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]
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
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
PCA in Facial Recognition

- PCA works by reducing dimensions in data to simplify calculations.
Methods

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

\[ EXG = \frac{(2G - B - R)}{(R + G + B)} \]  [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.
  - \( \text{SVD} = [U, S, V] \)
  - \( V = \text{principal vectors - similar to eigenvectors} \)
  - \( S^*V = \text{principal values - similar to eigenvalues} \)
  - Projection Matrix = \( \text{inv}(V^{'}) \) – this will remap the data into a matrix of values, determined by the Principal Components.
Methods
Methods

- Mask
Methods
Methods
Results on New Data
Accuracy

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

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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


Questions