295119 - 295I234 - Plant Monitoring & Fault Detection

**Coordinating unit:** 295 - EEBE - Barcelona East School of Engineering

**Teaching unit:**
- 749 - MAT - Department of Mathematics
- 707 - ESAII - Department of Automatic Control

**Academic year:** 2019

**Degree:** MASTER'S DEGREE IN INTERDISCIPLINARY AND INNOVATIVE ENGINEERING (Syllabus 2019).
  (Teaching unit Optional)

**ECTS credits:** 6  
**Teaching languages:** English

**Teaching staff**

**Coordinator:** Pozo Montero, Francesc  
Graells Sobre, Moises

**Others:** Blesa Izquierdo, Joaquin  
Mujica Delgado, Luis Eduardo  
Ruiz Ordoñez, Magda Liliana  
Solà Soler, Jordi  
Vidal Segui, Yolanda

**Prior skills**

It is assumed that the student has the fundamental concepts of calculus, algebra, systems theory of differential equations, and statistics acquired in the degree that allows access to the Master.

**Requirements**

There is not

**Degree competences to which the subject contributes**

**Specific:**
- CEMUEII-16. Design monitoring systems, planning and control of automated industrial processes that allow automated predictive maintenance by detecting and diagnosing plant failures. (Specific competence of the Advanced Manufacturing Systems specialty)

**Generical:**
- CGMUEII-01. Participate in technological innovation projects in multidisciplinary problems, applying mathematical, analytical, scientific, instrumental, technological and management knowledge.
- CGMUEII-05. To communicate hypotheses, procedures and results to specialized and non-specialized audiences in a clear and unambiguous way, both orally and through reports and diagrams, in the context of the development of technical solutions for problems of an interdisciplinary nature.

**Transversal:**
- 05 TEQ. TEAMWORK. Being able to work as a team player, either as a member or as a leader. Contributing to projects pragmatically and responsibly, by reaching commitments in accordance to the resources that are available.
- 06 URI. EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization. Taking a critical stance with regard to the results obtained.
- 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.
This course introduces the student in the field of detection and diagnosis of faults in processes, industrial systems and structures, as well as the supervision of them, making special use of data-based techniques (statistical methods) and models (analytical redundancy).

The student who has taken the course must be able to:
- Design and implement fault detection systems for processes, industrial systems and structures.
- Design and implement fault diagnosis systems for processes, industrial systems and structures.

Specific competences:
- The student should know the difference and similarities between data-based and model-based methods.
- The student must know the methods based on data that are applied for the detection of faults using statistical tools.
- The student must know the methods based on models that are applied for detection, isolation and fault estimation with analytical redundancy.
- The student must know the methods based on data that are applied to detect and diagnose defects or damages on structures.

### Teaching methodology

The development of class sessions follows a combined methodology. On one hand, a methodology close to the master classes will be applied, where the teaching staff will present the fundamental concepts of the subject. It is combined with a methodology close to the classes of problems and practices, where the students will work on examples and problems in numerical simulation proposed by the professor to reinforce and deepen the methodologies previously taught. Finally, there will be a session where the student can attend the laboratory to have contact with the available experiments.

### Learning objectives of the subject

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The student who has taken the course must be able to:
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- Design and implement fault diagnosis systems for processes, industrial systems and structures.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>22h</th>
<th>14.67%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>22h</td>
<td>14.67%</td>
</tr>
<tr>
<td></td>
<td>Guided activities:</td>
<td>4h</td>
<td>2.67%</td>
</tr>
<tr>
<td></td>
<td>Self study:</td>
<td>102h</td>
<td>68.00%</td>
</tr>
<tr>
<td>Content</td>
<td>Learning time</td>
<td>Description</td>
<td>Related activities</td>
</tr>
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<tr>
<td><strong>Introduction to the monitoring of processes and decisions</strong></td>
<td>5h</td>
<td>Decision support systems, Operator training systems, Performance criteria</td>
<td></td>
</tr>
<tr>
<td><strong>Data management</strong></td>
<td>17h</td>
<td>Data cleaning and filtering, Pre-processing, Reduction of dimensionality, Extraction of features, Review of the most common strategies (PCA, SVD, etc.)</td>
<td>Activity 1: Computer lab session: Application in wind power generation systems</td>
</tr>
<tr>
<td><strong>Statistical process monitoring</strong></td>
<td>26h</td>
<td>Univariable process monitoring, Multivariable process monitoring, Multivariable Statistical methods for projection, Continuous processes, Batch processes</td>
<td>Activity 2: Computer lab sessions: Application in the detection of faults in electrical energy transmission. Application in the detection of faults in wastewater treatment plants.</td>
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### Data-based fault diagnosis

**Description:**
- Condition indicators
- Classifiers as a decision model
  - Binary (healthy versus faulty)
  - Multiclass (diagnose among different type of faults)
- Application to wind turbines

**Related activities:**
- Activity 3: Computer lab sessions: Application in the detection of failures in wind turbines

**Learning time:** 26h
- Theory classes: 4h
- Laboratory classes: 4h
- Self study: 18h

### Structural Health Monitoring

**Description:**
- Introduction to Structural Health Monitoring (SHM)
- Pattern recognition as SHM paradigm
- Methods based on vibration and guided waves
- Practical cases

**Related activities:**
- Activity 4: Computer and experimental lab sessions: Application of Structural Health Monitoring on diverse kind of structures

**Learning time:** 29h
- Theory classes: 2h
- Laboratory classes: 6h
- Self study: 21h

### Fault detection based on models

**Description:**
- Introduction to fault detection based on models.
- Fault detection methods based on models: parity equations, observers and parameter estimation.

**Related activities:**
- Activity 5: Computer and lab sessions: Application in the detection of faults in wind turbines and drinking water distribution networks.

**Learning time:** 23h 30m
- Theory classes: 3h
- Laboratory classes: 3h
- Guided activities: 2h
- Self study: 15h 30m
Fault diagnosis based on models

Learning time: 23h 30m
- Theory classes: 3h
- Laboratory classes: 3h
- Guided activities: 2h
- Self study: 15h 30m

Description:
Model-based fault diagnostics methods: Structural analysis, directional residual and parameter estimation.

Qualification system
Partial exam 30%
Final exam 30%
Projects and exercises 40%

Bibliography

Basic: