**Team:** AgriVision

**Project Title:** Semantic Segmentation of Agricultural Field Patterns Using a Semi-Supervised Deep Learning Approach

**Project Summary:**

Agricultural production has been revolutionized by advancements in remote sensing to pinpoint problems in the field caused by weeds, nutrient deficiencies, and flooding etc., allowing farmers to manage their crops efficiently using RGB-NIR images taken from drone or satellites (Sishodia et al., 2020). Semantic segmentation models have been used to predict the boundary geometries of objects or areas from images (Gu et al., 2023; Li et al., 2024; Syed et al., 2023; Tao et al., 2023) and has many agricultural applications such as detection of grapevine trunks (Slaviček et al., 2024), crop row detection for automated field equipment (Cao et al., 2022), and differentiation between weeds and crops (Milioto et al., 2017; Steininger et al., 2023). However, the remote sensing image data needed to train deep learning models can be expensive to acquire and annotate for entire farms with hundreds to thousands of acres under cultivation. Semi-supervised deep learning seeks to solve some of these data limitations by training a supervised model using the labeled data, predict “pseudo-labels” on the unlabeled images, and then train a new model adding in the new labels, in an iterative fashion (van Engelen et al., 2020; Zhou, 2021) and has successfully been applied to different deep learning segmentation challenges in agtech (Casado-García et al., 2022; Jang et al., 2023; Picon et al., 2023) . This project seeks to apply different semi-supervised training methods to a recently released agricultural dataset containing labeled images of eight common cropping problems in aerial photos of farmland (Chiu et al., 2020).

**Approach:**

The 2024 dataset includes 105Gb of new, unlabeled RGB-NIR photos, whereas the original dataset released in 2021 is roughly 20Gb and is fully annotated. There are some baseline networks that have been trained on this first dataset over the past two years (Tik Chiu et al., 2020), so we need to work first to train a supervised network which can match some of the top performers on the leaderboard. Next, we will start to explore the space of semi-supervised training methods, as there are a variety of different ways we can approach this work, but we will start with self-training and then move on to other methods such as co-training, etc. The models will be evaluated against a holdout test set used for the Agriculture Vision 2024 challenge, with mIOU as the final evaluation metric.

Some stretch goals would be to deploy the final model using FastAPI or Torchserve, and have it embedded in a small, one page Django web application.

