Plants Study through Computational View

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Abstract: *The use of images, sensors and mathematical algorithms can assist in the technical attribute generation, facilitating of the health status plants diagnosis. Combined with this, the computer vision provides a non-destructive and non-invasive strategy in the collection of samples and quality-quantitative analysis of plant propagules, as well as subserving the preservation of plant organs, in case any kind of physical evidence is needed. With this in mind, the aim of this research was to identify signs of homeopathies applied to purslane plants (Pilea microphylla (L.) Liebm.), Using computational algorithms. The work of capturing the images was carried out in the ANIMA-UNISUL´s laboratory. To assess the plants, based on the images, algorithms from VibaHT software and ImageJ (64-bit Java 1.8.0_172) were used. The images were generated by webcam (online) and ultrahigh dilution (UHD) applied for 14 days. Two cameras were used: with a "blue" filter to capture the near infrared and normal ultraviolet filter, both, with precision of 640 × 480 pixels and 1920 × 1280 pixels, respectively. After capturing the images — (i) before and (ii) after the UHD application — mathematical analyzes were performed. The number of samples of pots with plants was small (4), but the number of repetitions of the experiment (20) was sufficient to identify significant differences at the level of 1% of probability between the images before and after the application of UHD. The algorithms used were also robust to identify the signs of UHD on the surface of purslane leaves.*

Keywords: *plants, UHD, microvibration, NIR, NDVI, vibraimage, VibraHT.*

Introduction

Image analysis for diagnosis of plant health status is well known (Zanco et al., 2021), and an area of computing that has a strong influence on this dimension of knowledge is "computer vision" (Patricio & Rieder, 2021). In this sense, images can be seen as a fundamental part of the computer vision methodology, improving our level of understanding and automating the process of human visual learning (Akimov & Minkin, 2020; Chouhan et al., 2021) and assisting in contactless and non-destructive investigation for plants (Zanco et al., 2021). On the other hand, *ultrahigh dilution (UHD* applied to agriculture lacks fast and efficient methodologies for necessary decisions, which most of the time happens in brief periods during the management of plants in the field. The application of technologies related to images contributes and offers a powerful support for these decisions

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The objective of this work was to identify, through laboratory tests, techniques for collecting images that could respond and to identify, in a short time, the activity of UHD in plants, as a future possibility for quality control in agrohomeopathic management.

Methods

The study was carried out on the premises of the University of the South of Santa Catarina, belonging to the Ânima Educação group. During the two-week period, tests were carried out to identify the condition that best captured measurable images of native plants in the region. After initial tests, a purslane species, Pilea microphylla (L.) Liebm., Belonging to the Urticaceae family (Fig. 1) was chosen.

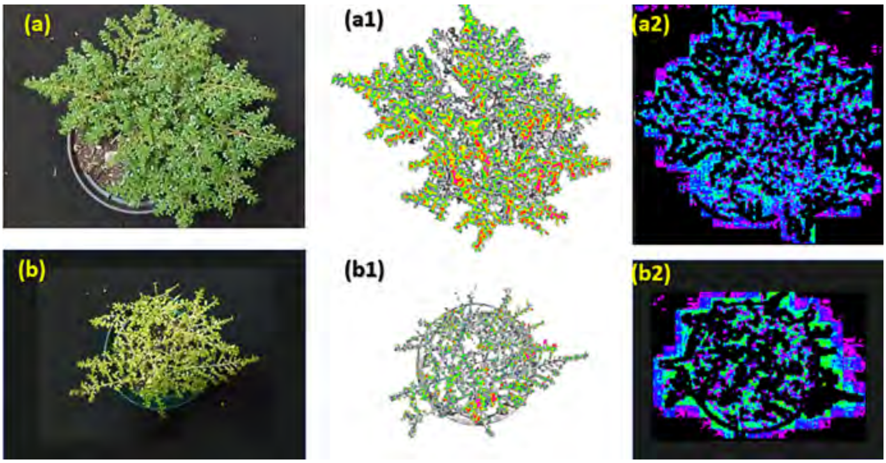

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Fig. 1. *Purslane plants with regular (a) and low (b) photosynthetic activity and respective NIR (a1, b1) and VibraHT (a2, b2) images*

In the laboratory a bench was set up with two cameras, one of them generic in low resolution (640 × 480 pixels), which allowed reaching a minimum pixel of 145 µm (640 × 480 px), which was modified to generate images, replacing the original lens filter for another “blue”, purchased at http://publiclab.org. Another camera, Logitech C270 HD 720p®, was installed at the same resolution, to measure signals in the plant without the use of filters. The distance between the cameras and the position of the plants was 30 cm. Also, so that there was no variation in light during the experiment, the images were generated under artificial lighting, with an LED lamp, measured between 3600 to 4180 lux (Fig. 2), using a Digital Lux Meter LD-200 Instrutherm luxmeter.

