9 MONTHS ENGINEER POSITION

Multiscale non-linear deep learning strategies to increase the spatial resolution of Land Surface Temperature

This project is multidisciplinary and focuses on the development of new non-linear multiscale Deep Learning models for super-resolution of remote sensing images of Land Surface Temperature.

Keywords : Artificial Intelligence; Neural Networks ; Inverse Modelling ; Remote Sensing ; Land Surface Temperature ; Signal and Image processing ; Multiscale analysis ;

1. Context

Nowadays, several operational Land Surface Temperature (LST) products are available but limitations remain, notably because there is still a trade-off between spatial and temporal resolutions. Thermal sensors such as MODIS or Sentinel 3 (1km spatial resolution) provide a high revisit (daily) and ASTER or the LANDSAT series provide a low revisit with high spatial resolution (around 16 days at 90 m and 100 m). Consequently, upscaling the spatial resolution helps improving the data fusion between different sensors, the generation of LST temporal series as well as a finer-scale analysis for different applications such as the monitoring of vegetation stress, forest fires or urban heat islands among others.

A large body of research has addressed this challenge with sharpening or disaggregation methods that are based on statistical relationships between high spatial resolution products and LST at low spatial resolution (Granero-Belinchon et al. 2019). However, these statistical approaches lead to limitations such as the need of high resolution products acquired in the same area and close in time, or scale invariant hypotheses which sometimes are not adapted.

Inspired by the existing research at the interface between AI and remote sensing, new AI-models continue to appear for the processing of spaceborne images, and more precisely for super-resolution applications, notably with CNNs (Convolutional Neural Networks) and GANs (General Adversarial Networks) (Brodu et al. 2017, Gargiulo et al. 2019).

Nguyen et al. 2022 showed that important improvements are still needed to correctly adapt CNNs for LST super resolution to overcome the invariance scale hypothesis and the blurring effect. Thus, the inclusion of a physical information can lead to better performances for LST super resolution.

2. Missions

This proposal focuses on the MODIS sensor due to the large state-of-the-art available on this mission, the dataset already processed by the involved partners and the recent studies on this sensor dealing with the super resolution of its LST previously mentioned.

Following (Brodu et al. 2017) or (Gargiulo et al. 2019), a first approach consists in combining high resolution information in the VNIR domain (NDVI for example) with coarse resolution LST to train the model for super-resolution. We call this approach Dual image super resolution (DISR). The main advantage of this approach is the direct use of high resolution information for upscaling LST.

For Single image super resolution (SISR), learning will be performed at degraded resolution. Thus for example for LST upscaling from 1 km to 250 m, training will be done from 4 km to 1 km. This strategy is commonly used when no ground truth is available at the desired resolution (in our case LST at 250 m), see (Nguyen et al. 2022). Consequently, a scale-invariance hypothesis is assumed, i.e. the learned model from 4 km to 1 km is valid when upscaling LST from 1 km to 250 m. However, scale-invariance is not necessarily exact and so this hypothesis must be corrected. We plan to overcome it by studying the statistical evolution of LST and reflectives indices such as NDVI across the involved scales and different landscapes (a hundred of meters to several kilometers) in order to deduce physical laws allowing us to correct the scale invariance hypothesis of current AI super resolution methods in remote sensing. For doing so, LANDSAT 9 or ASTER data will be used.

2. Eligibility Criteria

Candidates are expected to have good knowledge in Deep Learning/Machine learning with strong experience in Neural Networks. Ideally, the candidate will have previous experience in remote sensing and would have shown strong interest on these topics previously. Good skills in python, pytorch, pytorch lightning are also required, as well as a background in teamwork. Previous experience in a multidisciplinary research team will also be considered as positive.

3. Supervision and research team

The candidate will work in collaboration with Carlos Granero-Belinchon and Lucas Drumetz from IMT Atlantique, Aurélie Michel and Xavier Briottet from Onera Toulouse, Thomas Corpetti from CNRS and Julien Michel from CNES. Thus, the research team is composed by physicist, and researchers on artificial intelligence, signal and image processing and remote sensing from different laboratories, leading to a multidisciplinary project. Moreover, the candidate will develop within the OSE research team at IMT (https://cia-oceanix.github.io/) which is a dynamic research group on image processing and artificial intelligence for the study of the environment.

4. Terms of emplyment

The position is a 9 months full-time appointment starting during 2024. Gross salary will depend on the experience of the candidate. The candidate will also benefit from French social insurance, and will have up to 45 days of annual leave. The candidate will be able to benefit up to 90 days of remote working per year.

The candidate will be based at the IMT Atlantique Campus (Brest) in a dynamic and stimulating working environment at five minutes walking from the beach.

Within the framework of the ANR Chair OCEANIX the candidate will have access to compute servers : Datarmor and servers from OSE at IMT Atlantique.

Motivated candidates should send a CV and a motivation letter to: carlos.granero-belinchon@imt-atlantique.fr.

References

- N. Brodu, "Super-Resolving Multiresolution Images With Band-Independent Geometry of Multispectral Pixels," in IEEE Transactions on Geoscience and Remote Sensing, vol. 55, no. 8, pp. 4610-4617, Aug. 2017, doi: 10.1109/TGRS.2017.2694881.

- Gargiulo, M.; Mazza, A.; Gaetano, R.; Ruello, G.; Scarpa, G. Fast Super-Resolution of 20 m Sentinel-2 Bands Using Convolutional Neural Networks. Remote Sens. 2019, 11, 2635. https://doi.org/10.3390/rs11222635.

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