Friendly Fruit

PRACTICES PERFORMANCES & RESULTS

Monitoring of orchard irrigation by unmanned aerial systems and remotely-sensed imagery

(Drone and Artificial Intelligence to help saving water & producing high quality apples)

Magalie Delalande (INRAe) & Jean Luc Regnard (SupAgro)

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

History of experiments and selection of practice

Short overview of the experiments:

1- Identify Indicators of **response to tree's water status,** from remotely-sensed imagery collected by drone (UAV) **over a large collection of apple tree varieties**,

*Indicators selected were **reflectance** data from the **multispectral** camera and **canopy surface temperature** collected by the **thermal infrared** camera*

2- Collect as many multispectral and thermal **images as possible** from **commercial orchard.**
From these images, we **developed and trained an algorithm** that aims at estimating the **water status of the trees**, which should, in theory, **reflect the functioning or malfunctioning of the watering system**

Why choosing a Digital-based orientation ?

Agriculture ranks as a **leading sector in digital-based decision support system** (precision Ag).
Farmers are **one of the first professions** to connect to the **Internet** and use online services.
In the fields, **digital technology is ubiquitous** with GPS-guided tractors that use data from satellite images to develop **parsimonious and sustainable practices**,

Agriculture represent **the largest part** of civil **drone use** today,

With regard to fruit growing, two type of drone use are **emerging** today**: data acquisition and actions**

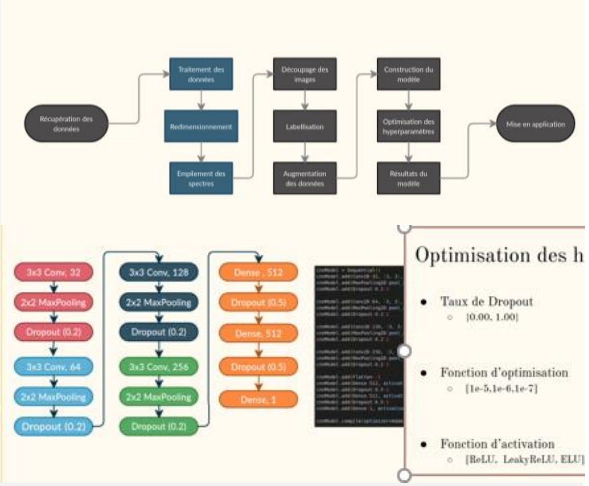
Our solution fits perfectly in the **expectations of the farmers** towards the **contribution of digital in the sustainable farm** of tomorrow : **identify irrigation malfunctioning** through **fast data acquisition** and **users friendly application** using **free software**

Description of the practice selected for the leaflet

What ?

We flew the drone embedding a multispectral and a thermal camera over commercial orchards (apple) and collect as many images as possible,

The images were used to train a neural network (Artificial Intelligence) to detect the signal of trees experiencing water deficit (= clogging) and trees experiencing over watering (=leaks)



Why ?

With parsimonious watering systems (drip irrigation monitored par soil moisture sensors), malfunctioning is difficult to detect, but are a real problem *(lifetime of irrigation system, quality of fruits, lifetime of trees)*

leaks => **waste of water** + **loss of apple quality** *(↗ large fruit >75mm, ↘ firmness)*
clogging => **loss of apple quality** *(↗ small fruit <70mm, ↗ fruit <40% color, ↘ fruit >60% color, ↘ starch index and ↗ acidity => change in maturity*

Status ?

Not so far from Ready-to-use, but the details take time !

Main steps to implement this practice

How should farmers proceed to implement this practice?

Two possibilities of implementation :
- farmer preferes to acquire data by its own
- farmer preferes to delegate the data acquisition (farmer advisor, service provider)

Farmer Advisers' most commonly used drones for data acquisition

1_ Install the application on a computer (laptop) (Internet required)

2- On a cloudless, little wind day, fly the drone with cameras = collect images
=> **about 18 min/ha** *Ensure to be in compliance with local aerial regulation*

3_ Copy the images from the SD card onto the laptop, and run the application

4_ Once the map and file are edited, send someone on the spots to check and solve the problem

5_ Regularly check the availability of updates
(new combo of cameras, more precise application, faster application, …)

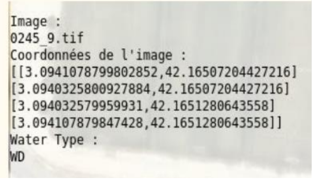


Image :
0245_9.tif
Coordonnées de l'image :
[[3.0941078799802852,42.16507204427216]
[3.0940325800927884,42.16507204427216]
[3.094032579959931,42.1651280643558]
[3.094107879847428,42.1651280643558]]
Water Type :
WD

