Digitizing Peanut Flower Counts and Distribution Patterns Through 3D Imaging Using Mobile Systems

Introduction

This project focuses on the three-dimensional reconstruction and flower detection of peanut plants using video footage. The primary aim is to create an accurate 3D model of the plants and identify the spatial positioning of the flowers. This approach is significant for in-depth plant phenotyping, offering insights into plant growth and aiding in agricultural research specific to peanut crops.

Implementation Process

1. Video Capture and Image Extraction:

Fig. 1. Original image and sequence

The project initiates with the capture of videos that pans along rows of peanut plants, ensuring comprehensive coverage from various angles for detailed modeling. Employing FFmpeg, this video is processed to extract images at 0.1-second intervals, thereby generating a sequence that encapsulates multiple perspectives of the entire row of plants, as **Fig. 1**.

Fig. 2. Sparse point cloud and rendered model

2. 3D Reconstruction:

We developed a 3D reconstruction method based on structure-from-motion principles, which is employed on the image sequence to reconstruct a sparse point cloud and provide crucial data on camera intrinsics and extrinsics. This point cloud acts as a preliminary 3D model. Further, the 3D Gaussian Splatting method is applied to enhance the model's visual fidelity, followed by a conversion into a mesh format using a dedicated 3D Mesh Reconstruction algorithm (**Fig.2**).

3. Depth Map Creation:

Fig. 1. Input image and depth map.

For each image in the sequence, depth maps are generated by projecting pixel coordinates onto the mesh model. This process involves calculating the intersection of projection rays (originating from the camera's perspective) with the model's surface, thereby determining the depth (z-coordinate) at each point of interest (**Fig. 3**).

4. Flower Detection and 3D Localization:

Fig. 2. Flower detection, 3D positions and flower distribution.

A specially trained neural network for detecting flowers on peanut plants processes each image, pinpointing the flowers' two-dimensional pixel coordinates. These coordinates, along with the depth information and camera parameters, are used to compute the three-dimensional coordinates of each flower (**Fig. 4**). Redundant detections across the image sequence are filtered out to maintain accuracy. The collected data is then compiled into a point cloud file, illustrating the flower distribution on the peanut plants in a 3D context. **Fig. 5** shows the entire row's flower detection results from top-down and side views in 3D space, which can be used for phenotyping and yield prediction research.

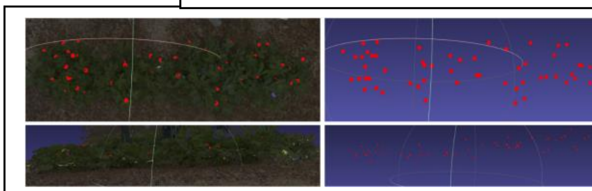

Fig 5. Flower distribution and peanut field model in 3D space from top and side views.

Summary

This project adeptly combines techniques from videography, computer vision, and 3D modeling to analyze flower distribution in 3D space for peanuts. By reconstructing the plants in three dimensions and accurately mapping the location of flowers, it provides a valuable tool for studying plant growth and development.