Conditional dependence tests reveal the usage of ABCD rule features and bias variables in automatic skin lesion classification

Christian Reimers, Niklas Penzel, Paul Bodesheim, Jakob Runge, Joachim Denzler

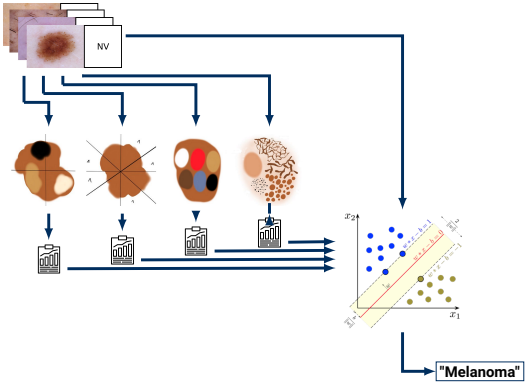
FRIEDRICH-SCHILLER-
UNIVERSITÄT
JENA

Computer Vision Group

DLR Deutsches Zentrum
für Luft- und Raumfahrt

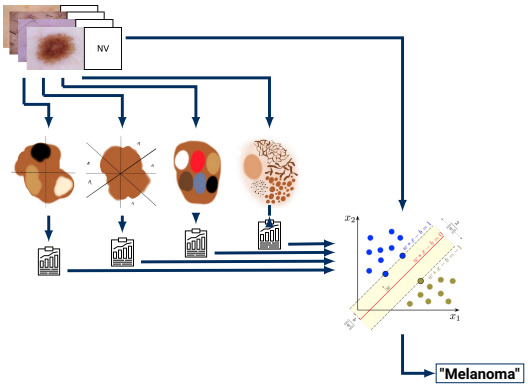
Motivation

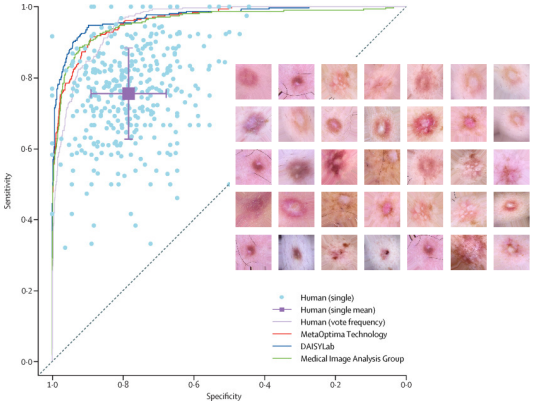
Deep Learning is the State of the Art



[4]: Tschandl et al.: “Comparison of the accuracy of human readers versus machine-learning algorithms for pigmented skin lesion classification: an open, web-based, international, diagnostic study”

Deep Learning is the State of the Art





[4]

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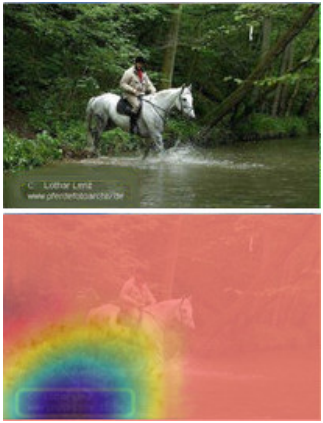
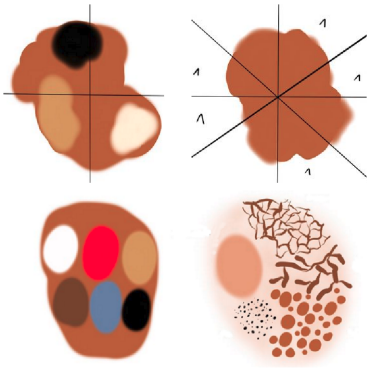
Testing if a Feature is used

