Internship at CEA Saclay 2023

Implicit neural representations (INRs) via spatially localized Fourier-type features

Keywords: neural networks, Fourier analysis, medical imaging, inverse problems

Implicit Neural Representations (INRs) recently reached the state-of-the art progress in a number of computer vision tasks (e.g., 2D-3D supervision, reconstructions of 3D scenes (neural radiance fields), a number of tomographical applications); see e.g., [Be+22], [Zh+22], [Ta+20], [Va+22]. The core of the method is to encode (via weights) a function into a network which then takes points of the domain on input and returns the value of the signal on output [Va+22]. When the space of functions represented by a network encodes some Fourier features (e.g., periodic functions with different frequencies) the network is able to learn high frequencies of the signal; see e.g., [Be+22]. Yet, in many applications signals are not periodic and spatially localized, therefore Fourier representation is not optimal for such tasks and other set of basis could be envisaged. For this internship we propose to adapt to INRs other Fourier-type basis but with better spatial localizaton.

Plan of work: Contract for the internship can last up to 6 months. First, we will begin with implementing toy-examples of INRs (mostly existing ones) and then will try to proceed with some new representations. The results are expected to be tested on medical imaging problems (CT, PET or MRI) first on synthetic data and if some time left on the real-data. Me (supervisor) will also actively work on the task, so it will be possible to concentrate either on the implementation side or the research side (more theory).

Profile of the candidate: Level M2 with formation in statistics, probability, elements of data analysis as well with good skills in Python programming. Acquataince with elements of deep learning (PyTorch or Tensorflow) is crucial. Prior knowledge of Fourier analysis is a strong plus among other equal points.

Working language: English, French, Russian (at least one)

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References

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[Ta+20] Tancik M., et al. "Fourier features let networks learn high frequency functions in low dimensional domains." Advances in Neural Information Processing Systems 33: 7537-7547, 2020

[Va+22] Vasconcelos F., et al., "UncertaINR: Uncertainty Quantification of End-to-End Implicit Neural Representations for Computed Tomography." arXiv preprint arXiv:2202.10847, 2022