Weed and Crop Discrimination Through an Offline Computer Vision Algorithm

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WEED(S)

Chemical Weed Control

- More than 1 billion pounds used by the U.S. annually
  - 5.6 billion pounds used worldwide [1]
- Chemicals remain in the soil for years, and eventually move to by water runoff to local water sources
  - USDA: 50 million people in the U.S. obtain their drinking water from sources potentially contaminated by pesticides and herbicides [1]
- Globally, 25 million agricultural workers unintentionally poisoned each year [2]

Organic Farming

- For small-scale farms, hand-weeding is the method of choice
  - Requires skilled laborers to identify and remove weeds
- Gray Farms in Watseka IL claims to hire multiple seasonal employees each year to help with this labor [3]

Robotics in Agriculture

- Because of advancements made in sensors, actuators, and electrical equipment, robotics has been proposed as a weeding solution
- Many robots have been developed and proposed although no fully autonomous robots are available for field use
- Bonirob

Deepfield Robotics

A Bosch Start-up Company

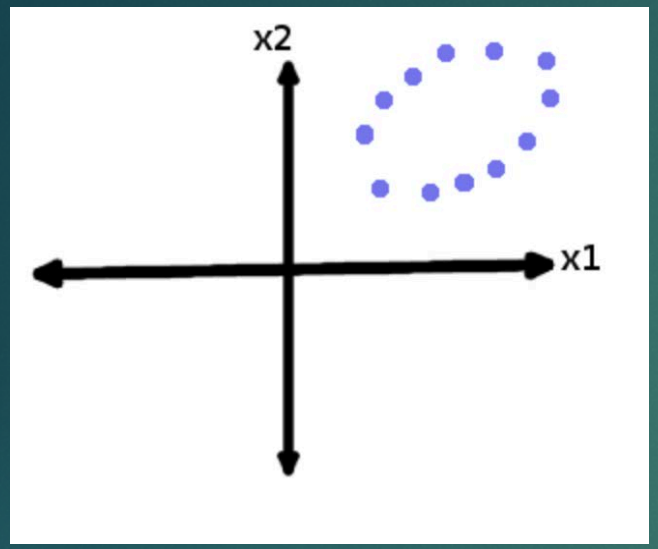
Hypothesis

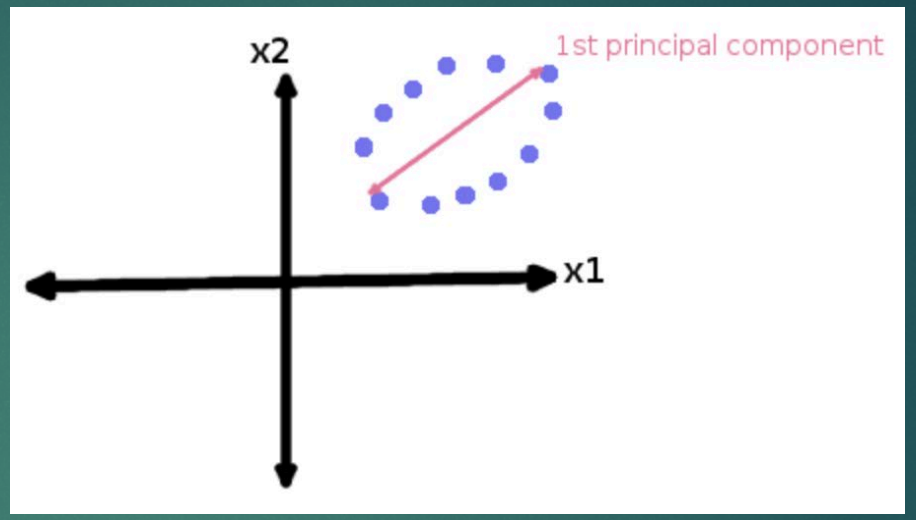
- Develop an offline computer vision algorithm that can discriminate between weeds and crops in a ground level photograph
- A simple algorithm like this can be adapted to low cost materials in the future to create a weeding machine/robot for small scale farmers

