Intelligence for Embedded Systems
(introduction to the course)

Ph. D. and Master Course
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Information about the course

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From the environment to the embedded systems, from the embedded systems to the applications

- The **emergence of non-trivial embedded sensor units, networked embedded systems and sensor/actuator networks** has made possible the design and implementation of several sophisticated applications.

- Main characteristic: **large amounts of real-time data** are collected to constitute a *big data* picture as time passes.

- Acquired data are then processed at local, cluster-of-units or server level to **take the appropriate actions or make the most appropriate decision**.
Environment

Embedded, Cyber-physical or Pervasive System

Applications
Changes (Nonstationary, seasonality, periodicity)

Faults, Uncertainty, Errors, memory energy constraints, finite precision

Performance reduction, cascade effects

Environment

Embedded, Cyber-physical or Pervasive System

Applications
Intelligence for Embedded Systems
An example of Intelligent Embedded Systems: Rock collapse and landslide forecasting

- Expert
- Rock Collapse and Landslide Forecasting Application
  - Burst Classification (Bursts / False Positives)
  - Analysis of low-frequency signals
- Intelligent Mechanisms
- Signal extraction
  - High-frequency signals
  - Low-frequency signals
- Raise an alarm
- Normal situation

Fig. 13
Intelligence or “is this an AI course?”

- The adjective **intelligent**, when associated with a sensing system, can be inflected **differently**, depending on the **reference community**

- As such, it may imply:
  - the ability to make decisions
  - the capability of learning from external stimuli
  - the promptness in adapting to changes
  - the possibility of executing computationally intelligent algorithms
The theoretical framework: three milestones

- All the above definitions, explicitly or implicitly, rely on a computational paradigm or application which receives and processes incoming acquisitions to accomplish the requested task.

- Under this framework, the literature generally assumes that sensors are fault free, that data are stationary, time invariant, available and ready to be used and that the application is capable of providing outputs and taking decisions.

- Unfortunately, assumptions about the quality and validity of data are so implicitly taken as valid by scholars that, most of the time, even their existence as assumptions is forgotten.
How is the course organized?

- The course presents the **intelligent-based methodological and technical aspects** making embedded systems and embedded applications able to deal with uncertainties and evolving environments.

- The **course addresses the following aspects**:
  - From metrology to digital data
  - Uncertainty, information and learning mechanisms
  - Emotional cognitive mechanisms for embedded systems
  - Adaptive mechanisms in embedded systems
  - Learning in nonstationary and evolving environments
  - Cognitive Fault Detection and Diagnosis
  - Robustness analysis and PACC (concepts)
## Schedule of the course

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Schedule</th>
<th>Room</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>07/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<tr>
<td>2</td>
<td>08/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<tr>
<td>3</td>
<td>14/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<td>4</td>
<td>15/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<tr>
<td>5</td>
<td>21/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<td>6</td>
<td>22/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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<tr>
<td>7</td>
<td>28/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
</tr>
<tr>
<td>8</td>
<td>29/01/15</td>
<td>Seminari (DEIB)</td>
<td>15.15-18.15</td>
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</tbody>
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- **Slides** provided by the lecturer
- **Reference book:**
  - “Intelligence for Embedded Systems: A Methodological Approach”,
    C. Alippi, Springer, 2014
- **Selected papers**
Software and Code

- **MathWorks – MATLAB**
  - Download from the POLIMI web site
  - Servizi On Line -> Servizi ICT -> Software Download -> Matlab

- **Codes and Examples** available on the course web page
LEARNING EVALUATION

- Project/Thesis
  a) Analysis of the literature
  b) Design of a solution
  c) Development of the designed solution
  d) Experimental Analysis

- Different combinations for a, b, c, d but a+b+c+d = 100%
- Different workloads for Ph.D. and Master Students
- Up to two people
- Knowledge of Matlab, C/C++, Java
- Topics available at the end of the course