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A visually explainable learning system for skin lesion detection using multiscale input with Attention U-Net

Ho Minh Duy Nguyen, Abraham Ezema, Fabrizio Nunnari and Daniel Sonntag

German Research Center for Artificial Intelligence, Saarbrücken, Germany

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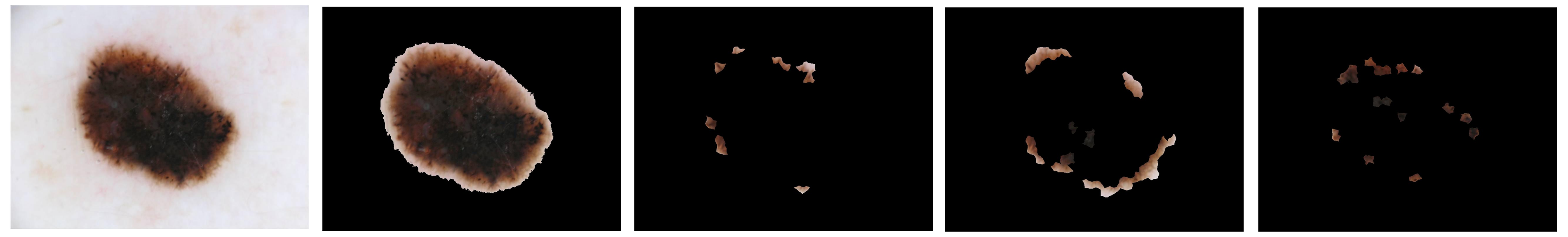
Introduction

- We introduce a learning system to segment five skin lesion structures based on ISIC Challenge 2018.



From left to right: the picture of a melanoma and its segmentation, followed by annotations of Steaks, Pigment Network and Globules.

Main Challenges:

- *Lack of Sample Data*: for e.g., Streaks (100 images), Negative Network (189 images)
- *Imbalanced Distribution*: for e.g., Streaks only accounts for 2.9% compared Pigment Network 58.7%.

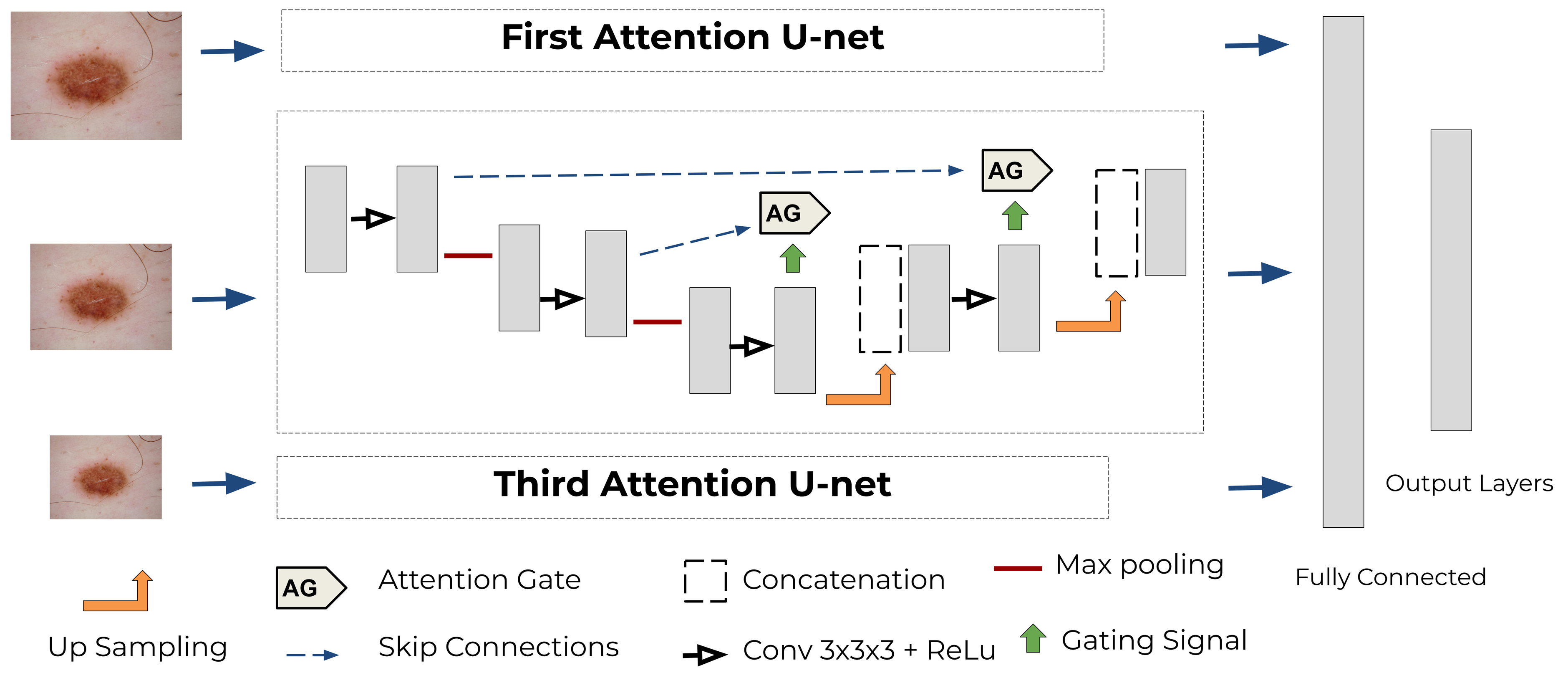
Table 1. Distribution of mask images

Lesion Attributes	Pigment Network	Globules	Milia-like Cysts	Negative Network	Streaks	Total Images
Mask Count	1522	602	681	189	100	2594
Rate	58.7%	23.2%	26.3%	7.3%	2.9%	100%

