MICCAI 2024 Marrakesh MOROCCO

27TH INTERNATIONAL CONFERENCE ON MEDICAL IMAGE COMPUTING AND COMPUTER ASSISTED INTERVENTION

6-10 OCTOBER 2024

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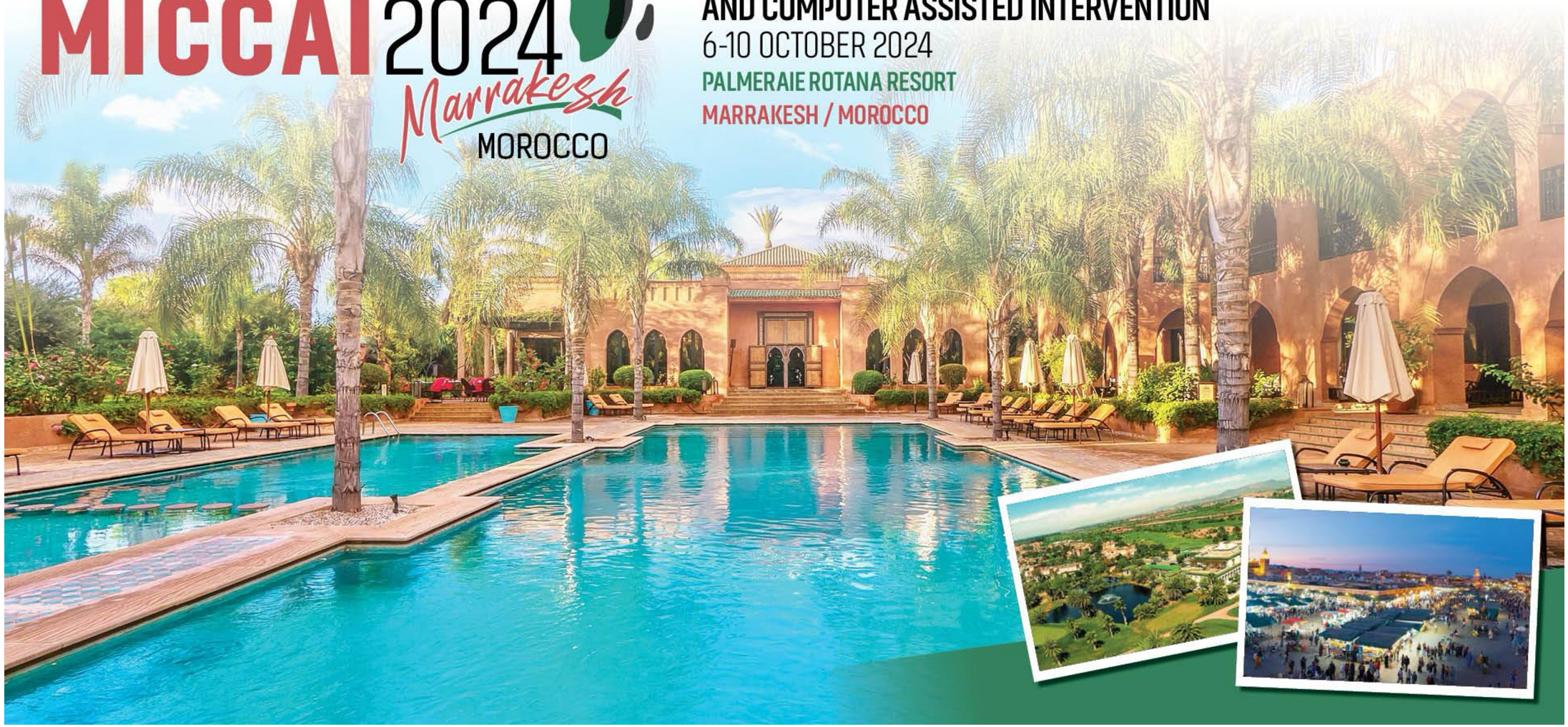

Revealing the Myths of Pre-Processing and Augmentation in Skin Images

Prof. Moi Hoon Yap

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Honorary Research Professor, Lancashire Teaching Hospitals