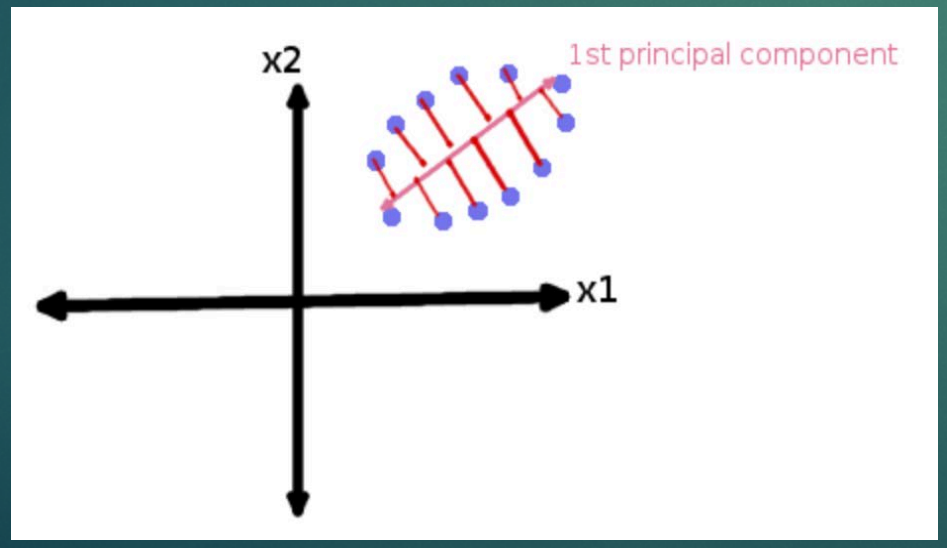
Computer Vision Systems

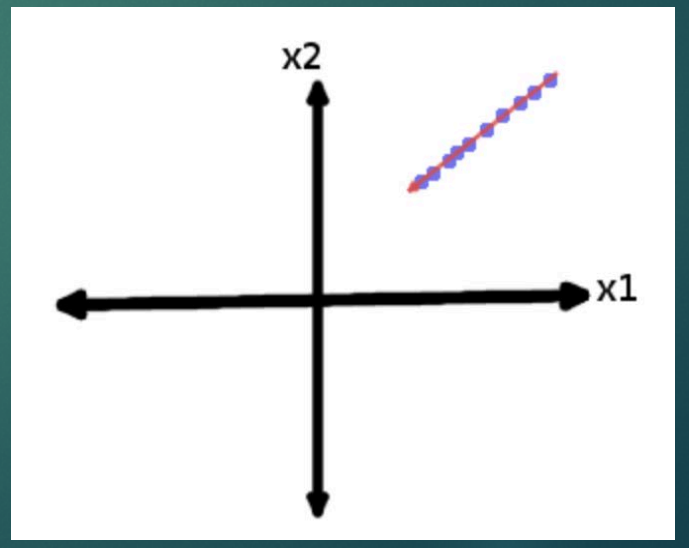
- Can be divided into shape-based analysis and color analysis
  - Shape analysis results can vary, depending on leaf overlap
  - Color analysis “tends to be less computationally-intensive than shape-based techniques” [4]
- Principal Component Analysis—a frequency spectrum analysis technique—is proposed

Principal Component Analysis









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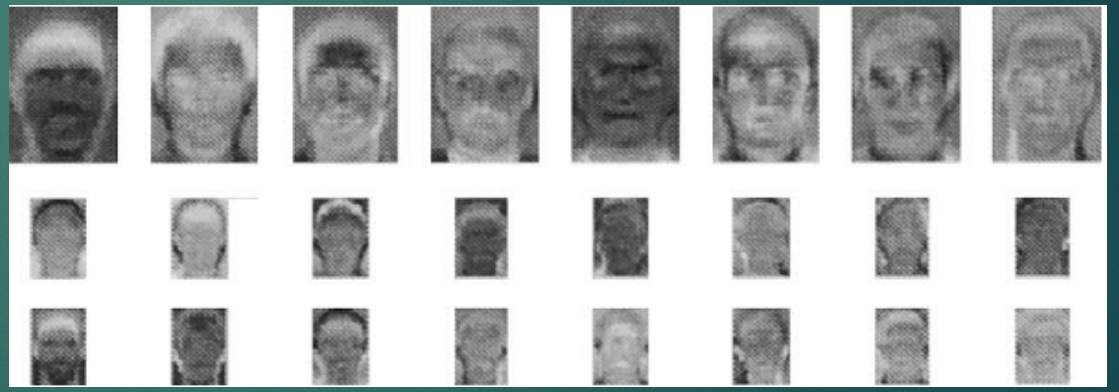
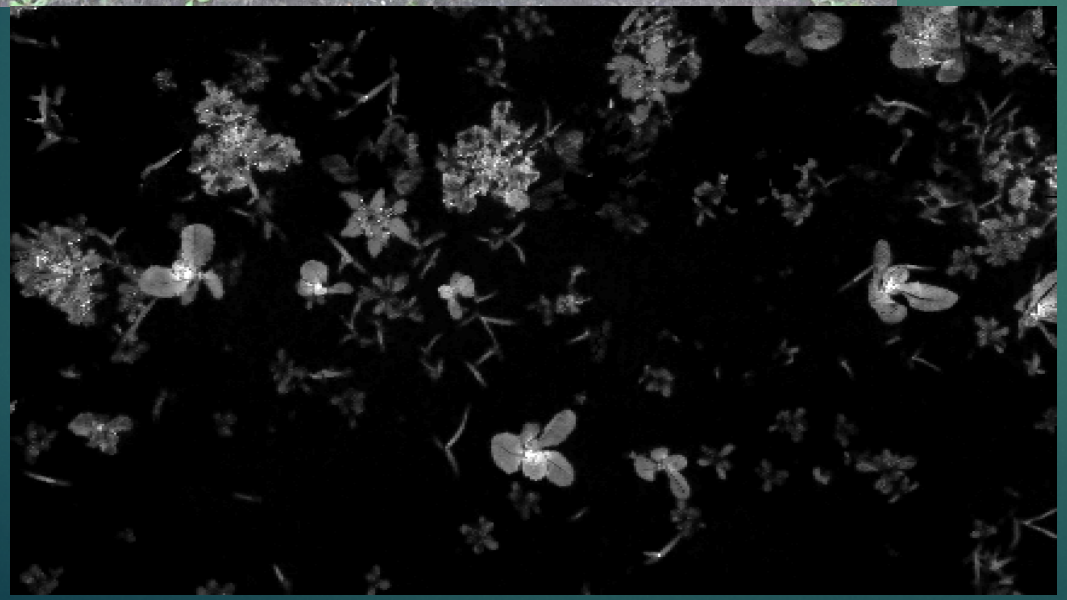
PCA in Facial Recognition

