DeepRegul

Titre de la thèse : Regularization with generative neural networks for satellite imaging

Directeur.rice.s de thèse : Thomas Oberlin (DISC), Marie Chabert (IRIT)
Cofinancements déjà sollicités : CNES
Cofinancements envisagés :
Argumentaire demande cofinancement ISAE : c'est un projet de recherche mûri cet été lors de la rédaction de mon HDR, que je soutiendrai le 24/11/2021. Il comporte une vraie part méthodologique en traitement d'images et IA, avec des aspects novateurs, mais aussi une partie applicative. Je pense donc qu'un financement CNES/ISAE est parfaitement adapté pour ce type de sujet. A noter que j'avais envisagé de déposer une ANR JCJC sur ce sujet, mais de nouvelles règles cette année m'ont rendu inéligible.
Thèses actuellement encadrées : 3 (50 %, 50 % et 25%), dont l'une se terminera au printemps.

Candidat.e : nous sommes en train de faire passer des entretiens pour le stage et la thèse, le choix n'est pas encore arrêté. L'offre a été publiée au niveau local comme national (GDR ISIS, MVA), et nous avons reçu de nombreuses candidatures, dont 4 qui nous paraissent de haut niveau : 2 étudiants ISAE parcours SDD, 1 étudiant UPS premier de son master, et une étudiante en double cursus aux Mines de Paris et au MVA.

Sujet de thèse

Deep neural networks achieved a major breakthrough in computer vision in the past decade, enabling a dramatic increase in performance for supervised tasks such as image classification or segmentation. In the last few years, neural networks have also been successfully applied to image processing or reconstruction tasks such as denoising, deblurring, compression, pan-sharpening or super-resolution [3, 2]. The standard approach directly solves the image reconstruction task, by end-to-end training a deep convolutional network on a large amount of data. If a physical model is known (for instance, the point-spread function for the deblurring task), it can be used to simulate the pairs of clean and degraded images. In spite of their impressive performance, such end-to-end approaches can hardly be used in satellite imaging, for at least two reasons. First, such deep architectures are hardly interpretable and exhibit instabilitites, which limit the confidence in the reconstructed image. Second, their training require both a large amount of GPU time and the tuning of numerous hyper-parameters. This is particularly problematic in the context of satellite imaging, since the specificities of the physical model (noise level, PSF, spectral responses) require to retrain the network for each instrument.

More recent works investigated an alternative way, which consists in using well-known model-based inversion, the neural networks being used only for regularization. The seminal work in the literature [1] capitalized on deep generative models, such as variational autoencoders (VAEs) or generative adversarial networks (GANs). It consists in a synthesis regularization, where the solution is searched in the latent space of the generative model. In a recent work [4], we showed that a direct inversion in the image space, termed analysis regularization, can lead to better results, especially in the

ISAE SUPAERO - Institut Supérieur de l'Aéronautique et de l'Espace
10, avenue Edouard-Belin - BP 54032 - 31055 Toulouse CEDEX 4 - FRANCE
Tél : 33 (0)5 61 33 80 80 - Télécopie : 33 (0)5 61 33 83 30 - Site internet : www.isae-supaero.fr

case where the sought image does not exactly lie in the range of the generative model. This will be the case in satellite imaging, where the size, diversity and complex nature of images prevent to learn a generative model that perfectly captures the statistics of the images in the dataset.

The objectives of the PhD are to consolidate and extend the results of [4], to make it cope with the diversity of satellite images. The proposed methods will be adapted and challenged on several real applications in satellite imaging, such as image denoising, compression artefact removal, image deblurring or super-resolution.

References

[1] Bora, A., Jalal, A., Price, E., & Dimakis, A. G. Compressed sensing using generative models. Proc. ICML, 2017.

[2] Cresson, R. Deep Learning for Remote Sensing Images with Open Source Software. CRC Press, 2020.

[3] Kim, J., Lee, J. K., & Lee, K. M. Accurate image super-resolution using very deep convolutional networks. In Proc. CVPR, 2016.

[4] Oberlin, T. & Verm, M. Regularization via deep generative models: an analysis point of view. Proc. ICIP, 2021.