Deep Learning-Based Semi-Supervised Weed Prediction for Precision Agriculture

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Background

Conventional weed management often relies on *blanket spraying* herbicides across entire fields, wasting chemicals and harming the environment. Weed growth, however, is typically clustered in patches. Precision Agriculture (PA) aims to optimize resources by treating only affected areas. The challenge lies in creating accurate weed density maps, which traditionally require time-intensive manual labelling of training data.

Problem Statement

Deep learning models like U-Net can accurately detect weeds, but they demand large, manually annotated datasets. This labelling process is a significant bottleneck. The project proposes a semi-supervised workflow that automates weed label generation, reducing manual effort while maintaining accuracy.

Objectives

1. Develop a semi-supervised pipeline to generate pixel-level weed masks without manual labelling.
2. Train and evaluate a U-Net model for weed segmentation using this generated dataset.
3. Integrate the model output with QGIS to create a weed density “prescription map” for precision herbicide application.

Research Questions

- Can combining a crop-segmentation model with traditional color-index methods produce accurate weed masks?
- How well can the semi-supervised U-Net segment weeds in unseen field images?
- Can the pixel-level outputs be effectively converted into a practical, GIS-based prescription map?

Methodology

Phase 1 – Semi-Supervised Labelling:
Train a crop-segmentation U-Net on a crop-only dataset (e.g., CWF-788).

Generate a vegetation mask using the Excess Green (ExG) color index and subtract the crop mask to obtain weed-only regions.

Phase 2 – Model Training:
Use the generated weed masks to train a U-Net_Weed model and evaluate its performance via Mean Intersection over Union (mIoU).

Phase 3 – GIS Mapping(Optional):
Import the model output into QGIS, apply a grid-based analysis, compute weed density per cell, and classify them into low, medium, or high infestation zones.

Expected Results

- A trained U-Net_Crop and U-Net_Weed model.
- A new semi-supervised weed mask dataset.
- A GIS-based, multi-color weed density prescription map ready for real-world agricultural use.

Keywords

Precision Agriculture, GIS, Weed Detection, U-Net, Semi-Supervised Learning, Deep Learning, Image Segmentation, QGIS, Prescription Map.

References

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