240AR015 - Computer Vision

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 707 - ESAII - Department of Automatic Control
Academic year: 2017
Degree: MASTER'S DEGREE IN AUTOMATIC CONTROL AND ROBOTICS (Syllabus 2012). (Teaching unit Compulsory)
MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ECTS credits: 4,5
Teaching languages: English

Teaching staff
Coordinator: ALBERTO SANFELIU CORTES
Others: Primer cuatrimestre:
JUAN ARANDA LÓPEZ - 10, 10, 10
ALBERTO SANFELIU CORTES - 10, 10, 10

Degree competences to which the subject contributes

Specific:
1. The student know selecting appropriate software and hardware elements to implement a solution in a system wardrobe.
2. The student will be able to recognize and represent problems in the area by automatic and robotic techniques optimization, and then apply analytical methods / numerical resolution.
3. The student will be able to select, plan, and evaluate different techniques to detect, extract and analyze data an image or sequence of images.

Generic:
4. Have adequate mathematical skills, analytical, scientific, instrumental, technological, and management information.
5. Ability to conduct research, development and innovation in the field of systems engineering, control and robotics, and as to direct the development of engineering solutions in new or unfamiliar environments, linking creativity, innovation and transfer of technology
6. Ability to reason and act based on the so-called culture of safety and sustainability

Transversal:
7. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.
8. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
9. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
10. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
The computer vision goal is to model real world and to recognise objects from digital images. These images can be acquired using cameras and video cameras, infrared cameras, radars, or specialised sensors such as those used in the medical field. The students will learn the fundamentals of the design of computer vision techniques and their applications for detection, identification, recognition, classification, tracking, etc. The students will acquire theoretical and practical knowledge in computer vision techniques to process and analyse images and sequence of images (videos). They will apply some of these techniques in a short project where they will have to prove their acquired knowledge.

Learning Outcomes:
- Use probabilistic models applied to robotics and computer vision.
- Understand the mechanisms of digital imaging and digital processing characteristics thereof.
- Extract information from digital images which are being processed, segment them and extract features.
- Use techniques for the analysis and interpretation of objects in images and tracking of moving objects.

Mandatory Contents:
- Digital imaging and processing
- Image segmentation
- Detection and description of features
- Modelling 2D and 3D objects
- Stereo vision
- Correspondence and motion detection

Study load

<table>
<thead>
<tr>
<th>Total learning time: 112h 30m</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22h 30m</td>
<td>18h</td>
<td>72h</td>
</tr>
<tr>
<td></td>
<td>20.00%</td>
<td>16.00%</td>
<td>64.00%</td>
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The methodology of the course will be of master classes of 2 h/session, where the teacher will explain the theory and will introduce exercises to improve the understanding of the subject. Moreover, there will be laboratory classes of 2 h/session, where the student will use cameras and illumination systems and will practise with software computer vision techniques on predefined images.
## 240AR015 - Computer Vision

### Content

<table>
<thead>
<tr>
<th>Problem domain</th>
<th>Learning time: <strong>4h</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: <strong>2h</strong></td>
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<tr>
<td></td>
<td>Practical classes: <strong>0h</strong></td>
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<tr>
<td></td>
<td>Self study: <strong>2h</strong></td>
</tr>
</tbody>
</table>

**Description:**
- This topic will deal with:
  - Basic concepts
  - Image formation

**Related activities:**
- Lectures

**Specific objectives:**
- CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

<table>
<thead>
<tr>
<th>Digital image processing</th>
<th>Learning time: <strong>11h</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: <strong>4h</strong></td>
</tr>
<tr>
<td></td>
<td>Practical classes: <strong>1h</strong></td>
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<tr>
<td></td>
<td>Self study: <strong>6h</strong></td>
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**Description:**
- This topic deals with:
  - Geometric transformations
  - Linear and nonlinear filtering
  - Image enhancement and smoothing
  - Scale space
  - Mathematical morphology

**Related activities:**
- Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
- CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13
240AR015 - Computer Vision

### Segmentation and feature extraction

- **Learning time:** 10h
  - Theory classes: 3h
  - Practical classes: 1h
  - Self study: 6h

**Description:**
This topic deals with:
- Region based segmentation (binarization, watershed, mean-shift, normalized cuts)
- Contour detection (Canny, LoG, DoG)
- Connectivity analysis and labelling
- Basic edge and region feature extraction

**Related activities:**
Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

### Feature detection and descriptors

- **Learning time:** 11h
  - Theory classes: 4h
  - Practical classes: 1h
  - Self study: 6h

**Description:**
This topic deals with:
- Concepts on feature invariants
- Point feature detection and descriptors (Harris, HoG, Random Ferns, SIFT)
- Line feature detection and descriptors (Hough transform)

**Related activities:**
Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13
<table>
<thead>
<tr>
<th>Representation and description</th>
<th>Learning time: 7h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 2h</td>
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<td></td>
<td>Practical classes: 1h</td>
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<tr>
<td></td>
<td>Self study: 4h</td>
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</tbody>
</table>

**Description:**
This topic deals with:
- Contour descriptors (Freeman chain, Fourier descriptors, shape context)
- Region and texture description (concurrence matrix, image moments, PCA)

**Related activities:**
Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

<table>
<thead>
<tr>
<th>Classification and Recognition</th>
<th>Learning time: 11h</th>
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<tbody>
<tr>
<td></td>
<td>Theory classes: 4h</td>
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<tr>
<td></td>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 6h</td>
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**Description:**
This topic deals with:
- Basic concepts
- Type of classifiers
- Matching
- Classifiers (Bayes, Mahalanobis, Fisher, K-nearest neighborhood)
- Boosting

**Related activities:**
Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13
### Motion detection

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Practical classes: 1h</td>
</tr>
<tr>
<td>Self study : 6h</td>
</tr>
</tbody>
</table>

**Description:**
This topic deals with:
- Basic concepts
- Image difference
- Optical flow
- Point correspondence
- Tracking

**Related activities:**
Master class, resolution of problems and independent learning through exercises

**Specific objectives:**
CB1, CB2, CB3, CB4, CB5, CG1, CG3, CG8, CT2, CT3, CT4, CT5, CT7, CE7, CE9, CE13

### Qualification system

Along the course, the student will have to solve specific exercises of the different topics of the subject. The exercises will be evaluated by the professor. There will also be a short project that will be selected by the student, where he/she will have to demonstrate the acquired knowledge. This short project will be presented and evaluated in an oral presentation. For the solution of some of the exercises and the complete project, the students will use a programming language. The evaluation system will consist on the following elements:

- Evaluation of the exercises: (20% of the course mark)
- Evaluation of a final exam: (40% of the course mark)
- Evaluation of the short project: (40% of the course mark)
240AR015 - Computer Vision

Bibliography

Basic:


Complementary:


