Generalization of a method enabling to update vineyard geographic databases from satellite data

Master internship

General information

- Keywords : image time series analysis, deep learning, optical satellite imagery, agriculture monitoring, crop type mapping, vineyard, VENUS images
- Duration : 6 months (standard stipend). To start between February and April 2023.
- Institutes : Université Paris Cité, Laboratoire d'Informatique Paris Descartes (LIPADE), and Université de Strasbourg, Laboratoire Image, Ville, Environnement (LIVE)
- Location : 45 rue des Saints-Pères, 75006 Paris (LIPADE)
- co-PIs : Camille Kurtz, Nicole Vincent (first.lastname@u-paris.fr), Anne Puissant
- Application : Please send a cover letter and a CV to Camille Kurtz. The position is opened until filled.

Proposed topic

Motivation

The available geographic databases, particularly in the agricultural landscapes, contain important information at parcel resolution for crop type detection (crop type maps) and monitoring (the RPG database). This database is mostly completed and updated by annual declarations of farmers within the framework of the Common Agricultural Policy (CAP) in Europe. Because of their manual aspect, these declarations may contain errors or inaccuracies and they are not exhaustive. Currently, thanks to the increasing availability of high spatial resolution satellite imagery and their accessibility via European programs, it is becoming possible to use these series of images to update this type of geographic database or to check the consistency of the data through an exploitation of the visual content of the images or of features extracted from the time sequence, more frequently. In particular, satellite image time series (SITS) make it possible to study from 2D+t imaging data the spatio-temporal evolutions of the territory, which may for example indicate a change in management of the cropping system. The objective of this internship is to use deep learning image analysis methods to deliver up-to-dated geographic vineyard databases in a timely and accurate manner over large areas and via an automatic analysis of SITS.

Background and state of the art

State-of-the-art approaches for most of the challenges in satellite image analysis are now based on deep learning-based strategies from machine learning (ML) [MAL19]. However, one bottleneck is due to the lack of learning data (generally obtained from manual annotation of images by experts), that does not allow to totally benefit from the last progresses of deep architectures in artificial intelligence. For several years, the LIPADE and the LIVE have collaborated together to propose original data analysis methods such as [CHE20]. In this work, the definition of spatio-temporal representations of a series of image contents enables to elaborate more easily a 2D+t classification

method, addressing the complex problem of the classification of ambiguous classes for land-cover mapping, see [STO19]. In the context of a previous Diip internship (Lucas Colomines, 2021), this approach has been successfully extended to embed it in a semantic segmentation task aiming to update land cover maps, in the context of the study of wine-growing areas [COL22].

Proposed work and implementation

Contributions of the work to the state-of-the-art Generally, for this task, supervised approaches such as segmentation or classification [MAL19] based on a single image are considered, when looking for crop classes. In our case, we focus on one type of crop, vineyard and the task is a one-class analysis. Furthermore, based on a medium resolution image (10 to 20m), the task is made difficult, so we intend to use a series of images as they are available with a high spatial resolution (5 m). Based on our previous model relying on spatio-temporal representation [COL22] that highlighted good performances on correcting maps from the Alsace vineyard region, our objective is twofold. On the one hand we want to show we have a general method to deal with uncertain data annotation and on the other hand we want to evaluate the generalisation power of our method when data are changed from resolution and geographical points of view. This is a challenging task in ML, in particular for vineyard mapping since these agricultural crops can have different visual appearances (color, spatial tree arrangements, etc.) depending on the geographical site. To deal with the generalization problem, transfer learning could be employed, limited to the feature calculation process or to the segmentation strategy ; a few additional samples would be sufficient to update the model. Our approach is original since it relies on a multi-view or multi-point of view strategy and mixes in the reasoning of local and global levels, while relying on machine learning.

Considered data Thanks to current European programs, numerous satellite images are becoming freely downloadable and usable for various applications. Many studies in remote sensing are currently focused on the use of images from Sentinel 2 satellites which produce data at high temporal frequency with a medium spatial resolution (10 to 20m). In this project, we want to explore new data from the Venus satellite, which also offers a good temporal frequency (3 days) but with a finer spatial resolution (5m). As proof of concept, images from the Planet sensors (3m) will be also considered. The LIVE laboratory started to take care of pre-processing and correcting the data to facilitate their use but such data were only considered in the literature for monitoring flooding. Here we want to take advantage of their fine spatial resolution to analyze the vineyards. These agricultural plots are indeed characterized by spatial patterns, difficult to observe at 10m via the Sentinel imagery. The first study area will be Alsace, we will then evaluate the property of generalization of our system on the South West zone (Bordeaux vineyard).

Program of the internship The intern will start by preparing the data (images, metadata, and ground-truth from RPG) and by choosing precisely the study area, in connection with the thematic needs of the laboratory in Strasbourg. Based on our CNN-based deep model [COL22], the next step will be to adapt the existing architecture to deal with the finer spatial resolution of the data (and the thematic application) and to involve the first results in a second learning step to improve the classifier. The last step will be to evaluate quantitatively and qualitatively (from ground inspection by the LIVE) the quality of the generalization.

References

CHE20 Chelali, M., Kurtz, C., Puissant, A. & Vincent, N. (2020) Image time series classification based on a planar spatio-temporal data representation, VISAPP 2020, pages 276-283

COL22 Colomines, L., Kurtz, C., Puissant, A. & Vincent, N. (2022) Dealing with incomplete land-cover database annotations applied to satellite image time series semantic segmentation, ICPRAI 2022, pages 211-222

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STO19 Andrei Stoian, Vincent Poulain, Jordi Inglada et al : Land Cover Maps Production with High Resolution Satellite Image Time Series and Convolutional Neural Networks : Adaptations and Limits for Operational Systems. Remote. Sens. 11(17) : 1986 (2019)