Expected Key result / Message to take home

1- It is possible to **identify malfunctioning of** on the orchard's **drip irrigation systems** (**without hail nets**) from **drone** embedding multispectral and thermal IR cameras

2- Artificial Intelligence may be of **great help** for **rapid detection/localization of malfunctioning** on orchard's drip irrigation systems

3 - A.I. application is **close to** the **Ready-To-Use status, <u>but</u>**

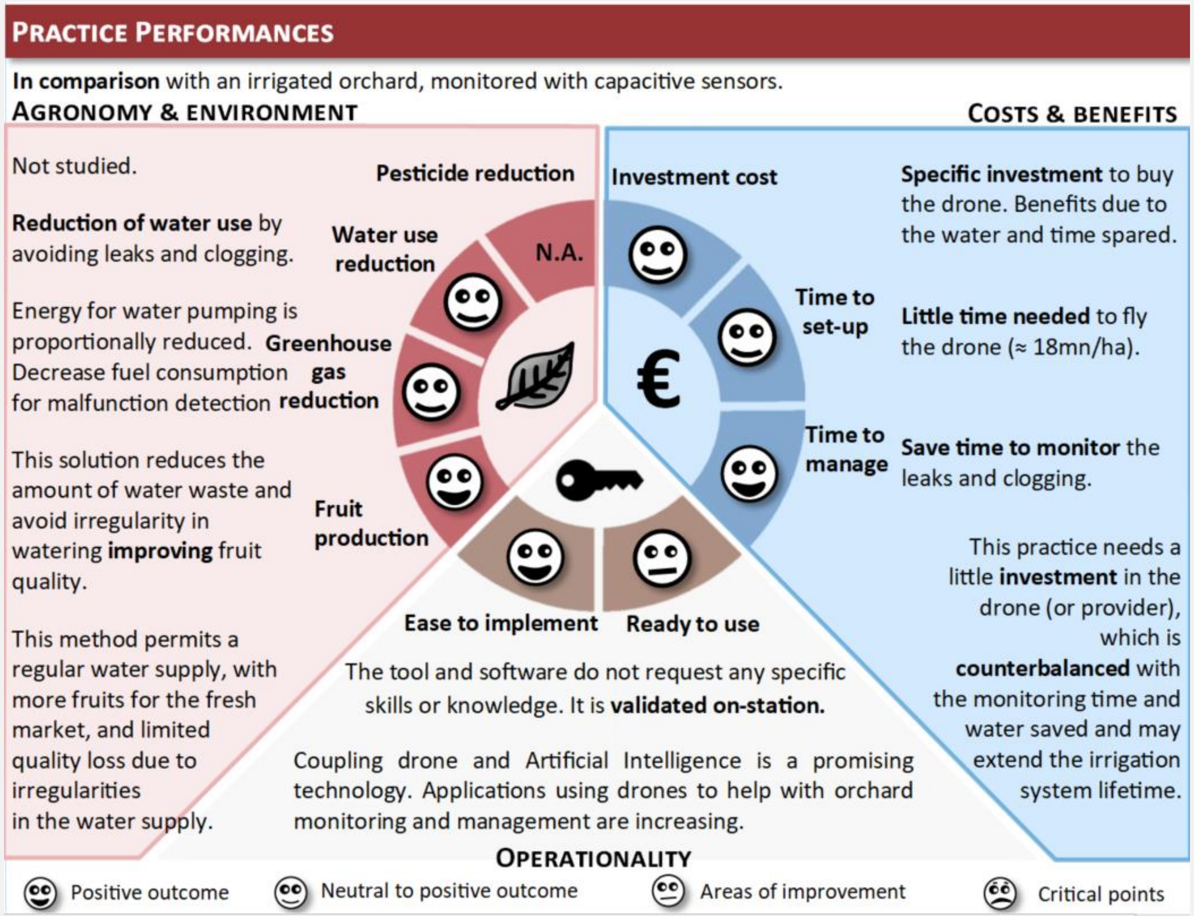
Before releasing the AI based application we need to improve its robustness (environmental conditions x agricultural practices –including other systems than drip irrigation, low cost cameras)

Continuation of the project : **improving the robustness of A.I. algorithm**

- by training the algorithm on different orchards (environmental conditions x agricultural practices) <u>with farmer and farmer advisers</u>
- by using other cameras (most commonly used - low cost - cameras)
- Improving the application for by being more sharp in the data selection (work on the algorithm)

