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Deep Herbal Vision: A Computer Vision Approach for Genuine versus Counterfeit Identification of Ngoc Linh Ginseng (Panax Vietnamensis Ha et Grushv.)

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Abstract

Ngoc Linh Ginseng (Panax vietnamensis Ha et Grushv.) is an endemic and highly valuable medicinal plant of Vietnam, noted for the exceptionally high saponin concentrationover 50 rare ginsenosides, including 26 unique compounds [1]. Majonoside-R2 (MR2) constitutes more than 50% of total saponins and is linked to strong antioxidant and anticancer activities[2]. Rising commercial demand has resulted in increasing adulteration, while traditional authentication techniques remain subjective, costly, or unsuitable for large-scale use. This study introduces Deep Herbal Vision (DHV), a computer-vision framework for distinguishing authentic and counterfeit Ngoc Linh ginseng using visual cues associated with saponin rich tissues. A curated NgocLinh-5k dataset of over 5,000 images is used to fine-tune ViT-S/16 and ResNet-50 models enhanced with ArcFace, Focal loss, and regions of interest (ROI) segmentation. The fine-tuned ViT achieves 96.3% accuracy, 95.1% F1-score, and ROC-AUC=0.982, outperforming CNN and classical baselines [3] Grad-CAM and attention visualizations confirm the model's focus on biologically relevant regions. The proposed framework provides a non-destructive and scalable AI solution for authenticating high value herbal materials and supporting conservation of Vietnam's Ngoc Linh ginseng.

Tables

TABLE I
PERFORMANCE (MEAN ± STD OVER 5 RUNS).

Model	Acc(%)	P(%)	R(%)	F1(%)
HOG+SVM	89.7	88.5	87.2	87.8
ResNet-50 (FT)	94.8	94.6	94.9	94.8
ViT-S/16 (FT)	95.4	95.0	94.7	94.8
DHV (ours)	96.3±0.3	96.0±0.2	95.1±0.3	95.1±0.2

Methods/Results

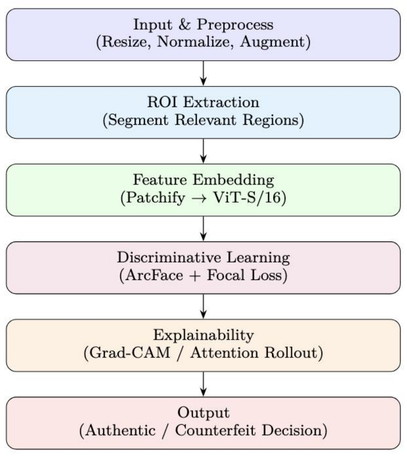

Fig. 1. DHV framework.

Figures

The illustration presents two centrally aligned components placed within the designated typing area. On the left, an original botanical drawing of *Panax vietnamensis* and *Panax notoginseng* highlights key morphological differences in root structure and leaf arrangement, serving as a visual reference for species discrimination in the NgocLinh-5k dataset. On the right, a receiver operating characteristic (ROC) curve compares the classification performance of three models-DHV, ViT-S/16, and ResNet-50 evaluated on the same dataset. The curves show distinct true-positive rate behaviors across varying false-positive rates, with DHV achieving the highest AUC value.
Both illustrations are positioned close to their first mention in the manuscript, and their dimensions are adjusted to ensure that no elements extend beyond the allowable typing region, complying fully with the formatting guideline. Captions remain optional and therefore are not included.

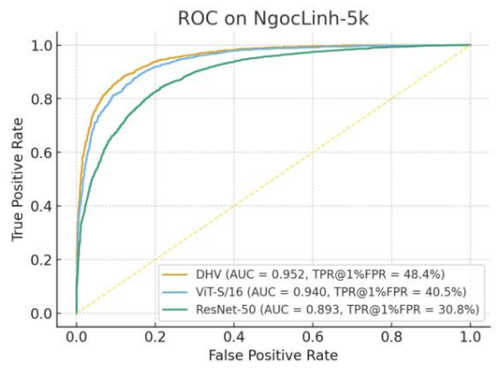

Fig. 2. ROC curves comparing DHV, ViT, and CNN baselines

Conclusions

This paper presented the DHV framework for visual authentication of Panax vietnamensis based on the NgocLinh-5k dataset with transformer-based representation learning, ArcFace metric optimization, and Focal loss. DHV achieved 96.3% accuracy and 0.982 ROC-AUC, surpassing CNN and standard ViT baselines while preserving interpretability through Grad-CAM and attention analysis.The DHV framework demonstrates how integrating morphological domain knowledge with transformer architectures enables non-destructive, real-time herbal quality control. the explainability aligns model attention with saponin-rich structures, supporting expert trust.