Our University

Manchester Metropolitan University

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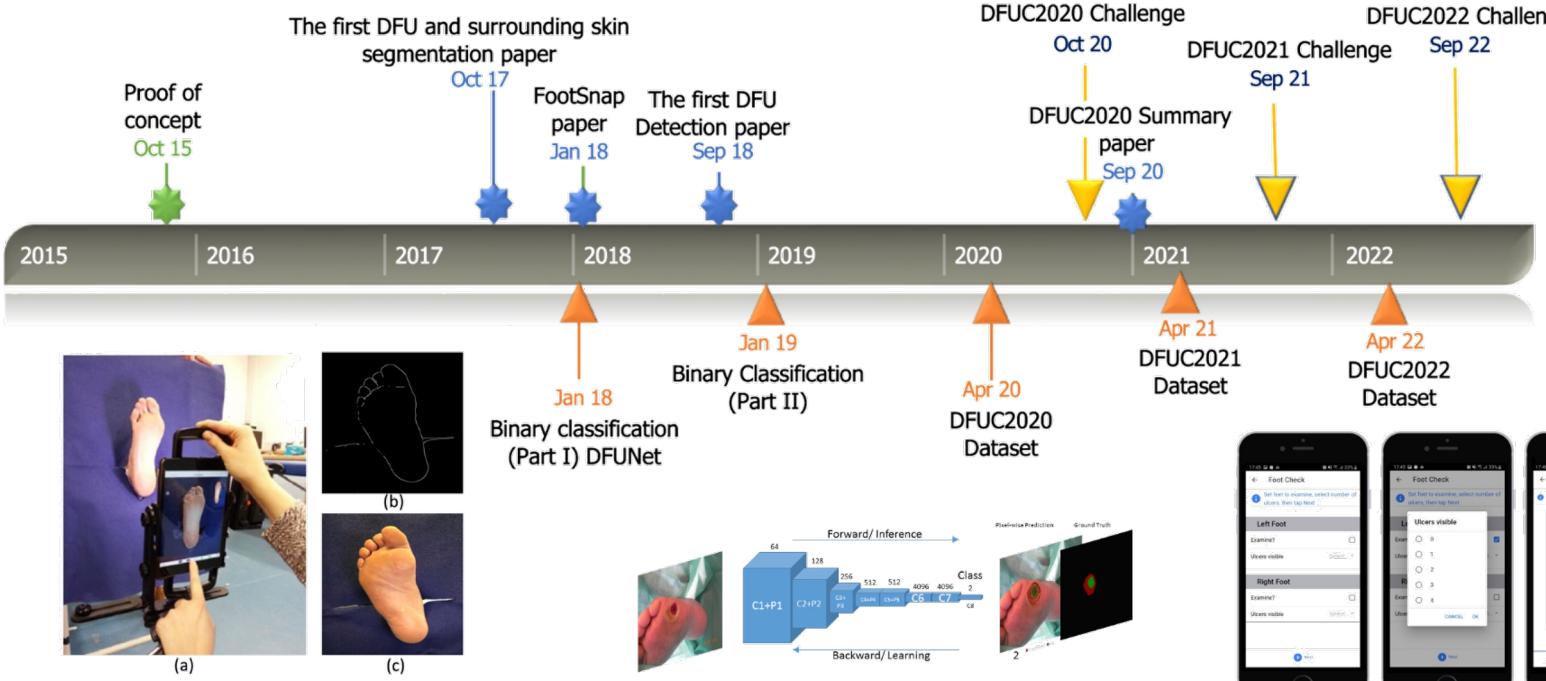
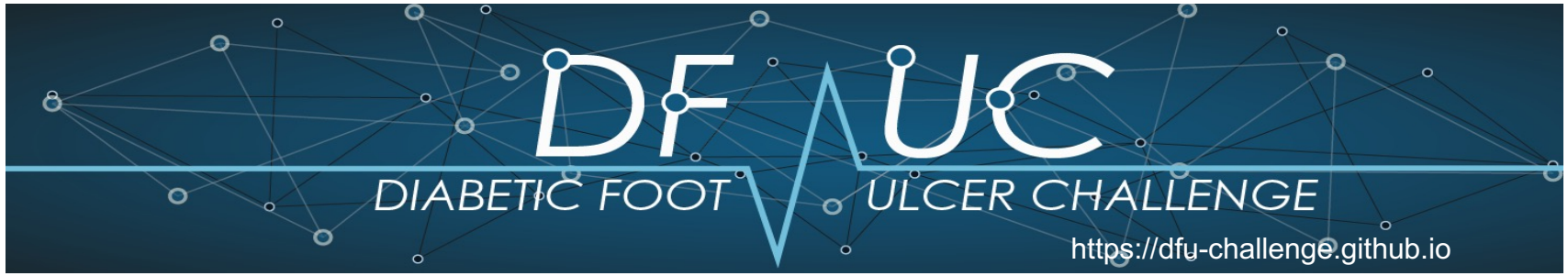
Diabetic Foot Ulcer Analysis



***Cassidy, B.**, **Reeves, N.D.**, Pappachan, J.M., Gillespie, D., O'Shea, C., Rajbhandari, S., Maiya, A.G., Frank, E.., …, **Yap, M.H.** 2021. The DFUC 2020 Dataset: Analysis Towards Diabetic Foot Ulcer Detection. touchREVIEWS in Endocrinology, 17(1), p.5.*

***Yap, M.H., Cassidy, B.**, Pappachan, J.M., O'Shea, C., Gillespie, D. and **Reeves, N.**, 2021. Analysis Towards Classification of Infection and Ischaemia of Diabetic Foot Ulcers. arXiv preprint arXiv:2104.03068.*



MICCAI2020 Lima PERU VIRTUAL

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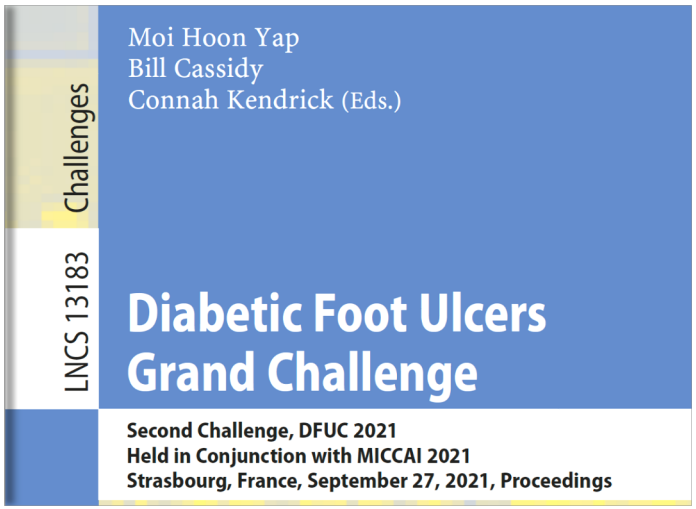
DFU Challenges



#DFUC2020 #MICCAI2020

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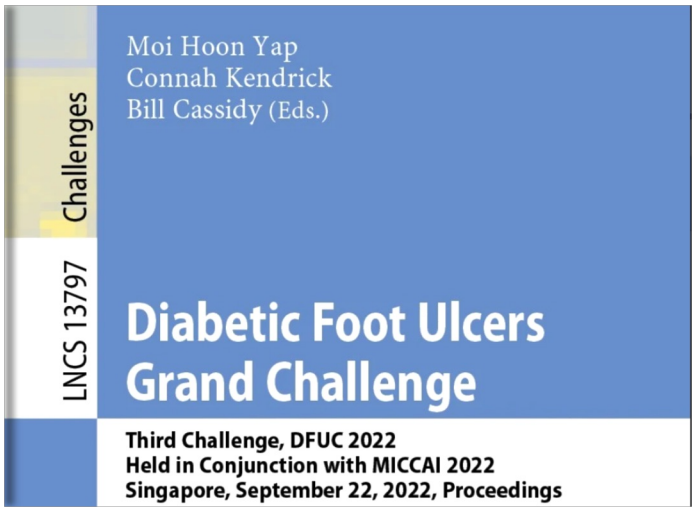
#DFUC2022 #MICCAI2022