Practice Performances

It allows low cost, simple and quick use, on a laptop, in the field, without internet



Robustness need to be improved before release

Roadmap for transfer– Next steps

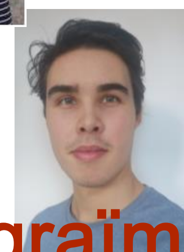
- First step before transfer : Improve the robustness of the algorithm (most currently used low cost cameras, more cultural design, improved accuracy)

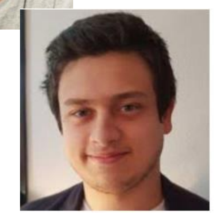
- Practice on commercial orchard with farmers and farm advisers interested by digital technology and using already drones for their tips

- Promote the application to users (farm advisers and farmers), open days, communicate, demonstrate on orchards, …

Meanwhile, continue to improve the robustness of the algorithm, to make it faster and more accurate, to adapt it to new technological developments of sensors, to other fruit species, and propose updates for the application

AI / informatic team



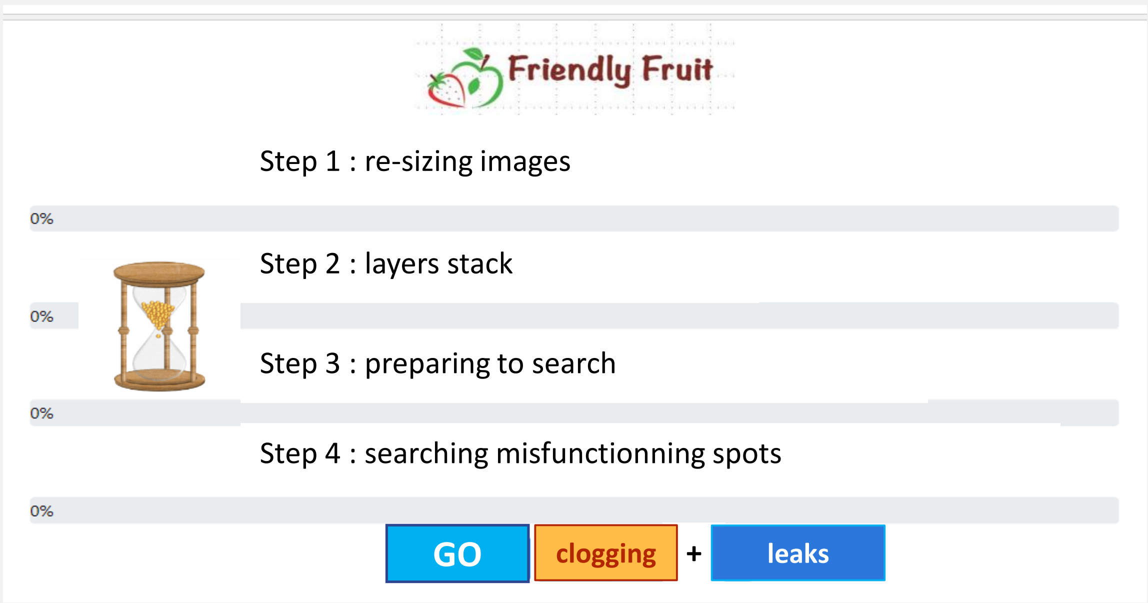


Field and drone team

Un gran agraïment a tots

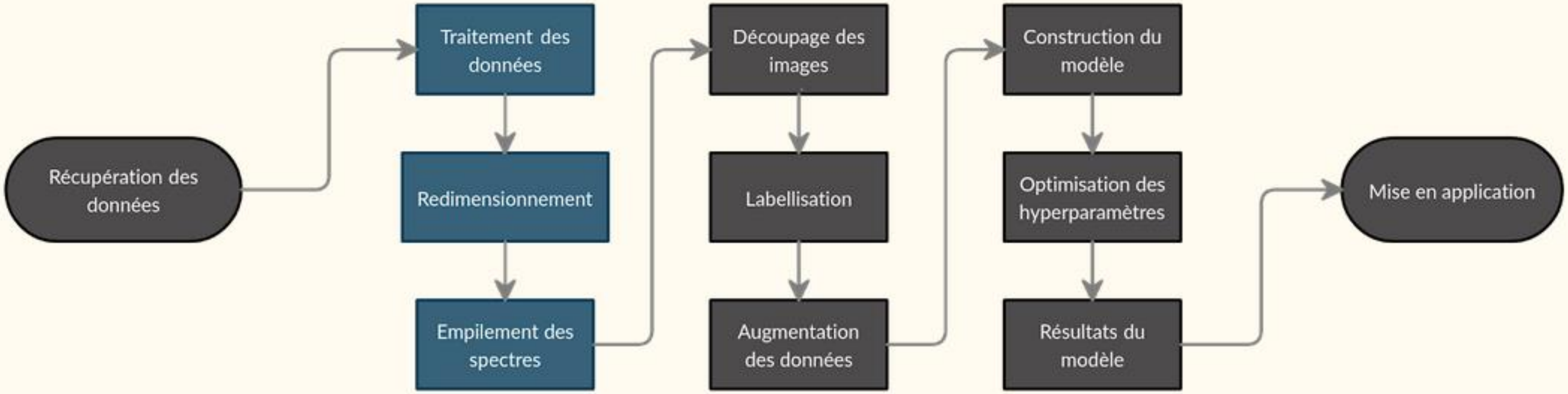
DRONE IRTA agap INRAE Montpellier SupAgro cirad

