Course guides
270181 - VC - Computer Vision

Unit in charge: Barcelona School of Informatics
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: BACHELOR’S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2021 ECTS Credits: 6.0 Languages: Catalan

LECTURER
Coordinating lecturer: - Joan Climent Vilaró (juan.climent@upc.edu)
Others: - Joan Aranda López (joan.aranda@upc.edu)
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PRIOR SKILLS
It is recommended that the student has passed the courses Probability and Statistics (PE) and Programming Project (PROP).

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CCO2.2. Capacity to acquire, obtain, formalize and represent human knowledge in a computable way to solve problems through a computer system in any applicable field, in particular in the fields related to computation, perception and operation in intelligent environments.
CCO2.3. To develop and evaluate interactive systems and systems that show complex information, and its application to solve person-computer interaction problems.
CCO2.4. To demonstrate knowledge and develop techniques about computational learning; to design and implement applications and system that use them, including these ones dedicated to the automatic extraction of information and knowledge from large data volumes.
CT1.2A. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to solve the mathematical problems presented in engineering. Talent to apply the knowledge about: algebra, differential and integral calculus and numeric methods; statistics and optimization.
CT2.5. To design and evaluate person-computer interfaces which guarantee the accessibility and usability of computer systems, services and applications.
CT4.1. To identify the most adequate algorithmic solutions to solve medium difficulty problems.
CT4.3. To demonstrate knowledge and capacity to apply the fundamental principles and the basic techniques of the intelligent systems and its practical application.
CT5.2. To know, design and use efficiently the most adequate data types and data structures to solve a problem.
CT5.5. To use the tools of a software development environment to create and develop applications.
CT8.1. To identify current and emerging technologies and evaluate if they are applicable, to satisfy the users needs.

General:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.
TEACHING METHODOLOGY

The teaching methodology will be in general deductive. Attempt to flee the classic lecture methodology. The approach is always the same:
- to propose a problem
- trying to solve it
- add pieces of theory needed to solve the problem.
During practices we’ll work also cooperative learning and independent learning by the resolution of a short project.

LEARNING OBJECTIVES OF THE SUBJECT

1. Understanding the mechanisms of digital imaging and their features thereof.
2. Compare and select the proper tools for image preprocessing based on the problem to solve.
3. Segment and label the parts of an image from its common characteristics and / or differences.
4. Understand, design and implement in an efficient way the most suitable descriptors for the characterization of regions, singular points or edges of an image.
5. Detect and identify the presence of certain items in a picture.
6. Successfully perform experiments designed to evaluate the chosen or proposed methods, their limitations and weaknesses, based on objective results.
7. Detect moving targets in a scene and tracking them.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
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<tbody>
<tr>
<td>Hours small group</td>
<td>30,0</td>
<td>20.00</td>
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<tr>
<td>Hours large group</td>
<td>30,0</td>
<td>20.00</td>
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<tr>
<td>Guided activities</td>
<td>6,0</td>
<td>4.00</td>
</tr>
<tr>
<td>Self study</td>
<td>84,0</td>
<td>56.00</td>
</tr>
</tbody>
</table>

Total learning time: 150 h

CONTENTS

- The digital image

  Description:
  Digital image properties. Discretization and quantification. Colour spaces

- Digital image processing

  Description:
  Grey-level transformations.
  Geometric transformations
  Linear operators. Convolution. Image smoothing and enhancement
  Edge detection
  Non linear operators. Morphological filters.
  Scale space
## Image segmentation

**Description:**
- Binarization.
- Region based segmentation: region growing, split & merge, watershed, k-means, normalized cuts...
- Edge based segmentation: LoG, DoG, Canny...
- Connectivity analysis and labelling, adjacency graph

## Shape descriptors

**Description:**
- Edge based descriptors
- Region based descriptors
- Translation, rotation, illumination, affine transformation, and/or scale invariance

## Recognition

**Description:**
- Feature vectors classification.
- Clustering and learning.
- Distance functions.
- Classifiers: Bayes, Mahalanobis, Fisher, K-nearest,...
- Methods for evaluating a classification.
- PCA. Dimensionality reduction

## Local features

**Description:**
- Histogram based descriptors: Colour histograms, HOGs.
- Hough transform.
- Keypoint detectors and descriptors: Harris, SIFT.
- Haar-like features. Face Detection using Viola-Jones

## Motion analysis

**Description:**
ACTIVITIES

(ENG) Que és una imatge? Quina informació conté?

Description:
(ENG) Captació d'imatges digitals, propietats i característiques. Formació de la imatge.

