



COPIL n°4 chaire BIGMECA, 13 janvier 2021 ■■

■ Mécanique des matériaux et des procédés de fabrication via l'apprentissage statistique

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SAFRAN

Ordre du jour

- 1 Dernières nouvelles des études en cours
- 2 Semaine de cours CVML fevrier 2021
- 3 Collaborations internationales
- 4 Dissémination

Plan

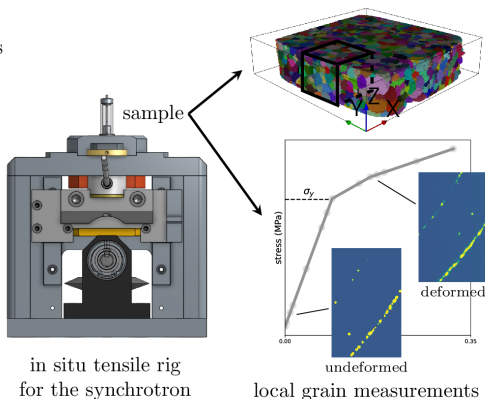
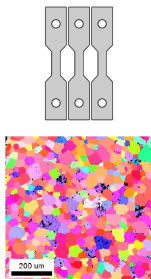
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Statistical 4D tomography of polycrystalline materials

PhD thesis Clément Ribart 2019-2022

- develop **4D tomography** at the Psiché beamline (SOLEIL)
- automation of the chain in situ 4D → **simulation** at the scale of the microstructure ($10^4 - 10^5$ grains)
- leverage **machine learning** analysis of deformation and failure mechanisms.

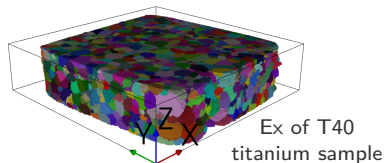
small Zr or Ti samples
(50 μm grain size)



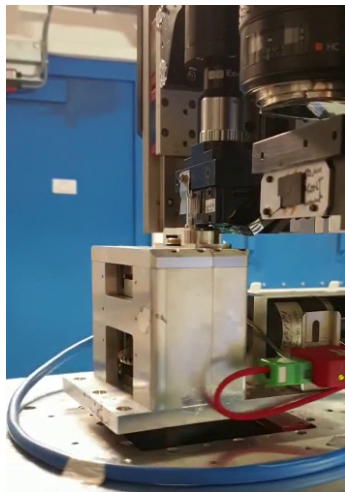
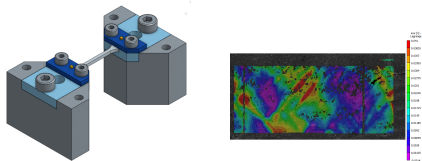
Statistical 4D tomography of polycrystalline materials

PhD thesis Clément Ribart 2019-2022

- *in situ* DCT now available at Psiché (including reconstruction machine)
- series of 4D experiments in March 2020 (2 To of data) and upcoming in July 2021

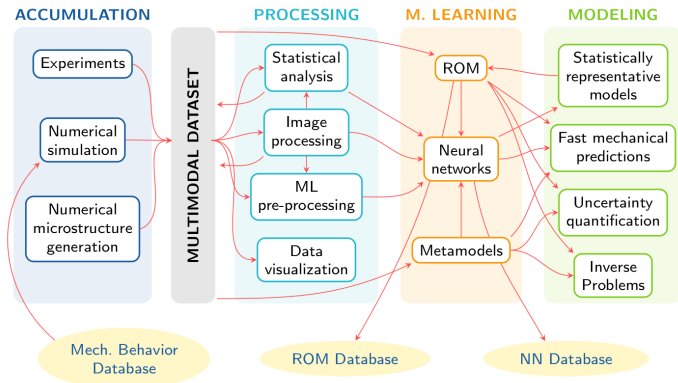


- new SEM *in situ* testing available



in situ testing machine Bulky
running at Soleil
[Pelerin et al., 2019]

Rapport et premiers développements de la plateforme de données BIGMECA (travaux Aldo Marano)

