Title

Towards digital twin of laser metal 3D printing: Combining machine learning-accelerated multiphysics model with Bayesian inference methods and benchmark experiments to extract unknown material properties and model parameters

Description and objectives

Laser processing and laser metal 3D printing in particular is a critical part of medical, automotive, space, electronic, and many other economically significant industries. Its on-growing importance requires fast and accurate multiphysics modeling and process optimization for every new material, which would reduce experimental efforts and ensure the high quality of the produced parts. In the Modeling&Simulations group at Empa-Thun, we perform cutting-edge research on designing multiphysics models for laser 3D printing of metals, running them on one of the best supercomputers in the world, accelerating them with machine learning tools, and applying Bayesian inference to extract missing model parameters from in-house benchmark experiments on state-of-the-art metal 3D printers installed at Empa-Thun. In this project, you will combine all the workflows developed in our group into one coherent digital twin of the copper 3D printing with the green laser. As the first step in the project, you will work on data acquisition by performing real experiments and analyzing samples with the help of several experts in the laboratory for Advanced Materials Processing. Please note that not less than 6 months of dedicated work is required for the successful completion of this project.

Workplan

As a part of an interdisciplinary team, you will be involved in interdisciplinary research, being on the edge of three fields simultaneously. Firstly, you will get in touch with several critical laser processing technologies such as laser welding, laser metal deposition, and selective laser melting. Secondly, you will get insights into physical modeling with the latest mathematical developments for the multiphysics simulations running them on CSCS - one of the best supercomputers in the world. Finally, you will use machine learning and Bayesian inference methods to analyze experimental and simulation data in one coherent workflow.

To achieve the project goals, you will be in close interaction with different specialists, involved in i) development of artificial intelligence applications, ii) laser processing simulations and iii) experimental work for investigation of different laser processing physical phenomena using state of the art equipment. Your main activity is to unify that knowledge within a single digital twin of Cu processing with the green laser.

Required skills

The applicants have to be familiar with the basics of machine learning, uncertainty propagation, Gaussian processes, and Bayesian inference. The knowledge of differential calculus (in the particular numerical solution of partial differential equations), as well as a basic understanding of finite element and finite volume methods, are required for project execution. This project assumes intense programming and integration of already developed code within a single framework using Python, requiring good knowledge and prior experience with the corresponding Python tools. A basic understanding of laser-matter interaction and interest in performing supporting benchmark experiments are essential for the execution of the first stage of the project.

Languages

English (Advanced)

Location

Empa Thun

Remark

This work is a part of intensive research in intelligent industrial automation that aims to develop digital twins for laser material processing. More details about current activities can be found on the group webpage:

https://www.empa.ch/web/s204/modeling-simulations

The technical details of the project can be discussed with Dr. Vladyslav Turlo vladyslav.turlo@empa.ch

Related masters

Electrical and electronic engineering	Mathematics
Mechanical engineering	Applied mathematics
Microengineering	Computational science and engineering
Materials science and engineering	Physics
Computer science	Applied physics
Data science	Related masters