

**Course Syllabus for
Industry 4.0 PhD
(years 2022-23 /2023-24)**

Course title	Artificial intelligence for quality control with active infrared thermography
Scientific Discipline Sector	ING-IND/14
Hours of instruction	20 hours
CFU	2 CFU
Semester	Second semester
Goal	<p>This course tackles the problem of automatic inspection of manufactured goods by comprehensive intelligent systems bridging artificial intelligence and quality control to detect and characterize non-visible defects.</p> <p>First, this course briefly summarizes the principles of active infrared thermography, the current state-of-the-art of sensory technologies, and Finite Element Method (FEM) simulation analyses. Then, it mainly focuses on the processing techniques for data analysis, ranging from deterministic approaches to machine- and deep-learning ones.</p> <p>The insight into the specific case study of non-destructive testing with active infrared thermography will bring to the participants detailed knowledge about automatic data processing through artificial intelligence. By the end of the course, participants will be able to design and develop processing pipelines, even referred to data different from thermal ones.</p> <p>Each lesson consists of a lecture with some numerical examples coded in the Matlab environment. Simulation studies will be also performed by the COMSOL Multiphysics software in dedicated laboratory experiences.</p>
Syllabus	<ul style="list-style-type: none"> • Review of non-destructive evaluation and testing techniques • Principles of active infrared thermography <ul style="list-style-type: none"> ○ Flash thermography ○ Long-Pulse/Step-Heating thermography ○ Lock-in thermography • FEM simulations of heat transfer in solids • Dataset analysis, image processing and data filtering • Differential approaches for defect detection • Feature extraction: knowledge based and data driven • Machine learning • Deep learning • Use case: Quality control of composite laminates for aeronautics

Bibliography	<p>Y.A. Çengel, Introduction to Thermodynamics and Heat Transfer, McGraw-Hill, Primis, ISBN: 0-390-86122-7, 1997</p> <p>R.C. Gonzalez, R.E. Woods, Digital Image Processing, Prentice-Hall, Inc., Upper Saddle River, New Jersey, ISBN: 0-201-18075-8, 2001</p> <p>C.C. Aggarwal, Neural Networks and Deep Learning - A Textbook, Springer, Cham, Switzerland, ISBN: 978-3-319-94462-3, 2018</p> <p>Slides and support material from the lecturer</p>
Examination method	Final examination in class