Course guide
300265 - IMAGE - Applied Image Processing

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Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN APPLIED TELECOMMUNICATIONS AND ENGINEERING MANAGEMENT (MASTEAM) (Syllabus 2015). (Optional subject).

Academic year: 2024 **ECTS Credits:** 3.0 **Languages:** English

LECTURER

Coordinating lecturer: Francesc Tarrés

Others: Francesc Tarrés

PRIOR SKILLS

Signals and Systems, Digital Signal Processing, Digital audiovisual communications fundamentals

REQUIREMENTS

Pre: No pre-requirements are identifyed in MASTEAM
Co: No co-requirements are identifyed in MASTEAM

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Generical:
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.

Transversal:
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

Basic:
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB7. Students will be able to apply the acquired knowledge and their ability to solve problems in new or little explored environments in broader (or multidisciplinary) contexts related to their study area.

TEACHING METHODOLOGY

Teaching is based mainly on lectures and some case studies which are analyzed with some detail. Lectures introduce image processing concepts, mathematic tools, algorithms, methods and technologies which are involved in the design of practical image processing and computer vision systems. Lectures are based on a collection of slides and additional notes provided as accompanying hangouts to the lecture.

Every lesson is summarized with a collection of exercises or computer exercises that help the student to summarize the theoretical and practical concepts. Computer exercises are acompanied with practical study cases that the student has to analyze carefully and select the best solution to the problem. Solutions have to developed in high level languages such as Python, OpenCV or Matlab and are presented as guided activities in class. Assesment is evaluated through test questions, exams and reports of case studies solutions

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student should be able to:

To know the technologies and characteristics of camera systems, capture and representation technologies in computer vision systems

Be able to select between different algorithms for extraction the useful information in still images and video. Understand algorithms for image enhacement and segmentation based on local or global features.

Know, understand and be able to select possible alternatives for computer video analysis based on salient feature analysis and other low level descriptors such as color color, motion and shape.

Understand and be able to used several deep learning architectures and learning algoruthms for image classification and object detection.

Have a perspective of different software packages and hardware components for developing custumer solutions using computer visions systems

STUDY LOAD

Type	Hours	Percentage
Hours small group	3,0	4.05
Hours large group	23,0	31.08
Self study	48,0	64.86

Total learning time: 74 h

CONTENTS

Introduction to Digital Image Processing

Description:
Presentation of algorithms and strategies for image enhancement

Specific objectives:
Point transforms. Histogram and Image equalization. Automatic Binarization: k-means, Otsu Methods. Image Linear Filtering. Gradient estimation filters. Contour estiomation using second derivatives: Marr-Hildreth. Non-linear filters. Basic morphological operations. Dilation, erosion, top-hat

Related activities:
Activity 1, 6, 7

Full-or-part-time: 11h
Theory classes: 4h
Self study : 7h

Cameras, Optics and Acquisition Systems

Description:
content This chapter introduces some basic principles of image formation and optics to help selection of optical parameters in computer vision applications. A perspective on cameras, ilumination and acquisition devises is also provided

Specific objectives:
Fundamentals of optics. Selecting the optics in different computer vision aplications. Types of cameras. Light and principles of lighting in computer vision applications. Types of lighting. Capturing images and video: frame grabbers, digital interfaces.

Related activities:
Activity 2, 6, 7

Full-or-part-time: 8h
Theory classes: 3h
Self study : 5h

Contour Detection and Segmentation

Description:
This chapter covers the classic algorithm for image segmentation based on contour or region analysis. It reviews the main techniques on image segmentation.

Specific objectives:
Canny method for contour detection. Hough Transform. Region Segmentation Techniques: Split & Merge, Region Growing, Watersheds. Region representation using contours. Graph Based segmentation. GraphCut

Related activities:
Activity 3, 6, 7

Full-or-part-time: 5h
Theory classes: 2h
Self study : 3h

Feature Extraction and Its Applications in Computer Vision

Description:
This chapter presents different techniques for extracting automatic features of an image and discusses alternatives for using these features and their descriptors to object detection and recognition

Specific objectives:
Defiining interest points, saliencies, corners, etc. Basic methods for corner extraction: Moravec, Harris, shi-tomasi, Nobles, Trigg, Broen.

Detection of interest points: Kadir & Brady, SUSAN: edge and corner detection, FAST corner detector.

Blob Detection. Laplacian of a Gaussian and Difference of Gaussians. MSER

Scale Invariant Feature Detection (SIFT). SIFT Variants: SURF, GLOH, BRISK, ORB, etc.

Face and person detection. Adaboost and Histogram of Gradients.

Related activities:
Activity 4, Activity 7

Full-or-part-time: 24h
Theory classes: 6h
Laboratory classes: 2h
Self study : 16h

Convolutional Neural Networks and Applications to Image Classification and Object Detection

Description:
Fundamentals of neural networks and deep learning are presented in the context of image recognition. The main architectures for image classification and object detection are covered. Examples are presented using Tensorflow or Pytorch developing environments

Specific objectives:
Introduction to Neural Networks and history. Neuron models. Elemental clasifiers. Linear regression. Learning Models. Multilayer perceptrons. Backpropagation. Training, Test and Validation. Batches and Epochs. Loss functions. Regularization. Data augmentation. Convolutional Neural Networks and main architectures: AlexNet, ZF Net, VGG Net, Inception, Resnet. Object detection and segmentation: R-CNN, Fast R-CNN, Faster R-CNN, Yolo, SSD, Retina Net, Yolo V3.

