

Postdoctoral fellowship

Feature engineering of experimental datasets

– Machine learning for tailoring microstructures –

Description of the postdoctoral work:

The postdoctoral researcher will be part of the team for the MAMIE NOVA (**M**achine **L**e**A**rning for **M**icrom**E**chanics: A **NO**VEL Approach) project, which is funded up to 610 k€ by the ANR (National Agency for Research) over 48 months.

The goal of materials science is to be able to adapt microstructures to achieve desired properties. However, no consistent constitutive models have been developed to date, primarily due to the need to statistically link the microscopic and macroscopic scales. In this project, we propose an innovative methodology that involves coupling a crystalline plasticity code with a supervised learning algorithm to create a system that can suggest the distribution of operating mechanisms in a polycrystal based on its microstructural parameters to achieve desired macroscopic mechanical properties. This new model, which is derived from the learning process, will be trained using a large set of experimental data obtained through scanning electron microscopy (SEM) and translated into an input-output system. The MAMIE NOVA project will have a significant impact on current societal issues by enabling energy savings and reducing the costs associated with tuning microstructures to achieve specific mechanical performance.

Supervised deep learning, which is based on classification and/or regression, is a machine learning approach that is known for its efficiency in handling numerical data. Initially, we will focus on predicting fundamental deformation mechanisms in relation to the specimen microstructure. This requires identifying relevant input and output variables, as well as a classifier. During the learning phase, the classifier will be trained to achieve the best match for the experimentally measured outputs. Extracting relevant information from datasets (i.e. feature engineering) is necessary for training the classifier. This involves transforming experimental data into useful information for the classifier. Our strategy is to use a combination of in-situ macroscopic uniaxial deformation testing [1] to obtain macroscopic data from a bulk polycrystalline sample and 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 SEM is its ability to acquire a relatively large amount of data (several thousands of points) over a bulk specimen and over large regions ($\sim \text{mm}^2$) [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

The following qualifications are required:

- Excellent knowledge in materials science and mechanics, including plasticity.
- Experience in characterizing microstructures using scanning electron microscopy
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The following qualifications are beneficial:

- Experience with programming languages such as Python and MatLab.
- Familiarity with the development of advanced techniques

We offer

18-month full-time contract (starting immediately) with benefits including health care and paid holidays. Dynamic international work environment. Direct mentorship by experienced scientists. Opportunity to gain expertise in experimental and numerical techniques such as microstructure characterization, machine learning, and deep learning, to support career growth in academia or industry. The gross salary for the position is approximately 2825 €/month¹.

¹ The median gross salary in France is 2500 €/month (source: French Ministry of Employment, <https://code.travail.gouv.fr/outils/simulateur-embauche>).

The team of MAMIE NOVA includes:

- **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 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.

Additionally, the team includes two doctoral researchers.

Host laboratory of the doctoral researcher:

The LEM3 laboratory (*Laboratoire d'Étude des Microstructures et de Mécanique des Matériaux*: Laboratory of Study of Microstructures and Mechanics of Materials) is a joint research center of the Université de Lorraine, the French National Center for Scientific Research (CNRS), and the engineer school Arts et Métiers. LEM3 is one of the largest research institutes for the physics of materials and engineering in France. It is located in Metz, near the tripoint along the junction of France, Germany, and Luxembourg, and forms a central hub for science in Europe. Over 250 scientists from France and around the world work at LEM3 to perform world-class research in materials science, mechanics, and processes. By conducting both fundamental and applied research, researchers at LEM3 work on long-term solutions for the major challenges facing society, industry, and science.

Advantages of working at the LEM3:

As a valued member of our team, you will have access to a comprehensive social protection system in France as a foreign worker, including:

- **Universal healthcare coverage:** Universal healthcare coverage: Our comprehensive healthcare system ensures that all necessary medical treatments, including doctor visits, prescription drugs, and hospital stays, are covered with a reference reimbursement rate of around 90% on average thanks to the Alsace/Moselle local regime (compared to 70% in the other regions of France).
- **Generous annual paid leave:** Take advantage of the LEM3's generous annual leave policy, which allows you to take up to 45 days of annual leave to recharge and rejuvenate.
- **Retirement pensions:** Contribute to the French retirement system and enjoy a pension when you reach retirement age.
- **Unemployment benefits:** If you lose your job, you may be eligible for unemployment benefits to help you cover your expenses while you search for new employment.
- **Sickness benefits:** If you are ill or injured, you may be eligible for daily sickness benefits to cover your lost income.
- **Maternity, paternity, and family leave:** Take time off to care for your family and bond with your new child.
- **Professional training and development opportunities:** Take advantage of the many professional training and development opportunities available in France, to improve your skills and advance your career.
- **Free education:** Education is free in France for children up to 18 years old.
- **Personalized housing allowance:** Assistance for housing costs for low-income individuals.
- **Participation in your public transportation subscription:** 50% of your subscription fees for home-work journeys on public transportation will be supported by the Université de Lorraine.

It is important to note that the level of financial assistance provided by the state may vary depending on your income and the composition of your household.

- **Opportunity for teaching:** There may be the opportunity for you to teach at the Université de Lorraine, which includes an additional salary for this responsibility.
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Application:

Please send a detailed CV and a cover letter to the email addresses provided in the header. Recommendation letters are not required, but please include the contact information of your references.

Applications without the requested attachments may not be considered.