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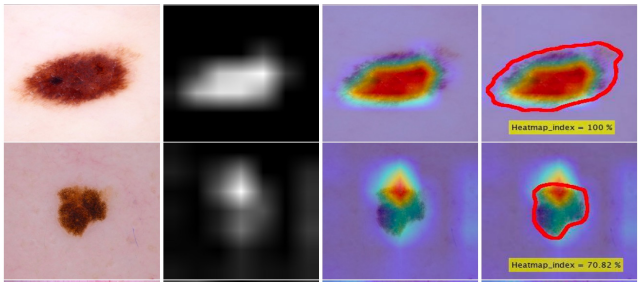
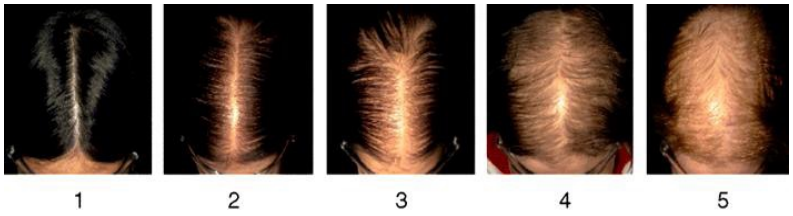
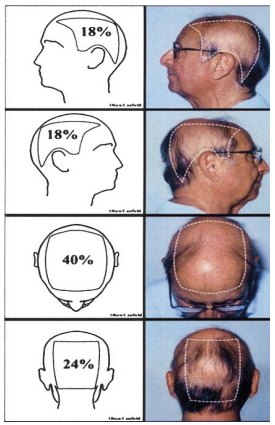


Bill Cassidy, Connah Kendrick, Andrzej Brodzicki, Joanna Jaworek-Korjakowska, Moi Hoon Yap (2022), Analysis of the ISIC Image Datasets: Usage, Benchmarks and Recommendations, Medical Image Analysis, 102305, ISSN 1361-8415,

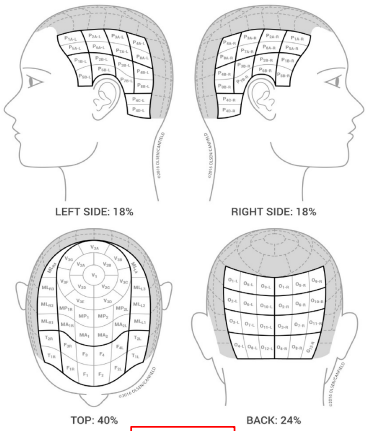
Generating Artificial Intelligence Assisted Assessment for Alopecia (GAIA)

IRAS 296888, NHR REC: 23/LO/0396





SALT I



SALT II

Dataset Curation

We analyse the usage of ISIC image datasets with a selection of well-cited research papers from the past 3-4 years and identify its related issues:

Researchers in medical image analysis on skin cancer-based on dermoscopic images are focused on developing new computer algorithms. However, ***issues inherent within the datasets used are often overlooked or under researched****.*

Cassidy, B., Kendrick, C., Brodzicki, A., Jaworek-Korjakowska, J. and Yap, M.H., 2022. Analysis of the ISIC image datasets: Usage, benchmarks and recommendations. *Medical image analysis*, *75*, p.102305. https://github.com/mmu-dermatology-research/

Dataset Curation

We propose a duplicate removal strategy to curate the datasets. By removing the duplicate images (overlap images between and within the test and training sets), we produced a cleaned (non-duplicate) dataset and a balanced dataset.

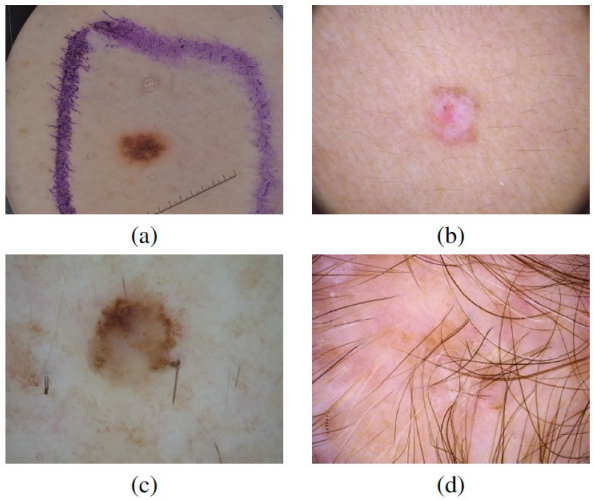


Illustration of (a) duplicate image with different filenames (ISIC_0016018.jpg and ISIC_0012271.jpg) found in the 2017 training and testing sets; (b) duplicate image with the same filename (ISIC_0029847.jpg) found in the 2018 and 2019 training sets; (c) duplicate image with the same filename (ISIC_0011132.jpg) found in two training sets (2017, 2019) and one testing set (2016); (d) duplicate image with different filenames (ISIC_5448850.jpg and ISIC_9881235.jpg) found in the 2020 training set.

Cassidy, B., Kendrick, C., Brodzicki, A., Jaworek-Korjakowska, J. and Yap, M.H., 2022. Analysis of the ISIC image datasets: Usage, benchmarks and recommendations. *Medical image analysis*, *75*, p.102305. https://github.com/mmu-dermatology-research/

Dataset Curation

Our duplicate removal strategy resulted in a curated dataset with a total number of image files is 56,987 (**4,905 melanoma** and **52,082 other**).