Related activities:
Activity 5, Activity 7

Full-or-part-time: 25h
Theory classes: 6h
Practical classes: 2h
Self study : 17h

ACTIVITIES

Activity 1. Computer exercise: Image Enhancement and basic analysis techniques

Description:
This activity is a computer exercise. The student have the option of developing the exercise using Python with the library scikit images or Matlab. The activity covers different algorithm already covered in class: equalization, automatic binarization, labelling, non-linear filtering, etc.

Specific objectives:
The main objective is to emphasize and consolidate the knowledge on image enhancement techniques that are studied in the first chapter

Material:
Document describing the activity, software to be used and questions to solve

Delivery:
Report of the activity

Related competencies :
03 DIS. (ENG) Diseñar aplicaciones de alto valor añadido basadas en las Tecnologías de la Información y las Comunicaciones (TIC), aplicadas a cualquier ámbito de la sociedad.
03 TLG. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
CB6. Possess and understand knowledge that provides a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB7. Students will be able to apply the acquired knowledge and their ability to solve problems in new or little explored environments in broader (or multidisciplinary) contexts related to their study area.

Full-or-part-time: 2h
Self study: 2h

Activity 2. Exercises for cameras, optics and acquisition system

Description:
This exercise is a questionaire with different problems including concepts of cameras, geometric optics and acquisition systems

Specific objectives:
Emphasize and improve the knowledge on optics, cameras and acquisition systems

Material:
Documentation including the problems, questions and systems that the student has to obtain further information

Delivery:
The student has to deliver a report with her answers to the questionnaire

Full-or-part-time: 2h
Self study: 2h

Activity 3. Computer Exercise. Contour Detection and Segmentation

Description:
The activity consist in implementing a series of contour detection and sigmentation algorithm in practical cases using Python and the OpenCV library

Specific objectives:
The objective is to consolidate through a series of computer exercises the methods studied in module 3

Material:
Documentation including the different computer exercises to perform and a series of images to analyze

Delivery:
The student has to deliver a report with the activity performed

Full-or-part-time: 2h
Self study: 2h

Activity 4. Computer Exercise. Feature Extraction.

Description:
This activity proposes a series of computer exercises to analyze the performance of different algorithm for automatic feature extraction. The computer exercise is proposed in Matlab but students may implement it in any other language if they feel more comfortable

Specific objectives:
The objective is to consolidate through a series of computer exercises the methods studied in module 4

Material:
Documentation including the different computer exercises to perform and a series of images to analyze

Delivery:
The student has to deliver a report with the activity performed

Full-or-part-time: 2h
Self study: 2h

Activity 5. Computer Exercise. Artificial Neural Networks for Image Classification

Description:
The student has to program different architectures of artificial neural networks for recognizing different types of images. The first part of the exercise proposes to classify the MNIST handwritten digit database using 3 different approaches that cover a linear classifier a multilayer perceptron and a convolutional neural network. A second part of the exercise proposes to train and test a CNN to classify fruits.

Specific objectives:
The objective is to consolidate through a series of computer exercises the methods studied in module 5

Material:
Documentation including the different computer exercises and databases to perform and a series of images to analyze

Delivery:
The student has to deliver a report with the activity performed

Full-or-part-time: 2h
Self study: 2h

Activity 6. Control Exam

Description:
This exercise is an exam with questions about modules 1-2-3

Specific objectives:
Verify assessment of the first 3 modules

Material:
Question Sheet

Delivery:
After finishing the 90 min session

Full-or-part-time: 1h 30m
Practical classes: 1h 30m

Activity 7. Final Exam

Description:
This exercise is an exam with questions about all the course

Specific objectives:
Verify assessment of the course contents

Material:
Question Sheet

Delivery:
After finishing the exam

Full-or-part-time: 2h
Practical classes: 2h

GRADING SYSTEM

Evaluation takes into account the following topics

30 % Final Exam
20 % Control Exam
20 % Exercises and Computer Exercises Modules 1-2-3
20 % Exercises and Computer Exercises Modules 4-5
10 % Participation

EXAMINATION RULES.

Exams consist on short questions, problems and a True/False Quiz.

The exercises and computer exercises have to be presented individually in a report and answering the different questions.

BIBLIOGRAPHY

Basic:
- Shapiro, Linda G; Stockman, George C. Computer vision. Upper Saddle River: Prentice Hall, cop. 2002. ISBN 0130307963.
- Parker, J. R. Algorithms for image processing and computer vision. 2nd ed. New York, [etc.]: John Wiley & Sons, cop. 2011. ISBN 9780470643853.
- Géron, Aurélien. Hands-on machine learning with scikit-learn & tensorflow : concepts, tools, and techniques to build intelligent systems [on line]. Sebastopol, CA: O'Reilly Media, Inc, [2017] [Consultation: 26/07/2022]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=4822582. ISBN 9781491962299.