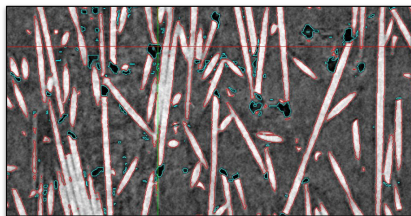
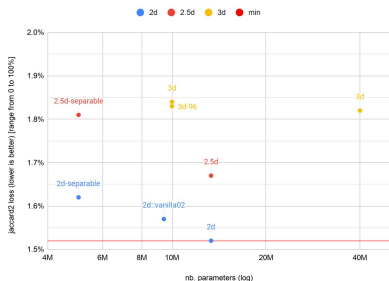


- Bibliographic report, first release in November 2020
- Applications : image based modelling, uncertainty propagation, digital twins for predictive maintenance
- GENCI project on *Massive uncertainty propagation in crystal plasticity for 4D mechanical testing analysis*

Automated tomographic segmentation using CNN

Work of Joao Bertoldo, collaboration with E. Decencière CMM

validation loss vs. nb. parameters



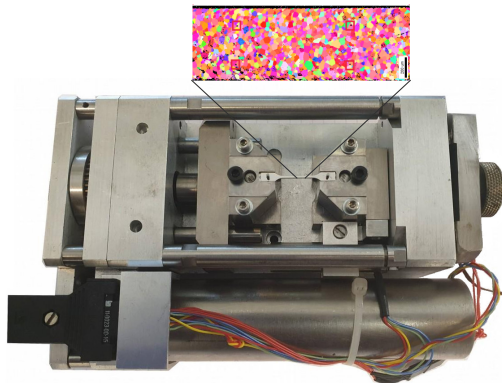
red: fiber

blue: porosity

- U-net-based architecture
- Different convolution types tested
- 2D convolutions yield lower losses on unseen data
- Image \rightarrow segmentation mapping overall well learned in general
- Model convergence \sim 5 hours
- Using separable convolutions reduces 60% of parameters at a low performance cost
- Results are comparable to human segmentation precision

Projet DMS de Kenza Zougagh

Identification of crystal plasticity constitutive behaviour using local characterization methods



SEM in situ tension
at Centre des Matériaux



Nano-indentation
at SafranTech

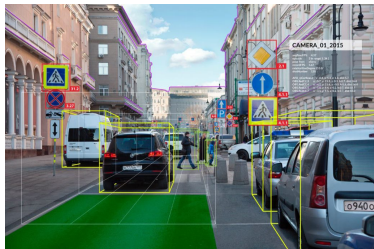
Advising team

H. Proudhon & C. Ribart (CDM), S. Gourdin & F. Coudon (Safran)

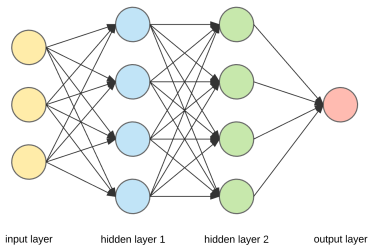
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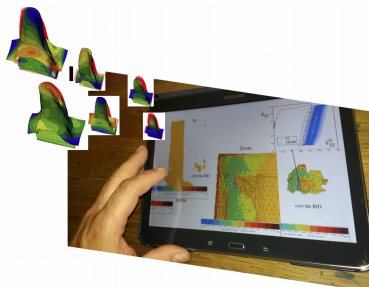
Computer vision and machine learning for the material scientist



