Grape Vine Disease Detection

An Innovative Computer Vision Technique Using Drones

Grape Vision

Presented By

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Outline

Grape
Vision

Motivation

The Grape's health determines the Wine's quality.

For viticulturists across the world and in Interior British Columbia, grapevine diseases remain a persistent threat to **grape quality** that can result in up to 100% losses in annual revenue and yields.[1,2,3,4,5]

Major Vineyard Health Management Goals:

- Disease mitigation (affects taste and yield)

- Optimizing water management (affects final sugar content)

- Optimizing fertilizer application (affects growth rate, taste, and yield)

The Problem

Vineyard health monitoring techniques are manual, laborious, inefficient, and unreliable.

- Forces reliance on **aggressive disease prevention strategies** via blanket fungicide application.

  - Preventative spraying costs $11,677 is spent /year /average 29 acre vineyard.[6]
  - This increases the likelihood of fungicide resistant strains.
  - Later, fungicide abuse can deplete biological soil quality via accumulation of potent toxins (copper fungicides are one of the most detrimental substances for freshwater system ecotoxicity).[7,8]
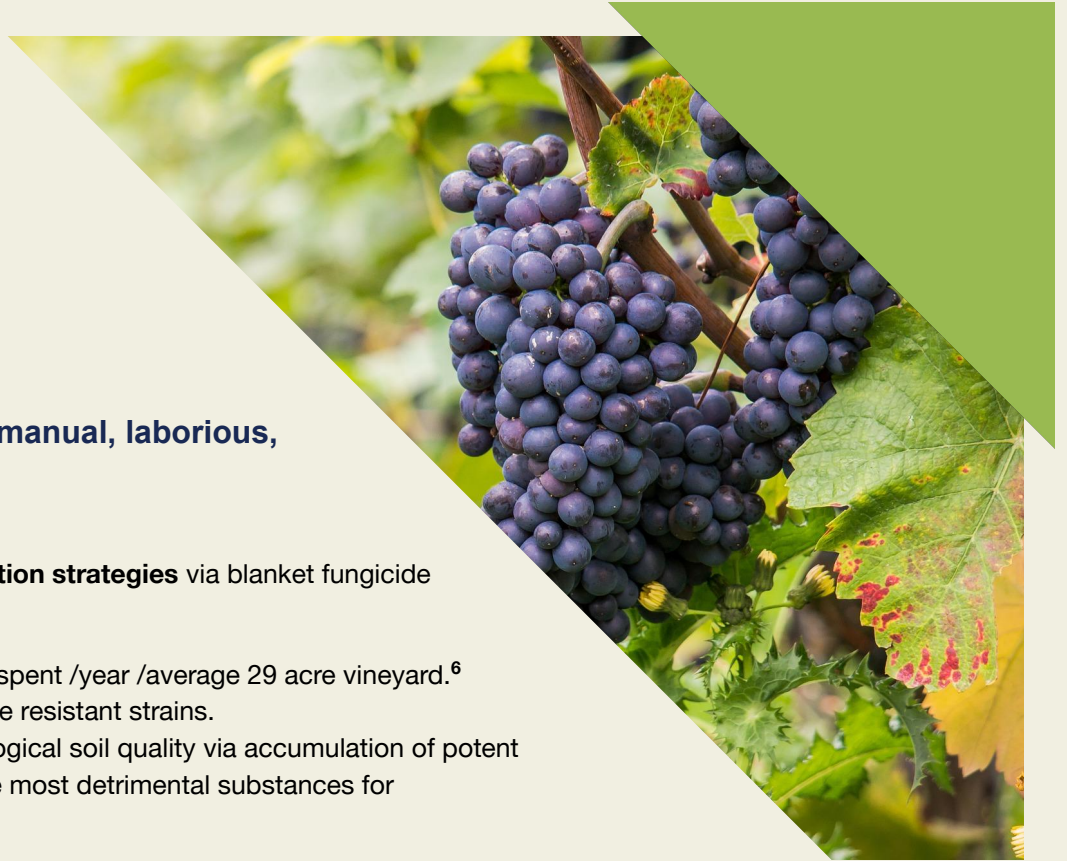
Grape Vision

Grape Vision

Solution

Testimonials from grape experts suggest that leaf colour, size, texture, and other unknown features can **predict grapevine health in terms of disease, water and fertilizer needs.**

Idea: automated drone monitoring with live image analysis.

- Anomaly and pattern detection in foliage using our homemade convolutional neural network.
- Provide viticulturists with anomaly types and locations to determine what measures need to be conducted.

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"You're always innovating, you're always looking for some way to cut costs and get you better qualities so you can get better pricing. You're always looking for an edge, and if technology can give it to you, I'm going to incorporate it."