Testing if a Feature is used



Medically Relevant vs. Biases



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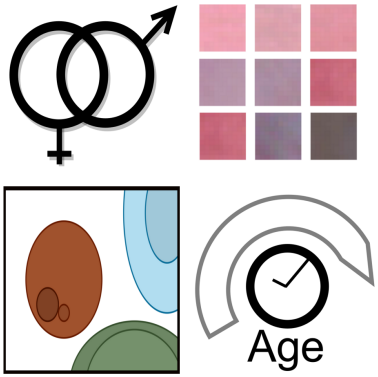
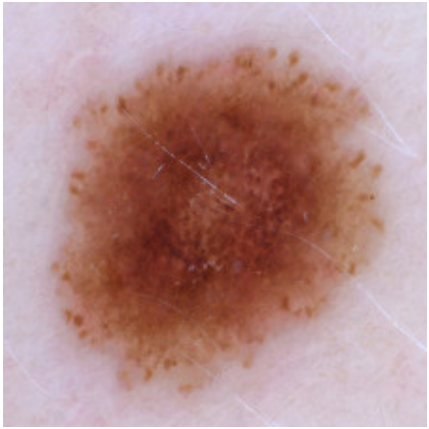


[1] https://dermoscopedia.org/ABCD_rule

Saliency Maps

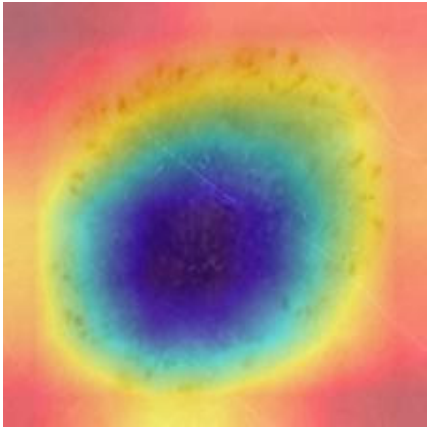
Main Approaches



Saliency Maps

Main Approaches

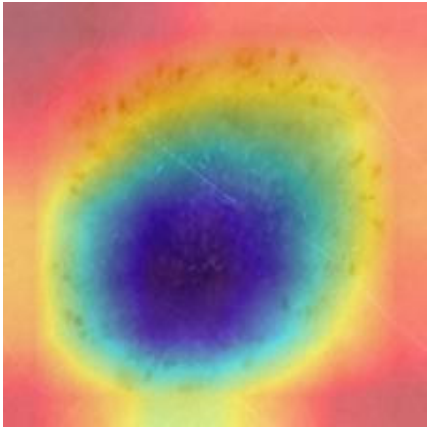
- Gradient-based ($S = \partial F(I)/\partial I$)



Saliency Maps

Main Approaches

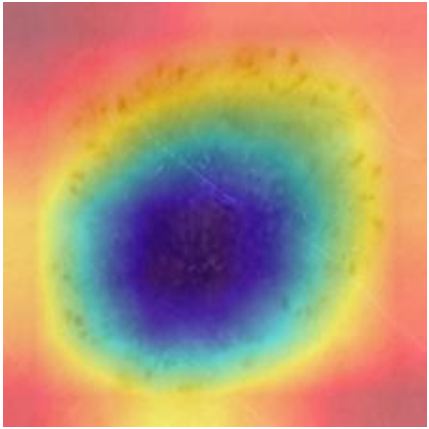
- Gradient-based ($S = \partial F(I)/\partial I$)
- Ablation-based ($S = F(I) - F(I_{\setminus(x,y)})$)



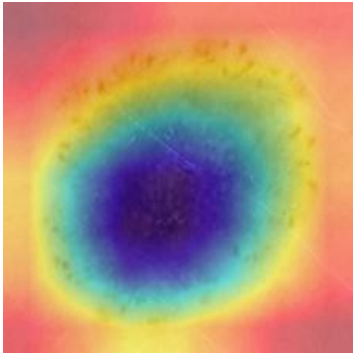
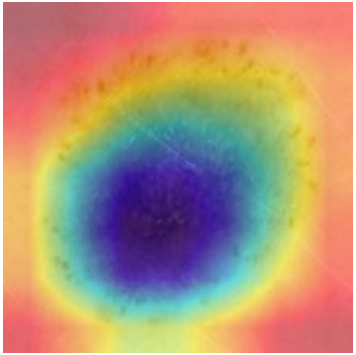
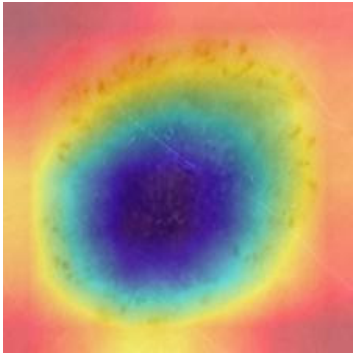
Saliency Maps

