DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 35TH CYCLE

Title of the research activity:	**Data analysis and processing for smart sensing in advanced manufacturing** Development of data analysis and processing solutions to power smart sensors for manufacturing process monitoring, part quality inspection and adaptive process optimization
State of the Art:	The introduction of advanced manufacturing technologies in production scenarios aiming to conform to the Industry 4.0 paradigm calls for a tighter integration between manufacturing machines, and promotes the adoption of smart technologies for process monitoring, optimisation and continuous part quality inspection. In such scenarios, smart sensors, i.e sensor-based solutions capable of automated interpretation of measured data, play a crucial role. Intelligent imaging devices, for example, can better intepret acquired data (scene understanding) and help detect the insurgence of part quality of process-related issues as early as possible during fabrication. Advances in knowledge modelling, automated reasoning and decision making and data/signal/image processing are at the core of smart sensing. Solutions based on combining deep learning and advanced statistical modelling are gaining traction for application in manufacturing process monitoring. Multi-sensor data fusion, i.e. the synergistic aggregation of heterogenous sensor information is also showing considerable promise.
Short description and objectives of the research activity:	The research project will investigate the combined use of mathematical/statistical modelling, machine learning, and advanced data/image/signal processing technologies to develop the computational core of smart sensing solutions applicable to manufacturing process monitoring and optimisation, and part quality inspection. Solutions will be developed to target a range of advanced manufacturing processes including additive technologies. As the focus is on data analysis/processing, existing sensor technologies will be adopted to generate data. Priority will be given to image-based sensors (2D and 2.5D) and point-cloud scanning sensors. The following research themes will be pursued: - automated scene understanding from measured data: scene decomposition from image and point-cloud data; algorithmic identification, characterisation and classification of objects and features in the scene via statistical shape modelling and machine learning.

	- knowledge-driven machine reasoning based on combining sensor data and mathematical models/ simulations of the manufacturing process for more effective and efficient interpretation of measured data. - multi-sensor data fusion to combine heterogeneous data sources from multiple sensors performing process and part quality monitoring: statistical modelling and machine learning for data mining to identify effective and parsimonious performance indicators and characteristic patterns predicting insurgence of part or process quality issues. The developed data analysis and processing solutions will be validated on a selected set of test cases.
Bibliography:	1) W. Gao, H. Haitjema, F.Z. Fang, R.K. Leach, C.F. Cheung, E. Savio, J.M. Linares, On-machine and in-process surface metrology for precision manufacturing, CIRP Annals,2019, https://doi.org/10.1016/j.cirp.2019.05.005. 2) S.K. Everton, M. Hirsch, P. Stravroulakis, R.K. Leach, A.T. Clare, Review of in-situ process monitoring and in-situ metrology for metal additive manufacturing, Materials & Design, 95, 2016, https://doi.org/10.1016/j.matdes. 2016.01.099. 3) A. Weckenmann, X. Jiang, K.D. Sommer, U. Neuschaefer-Rube, J. Seewig, L. Shaw, T. Estler, Multisensor data fusion in dimensional metrology, CIRP Annals, 58, 2009, https://doi.org/10.1016/j.cirp.2009. 09.008. 4) B.M. Colosimo, M. Pacella, N. Senin, Multisensor data fusion via Gaussian process models for dimensional and geometric verification, Precision Engineering, 40, 2015, https://doi.org/10.1016/j.precisioneng.2014.11.011.
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