— Bryan Hardman, CEO

Deep Roots Winery

Grape Vision

Market Validation

*"There's **absolutely need for better fertilizer management**. Drones can cut down fertilizer use and reduce runoff by a significant percentage... Drone surveillance can **isolate areas of need** so we don't always have to blanket spray [fungicides]."*

Bryan Hardman, CEO — Deep Roots Winery

*"Grapes are by far the **most labor intensive crop**. They grow like crazy. They require strict water management. If the grapes grow too vigorously, the quality of grapes does down. We want the grapes to be slightly stressed because it produces more concentrated flavours... Drones can help identify wilt and browning **without needing to walk every single panel.**"*

Del Hallaway, CEO — Elephant Island Winery

*"Time. It would save time. 1 acre, 1000 plants. It would **make our lives easier** so we do not have to go through the entire vineyard."*

Elizabeth van Heerden, CEO — Clean Face Vineyards

Prototype: Disease Detection using CNN

The current prototype focuses solely on disease detection.

Methodology

- Images from the field are taken by drones at regular intervals.

- Images are tested for diseases using a pre-trained Neural Network.

- Anomaly detection generates red flags and notifications.

- Human inspection further verifies the anomalies

- Unhealthy plants are removed from healthy ones in timely manner to prevent spread of infection.

- Process is repeated.

Deep Convolutional Neural Networks (CNNs) used for image recognition can **improve** vineyard disease detection.

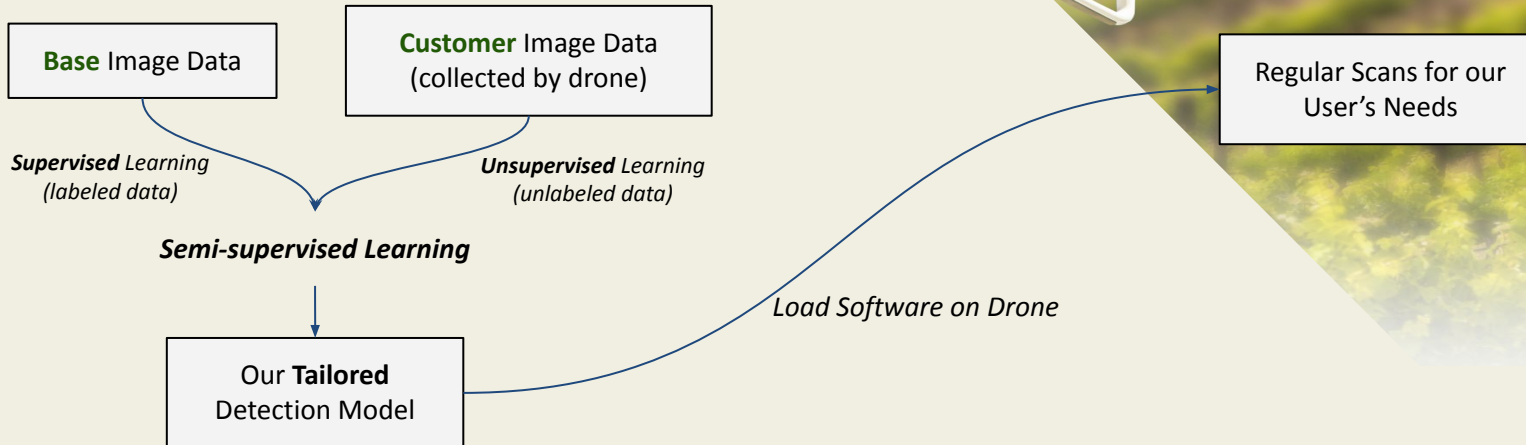Effectively reduces the need for excessive fungicide application.

Saves agricultural management costs, surveying time, crop yields, and can lessen cumulative environmental impacts.

User-Centered Design

Semi-supervised model training on customer vineyards lets us tailor drone scans to each grape grower's needs—whether it be disease, water, and/or fertilizer management.

Base Image Data

Customer Image Data (collected by drone)

Supervised Learning (labeled data)

Unsupervised Learning (unlabeled data)

Semi-supervised Learning

Our **Tailored** Detection Model

Load Software on Drone

Regular Scans for our User's Needs

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Model Implementation

Image Data

Controlled Environment
PlantVillage project public datasets on healthy diseased grapevine leaves.[9]

Field Observations
Customer vineyards can act as a baseline sources for data to tailor each model to the customer.
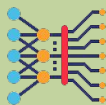
Data Augmentation

Dataset Expansion
Increased training set diversity and size by duplicating images with noise and transformations.

Image Enhancement
Implement algorithms to enhance image quality for CNN performance improvements.