The interface: needs a better design

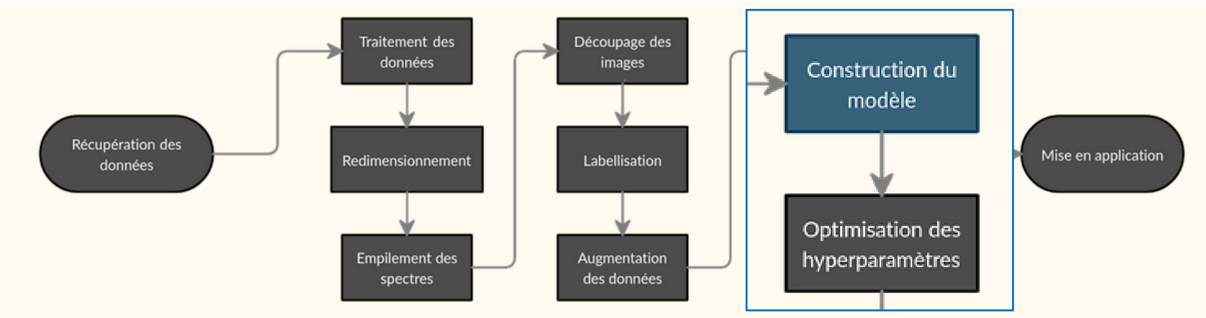


Overview of data treatment

Max JEAN – M2 student



Model Building and optimization of hyperparameters

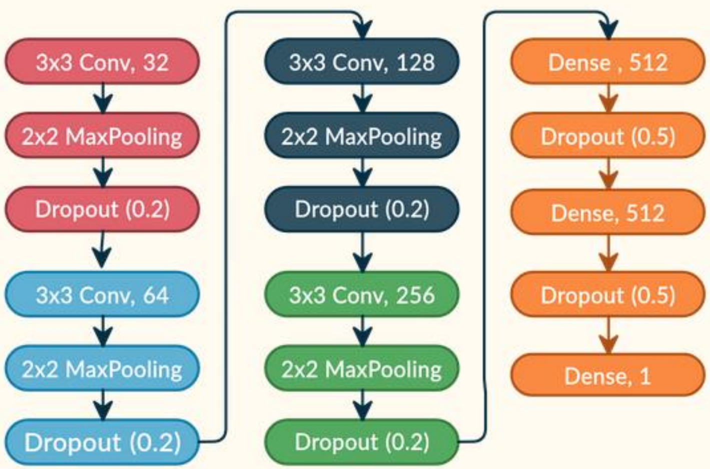


Max JEAN – M2 student

Training step:
inputs: images 160x128 pi et 7 channels
Partition of dataset:
Training / validation / test: 80/10/10
2 networks developed: Leaks + Clogging

Convolutional Neural Network

Construction du modèle




```
cnnModel = Sequential()
cnnModel.add(Conv2D(32, (3, 3),
cnnModel.add(MaxPooling2D(pool_
cnnModel.add(Dropout(0.2))

cnnModel.add(Conv2D(64, (3, 3),
cnnModel.add(MaxPooling2D(pool_
cnnModel.add(Dropout(0.2))

cnnModel.add(Conv2D(128, (3, 3)
cnnModel.add(MaxPooling2D(pool_
cnnModel.add(Dropout(0.2))

cnnModel.add(Conv2D(256, (3, 3)
cnnModel.add(MaxPooling2D(pool_
cnnModel.add(Dropout(0.2))

cnnModel.add(Flatten())
cnnModel.add(Dense(512, activat
cnnModel.add(Dropout(0.5))
cnnModel.add(Dense(512, activat
cnnModel.add(Dropout(0.5))
cnnModel.add(Dense(1, activatio

cnnModel.compile(optimizer=Adam
```