Main Approaches

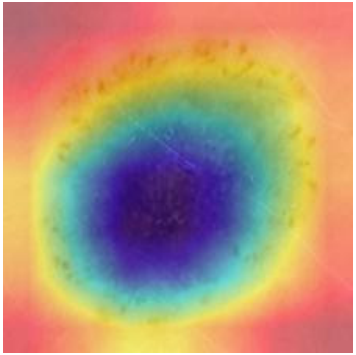
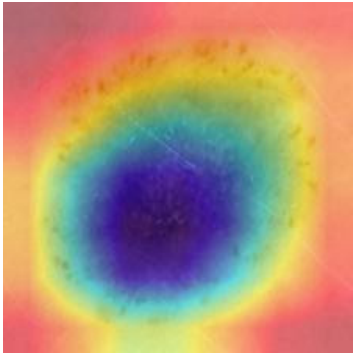
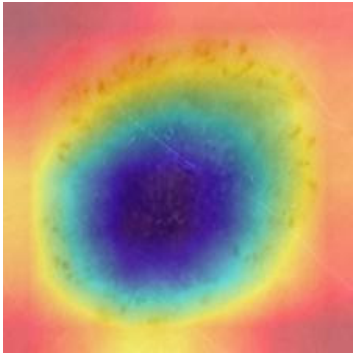
- Gradient-based ($S = {}^{\partial F(I)}/_{\partial I}$)
- Ablation-based ($S = F(I) - F(I_{\setminus(x,y)})$)
- Gradient and Value-based ($S = {}^{\partial F(I)}/_{\partial I} \odot I$)



Example: Asymmetry

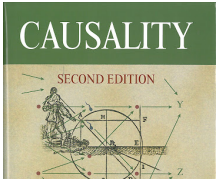
Example: Asymmetry

Does the Network use the Asymmetry of the lesion?

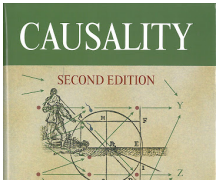
Method

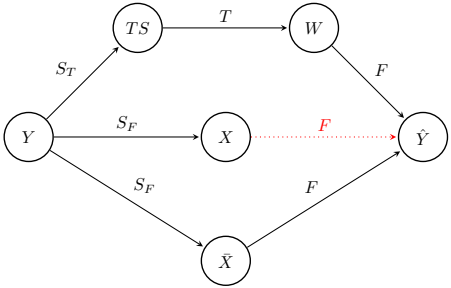
The Method of Conditional Dependence



[3]: Reimers et al. “Determining the Relevance of Features for Deep Neural Networks” 2020.

The Method of Conditional Dependence





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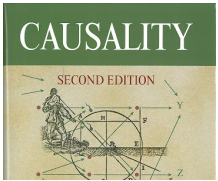

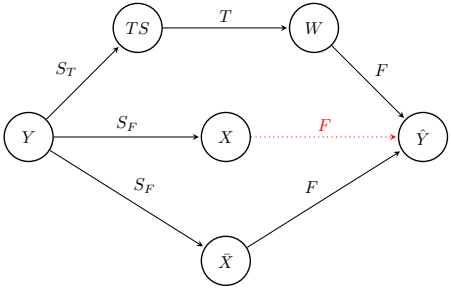

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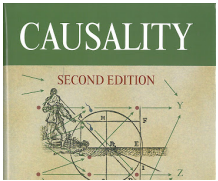
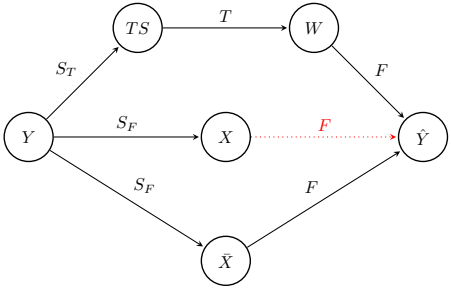
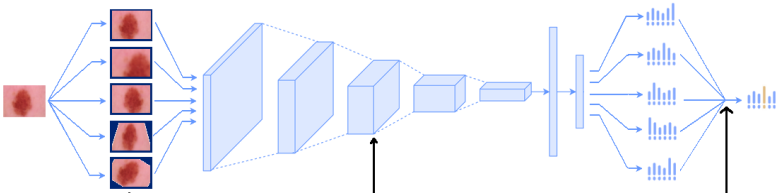




$$\hat{Y} \perp\!\!\!\perp X \mid Y$$

[3]: Reimers et al. “Determining the Relevance of Features for Deep Neural Networks” 2020.

Classifiers: *Perez et al.*

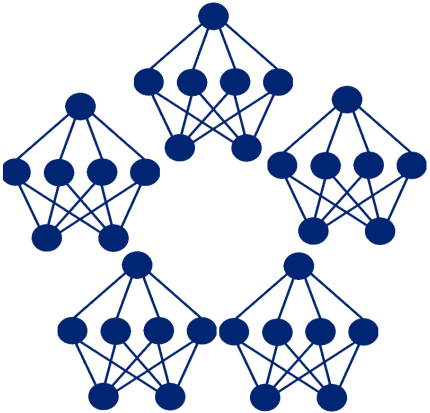


Different **No. of Augmentations**, **Backbones**, **Aggregation method**

Twelve binary models for melanoma prediction and twelve binary models for seborrheic keratosis.

[2]: Perez et al. “Data augmentation for skin lesion analysis”, 2018.

Classifiers: *Gessert et al.*



Ensemble of EfficientNets

- Multi-class Classifier
- Ensemble of pretrained CNNs
- Recognizes 8 Classes
- Test-time Augmentation

[1]: Gessert et al. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”, 2020.

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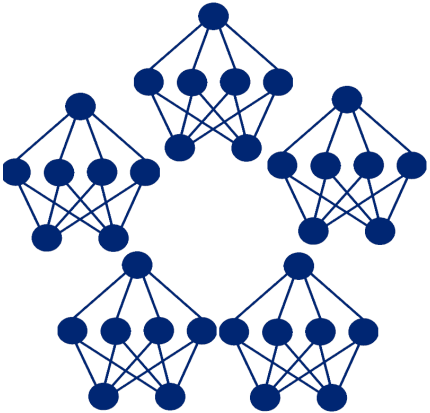

Ensemble of EfficientNets

- Multi-class Classifier
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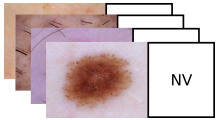
- Recognizes 8 Classes
- Test-time Augmentation

Caution

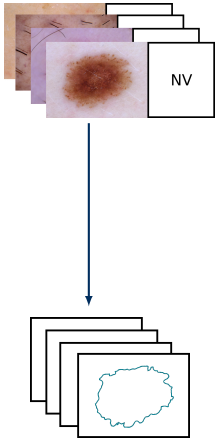
We did not train the full ensemble, but only five EfficientNet B0

[1]: Gessert et al. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”, 2020.

Experimental Setup



Experimental Setup



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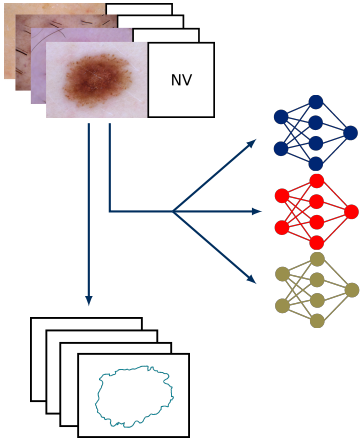
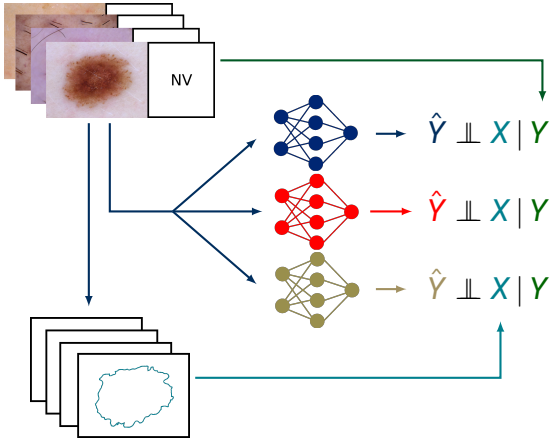


Experimental Setup



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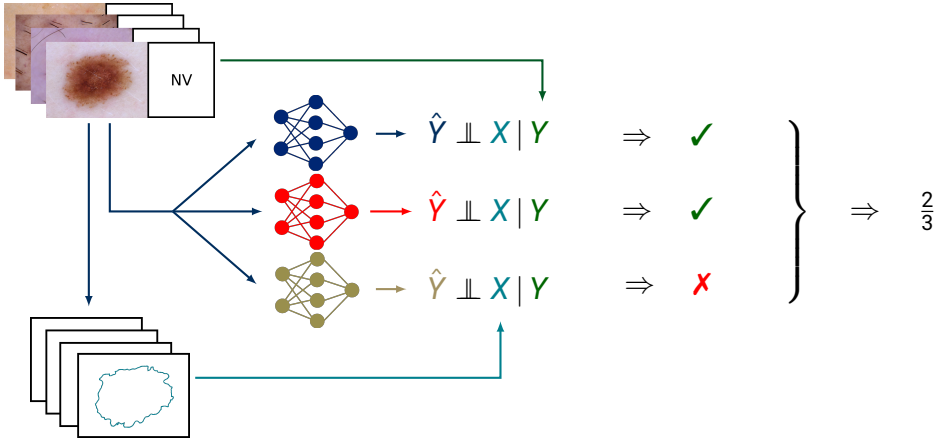


Results

“Placebo” Features

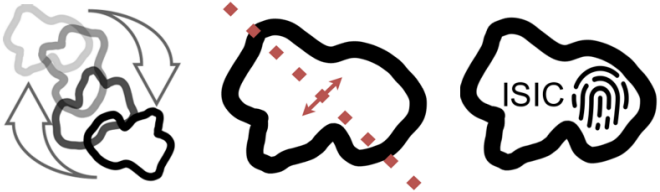
Orientation

“Placebo” Features

Orientation

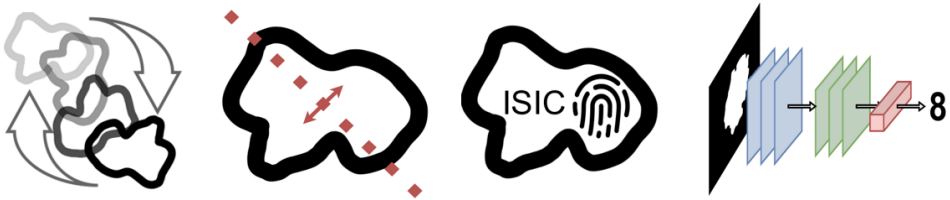
Rand. Symmetry

“Placebo” Features



Orientation Rand. Symmetry Image ID

“Placebo” Features



Orientation | Rand. Symmetry | Image ID | MNIST Class

“Placebo” Features – Results

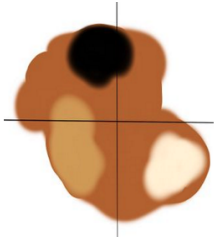
Model Group	Orientation	Rand. Symmetry	Image ID	MNIST Class
Perez et al. [2] : Mel	0/12	1/12	0/12	0/12
Perez et al. [2] : SK	0/12	0/12	0/12	0/12
Gessert et al. [1]	0/8	1/8	2/8	0/8

< 25% 25% - 75% > 75%

[1]: Gessert et al. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”, 2020.

[2]: Perez et al. “Data augmentation for skin lesion analysis”, 2018.

ABCD Rule Features

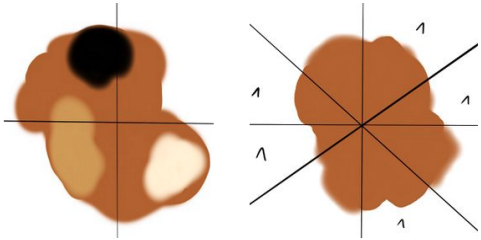


Asymmetry

2

[2] https://dermoscopedia.org/ABCD_rule

ABCD Rule Features

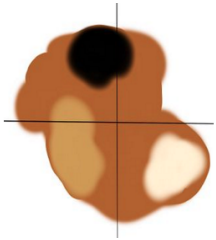


Asymmetry **B**order

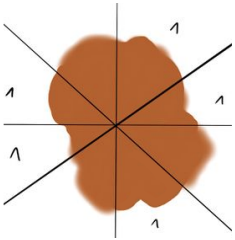
2

[2] https://dermoscopedia.org/ABCD_rule

ABCD Rule Features



Asymmetry



Border

Color

2

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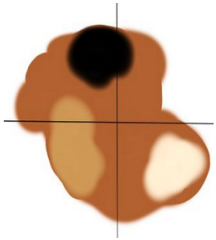
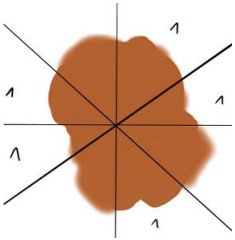
ABCD Rule Features

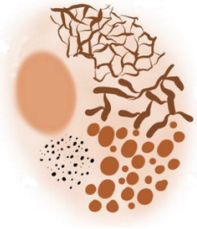


Asymmetry



Border

Color



Derm. Structures

[2]

[2] https://dermoscopedia.org/ABCD_rule

ABCD Rule Features – Results

Model Group	Asymmetry	Border	Color	Derm. Structures
Perez et al. [2] : Mel	$^{12}/_{12}$	$^{12}/_{12}$	$^{4}/_{12}$	$^{0}/_{12}$
Perez et al. [2] : SK	$^{0}/_{12}$	$^{0}/_{12}$	$^{0}/_{12}$	$^{5}/_{12}$
Gessert et al. [1]	$^{0}/_{8}$	$^{6}/_{8}$	$^{3}/_{8}$	$^{1}/_{8}$

< 25% 25% - 75% > 75%

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[2]: Perez et al. “Data augmentation for skin lesion analysis”, 2018.

ABCD Rule Features – Results

Model Group	Asymmetry	Border	Color	Derm. Structures
Perez et al. [2] : Mel	12/12	12/12	4/12	0/12
Perez et al. [2] : SK	0/12	0/12	0/12	5/12
Gessert et al. [1]	0/8	6/8	3/8	1/8

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Perez et al. [2] : SK	$^{0}/_{12}$	$^{0}/_{12}$	$^{0}/_{12}$	$^{5}/_{12}$
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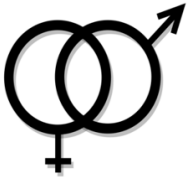
Bias Features

Age

Bias Features

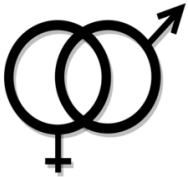
Age



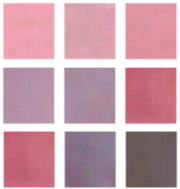
Sex

Bias Features

Age



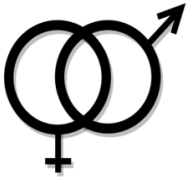
Sex



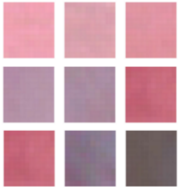
Skin Color

Bias Features

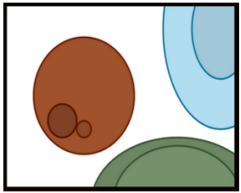
Age



Sex



Skin Color



Colorful Patches

Bias Features – Results

Model Group	Age	Sex	Skin Color	Colorful Patches
Perez et al. [2] : Mel	$^{12}/_{12}$	$^{4}/_{12}$	$^{2}/_{12}$	$^{12}/_{12}$
Perez et al. [2] : SK	$^{12}/_{12}$	$^{4}/_{12}$	$^{12}/_{12}$	$^{12}/_{12}$
Gessert et al. [1]	$^{5}/_{8}$	$^{1}/_{8}$	$^{6}/_{8}$	$^{5}/_{8}$

< 25% 25% - 75% > 75%

[1]: Gessert et al. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”, 2020.

[2]: Perez et al. “Data augmentation for skin lesion analysis”, 2018.

Bias Features – Results

Model Group	Age	Sex	Skin Color	Colorful Patches
Perez et al. [2] : Mel	12/12	4/12	2/12	12/12
Perez et al. [2] : SK	12/12	4/12	12/12	12/12
Gessert et al. [1]	5/8	1/8	6/8	5/8

< 25% 25% - 75% > 75%

[1]: Gessert et al. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”, 2020.

[2]: Perez et al. “Data augmentation for skin lesion analysis”, 2018.