**Resources/Related Work:**

Cao, M., Tang, F., Ji, P., & Ma, F. (2022). Improved Real-Time Semantic Segmentation Network Model for Crop Vision Navigation Line Detection. *Frontiers in Plant Science*, *13*, 898131. <https://doi.org/10.3389/FPLS.2022.898131/BIBTEX>Casado-García, A., Heras, · J, Milella, · A, & Marani, · R. (2022). *Semi-supervised deep learning and low-cost cameras for the semantic segmentation of natural images in viticulture*. *23*, 2001–2026. <https://doi.org/10.1007/s11119-022-09929-9>Chiu, M. T., Xu, X., Wei, Y., Huang, Z., Schwing, A., Brunner, R., Khachatrian, H., Karapetyan, H., Dozier, I., Rose, G., Wilson, D., Tudor, A., Hovakimyan, N., Huang, T. S., & Shi, H. (2020). Agriculture-Vision: A Large Aerial Image Database for Agricultural Pattern Analysis. *CVPR*. <https://www.agriculture-vision.com>. Gu, E., Xiao, G., Lian, F., Mu, T., Hong, J., & Liu, J. (2023). Segmentation and Evaluation of Crack Image From Aircraft Fuel Tank via Atrous Spatial Pyramid Fusion and Hybrid Attention Network. *IEEE Transactions on Instrumentation and Measurement*, *72*. <https://doi.org/10.1109/TIM.2023.3272052>Jang, S.-Y., Moon, G.-Y., & Kim, J.-O. (2023). Enhancing Plant and Disease Segmentation through Semi-Supervised Learning with Feature Distillation. *IEEE International Conference on Consumer Electronics-Asia*. <https://doi.org/10.1109/ICCE-Asia59966.2023.10326382>Li, X., Jia, L., Lin, F., Chai, F., Liu, T., Zhang, W., Wei, Z., Xiong, W., Li, H., Zhang, M., & Wang, Y. (2024). Semi-supervised auto-segmentation method for pelvic organ-at-risk in magnetic resonance images based on deep-learning. *Journal of Applied Clinical Medical Physics*, *25*(3). <https://doi.org/10.1002/ACM2.14296>Milioto, A., Lottes, P., & Stachniss, C. (2017). Real-time Semantic Segmentation of Crop and Weed for Precision Agriculture Robots Leveraging Background Knowledge in CNNs. *Proceedings - IEEE International Conference on Robotics and Automation*, 2229–2235. <https://doi.org/10.1109/ICRA.2018.8460962>Picon, A., Eguskiza, I., Galan, P., Gomez-Zamanillo, L., Romero, J., Klukas, C., Bereciartua-Perez, A., Scharner, M., & Navarra-Mestre, R. (2023). Improving Disease Quantification in Agricultural Imagery: Multi-Crop Neural Networks for Semantic Segmentation with Contextual Metadata and Semi-Supervised Learning. *Artificial Intelligences in Agriculture*. <https://ssrn.com/abstract=4663174>Sishodia, R. P., Ray, R. L., & Singh, S. K. (2020). Applications of Remote Sensing in Precision Agriculture: A Review. *Remote Sens.* <https://doi.org/10.3390/rs12193136>Slaviček, P., Hrabar, I., & Kovačić, Z. (2024). Generating a Dataset for Semantic Segmentation of Vine Trunks in Vineyards Using Semi-Supervised Learning and Object Detection. *Robotics*, *13*(2), 20. <https://doi.org/10.3390/ROBOTICS13020020/S1>Steininger, D., Trondl, A., Croonen, G., Simon, J., & Widhalm, V. (2023). The CropAndWeed Dataset: a Multi-Modal Learning Approach for Efficient Crop and Weed Manipulation. *Winter Conference on Applications of Computer Vision (WACV) 2023*. <https://github.com/cropandweed/cropandweed-dataset>Syed, S., Anderssen, K. E., Kristian Stormo, S., & Kranz, M. (2023). Weakly supervised semantic segmentation for MRI: exploring the advantages and disadvantages of class activation maps for biological image segmentation with soft boundaries. *Scientific Reports |*, *13*, 2574. <https://doi.org/10.1038/s41598-023-29665-y>Tao, J., Chen, Z., Sun, Z., Guo, H., Leng, B., Yu, Z., Wang, Y., He, Z., Lei, X., & Yang, J. (2023). Seg-Road: A Segmentation Network for Road Extraction Based on Transformer and CNN with Connectivity Structures. *Remote Sensing 2023, Vol. 15, Page 1602*, *15*(6), 1602. <https://doi.org/10.3390/RS15061602>Tik Chiu, M., Xu, X., Wang, K., Hobbs, J., Hovakimyan, N., Huang, T. S., Shi, H., Wei, Y., Huang, Z., Schwing, A., Brunner, R., Dozier, I., Dozier, W., Ghandilyan, K., Wilson, D., Park, H., Kim, J., Kim, S., Liu, Q., … Tang, J. (2020). The 1st Agriculture-Vision Challenge: Methods and Results. *CVPR*. <https://www.agriculture-vision.com>. van Engelen, J. E., Hoos, H. H., Fawcett Jesper E van Engelen, T. B., & Hoos hh, H. H. (2020). A survey on semi-supervised learning. *Machine Learning*, *109*, 373–440. <https://doi.org/10.1007/s10994-019-05855-6>Zhou, Z.-H. (2021). Semi-Supervised Learning. In *Machine Learning* (pp. 315–340). Springer Nature .

**Datasets:**

We will be using two related datasets for this project.

First, the 2021 agriculture vision dataset which is fully annotated

<https://www.agriculture-vision.com/agriculture-vision-2022/prize-challenge-2022/agriculture-vision-challenge-2022>

<https://github.com/SHI-Labs/Agriculture-Vision>

Second, the 2024 agriculture vision dataset, which contains unlabeled images

<https://www.agriculture-vision.com/agriculture-vision-2024/prize-challenge-2024>

<https://www.dropbox.com/scl/fo/7yzzc8hqtvaki2y1md6h4/h?rlkey=su71dij6xfb964zfwe1d6kros&dl=0>

**Team Members:**

Francis Lin [flin96@gatech.edu](mailto:flin96@gatech.edu)

Stanislav Sheludko [ssheludko3@gatech.edu](mailto:ssheludko3@gatech.edu)

Juanwen (Rebecca) Lu [jlu435@gatech.edu](mailto:jlu435@gatech.edu)

Bryce (Bo) Meyering [bmeyering3@gatech.edu](mailto:bmeyering3@gatech.edu)