Expert-Informed Melanoma Classification with Dermoscopic and Histopathological Data: Results and Recommendations for Practice

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Research for a Life without Cancer

MOTIVATION

Deep learing models have achieved human-level performance in **skin cancer classification tasks.** However, uncertainties in ground truth labeling – particularly in borderline cases – can compromise model reliability and clinical safety.

To adress this, we developed expert-informed classifiers for **dermoscopic** and **histopathological whole slide images**, trained on **majority-labels** and **soft-labels** (i.e., incorporating reviewer uncertainties) annotated by an **international expert panel** of eight (dermato-)pathology experts.

METHODS

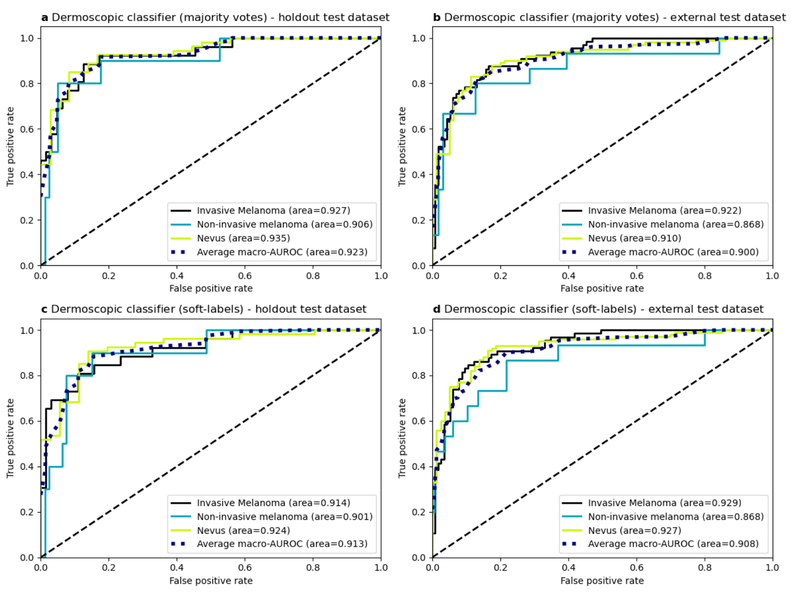
Models were evaluated on a **holdout** and an **external test dataset** comprising 792 **prospectively collected**, clinically representative cases from eight German university hospitals.

Data were acquired using **standardized HEINE dermatoscope setups** and distributed across **three classes**: invasive melanomas, non-invasive melanomas, and nevi.

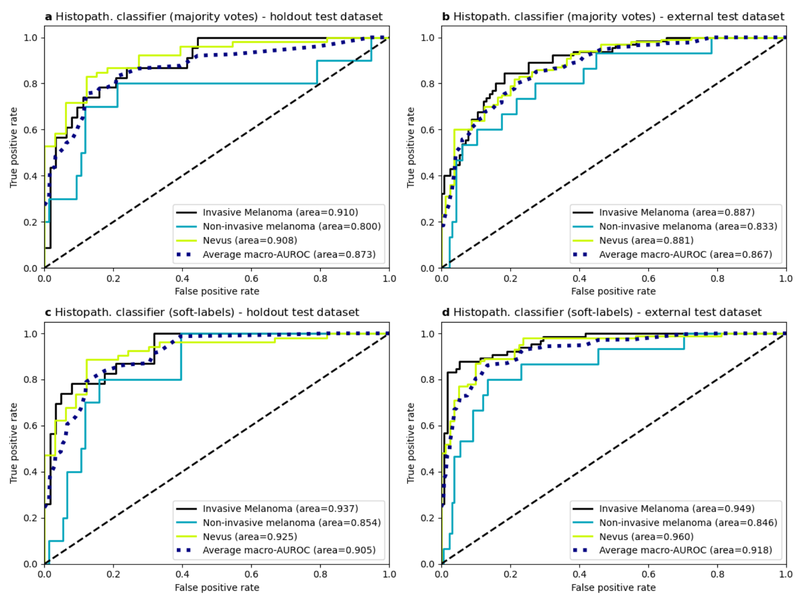
Furthermore, the algorithms, inherently embedding expert knowledge, were compared to **local dermatologists** and **pathologists** to assess their clinical utility.

RESULTS and DISCUSSION

The **dermoscopic classifiers** achieved AUROC scores of 0.923 (0.866-0.969) and 0.900 (0.845-947) using **majority votes**, and 0.913 (0.855-0.962) and 0.908 (0.858-0952) using **soft-labels**.



The **histopathological classifiers** achieved AUROC scores of 0.873 (0.787-0.941) and 0.867 (0.807-0.916) using **majority votes**, and 0.905 (0.851-0.952) and 0.918 (0.874-0.954) using **soft labels**.



Compared with **local dermatologists** and **pathologists**, expert-informed models demonstrated comparable performance while exhibiting **complementary diagnostic strengths**, supporting their use as **digital second-opinion tools** in routine clinical care.

By extending beyond binary classification to a **multiclass setting** and **incorporating expert uncertainty** through soft-label training, our approach better reflects **real-world diagnostic complexity** without compromising performance.

Notably, both human experts and AI systems encountered difficulties with **non-invasive melanomas**, underscoring their **intrinsic diagnostic ambiguity**.

These findings highlight the **importance of uncertainty-aware**, human-in-the-loop AI systems and emphasize the need **for high-quality prospective datasets** and ground truth definitions beyond conventional histopathology alone to enhance the clinical **robustness, safety**, and **translational relevance** of diagnostic models.

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