Counting Plants With Deep Learning

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Introduction

- Agronomists and farmers need to know the number of plants in their crops to predict future yield
- Can we count without locating?
- We count plants in a crop field without knowing where they are
- We build our plant dataset from a single image of the entire crop field
- We describe a method to extract images sections or "plots" from an orthorectified image



1. Plot Extraction



November 15, 2017

Dataset



420 meters ~ 4 football fields



VIPER

November 15, 2017

Dataset

1,240 images were extracted



420 meters ~ 4 football fields



VIPER

November 15, 2017

Vertical Projection



Profile Function

• Vertical profile over the entire crop field:



- *N* : # lines
- $X_0, ..., X_{N-1}$: Coordinates of each plot-separating line
- $X_n = X_0 + n\Delta X$ n = 0, 1, ..., N 1



VIPER

November 15, 2017

The Cost Function

• It does not seem appropriate for gradient descent:



November 15, 2017

- 1. User provides: (a) number of rows and (b) number of ranges
- 2. Find range-separating lines:

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Slide 9				

3. For each range, find row-separating lines:

4. Select the *n*-th row of each range





VIPER

4. Find range-separating lines for the *n*-th row





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Resulting Cropped Images

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Resulting Cropped Images



Dataset

• We groundtruthed 2,480 labeled images

- 80% for training, 10% for validation, 10% for testing



2. Plant Counting



Counting Plants With Deep Learning



Cost Function

• Most research uses cross entropy as cost function, which reduces to

$$H(p,q) = -\log q(C)$$

where q(x) are the activations of the last layer, and *C* is the true number of plants

- This cost function is not appropiate when the classes are not independent, and there is label noise
- We want to count, not classify
- We propose to use the L_p norm

$$L_p(x,\hat{x}) = \left| x - \hat{x} \right|^p$$

and test which value of *p* provides the lowest error



Network Architectures

- We examined several CNN architectures:
 - Alexnet
 - Inception-v2
 - Inception-v3
 - Inception-v4
- We modify the last layers to be able to process non-rectangular images (of size 546 \times 103)



Stopping Criteria





Stopping Criteria





Value For *p*

Our metric for testing is Mean Average Percentage Error

$$MAPE = 100 \frac{|\hat{x} - C|}{C}$$

• Effect of *p* on the error, evaluated using AlexNet

р	MAPE
2	8.2%
1.8	8.4%
1.5	8.5 %
1	7.9 %



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Results

• Performance of different architectures was evaluated

Network	MAPE	MAPE	
	(w/o data augm)	(w/ data augm)	
AlexNet	8.3%	7.9%	
Inception-v2	8.2%	6.7%	
Inception-v3	7.1%	6.7%	-
Inception-v4	12.4%	11.4%	

• (using *p*=1)

Conclusions

- We presented a CNN-based method to count plants without locating them
- We presented a method to segment (or extract) image sections, or plots, from an orthorectified image
- Future work will include investigating loss functions more stable than the L1, such as the smooth L1, and training with larger datasets

