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► To cite this version:

Élodie Faure, Rémi Ratajczak, Carlos F Crispim-Junior, Olivia Pérol, Laure Tougne, et al.. Development of a software based on automatic multi-temporal aerial images classification to assess retrospective environmental exposures to pesticides in epidemiological studies. CLARA 2018 Cancer Research Forum, Apr 2018, Lyon, France. hal-01784654

HAL Id: hal-01784654

<https://hal.science/hal-01784654>

Submitted on 3 May 2018

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Development of a software based on automatic multi-temporal aerial images classification to assess retrospective environmental exposures to pesticides in epidemiological studies

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1. Context

- Pesticides have been suggested as **risk factors** for different pathologies (cancers, infertility, Parkinson's...)
- Geographical Information Systems (GIS)** are increasingly used to assess **environmental exposure to agricultural pesticides (EEAP)** in epidemiological studies by taking into account **long latency period**
- There is a **lack of annotated land cover data** in France before 1990
- Large scale retrospective epidemiological studies** like TESTIS (Béranger et al. 2014) are carried out **over 45 years** in the past and involve **hundreds of subjects** (1500 for TESTIS)
- The **manual annotation** of a single historical aerial image (National Geographic Institute – IGN) representing a **9 km² area** takes **6 to 10 hours** (1 subject/1 date/1 location in TESTIS)

Goal: Assess the lack of annotated historical land cover data in France by developing an automated image processing software for fast annotations of historical aerial images

2. Method - Creation of a new dataset : HistAerial

- 4.9 millions annotated land cover patches** issued from historical aerial images acquired between **1970 and 1990** by the IGN (non-overlapping, monochromatic)
- 7 classes** (Arable, Water, Forest, Grassland, Urban, Orchard, Vineyard)
- 3 scales** (100 x 100 pixels, 50 x 50 pixels, 25 x 25 pixels)
- Patches represent **inhomogeneous textures**

Fig. 1 : Examples of historical land cover patches in the HistAerial dataset

3. Method - An extensive comparative study : Overview

- 12 state-of-the-art local texture filters**, low dimensional representations based on the Local Binary Pattern (LBP), and one variant (LBP_riu2)
- 2 novel local texture filters**, namely LCOLBP and R-CRLBP
- 4 classifiers** (K-Nearest Neighbors, Support Vector Machine, Multi-Layer Perceptron, Random Forest), trained with grid search
- 3 finetuned end-to-end deep convolutional neural networks**
- Evaluation on an equilibrated and randomly sampled subset of HistAerial (6 000 images / class)

4. Results - An extensive comparative study : Evaluation

- Our understandable handcrafted filter **LCOLBP** achieves similar results with deep learning method AlexNet
- LCOLBP generates features vector 17 times shorter than AlexNet**, thus yielding to faster training and inference

Fig. 2 : Best accuracy rates obtained on the HistAerial dataset

5. Results - Software

- Development of a **scribble-patch based software**
- Integrate best evaluated methods
- Enable annotation of **9 km² in 5 to 10 minutes** instead of 6 to 10 hours on a single CPU thread (1.7Ghz) ; **scribble, training and test times included**

Fig. 3 : (a) Software workflow, (b) Left - scribbled historical aerial image ; Center - result with the software learning solely from scribbles ; Right - ground truth, unseen by the software

6. Conclusion and perspectives

- Novel large scale dataset** for historical aerial images classification
- Extensive comparative study** including **two novel texture filters**
- Innovative software prototype for **fast annotations of historical aerial images**
- Combine deep learning methods with handcrafted methods
- Integrate results in a Geographical Information System
- Creation of new land use datasets
- Use the software on large scale retrospective epidemiological studies