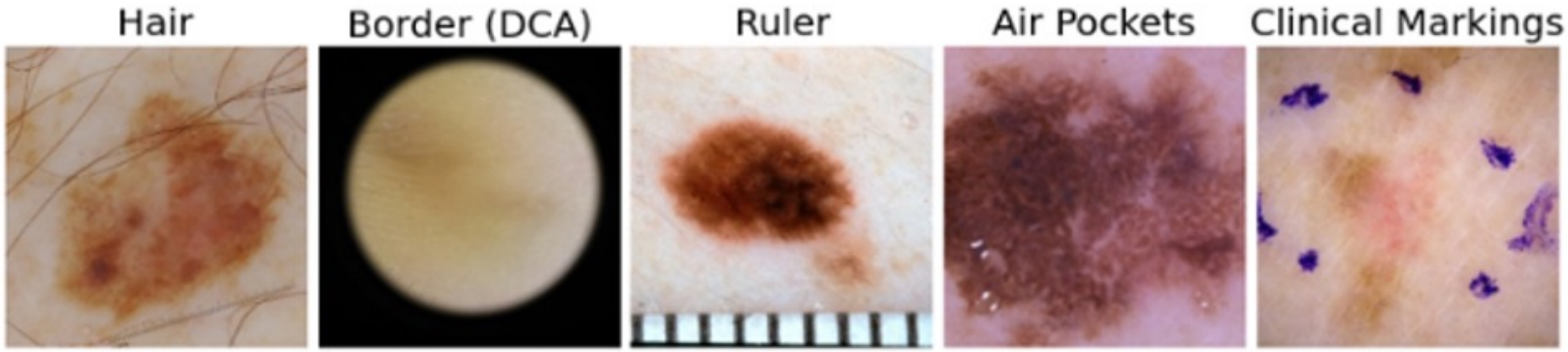
With computational resources: A total of 45,590 image files in the training set (3,924 melanoma and 41,666 other) and a total of 11,397 image files in the validation set (981 melanoma and 10,416 other).

ISIC Balanced Dataset: A total number of image files is 9,810 (**4,905 melanoma** and **4,905 other**) with a 1:1 ratio. This resulted in a total of 7,848 image files in the training set (3,924 melanoma and 3,924 others) and 1,962 image files in the validation set (981 melanoma and 981 others).

Cassidy, B., Kendrick, C., Brodzicki, A., Jaworek-Korjakowska, J. and Yap, M.H., 2022. Analysis of the ISIC image datasets: Usage, benchmarks and recommendations. *Medical image analysis*, *75*, p.102305. https://github.com/mmu-dermatology-research/

Artifacts

There are a broad range of artifacts present within skin lesion datasets (hair, borders, rulers, etc..).



This research investigates artifacts proposes methods in handling artifacts, including artifacts removal methods.

Artifacts Labelling

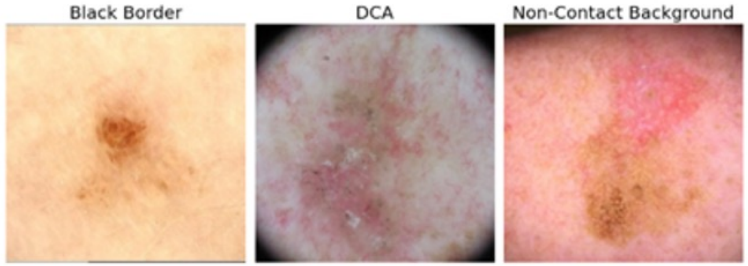
Each image has been manually inspected under 600x magnification and annotated across the following:

All Artifacts

Artifact Category	Subset				Artifact Totals
	Train Mel	*Train Oth*	*Val Mel*	*Val Oth*	
Borders	1721	663	417	179	2980
Hair	2224	2595	560	617	5996
Measurement Device	962	749	202	183	2096
Air Pockets	1129	637	442	142	2350
Clinical Markings	124	90	29	20	263
Other	100	55	55	18	228
No Artifacts	377	616	57	172	1222

Border Artifacts (Drill down)

Border Type	Subset				Border Type Totals
	Train Mel	*Train Oth*	*Val Mel*	*Val Oth*	
Black Bar(s)	56	212	10	58	336
DCA	1657	451	405	118	2631
Non-Contact BG	8	0	2	3	13
Dataset Totals	1721	663	417	179	2980



Pewton, S.W. and Yap, M.H., 2022. Dark corner on skin lesion image dataset: Does it matter?. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (pp. 4831-4839).