- PCA works by reducing dimensions in data to simplify calculations



[6]

Methods



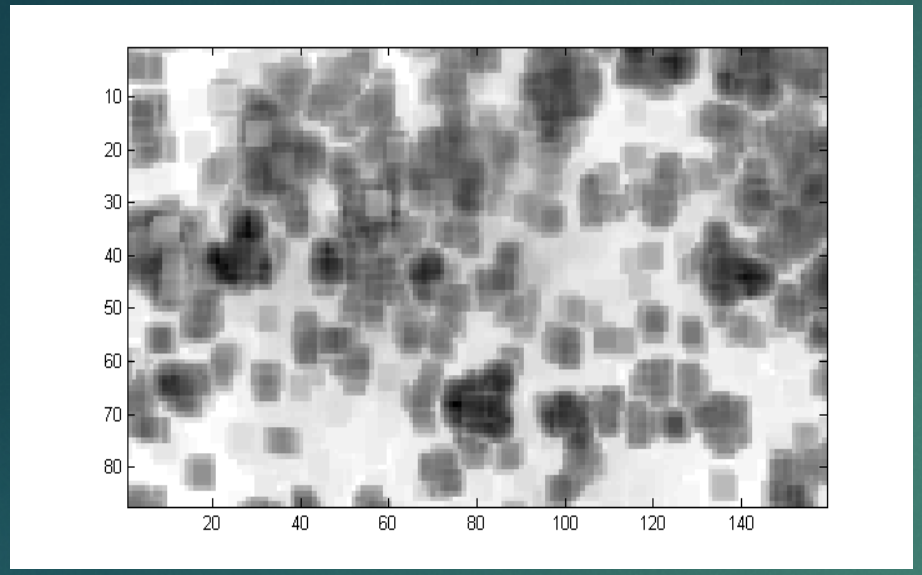
- 40+ images were captured at Gray Farms of various weed/crop fields

$$EXG = (2G - B - R)/(R + G + B) \quad [7]$$

Methods

- Block-based analysis was used to “chop” the image with 80% overlap
- A *fast-Fourier transform* was used to transform each block from a 2D feature-space into a frequency spectrum of values to be analyzed
- The spectra were then reshaped in order to perform Singular Value Decomposition, the first step of PCA
  - SVD = [U, S, V]
  - V = principal vectors – similar to eigenvectors
  - S*V = principal values – similar to eigenvalues
  - Projection Matrix = inv(V’) – this will remap the data into a matrix of values, determined by the *Principal Components*

Methods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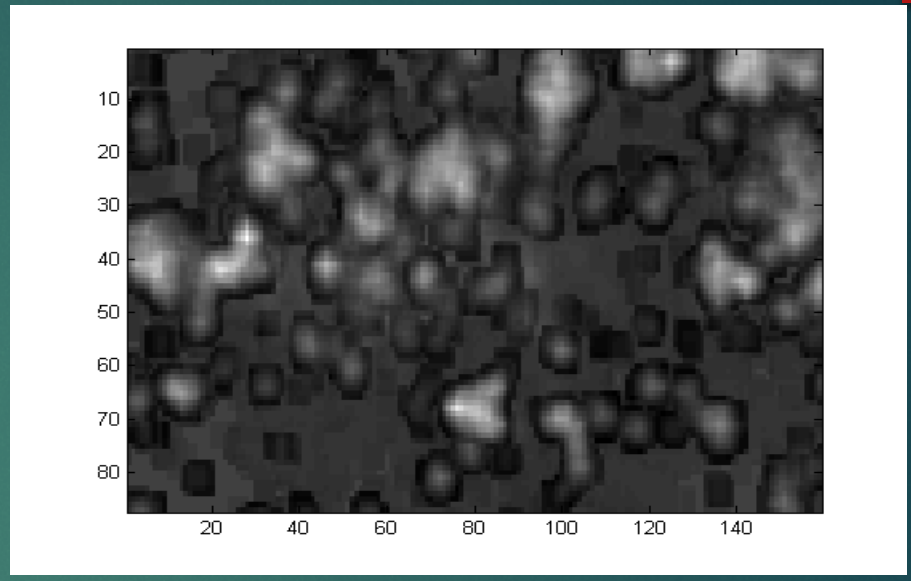
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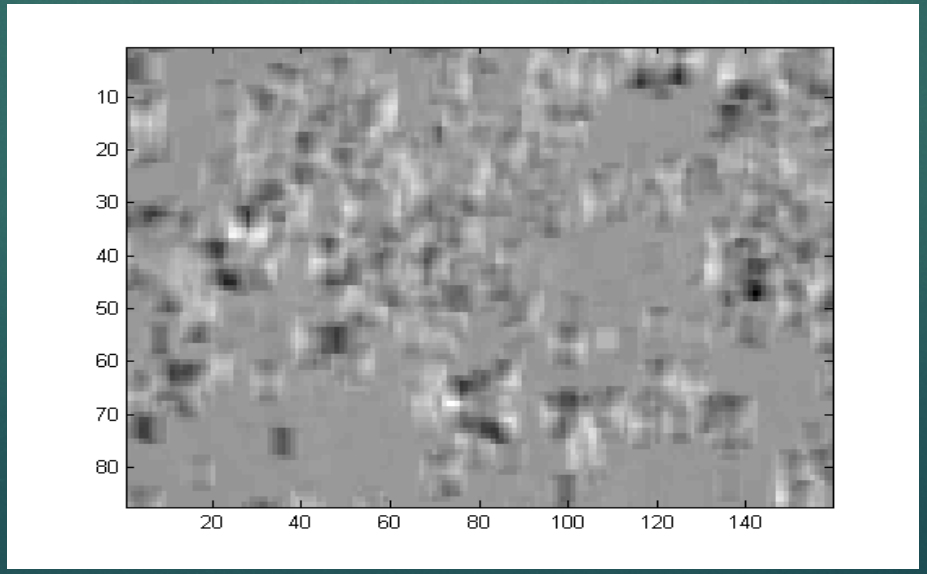
