ERATH
WINERY

Grape Yield Estimation

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Background

Vineyards often have a difficult time predicting their yield, which leads to problems with scheduling labor, predicting sales, and setting production schedules. The current method is to take a small destructive sample of grapes halfway into their growth cycle, known as “lag”, and to predict the final yield by approximately doubling the lag weight. An error rate of 10% is considered good with this technique. Figure 1 illustrates the growth cycle of a grape, and how it slows drastically during lag phase.

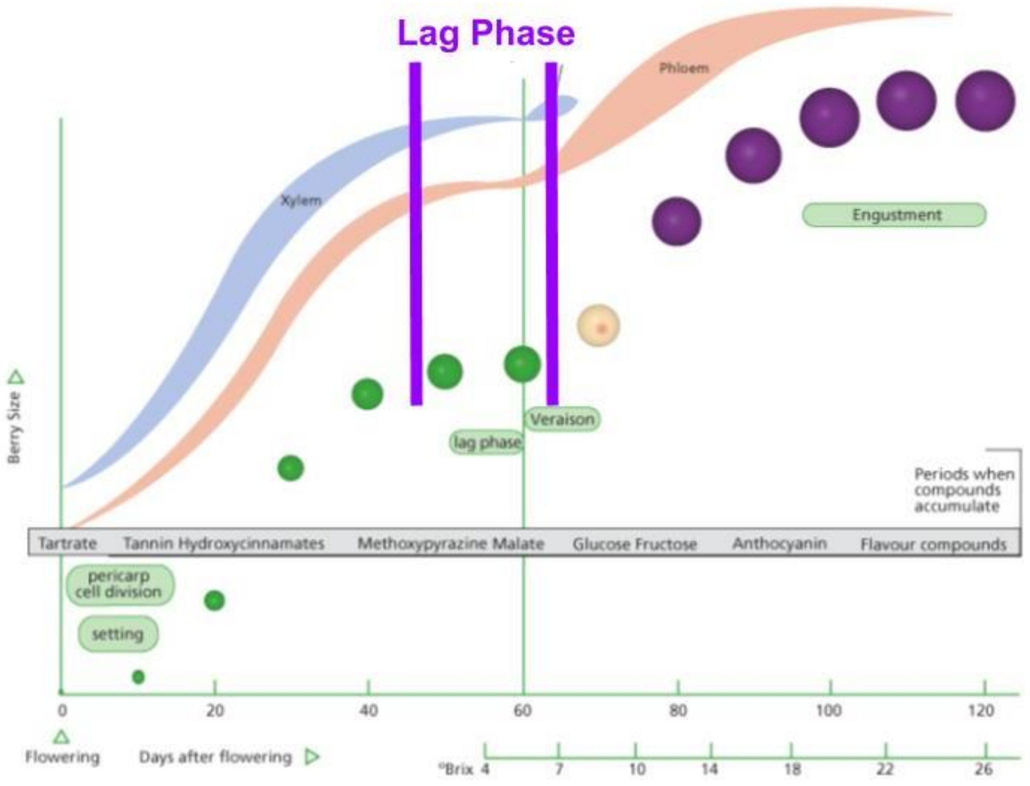


Figure 1. Growth Cycle of a Grape

If a better prediction method could be developed, vineyards and wineries could save a significant amount of money through the better apportionment of resources and labor.

Research

A significant portion of the project was devoted to understanding the current methodology and getting up to date on research surrounding this issue. The project started in September, so immediately the team visited the vineyard to harvest and weigh grapes that had been imaged throughout the summer. Figure 2 shows a photo taken of grapes at harvest. The team photographed, weighed, and took volume measurements of each individual grape cluster.

Figure 2. Labeled Grapes

One of the most common ways that researchers have attempted to solve this issue is by photographing the grapes throughout the growing season, especially during the lag phase. If enough data can be collected then an image processing algorithm could be developed to predict grape yield based on how the grapes look at the lag phase. This method is attractive as equipment cost is relatively low and set up is simple, but it creates a very difficult problem in terms of image processing, especially since during lag the grapes are green, the same color as the surrounding leaves.