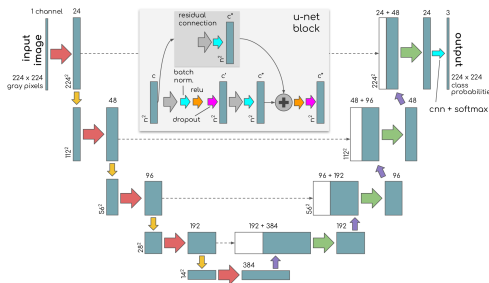
machine vision



neural network



meta model



semantic segmentation

CVML : February 2021 schedule

Monday	Tuesday	Wednesday	Thursday	Friday
Computer vision (HP), industrial intro (EDF)	Machine learning 2 (HP)	Meta model 2 (PK)	Deep learning (HP)	Yolo : real time object detection (BF)
Tutorial classification k-NN (HP, AM)	Tutorial machine learning 2 (HP, AM)	Tutorial meta model 2 (PK, AM)	Tutorial deep learning (HP, AM)	Tutorial Yolo (BF)
Machine learning 1 (HP)	Meta Model 1 (PK)	Introduction to neural networks (HP)	Convolutional neural nets (HP)	CNN for Semantic segmentation (JCB)
Tutorial machine learning 1 (HP, AM)	Tutorial meta model 1 (PK, AM)	Tutorial neural networks (HP, AM)	Tutorial CNN (HP, AM)	Written exam

Equipe pédagogique 2021 Henry Proudhon, Aldo Marano, Pierre Kerfriden, Bruno Figliuzzi, Joao Casagrande Bertoldo.

Travaux pratiques avec Python sous jupyter ou Google collab.

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Collaborations internationales

- **Samantha Daly** (UCSB, USA), visite de H. Proudhon en février 2020. Interêts convergents, séminaire interne en janvier 2021, échange de techniques expérimentales en cours (nano-speckle)
- **Stefan van der Walt** (BIDS, USA), visite de D. Ryckelynck en février 2020 → proposition d'envoyer A. Marano 3 mois à Berkeley
- **Stephen Hall** (Univ Lund, Sweden) → séjour de Clément Ribart pour des expériences de tomographie (Novembre 2020 retardé à cause de la crise sanitaire).
- **Matti Lindroos** (VTT, Norway) → expériences au synchrotron en mars 2020 sur matériau HEA fourni par VTT
- **Peter Reischig** (InnoCryst, UK) → may join the project for 2 months to work on installing the DCT code at Psiché

Colloque international sur la mécanique du polycrystal

2 jours, 18 orateurs invités de classe internationale, 4 thèmes

- Tresa Pollock (UCSB)
- Fion Dunne (Imperial College)
- Albrecht Bertram (TU Berlin)
- Matti Lindroos (VTT)
- Stéphane Berbenni (Univ Lorraine)
- Fabrice Barbe (INSA Rouen)
- Jonathan Cormier (ENSMA)
- Lionel Gelebart (CEA)
- Romain Quey (EMSE)
- Thomas Antretter (Univ Leoben)
- Wolfgang Ludwig (ESRF)
- Hugh Simons (Denmark TU)
- David Ryckelynck (MINES ParisTech)
- Ludovic Thilly (Institut P')
- Arjen Roos (Safran)
- Cecile Miller (EDF)
- Samantha Daly (UCSB)
- Henry Proudhon (MINES ParisTech)

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Conférences à venir

- 28 janvier 2021 H. Proudhon, GT Mecamat *Combining 3D experiments and crystal plasticity simulations with machine learning to predict short fatigue crack growth*
- 01 février 2021 H. Proudhon, 5th Annual Workshop on Advances in X-ray imaging *Advancement in the understanding of plasticity via in situ synchrotron methods*
- 04 février 2021 J. Bertoldo ISIS, workshop *Deep learning for automated segmentation of tomographic images*
- fin juin 2021 C. Ribart, 3DMS conference *Statistical Analysis of Crystal Plasticity on Commercially Pure Titanium by Coupling 4D Testing and Finite Element Simulations*
- septembre 2021 D. Ryckelynck, Mechanistic Machine Learning and Digital Twins for Computational Science, Engineering & Technology *Transfer learning via Rom-nets in mechanical engineering*



Pelerin, M., Laiarinandasana, L., King, A., and Proudhon, H. (2019).

Development of a versatile mechanical testing device for in situ synchrotron tomography and diffraction experiments.

Integrating Materials and Manufacturing Innovation, 8(3) :378–387.