The Use of Images in Digital Agriculture:
Current Limitations and Examples

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Introduction - Why is it so important to use images in Digital Agriculture?

Images are, in several cases, the **unique available approach** to measure or estimate several parameters from the crops.

- *Such as the presence of pests and disease or to estimate the yield.*

In other cases, the huge spatial variability of a parameter requires a **high number of sensors** for its acurate monitoring which can **be replaced by an image** covering the whole area.

- *Such as soil moisture*

Finally, in other cases, **the result of a sensor** or a group of sensors in used to generate an image.

- *Such as the GreenSeeker, which measures the Normalized Difference Vegetation Index (NDVI), a measure of plant vigour, or the Laser Imaging Detection and Ranging (LiDAR).*

Introduction - What image sources we can identify?

During the last decades, remote sensing was based on satellite imagery with a relative high temporal resolution, low spatial resolution and high spectral resolution.

The inclusion of aerial images has also been used but with very low temporal resolution and spatial resolution.

In the last years, drones have become an important source of images due to their flexibility in spatial and temporal resolution and including multispectral cameras.

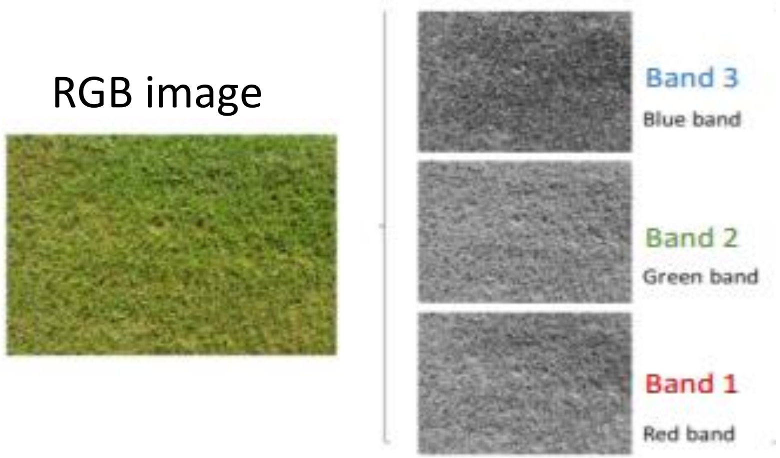
The use of RGB cameras and hyperspectral cameras as proximal sensing should not be underestimated.

Finally, other devices as certain NDVI meters or LiDAR stations can generate images with information as a result.

Introduction - What information provide the image?

In most cases, the images provide information about the reflection of light at a certain wavelength of the surfaces.

The most common images are the Red-Green-Blue (RGB) pictures.



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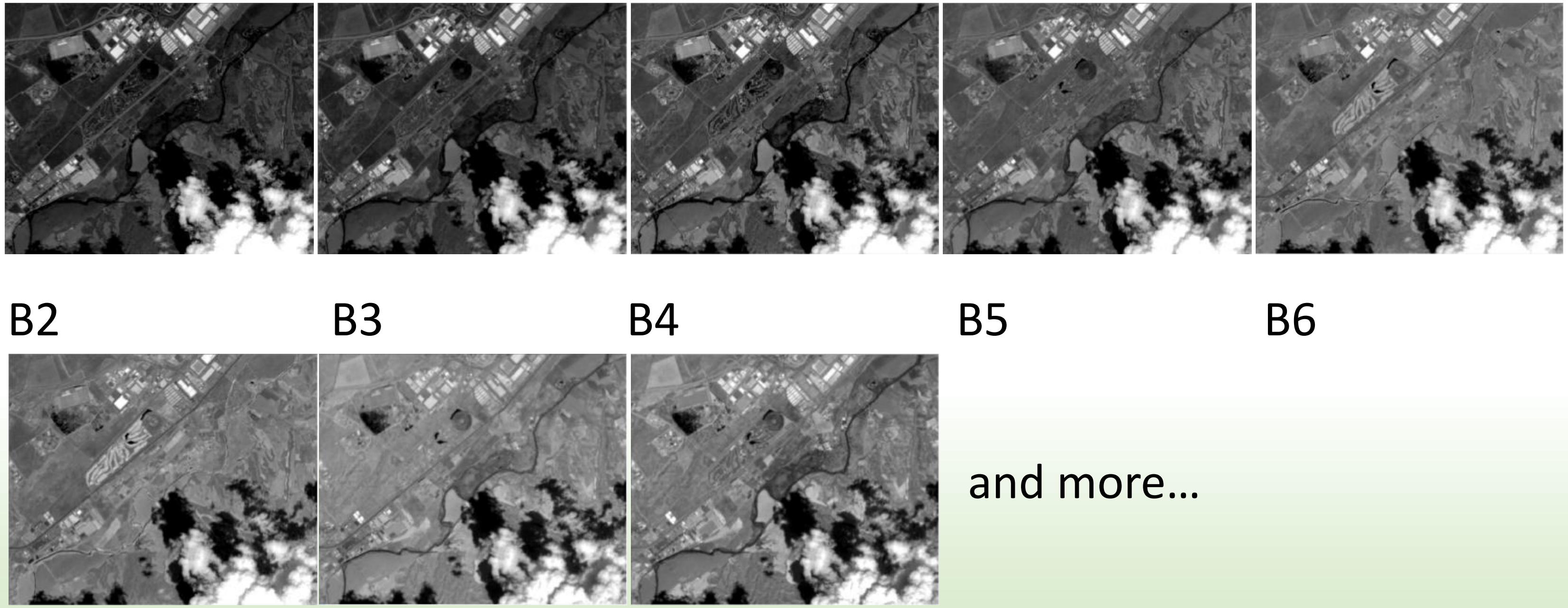
In other cases, we use multispectral images compose of more than three bands.

True color image



B2 B3 B4 B5 B6

B7 B11 B12

and more…

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In other cases, we use multispectral images, compose of more than 3 bands.

Finally, we can find hyperspectral images composed of thousands of bands.

Introduction - What information provide the image?

In most cases, the images provide information about the reflection of light at a certain wavelength of the surfaces.

On the other hand, some images do not provide information about the reflection at a certain wavelength. We can find two cases:

- Processed products, based on the mathematical operation of images with information about the reflection at a certain wavelength.
  - For example, the NDVI, which is on based the combination of red and infrared images.
  - The application of filters to a single image or the reclassification of the pixel values.

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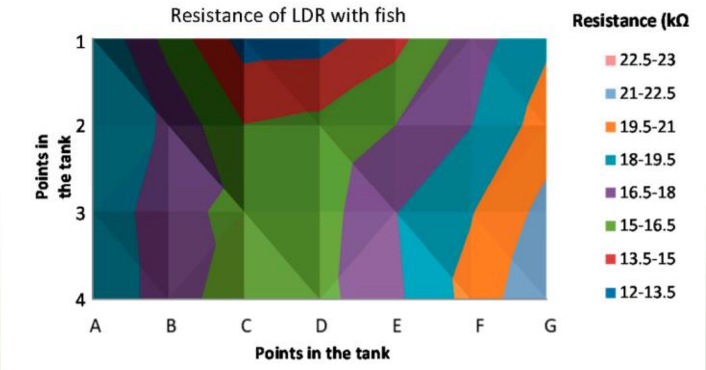
- Processed products, based one the mathematical operation of images with information about the reflection at a certain wavelength.
- Generated images based on the spatial variation of data of a sensed variable and the interpolation of the sensed values.



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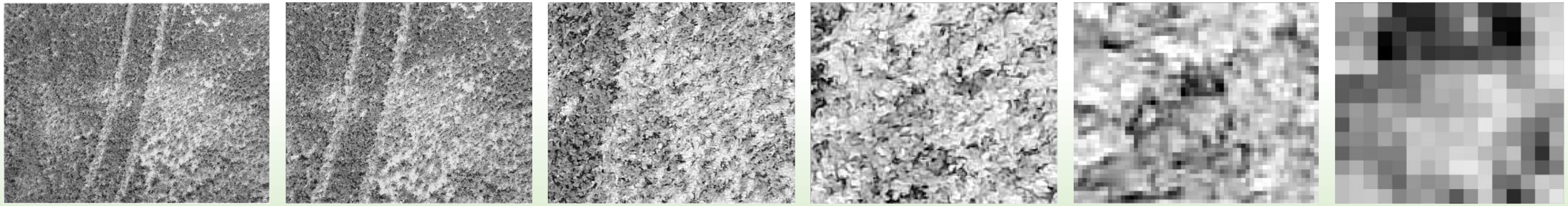
On the other hand, some images do not provide information about the reflection at a certain wavelength, we can find two cases:

In all the cases, the images are composed of pixels that have the sensed parameter value. Images can be considered as huge matrixes of data.



106	144	157	152
135	144	144	152
185	175	168	187
175	184	175	174

Current limitations

Considering the variability of images sources, not all of them can be processed equally.

Satellite images have a huge size, formed of up to 15 bands (example of Sentinel 2), including information of 100 x 100 km. The whole document downloaded from their database is greater than 1 GB. A single band contains up to 120,560,400 pixels

Images from drones or cameras mounted on machinery have fewer bands, generally 3 to 5. Usually, they to contain only the information of the target area. The bands are composed of fewer pixels.

Example of reflex camera Canon EOS 77D: 24,000,000 pixels

Example of images form Parrot BeBop-Pro Thermal: 1,555,200 pixels

Example of images from CMOS OV7670 Camera Module: 307,200 pixels

Current limitations

Considering the variability of images sources, not all of them can be processed equally.

If we expect to have and autonomous system operating in the fields, capable of activating or disactivating actuators locally and in real time or near-real time, based on images the system becomes complex.

Several issues must be considered before having this sort of systems in the fields:

The system itself must gather the images. It cannot rely on satellite images due to the huge bandwidth required to download the images and their low temporal resolution. **Therefore, drones or cameras mounted on machinery are the sole options.**

The use of object recognition should be avoided if a fast response is needed. The large size of images precludes cloud computing. **Therefore, simple image processing is preferred.**

Current limitations

Considering the variability of images sources, not all of them can be processed equally.

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Drones or cameras mounted on machinery are the sole options and simple image processing is preferred.

If we expect to create an online platform to assess the farmers, more flexibility is allowed since more powerful computing resources and higher bandwidth are allocated.

In this case, no restrictions should be applied.

Current limitations – Simple image processing

In the case that we expect to have a node in the field collecting images and connected into a network with actuators, we should ensure that the node can process the data.