The capture and partial analysis of the images was carried out initially with the VibraHT program (Minkin et al., 2020) provided through a partnership between the Research Group on Plant Production and Biotechnology (Anima-UNISUL) and the company Elsys Corp, St. Petersburg, Russia. After the images were generated by VibraHT, they were transferred to the free software ImageJ. The images generated before and after treatment with UHD were compared. The chosen UHD (Magnetitum) was provided by the company Homeopatia Rural (https://nossofoco.eco.br/wp-content/uploads/2020/05/Cartilha-Homeopatia-Rural-1.pdf) and its main characteristic was the shape of preparation, according to the Brazilian Homeopathic Pharmacopoeia (2015): with dilution suctioned in the 250 milesimal (CCLM).

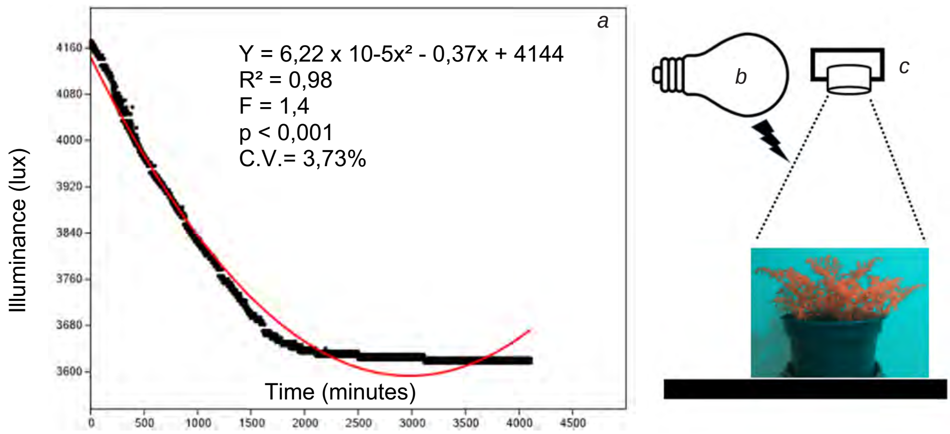

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Fig. 2. *Behavior of light intensity density (a) measured at the location of the experiment, emitted by an LED lamp (b) on the analyzed plants. The camera lens (c) formed a 90 degree angle on the surface of the bench and on the apex of the plants in the pots (d)*

To generate the images, purslane plants were placed on the benches and photographed every 10 seconds for 12 hours. Then, the generated images were collected ("stacked") in AVI format (Audio and Video Interlayer file), with 1 frame per second (fps). After that, the first stage of the analysis was to take the AVI video to read the VibraHT program that transforms the images into numerical data (Minkin, 2020; Akimov & Minkin, 2020). The second step was to perform the same analysis of the VibraHT images, but, within the ImageJ program, using other numerical algorithms (Zanco et al., 2021).

The experiments were repeated 10 times for each analyzed plant. During this procedure, the same plant was treated with UHD, more than once, depending on the duration of the experiment. The repetition took place alternately: one day with treatment and another day without any treatment, totaling 20 days of experiment.

Results

After analyzing the images referring only to the model generated in VibraHT, without the participation of a NIR filter, it showed a signal, but with less intensity in the image's pixels (Fig. 3).

As the tests were conducted and partial results appeared, the dimension that the model was able to identify the signs of UHD in plants became evident. A fundamental part of the experiment was to transform a common camera into another capable of measuring the near infrared spectrum (near infrared — NIR), as well as, the separate analysis of the NIR images, all showing the signs of the application of UHD (Fig. 3).