Architecture

CNN Framework
Used a homemade neural network architecture with Rectified Linear Activation Functions (ReLu) and combined feature sets to increase accuracy of predictions.

Tools and Technologies

Services: Azure Data Science Virtual Machine to train our prototype.

Future Pipelines to be created in the Azure Machine Learning Studio.

Libraries: TensorFlow, Keras, and PyTorch.

Classification Prediction

Training
Train deep learning model on 70% of the healthy and diseased grape leaf datasets.

Testing
Test on 30% of the remaining images.

Business Questions I

Product

Tailored and automated vineyard drone surveying to help viticulturalists reach their management goals

Customer Segments

1) British Columbian Grape Growers
2) Viticulture Companies
3) Wineries

Key Activities

1) Initial data collection surveys
2) Customer model training via Azure
3) Biweekly drone scans for customer surveillance needs

Resources

1) A small drone fleet
2) Microsoft cloud storage for customer image data
3) Microsoft Azure for future model pipelines

Business Questions II

Cost Structure: Tier Based Subscription Service for User Management Goals

Management Goals

1) Disease surveillance
2) Optimizing water needs
3) Optimizing fertilizer needs
4) Other...

Tier	Number of Management Goals	Base Cost per Season
Silver Tier	1	$149.99
Gold Tier	2	$199.99
Platinum Tier	3+	$249.99

Acreage Adjustment

We always consider the customer's scale of operation when delivering our service.

Acres	≤ 1	≤ 4	> 4
Adjustment	$ 0	$ 100	$ 100 + $40 x Acres

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Market Analysis

- Long-term market demand for wine is primarily driven by its increased **accessibility** and **quality** along with positive wine culture sentiment across age demographics.[10]

- With few competitors and confidence in the growth of Agricultural AI, there's significant opportunity for our solution to help local grape growers.

Industry Metrics (from 2015 - 2020)	Canada	World
Grape Market Revenue (billions)	$ 0.202 (CAD) [2]	$ 167.9 (US?) [9]
Production Volume Year-Over-Year [2]	+5.5% ▲	+3.7% ▲
Grape Growers (2015) [3]	>1770	-
Vineyard Land (hectares) [2]	12,518	7,157,658
Grapes Produced (tonnes) [2]	114,637	79,125,982

Competitors	Cost	Weaknesses
Manual Crop Scouting [3]	$15.73 (CAD) × workers × seasonal hours	Slow, Inconsistent, and Inefficient
Spectrum Technologies Inc Predictive Disease Model Software[4]	$ 255.61- 377.02 (CAD)	Complicated, manual; **prediction not based on direct field data**; models not adapted to local Canadian conditions.

Economic Loss from Major Fungal Diseases

Fungicide Application Costs / Average Vineyard (FAC) [4]	≈ $11,677.81
Average Loss in Grape Yield by Weight due to PM [5]	12-20%
Estimated Vineyard Loss in Revenue (ELR) [6,7]	≈ 5 %

Idea Valuation = $14.2 million
Assumes a 20% reduction in Fungicidal spraying

*CADGrapeMarketValue * ELR + FAC * %ApplicationReduction * GrapeGrowers*

Marketing Strategy

Phase 1 — Market Exposure

- Client outreach

- **Free** vineyard surveying to provide clients a proof of concept

- Second wave data collection

- Feedback implementation and model improvement

Phase 2 — Launch

- Free trial rollout throughout the Okanagan Valley

- Subscription based pricing for continued Grape Vision surveying

- Drone servicing teams put in place to help clients when needed

Phase 3 — Scaling

- Successful rollout provides leverage to scale to new crops and diseases across Canada and even internationally.

- Growth and expansion of Grape Vision's drone fleet

Our Value Proposition

*What makes Grape Vision **unique**?*

*How can we be **competitive** & **flexible** in the Agri-AI market?*

Customer Flexibility

All vineyards are unique.

Semi-supervised model training with customer vineyard data tailors each model to their precise vineyards (ie. grape strains)

Vineyard Scalability

The Grape Vision solution lets viticulturists increase acreage and scale their businesses with ease.

Managing and surveying larger vineyards has never been easier.

Model Scalability

Our subscription service-based solution aims to branch into other agricultural sectors. It is both cost effective and has the potential to scale beyond grape crops and diseases.

TEAM

	Graham Kerford	Luka Vukovic	Naveen Chalasani	Tony Zhou
About	*Squash loving explorer filling the gaps between what is known and what is not.*	*Track sprinting-cycling-ski obsessed speed demon running on light roast coffee and vibrant dreams.*	*Passionate about bridging the gap between data analysis and business decision-making processes.*	*Avid data enthusiast with a passion for the arts, basketball, books, and comedy.*
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Dasa Riadi, *Mentor*

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