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MACHINE SENSING AND DATA FOR IMPROVED AGRICULTURAL FIELD SURFACE MANAGEMENT

Dissertation presented to University of Illinois Urbana Champaign, Urbana, Illinois, USA

Sagar Regmi

School of Science and Technology, Quincy University, Quincy, USA

✉: s.regmi31@quincy.edu ☎: (217)-228-5360

1 Residue estimation from on-machine cameras

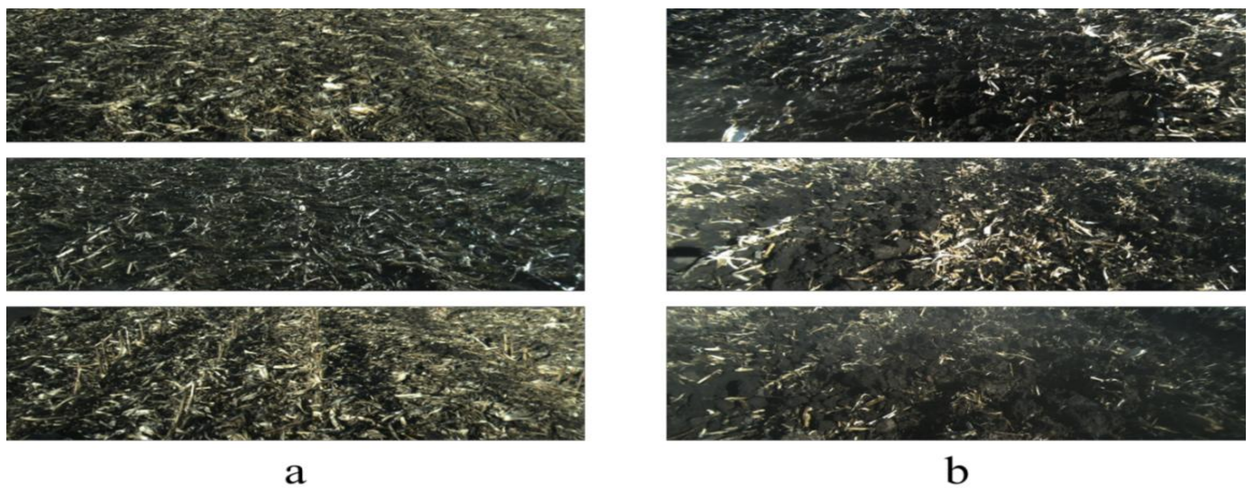


Figure: Example on-machine camera frames from one tillage pass.

- 25,803 clean, pre-processed images from multiple fields and years, collected during tillage.
- Labelled to the nearest 5% residue cover using line-transect, virtual-transect and scatter methods.
- Fine-tuned ResNet18 reached up to 96% accuracy on same-field test images, but below 58% on new fields.
- More confident labels and five broader residue classes, with confidence-weighted training, improved unseen-field accuracy.

Key Results:

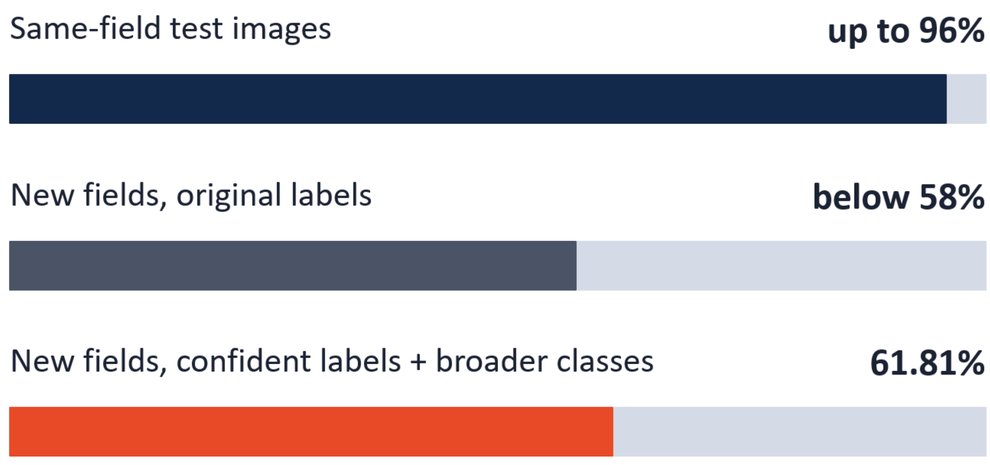
+18.3%

Corn yield, Field 1, after data-informed surface drainage (whole field)

61.8%

Residue-class accuracy on unseen fields (fine-tuned ResNet18)

Accuracy: same field vs. new fields



2 Residue Segmentation Tool and deep learning

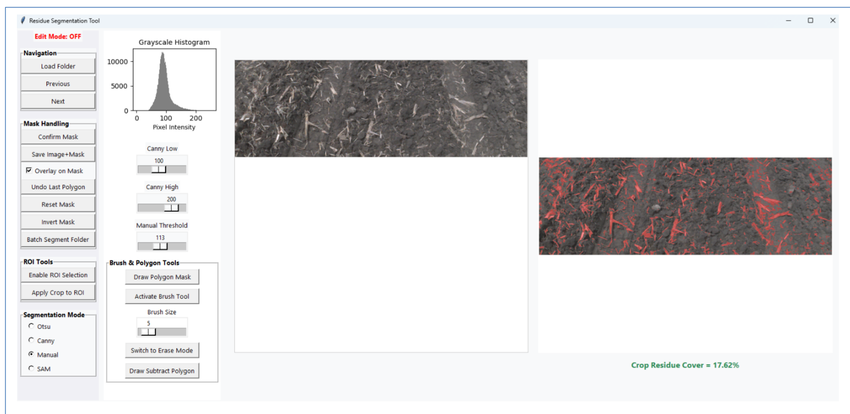


Figure: Residue Segmentation Tool: histogram, Canny, Otsu, manual and SAM-assisted masks, with a live crop-residue readout.