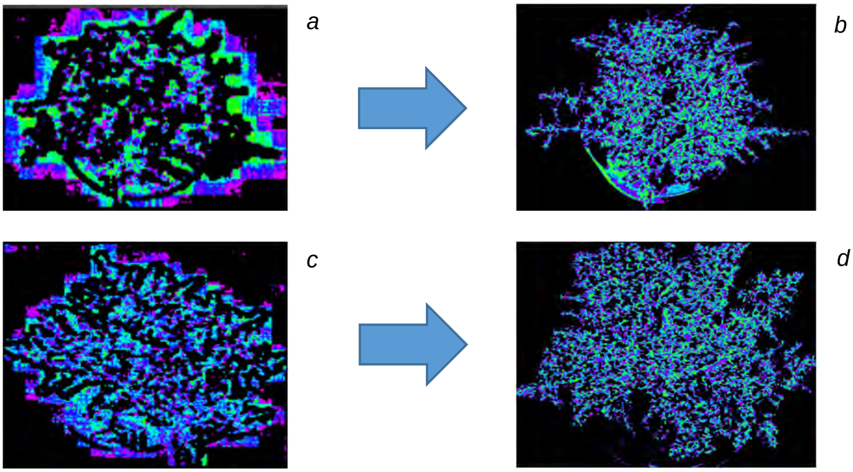

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Fig. 3. *Analysis of the application of UHD using the "blue" filter and the analysis with VibraHT, where two plants were treated: with less photosynthetic activity (a: with UV filter; b: with blue filter) and greater photosynthetic activity 4.2 (c: with UV filter; c: with blue filter)*

Then, the experiments showed results with more significant differences when there was a combination between the images in the near-infrared (NIR) spectrum and the VibraHT (Fig. 4), implying in less imaging time.

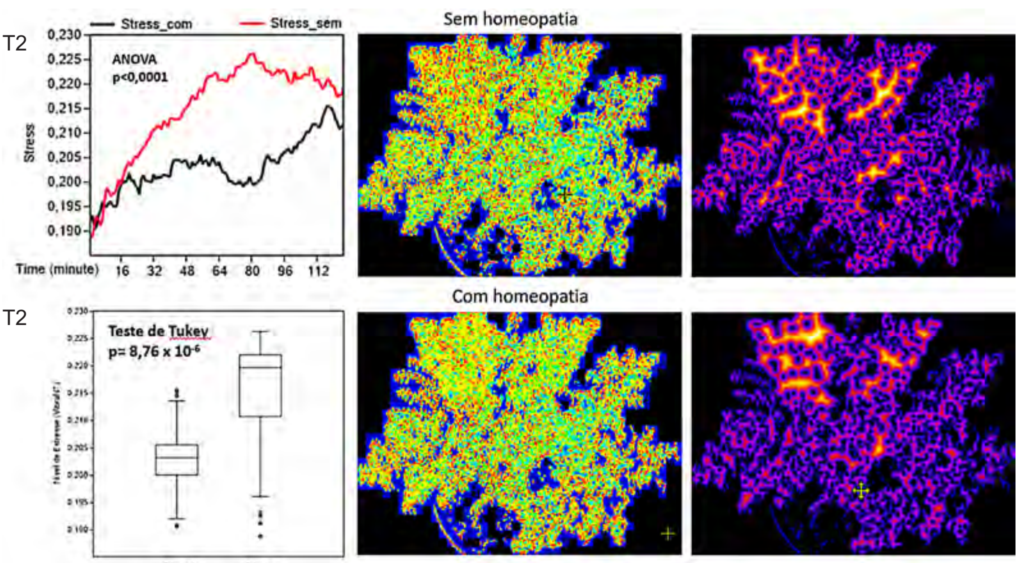

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Fig. 4. *UHD applied to plants using NIR-VibraHT image analysis, with observation of the T2 parameter, generated by VibraHT*

Discussion

The algorithm processing of VibraHT software was fundamental in the research carried out by different applications (Minkin, 2020; Minkin et al., 2020; Akimov & Minkin, 2021), and with that, they managed to differentiate very different situations, demonstrating microvibrational signals hitherto unheard of for the diagnosis of COVID-19. This extraordinary result aroused our expectations regarding research with biophotonics, which guided a partnership with Elsys Corp researchers to use the VibraHT software in the analysis of plants.

Another fundamental aspect was the use of a blue filter to modify the light input of the digital camera. Through this change, it was possible to block most of the visible light in a channel and then use that channel for near infrared light. This favored that the camera could be used to take simultaneous photos of visible and infrared light — one in the red channel, the other in the blue channel (discarding the green channel). The wavelength generated with the use of a blue filter was close to 450 nm, therefore, capable of measuring some change in the photosynthetic level, since chlorophyll absorbs this wavelength of light.

In general, the pixel intensity was significantly expressive with the help of the blue filter associated with VibraHT, as shown in Figures 5 and 6, below.

