

## Problem Statement

- Yield estimation is a critical crop management operation
- Computer vision systems can automate the tedious, inaccurate, and time-inefficient task of manual hand counting
- Although current vision-based solutions show promise, occlusions such as foliage often obstruct the view of crops and degrade accuracy of yield estimation
- How can occlusions be dealt with in order to prevent a severe decrease in count accuracy?

## Solution

- Camera and blower are attached to tractor, and are driven in between vineyard rows while taking pictures and blowing
- We use a leaf blower to raise leaves off of wine grapes and take pictures
- While leaves are moving around, our stitching algorithm creates a mosaic-like image of all the detected grapes, thus increasing accuracy of yield estimate



Figure 1: Picture of camera rig and leaf blower in vineyard row.

### Algorithm 1 Image Stitching with Maximum Cell Count

```

1: procedure COUNTSTITCH(points, curImg, gridX, gridY)
2:   finalCount ← 0
3:   tempCount ← 0
4:   deltaX ← ImageWidth/gridX
5:   deltaY ← ImageHeight/gridY
6:   for i ← 0; i < deltaX do
7:     for j ← 0; j < deltaY do
8:       for k ← 0; k < points.size() do
9:         if points[k] isInCell(tempCount[i][j]) then
10:          tempCount[i*(1/deltaX)][j*(1/deltaY)] += 1
11:        end if
12:      end for
13:    end for
14:  end for
15:  for i ← 0; i < gridX do
16:    for j ← 0; j < gridY do
17:      if tempCount[i][j] > finalCount[i][j] then
18:        finalCount[i][j] = tempCount[i][j]
19:        imageSubRegion = curImg.subRegion(i,j)
20:        imageSubRegion.copyTo(finalImg(i,j))
21:      end if
22:    end for
23:  end for
24: end procedure

```

Figure 2: Pseudocode for stitching algorithm

## Results

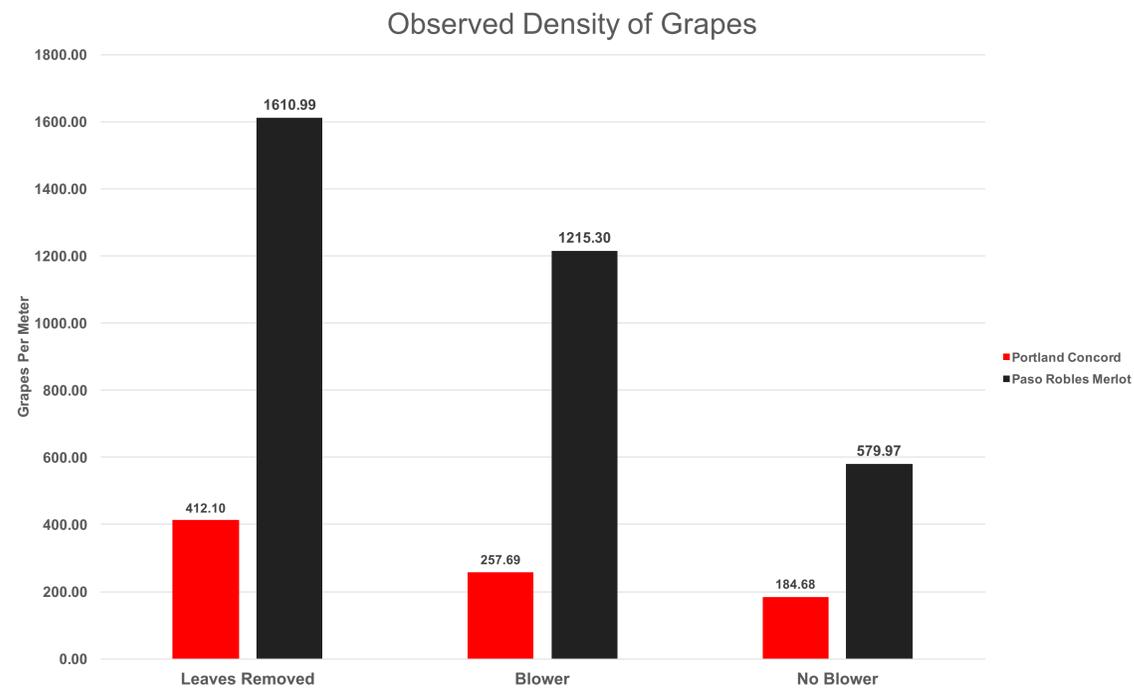


Figure 3: A bar graph showing the effect of using our method in two different grape vineyards. The bars show the grape density counts of each scenario. The leaves removed case is when we remove all leaves from the vine to acquire a ground truth. The two other cases, blower and no blower illustrate the number of grapes seen in those use cases. Our technique resulted in a 109.5% and 39.5% increase in the number of grapes seen in the Paso Robles, CA and Portland, NY vineyards, respectively.



Figure 4: The image on the left is a view of the grape vine without our method applied. The image on the right is the mosaic created after using the leaf blower and our algorithm. The red circles indicate where our algorithm has revealed the occluded grapes

## Conclusion

- The leaf blower provides an inexpensive means of active occlusion handling
- Our method was able to uncover more grapes, thus increasing accuracy of yield estimation
- Although we cannot uncover every single occluded grape, our work shows a significant increase in the number of grapes detected

## Future Work

- Adapt stitching algorithm to work while camera is moving
- Perform same experiment with other fruits and see results

## Acknowledgements