- Windows GUI for building ML-ready binary masks. 500 images were labelled with it.
- U-Net and DeepLabV3 were trained on as few as 350 images and reached accuracy up to 86.40%.
- Dice and IoU: U-Net 74.80% / 52.70%; DeepLabV3 68.40% / 55.50%.

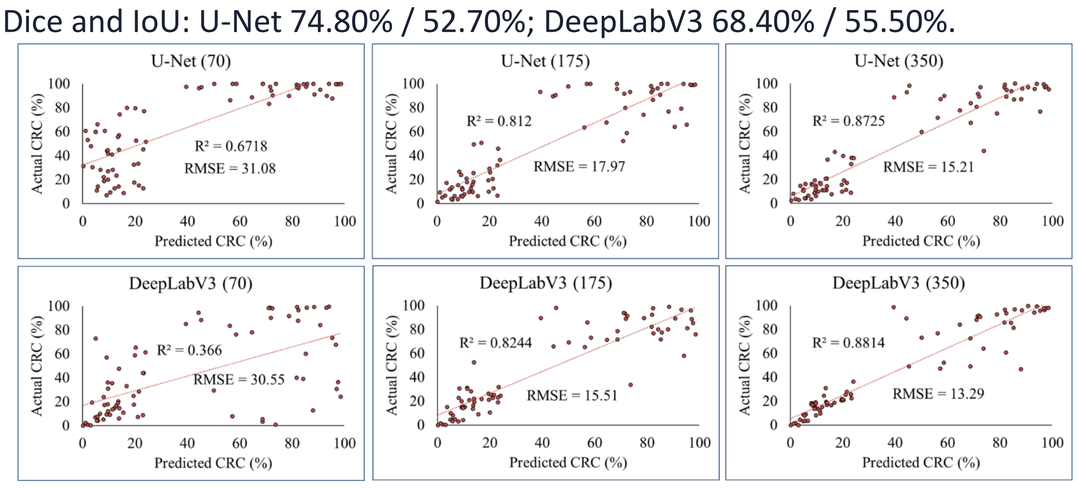


Figure: Predicted vs. actual residue cover. Best model: DeepLabV3 with 350 training images (R^2 = 0.88).

3 Data-informed surface drainage and yield

Two fields, 2008–2021 corn and soybean yields. Ditches were designed from topography, flow direction and mapped ponding after heavy rain.

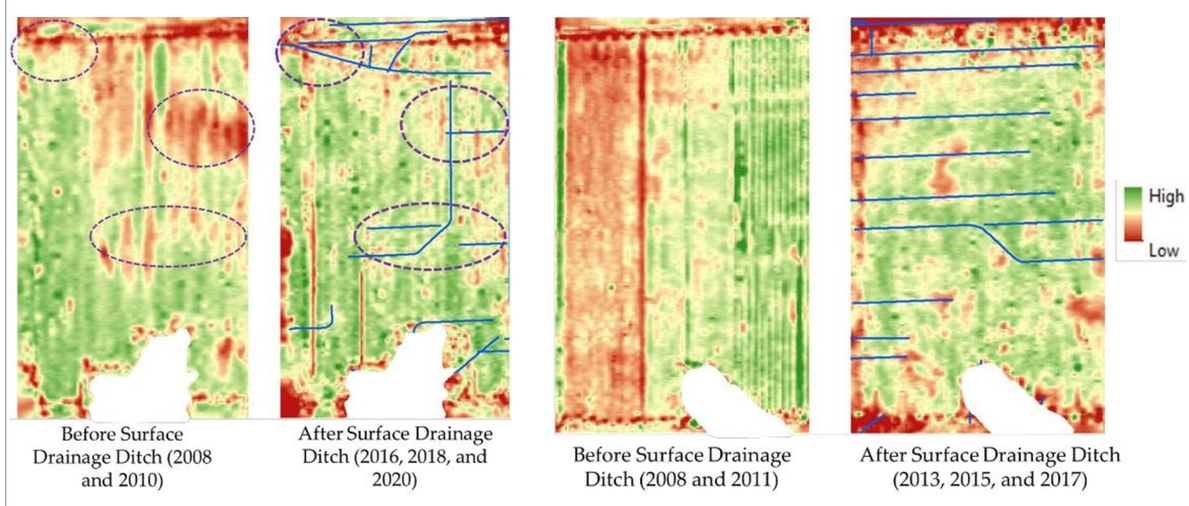


Figure: Field 2 average normalised yield before and after drainage. Left: corn; right: soybean. Blue lines are drainage ditches.

- Whole-field change after drainage: corn +18.3% (Field 1) and +13.9% (Field 2); soybean +5.5% (Field 1) and +23.1% (Field 2).
- Isolated affected areas gained more: corn up to +40.2%, soybean up to +42.2%.
- Gains were largest in low areas where water ponds. Flow direction matters as well as topography.

4 Final Remark(s)

- On-machine cameras with deep learning can estimate residue cover. Generalising to new fields depends on careful labelling and class design.
- The Residue Segmentation Tool provides an annotation workflow and a benchmark for U-Net and DeepLabV3 with about 350 training images.
- Data-informed surface drainage raised corn and soybean yields in both fields, most in areas where water ponds.