Optimisation des hyperparamètres

=> To improve model accuracy

- Taux de Dropout
  - {0.00, 1.00}
- Fonction d'optimisation
  - [1e-5,1e-6,1e-7]
- Fonction d'activation
  - [ReLU, LeakyReLU, ELU]

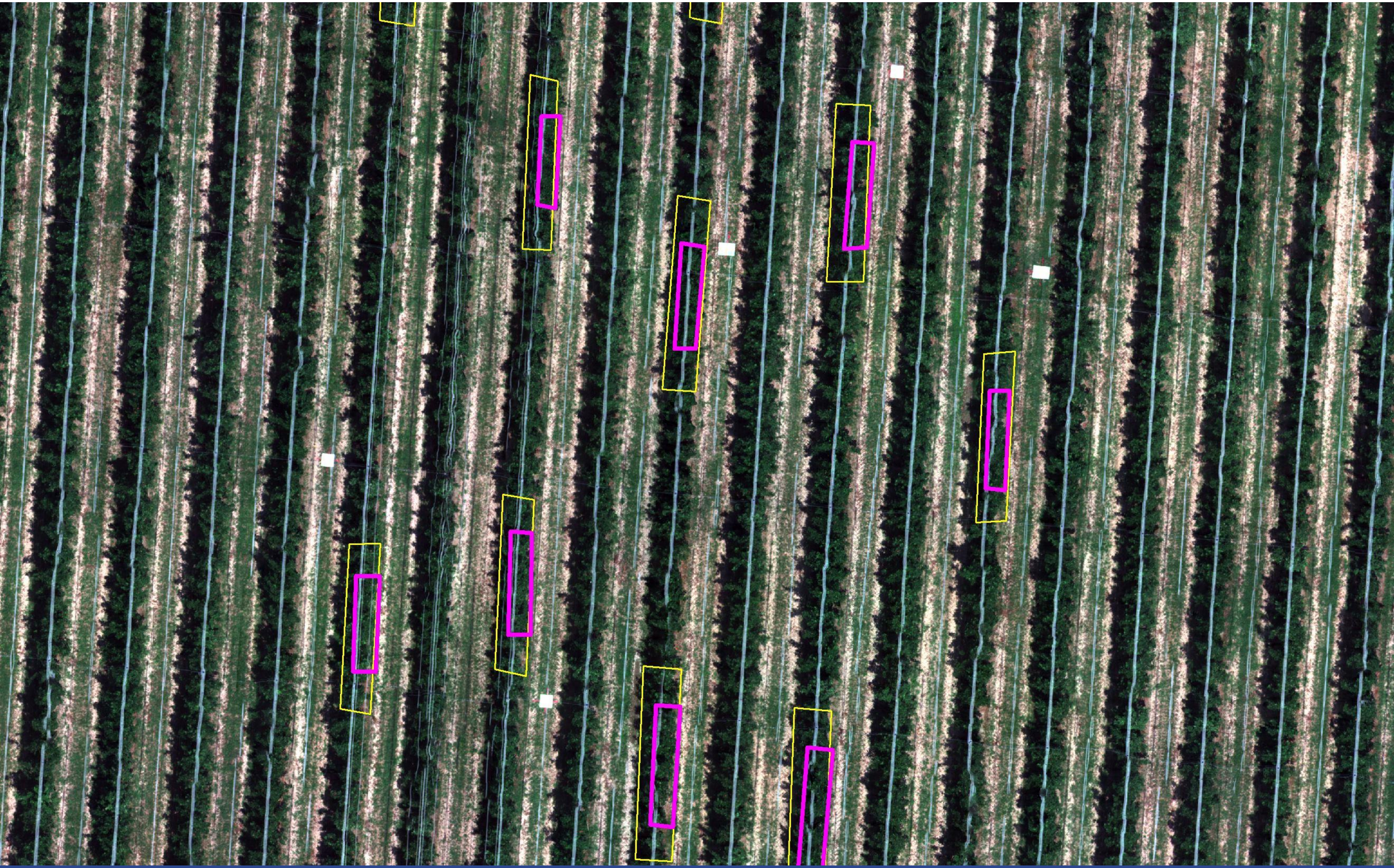
```
('Best validation acc of epoch:', 0.81944
[51:34<00:00, 1547.07s/trial, best loss: 0
Evalutation of best performing model:
72/72 [==============================] - 0
[0.5507584810256958, 0.8055555555555556]
Best performing model chosen hyper-parame
{'Dropout': 0.20111064347180818, 'Dropout
 'Dropout 3': 0.29128294469805704,
 'Dropout 2': 0.2836666684711582,
 'kernel regularizer': 0,
 'Adam': 1, 'activation': 0}
```

