Technical Report

Crop Scanning & Disease Detection

I. Executive Summary

This comprehensive report unveils a groundbreaking project poised to revolutionize disease detection and management within the realm of tomato agriculture. By harnessing the power of advanced technologies — including 3D modelling, real-time data integration, machine learning, and LiDAR scanning — this initiative aims to surmount the limitations of traditional methodologies. The goal is to bolster the resilience and productivity of tomato farming through enhanced, early disease detection mechanisms.

II. Introduction

This report introduces a pioneering project designed to transform how we identify and handle diseases in tomato farming. By using modern technologies like 3D modelling, instant data gathering, smart algorithms, and LiDAR scanning, this project plans to improve upon older methods. The main aim is to make tomato crops stronger and more productive by spotting and managing diseases earlier and more efficiently.

III. Background

Conventional disease detection in agriculture is predominantly manual, labour-intensive, and suffers from Traditional ways of finding diseases in farming rely heavily on manual work, are hard, and take time, leading to a need for newer, automated methods. While combining overhead hyperspectral imaging with LiDAR has helped understand plant health, it's not perfect. These techniques usually miss important signs of disease in the lower parts of plants because they only capture images from above. This gap between what studies show and what's used in the field highlights the need for practical technology that works in the real world.

IV. Advanced Texture Mapping in Blender

Recent advancements have enabled the project to transcend traditional texture mapping techniques, marking a significant leap forward in the field of agricultural disease detection and management. The cornerstone of this progression is the introduction of a custom script, tailored specifically for this project, which eliminates the previously process of manual texture application. By automating this process, the project not only achieves a significant reduction in man-hours.

Custom Script Revolution: The true game-changer in this project is the custom script, designed exclusively for Blender. Before its introduction, texture application was a tedious, manual task that required extensive human intervention and left room for inconsistencies. This script automates the texture mapping process, meticulously applying predefined textures to scanned 3D models of plants. It intelligently adapts the texture to the contours of the model, ensuring accurate representation of various plant conditions.

A screenshot of a computer

Description automatically generated

Technology Used: A custom script, formulated using Blender's Python API, automates the texture application, allowing for the direct insertion of images onto the 3D models. This script precisely aligns the textures based on the models' geometry and surface contours, maintaining the models' realism and detail.

A screenshot of a computer

Description automatically generated

Process: The script automates the UV unwrapping process, applies the selected image as a texture, and adjusts it to fit the model's unique dimensions and surface details. This innovation expedites the texture mapping process and reduces the potential for human error.

V. Enhanced 3D Scanning in Unity

Overview: The 3D scanning process has been refined to enable the preservation of detailed LiDAR scans, facilitating in-depth analysis and temporal comparisons, thereby contributing to precise disease detection and monitoring.

A red heart shaped object on a pink surface

Description automatically generated

Technology Used: Unity, in conjunction with ARKit and a custom script, captures and stores LiDAR data, resulting in a detailed point cloud that accurately represents the tomato plants' spatial attributes.

Process: Imagine a camera that, instead of taking flat images, scans an environment and captures it as a cloud of data points. This is what happens when the LiDAR technology on compatible iOS devices is used. When you scan the tomato plants, it's like taking a super-detailed 3D photograph made up of points in space that represent where each part of the plant is located.

Data Capture and Storage: The custom script acts like a diligent librarian. When LiDAR creates the "3D photograph," this script ensures that the data is properly filed and stored in a way that can be easily accessed later. It's not just shoving a book into a shelf; it's cataloging information for quick retrieval.

Review and Analysis: Because of the way the data is stored, you can come back to it at any time. This means you can compare the "3D photographs" from different times to see how the tomato plants have changed. It's like having a time-lapse photo series where you can spot when the plants started to show signs of disease or stress.

A grey object with a face

Description automatically generated with medium confidenceVI. Model Integration and Customization

VII. Objectives and Scope

Comprehensive Disease Detection and Management:

- The first and foremost objective is to offer a comprehensive platform for detecting various diseases in plants. This is crucial for timely interventions and ensuring the health and productivity of the crops.

- Beyond detection, the project aims to provide effective management solutions. This includes suggestions and guidelines on how to treat or manage the identified diseases, aiding in reducing potential losses and promoting sustainable farming practices.

User-Friendly iPhone Application:

- The initiative seeks to design an intuitive iPhone application that will serve as the primary interface for users. The app aims to be simple yet effective, providing a hassle-free experience even for individuals who may not be tech-savvy.

High-Fidelity 3D Plant Models:

- A significant aspect of this project is the creation of high-fidelity 3D models of plants. These models aim to replicate the physical characteristics of plants accurately, providing a realistic representation that is crucial for precise disease detection.

