Semantic segmentation-based approach for autonomous navigation in challenging farm terrains

Abstract:
The rapid advancements in technology have allowed the agriculture sector to leverage autonomous robots for effective farm management. However, navigation in complex farm terrains, particularly within crop rows, remains a challenging task. This study focuses on applying semantic segmentation for robot navigation in difficult farm terrains. The project scope was narrowed down to developing semantic segmentation models and generating waypoints for robot navigation, a step crucial for autonomous control and navigation of robots. This involved the creation of a unique dataset consisting of original images of corn rows and corresponding CSV files with line coordinates denoting the drivable area. A novel, time-saving approach of creating binary masks through sparse annotation was devised, facilitating effective training of a U-Net model for semantic segmentation. The U-Net model achieved a mean Intersection over Union (mIoU) of 68%. Further, the semantic segmentation results were used to generate navigation waypoints following the centroid of the drivable areas. The waypoints, initially in the camera's coordinate system, were transformed to world coordinates using the camera's intrinsic and extrinsic properties. Additionally, an exploration was made into a new method, the Segment Anything Model, which provided segmentation beyond binary output. The findings from this study lay the foundation for enabling under-canopy robots to navigate in diverse crop environments, demonstrating potential for future real-world applications. The results also open avenues for further research into improving the semantic segmentation models and expanding the robot's adaptability to different crops and terrains.