Gala ® Brookfield

2019 : 5 days * 1 flight * 2 tracks
2020 : 3 days * 3 flights/day * 3 tracks/flig

Mosaic scale
1 pixel =
2cmx2cm

Gala ® Venus under grey hail-nets : analyse still on-going (2 days * 3 flights/day * 3 tracks/flight = 18 mosaics)



Friendly Fruit

PRACTICES PERFORMANCES & RESULTS

An Internet of Things (IoT) solution for improved irrigation scheduling

Joan Bonany (IRTA), Luca Corelli Grappadelli (UNIBO

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

History of experiments and selection of practice

<write a **short overview of the experiments that have been tested since the start of the project**
AND

The experiments consisted in using capacitance soil water content sensors and volumetric meter in commercial apple orchards in Spain, France and Italy. The data from these probes have been collected and integrated in a web platform where the data was combined with weather forecast to provide an irrigation scheduled fitted to the conditions of each under test.

The system was tested in two different ways. In France and Italy, the system provided irrigation schedule in a weekly basis that was implemented by the grower in commercial orchard (DSS). The results of the DSS orchard were compared to a similar orchard of the same cultivar managed by the grower without using the DSS.

In Spain, the experiment consisted of comparing an irrigation scheduling based on using the platform and manually changing the irrigation controller, approximately once a week with the system changing automatically on a daily basis the water volume or time directly on the irrigation controller.

Description of the practice selected for the leaflet

What ? An irrigation scheduling system combining on-site sensors to now-casting meteorological conditions to better fit irrigation water restitutions to actual crop needs.

Why ? Under climate change, water availability can be a limiting factor for agriculture productivity. Better management of irrigation by use of soil sensors and weather data can lead to significant water savings without compromising production or quality

Status ? Ready to use with the appropriate training

Main steps to implement this practice

< **How should farmers proceed to implement this practice**, describe the main steps (do not mention here the experimentation protocole)>

A farmer or a group of farmers should:

- **Install capacitance soil water content sensors at 20, 40, 60 cm depth**
- **Install water meter in the irrigation line**
- **Use a cloud platform that captures data from these probes and combines it with weather data forecast to calculate an irrigation schedule based on water budget method corrected by soil probes**
- **Use the irrigation schedule to change periodically (usually on a weekly basis) the irrigation controller**
- **Or link the web platform with the irrigation controller to change the schedule on a daily basis**

Expected Key result / Message to take home

< Key result of the experimentation, message to take home >

The proper implementation of the practice should result in the majority of the ocasions in a better irrigation management, including:

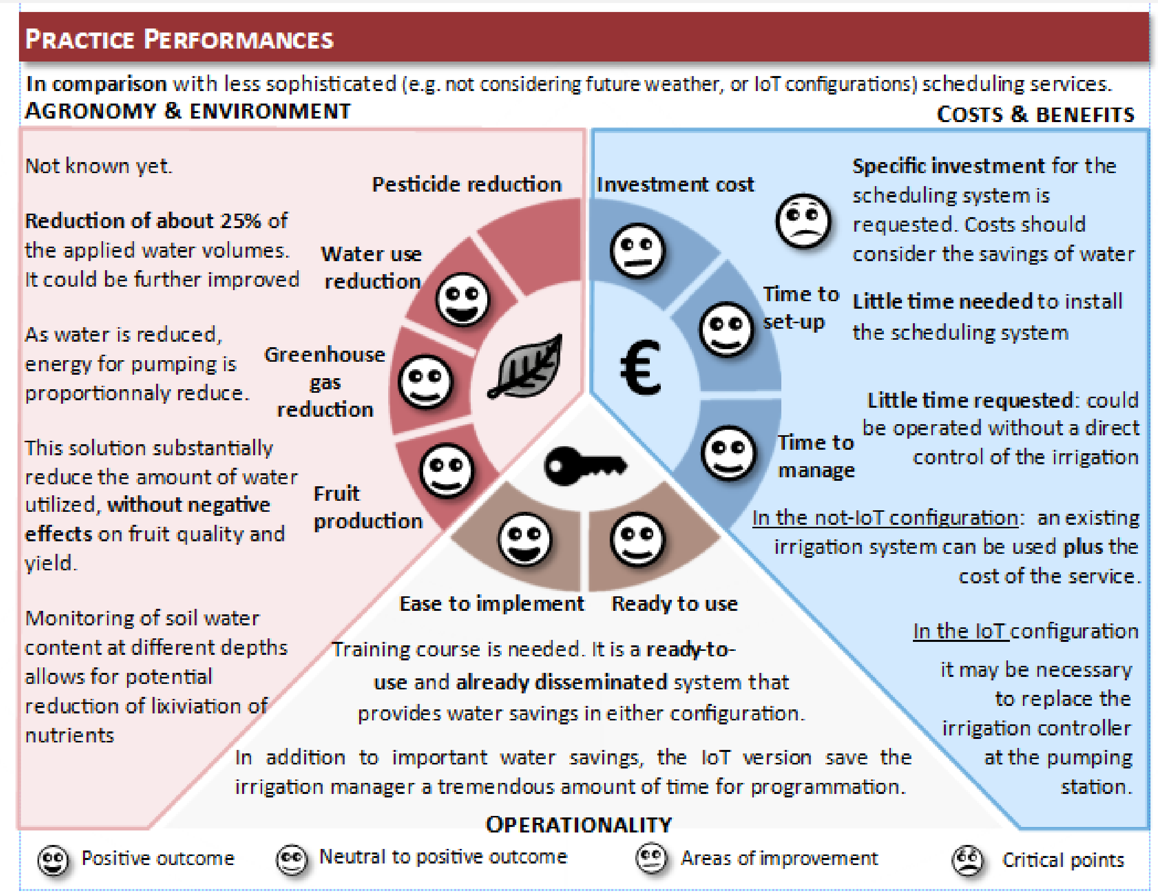
- **Water savings in the order of 20-30% compared to utilization of water budget method alone or grower standard practice**
- **Further savings of irrigation water when a layer of automation is added to the system by which the irrigation schedule is automatically delivered to the irrigation controller in a daily basis**
- **No indication of production or quality losses**
- **If the water for irrigation is pumped, it is expected a logical reduction in energy**
- **Reduction of nutrient losses by lixiviation out of the root zone**

Practice Performances

< If you have completed the Excel file for the **Leaflet** you can obtain your **Performance Graph to be inserted here** by contacting:

- **-> Aude Alaphilippe** aude.alaphilippe@inrae.fr **for Apple**
- **-> Marion Casagrande** marion.casagrande@inrae.fr **for Strawberry**

In any case **please highlight the most positive outcome and the most negative outcome** >



Roadmap for transfer– Next steps

<please describe how the practice can/ will be transferred to growers after the end of Friendly Fruit>

The practice is ready to be used by growers. The web platform that collects and integrates soil water content and weather data forecast into irrigation schedule is ready available. Interested growers or fruit growing companies can contact either IRTA or UNIBO for commercial implemention of the practice.

On the other hand, recently, there it has been other initiatives that have made available similar solutions on a commercial basis. So there are diferent commercial solutions that can help to implement the practice in fruit orchards.

Friendly Fruit

PRACTICE PERFORMANCES & RESULTS

Optimization of the irrigation of strawberry field crops : Monitoring based on tensiometers

François Lecompte (INRAE), Fanny Thierry (Invenio), Soukaina EL Mrini (INRA Maroc), Ahlam Hamim (INRA Maroc), Sophie Bomel (INRAE), Marion Casagrande (INRAE), Douae Lamrahli (Messem), Hicham Essrifi (Messem), Ahmed Taleb (Danone), Aziz Didicheikh (GIZ)

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

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History of experiments and selection of practice

- **Water related issues**: Water availability, water cost, leaching and pollution → Water management

- **Strategy:** Setting soil water tension thresholds for irrigation based on tensiometers = effective, fast and low cost.

- **Experiment**:

5 farm labs (Morocco), first 6 months of the growing season 2019-2020
1 experimental site (France), growing season 2019-2020

Practice description

What ?

Irrigation management based on sensors wich measure soil water tension, a component of the water potential, in strawberry field crops.

Why ?

To preserve water resource by adjusting irrigation to the crop's needs while maintaining yield level.