The images should be processed as data matrices using **mathematical operators**, **combining bands**, **aggregation techniques**, etc. The application of preestablished rules as **thresholds** to reclassify the image is also possible. **Edge detection** based on filters and aggregation techniques are feasible too.

Current limitations – Simple image processing

Finally, the solutions must be tailored for each crop or group of crops since the problems and characteristics are different.

The size and distribution of the crop are important.

To identify the harvest moment, the spatial resolution needed for oranges (diameters of fruit 6-10 cm) is not the same as that for chickpeas (diameter of pod <2 cm).

To identify weed plants, the technique for cereals (sowed in lines) is not valid for urban lawns (sower to cover the whole surface).

Current limitations – Simple image processing

Finally, the solutions must be tailored for each crop or group of crops since the problems and the characteristics of each one is different.

- The size and distribution of crop is important.
- The problems of each crop might be different.
  - Rainfed vs. irrigated crops.
  - Annual vs. pluriannual crops.
  - Monocrop vs. intercropping managements.

Examples of proposed solutions in real cases

Motivation: Identify weed plants

When weeds are detected from an image gathered with a drone with the aim of applying the appropriate phytosanitary product, the system needs to process data in real-time or near-real-time. Thus, simple image processing methods should be applied.

On the other hand, given the size of weed plants, drones or cameras mounted on machinery must be used.

Examples of proposed solutions in real cases

Motivation: Identify weed plants

Task: Determine if band combination can be used to detect weed plants in chickpea

Objectives:

1. Define a methodology based on band combination to identify weed plants in chickpea.
2. Compare the proposed index with existing ones.

Chickpea
Crop

Prickly burweed
Weed plant

Parra, L., Yousfi, S., Mostaza, D., Marín J.F., Mauri P.V. (2021). Propuesta y comparación de índices para la detección de malas hierbas en cultivos de garbanzo. XI Congreso Ibérico de Agroingeniería 2021, Valladolid, Spain, 11 November 2021.

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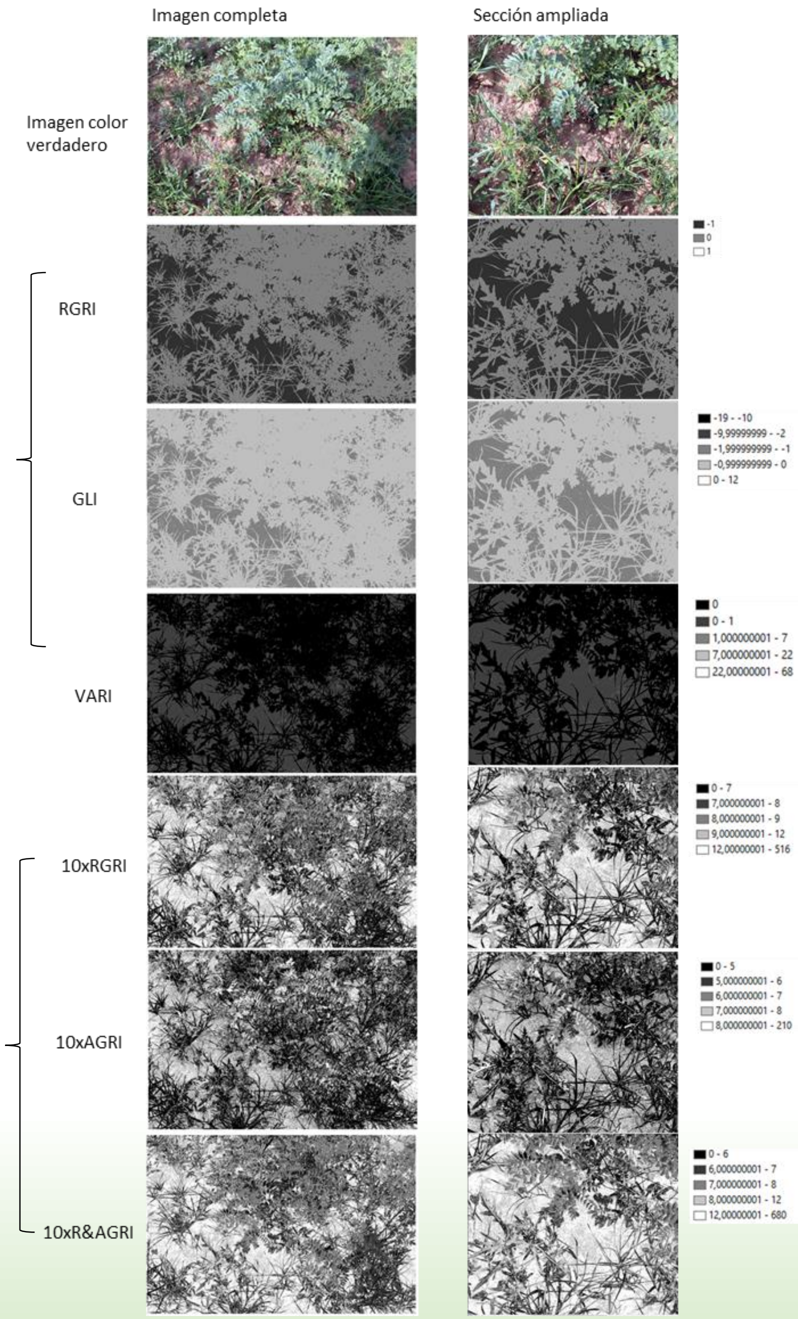

Proposed indexes improve the performance of existing ones

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Examples of proposed solutions in real cases

Image is subdivided into six fragments, and Fasle Negatives (FN) with proposed indexes are analyzed

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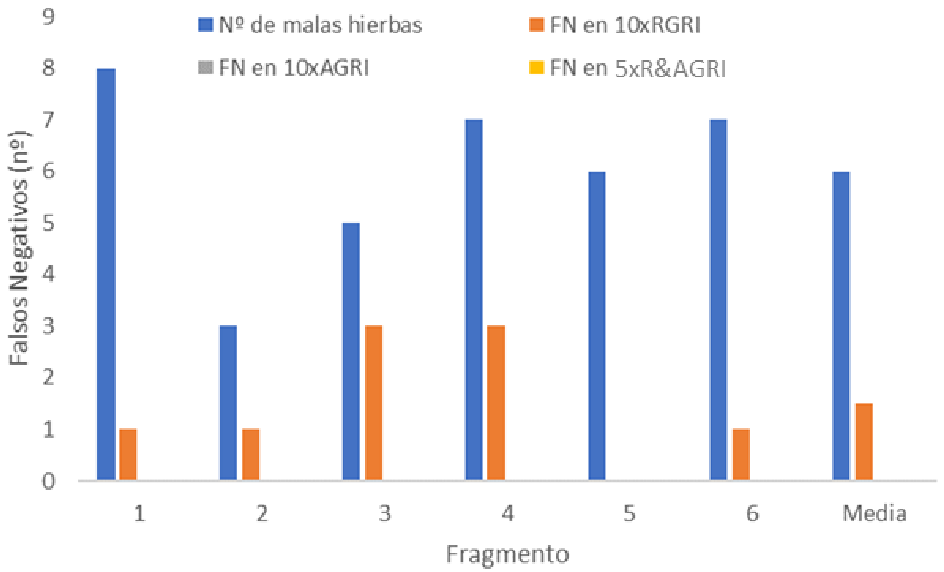

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In blue nº of weed plants in orange, grey and yellow, the nº of FN for proposed indexes

10xAGRI and 5xAGRI show similar performance in weed detection

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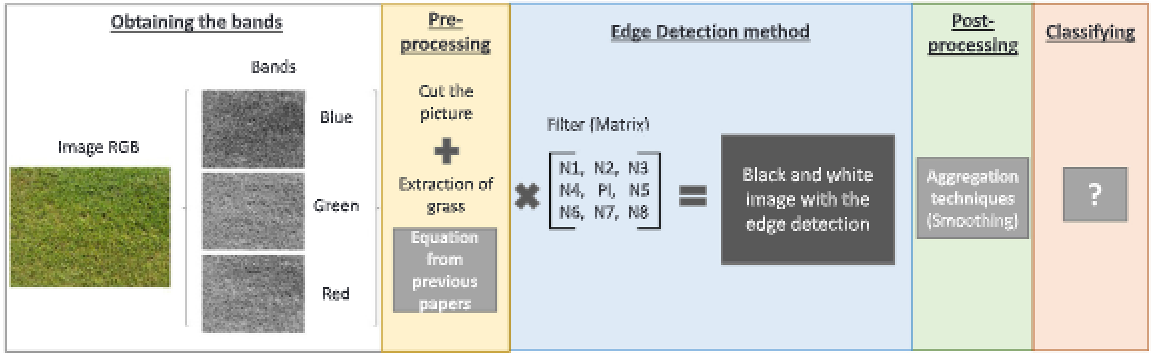
Motivation: Identify weed plants

Task: Determine if edge detection can be used to detect weed plants in golf course

Objectives:

1. Define a methodology based on edge detection to identify weed plants in turfgrass



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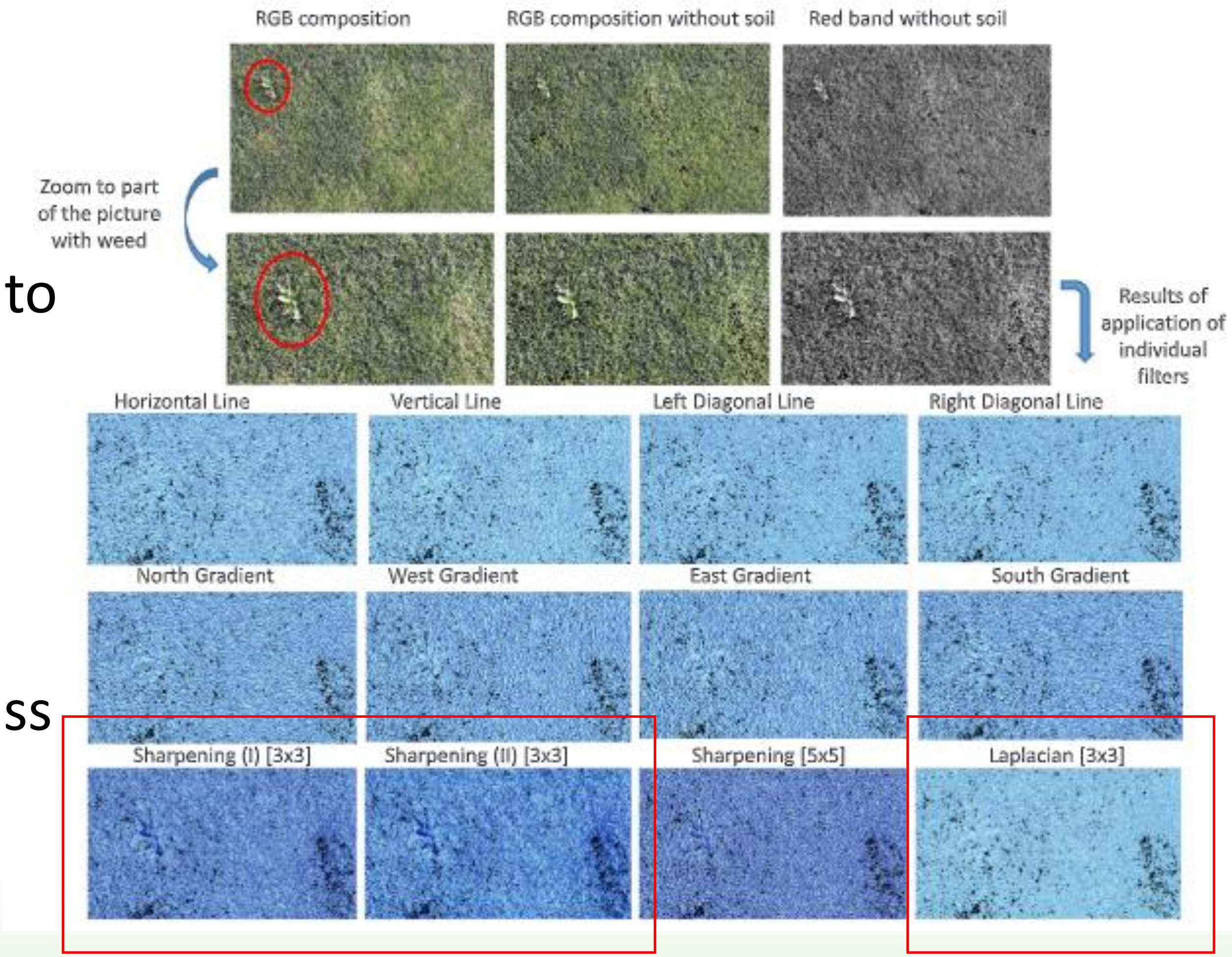

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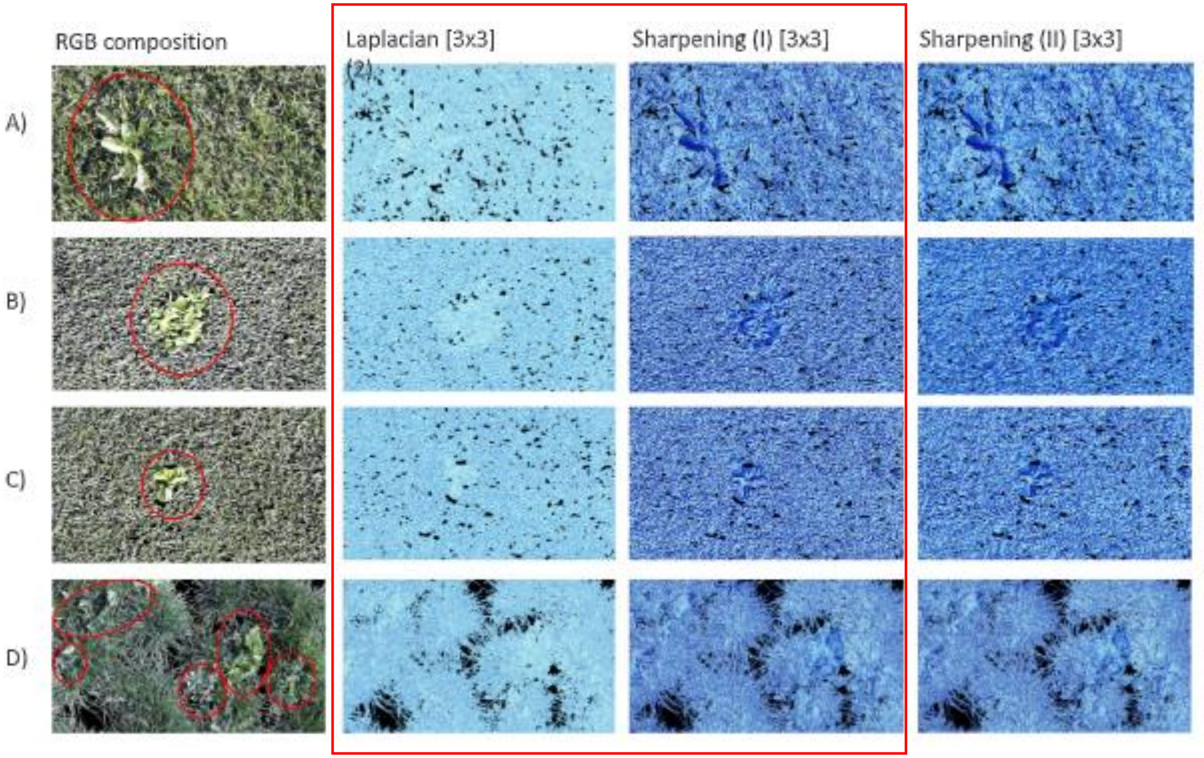

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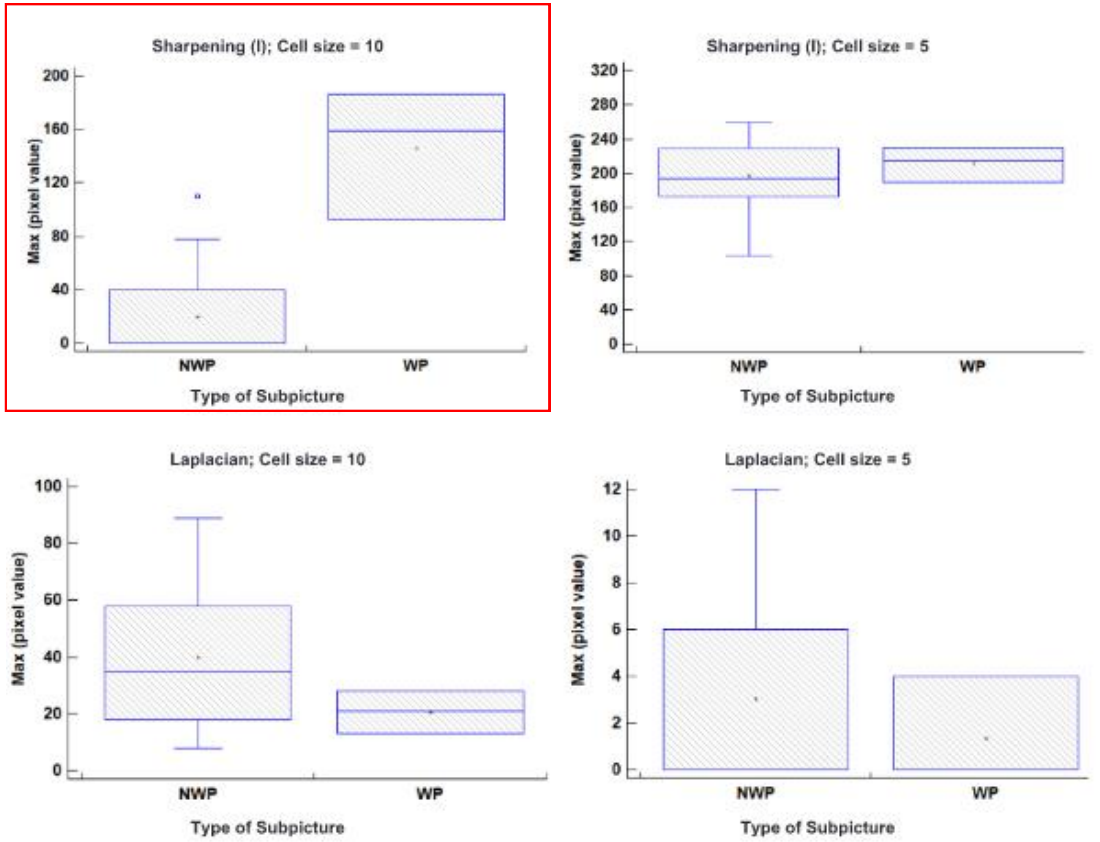

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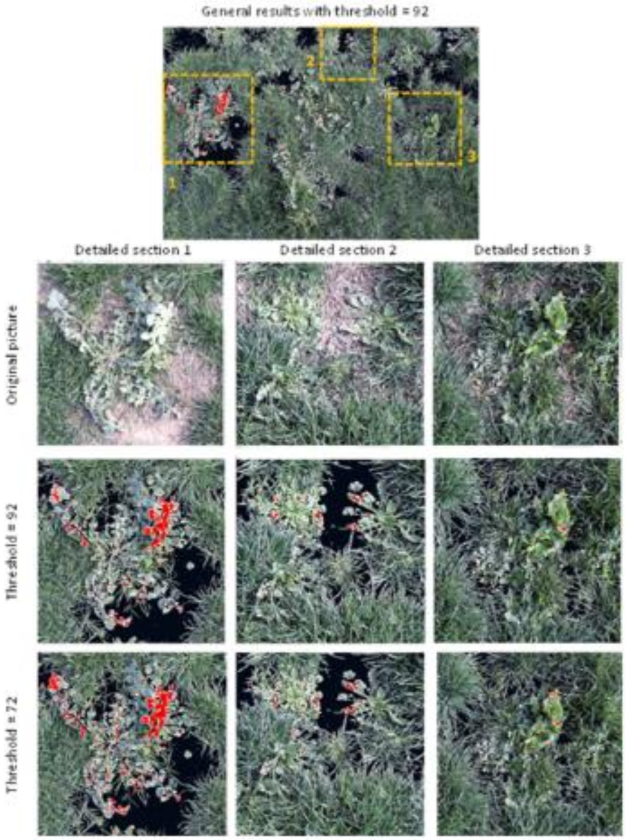

Value of Precision (Pre), Recall (Rec) and F1 Score (F1) for the different thresholds.

