Multidimensional Image Data Generation for Neural Network–Based Differentiation of Benign and Malignant Melanocytic Lesions

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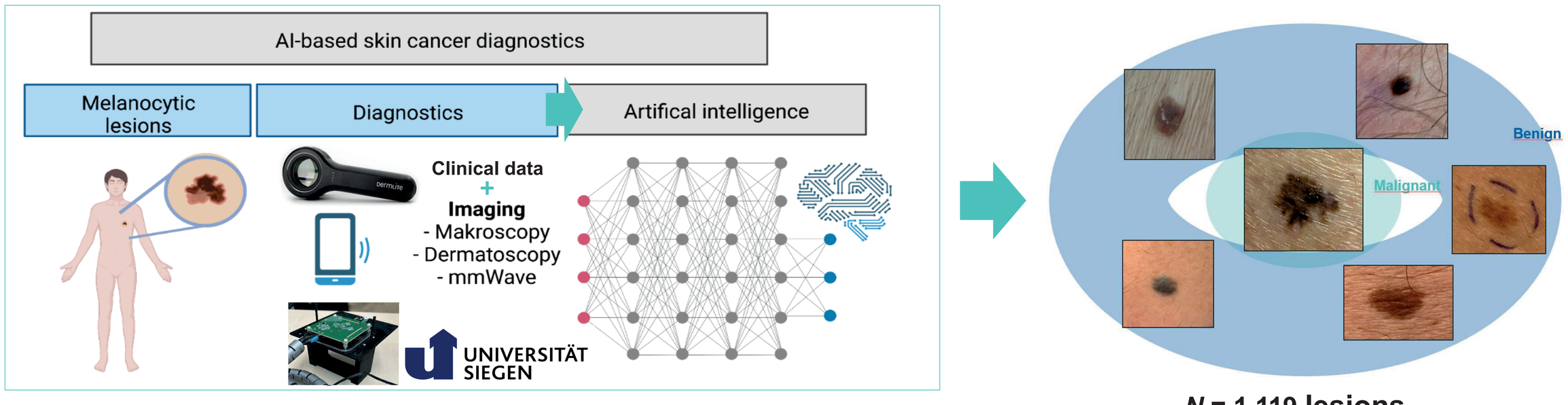

Figure 1: Approach.

Introduction:

Numerous studies have demonstrated the potential of artificial intelligence (AI) in distinguishing between benign and malignant melanocytic lesions. However, most published datasets lack real-world "borderline" cases such as dysplastic nevi, and thin (< 1mm) melanomas, limiting model performance in real-world scenarios. In addition, current approaches often rely on single-dimensional data and lack the multidimensional integration needed to improve diagnostic accuracy and robustness. ***MoleVision*** aims to develop and validate a neural network trained on a multidimensional, histopathologically confirmed real-world dataset to reliably distinguish benign from malignant melanocytic lesions. Secondary goals include integrating radar technology and explainable AI within an embedded system

Materials & Methods:

MoleVision integrates high-quality macroscopic and dermoscopic images with detailed clinical data as the foundation of its learning algorithms (**Figure 1**). A special focus is placed on real-world "borderline" melanocytic lesions, such as dysplastic nevi in situ melanomas, and melanomas with a tumor thickness of < 1mm. Patients are prospectively enrolled at two skin cancer centers (UKB and UKD), with ambiguous cases undergoing standard excision and histopathological review. The neural network will be trained and validated on two independent datasets (UKB and UKD), while the potential of radar sensor technology is explored to further enhance diagnostic performance (**Figure 1**).

Results:

By now, we have collected and annotated multidimensional image and clinical data from a total of *N* = 1,119 melanocytic lesions, including 703 cases from 433 patients at the University Hospital Bonn (**Figure 2**). 472/703 lesions were confirmed histologically. At this site, image data is currently available for 288 invasive melanomas (IM) and 30 in situ melanomas (NIM), while multidimensional image and clinical data have been acquired for 43 IM and 17 NIM. Both subcohorts include a particularly high proportion of thin (tumor thickness < 1mm) melanomas (**Table 1**). Comprehensive radar data has been collected from a subcohort of *N* = 23 skin lesions. Preliminary hierarchical clustering after dimensional reduction enabled an accurate distinction between benign and malignant melanocytic lesions.

Lesion Characteristics			
	All Patients (N=703)	Prospective UKB Cohort (N=366)	Retrospective UKB Cohort (N=337)
Lesion Type - No. (%)			
IM	288 (41%)	43 (11.7%)	245 (72.7%)
NIM	30 (4.3%)	17 (4.6%)	13 (3.9%)
Nevus	263 (37.4%)	214 (58.5%)	49 (14.5%)
Others	122 (17.4%)	92 (25.1%)	30 (8.9%)
Breslow Thickness (mm) - No. (%)			
≤ 1.0 (pT1)	94 (13.4%)	16 (4.4%)	78 (23.1%)
> 1.0 - 2.0 (pT2)	58 (8.3%)	9 (2.5%)	49 (14.5%)
> 2.0 - 4.0 (pT3)	52 (7.4%)	3 (0.8%)	49 (14.5%)
> 4.0 (pT4)	51 (7.3%)	6 (1.6%)	45 (13.4%)
Not available/applicable	448 (63.7%)	332 (90.7%)	116 (34.4%)

Table 1: Clinical characteristics of prospectively and retrospectively collected lesions.

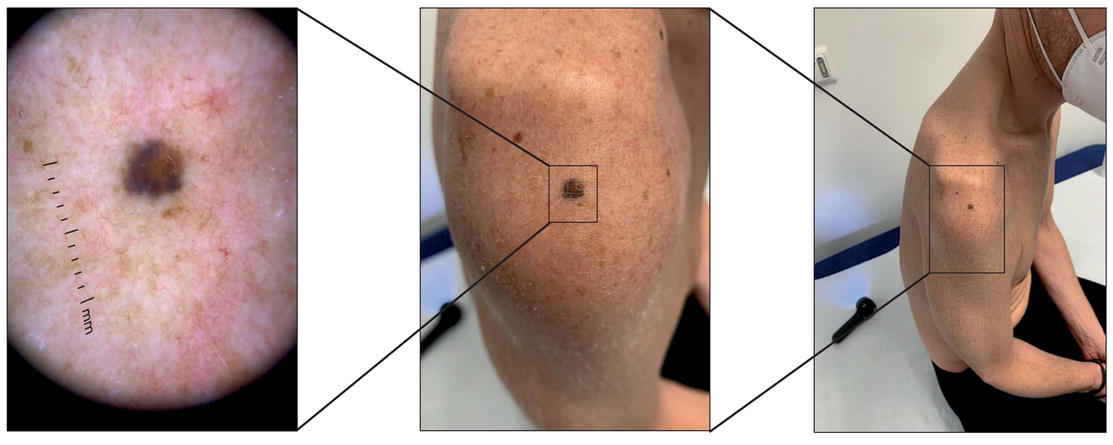

Figure 2: Multidimensional image data of a dysplastic nevus.

Outlook:

Recent studies (Brinker et al., Nature Communications, 2025) have shown that even experienced dermatopathologists often arrive at divergent diagnoses when assessing "borderline" melanocytic lesions. To enhance diagnostic accuracy and consistency, > 400 histopathological diagnoses (UKB cohorts) will therefore be re-evaluated by an expert panel of 5–8 dermatopathologists. Subsequently, our pre-developed AI will be trained and validated on the newly generated multidimensional real-world data.