270181 - VC - Computer Vision

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 707 - ESAII - Department of Automatic Control
Academic year: 2019
Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff
Coordinator: - Joan Climent Vilaró (juan.climent@upc.edu)
Others: - Manel Frigola Bourlon (manel.frigola@upc.edu)

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.
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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 shortproject.

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>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>30h</th>
<th>20.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours small group:</td>
<td>30h</td>
<td>20.00%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>6h</td>
<td>4.00%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>84h</td>
<td>56.00%</td>
</tr>
</tbody>
</table>
# Content

## The digital image

**Degree competences to which the content contributes:**

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

## Digital image processing

**Degree competences to which the content contributes:**

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

## Image segmentation

**Degree competences to which the content contributes:**

**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

**Degree competences to which the content contributes:**

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

## Recognition

**Degree competences to which the content contributes:**
### 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

**Degree competences to which the content contributes:**

**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

**Degree competences to which the content contributes:**

**Description:**
## Planning of activities

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(ENG) Que és una imatge? Quina informació conté?</strong></td>
<td>8h</td>
<td>4h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>4h</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td></td>
<td>(ENG) Captació d'imatges digitals, propietats i característiques. Formació de la Imatge.</td>
<td></td>
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</tr>
<tr>
<td><strong>Support materials:</strong></td>
<td></td>
<td>(ENG)</td>
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<tr>
<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
<td></td>
<td>(ENG)</td>
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</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
<td>(ENG) 1</td>
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</tr>
<tr>
<td><strong>(ENG) Processat digital d'imatges</strong></td>
<td>38h</td>
<td>6h</td>
<td>0h</td>
<td>12h</td>
<td>0h</td>
<td>20h</td>
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<tr>
<td><strong>Description:</strong></td>
<td></td>
<td>(ENG) Histògrama de la imatge, modificacions, realçat. Filtrat espacial i freqüèncial. Filtres morfològics. Transformacions geomètriques. Espai d'escala</td>
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<tr>
<td><strong>Support materials:</strong></td>
<td></td>
<td>(ENG)</td>
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<td><strong>Descriptions of the assignments due and their relation to the assessment:</strong></td>
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<td>(ENG)</td>
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<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
<td>(ENG) 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(ENG) Segmentació d'imatges.</strong></td>
<td>18h</td>
<td>4h</td>
<td>0h</td>
<td>4h</td>
<td>0h</td>
<td>10h</td>
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<td><strong>Description:</strong></td>
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<tr>
<td><strong>Support materials:</strong></td>
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<tr>
<td><strong>Specific objectives:</strong></td>
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</tr>
</tbody>
</table>
### Description:
(ENG) Tècniques 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.

### Support materials:
(ENG)

### Descriptions of the assignments due and their relation to the assessment:
(ENG)

### Specific objectives:
(ENG) 3, 6

<table>
<thead>
<tr>
<th>(ENG) Detecció i descripció de característiques.</th>
<th>Hours: 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>(ENG) Característiques locals i globals.</td>
<td></td>
</tr>
<tr>
<td>Descriptors de regions, contorns i punts singulars.</td>
<td></td>
</tr>
<tr>
<td>Concepte d’invariancia a translació, rotació i/o escala.</td>
<td></td>
</tr>
<tr>
<td>Support materials:</td>
<td></td>
</tr>
<tr>
<td>(ENG)</td>
<td></td>
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<tr>
<td>Descriptions of the assignments due and their relation to the assessment:</td>
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<tr>
<td>(ENG)</td>
<td></td>
</tr>
<tr>
<td>Specific objectives:</td>
<td></td>
</tr>
<tr>
<td>(ENG) 4, 6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>(ENG) Reconeixement</th>
<th>Hours: 12h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
</tr>
<tr>
<td>(ENG) Conceptes bàsics.</td>
<td></td>
</tr>
<tr>
<td>Classificació mitjançant vectors descriptors.</td>
<td></td>
</tr>
<tr>
<td>Construcció de les classes (Clustering, aprenentatge ...)</td>
<td></td>
</tr>
<tr>
<td>Funcions distància.</td>
<td></td>
</tr>
<tr>
<td>Tipus de classificadors: Bayes, Mahalanobis, Fisher, K-nearest,…</td>
<td></td>
</tr>
<tr>
<td>Identificació d'objectes. Reconeixement de categories.</td>
<td></td>
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<tr>
<td>Support materials:</td>
<td></td>
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<tr>
<td>(ENG)</td>
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</tr>
</tbody>
</table>
### Descriptions of the assignments due and their relation to the assessment:

(ENG) **Specific objectives:**
(ENG) 5, 6

### (ENG) Detecció i anàlisi de moviment

#### Description:
- Imatge diferencia.
- Fluxe òptic.
- Correspondencia de punts.
- Seguiment d'objectes.

#### Support materials:
(ENG)

#### Description:
(ENG) **Specific objectives:**
(ENG) 5, 6, 7

### (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.

#### Support materials:
(ENG)

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

### Hours:

<table>
<thead>
<tr>
<th>Theory classes</th>
<th>Practical classes</th>
<th>Laboratory classes</th>
<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>4h</td>
<td>0h</td>
<td>0h</td>
<td>0h</td>
<td>4h</td>
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</tbody>
</table>

<table>
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<tr>
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<th>Guided activities</th>
<th>Self study</th>
</tr>
</thead>
<tbody>
<tr>
<td>0h</td>
<td>0h</td>
<td>14h</td>
<td>0h</td>
<td>28h</td>
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</tbody>
</table>
## Prova d'assoliment d'objectius

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

**Support materials:**
(ENG)

**Descriptions of the assignments due and their relation to the assessment:**
(ENG)

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

### Hours
3h
- Guided activities: 2h
- Self study: 1h

## 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.

**Support materials:**
(ENG)

**Descriptions of the assignments due and their relation to the assessment:**
(ENG)

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

### Hours
2h
- Guided activities: 1h
- Self study: 1h

## Presentació dels resultats del miniprojecte

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

**Support materials:**
(ENG)

**Descriptions of the assignments due and their relation to the assessment:**
(ENG)

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

### Hours
7h
- Guided activities: 3h
- Self study: 4h
### Description:
(ENG) Prova de coneixements

### Support materials:
(ENG)

### Descriptions of the assignments due and their relation to the assessment:
(ENG)

### Specific objectives:
(ENG) 1, 2

### Hours:
0h
- Guided activities: 0h
- Self study: 0h

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### Description:
(ENG) Prova de coneixements

### Support materials:
(ENG)

### Descriptions of the assignments due and their relation to the assessment:
(ENG)

### Specific objectives:
(ENG) 1, 2

### Hours:
0h
- Guided activities: 0h
- Self study: 0h

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### Description:
(ENG) Prova de coneixements

### Support materials:
(ENG)

### Descriptions of the assignments due and their relation to the assessment:
(ENG)

### Specific objectives:
(ENG)

### Hours:
0h
- Guided activities: 0h
- Self study: 0h
(ENG) Prova de coneixements

Description:
(ENG) Prova de coneixements

Support materials:
(ENG)

Descriptions of the assignments due and their relation to the assessment:
(ENG)

Specific objectives:
(ENG)

Qualification system

This section is untranslated deliberately in order to avoid misinterpretations.

Bibliography

Basic:


Complementary:

