



Offer #2022-05425

Post-Doctoral Research Visit F/M Multi criterion optimization for FDM 3D printing

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

About the research centre or Inria department

The Inria Rennes - Bretagne Atlantique Centre is one of Inria's eight centres and has more than thirty research teams. The Inria Center is a major and recognized player in the field of digital sciences. It is at the heart of a rich R&D and innovation ecosystem: highly innovative PMEs, large industrial groups, competitiveness clusters, research and higher education players, laboratories of excellence, technological research institute, etc.

Context

3D printing using fused filament deposition (FDM) [1] has many fields of application including prototyping, maintenance and custom manufacturing. Recently, during COVID, large-scale emergency production of innovative solutions for crisis situations has been made possible by this technology, which is easily deployable and allows on-site production.

Within the Ofast3D exploratory project, we aim to increase the production capacity of players using 3D printing by fused filament deposition without modifying their infrastructures. This project is a collaboration between the PACAP team for the compilation and optimization aspects for performance, MFX for its experience in 3D printing and MimeTIC for the planning and scheduling aspects.

The 3D printing process includes several steps including the 3D modeling of the object to be printed, the slicing of this object (including the addition of material to ensure physical properties of flexibility or robustness) via dedicated software. At the end of the slicing process, a g-code that describes the displacement of the nozzle during the printing of the object is generated. This g-code is then interpreted by the firmware of the machine in order to print the final object. Each link of this chain has an impact on the printing time but also on the final quality of the print. For complex objects the printing time can reach several hours or even days.

Main activities

In this postdoc we want to focus on the optimization of printing time through the management / modification of the nozzle trajectory. This trajectory is originally determined by the slicer and a number of works have already demonstrated that it is possible to propose strategies that improve the trajectories with regards to the reduction of printing time [2,3,4,5,6,7,9]. However, these works do not take into account the nature of the printed elements and thus do not take into account the printing quality. Moreover, the optimization strategy itself is hardly parameterizable.

Our ambition is to propose a new formulation of the optimization problem that would lead to the proposition of a fully configurable optimization algorithm. A user could then sketch optimization strategies specific to his machine and/or his needs. This would allow to optimize the printing times according to the characteristics of the target machine while taking into account the notion of quality (to authorize to degrade the quality or on the contrary to reinforce it) [8]. We also want, thanks to our collaboration with the MFX team, to explore the relationship between the optimization process and the slicer in order to determine if the optimization could guide the slicer in its choices upstream of the trajectory generation.

Within the project, we already have a g-code compiler at our disposal. This compiler is able to extract information on the nature of the printed elements and abstracts the user from the g-code to be able to focus on the optimization of the nozzle trajectory. We have already been able to test a few algorithms that are promising. We also have an experimentation platform composed of several 3D printers to perform test benches. The postdoc will work in collaboration with researchers of the different teams of the Ofast3D project as well as with the two engineers associated with the project.

References

[1] Livesu, Marco and Ellero, Stefano and Martínez, Jonàs and Lefebvre, Sylvain and Attene, Marco *From 3D models to 3D prints: an overview of the processing pipeline*. Computer Graphics Forum 36(2), 2017.

- [2] Kai-Yin Fok, Nuwan Ganganath, Chi-Tsun Cheng, Herbert Ho-Ching Iu, Chi K. Tse. *A Nozzle Path Planner for 3D Printing Applications*. IEEE Transactions on Industrial Informatics 99 (2019)
- [3] Kai-Yin Fok, Chi-Tsun Cheng, Chi K. Tse, Nuwan Ganganath. *A Relaxation Scheme for TSP-based 3D Printing Path Optimizer*. International Conference on Cyber-Enabled Distributed Computing and Knowledge, 2016.
- [4] Kai-Yin Fok, Chi-Tsun Cheng, Chi K. Tse. *A Refinement Process for Nozzle Path Planning in 3D Printing*. IEEE International Symposium on Circuits and Systems (ISCAS), 2017.
- [5] Samuel Lensgraf, Ramgopal R. Mettu. An Improved Toolpath Generation Algorithm for Fused Filament Fabrication. IEEE International Conference on Robotics and Automation (ICRA), 2017.
- [6] Samuel Lensgraf, Ramgopal R. Mettu. Beyond Layers: A 3D-Aware Toolpath Algorithm for Fused Filament Fabrication. IEEE International Conference on Robotics and Automation (ICRA), 2016.
- [7] Chanyeol Yoo¹, Samuel Lensgraf², Robert Fitch¹, Lee M. Clemon¹, Ramgopal Mettu³. *Toward Optimal FDM Toolpath Planning with Monte Carlo Tree Search*. IEEE International Conference on Robotics and Automation (ICRA), 2020.
- [8] Jingchao Jiang¹, Yongsheng Ma. Path planning strategies to optimize accuracy, quality, build time and material use in additive manufacturing: a review. Micromachines 11(7), 2020.
- [9] Manuel Iori and Stefano Novellani. Optimizing the Nozzle Path in the 3D Printing Process. Lecture Notes in Mechanical Engineering, 2019.

Skills

Profile / competences

This position requires a strong background in algorithmics (graphs, travelling salesman problem, rural postman problem...) and some knowledge in motion planning would be appreciated.

Technical skills and level required:

- Proficiency in algorithmics especially about the travel salesman problem and the rural postman problem is required
- Knowledge in motion planning is a plus
- Knowledge in 3D computer graphics is a plus
- Proficiency in modern C++ language is required
- Knowledge in Lua is a plus
- Understanding compiler infrastructure is a plus
- Knowledge in FDM 3D printing is a plus
- Languages: English (read, written, spoken)
- Relational skills: ability to work in a team

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking (90 days per year) and flexible organization of working hours
- partial payment of insurance costs

Remuneration

monthly gross salary amounting to 2746 euros

General Information

- **Theme/Domain** : Optimization and control of dynamic systems
Scientific computing (BAP E)
- **Town/city** : Rennes
- **Inria Center** : [Centre Inria de l'Université de Rennes](#)
- **Starting date** : 2023-09-01
- **Duration of contract** : 1 year, 6 months
- **Deadline to apply** : 2023-09-30

Contacts

- **Inria Team** : [PACAP](#)

- **Recruiter :**
Hardy Damien / Damien.Hardy@irisa.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Please submit online : your resume, cover letter and letters of recommendation eventually

For more information, please contact damien.hardy@irisa.fr ou fabrice.lamarche@irisa.fr

Defence Security :

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :

As part of its diversity policy, all Inria positions are accessible to people with disabilities.