PlantPersona: Uniquely Identifying Plant Instances for Modern Agriculture

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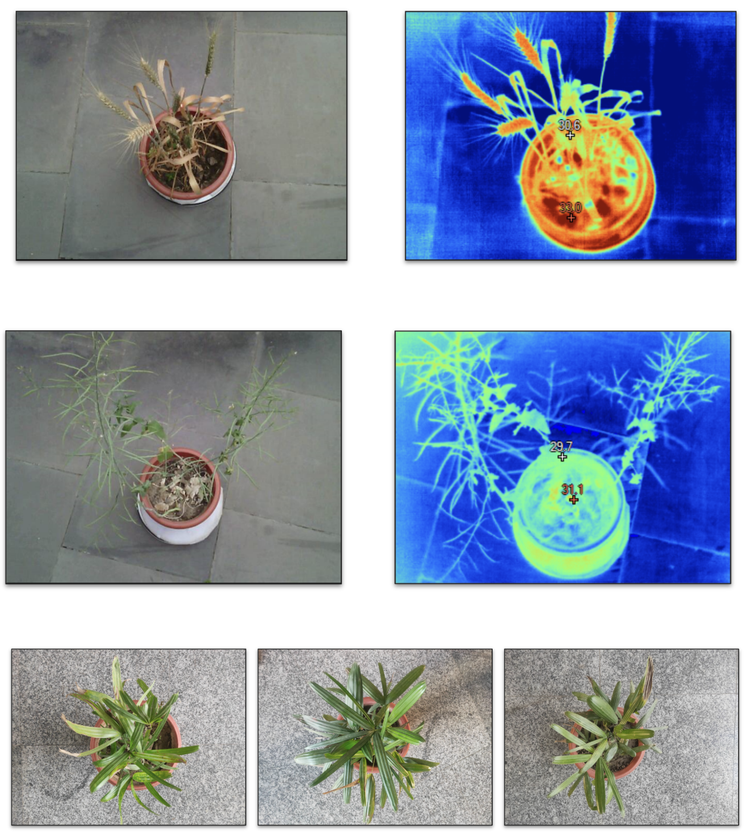
1. Introduction

Modern agriculture relies on technological innovations for optimal crop management and increased yield. Precise identification and monitoring of individual plants are crucial for tasks like 3D modeling, targeted pesticide application, yield estimation, and plant health monitoring. However, accurately identifying plants, especially multiple instances of the same species, presents challenges. Our research aims to address the challenges of plant identification in agriculture. We provide comprehensive Dataset: Infrared and RGB images of Wheat and Mustard plants captured using a Fluke Thermal Imager TiX580. Additionally, RGB images of Palm pot plants obtained using a RealMe 3 Pro smartphone. Our objective is to uniquely identify each plant instance within a species, enabling precise crop management.

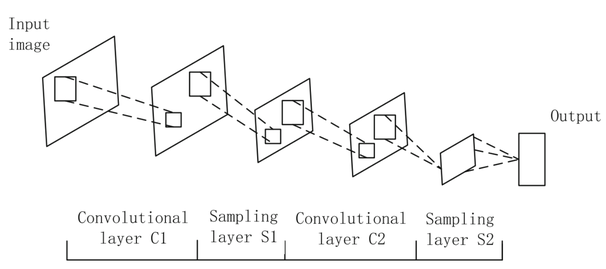
2. Dataset



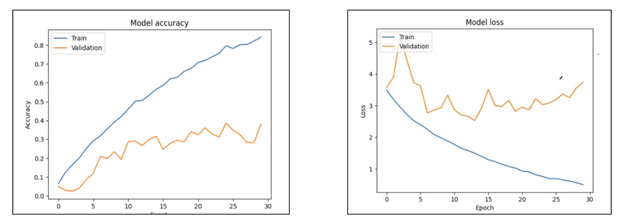
3. Classification Models

In our study, we employed three distinct classification models to identify and classify plant instances within our dataset: Convolutional Neural Networks, Support Vector Machines and Restnet50.

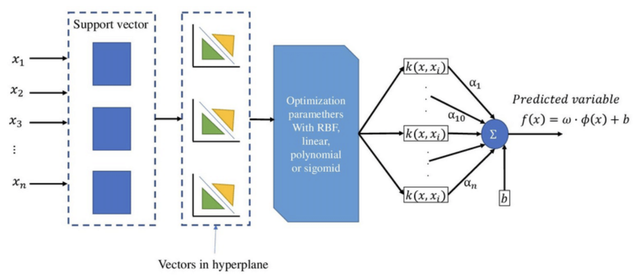
1. Convolutional Neural Networks (CNN) are deep learning models tailored for image analysis, capturing hierarchical visual features for precise plant instance classification.[1]