There were several other options explored, all centered around alternative ways to gather images of the grapes. One such option was to use a thermal camera to image grapes. Grapes are mostly made of water, and retain heat much more effectively than the leaves around them. If the grapes are imaged after the sun has set, then they stand out from the leaves around them, making the images far easier to process. Figure 3 shows the grapes imaged just after sunset.

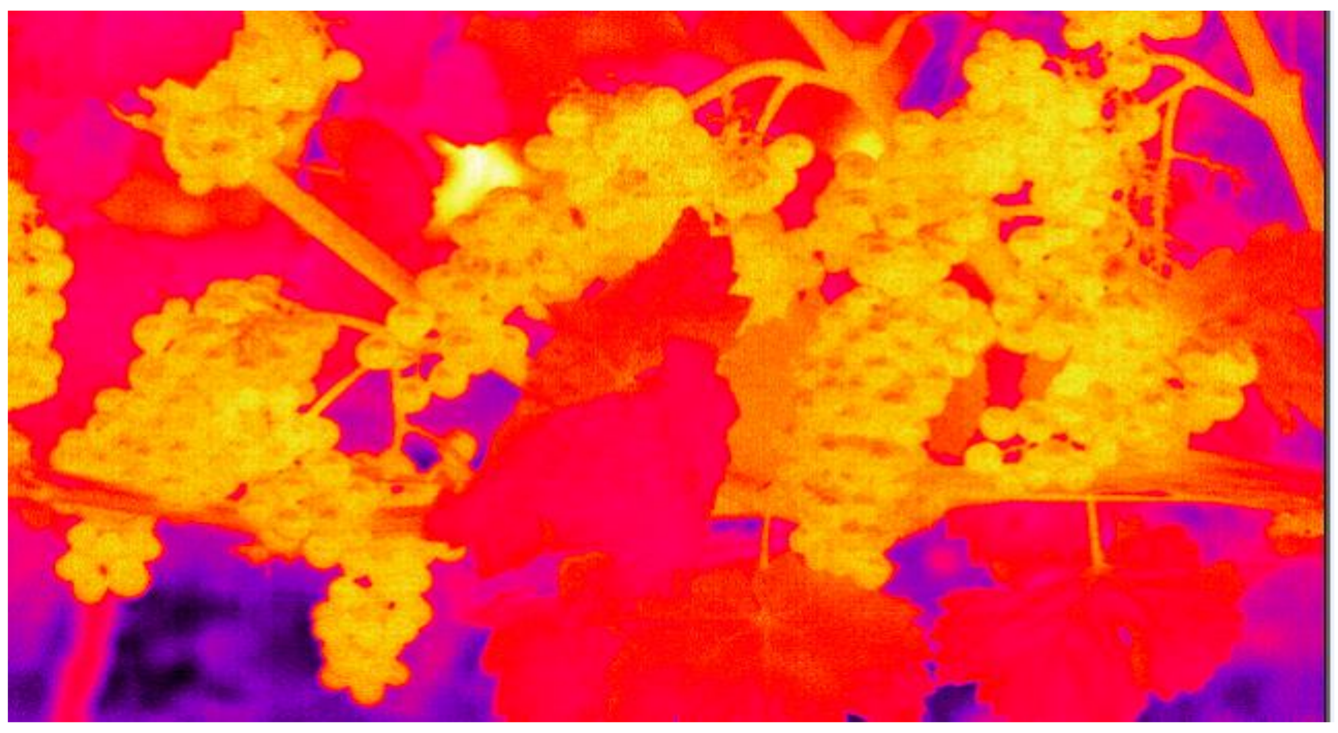


Figure 3. Thermal Image of Grapes after Sunset

The high color contrast between the grapes and the surrounding leaves is ideal for image processing. However, this idea was eventually abandoned due to the high cost of thermal cameras, the short timeframe in which the grapes could imaged, and the inability of the camera to identify the grapes through the leaves.

