Project Proposal: AI and Remote Sensing for Agricultural Drainage Mapping

1. Introduction

Agricultural drainage is crucial for managing excess water in croplands, enhancing productivity, and preventing waterlogging. However, accurate mapping of subsurface drainage systems remains a significant challenge due to the lack of high-resolution, publicly available data. Traditional methods for detecting drainage networks, such as trenching and tile probes, are labor-intensive and not scalable. In this proposal I would like to present a project idea based around the drainage paper shared with me by you today. But with a few tweaks and ideas for future research.

2. Problem(s) with current status quo

While prior studies have explored the use of remote sensing for detecting drainage pipes, existing methods face challenges such as dependency on rainfall events, limited ground truth validation, and low automation efficiency. Many RS techniques require ideal conditions (e.g., wet soils) for effective detection, restricting their application in variable weather conditions. Also, the complete lack of historical data (as in, some farmers have no clue where their drainage systems are even at, with zero documentation) has to be overcome

3. Proposed Approach

This project will expand upon previous methodologies by integrating additional data sources and leveraging cutting-edge AI models. Essentially, this project serves as an enhancement to the approach outlined in the paper you sent to me after our discussion on Thursday 3.6 (attached PDF to this assignment submission). The general gist is to expand scope on two fronts: Use newer and more novel AI techniques to try and provide better identification of drainage pipes, and use of use of Synthetic Aperture Radar (SAR) Imagery as a new data source. By integrating these into the approach, I believe it is possible to get improvement and lay the foundation for this project to get funded

The key proposals I want to run by you are:

1. Use of Synthetic Aperture Radar (SAR) Imagery: Unlike optical sensors, SAR can detect subsurface moisture differences independent of weather conditions. https://www.euspaceimaging.com/blog/2024/04/05/what-is-sar-imagery/. Overall, I'd like to explore if this would be a viable option to integrate into an ML model. I did not see use of these mentioned at all in the paper shared with me today. Obviously, it cannot get around the need for rainfall to help detect drainage, but it could help

2. On that above point, I'm not sure if this is a radical or dumb solution to the problem I just mentioned (needing rainfall) but whats stopping us from dumping an absurd amount of water on specific points or areas of a cropfield either manually or with drones – saturating the ground enough to trigger temperature variations and activate other key indicators?

- 2. Integration of Geospatial Databases: Soil maps (SSURGO), historical drainage data, and topographic features will be used to enhance predictive models. Not sure how much more historical data like this can be added, but it could be worth exploring if an expansion can be made here

- 3. Integration of self-supervised and graph Neural Networks: Incorporation of self-supervised learning and Graph Neural Networks (GNNs) to improve automated detection of tile drainage networks. The previous approaches included use of Decision tree models and CNN's. A self-supervised approach could possibly alleviate the need for sufficient training data

Possibility of Future Work in Mapping Out Efficient and New Drainage Pipe Systems

- This bullet point is me thinking out loud as I just have a days worth of thoughts on this specific project, but I think an extension of this work could also dive into the feasibility of mapping out new locations for efficient drainiage pipe systems for land that either needs replacement pipes or needs a new drainage system in its entirety. We could have a model predict the best locations for pipes to be laid as well as the impacts the new system could have on the farmland

Conclusion

By leveraging recent advancements in AI and remote sensing, this project aims to bridge the gap in large-scale agricultural drainage mapping. The refined methodology could serve as a foundation for future research as outlined above, and could be an exciting project for me to start this semester.