Integration of Sophisticated Hardware and Software:

- Lastly, the project aims to integrate sophisticated hardware and software for meticulous field scanning. This involves employing cutting-edge technology to capture detailed field data, which is crucial for accurate disease detection and management.

The overarching scope of this project is quite extensive, embodying a multi-faceted approach towards advanced model development, intricate 3D visualizations, and the seamless integration of high-end hardware and software. This comprehensive endeavour seeks to bring a significant positive impact in the field of agriculture, particularly in mitigating the challenges posed by plant diseases.

VIII. Data Acquisition and Model Implementation

Conclusion

Project underscores a significant milestone in the realm of agricultural technology. By ingeniously melding various frontier technologies, it stands as a beacon of advancement, forging a powerful linkage between rigorous scientific exploration and on-ground farming operations. It heralds a promising horizon where the synergy between technology and agriculture is harnessed to foster enduring and fruitful development. This project is more than just a convergence of technology and farming; it is a testament to the boundless possibilities that such a union holds for the future. Through its execution, a blueprint is laid down, indicating a path that, when followed, can lead to a revolution in farming practices, making them more efficient, sustainable, and responsive to the ever-evolving challenges.

X. References

1. ARKit - Apple Developer

2. Kaggle: Your Machine Learning and Data Science Community

3. DJI Developer - SDK

4. GitHub: Where the world builds software

5. MLflow: An Open-Source Platform for the Complete Machine Learning Lifecycle

6. Sketchfab - The best 3D viewer on the web

Summary Report:

Advanced Crop Scanning & Disease Detection System

I. Background and Importance:

Global agriculture heavily relies on tomato cultivation, a critical nutritional and economic resource. Yet, the sector is besieged by various diseases, often leading to significant losses in both yield and quality. Traditional disease detection methods are no longer sufficient, necessitating a groundbreaking approach to disease detection and management in tomato farming.

II. Project Vision:

This project is at the cutting edge of agricultural technology, aiming to overhaul disease detection and management in tomato cultivation through a fusion of advanced technologies. The focus is on creating an efficient, precise, and scalable system that converges intensive research with practical applications, thereby improving agricultural productivity on a global scale.

III. Core Objectives:

1. Development of an Intuitive iPhone App:

- The cornerstone of this project is a user-friendly application designed for real-time scanning and detailed 3D visualization of plant health. The app is crafted to be easily navigable, making sophisticated agricultural technology accessible to a broad user base.

2. Integration of Advanced Detection Models:

- The project integrates cutting-edge machine learning models for enhanced detection capabilities. The models are fine-tuned for rapid, accurate object detection and disease segmentation, forming the backbone of the system's diagnostic precision.

IV. Methodological Innovations:

Streamlined 3D Plant Visualization:

- In a significant methodological shift, the project employs a direct image insertion technique in 3D Blender, eliminating the need for traditional texture mapping and displacement. This streamlined process is critical for producing accurate, real-time visual representations of plants, essential for subsequent analysis and detection stages.

Enhanced Model Training:

Seamless System Integration:

The project underscores the seamless integration of diverse technological elements to assemble a unified, robust system. Rigorously validated for performance and accuracy, this system is fine-tuned for compatibility with real-world agricultural practices.

V. Outcome and Impact:

The system's deployment is set to radically alter the landscape of global tomato cultivation. It transcends the limitations of conventional methods, enabling early, accurate disease detection, promoting prompt intervention, and leading to improved crop yield and quality. Its capability for real-time disease visualization offers immediate, actionable insights, revolutionizing disease management practices.

VI. Future Directions:

The project's innovative use of drones equipped with hyperspectral imaging charts a path forward in addressing the complex challenges faced in tomato cultivation. Continuous enhancement and evolution of this technology are crucial in responding to the ever-changing demands and hurdles in agriculture. Future endeavors should aim at the integration of this advanced technology with existing agricultural operations, expanding its use to other crops, and maximizing its impact within the broader agricultural domain.

VII. Relevance and Contribution:

This initiative embodies the transformative power of technology in agriculture. By tackling the urgent challenges in tomato cultivation through an innovative approach, it stands as a significant contribution to the global agricultural community, signaling a move towards more sustainable and technologically driven practices.

VIII. Conclusion:

This project represents a g step in the realm of agricultural technology, with its unique blend of advanced technologies and methodologies. It holds the promise of reshaping farming practices globally, aligning in-depth research with practical, scalable solutions, and fostering a future where technology and agriculture synergize to enhance global food security.