Remote sensing-assisted scouting of virus infections in vineyards

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Abstract

The cost of virus infections per acre in vineyards with an average lifespan ranges from $10,000 to $16,000, and with 880,000 acres, California is the largest vineyard of USA (80%). Early detection and eradication of infected plants are crucial to managing pathogen spread in field conditions as there is no cure for viruses in the field. Chemical control of insect vectors of viruses is of limited efficacy and often not an option in organic agriculture.

Supported by preliminary data the project seeks to demonstrate that remote sensing coupled to machine-learning can be used to detect major grapevine diseases (red blotch and leaf roll) more efficiently than traditional methods.

During 2020 we monitored grapevine infections in two vineyards located in Madera and Rutherford, planted with Cabernet Sauvignon and Cabernet Franc respectively. A total of ~400 plants in each of the vineyards were imaged twice with a VIS-NIR hyperspectral, thermal, and high-resolution RGB camera mounted on a tripod, an ATV, and a UAV. Leaves were collected to be further imaged in a dark room in the laboratory and then submitted to molecular analyses to assess virus presence. All the plants in the vineyard blocks were also scouted to assess the presence of the infection and compared to high-resolution satellite imagery. The imagery was used to train machine-learning algorithms to predict grapevine infection, which are showing promising performances and will be further optimized in the second season of measurements.

Scope

Despite industries cultural and chemical strides toward preventing and managing viral infections in vineyards, the impact on California production is considerably prevalent. The use of remote sensing and machine learning methods allows not only researchers, but growers to expand their management practice beyond traditional methods.

Can modern tools aid in timely detection of viral infections and mitigate the spread?

1: Pre- and post-symptomatic, autonomous detection and mapping of grapevines infected by red blotch through machine-learning analysis of very high-resolution remote hyperspectral images.

2: Pre- and post-symptomatic, autonomous detection and mapping of grapevines infected by leaf roll through machine-learning analysis of very high-resolution remote hyperspectral images.

3: Post-symptomatic autonomous detection and mapping of grapevines infected by leaf roll or red blotch at landscape scale through machine-learning analysis of high-resolution satellite images.

The objectives of this research are in direct alignment to our overall research goals .

Material & Methods

3 Vineyard sites:
Rutherford
Madera
Fresno

- In all experimental sites, ~500 vines were identified and tagged.
- Each experimental vine was imaged in the field with:
  - a VIS-NIR hyperspectral camera,
  - RGB camera,
  - thermal camera
- Cameras were mounted on a tripod (maximum spectral resolution), or an UAV (Fig. 1).
- 4 leaves per plant were sampled and imaged in controlled conditions in the lab (Fig. 2).
- Leaves were then analyzed for virus presence through molecular testing.

The operation was repeated four times, once a month in Rutherford and Madera sites, the Fresno site (Fresno State campus) was used for training and preliminary assessment of the methods.

All plants within the vineyard were visually assessed for virus presence, twice during the growing season, and high-resolution satellite imagery was tasked.

Fig. 1 The experimental sites in Rutherford and Madera

Fig. 2 Laboratory set-up for hyperspectral imagery acquisition and processing

Fig. 3 Imagery acquisition through multiple platforms in the field

Results

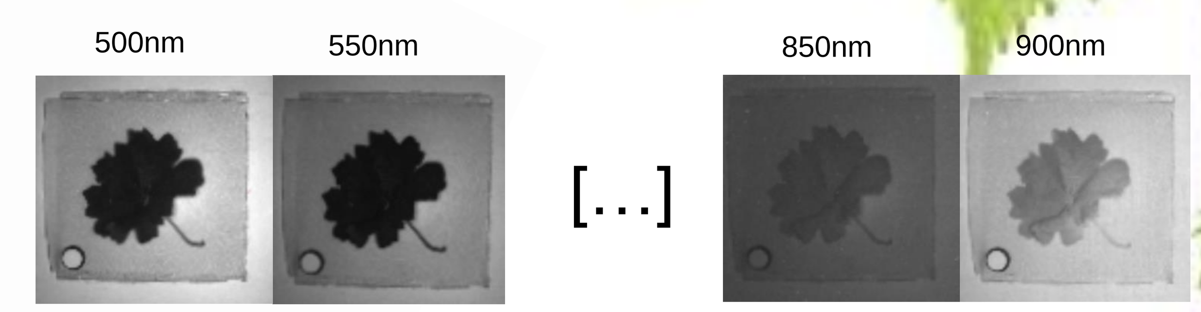

Fig. 4 Examples of imagery acquired in the laboratory at different wavelengths

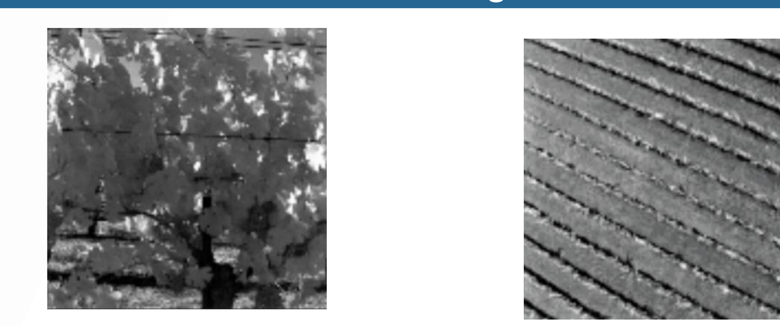

Fig. 5 Imagery acquired from a tripod (left) and from an UAV (right)

Conclusions

This is a three-year project and during the first season we successfully collected a large dataset (over 2000 samples) that we are currently elaborating. In an effort to achieve our research goals of implementing more sustainable and reliable methods for viral infection management; the acquisition research will be conducted in replicate during the 2021 growing season for further data collection and analysis.

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