The next three imaging ideas explored were similar in that they did not operate in the visible spectrum. The team investigated radar systems, gigahertz imaging systems, and even x-ray systems. The main benefit of operating at these different frequencies is that they would be able to see through the leaves, but would still be able to identify the grapes due to their thickness and high water content.

However, these ideas were all abandoned due to cost, complexity, and safety concerns. The team decided to settle on optical as the best way forward. Figure 4 shows an image processing algorithm running.

Figure 4. Image Processing Algorithm Over Grape Photo

Prototype

After deciding to go with optical images as the data type, the team realized that data collection was the next challenge. After evaluating several different options, the team decided to go with an autonomous robot as the way to collect data. To simplify the build process, a Jazzy 500 electric wheelchair was used as the chassis. The base of chair was modified for off road use, and is depicted in Fig. 5.

Figure 5. Jazzy 500 Before/After Modifications

Larger wheels were added, and a waterproof box on top of the Jazzy holds all of the necessary electronics. Cameras affixed to the sides and front of the box are responsible for both imaging the grapes and helping navigate up and down the rows. GoPros are used because of their fast shutter speed and ease of use. Ultrasonic sensors are used as a failsafe to avoid any collisions. Figure 6 shows the ultrasonic and GoPro positioning.

Figure 6. Ultrasonics and GoPros

The Jazzy will spend its summer collecting data, and that data will be stored for next year’s team to process. In addition, next year’s team will be able to improve the Jazzy by adding additional sensors and improving its autonomous navigation. Figure 7 shows a collage of grape photos. In order to complete this project, the team will need many times the amount of data currently available.

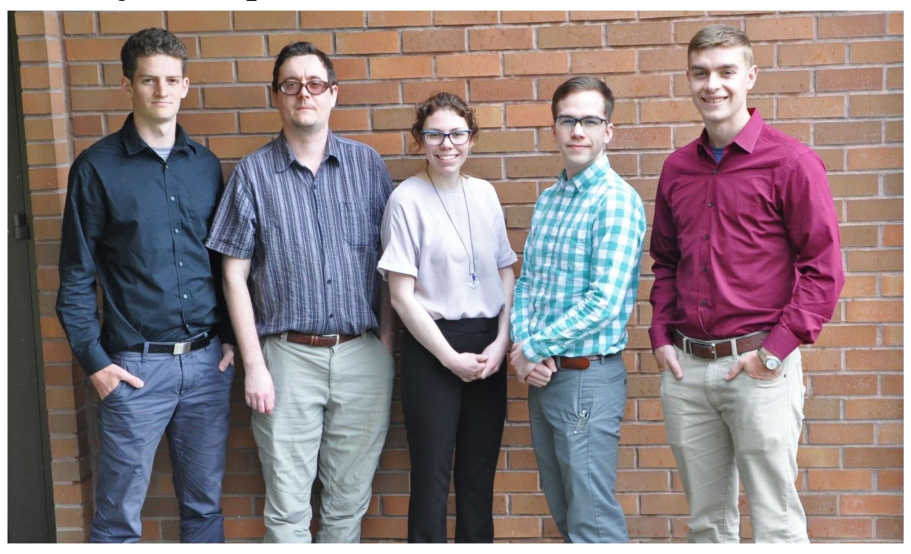
Figure 7. Collage of Data.

Grant Application

The team’s critical literature review was used to support a grant application for future funding. With a grant, the project can provide a large amount of data for the public to use. There is currently no open-source data like this, so we could provide a unique service to the wine grape research community.

Deliverables

- Operational Data Collection Device
- Critical Literature Review of Wine Grape Yield Estimation
- Project Report



From Left: Tobias Webb, Paul Holman, Chelsea Sutfin, Ben Delaney, Michael Peterson

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