	Threshold = 78			Threshold = 85			Threshold = 92		
	Pre	Rec	F1	Pre	Rec	F1	Pre	Rec	F1
Picture D)	80%	86%	83%	83%	68%	75%	84%	57%	68%
Picture E)	67%	86%	75%	71%	71%	71%	75%	43%	55%

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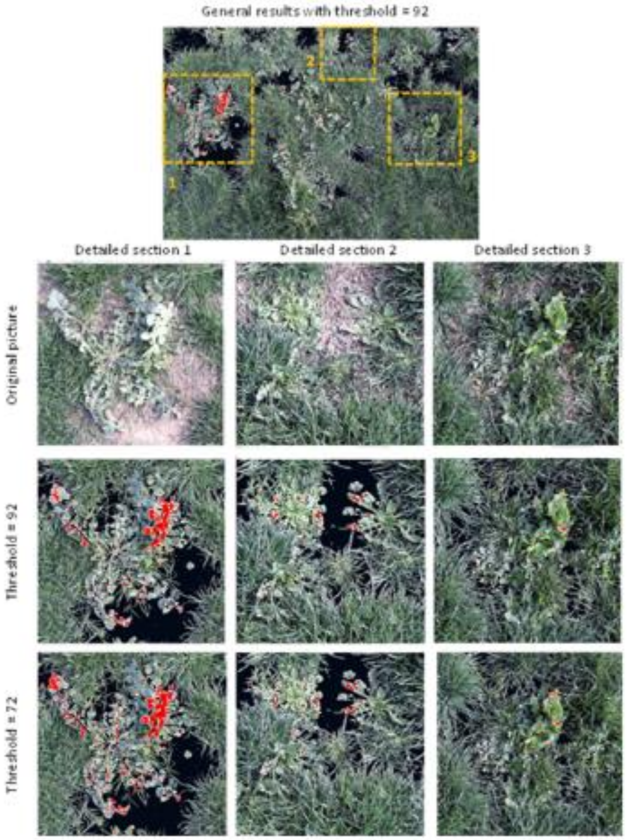
Proposed methodology has good performance



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Examples of proposed solutions in real cases

Motivation: Identify weed plants

Task: Determine the maximum flying height which can be used to detect weed plants in a golf course with a low-cost drone.

Objectives:

1. Define a methodology to detect weed plants in greens of a golf course.
2. Identify the maximum height at which this methodology can be applied.

Marin, J.F., Mostaza-Colado, D., Parra, L., Yousfi, S., Mauri, P.V., Lloret, J., (2021). Comparison of Performance in Weed Detection with Aerial RGB and Thermal Images Gathered at Different Height. The Seventeenth International Conference on Networking and Services (ICNS 2021), Valencia, Spain, 30 may – 3 June, 2021.

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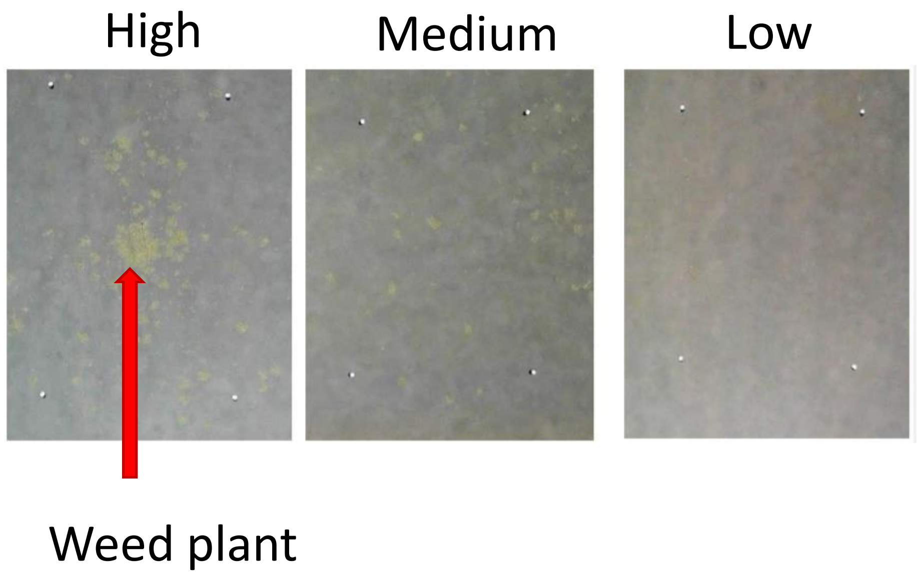
Three testing areas with variable weed presence



Tested flying heights: 4, 8, 10, 12, and 16m

Vegetation Index= B1+B2-B3

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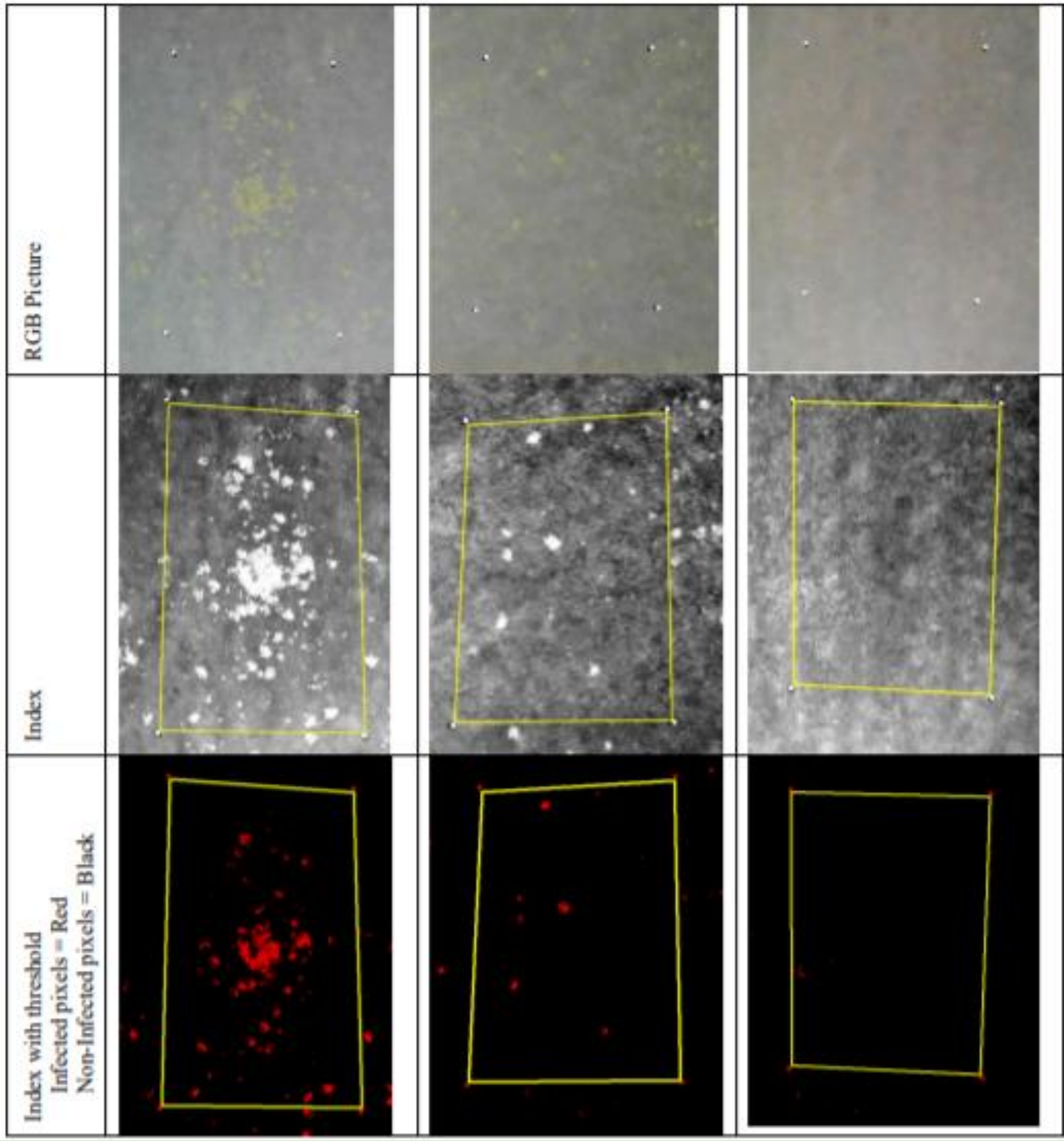
Proposed index is good for weed detection



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Maximum height of 10 m for this methodology

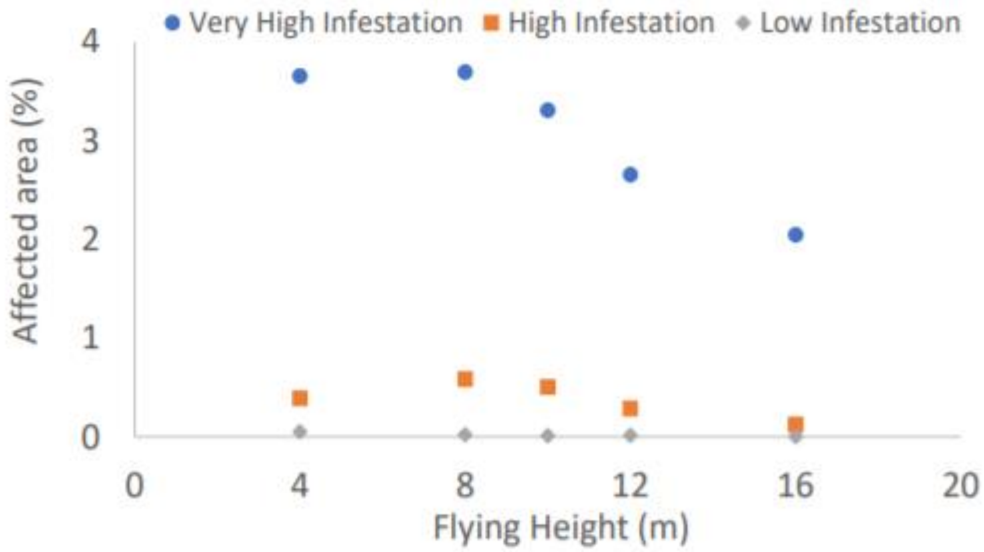

Figure 2. Comparison of estimated affected areas at each height

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Examples of proposed solutions in real cases

Motivation: Identify different crops in intercropping

In some scenarios, the presence of two species is not related to the crop+weed case. Intercropping is the simultaneous cropping of two or more species. In this case, it is essential to identify the species initially before applying other operations correctly. Different crops might have different plant vigour without implying a stress condition of a disease.

