Title: Crops disease detection with computer vision and machine learning approaches

Key words: Artificial intelligence, deep learning, remote sensing, image processing, precision agriculture, plant disease.

Context: One of the major challenges of today's agriculture is to increase agricultural productivity and, especially, the quality of production while sharply reducing the use of inputs. Responding to this challenge, particularly through scientific and technological progress, is an objective sought by many worldwide countries. Plant pathologies are among the main causes slowing down the sustainable development of the agriculture. They generate serious economic and environmental problems, driving agricultural activity in increasing difficulty. The common means used to limit the damage caused by diseases are phytosanitary treatments. Often, these products are spread over the entire field with a preventive approach. But this technique has not always proven to be effective. Moreover, it engenders economic losses and has a negative impact on the environment, since the treatment products contain toxic chemical components that are harmful to the ecosystems.

Detection of infections in earlier stages, would allow the development of targeted control methods against pathogens and to propose more effective early treatments. Anomaly detection is an essential step for disease control. Traditional methods of detecting plant diseases includes direct visual diagnosis (naked eye, magnifying glass, chemical analysis…). These methods are time-consuming and require a large number of personnel. One of the most promising techniques for disease control and prevention is the use of computer vision, remote sensing, and big data with artificial intelligence approaches. Indeed, improved accuracy for identifying sensitive areas in earlier stage will lead to a reduction of inputs and a range of associated benefits.

Objective: In this context, the aim is to study and implement approaches for early stage detection and mapping the crops diseases, using remote sensing (Drones, satellite images) and ground cameras. Data will be acquired in multispectral and visible ranges; other sensors can be used to supplement the visual data. The PhD work consists in developing methods using this type of information and artificial intelligence approach to tackle the automatic detection of diseased areas. Recently, artificial intelligence has seen major breakthroughs thanks to deep learning algorithms, which enabled to address difficult problems, such as object recognition, segmentation, classification, etc. However, the success of the deep learning techniques is related to the large annotated image databases. Difficulties remain, especially when it comes to specific applications such agriculture for which we do not have large annotated image databases. In addition, the regions of interest are not always salient in the images generating weak visual information. For that purpose, robust algorithms based on machine learning methods will be developed to identify particular patterns, extract features and display the results on geographic information tools. Also, 3D imaging is envisaged to obtain in-depth characteristics and improve performance. The focus will be on one or two types of crops with some specific diseases, such as vine and its main pathologies…

Work plan: The research work will address the question of how the data can be exploited to extract useful information and build an efficient tool for early detection of plant diseases. For this purpose, the PhD thesis will be conducted with the following main stages:

- Study the imaging systems for crops such as UAV, satellite (Sentinel)…
- Study theoretical and technical approaches of machine learning
- Extend methods developed by our research team
- Develop new methods to extract consistent patterns in small labeled training sets
- Implement multi-scale image registration and information fusion
- Developing robust deep learning algorithms for noisy data
- Test and evaluation in real data

Expected results: The expected results are as follow, but not exhaustive:

- Good accuracy of automatic disease detection
- Increase robustness of the existing method
- New approach for deep learning with small dataset
- AI based tool for crops diseases mapping and monitoring
- Scientific publications

Background from the applicant: The candidate should have basics at least in one of the following domains: computer vision, machine learning, remote sensing.

Programming skills: Python, Matlab or C++.

References:

1. M. Kerkeche, A. Hafiane, R. Canals, F. Ros. "Vine disease detection by deep learning method combined with 3D depth information", 9th International Conference on Image and Signal Processing, 2020

2. M. Ouhami, Y. Es-Saady, M. El Hajji, A. Hafiane, Raphael Canals and Mostafa El Yassa. "Deep transfer learning models for tomato disease detection", 9th International Conference on Image and Signal Processing, 2020

3. M-D. Bah, A. Hafiane, R. Canals. "CRowNet: Deep network for Crop row detection in UAV images", IEEE Access, 2019

4. M. Alkhatib, A. Hafiane. "Robust Adaptive Median Binary Pattern for noisy texture classification and retrieval", IEEE Transactions on Image Processing, Volume 28 (11), Nov. 2019, pp. 5407-5418.

5. M-D. Bah, A. Hafiane, R. Canals, B. Emile. "Deep Features and One-class Classification with Unsupervised Data for Weed Detection in UAV Images", International Conference on Image Processing Theory, Tools and Applications (IPTA), 2019

6. M-D.Bah, A.Hafiane, R.Canals. "Deep Learning with Unsupervised Data Labeling for Weed Detection in Line Crops in UAV Images", Remote Sensing, Volume 10, 2018

7. M. Kerkeche, A. Hafiane, R. Canals. "Deep leaning approach with colorimetric spaces and vegetation indices for vine diseases detection in UAV images", Computers and Electronics in Agriculture, Elsevier, Volume 155, pp. 237-243, 2018.

8. M-D. Bah, E. Dericquebourg, A. Hafiane, R. Canals. "Deep Learning based Classification System for Identifying Weeds using High-Resolution UAV Imagery", IEEE Computing Conference, 2018

9. M-D. Bah, A. Hafiane, R. Canals. Weeds detection in UAVs imagery using SLIC and Hough Transform, The 7th International Conference on Image Processing Theory, Tools and Applications (IPTA), 2017.

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