



Course Syllabus for DAUSY National Ph.D. Program in Autonomous Systems (year 2023-24)

Course title	Data-driven fault diagnosis and fault prognosis
Scientific Discipline Sector	ING-INF/04
Hours of instruction	10 hours
CFU	1 CFU
Semester, period	June - July 2024
Goal	<p>This module aims at providing PhD students with the main concepts of data-driven fault diagnosis and fault prognosis which are at the base of modern condition-based and predictive maintenance.</p> <p>During the module, the students will learn how to apply a data-driven workflow to solve real case studies and to adapt it to the specific cases of fault diagnosis and fault prognosis. The workflow will include data processing, feature extraction and model training, with some insights on deployment complexity; problem resolution will also be implemented by using a common engineering software (MATLAB).</p> <p>The final goal is to provide PhD students with the necessary background to process sensors data and use them to monitor the condition of a physical system, classify possible undesired behaviours and eventually estimate the remaining useful life of specific components.</p> <p>Each lesson consists in lectures, numerical examples and analysis of case studies.</p>
Syllabus	<p>Motivating examples: from industry to robotic applications.</p> <p>Nomenclature: fault, maintenance and supervision.</p> <p>Reliability and safety.</p> <p>Limit checking, trend checking and hypothesis testing.</p> <p>Data types and data normalization.</p> <p>Filtering (signal processing).</p> <p>Signal features in the time and frequency domain.</p> <p>Features selection and dimensionality reduction.</p> <p>Fault diagnosis: features extraction and classification.</p> <p>Bias-variance trade-off.</p> <p>Overfitting and cross validation.</p> <p>Loss functions and performance indicators.</p> <p>Hyperparameters optimization.</p> <p>Fault prognosis: condition indicators and remaining useful life estimation.</p> <p>Data-driven fault diagnosis and fault prognosis workflows.</p> <p>MATLAB Predictive Maintenance Toolbox.</p> <p>Case studies and benchmarks.</p>

Bibliography	Recommended books: <ul style="list-style-type: none">• Isermann, Rolf. <i>Fault-diagnosis systems: an introduction from fault detection to fault tolerance</i>. Springer Science & Business Media, 2005.• Bishop, Christopher M., <i>Pattern Recognition and Machine Learning</i> (Information Science and Statistics), 2006, Springer-Verlag.• G. Pillonetto, T. Chen, A. Chiuso, G. D. Nicolao, and L. Ljung, <i>Regularized System Identification</i>. Springer, 2022. Slides and supporting material from lecturer.
Examination method	End-course examination based on a project work.