Status ? Ready to use ?

Practice implementation

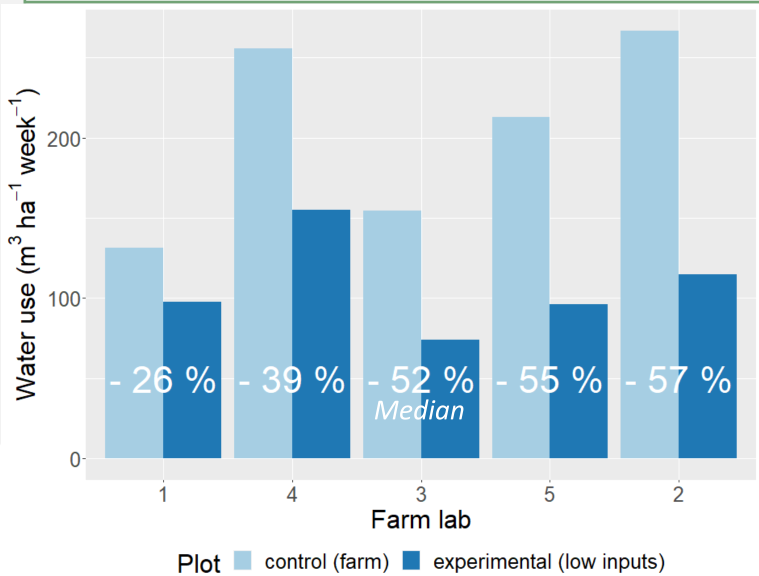
1. **Install 3 to 5 pairs of sensors** (10 & 30 cm) on each homogeneous area.
2. **Check sensors** at least once a week during the growing season.
3. **Fractionate irrigation inputs** to maintain soil water tension between 10-15 cbar.
   Surface soil water tension (10 cm): trigger irrigation if > 15 cbar
   Lower soil water tension (30 cm): manage irrigation duration (cf. Chart)

Lower soil water tension	Water amount
0 - 10 cbar	Decrease amount
10 - 15 cbar	No change
> 15 cbar	Increase amount

Key results

Results October-March	« Experimental » plot	« Farm » plot	Difference between plots
Average water use (m³/ha)	2 889 ± 380	5 451 ± 705	- **46 ± 6 %** **(wilcoxon p-value = 0,032)**
Average Water Use Efficiency (WUE)	0.13 ± 0.01	0.07 ± 0.01	**+ 85 ± 17%** **(wilcoxon p-value = 0,008)**

France: Similar results **- 40 %**



Key expected results (Morocco): - 30% water use, yield level maintained → Goals are achieved and even exceeded

Long and significant irrigation leads to soil saturation. **Fractionated irrigation and sensors use enable the reduction of water use.**

Practice Performances

Positive outcome | Neutral to positive outcome | Areas of improvement | Critical points

AGRONOMY & ENVIRONMENT

Pesticides reduction — Has not been studied

Climate change mitigation potential — Reduction in the use of energy (water pumping)

Fruit production — High yield maintained

Water use reduction.

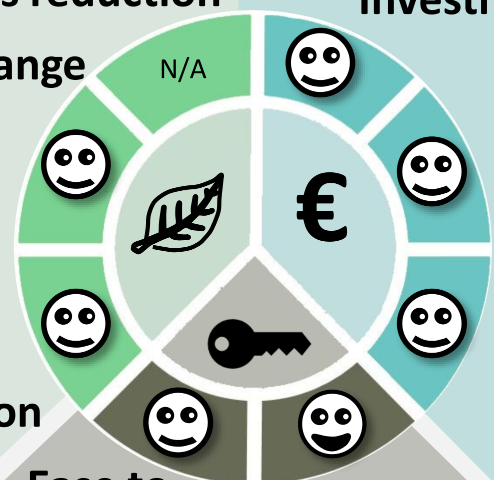
COSTS & BENEFITS

Investment cost — Low investment cost

Time to set-up — Low time required to settle and remove sensors.

Time to manage — Time required for monitoring is low

Reduction costs related to water use.



Ease to implement

Ready to use

Fairly easy to set-up

Well-known practice

HUMAN ASPECTS & FEASIBILITY

Dissemination

- **FRIENDLY FRUIT OUTPUT: Leaflet** (overall method and results)
- **Short report** (detailed method and results) to be distributed to the 5 partner farmers
- **Short training session** for the technical consulting staff
- **Berry School event** (Morocco)