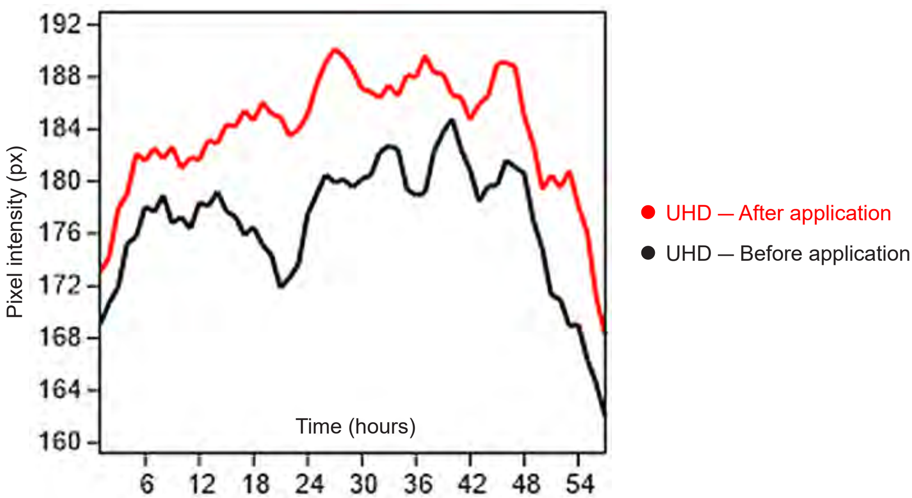

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Fig. 5. *Average pixel intensity of the images, referring to 10 repetitions, before and after the application of homeopathy*

When the images were measured separately, as to the ability to show signs of the application of UHD, using the blue filter or just the normal image from the camera, the result showed the advantage of combining VibraHT with NIR (Fig. 6), although, the variables and parameters measured in VibraHT indicate sensitivity to identify the signs of UHD.

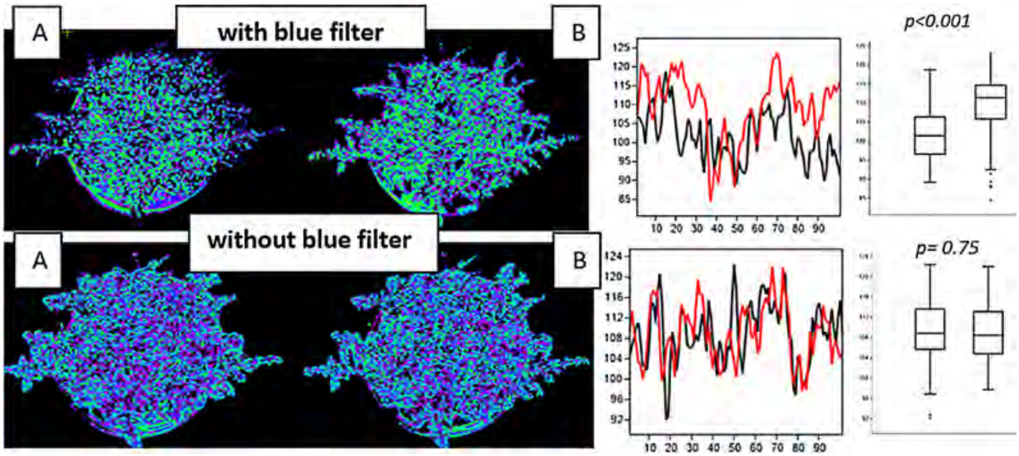

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Fig. 6. *Presentation of VibraHT images, with and without the use of a blue filter, before (A) and after (B — 20 minutes) the application of UHD, using numerical variables generated in ImageJ®*

The variables of the image analysis used by VibraHT refer to human psychophysiological states and, therefore, difficult to be transposed to a plant analysis. Even so, in Figure 6, there is a trend in which these parameters seem to corroborate the analysis of pixels used to evaluate the experiment.

Considering also these internal variables generated by VibraHT and without the use of the NIR filter, there were significant differences in the signs, before and after the application of UHD, as can be seen in Figure 7, below.

Although the signs of water application and UHD (via leaf) are not well differentiated through the VibraHT T2 variable (Minkin, 2020), it is possible to see, in Figure 7, that UHD and its signs in the plant take longer to mitigate its effects than water (control). This difference is not due to alcohol because in the application water was chosen as the only vehicle for Magnetitum UHD. Another aspect observed in the evaluation of the experiments are unexplained variations regarding the measurement period (day or night) and the prolonged period of the evaluations in which the plants were subjected to water treatment (control) and UHD.

When UHD and water were compared, using the modified camera with a blue filter, the VibraHT + NIR images showed little difference in relation to T2 variable, but were statistically relevant for T7 variable (Fig. 8). This behavior shows the need to continue the research, in order to understand the other mathematical variables included in VibraHT.

