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Postdoctoral fellowship

Feature engineering of experimental datasets

– Machine learning for tailoring microstructures –

The postdoctoral researcher will be part of the team of the MAMIE NOVA (**M**achine le**A**rning for **MI**crom**E**chanics: a **NOV**el **A**pproach) project granted by the ANR (***A**gence **N**ationale de la **R**echerche*: National Agency for Research).

The ultimate objective of materials science is to be able to adapt microstructures to reach desired properties. However, no consistent constitutive models were made to date essentially because of the need to statistically link the microscopic and macroscopic scales. In this project, we propose an original methodology whereby a crystalline plasticity code will be coupled to a supervised learning algorithm to obtain a system capable of suggesting the distribution of operating mechanisms in a polycrystal with its microstructural parameters in order to obtain desired macroscopic mechanical properties. This new model resulting from the learning process will be instructed from a large set of experimental data obtained by scanning electron microscopy (SEM) and translated into an input-output system. MAMIE NOVA project will have a major impact in current societal issues by enabling energy savings and limited costs associated with the tuning of microstructures targeting specific mechanical performances.

Supervised deep learning based on classification and/or regression is a machine learning approach known for being very efficient for treating numerical data. At first time, we will focus on the prediction of fundamental deformation mechanisms with respect to the specimen microstructure. It requires, on one hand, to identify the relevant input and output variables, and on the other hand a classifier. During the learning phase, the classifier will be trained to match at best the outputs, experimentally measured.

Extracting relevant information from datasets (*i.e.* feature engineering) is necessary for training the classifier. It consists in transforming experimental data into useful information for the classifier. Our strategy is to use a combination between *in-situ* macroscopic uniaxial deformation testing [1], to obtain macroscopic data of a bulk polycrystalline sample, with *in-situ* SEM characterizations by Electron BackScatter Diffraction (EBSD), High-Resolution EBSD (HR-EBSD) and Electron Channeling Contrast Imaging (ECCI) [2-4]. The main advantage of the SEM is its ability to acquire a relatively large amount of data (several thousands of points) over a bulk specimen and over large regions (~ mm^2) [5].

[1] M. Ben Haj Slama, N. Maloufi, J. Guyon, S. Bahi, L. Weiss, A. Guitton; MATERIALS, 2019, 12 (15), 2479
[2] C. Ernould, B. Beausir, J.J. Fundenberger, V. Taupin, and E. Bouzy; ACTA MATERIALIA, 2020, 191, 121-148
[3] H. Kriaa, A. Guitton, N. Maloufi; SCIENTIFIC REPORTS, 2017 (9742)
[4] M. Ben Haj Slama, V. Taupin, N. Maloufi, K. Venkatraman, A.D. Rollett, R.A. Lebensohn, S. Berbenni, B. Beausir, A. Guitton; MATERIALIA, 2021, 100996
[5] K. Venkatraman, M. Ben Haj Slama, V. Taupin, N. Maloufi, A. Guitton; MODELLING AND SIMULATION IN MATERIALS SCIENCE AND ENGINEERING, 2021, 29 (5), 055014

Your skills

Required: Excellent knowledge in materials science and mechanics, including plasticity. Experience in characterization of microstructures by scanning electron microscopy.

Beneficial: Experience with computation languages (python, MatLab…). Knowledge in the development of cutting-edge techniques.

We offer

18 months full-time contract (starting from 01/01/2023) including health care, paid holidays. Dynamic international environment. Close supervision by senior scientists. Opportunity to develop experimental and numerical skills (microstructures characterizations, machine learning, deep learning…) to foster a career in academia or industry.

The team of MAMIE NOVA is composed by researchers from 3 French labs: LEM3, UMET and LORIA

Dr. Antoine GUITTON (PI), associate professor HdR, expert in microscopy and materials plasticity. [www.antoine-guitton.fr]
Dr. Vincent TAUPIN, CNRS research scientist HdR, expert in continuum modeling of materials mechanics.
Dr. Benoît BEAUSIR, associate professor, expert in microstructure characterization [www.atex-software.eu].
Dr. Alexandre MUSSI, associate professor HdR, expert in tomography by transmission electron microscopy.
Dr. Lydia BOUDJELOUD-ASSALA, associate professor HdR, expert in machine learning and data mining.
Dr. Frédéric PENNERATH, associate professor, expert in statistical modeling, neural networks, and Bayesian deep learning.
Dr. Brieuc CONAN-GUEZ, associate professor, expert in data mining and neural networks.
Dr. Amedeo NAPOLI, emeritus CNRS research scientist, expert in data mining and machine learning.
2 doctoral researchers and 1 postdoctoral researcher.

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Host laboratory of the postdoctoral researcher

The LEM3 laboratory (***L**aboratoire d'**É**tude des **M**icrostructures et de **M**écanique des **M**atériaux*) is a French laboratory located in Metz. As an interdisciplinary research center, the LEM3 combines solid mechanics, metallurgy, materials science, chemistry and physics. The scientific excellence of the laboratory is acknowledged by internationally recognized researchers and the combined authority of the CNRS, the Université de Lorraine and the engineering school "Arts et Métiers". The LEM3 is part of the Carnot Institute ARTS, the DAMAS laboratory of excellence (*LabEx*) and currently employs more than 250 persons.

Application

Please send a **detailed CV** and an **application letter** to the **two emails** indicated in the header. There is no need to join recommendation letter, but please **indicate the contact information for references**.

Application without enclosures mentioned may not be accepted.