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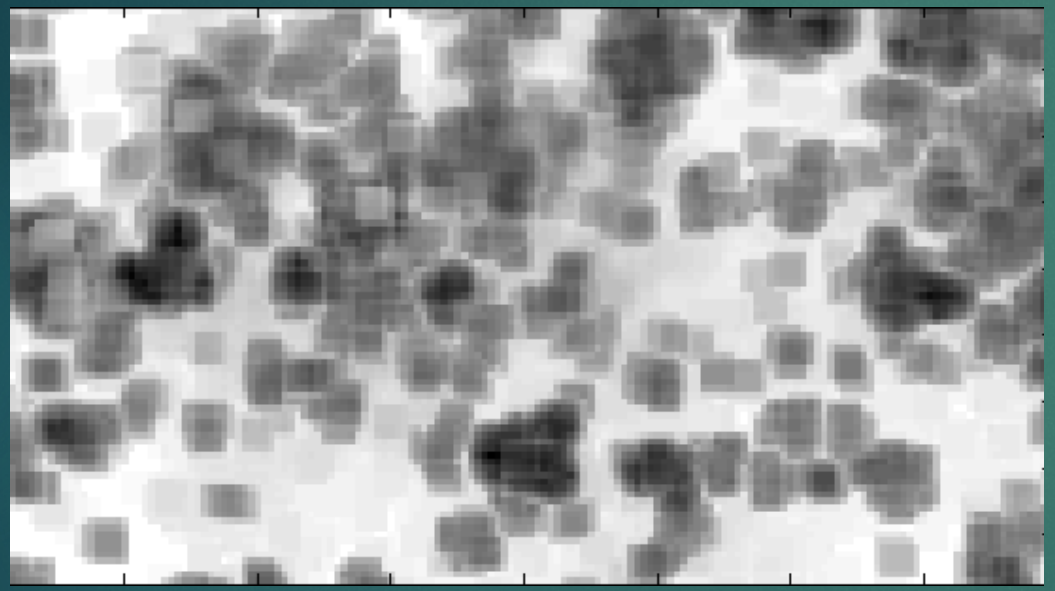
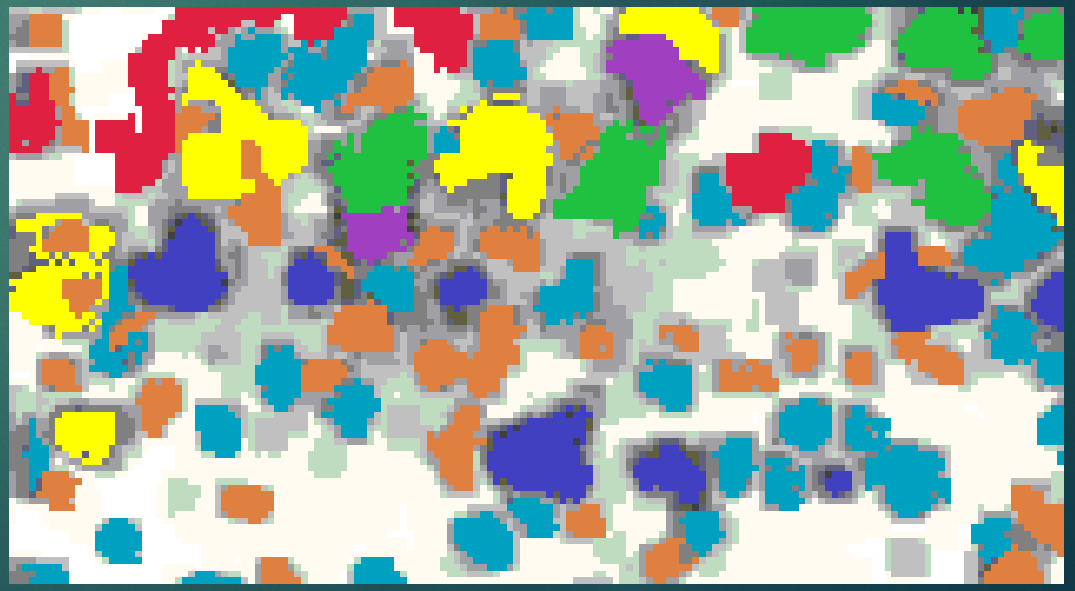
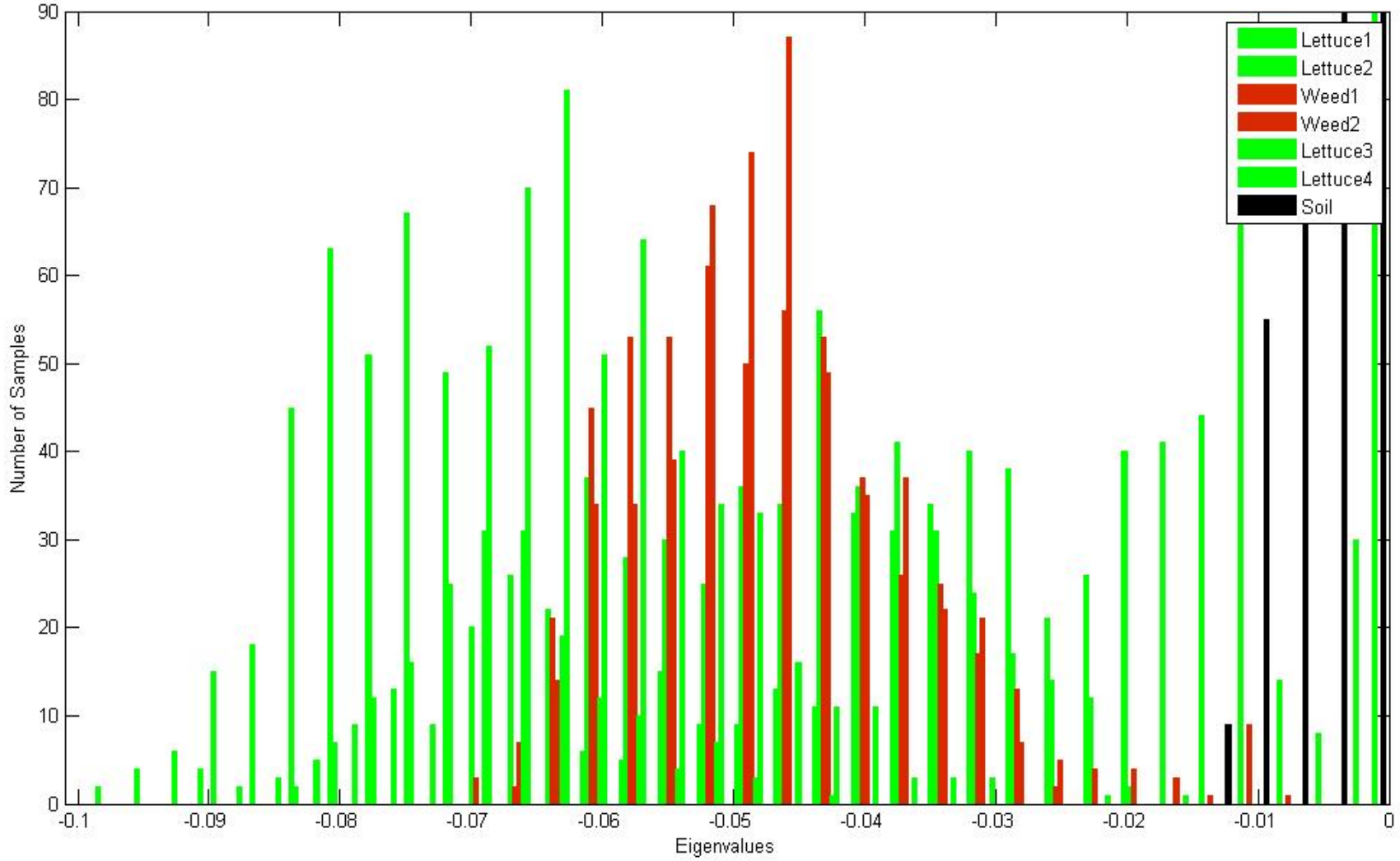
Methods

- Mask





Methods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Lettuce2
Weed1
Weed2
Lettuce3
Lettuce4
Soil
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Eigenvalues
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20
10
0
-0.1
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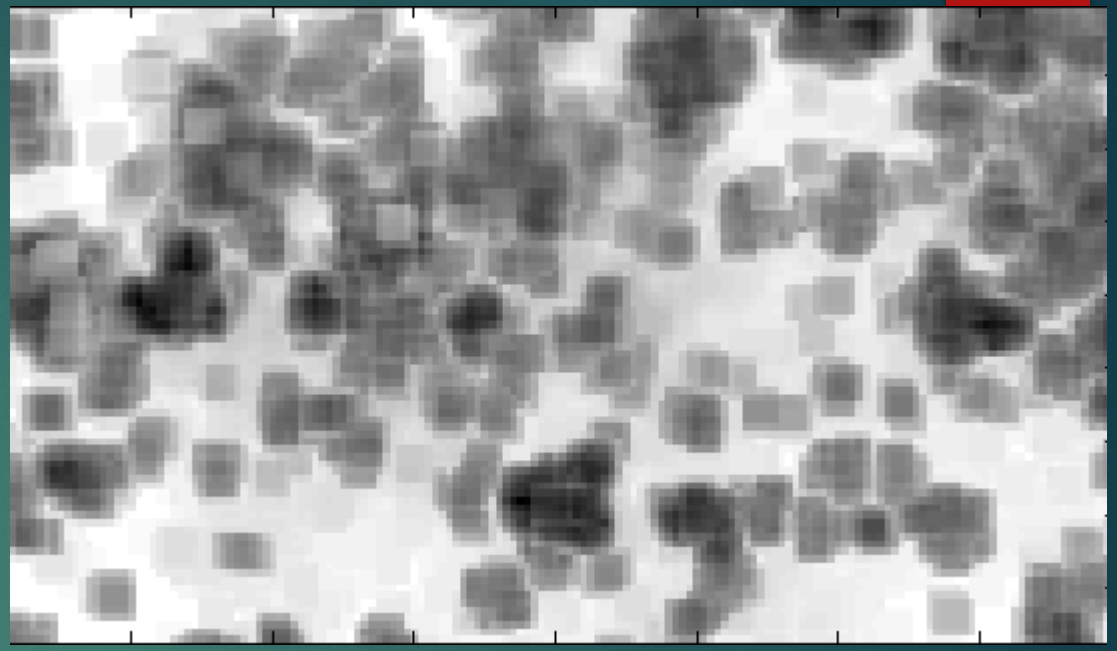
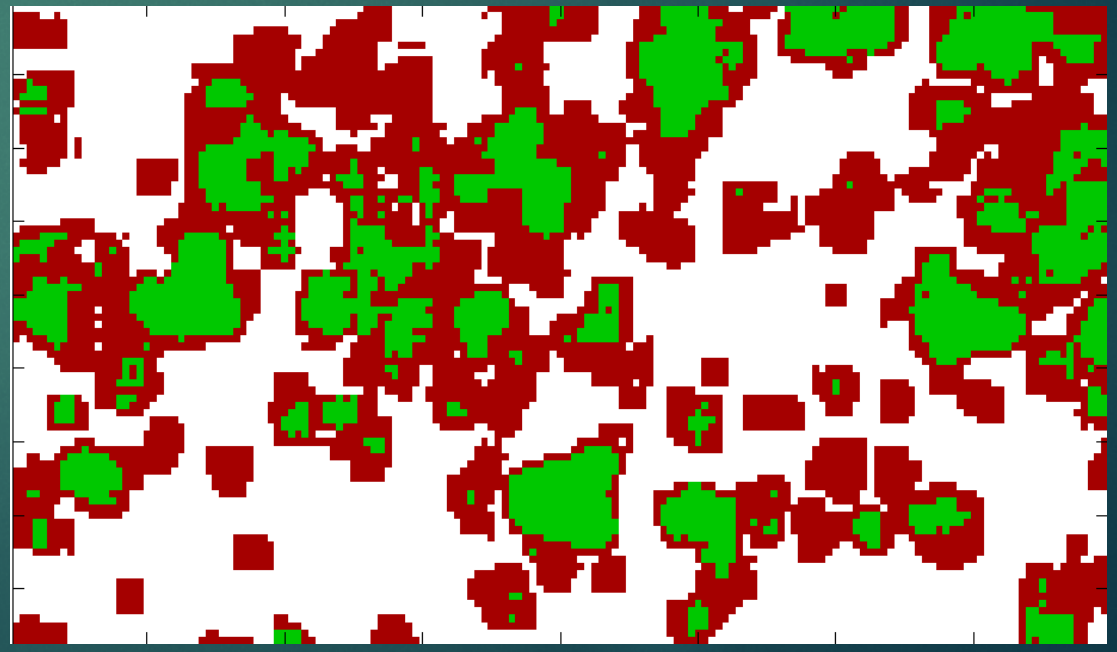
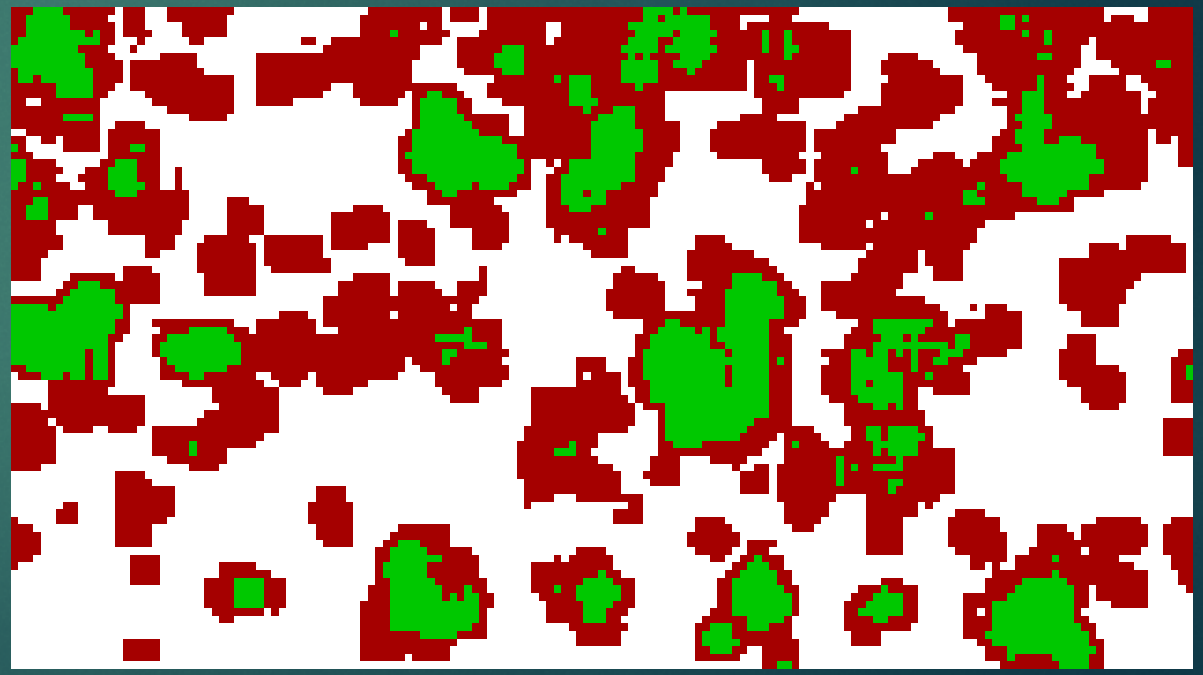
Methods

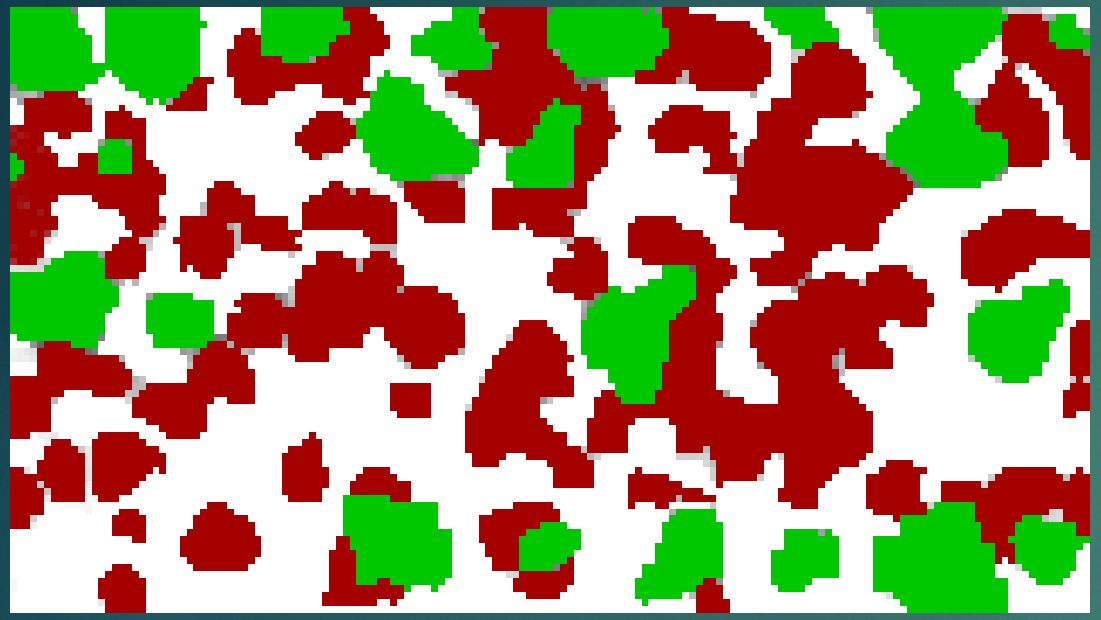




Results on New Data



Accuracy



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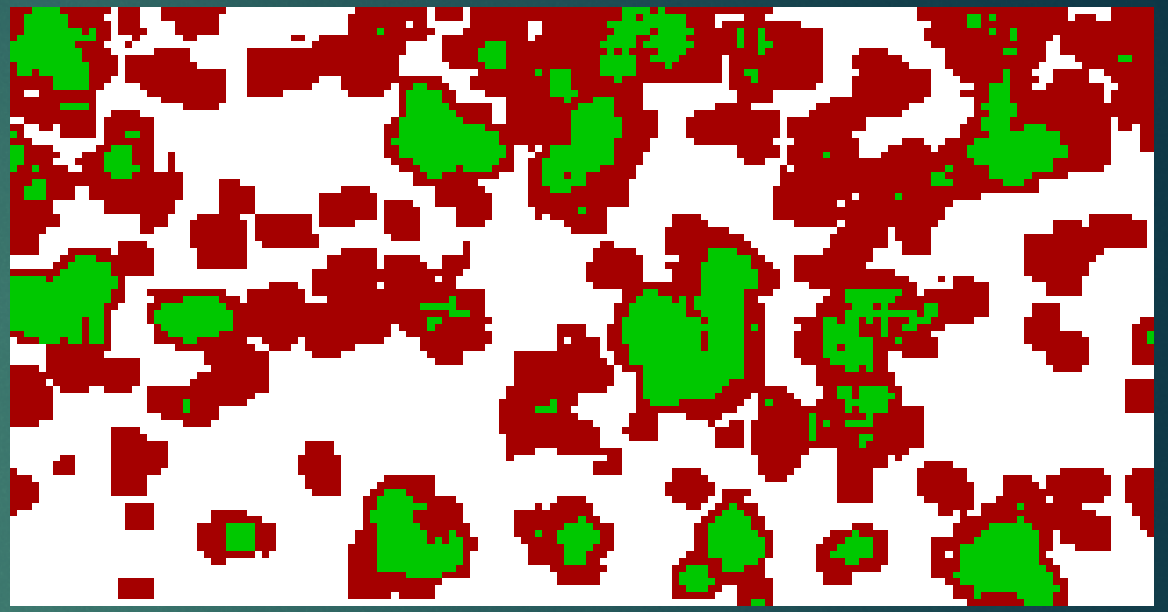


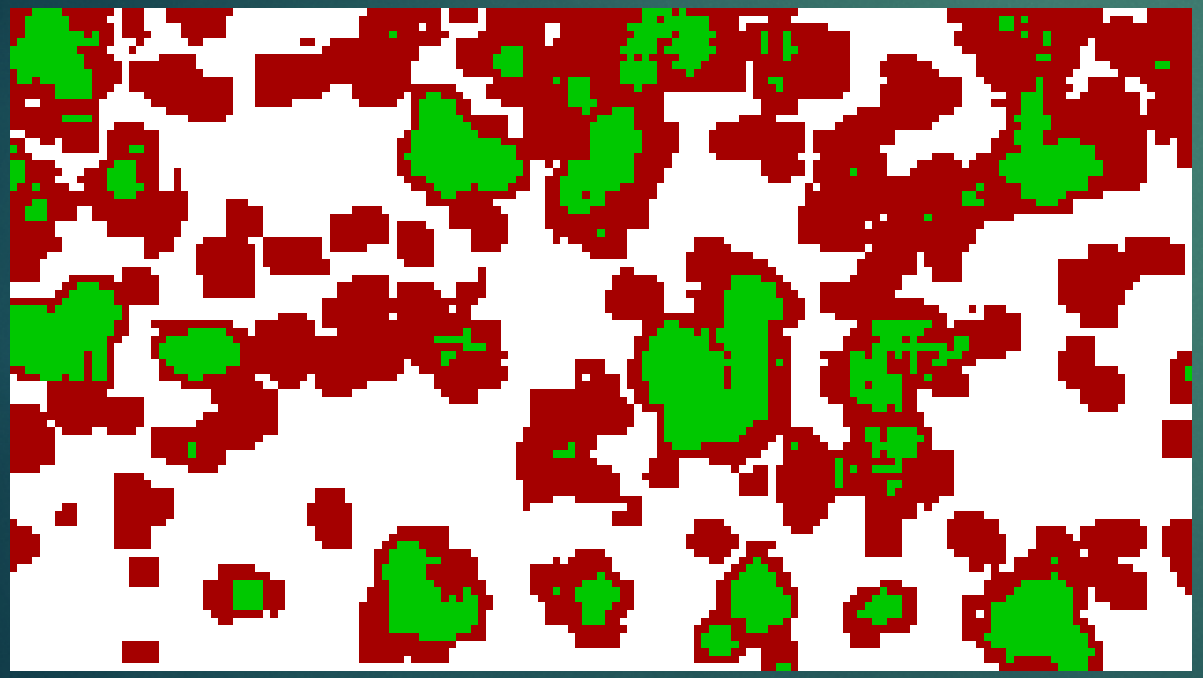
Predicted

Actual		Crop	Weed	Soil
	Crop	1221	1085	373
	Weed	339	3936	787
	Soil	6	528	5269

- Crops: 46%
- Weeds: 78%
- Soil: 91%

Misclassifications

- 40% of all identified crops regions were misclassified as weeds
  - Unusually high compared to other misclassification rates



Edge-Detection

- Prominent sub-field of image processing
- PCA results in a “fuzzy” edge
- A more prominent edge could result in better classification of weeds and crops
- Popular techniques
  - Roberts Detection
  - Sobel Edge Detection
  - Canny Edge Detection

Conclusion

- Overall Accuracy 77%
- PCA can be used to reduce dimensions in image analysis
- This method can be used to discriminate between crops and weeds
- With evolving technology and other image analysis techniques, greater accuracy can be attained

References

- [1] M. C. R. Alavanja, “Pesticides Use and Exposure Extensive Worldwide,” *Rev Environ Health*, vol. 24, no. 4, pp. 303–309, 2009.
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- [3] M. Gray, “Organic Farming,” 30-Sep-2016.
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- [5] “Introduction to Principal Component Analysis (PCA) - Laura Diane Hamilton.” [Online]. Available: http://www.lauradhamilton.com/introduction-to-principal-component-analysis-pca. [Accessed: 31-Oct-2017].
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- [7] H. Y. Jeon, L. F. Tian, and H. Zhu, “Robust Crop and Weed Segmentation under Uncontrolled Outdoor Illumination,” *Sensors*, vol. 11, no. 6, pp. 6270–6283, Jun. 2011.

Questions