Method

Transfer Learning from Segmentation Task

- Unlike previous works, our method initialize all parameters directly from the segmentation task instead of transfer learning from ImageNet [1].
- 70% of the total 2594 images in segmentation task is used to train network, remaining 30% as the held-out set.
- Each image is constructed multi-scale versions with three corresponding sizes: 180×180, 256×256, and 450×450 then fed into our architecture.



Our proposed architecture

Network Architecture

- We adapt a modified version of U-Net, namely Attention U-Net [2], which has been proven to be very effective on small dataset.
- Each input feature map x^L at layer L is multiplicated by attention coefficient α to create a semantical feature $\tilde{x}^L = x^L \odot \alpha$ ($\odot$ is element-wise product).
- "Pyramid" feature with with different resolutions 180x180, 256x256, and 450×450 supports to search objects faster using a coarse-to-fine strategy.
- Network is trained with Jaccard-index based loss function (α= 1e - 05):

$$L = 1 - \frac{\sum y_{truth}\, y_{predict}}{\sum y_{truth}^2 + \sum y_{predict}^2 - \sum y_{truth}\, y_{predict} + \alpha}$$

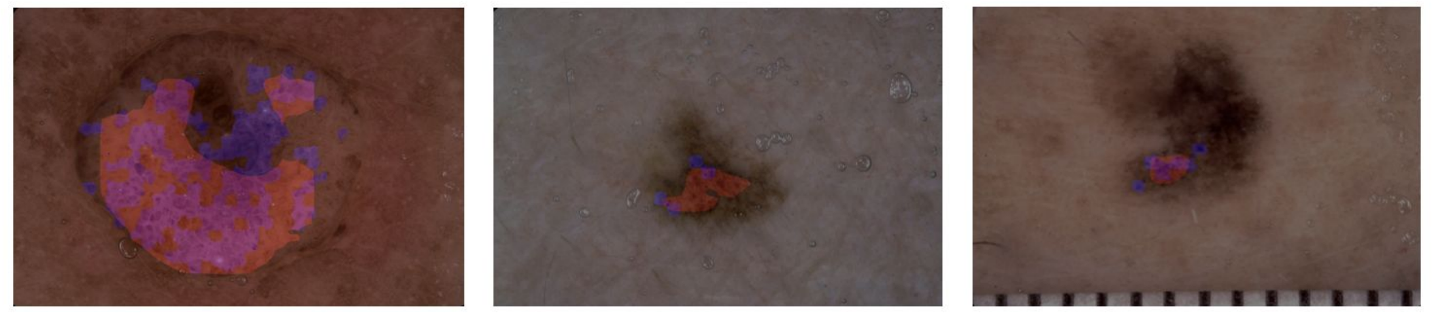
Lesion Attributes Detection

- Given the trained segmentation network, this model is cloned into five new instances, one for each lesion attribute.
- This strategy can alleviate the data imbalance problem (Table 1) and produce an uncertainty score as a pixel can be assigned to several attributes with distinct probabilities.

Experiments and Results

- Our method surpasses two leadingboard methods in two categories: Globules and Streaks.
- Our transfer learning strategy improves the performance of all attributes; especially for the classes with the least data (Streaks and Globules).
- For each attribute, we use 2320k parameters while NMN's team uses 60344k. (~30 times)

Method	Pigment Network	Globules	Milia-like Cysts	Negative Network	Streaks	Average
Our Method	0.535	**0.312**	0.162	0.187	**0.197**	0.278
Our Method (not transfer)	0.493	0.221	0.145	0.156	0.118	0.227
1st - NMN's team [3]	**0.544**	0.252	**0.165**	**0.285**	0.123	**0.307**
2nd-LeHealth's team [4]	0.482	0.239	0.132	0.225	0.145	0.276



Results for Globules: the blue regions indicate the ground-truth labels. the red regions indicate our visual predictions. Further examples, please look at our project [5].

References

[1] Deng, Jia, et al. "Imagenet: A large-scale hierarchical image database." 2009 IEEE conference on computer vision and pattern recognition. Ieee, 2009.
[2] Oktay, Ozan, et al. "Attention u-net: Learning where to look for the pancreas." arXiv preprint arXiv:1804.03999 (2018).
[3] Koohbanani, N.A., Jahanifar, M., Tajeddin, N.Z., Gooya, A., Rajpoot, N.: Lever-aging transfer learning for segmenting lesions and their attributes in dermoscopy images. arXiv preprint arXiv:1809.10243 (2018)
[4] Zou, J., Ma, X., Zhong, C., Zhang, Y.: Dermoscopic image analysis for isic challenge 2018. arXiv preprint arXiv:1807.08948 (2018)
[5] Sonntag, Daniel, Fabrizio Nunnari, and Hans-Jürgen Profitlich. "The Skincare project, an interactive deep learning system for differential diagnosis of malignant skin lesions. Technical Report." arXiv preprint arXiv:2005.09448 (2020).