Since posterior indexes might be applied in real-time to take the appropriate decisions, this task has the same restrictions as the subsequent ones.

Depending on the size of the crops and the lines of the crops, satellite images can be used or not.

Examples of proposed solutions in real cases

Motivation: Differentiate species in intercropping

Task: Differentiate three legumes (chickpea, lentil, and ervil)

Objectives:

1. Evaluate if a low-cost drone with an RGB camera can serve as an information source to differentiate crops.

   Drone used: Parrot BeBop2 Pro Thermal

2. Generate a procedure based on an index to differentiate crops.

Parra, L., Yousfi, S., Mostaza-Colado, D., Marin, J.F., Lloret, J., Mauri, P.V. (2021, October). Evaluación del uso de imágenes para diferenciar garbanzos, lentejas y yeros en cultivos mixtos. XVI CONGRESO NACIONAL DE CIENCIAS HORTÍCOLAS, Cordoba, Spain, 17-22 October 2021.

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Image gathered at 16m

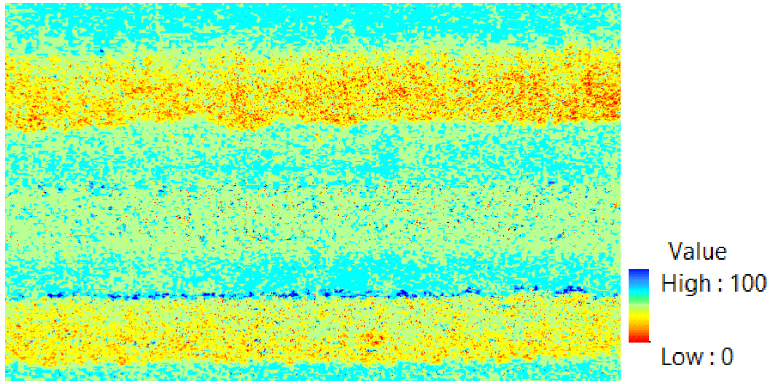
Ervil

Chickpea

Lentil

Index application

$$\textbf{Index} = \frac{\textbf{\textit{Blue band}} \times \textbf{10}}{\textbf{\textit{Green Band}}}$$



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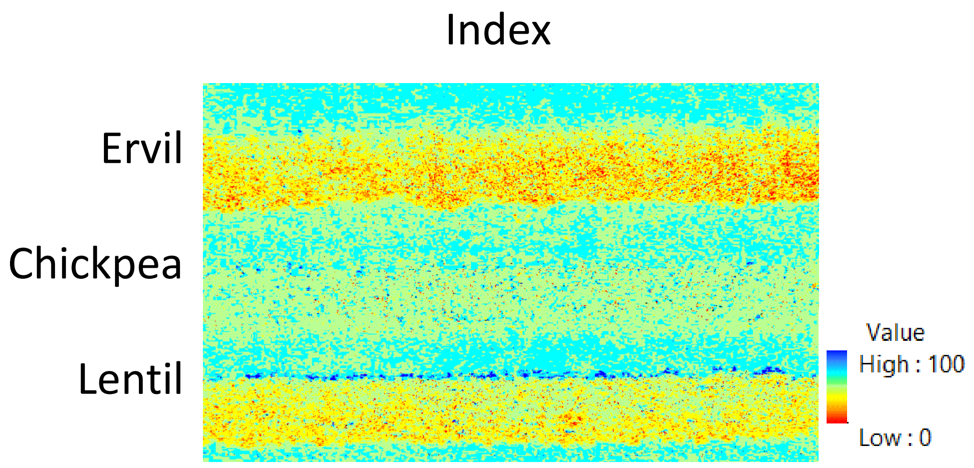
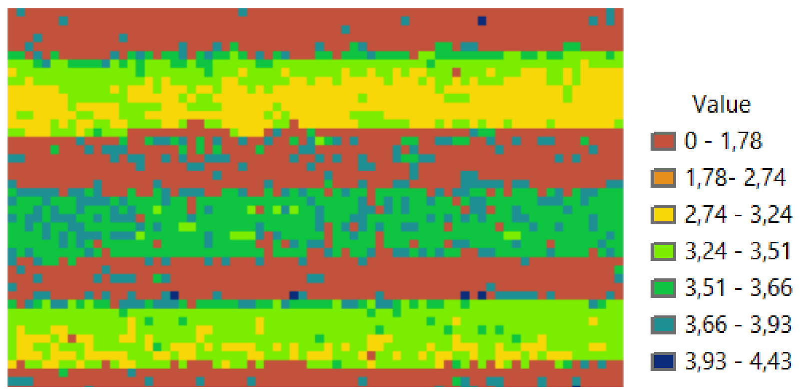


Aggregation technique
Summation & Cell size=20



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It was possible to differentiate the crops in intercropping with low-cost drone

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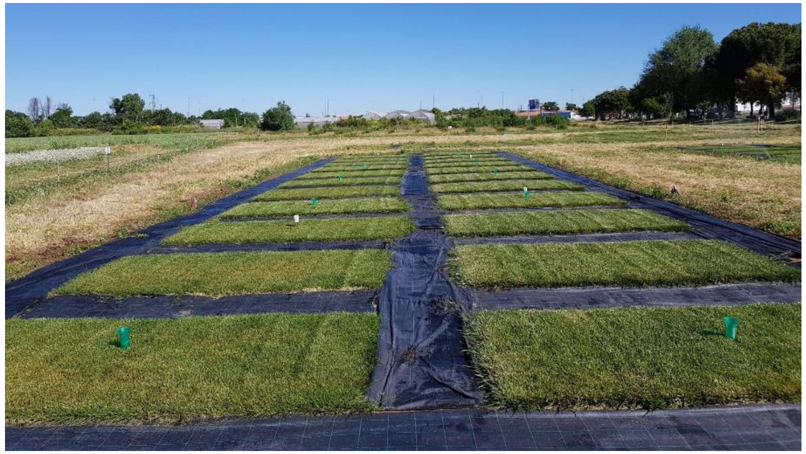


Motivation: Differentiate species in intercropping

Task: Use pictures gathered at 1.5m to differentiate grass species with Green Area (GA) and Greener Area (GAA) index.

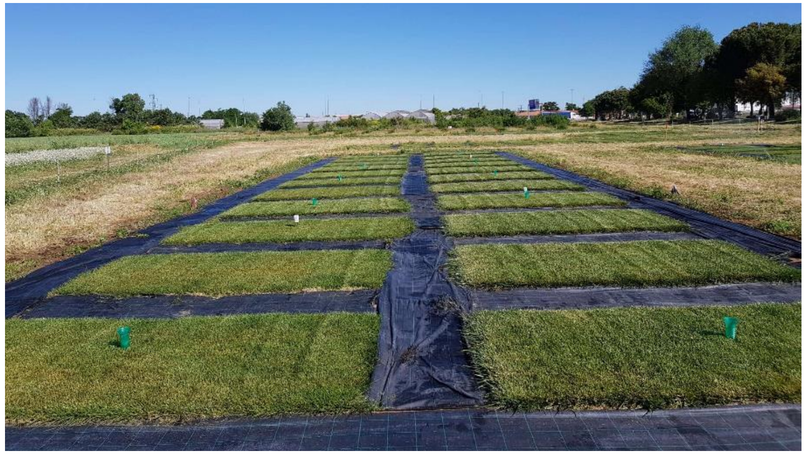
Objectives:

1. Evaluate if GA and GAA can differentiate plant species.
2. Compare its performance with
other variables measured from sensors

Mauri, P.V, Parra, L. Lloret, J., Yousfi, S., Marín J.F. (2020, October). Testing and Validation of Monitoring Technologies to Assess the Performance and Genotyping of Poa pratensis (C3) Mixed with Other Grass Species (C4). The Twelfth International Conference on Advances in System Testing and Validation Lifecycle (VALID 2020) (pp. 1-6)

Examples of proposed solutions in real cases

Motivation: Differentiate species in intercropping



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	SM	CT	NDVI	GA	GGA
Control	35.2583 [a]	14.6125 [a]	0.76 [a]	0.67875 [b]	0.35 [a]
PC	35.5 [a]	14.8417 [a]	0.745 [a]	0.61805 [a]	0.295 [a]
PB	34.3944 [a]	14.6056 [a]	0.79 [b]	0.77944 [c]	0.48 [b]
PZ	36.3722 [a]	14.4694 [a]	0.77 [b]	0.76472 [c]	0.425 [b]
Level of significance	0.8727 [ns]	0.9579 [ns]	0.0005***	0.0000***	0.0000***

GA is the best indicator of grass species

Mauri, P.V, Parra, L. Lloret, J., Yousfi, S., Marín J.F. (2020, October). Testing and Validation of Monitoring Technologies to Assess the Performance and Genotyping of Poa pratensis (C3) Mixed with Other Grass Species (C4). The Twelfth International Conference on Advances in System Testing and Validation Lifecycle (VALID 2020) (pp. 1-6)

Examples of proposed solutions in real cases

Motivation: Identify different management options

In certain cases, weed plants might not be a problem itself and are considered as a potential benefit since they stabilize and even improve some soil parameters. The evaluation of the most common management options in a given area can be done without the constrictions of real-time.

Nonetheless, the future application of these processes in large areas to evaluate the management option of a river basing, for example, precludes the use of drones. Thus, it is necessary to focus on satellite imagery.

The main problem is that open sources satellite imagery has lower spatial resolution than the required one. Therefore, it will be impossible to identify the spontaneous vegetation and the crop.

Examples of proposed solutions in real cases

Motivation: Identify different management options

Task: Identify the plot with spontaneous vegetation maintenance in vineyards with satellite imagery.

Objectives:

1. Evaluate if time series analysis can be applied to obtain information that cannot be obtained with the actual pixel dimensions.

Basterrechea, D.A., Parra, L., Lloret, J., Mauri, P.V.. (2020, October). Identifying the Existence of Grass Coverage in Vineyards Applying Time Series Analysis in Sentinel-2 Bands. The The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2020), Valencia, Spain, 21-25 November, 2020.

Examples of proposed solutions in real cases

Motivation: Identify different management options

Task: Identify the plot with spontaneous vegetation maintenance in vineyards with satellite imagery.

Objectives:

1. Evaluate if time series analysis can be applied to obtain information that cannot be obtained with the actual pixel dimensions.

Basterrechea, D.A., Parra, L., Lloret, J., Mauri, P.V.. (2020, October). Identifying the Existence of Grass Coverage in Vineyards Applying Time Series Analysis in Sentinel-2 Bands. The The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2020), Valencia, Spain, 21-25 November, 2020.

