Using Agents and Unsupervised Learning for Counting Objects in Images with Spatial Organization

Eliott Jacopin
Naomie Berda
Léa Courteille
William Grison
Lucas Mathieu
Antoine Cornuéjols
Christine Martin

UMR-MIA, AgroParisTech, INRAE, Université Paris-Saclay, 75005, Paris, France

0 Overview

1. With this work, we present a method to **detect objects** that are **not randomly positioned** in images, **but spatially organized**. We focus on plants in crop fields as a case study.

2. We relied on **synthetic datasets** to overcome the lack of public labelled datasets of crop fields. We built a crop field generator with the game engine **Unity**. We use synthetic datasets both **to design** our strategy and **to test** its performances in the case of **plant overlapping**.

3. Our method proceeds in **TWO STEPS** to detect spatially organized objects. In the first one the spatial organization is approximated using **unsupervised learning**. In the second step a **multi-agent system** is initialized based on the approximation and refines the detection of the objects.

4. Our method yields a **counting accuracy** equivalent to state-of-the-art methods in easy cases; and it is **much better on hard cases**.

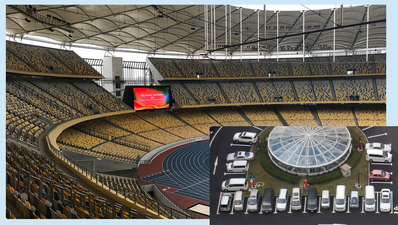
eliott.jacopin
antoine.cornuejols @agroparistech.fr
christine.martin

@LittleCoinCoin1

LittleCoinCoin

1 Spatially Organized Images

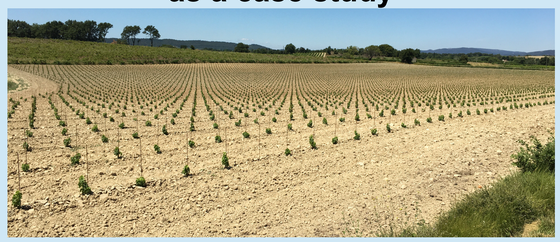
Examples are:



Sits in stadiums

Cars in a parking

We use plants in crop fields as a case study



2 Datasets

Public labelled datasets of crop fields are **rare**

→ We generate different **synthetic datasets** both for training and testing

Made with

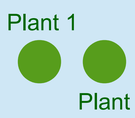
unity

Unity is a professional game engine

State-of-the-art methods struggle against plant overlapping. For testing, we generate **3 datasets with different levels of difficulty**

Overlapping occurs as the crops grow

Plants are **well separated**



→ **EASY**

Plants are at the **limit of overlapping**

→ **MEDIUM**

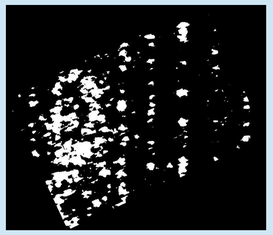
Plants are **overlapping**

→ **HARD**

3 Detecting the target objects in 2 STEPS

Pre-Processing

Otsu Segmentation + Automatic Vertical Adjustment



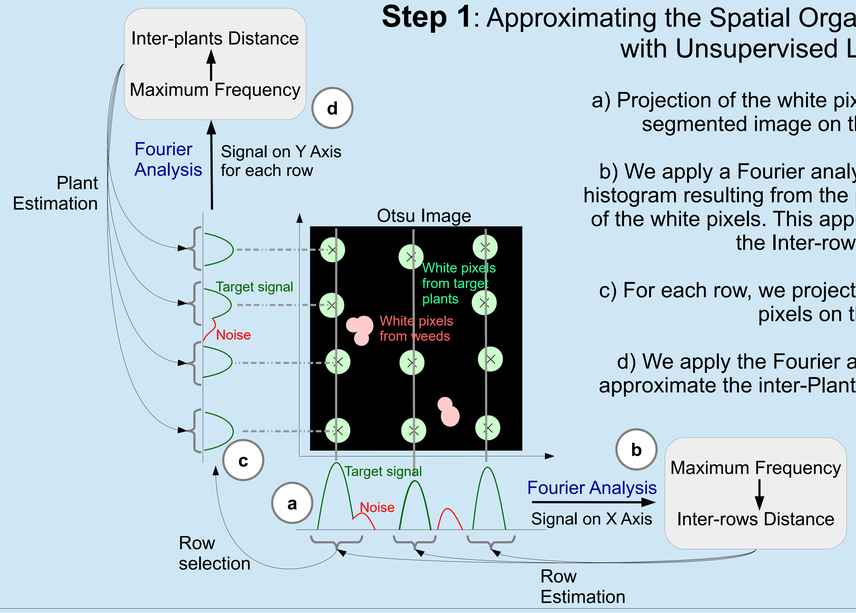
Step 1: Approximating the Spatial Organization with Unsupervised Learning

a) Projection of the white pixels of the segmented image on the X axis.

b) We apply a Fourier analysis to the histogram resulting from the projection of the white pixels. This approximates the Inter-row distance.

c) For each row, we project the white pixels on the Y axis.

d) We apply the Fourier analysis to approximate the inter-Plant distance.



The Multi-Agent System is a corporate hierarchy with 4 layers

Step 2: Refining the approximation of the Spatial Organization with a Multi-Agent System

- The **RAs** and **PAs** are instanciated based on the approximation of the positions of the rows and plants during **STEP 1**. Each **RA** commands a group of **PAs**. Each **PA** commands a group of **PXAs**.
- **PAs** move on the image toward the white pixels indicated by their **PXAs**.
- The simulation of the system is a repetition of Move, Initialize, Merge and Destroy of the **PAs**.
- At the end of the simulation, 1 **PA** equals 1 **Counted Plant**.

4 Counting Accuracy (CA) on Synthetic & Real Datasets

$$\text{Counting Accuracy} = \frac{\text{Number of PAs}}{\text{Number of real Plants}}$$

Terres Inovia
l'agronomie en mouvement

EASY	MEDIUM	HARD	REAL
0.97 ±0.07	1.00 ±0.04	1.03 ±0.07	1.03 ±0.12

OTHER METHODS

State-of-the-art methods rely on supervised learning

Example of studies tackling the issue of plant counting with various plant overlapping conditions:

García-Martínez et al. (2020)
Gnädinger & Schmidhalter (2017)
Ribera et al. (2017)

→ ≈ 5% error in **EASY**-like datasets
≈ 20% error in **HARD**-like datasets