In Figure 8, the measures of T2 and T7 (Minkin, 2020) are compared, according to the application of UHD, observed in the VibraHT and NIR images, together.

As seen in Figure 8, the use of the filter camera was more sensitive to the change signaled by UHD when measured through T7 variable.

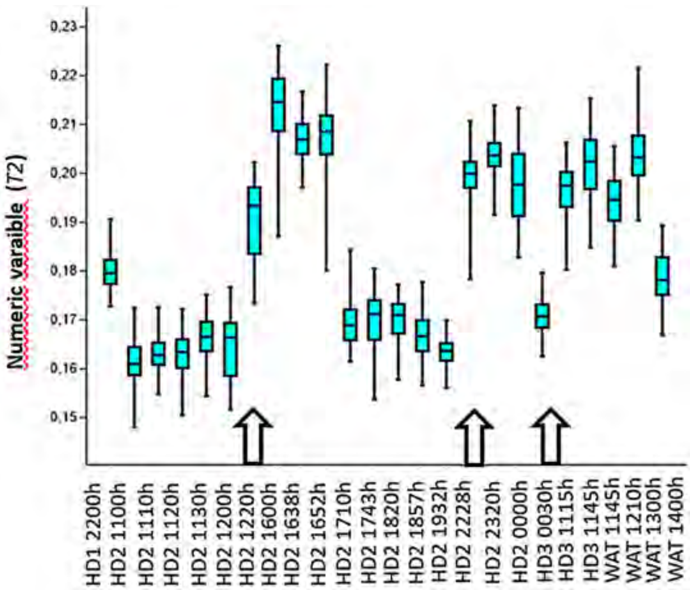

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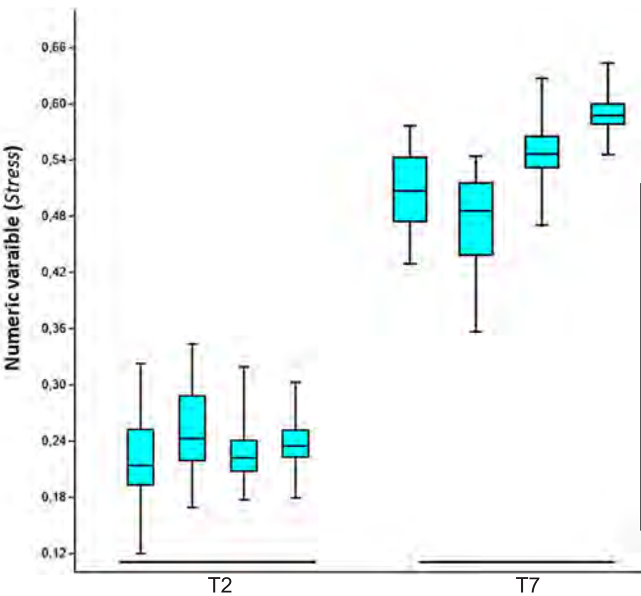
Fig. 7. *Presentation of VibraHT® images, with 120 seconds samples, without the use of a blue filter, before (A) and after (B) the application of UHD. Abbreviations: H = UHD; D1, D2 and D3 = day one, two and three; WAT = water. And the leaked arrows show the moment of application of UHD or water*



At this specific point in the research, it is important to highlight that the signs were better differentiated with the use of the T7 variable, presenting a higher average in relation to the values obtained in the first two times evaluated, which did not happen when using the T2 variable. In this case, the differences between the reaction period of the plants and the application of UHD were significant, in the evaluation of the T7 variable.

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Fig. 8. *Differences between T2 and T7 variables, generated by VibraHT, after the application of UHD and using a blue filter camera*

Conclusion

The images generated by VibraHT were sufficient to find signs of homeopathies applied to plants, however the use of the blue filter, enhanced the ability of the imaging system to recognize the signs. On the other hand, the application of water (control) in the plants was also noticed in the VibraHT images and, in this case, there was a significant difference only when the NIR images were analyzed together with the VibraHT images.

The results found in this research are extremely important because they demonstrate the efficiency of the proposed image analysis technology, in addition to having an unprecedented component in the measurement of plants in real time. The model awakens a great potential for the management of plants, in the anticipation of decisions and in the evolution of non-destructive and non-invasive sampling techniques.

The flexibility of using the computer vision technology developed in VibraHT can even assist laboratory and agronomic fieldwork using dynamic images from drones, smartphones or any variety of video capture equipment.

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