Artifacts - hair

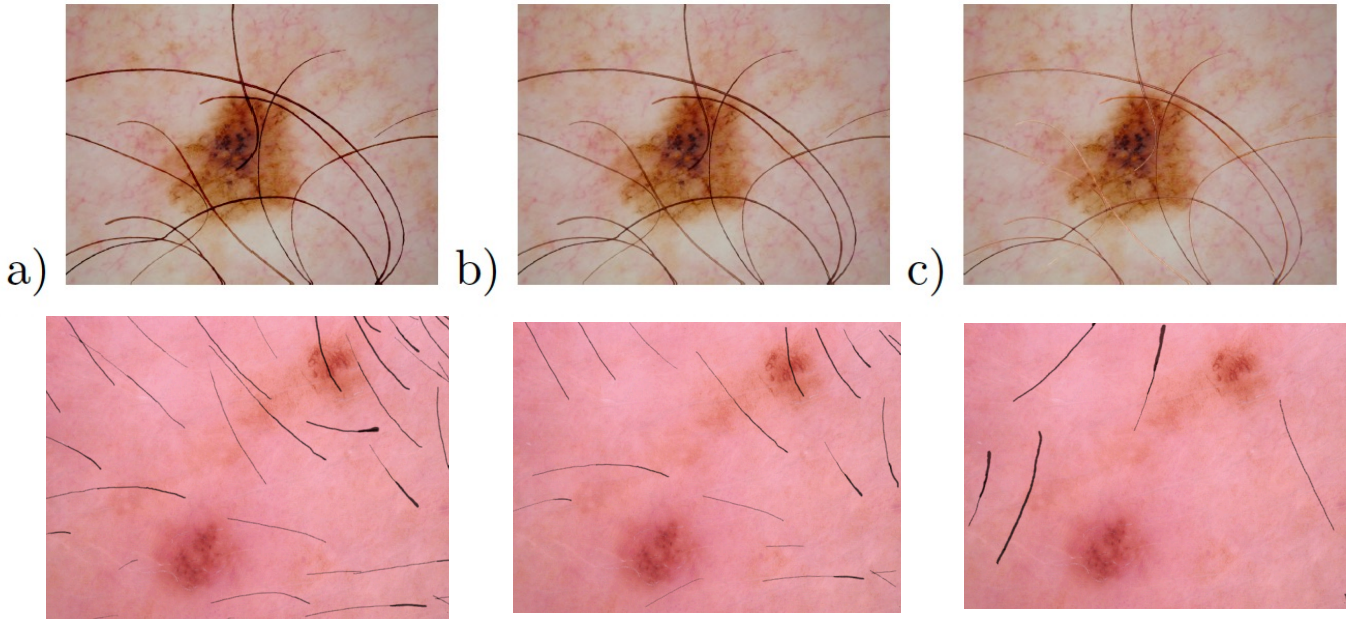
Skin Hair dataset contains over 252 dermoscopic images including artificial hair and will be expanded over time.

It contains: (a) dermoscopic images, (b) images containing artificial hairs and the corresponding ground-truth masks (c).

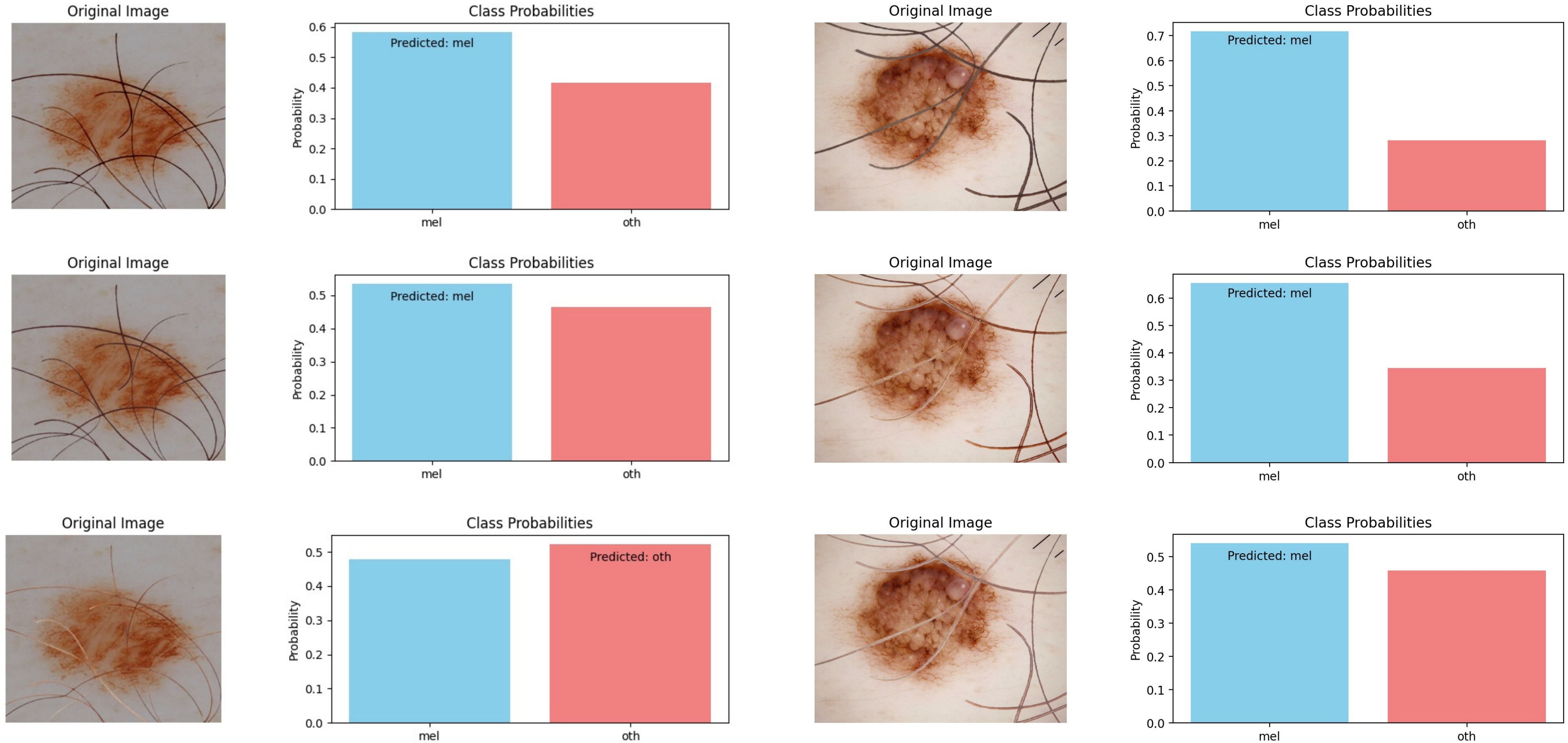
Jaworek-Korjakowska, J., Wojcicka, A., Kucharski, D., Brodzicki, A., Kendrick, C., Cassidy, B. and Yap, M.H., 2022, October. Skin_Hair Dataset: Setting the Benchmark for Effective Hair Inpainting Methods for Improving the Image Quality of Dermoscopic Images. In *European Conference on Computer Vision* (pp. 167-184). Cham: Springer Nature Switzerland. ttps://skin-hairdataset.github.io/SHD/

