

Vine Line Detection in Diverse Environments Aerial Images using Machine Learning

Jérôme Treboux

Background — Precision agriculture, which aims to optimize the yield of an agricultural field using technology, may be used to automatize spraying pesticides in vineyards using drones while increasing profitability and reducing ecological impact. To automate the creation of flight plans, vine lines in aerial images need to be detected. Vine line detection may have other applications, such as cadastral measurements and visual inspection.

Purpose — Classical methods to detect vine lines have weak performance, and state-of-the-art machine learning (ML) models for image analysis are limited by imagery requirements and natural environmental variability. Therefore, this research intends to improve existing ML models to detect vine lines more robustly.

Methods — A baseline performance is obtained using classical methods and state-of-the-art ML models. An original approach then combines a convolutional neural network (CNN) to segment vine lines and a random forest (RF) to confirm or reject the segmentation.

Results — The original approach outperforms existing methods with an f-score improvement of about 35%, with the models reaching an f-score of approximately $86\% \pm 4\%$. In addition to achieving such performance, ML models demonstrate their ability to be generalized to segment images with a wide spectrum of features.

Contributions — Our main contributions are twofold. We created, to our knowledge, the first open-source dataset of vineyard aerial images, distinguished by imaging diversity (novel drone images and existing mapping platforms images), the inclusion of ground truth (binarized vine lines traces), and heterogeneity of natural environments (seasonality, time of day, presence of roads, buildings, cars, etc.). We developed an innovative method that combines a CNN and an RF and outperforms classical methods and state-of-the-art ML models in terms of precision, robustness, and generalization capabilities to detect vine lines in diverse environments aerial images.

Jury :

Prof. Dr. Rolf Ingold — Thesis supervisor
Prof. Dr. Dominique Genoud — Thesis co-supervisor
Prof. Dr. Michael Berthold — Co-examiner
Prof. Dr. Jean Hennebert — Co-examiner
Prof. Dr. Marino Widmer — President of the jury