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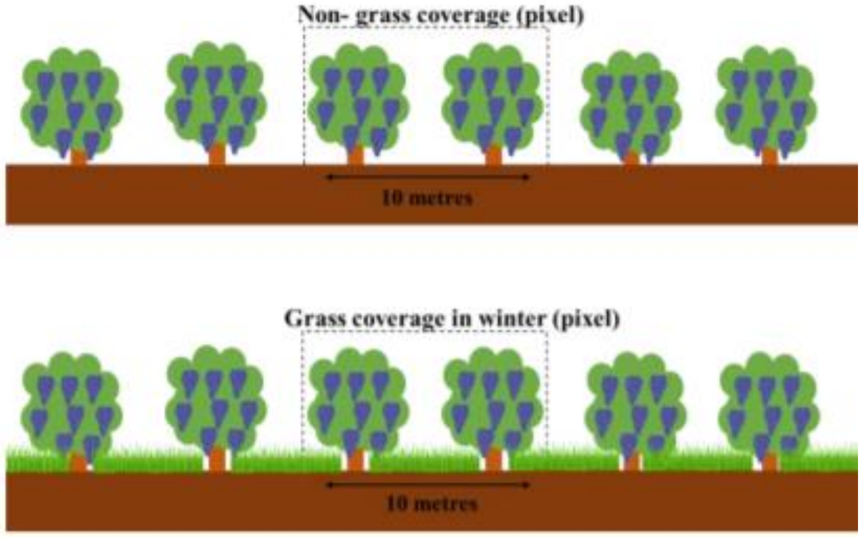

Figure 1. Scheme of pixel information content.

Bands	Reflectance GC=1	Reflectance GC=0	Differences in reflectance GC=1	Differences in reflectance GC=0
B2	Low	Low	Low	Low
B3	Higher	High	High	Low
B4	Low	High	High	Low
B8	High	High	Low	Low
B9	Higher	High	High	Low
Pixels of:	**GC=1 Winter**	**GC=1 Summer**	**GC=0 Winter**	**GC=1 Summer**
Vid	High percentage	High percentage	High percentage	High percentage
Soil	Almost null	Low percentage	Low percentage	Almost null
Green grass coverage	Low percentage	Almost null	Almost null	Almost null

Basterrechea, D.A., Parra, L., Lloret, J., Mauri, P.V.. (2020, October). Identifying the Existence of Grass Coverage in Vineyards Applying Time Series Analysis in Sentinel-2 Bands. The The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2020), Valencia, Spain, 21-25 November, 2020.

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Original information from satellite

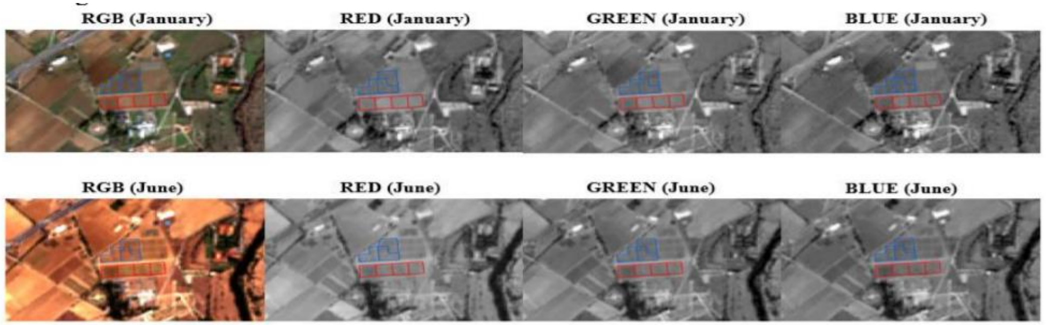

Figure 3. Visible spectrum bands.

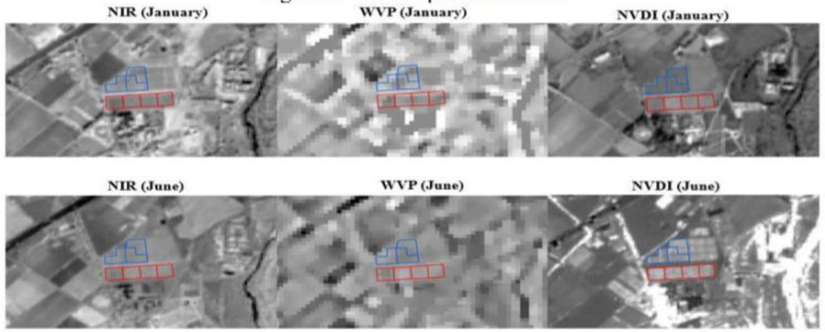

Figure 4. Near-infrared band, water vapour band, and vegetation index band.

Results

Combined images of January and June as:

Pixel value in January- Pixel value un June

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Examples of proposed solutions in real cases

Results
Combined images of January and June as:
Pixel value in January- Pixel value un June

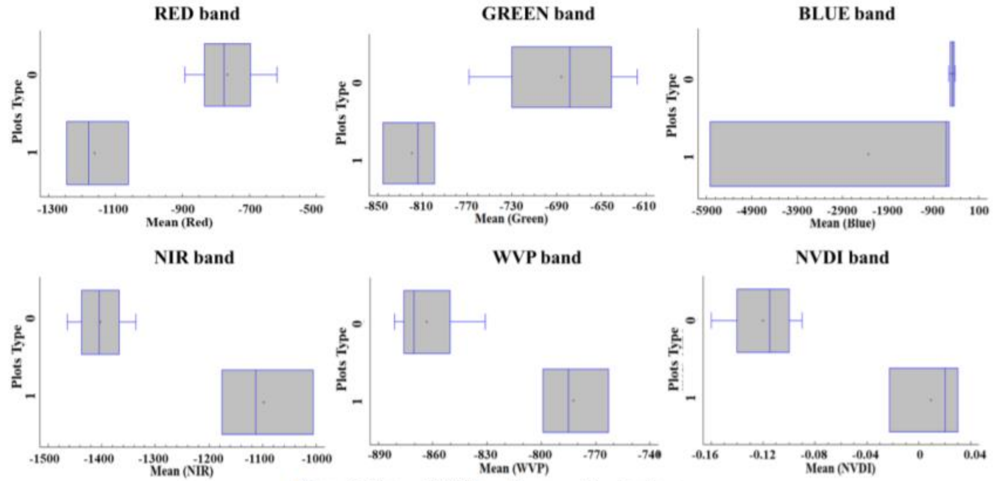

Figure 6. Box and Whiskers diagram of band values.

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Type 1=With spontaneous vegetation
Type 0=Without spontaneous vegetation

Best information is from the NIR band.
With grass coverage: pixel values from -1000 to -1200.
Without grass coverage: pixels with values from -1200 to -1500.

Is it possible to use time series to evaluate different management options

Basterrechea, D.A., Parra, L., Lloret, J., Mauri, P.V.. (2020, October). Identifying the Existence of Grass Coverage in Vineyards Applying Time Series Analysis in Sentinel-2 Bands. The The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2020), Valencia, Spain, 21-25 November, 2020.

Examples of proposed solutions in real cases

Motivation: Identify establishment success

In agriculture, the establishment success, correct germination, and crop emergence is a vital moment. While some crops have elevated establishment success rates, other crops such as chickpea have relatively low establishment success.

In this case, no real-time is needed, but the small size of the plants requires drone imagery. Although artificial intelligence and object recognition might be planned, the local processing of images as the drones fly, allows the farmer to have a prompt evaluation of the lands.

A secondary issue arises at this moment. The continuous collection of images is starting to suppose a problem for the drone operator, the required space to store the generated information is growing exponentially.

Examples of proposed solutions in real cases

Motivation: Identify establishment success

Task: Compare the establishment success of a given area with lentil and chickpea.

Objectives:

1. Evaluate the use of band combination to estimate the establishment success of legumes.
2. Evaluate the use of different aggregation techniques and flying height that maintains the accuracy while reducing the required storage capacity.

Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

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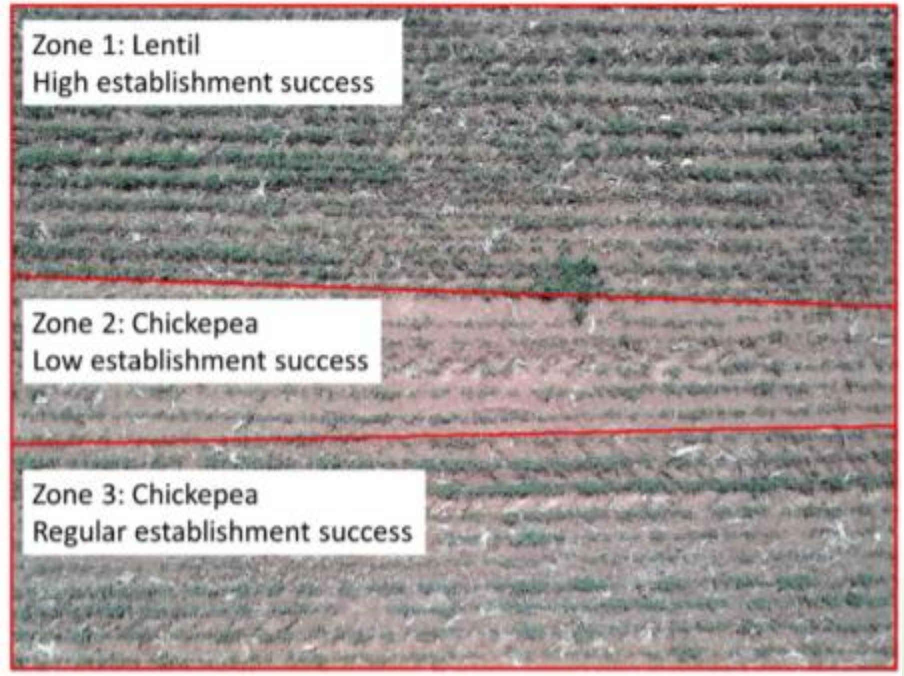
Selected drone: Parrot BeBop 2 Pro Thermal

The area is divided into three zones



Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

Examples of proposed solutions in real cases

Images are gathered at 3 different height, and divided into 5 subzones for each zone

