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**M.Sc. thesis proposal with international collaboration**

**(in collaboration with CNR and CERN)**

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| **Title** | Artificial Intelligence-Based Prescriptive Maintenance by Federated Learning |
| **Motivations and objectives of the research** | Prescriptive Maintenance (PM) in Industry 4.0 amounts to detecting the onset of anomalous conditions, diagnosing their causes, predicting the remaining useful life of the machinery and proactively managing its failures. The outcomes of these tasks are used to guide maintenance strategies for increasing productivity, optimizing operation, reducing lifecycle costs, extending operating periods between maintenance and reducing downtimes due to unanticipated failures.  The integration of a new generation of Internet-of-Things enabled machinery, supporting advanced Machine Learning (ML) and communication tools, is a key opportunity for PM.  Recently, ML has witnessed a major shift from the “big-data” paradigm, in which data are collected, stored, and processed on a data center, towards distributed or “federated data” paradigms, in which devices cooperate to process their data at the edge of the network. The emerging Federated Learning (FL) technology leverages federations of devices that are cooperating for training a machine learning model. FL addresses the issues of decision making at the asset level and data ownership, since the data used for model training never leave the industrial equipment responsible for its production.  The objective of the thesis work is the development of federated learning methods for the prediction of the remaining useful life of industrial machineries. FL technology allows the networked machinery to identify the optimal prescriptive operation and maintenance policy at the asset level, based on the failure time predictions obtained at the components level.  The goal is to showcase the benefits of the technology based on an evolved implementation of an existing FL platform. Case study based on synthetic and real data will be considered. The thesis will be developed in collaboration with CERN where the master thesis student could stay for some periods |
| **Activities** | * Initial study of the federated learning methods (literature review, theory, algorithms and communication models); * Analysis of possible solution methods for the machinery prescriptive maintenance; * Selection of the most promising solution methods; * Development and implementation of the selected FL methods; * Application to selected case studies. |
| **Academic collaborations** | CERN, the European Organization for Nuclear Research, Geneva, Switzerland  [CNR,](https://www.researchgate.net/institution/Federal_University_of_Pernambuco) Consiglio Nazionale delle Ricerche, Italy |
| **Required competencies and skills** | * Interest in developing innovative Artificial Intelligence algorithms for complex systems (e.g., cryogenic system of the CERN LHC), * Interest in implementing of the methods explored in Python, Matlab or C |
| **Composition of the research group** | * Number of Full Professors: 2 * Number of PhD students: 1 |
| **Name of the research director** | Enrico Zio |
| **Email address** | Prof. Piero Baraldi: piero.baraldi@polimi.it  Dr. Stefano Savazzi: stefano.savazzi@cnr.it  Prof. Enrico Zio: enrico.zio@polimi.it |
| **Web page** | lasar.polimi.it |
| **Duration of the dissertation** | |
| **Total thesis duration** | 8 - 10 months. At most 1 pending exam |