

Deep learning change detection from heterogeneous multitemporal remote sensing data

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Note 1: Candidates must be nationals of a Member State of the European Union or an Associated Country or must have resided in a Member State for at least five years prior to the start of the contract.

Note 2: The application procedure is described at the end of this document.

Thesis Context

The research project, lying at the interface of computer vision, machine learning, and remote sensing fields, involves **updating georeferenced information in France and around the world using advanced deep learning techniques**. Four possible scenarios/use-cases have been identified, all related to change detection in images/3D models:

- update the French “Simplified Street Map Plan (PCRS)”,
- update a high-resolution 3D model of French territory,
- update (identify) peri-urban wastelands worldwide (mostly, Africa and Asia),
- update agricultural plot delineations worldwide.

The objective is to update various geo-related products (e.g., the PCRS, the 3D model of French territory, peri-urban wastelands, or agricultural plots) as soon as a change occurs in situ. Doing this properly requires regularly triggering high-resolution 2D and/or 3D data acquisition campaigns across the entire study area under consideration. Naturally, due to financial costs and processing time, it is not feasible to regularly launch a complete high-resolution data acquisition campaign. A much more cost-effective solution is to trigger a

high-resolution acquisition only in areas that have actually changed and therefore require an update.

Such a strategy makes it necessary to establish a “change alert” mechanism—i.e., change detection based on alternative data more accessible (in time and frequency) and less expensive. These alternative data sources are, by nature, of lower resolution, must be temporally frequent (from a few months to a few days), easily accessible, and low-cost, such as Landsat and Sentinel data.

Given high-resolution data acquired at a past date—not too far in the past (with spatial resolutions ranging from 20 cm to 5 m)—and a time series of medium-resolution satellite images available from that past date up to the present, the goal is to design a change detection algorithm capable of identifying areas within the high-resolution image that have changed, or are likely to have changed with a sufficiently high probability.

From an operational perspective, such a mechanism would allow the rapid deployment of new high-resolution acquisition campaigns, but only over the areas identified as having changed.

Scientific objectives

To tackle the main objective of this doctoral project, the PhD candidate is expected to develop novel deep learning frameworks. In this context, it is possible to rely on the rich literature from computer vision and machine learning fields to adapt some existing solutions to our specific problem. This will require to tackle several scientific challenges, including dealing with the lack of labelled data to train our models, managing super-resolution for time series jointly with super-resolved data, handling generalization when training data is very different from test data, and using auxiliary data such as cadastral maps, OpenStreetMap, or mapping tools, etc.

The machine learning setting relies mostly on unlabeled data, since change masks are not available, or only in very limited quantities. However, ancillary reference data such as annotations of the high-resolution image (for example, via rasterized BDTopo) can be exploited. Among the existing methodologies that appear relevant in the proposed scenario, foundation models, trained with self-supervised learning, will be assessed in the considered settings to set up some baselines through the use of existing datasets. We will also combine these solutions with change detection/classification using few examples or training on other domains, synthetic/artificial data augmentation based on simulation or generative models (e.g., GANs or diffusion models), as well as zero-shot and few-shot methods. Particular attention will be given to Google's Open Building 2.5D approach, which enables tracking land use changes for buildings ([paper](#)).

Furthermore, it is planned to adapt the methodology to image time series. A series may have variable frequency and duration. There may be missing values for certain pixels (e.g., due to clouds) or missing images in the series. It may also be necessary to synchronize the series with time (due to seasonal phenomena, which could desynchronize the understanding of spatio-temporal patterns from one series to another). The use of a graph structure as a proxy representation between the different remote sensing modalities seems a promising approach and could lead to exploring Graph Neural Networks in this context, following some recent activities in our lab.

In this thesis, a specific attention will be paid to the ability to explain the model's decisions, in order to ensure the acceptance of the AI solution by end-users. The issue of geographic bias will also be tackled, especially for applications where the models are deployed in geographical areas different from the ones used during training.

