, Pattern Classification, 2nd ed., John Wiley&Sons, 2001
1. Venkatesan R, Li B. *Convolutional Neural Networks in Visual Computing: A Concise Guide*. CRC Press; 2017 Oct 23

On-line teaching materials:

1. M. Gordan – lecture slides, http://ctmtc.utcluj.ro:8080/sites/pni/msva/Curs/Forms/AllItems.aspx
2. M. Gordan, sample exercises, http://ctmtc.utcluj.ro:8080/sites/pni/msva/Materiale/Forms/AllItems.aspx

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

Competences acquired will be used in the following COR occupations (Electronics Engineer; Telecommunications Engineer; Electronics Design Engineer; System and Computer Design Engineer; Communications Design Engineer; Security Systems Engineer) or in the new occupations proposed to be included in COR (Multimedia Applications Developer; Project Manager; Image and Sound Processing Engineer; Communications Systems Consultant).

10. Evaluations

Activity type	10.1	Assessment criteria	10.2	Assessment methods	10.3	Weight in the final grade
Course		One written test in the exam session: three theoretical questions (short essays) and three exercises (design of a sub-system, or verification of a sub-system on test data, manually, by numerical computations)		Written verification		E, max 10 pts. 75%
Laboratory		The level of acquired abilities based on reports provided at the end of each lab session/one mini-project per class.		Average of the graded individual laboratory reports/grade for the mini-project		L, max. 10 pts. 25%
10.4 Minimum standard of performance						
L ≥ 5 and 0.8E+0.2L≥ 4.5. The final grade is computed as: 0.75E+0.25L, rounded to the nearest integer.						

Date of filling in
11.02.2020

Course responsible
Associate Professor
Mihaela GORDAN, PhD

Teachers in charge of applications
Assistant Professor
Camelia FLOREA, PhD

Date of approval
in the department
1.10.2020

Head of Communications
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