Bias Features – Results

Model Group	Age	Sex	Skin Color	Colorful Patches
Perez et al. [2] : Mel	12/12	4/12	2/12	12/12
Perez et al. [2] : SK	12/12	4/12	12/12	12/12
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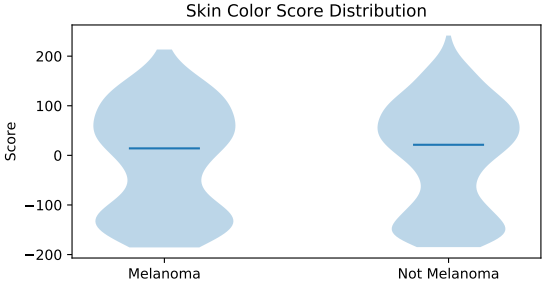
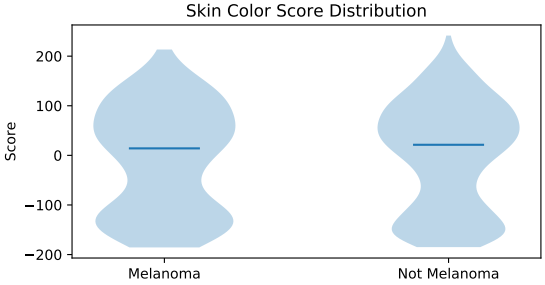
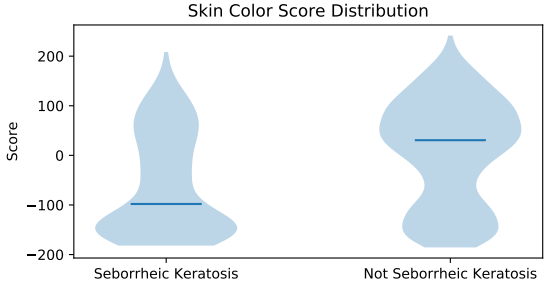
Skin Color Bias



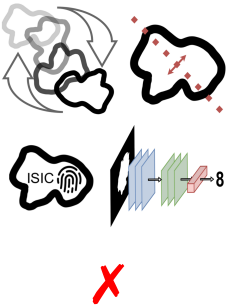
Skin Color Bias



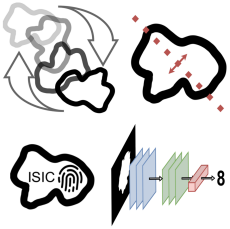


- bias in the ISIC 2017 challenge dataset

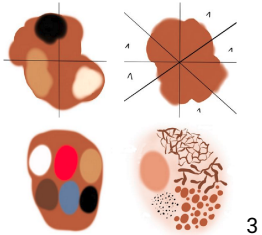
Summary



Summary



✗



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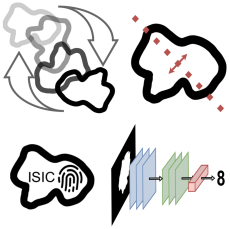
(✓)

[3] https://dermoscopedia.org/ABCD_rule

Summary



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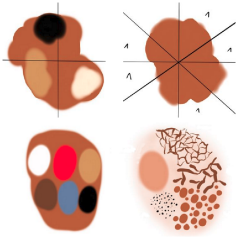

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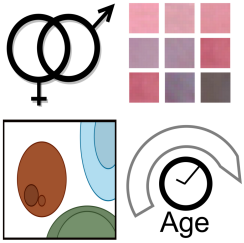

(✓)

[3] https://dermoscopedia.org/ABCD_rule

Thank You

Thank You!

References

References I

[1] Nils Gessert, Maximilian Nielsen, Mohsin Shaikh, René Werner, and Alexander Schlaefer. “Skin lesion classification using ensembles of multi-resolution EfficientNets with meta data”. In: *MethodsX* 7 (2020), p. 100864. ISSN: 2215-0161. DOI: https://doi.org/10.1016/j.mex.2020.100864. URL: https://www.sciencedirect.com/science/article/pii/S2215016120300832.

[2] Fábio Perez, Cristina Vasconcelos, Sandra Avila, and Eduardo Valle. “Data augmentation for skin lesion analysis”. In: *Proceedings of the Third ISIC Workshop on Skin Image Analysis*. Springer, 2018, pp. 303–311.

[3] Christian Reimers, Jakob Runge, and Joachim Denzler. “Determining the Relevance of Features for Deep Neural Networks”. In: *European Conference on Computer Vision*. 2020, pp. 330–346.

[4] Philipp Tschandl, Noel Codella, Bengü Nisa Akay, Giuseppe Argenziano, Ralph P Braun, Horacio Cabo, David Gutman, Allan Halpern, Brian Helba, Rainer Hofmann-Wellenhof, et al. “Comparison of the accuracy of human readers versus machine-learning algorithms for pigmented skin lesion classification: an open, web-based, international, diagnostic study”. In: *The Lancet Oncology* 20.7 (2019), pp. 938–947.