Artifacts - hair

Experiment: Effect of hair on prediction



Jaworek-Korjakowska, J., Wojcicka, A., Kucharski, D., Brodzicki, A., Kendrick, C., Cassidy, B. and Yap, M.H., 2022, October. Skin_Hair Dataset: Setting the Benchmark for Effective Hair Inpainting Methods for Improving the Image Quality of Dermoscopic Images. In *European Conference on Computer Vision* (pp. 167-184). Cham: Springer Nature Switzerland. https://skin-hairdataset.github.io/SHD/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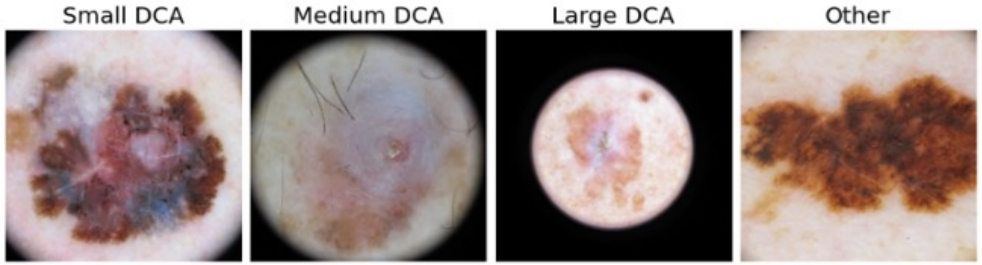
DCA Types Labelling

Sizing categories recommended by Sies et al. used:

- Small = 1-24% (inclusive)
- Medium = 25-49% (inclusive)
- Large = 50%+ (inclusive)
- Other = <1% (exclusive)

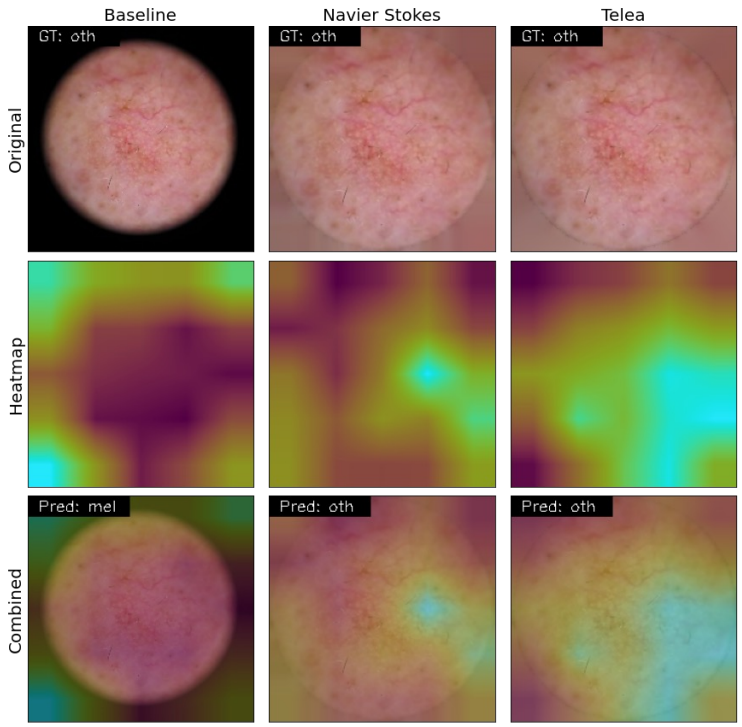


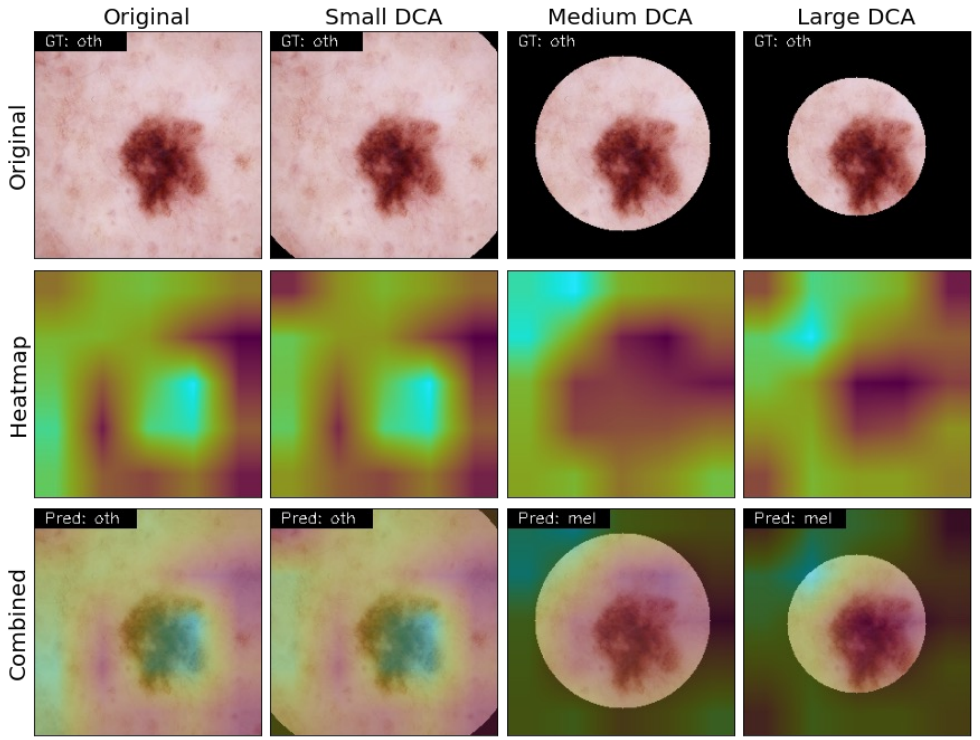
DCA Type	Subset				DCA Type Totals
	Train Mel	*Train Oth*	*Val Mel*	*Val Oth*	
Small DCA	742	237	167	58	1204
Medium DCA	393	79	95	16	583
Large DCA	343	78	80	25	526
Other	179	57	63	19	318
Dataset Totals	1657	451	405	118	2631

Other is an extra category added to highlight images which may be difficult to detect.

Pewton, S.W. and Yap, M.H., 2022. Dark corner on skin lesion image dataset: Does it matter?. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (pp. 4831-4839).

DCA Removal: Does it work?





Pewton, S.W. and Yap, M.H., 2022. Dark corner on skin lesion image dataset: Does it matter?. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition* (pp. 4831-4839).

DCA Removal: Friend or Foe?

Research question*:* Is removal and inpainting dark corner artifacts, with the intention of creating an ideal condition for models, the best solution?

Previous research has shown to be inconclusive due to a lack of available datasets with corresponding labels for dark corner artifact cases.

Research idea: Introduce synthetic dark corner artifacts and superimpose onto the training set to improve the performance.

Which preprocessing method provides the best results: inpainted DCA or superimposed synthetic DCA?

Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

DCA Removal: Friend or Foe?

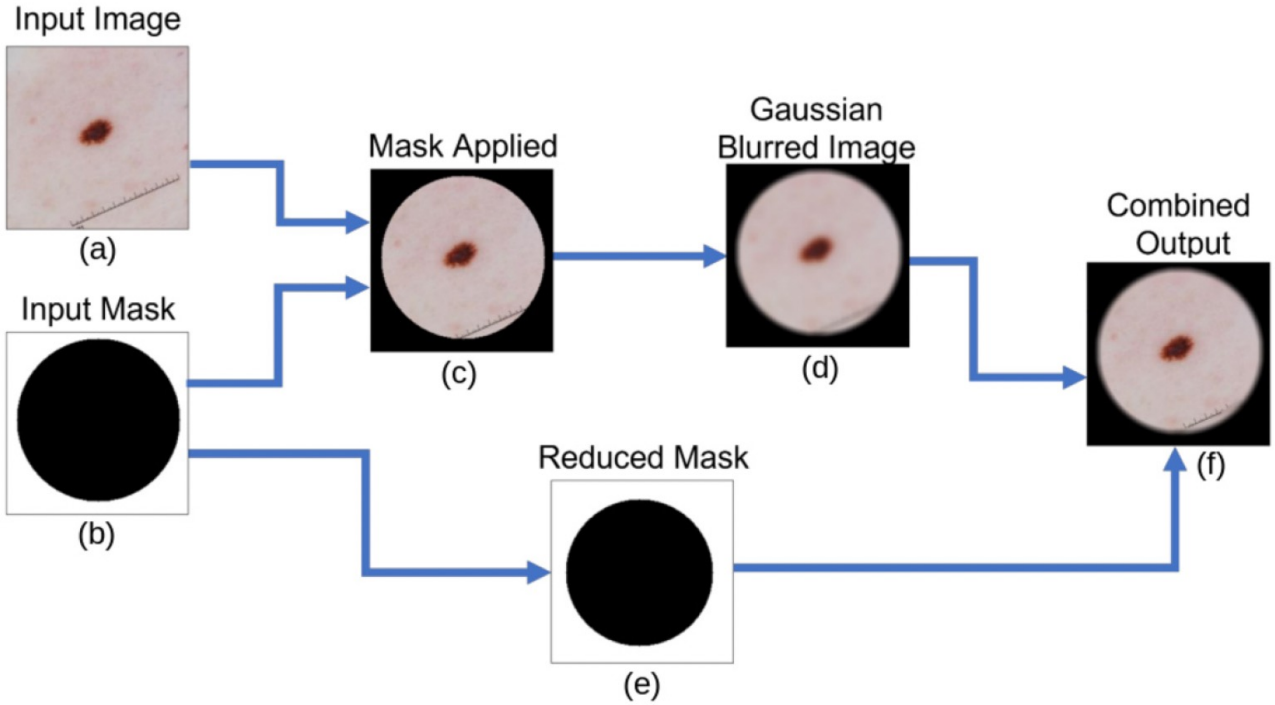
Curated balanced datasets from ISIC and Fitzpatrick 17k datasets.
Training set (train and val): clean datasets (without DCA).
Testing set: datasets with DCA, curated from ISIC and Fitzpatrick 17k.

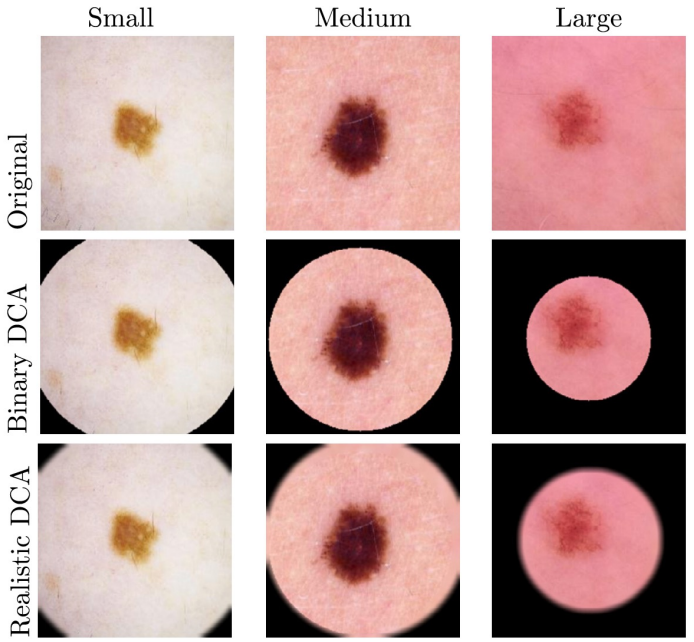
Summary of the DCA Split Balanced Dataset which contains a total of 10,250 images. Mel - melanoma; Non-Mel - Non-melanoma.

	Training set		Testing set (DCA sizes)			
	Train	*Val*	*Small*	*Medium*	*Large*	*Other*
Mel	2756	307	909	488	423	242
Non-Mel	2756	307	909	488	423	242

Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Realistic DCA Creation

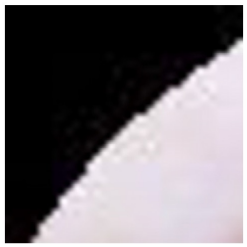




Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Results


True DCA


Binary DCA

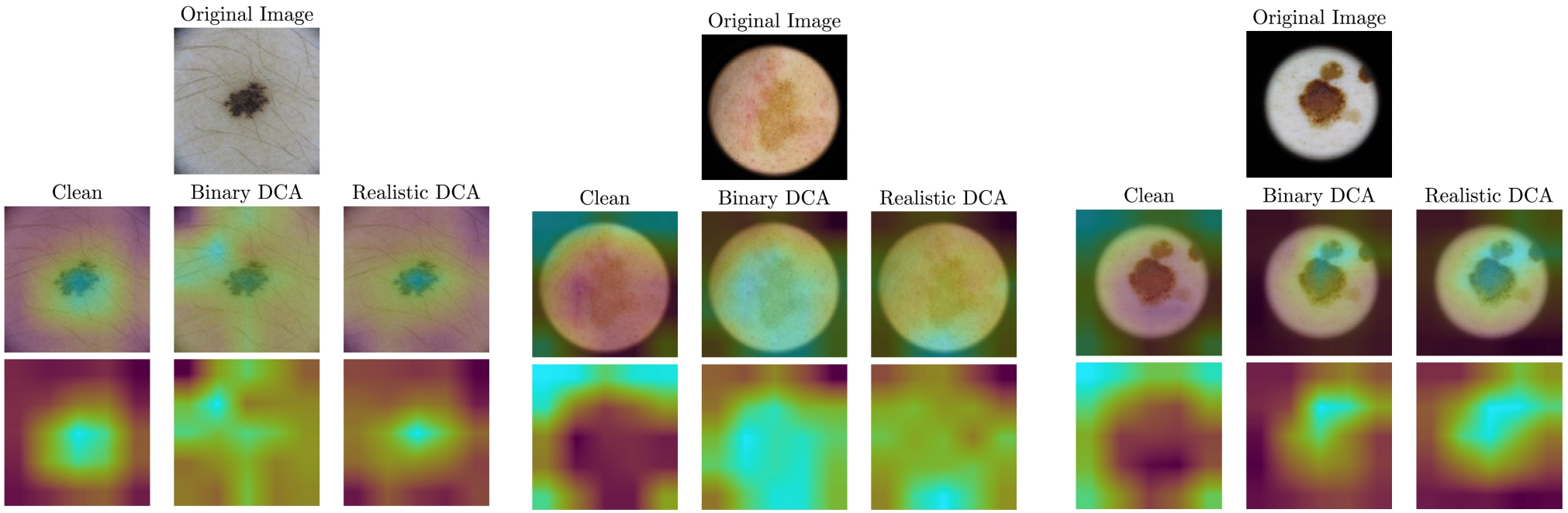

Realistic DCA

The performance of all trained networks (clean model, superimposed binary DCA model and superimposed realistic DCA model) on the test set.

Model	Metrics					
	Acc	TPR	TNR	Precision	F1	AUC
Clean	0.57	0.90	0.23	0.54	0.68	0.61
Binary DCA	0.60	**0.91**	0.29	0.56	**0.70**	**0.66**
Realistic DCA	**0.61**	0.73	**0.49**	**0.59**	0.65	**0.66**

Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Results



Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Results

The performance of the best TNR from the inpainted method and the superimposed method on the test set with different DCA sizes.

DCA size	Method	Metrics					
		Acc	TPR	TNR	Precision	F1	AUC
Small	Inpainted	0.58	**0.87**	0.30	0.55	0.67	0.62
	Superimposed	**0.60**	0.85	**0.35**	**0.57**	**0.68**	**0.65**
Medium	Inpainted	0.59	**0.88**	0.30	0.56	0.68	0.66
	Superimposed	**0.64**	0.75	**0.53**	**0.62**	0.68	**0.70**
Large	Inpainted	**0.61**	**0.72**	0.50	0.59	**0.65**	**0.68**
	Superimposed	0.60	0.39	**0.80**	**0.66**	0.50	0.63
Other	Inpainted	0.57	**0.87**	0.27	0.54	0.67	0.65
	Superimposed	**0.60**	0.83	**0.36**	**0.57**	0.67	**0.67**

Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Findings

- Binary DCA model achieved better TPR than the realistic DCA model in our experiments, but it did not outperform the clean model.
- DCA regions may exhibit artifacts that were not visible to the human eye where the deep learning model might tend to use those features for decision making.
- The focus is on the region of interest (skin lesions), there is an apparent randomness in the predictions due to the challenging nature of melanoma classification.
- As external ocular images exist in different imaging for other applications, such as eye imaging and colon imaging, this study potentially can be expanded in other domains.

Pewton, S.W., Cassidy, B., Kendrick, C. and Yap, M.H., 2024. Dermoscopic dark corner artifacts removal: Friend or foe?. *Computer Methods and Programs in Biomedicine*, *244*, p.107986.

Future Directions

- Multimodal Datasets

  CM-CBD-17K dataset (Ongoing) and ISIC 2024 Challenge
- Domain adaptation – clinical images and dermoscopic images
- Self-supervised learning / unsupervised learning methods
- Alignment with Clinical practices
- Engage with ISIC AI Working Group

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Collaborators:

Code:
https://github.com/mmu-dermatology-research/
https://github.com/mmu-dermatology-research/dark_corner_artifact_removal
https://skin-hairdataset.github.io/SHD/