Internship in ESA's Advanced Concepts Team
On

Exploring Neural Network Approximators For Non-vectorizable Linear Algebra Operations

European Space Research and Technology Centre
ESA ESTEC

Candidates interested are encouraged to visit the ESA website:
www.esa.int/gsp/ACT/

Topic description

Upcoming spacecraft are increasingly likely to feature computational units for machine learning applications which are typically particularly efficient for highly parallel computations. However, many classical numerical algorithms are not targeted at this hardware. Hence, it is of great interest to ESA to investigate neural network approximators for these operations which are ideal for this upcoming hardware. Recently, differentiable computing has become virtually ubiquitous. Several libraries, such as PyTorch, Tensorflow or JAX, enable performing linear algebra operations fully differentiably. Some operations, such as matrix inversion, eigenvalue computation or linear system solver algorithms, are often iterative and difficult to vectorize efficiently on GPUs and specialized machine learning hardware. Hence, it would be of interest to investigate, if it is possible to train neural network approximators for these operations to serve as efficient surrogate models. The topic has received some attention before in the 90s [1,2] and 2000s [3,4] but not since recent breakthroughs in machine learning.

This project is particularly promising as, even if the achieved numerical accuracy may be insufficient or too unstable for a utilization in numerical solvers, it can still be used in neural network training in several ongoing projects [5,6].

Candidate's tasks

- Pick the most promising target operations (matrix inversion, eigenvalue computation, linear solver, ...)
- Create a training dataset using linear algebra libraries
- Design a neural network for the task
- Train, test & reiterate in e.g. Jupyter notebook or similar
- Publish open source code with appropriate documentation and datasets

References

[1] - https://www.sciencedirect.com/science/article/abs/pii/0096300393900072
[2] - https://link.springer.com/article/10.1007/BF00201437
[3] - https://www.sciencedirect.com/science/article/pii/S0898122104901101
[4] - https://ieeexplore.ieee.org/abstract/document/1528525
[5] - https://www.esa.int/gsp/ACT/projects/radiflector_OSR_inverse_design/
[6] - https://www.esa.int/gsp/ACT/projects/geodesy/