Organization and planning

The PhD candidate will be enrolled at Université Bretagne Sud and based either in Nantes or Vannes. He will spend 1-2 days per week in the other location (1h train journey). The exact schedule and company/academia balance will be flexible, e.g., it might be preferable to spend more time in the company at the beginning of the thesis to learn about the industrial environment and understand the use case and be full time in the lab while writing the PhD dissertation.

The tentative schedule is as follows:

- M0-M6: introduction to the use cases, review of the state of the art
- M6-M12: benchmark existing approaches and develop a first proposal
- M12-M18: experimental assessment
- M18-M24: second proposal or improvement of the first model
- M24-M30: transfer in operational settings
- M30-M36: writing of the PhD dissertation

The main expected outcome is the implementation that will be realised using (Python/PyTorch). The results will be disseminated through open-access peer-reviewed publications in major international conferences and top journals in machine learning and computer vision (ICML, CVPR, ICLR, Neurips, or ICCV) and remote sensing (ISPRS PHOTO, IEEE TGRS, RSE, or Earth Vision).

Desired Profile

Candidates must be nationals of a Member State of the European Union or an Associated Country or must have resided in a Member State for at least five years prior to the start of the contract.

- Master's degree (M2) or engineering diploma in data science, artificial intelligence, or computer science with strong academic results
- Proficiency in a low-level programming language (e.g., C++)
- Proficiency in a scripting language (e.g., Python)
- Knowledge of image processing
- Experience with deep learning
- Interest in Earth observation
- Additional knowledge in the following areas is a plus:
 - System-level skills
 - Familiarity with remote sensing domain
 - Time-series analysis
 - Knowledge of GIS libraries, APIs and softwares (e.g. rasterio, geopandas, geoservices, planetary_computer, QGis)
- Initiative and good interpersonal skills: this is a collaborative project between an industrial partner and an academic research team
- Good communication skills
- Fluency in scientific English

Scientific partners

French company created in 1968 in Nantes, [GEOFIT](#) is today a key player in regional and city development, bringing together more than 1,400 employees with its subsidiaries. GEOFIT business consists of measuring, quantifying, and analysing geospatial data to transform them into real decision-making tools. Thanks to a fleet of eight aircrafts equipped with best-in-class Vexcel cameras and last generation LiDAR sensors, GEOFIT covers a wide range of applications for aerial imagery and it's a major actor for acquisition campaigns related to planning at national level such as the PCRS and the [LiDAR HD program](#) by IGN. Innovation has always been at the heart of GEOFIT's corporate culture. GEOFIT's [R&D team](#) is composed of researchers and engineers with several years of experience in different domains. Among the team's pool of expertises we can find deep learning (e.g., semantic segmentation and object detection) with different data types (e.g., rasters, vectors and point clouds) on aerial and satellite imagery. The team works to continuously develop new models using SOTA architectures for its clients needs and their use cases.

The academic partner is IRISA (**Institut de Recherche en Informatique et Systèmes Aléatoires**, <http://www.irisa.fr>) - one of the largest French research laboratories in the field of computer science and information technologies. The research team involved in this doctoral project is **OBELIX** (<https://www.irisa.fr/obelix>), located in the city of Vannes. The team's overall activity relates to Artificial Intelligence for Earth Observation (AI4EO). Recent/ongoing PhD theses include deep learning change detection over 3D points clouds (PhD of Iris de Gélis), analysis of satellite image time series through graph learning (PhD of Corentin Dufourg), foundation models for Earth Observation (PhD of Pierre Adorni),

super-resolution from satellite image time series with generative models (PhD of Aimi Okabayashi), thus providing an excellent scientific environment for the this doctoral project.

How to Apply?

Incomplete applications will not be considered.

Please send the following four documents (in PDF format for text files) in either French or English to the following email address: changedetectionthesis@gmail.com

1. Curriculum Vitae
2. Motivation letter (maximum two pages)
 - explaining your understanding and interest in the topic
 - **listing two references** (scientific articles, patents, websites, etc.) that you consider relevant to the thesis topic, accompanied by a short explanation (5–10 lines) for each
3. Academic transcripts for the M1 and M2 years (provisional transcripts accepted)

After reviewing the applications, interviews with both the industrial and academic partners will be conducted during June – July 2025

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