SYLLABUS

Discipline name	Digital Image Processing
Profile	Electronics and Telecommunications Engineering
Specialization	Telecommunications Technologies and Systems
Code	51325009-2
Course leader	Professor Aurel Vlaicu, Ph.D – Aurel.Vlaicu@com.utcluj.ro
Collaborators	Assoc. Prof. Mihaela Gordan, Ph.D. – Mihaela.Gordan@com.utcluj.ro Assistant Camelia Florea – Camelia.Florea@com.utcluj.ro Adrian Chioreanu, Ph.D. – Adrian.Chioreanu@com.utcluj.ro
Department	Communications
Faculty	Electronics, Telecommunications and Information Technology

Sem.	Type of discipline	Course	Applications			Course	Applications			Ind. study	TOTAL	Credits	Form of assessment
		[hours/week]				[hours/semester]							
			S	L	P		S	L	P				
7	**Speciality, Optional**	**2**	**-**	**2**	**-**	**28**	**-**	**28**	**-**	**64**	**120**	**4**	**Exam**

Acquired competences :

Acquired skills (what the student is able to do):

- understand and master the main methods for image digitization and digital image representation;
- understand, be able to apply and to select the two-dimensional unitary transformations on digital images, depending on the practical application intended (compression, filtering, enhancement, analysis)
- understand, select and apply the most common mathematical algorithms used in digital image enhancement (grey scale transformations and spatial operations)
- understand the principle and be able to apply the most common algorithms used in digital image analysis and understanding: edge detection and contour extraction; region and contour descriptors; image segmentation;
- be able to apply and select the suitable algorithms for morphological processing and binary objects recognition
- understand the basic principles of digital image compression; evaluate the compression performance
- be able to apply basic still image coding techniques: pixel coding; predictive coding; transform-based coding
- understand the principles of inter-frame video coding and apply motion estimation and motion compensation
- be able to apply and implement the basic algorithms implied in current image and video coding standards

Acquired abilities (what type of equipment/ instruments/ software the student is able to handle):

- use the LabView application development environment and the NI library IMAQ Vision to implement a fully functional application (medium complexity) for image enhancement, basic image processing or basic image analysis, from image acquisition to image rendering and image file compression/coding
- develop an image enhancement application in LabView, using the IMAQ Vision library components, with an interactive, user-friendly interface and various visualization options
- develop an image analysis application in LabView, using IMAQ Vision, with user-friendly interface
- develop LabView components and LabView virtual instruments to implement various modules devoted to transform-based image processing, filtering and compression
- develop LabView components and LabView virtual instruments to implement various modules for still image compression and video sequences compression, especially based on image transforms and motion estimation

Prerequisites (if necessary):

Knowledge of discrete mathematics, matrix and vector mathematics, probability theory; basic notions about the one-dimensional signals, their representation and processing; digital signal processing basics

A. Course/Lecture (course/lecture titles)	
1	Basic concepts in digital image processing, analysis and compression. General structure of digital image processing systems. Mathematical representation of digital grey level images and digital color images
2	Image digitization. Image sampling: the sampling theorem in two-dimensional space; the Nyquist rate and the alias effect; image reconstruction from its samples; optimal image sampling
3	Image quantization. Uniform quantization; optimal quantization; visual quantization. Color quantization.
4	Digital image representation spaces. Two-dimensional unitary separable transforms of digital images: sinusoidal transforms (DFT, DCT); rectangular transforms (Walsh, Haar)
5	Eigenvectors based digital image transforms (Karhunen-Loeve; SVD). Applications of transformed domain image representation: image compression; noise filtering
6	Digital image content modeling by grey level histograms. Point operations for digital image enhancement: grey scale transforms; contrast stretching and contrast enhancement algorithms
7	Spatial operations for digital image enhancement: low-pass filtering for noise reduction; edge enhancement;

