In-field detection of a multi-symptom grape vine disease by proximal sensing and artificial intelligence

Autors: Malo Tardif, Ahmed Amri, Barna keresztes, Aymeric Deshayes, Marc Greven, Jean-Pierre Da Costa.

Laboratory: laboratoire de l'Intégration du Matériau au Système (IMS, CNRS UMR5218).

"Flavescence dorée" (FD) is a grape vine disease caused by the bacterial agent *Candidatus phytoplasma vitis* and spread by a leafhopper (*Scaphoideus titanus*). The disease is very closely monitored in Europe as it reduces vine productivity and causes vine death while being highly infectious and hard to control. It was classified as a quarantine disease at the European level in 1993 and is now subject to mandatory reporting. A grape vine that has contracted this disease must be uprooted as soon as possible to avoid the spread of the disease. These days, the control method used against this disease is a two-pronged approach: i) Spray insecticide on a regular basis to kill the vector and ii) Survey each row in a vineyard by experts of this disease. Unfortunately, these experts are not able to carry out such a task every year on every vineyard and need decision support tools as an aid for planning their survey.

We propose and evaluate an original automatic method for the detection of FD, based on computer vision and artificial intelligence algorithms applied to images acquired by proximal sensing in vineyards. A two-step approach is used, mimicking expert's prospection in the vine rows: (i) the three known isolated symptoms (red or yellow leaves depending on variety, together with a lack of shoot lignification and the presence of dried off bunches) are detected, (ii) isolated detections are combined to make a diagnosis at image scale, i.e, vine scale. A detection deep neural network is used to detect and classify non-healthy leaves into 3 classes - namely 'FD symptomatic leaf', 'Esca leaf' and 'Confounding leaf' - while a segmentation network (ResUnet) allows to retrieve FD symptomatic shoots and bunches. Finally, the association of detected symptoms is performed by a RandomForest classifier, which allows a diagnosis at the image scale. The experimental evaluation was conducted on more than 1000 images collected in 2020 and 2021 on 4 plots planted with *Cabernet Sauvignon*, 1 with *Cabernet Franc* and 1 with *Merlot* for the red grapes varieties, 6 with *Ugni blanc* and 1 with *Sauvignon blanc* for the withe grapes varieties, with a ground truth associated with each image. By annotating FD symptoms on a set of images, the detection of symptomatic shoots, bunches and leaves achieves a precision between 67% and 82% and a recall between 39% and 59% on test sets. Plant-scale classification reaches a precision of more than 75% on all data sets, despite reduced learning sets including only two grape varieties and the presence of many confounding factors.