Observations with CNN Model

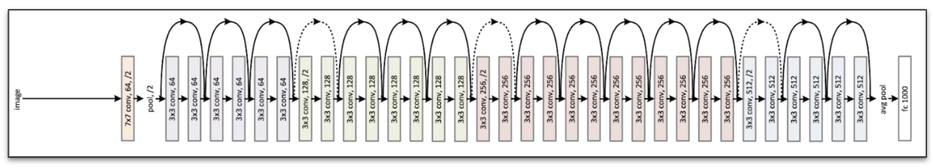


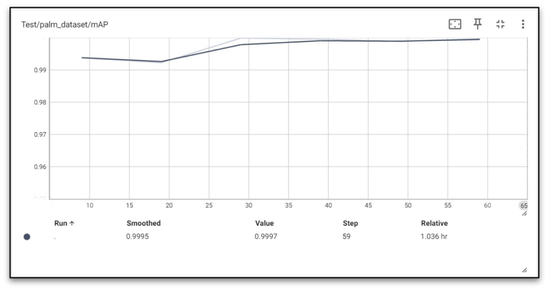
2. Support Vector Machines (SVM) is a classic Machine Learning algorithm, excels in classification by finding optimal hyperplanes. Leveraging its efficacy with high-dimensional data, we employed SVM for plant instance classification.[2]



Plant Type	Accuracy (in %)
Mustard - Infrared	72.41
Mustard - RGB	65.51
Wheat - Infrared	82.75
Wheat - RGB	58.62
Lady Palm - RGB	71.25

3. ResNet50 is renowned for its deep architecture and skip connections, significantly enhances image classification accuracy, making it a prime choice for our plant instance classification pipeline. [3]





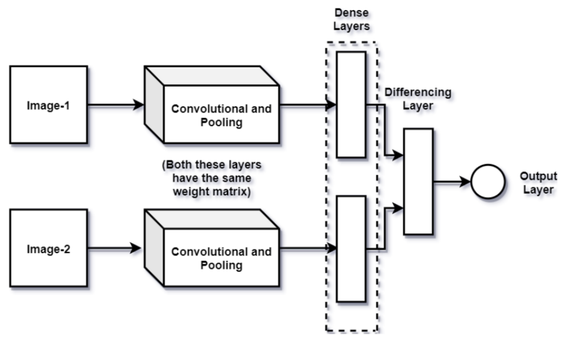
4. Reidentification Models

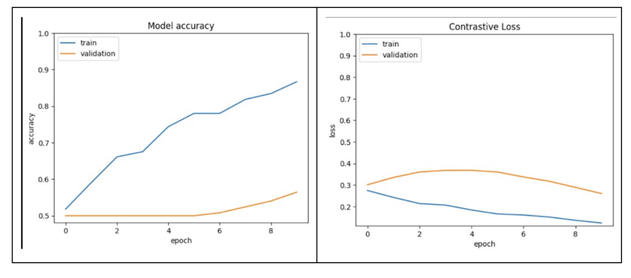
In Reidentification, we have have used two distinct model are GhostFaceNet and Siamese.

1. GhostFaceNet outperforms current SOTA models in person reidentification, offering flexibility by easily incorporating other models like ArcFace, FaceNet, SFace, and VGG-Face with parameter adjustments. Euclidean Distance serves as the similarity metric for evaluation.[4]

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

2. Siamese which employ twin networks with shared weights, to convert images into low-dimensional feature vectors. These vectors were subsequently compared using both Euclidean distance, Manhattan distance and KL divergence.[5]





While effective for face reidentification, these models struggled with plant instances. The similarity metric showed consistent results for distinct instances of the same plants, indicating recognition of species but not individual instances. Despite their success in human tasks, Siamese Networks performed suboptimally on our plant dataset, with a 27% contrastive loss and 55% accuracy.

5. Conclusions

1. We identifed the plant instances with upto 70% and 80% accuracy for Mustard and Wheat plants respectively, using SVM classification.
2. For reidentification techniques, the similarity metric gives inconsistent values throughout the experimentation, resulting in indistinguishable from other plant instacnes.
3. We concur that the top view of plants could help when the crops have larger canopy such as lettuce and cauliflower, but for crops such as Wheat and Mustard, we may require side view to capture more details.

6. References

[1] Zhao D. Sun J. et al. Zhang, Y. Adaptive convolutional neural network and its application in face recognition. *Neural Process Lett 43, 389–399*, 2016.

[2] José Álvarez Alvarado, G.J. Moreno, Saul Obregón-Biosca, Guillermo Ronquillo, Eusebio Ventura-Ramos, and Jr Trejo-Perea. Hybrid techniques to predict solar radiation using support vector machine and search optimization algorithms: A review. *Applied Sciences*, 11:1044, 01 2021.

[3] Hassan Ali Khan, Wu Jue, Muhammad Mushtaq, and Muhammad Umer Mushtaq. Brain tumor classification in mri image using convolutional neural network. *Mathematical Biosciences and Engineering*, 2021.

[4] Mohamad Alansari, Oussama Abdul Hay, Sajid Javed, Abdulhadi Shoufan, Yahya Zweiri, and Naoufel Werghi. Ghostfacenets: Lightweight face recognition model from cheap operations. *IEEE Access*, 11:35429–35446, 2023.

[5] Krishna Prasad. Siamese networks: Line by line explanation for beginners. *Towards Data Science*, 2020.