Specific objectives:
(ENG) 1

Material:
(ENG)

Delivery:
(ENG)

Full-or-part-time: 8h
Theory classes: 4h
Self study: 4h

(ENG) Processat digital d'imatges

Description:
(ENG) Histograma de la imatge, modificacions, realçat.
Filtrat espacial i freqüencial.
Filtres morfològics.
Transformacions geomètriques.
Espai d'escala

Specific objectives:
(ENG) 2

Material:
(ENG)

Delivery:
(ENG)

Full-or-part-time: 38h
Theory classes: 6h
Laboratory classes: 12h
Self study: 20h
(ENG) Segmentació d'imatges.

Description:
(ENG) Técnicas basades en regions: Binarització, watershed, mean-shift, normalized cuts....
Tecnicas basades en contorns: Gradients, LoG, DoG, Canny...
Analisi de connectivitat i etiquetat, graf d'adjacència.

Specific objectives:
(ENG) 3, 6

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 18h
Theory classes: 4h
Laboratory classes: 4h
Self study: 10h

(ENG) Detecció i descripció de característiques.

Description:
(ENG) Característiques locals i globals.
Descriptors de regions, contorns i punts singulars.
Concepte d'invariancia a translació, rotació i/o escala.

Specific objectives:
(ENG) 4, 6

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 12h
Theory classes: 6h
Self study: 6h
(ENG) Reconeixement

Description:
(ENG) Conceptes bàsics. Classificació mitjançant vectors descriptors.
Construcció de les classes (Clustering, aprenentatge ...)
Funcions distància.
Tipus de classificadors: Bayes, Mahalanobis, Fisher, K-nearest,...
Identificació d'objectes. Reconeixement de categories.

Specific objectives:
(ENG) 5, 6

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 12h
Theory classes: 6h
Self study: 6h

(ENG) Detecció i anàlisi de moviment

Description:
(ENG) Imatge diferencia.
Fluxe òptic.
Correspondencia de punts.
Seguiment d'objectes.

Specific objectives:
(ENG) 5, 6, 7

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 8h
Theory classes: 4h
Self study: 4h
**(ENG) Dissenyar i desenvolupar una aplicació senzilla de visió per computador (miniprojecte).**

**Description:**
(ENG) L'alumne haurà de triar i combinar els mètodes i tècniques que trobi més adients per donar solució al problema presentat. Haurà d'avaluar el seu treball dissenyant jocs de proves i delimitant l'abast de la solució proposada.

**Specific objectives:**
(ENG) 1, 2, 3, 4, 5, 6

**Material:**
(ENG)

**Delivery:**
(ENG)

**Related competencies:**
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

**Full-or-part-time:** 42h
Laboratory classes: 14h
Self study: 28h

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**(ENG) Prova d'assoliment d'objectius.**

**Description:**
(ENG) Prova de coneixements.

**Specific objectives:**
(ENG) 1, 2, 3

**Material:**
(ENG)

**Delivery:**
(ENG)

**Full-or-part-time:** 3h
Guided activities: 2h
Self study: 1h
(ENG) Control de seguiment del miniprojecte

Description:
(ENG) L'alumne a de presentar un informe parcial d'evolució del miniprojecte: decisions de disseny i primeres proves si n'hi han, així com una planificació temporal del treball que falta. Es tracta d'una prova de seguiment de la evolució correcta del miniprojecte. També serveix per re-orientar a l'alumne en cas necessari.

Specific objectives:
(ENG) 2, 3, 4, 6

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 2h
Guided activities: 1h
Self study: 1h

(ENG) Presentació dels resultats del miniprojecte

Description:
(ENG) L'alumne fa una presentació davant els companys amb els resultats del seu miniprojecte.

Specific objectives:
(ENG) 2, 3, 4, 5, 6

Material:
(ENG)

Delivery:
(ENG)

Related competencies:
G7. AUTONOMOUS LEARNING: to detect deficiencies in the own knowledge and overcome them through critical reflection and choosing the best actuation to extend this knowledge. Capacity for learning new methods and technologies, and versatility to adapt oneself to new situations.

Full-or-part-time: 7h
Guided activities: 3h
Self study: 4h
(ENG) Prova de coneixements

Description:
(ENG) Prova de coneixements

Specific objectives:
(ENG) 1, 2

Material:
(ENG)

Delivery:
(ENG)
GRADING SYSTEM

This section is untranslated deliberately in order to avoid misinterpretations.

BIBLIOGRAPHY

Basic:

Complementary: