Active learning for efficient annotation in crop-weed semantic segmentation

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Background

- Most of the time in developing computer vision applications are spent in annotating images
- **Annotation of redundant images** that have already been used for training a deep learning model **does not significantly improve** the performance of a model
- **Active learning** can be proposed as an approach to **find images in which a model is still uncertain with**; therefore, improving performance
- Active learning for agricultural data is still not frequently applied

Objective

- Investigate the **added value of active learning** for training a semantic segmentation model for **agricultural application**

Research question:

- Can **active learning reduce annotation effort** on non-diverse and unbalanced agricultural datasets?

Material and methods

- In this work, uncertainty was determined using Monte-Carlo dropout
- FCHardNet was used with an additional dropout (DO) layer

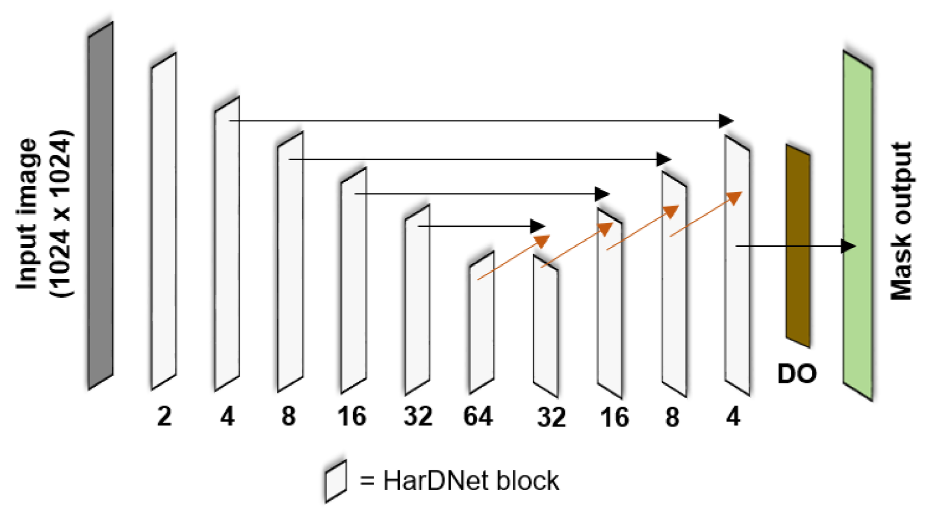

Figure 1. FCHarDNet with dropout (DO) layer

- Uncertainty was calculated using Bayesian Active Learning by Disagreement (BALD) and PowerBALD
- $BALD\ (y;\omega|x,D) = H(y|x,D) - \mathrm{E}[H(y|x,\omega,D)]$
  - Focuses on epistemic uncertainty rather than aleatoric uncertainty
  - $H(y|x,D) = Marginal\ Entropy$ triggers images with large fractions of pixels with similar probability over all classes
  - $\mathrm{E}[H(y|x,\omega,D)] = Conditional\ Uncertainty$, penalizes images with inherent nose (i.e. aleatoric uncertainty)
- PowerBALD -> sample images with probability p, with $p_x = \frac{BALD_x}{sum(BALD)}$

Experiments

- Agricultural image data are often not that diverse unlike well-known datasets like CityScapes. In this work, active learning was tested on two datasets:
  - CityScapes (for proof of principle)
  - Non-public Corn-Weed dataset

Dataset	Train	Validation	# classes	Majority class
Cityscapes	2975	500	19	44.1% (road)
Corn-Weed	1190 (Field A)		3	90.9% (soil)
	331 (Field B)	117 (Field B)		

Table 1. Statistical summary of both datasets

- The Corn-Weed consist of two fields A & B.
- In our experiment, a model was pre-trained on field A and active learning had to sample the most uncertain images of field B.

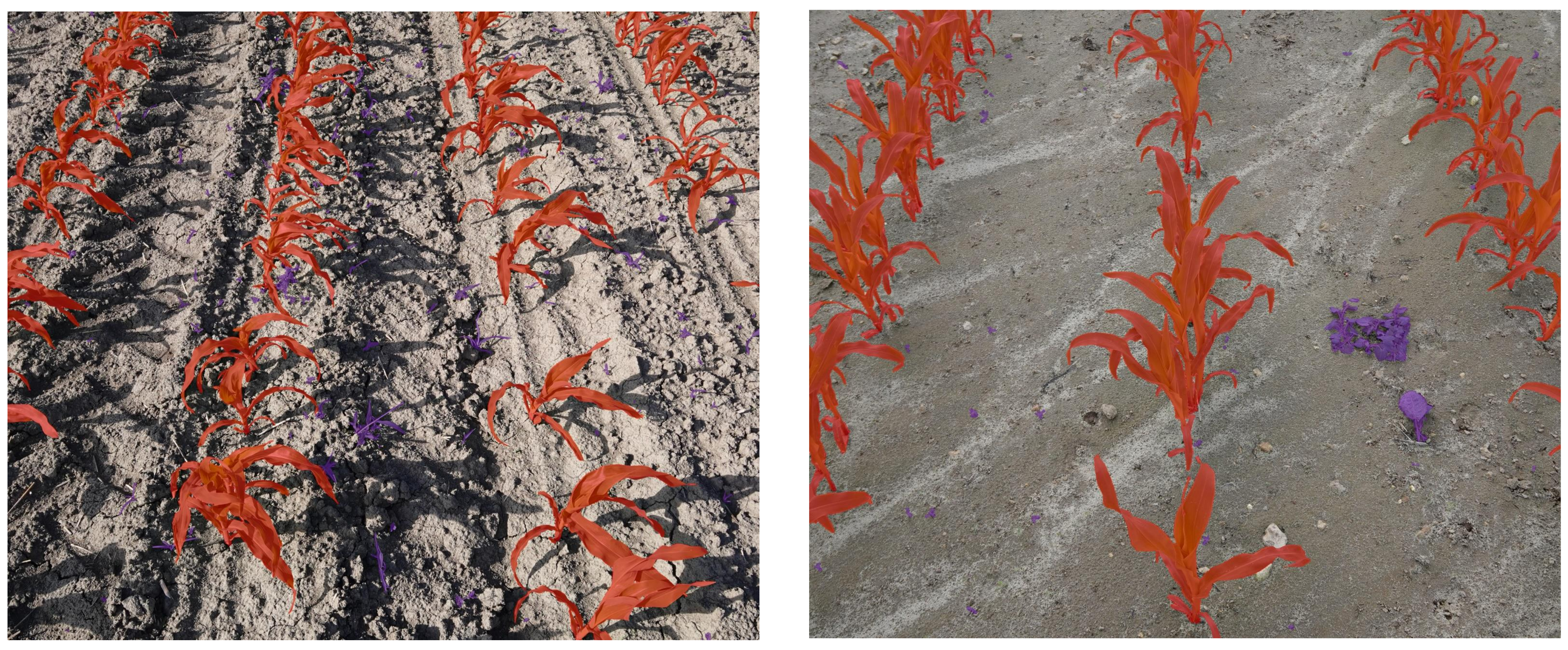

Figure 2. Sample dataset images: (Left) Field A; (Right) Field B, Red annotations correspond to corn while purple annotations correspond to weed.

Results

- Active learning worked on diverse datasets like CityScapes
- Both BALD and PowerBALD outperformed random sampling

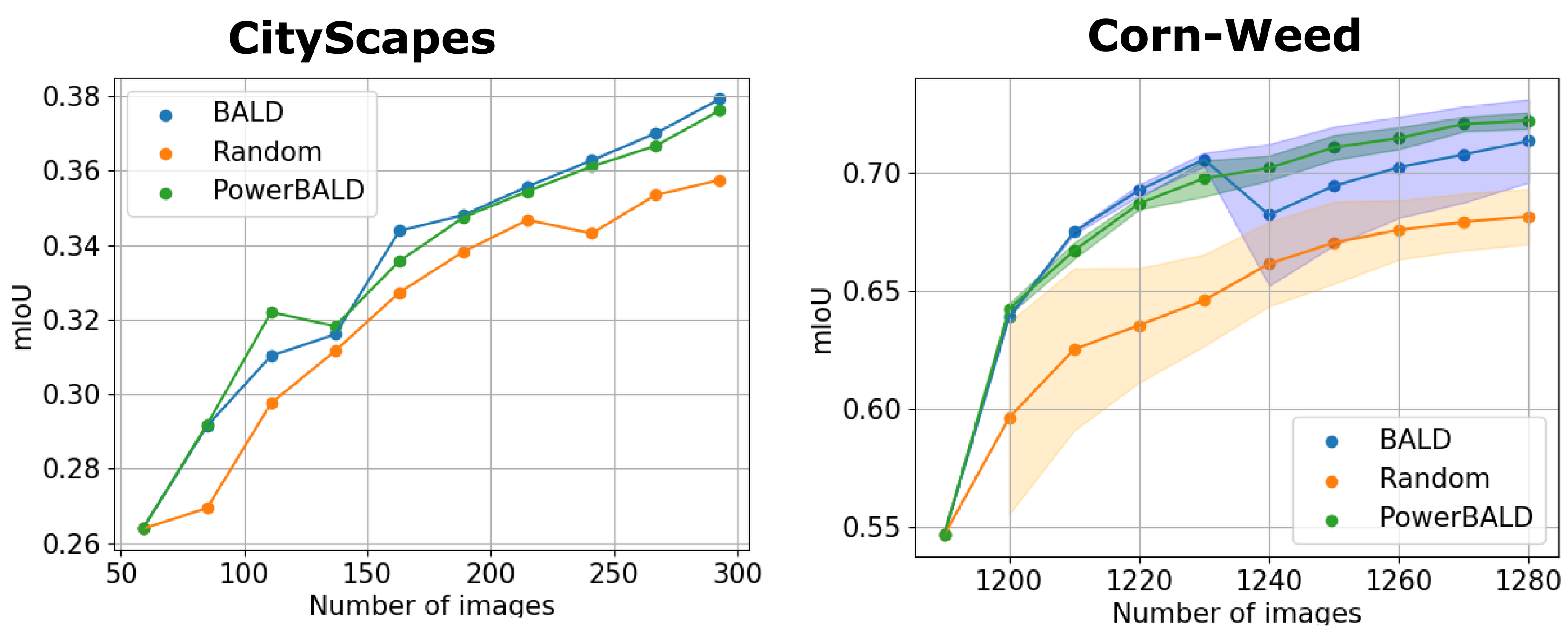

Figure 3. Experimental results: (Left) CityScapes; (Right) Corn-Weed dataset. Plots are shown as function of number of images.

- Corn-Weed dataset:
  - Significant difference between PowerBALD and Random (p=0.01) was observed
  - BALD and PowerBALD achieved the same mIoU than random requiring 70 less images

Discussion

- PowerBALD performed better than BALD
  - PowerBALD was able to output the highest uncertainty even with many common features between images; this was unexpected since only 10 images were selected
- BALD currently samples average uncertainty
  - Large influence of majority class
  - Potentially adding an excessive green filter could help in pre-selecting the pixels to be included in the uncertainty calculation

Conclusions

- **PowerBALD performs better than Random sampling** on corn-weed dataset
- Even with 90.9% pixels belonging to the soil class, **active learning for agricultural data shows potential**

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