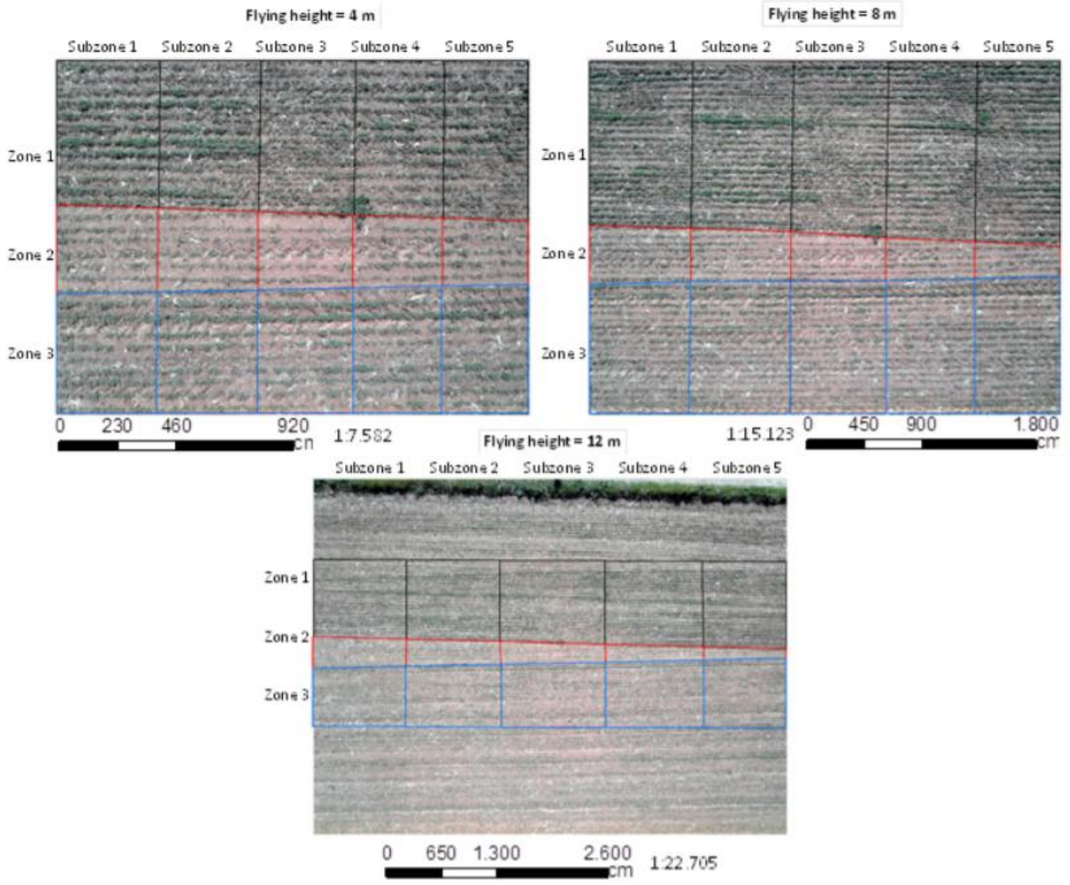


Figure 3. The division into zones and subzones of the used images with scale and text bar.

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Examples of proposed solutions in real cases

Followed approach:

Differentiate the green leaves from the soil with an index and apply the following process:
Index: B1/B2

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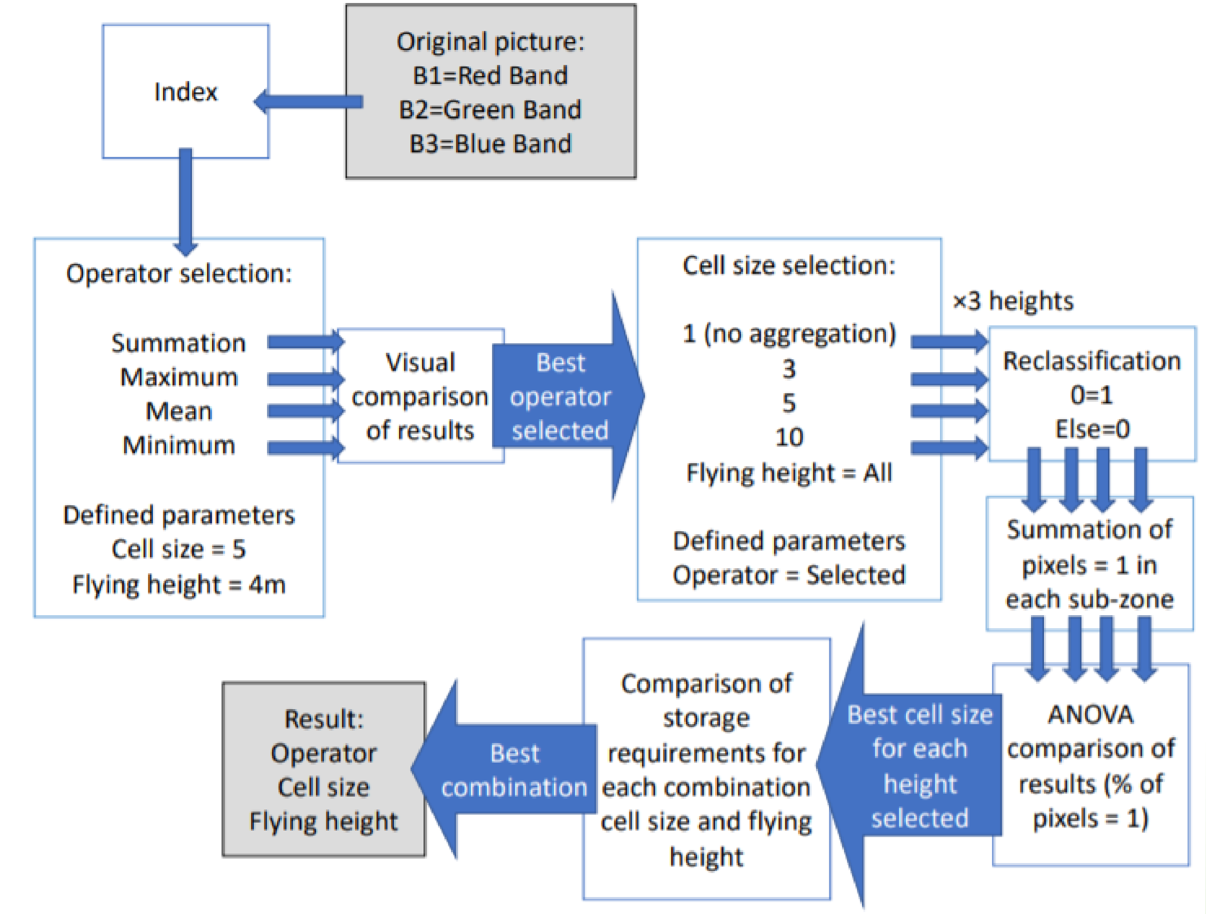

Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

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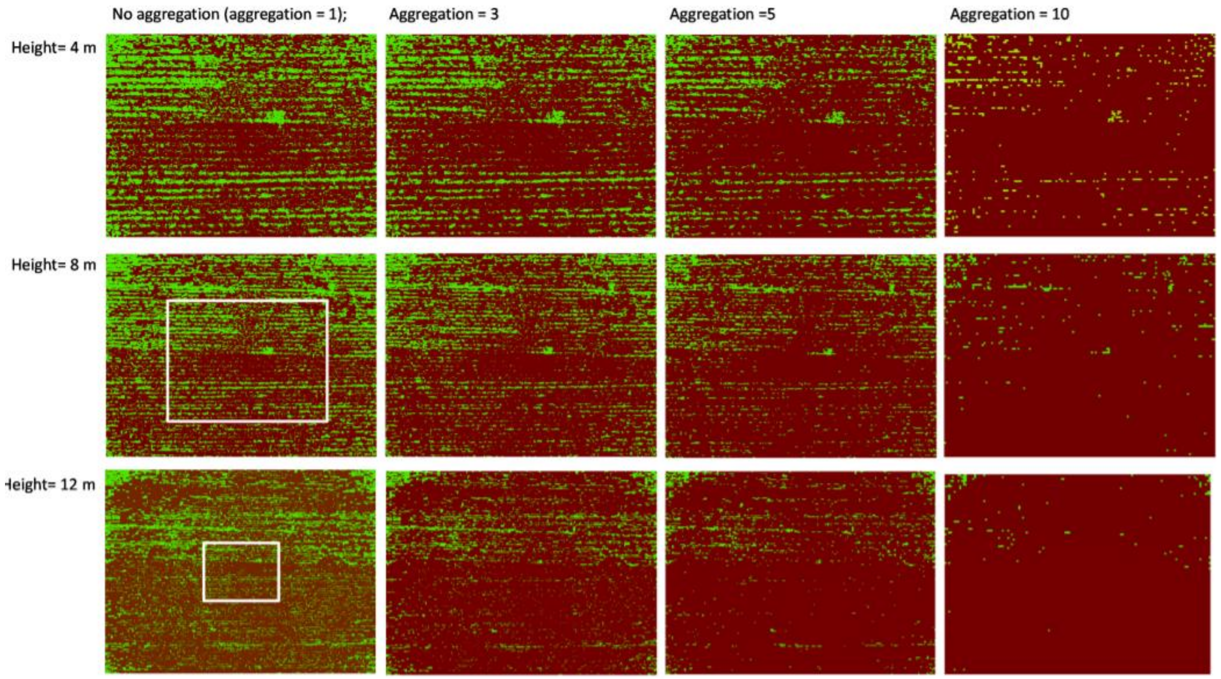
Initial results:

Differentiate the green leaves from the soil with an index and apply the following algorithm:
Index: B1/B2



Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

Examples of proposed solutions in real cases

Classification of results for different flying height and aggregation techniques

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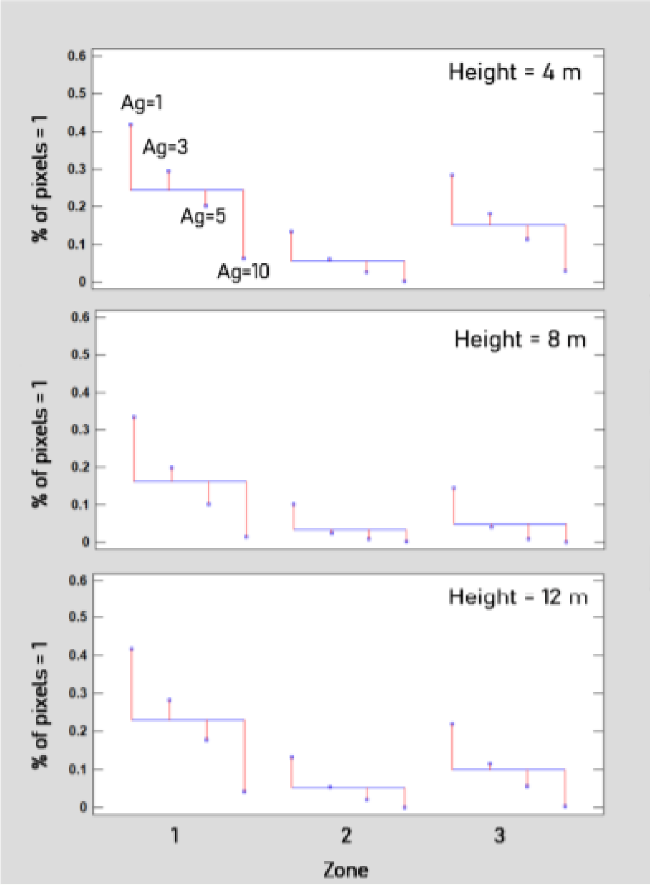

Combination flying height and cell size	4 m 1 pixel	4 m 3 pixel	4 m 5 pixel	4 m 10 pixel
p-value	0.0001	0.0003	0.0010	0.0097
Nº of groups	3	3	3	2
Zone 1	C	C	C	B
Zone 2	A	A	A	A
Zone 3	B	B	B	AB
Combination flying height and cell size	**8 m 1 pixel**	**8 m 3 pixel**	**8 m 5 pixel**	**8 m 10 pixel**
p-value	0.0000	0.0000	0.0002	0.0012
Nº of groups	3	3	2	2
Zone 1	C	C	B	B
Zone 2	A	A	A	A
Zone 3	B	B	A	A
Combination flying height and cell size	**12 m 1 pixel**	**12 m 3 pixel**	**12 m 5 pixel**	**12 m 10 pixel**
p-value	0.0000	0.0000	0.0000	0.0061
Nº of groups	3	2	2	2
Zone 1	C	B	B	B
Zone 2	A	A	A	A
Zone 3	B	A	A	A

Band combination is useful to estimate establishment success

Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

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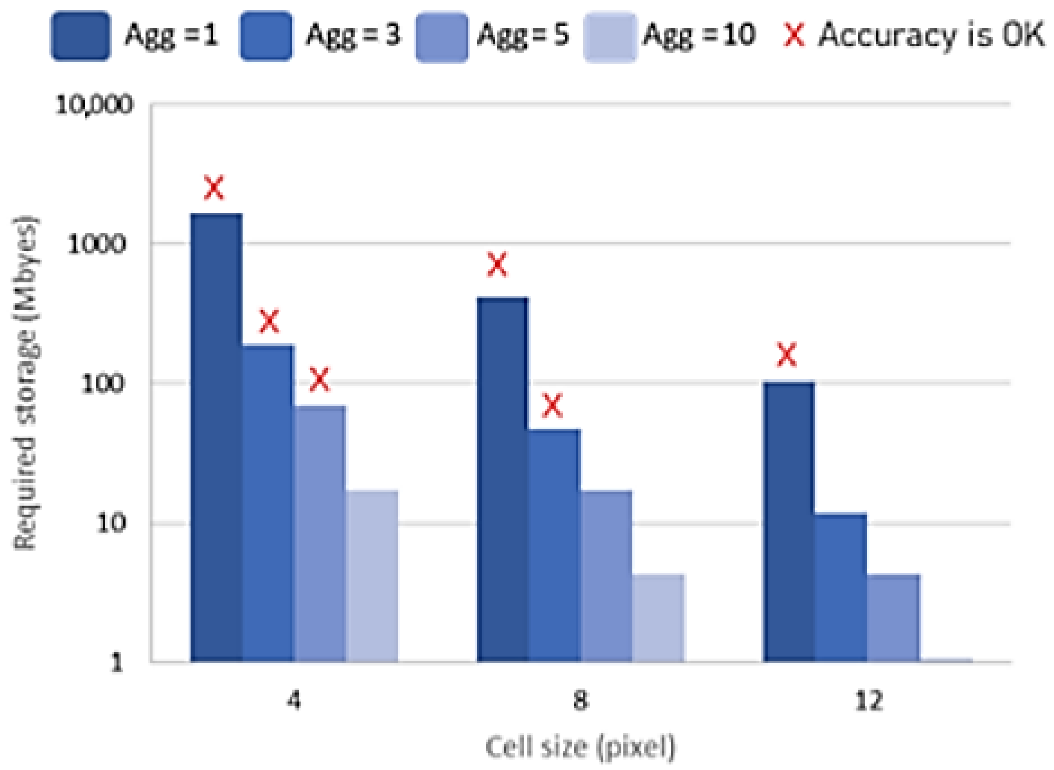
Required storage capacity for each option



The combination of flying height of 8 m and a aggregation technique with cell size = 3 is the one that minimizes the required storage capacity.

Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

Future perspective

In the near future, drones will have an even more relevant role in the digitalization of agriculture.

The use of images will be common and will be integrated with sensors, creating a diverse network.

The storage capacity will be a real constrain, which should be addressed soon.

Future perspective

The inclusion of multispectral or hyperspectral cameras will allow a better management of agriculture. The generated data will be used for new applications such as phenotyping or selecting individuals in breeding lines.

The multispectral cameras will require more powerful nodes to be able to process the generated information. At the same time, this will exacerbate the problems related to storage requirements.

Future perspective

The advances in telecommunication of devices and its nodes will allow the management of a greater amount of data, allowing the inclusion of object detection techniques and cloud computing in the fields.

Nevertheless, the new multispectral cameras and the enhanced spatial resolution will incorporate new processing requirements.

Future perspective

The continuous improvement of the different included technologies (cameras, nodes, and telecommunication infrastructure) will solve and incorporate different bottlenecks to this process.

Therefore, there will always be constraints in each technology that will need to be overcome.

The optimal solution in many cases will be to find the balance between the available technology and the required accuracy to the specific problems offering a tailored solution.

List of papers included in this tutorial:

Parra, L., Yousfi, S., Mostaza, D., Marín J.F., Mauri P.V. (2021). Propuesta y comparación de índices para la detección de malas hierbas en cultivos de garbanzo. XI Congreso Ibérico de Agroingeniería 2021, Valladolid, Spain, 11 November 2021.

Parra, L., Marin, J., Yousfi, S., Rincón, G., Mauri, P. V., & Lloret, J. (2020). Edge detection for weed recognition in lawns. Computers and Electronics in Agriculture, 176, 105684.

Marin, J.F., Mostaza-Colado, D., Parra, L., Yousfi, S., Mauri, P.V., Lloret, J., (2021). Comparison of Performance in Weed Detection with Aerial RGB and Thermal Images Gathered at Different Height. The Seventeenth International Conference on Networking and Services (ICNS 2021), Valencia, Spain, 30 may – 3 June, 2021.

Parra, L., Yousfi, S., Mostaza-Colado, D., Marin, J.F., Lloret, J., Mauri, P.V. (2021, October). Evaluación del uso de imágenes para diferenciar garbanzos, lentejas y yeros en cultivos mixtos. XVI CONGRESO NACIONAL DE CIENCIAS HORTÍCOLAS, Cordoba, Spain, 17-22 October 2021.

Mauri, P.V, Parra, L. Lloret, J., Yousfi, S., Marín J.F. (2020, October). Testing and Validation of Monitoring Technologies to Assess the Performance and Genotyping of Poa pratensis (C3) Mixed with Other Grass Species (C4). The Twelfth International Conference on Advances in System Testing and Validation Lifecycle (VALID 2020) (pp. 1-6)

Basterrechea, D.A., Parra, L., Lloret, J., Mauri, P.V.. (2020, October). Identifying the Existence of Grass Coverage in Vineyards Applying Time Series Analysis in Sentinel-2 Bands. The The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2020), Valencia, Spain, 21-25 November, 2020.

Parra, L., Mostaza-Colado, D., Yousfi, S., Marin, J. F., Mauri, P. V., & Lloret, J. (2021). Drone RGB Images as a Reliable Information Source to Determine Legumes Establishment Success. Drones, 5(3), 79.

Other similar published papers:

Parra, M., Parra, L., Mostaza-Colado, D., Mauri, P., & Lloret, J. (2020). Using satellite imagery and vegetation indices to monitor and quantify the performance of different varieties of Camelina Sativa. In *GEOProcessing 2020 The Twelfth International Conference on Advanced Geographic Information Systems, Applications, and Services. IARIA, Valencia, Spain* (pp. 42-47).

Garcia, L., Parra, L., Basterrechea, D. A., Jimenez, J. M., Rocher, J., Parra, M., ... & Andrés, J. (2019). Quantifying the production of fruit-bearing trees using image processing techniques. *Proceedings of the INNOV*.

Parra, L., Torices, V., Marín, J., Mauri, P. V., & Lloret, J. (2019, March). The use of image processing techniques for detection of weed in lawns. In *Proccedings of the Fourteenth International Conference on Systems (ICONS 2019), Valencia, Spain* (pp. 24-28).

Parra-Boronat, L., Parra-Boronat, M., Torices, V., Marín, J., Mauri, P. V., & Lloret, J. (2019). Comparison of single image processing techniques and their combination for detection of weed in Lawns. *International Journal On Advances in Intelligent Systems*, *12*(3-4), 177-190.

Marín, J. F., Parra, L., Lloret, J., Yousfi, S., & Mauri, P. V. (2020, December). Correlation of NDVI with RGB Data to Evaluate the Effects of Solar Exposure on Different Combinations of Ornamental Grass Used in Lawns. In *International Conference on Industrial IoT Technologies and Applications* (pp. 207-220). Springer, Cham.

Marín, J., Yousfi, S., Mauri, P. V., Parra, L., Lloret, J., & Masaguer, A. (2020). RGB vegetation indices, NDVI, and biomass as indicators to evaluate C3 and C4 turfgrass under different water conditions. *Sustainability*, *12*(6), 2160.

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GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA Y PESCA, ALIMENTACIÓN Y MEDIO AMBIENTE

PNDR
Programa Nacional de Desarrollo Rural 2014-2020

Go TecnoGAR
Tecnificación del garbanzo

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Tutorial 2

November 14, 2021 to November 18, 2021 - Athens, Greece

TrendNews 2021

The Use of Images in Digital Agriculture:
Current Limitations and Examples

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