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Deep learning for the super resolution of SAR images.

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In this study, we are interested in Synthetic Aperture Radar (SAR) data, in particular those captured during campaigns carried out by unmanned aircraft. SAR data is data captured by a radar antenna placed underneath either an aircraft or a satellite and poiting to the sides. The instrument consists of a vertically or horizontally polarised transmitting antenna and a vertically or horizontally polarised measuring antenna. During its flight path, the aircraft emits waves of varying frequency (a chirp) and the backscattered signal conveys information about the reflectivity of the imaged scene (its distance, its velocity, objects). From these measurements, one can for example detect ground movements, detect objects, buildings, segregate land use, etc... In contrast to optical measurements, SAR data can be captured day and night and are not as disturbed as optical measurements ; for example, they can penetrate a cloud layer and, depending on the working wavelength, snow, foliage...

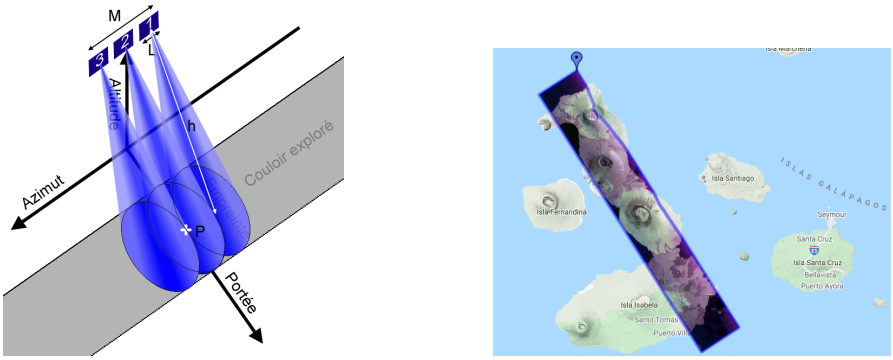

Figure 1 – Principle of SAR measurements during an UAV mission and exemple of a SAR image over the Galapagos islands (JPL 2015).

Subject

We propose to use the data recorded by the Nasa Jet Propulsion Laboratory[1] [1]. In the first phase of the study, we will start from the recorded data, which we will degrade, and we will then try to reconstruct the original full resolution data from the degraded data. In this first part, the SAR data will be seen as single-channel images and super-resolution techniques from the computer vision literature can be applied [2, 3].

In a second part, we will study different extensions. In particular, given the fact that part of the patterns observed in SAR aerial imagery seem to overlap with the observable patterns of satellite SAR imagery, and that a much larger amount of data is available for satellite imagery within the SENTINEL project[4], we can envision using the sentinel data to pretrain a reconstruction deep network finetuned on the aerial measures. The sentinel data are open and accessible through the Copernicus hub [2]). Even if the resolution of the satellite measures is rougher than the aerial measures, it might still be a valuable option.

1. available on the Jet Propulsion Laboratory site`https://uavsar.jpl.nasa.gov/cgi-bin/data.pl`
2. `https://scihub.copernicus.eu/`

One objective of this study is to evaluate to which extend we are able to reconstruct, from the measurements in a given band (e.g. l-band), the observations from another band (e.g. X-band). The difference between these two bands is that the different frequencies do not allow to observe the exact same details. The problem is adressed in the first phase by simply downscaling the high resolution images but we may think about more appropriate degradation to be closer to the final task.

In the first part of the study, the input data is an intensity map, but this was constructed from polarised measurements and projection onto an intensity map necessarily results in a loss of information. The quality of the reconstruction of the high resolution intensity map from the low resolution polarised measurements can therefore be studied.

Finally, in the first phase of the study, a quadratic loss could be considered to measure the reconstruction error and guide the training of the neural network but, very often, the task does not require a reconstruction of the same quality for all types of object. Therefore, we may consider crafting a specific loss to concentrate the quality of the reconstruction on the objects of interest.

Skills

This subject is very research-oriented and lies at the crossroads of signal processing and computer science. It is particularly aimed at students with a strong taste for research, open problems and abstraction, and who are also interested in signal processing (Fourier transforms), programming and the practical implementation of learning algorithms (python, pytorch).

The meeting will be done in French but all the delivrables (reports, defense slides, code) will have to be provided in English.

Références

[1] Paul A. Rosen, Scott Hensley, Kevin Wheeler, Greg Sadowy, Tim Miller, Scott Shaffer, Ron Muellerschoen, Cathleen Jones, Soren Madsen, and Howard Zebker. Uavsar : New nasa airborne sar system for research. *IEEE Aerospace and Electronic Systems Magazine*, 22(11) :21–28, 2007.

[2] Yulun Zhang, Yapeng Tian, Yu Kong, Bineng Zhong, and Yun Fu. Residual dense network for image super-resolution. In *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, June 2018.

[3] Francesco Cardinale et al. Isr. `https://github.com/idealo/image-super-resolution`, 2018.

[4] Francesco Cardinale et al. Sentinel sar. `https://github.com/idealo/image-super-resolution`, 2018.