	contrast inverse transformation and statistical scaling; zooming
8	General structure of digital image analysis systems. Feature spaces for regions of interest description in digital images. Contour detection; edge detection algorithms and contour detection algorithms
9	Contour extraction and representation. Extraction and representation of homogeneous regions. Texture representation. Texture descriptors. Digital image segmentation algorithms
10	Shape descriptors. Geometric features; statistical moments; regenerative features; syntactical features. Morphological image processing and analysis. Medial axis transforms; objects skeletons; boundary thinning
11	Introduction to digital image compression. Lossless compression versus lossy compression. Measures of the compression efficiency. Pixels coding. Arithmetic coding. Predictive coding techniques
12	Transform compression of digital images. Bits allocation. Compression algorithm using 2-D DCT. Zonal and threshold coding. Adaptive transform based image coding. Color and multi-spectral image coding
13	Video coding. Interframe coding. Conditional replacement interframe coding. Adaptive predictive video coding. Predictive video coding with interframe motion compensation. Motion estimation algorithms
14	Compression standards for still images and video sequences. The JPEG standard. Baseline JPEG based on DCT. Basic video coding standards: H.261; H.263. The MPEG compression standards

B. Applications – **Laboratory** (list of laboratories), **Seminar** (contents), **Project** (project contents)	
1	Introduction to IMAQ Vision. Structure of digital image processing applications using IMAQ Vision
2	Digital image acquisition, rendering and storage in LabView with a video capture board
3	Image histogram: histogram based image processing algorithms; histogram equalization
4	Image enhancement algorithms: contrast enhancement; image thresholding; image inversion
5	Spatial image processing: filtering by spatial averaging; directional filtering; median filtering; zooming
6	The two-dimensional discrete Fourier transform and applications: image filtering in the frequency domain
7	Edge detection: gradient-based edge detection; Laplace operators for edge detection
8	Laboratory test 1
9	Morphological image analysis. Binary morphology operations
10	Quantitative image analysis; intensity calibration; digital particles; particles measurements; densitometry
11	The discrete cosine transform. Digital image compression algorithm based on the two-dimensional DCT
12	Inter-frame coding. Block motion estimation. Inter-frame motion compensation
13	The JPEG compression standard. Grey scale and color image processing in the compressed domain
14	Review of the laboratory work. Laboratory test 2

C. Individual study (reference study contents, synthesis materials, projects, applications etc.)

Basic mathematical fundamentals of digital images; Two-dimensional image transforms for image analysis applications; Advanced image coding standards; Problem solving on the lectures' topics

Individual study structure	Course study	Problem solving, laboratory, project	Applications preparation	Examination time	Additional reference study	Total no. of individual study hours
Hours	23	14	14	3	10	64

References (Textbooks, courses, laboratory manual, exercise book)

1. Rafael C.Gonzalez, Richard E.Woods, *Digital Image Processing (3rd Edition)*, Prentice Hall, 2008
2. M. Sonka, V. Hlavac, R. Boyle, *Image Processing, Analysis, and Machine Vision*, Thomson Learning, 2007
3. A. Vlaicu, *Prelucrarea numerică a imaginilor*, Editura Albastră, Cluj-Napoca, 1997
4. B. Orza, A. Vlaicu, C. Popa, M. Gordan, *Viziunea computerizată în exemple şi aplicaţii practice*, UT Press, Cluj-Napoca, 2007

On – line references

1. A. Vlaicu, M. Gordan, *Digital image processing – lecture slides (Powerpoint)*, icar.utcluj.ro – Discipline
2. B. Orza, A. Vlaicu, M. Gordan, C. Popa – *Image processing – laboratory support*, icar.utcluj.ro – Discipline
3. M. Gordan, A. Vlaicu, *Digital image processing – practical examples (exercises)* – to appear

Final evaluation	
Evaluation method	Written exam (E): problem solving (50%) and theoretical subjects (50%).
Mark components	Exam (E: 0…10 pts); Laboratory (L: 0…10 pts); Lecture discussions (LD: 0…10 pts);
Mark computation	M = 0.7E + 0.2L + 0.1LD. Pass if: E≥5 and L≥5 and M≥5

Course leader,

Professor Aurel VLAICU, Ph.D.