Beyond Labels: Contrastive Representation Learning for Scalable Image-based Plant Disease Diagnosis

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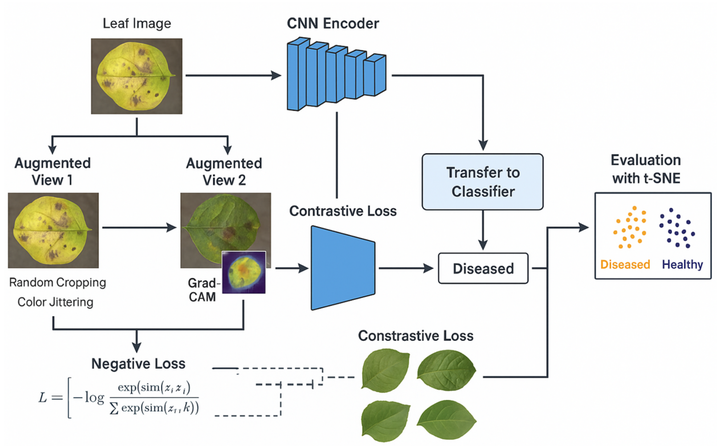
Abstract

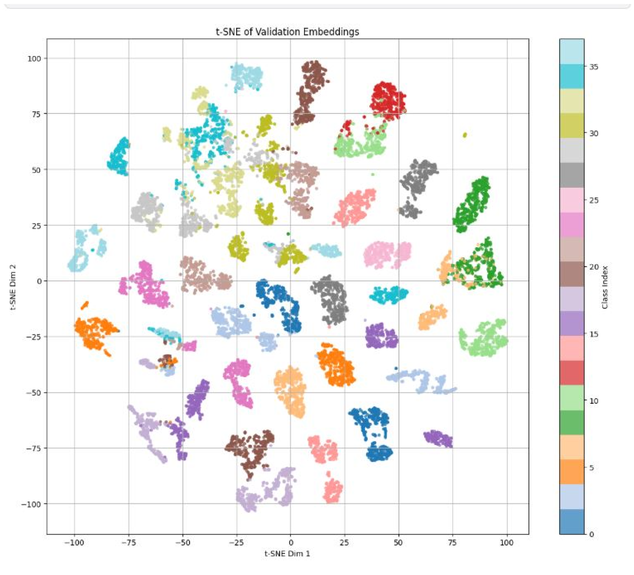
SimCLR-based SSL with a lightweight ConvNeXt-Tiny head delivers 97.67% accuracy and 98.12% F1 on PlantVillage, lowering label needs and yielding clear t-SNE separation

Methodology

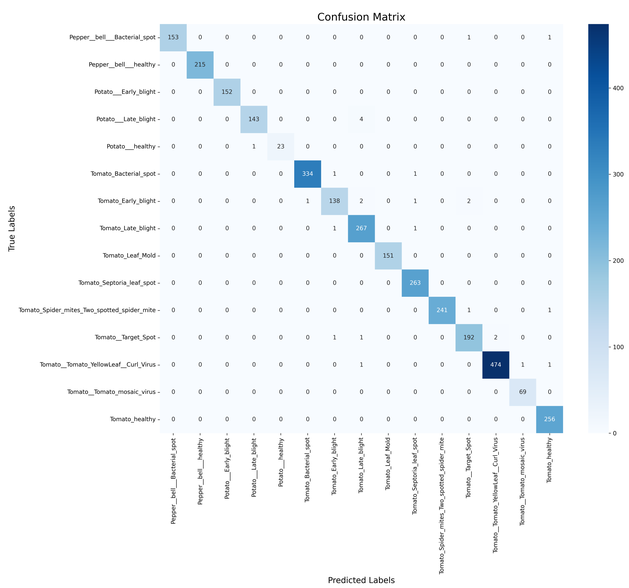


SimCLR pretraining (NT-Xent, twin augmentations) → freeze encoder → linear fine-tuning on a small labeled subset with MixUp/CutMix/label smoothing → report accuracy/F1 and visualize clusters via t-SNE.

RESULTS

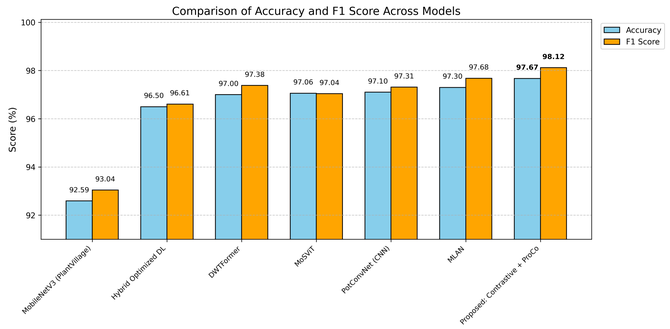


t-SNE confirms **semantically rich, class-separable features** learned via contrastive SSL.



Predictions are **highly accurate across classes**; remaining confusions are between **look-alike diseases**

SOTA Comparison



Proposed method leads all benchmarks in both Accuracy and F1, confirming stronger generalization with fewer labels

CONCLUSIONS

We learn rich visual features from unlabeled leaves via SimCLR, then fine-tune a lightweight classifier with strong regularization, achieving high accuracy/F1 and clear separability. This demonstrates SSL as an effective, accessible approach for real agricultural settings.