Méthode de super-résolution basée sur l'utilisation d'images à basse résolution Landsat et haute résolution Sentinel-2 pour la caractérisation des paysages fluviaux à larges échelles

Super-resolution method based on the use of low resolution Landsat and high-resolution Sentinel-2 images to characterize large-scale river landscapes

Pierre Audisio[1,2] , Nelly Pustelnik[1] , Barbara Belletti[2]

[1]) Ens de Lyon, CNRS, Laboratoire de Physique, F-69342, Lyon, France.
[2]) Université Jean Monnet, CNRS, UMR 5600 Environnement Ville Société, Saint-Etienne, France.
pierre.audisio@ens-lyon.fr , nelly.pustelnik@ens-lyon.fr, barbara.belletti@cnrs.fr

RÉSUMÉ

La dynamique des rivières peut-être caractérisée à l'aide d'indicateurs spécifiques tels que l'indice de tressage ou la largeur moyenne de la bande active, permettant le suivi des changements géomorphologiques du cours d'eau, mais aussi potentiellement de déterminer la nature des éléments à l'origine des transformations.

Dans cette étude, ces descripteurs sont obtenus avec les satellites Landsat et Sentinel-2. Si la couverture temporelle est plus large avec les données Landsat, la résolution spatiale est nettement meilleure avec Sentinel-2 permettant une extraction des descripteurs bien plus fine mais sur une période réduite.

Afin d'extraire à haute résolution et sur une longue période de temps les descripteurs, nous proposons une méthode de super-résolution dans le but d'augmenter la résolution spatiale des données d'archive Landsat en utilisant une stratégie informée d'apprentissage profond se basant sur l'exploitation de couples d'images à haute et basse résolution Sentinel-2/Landsat.

ABSTRACT

River dynamics can be characterized using specific indicators such as the braiding index or the average width of the active band, making it possible to monitor geomorphological changes in the river, but also potentially to determine the nature of the elements at the origin of the transformations.

In this study, these descriptors are obtained using Landsat and Sentinel-2 satellites. While the temporal coverage is wider with Landsat data, the spatial resolution is much better with Sentinel-2, enabling much finer descriptor extraction over a shorter period.

In order to extract high-resolution descriptors over a long period of time, we propose a super-resolution method to increase the spatial resolution of Landsat archive data, using an model-based learning learning strategy based on the exploitation of Sentinel-2/Landsat high- and low-resolution image pairs.

KEYWORDS

Geomorphology, Remote sensing, Satellite imagery

1 INTRODUCTION

Man-made pressures (e.g. urbanisation, agriculture, deforestation) and climate change are causing short- and long-term changes in watercourses. A large amount of accurate data is required to extract the indicators needed to quantify these changes over time and space [1, 2].

Satellite imagery meets these criteria [3], by providing a large amount of data on rivers at different scales, allowing systems of different sizes to be taken into account, but the temporal periodicity of the acquisitions and their spatial resolutions are highly dependent on the satellite in question. The aim of this study is to develop a super-resolution method that takes advantage of both the high temporal availability of Landsat data since the 1980s and the recent higher-resolution data from Sentinel-2.

A so-called super-resolution method was therefore implemented using an model-based learning approach, based on the exploitation of pairs of high- and low-resolution Sentinel-2/Landsat images, making it possible to increase the spatial resolution of the data from 30 m to 10 m. This work is part of the GloUrb project, which takes an interdisciplinary and integrated approach to the complex issue of the urbanisation of alluvial plains since the 1980s on a global scale.

2 METHODOLOGY AND EXPECTED RESULTS

To increase the spatial resolution of Landsat data, we explored traditional variational approaches [4] on the one hand and an model-based learning strategy (see Fig.1) on the other based using a dataset involving degraded images (low resolution) and target images (high resolution).

In our study, the Landsat images from the HLS project [5] were considered as the low-resolution images, while the higher-resolution Sentinel-2 images were used as the reference or target. Various criteria were taken into account when creating the database needed to train the deep learning model, such as the temporality of the acquisitions under consideration, the corresponding spatial coverage and the cloud cover over the study area.

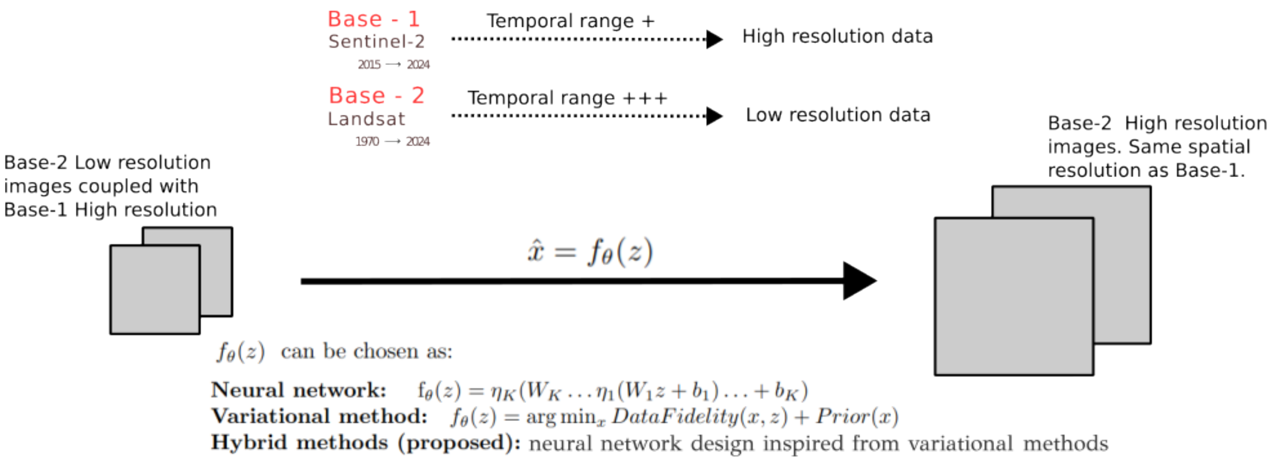

Figure 1: Super-résolution method flow chart

Another essential aspect of this approach is the rigorous evaluation of the performance of the models developed. To do this, quantitative metrics such as mean square error (MSE) and structural similarity index (SSIM) were used to measure the quality of the high-resolution images generated.

These metrics were used to compare the results obtained with the Sentinel-2 reference data, guaranteeing reliable validation of the improvements made. An assessment of descriptors specific to the structure of watercourses was also possible using photo-interpretation. These descriptors include the braiding index and the average width of the active band, as well as standardised spectral indices such as NDWI and NDVI.

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