Dermatologist-level classification of skin cancer with deep neural networks

Enhancing the Expert

Andre Esteva
PI: Sebastian Thrun
Stanford University

How can technology assist a human?

How can AI assist a dermatologist?

Skin Cancer

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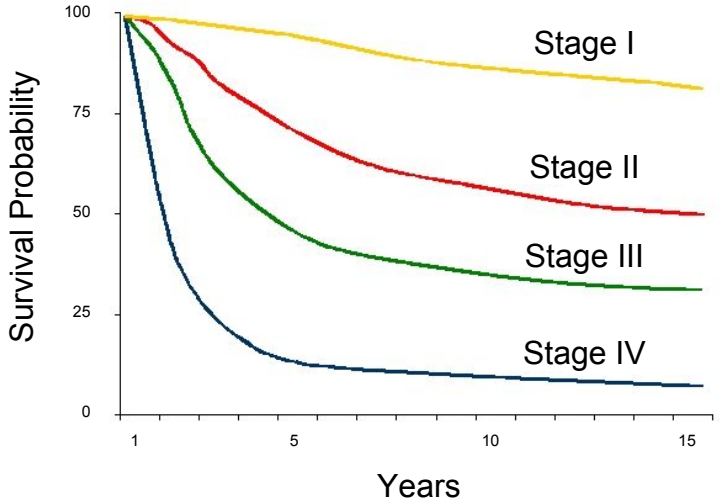

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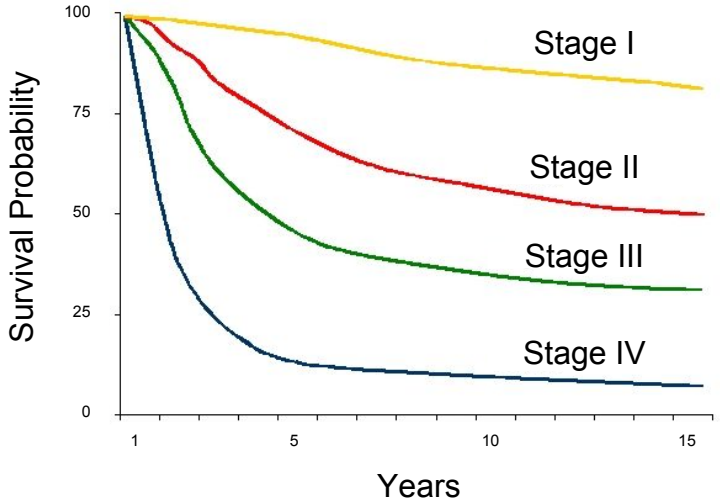

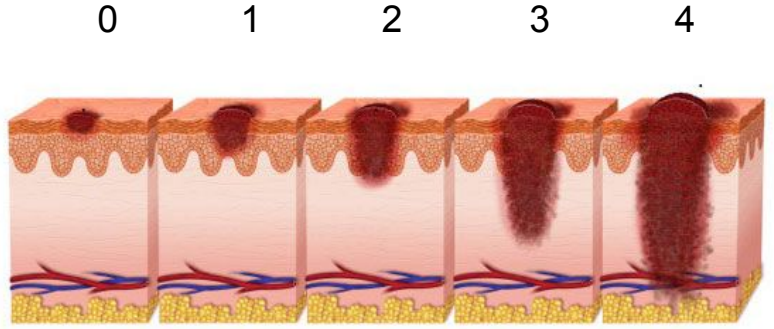

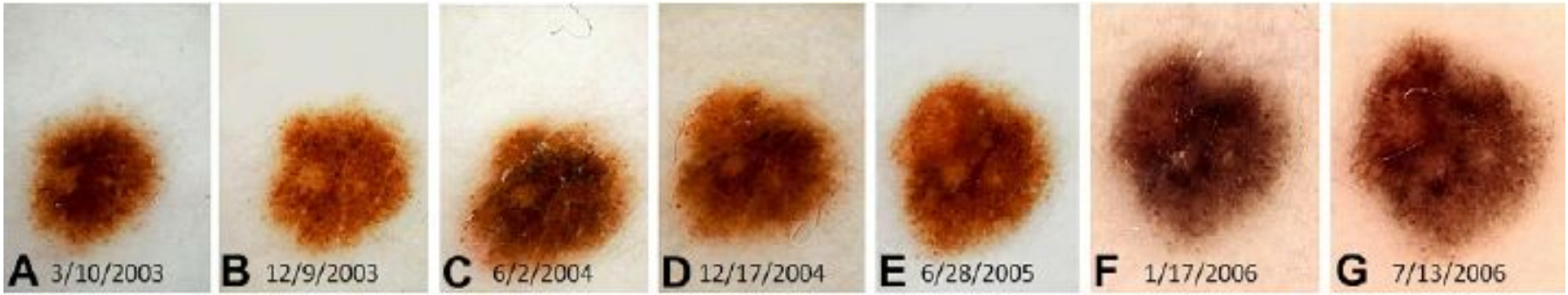
A 3/10/2003
B 12/9/2003
C 6/2/2004
D 12/17/2004
E 6/28/2005
F 1/17/2006
G 7/13/2006


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Early detection is critical

6.3 billion smartphones

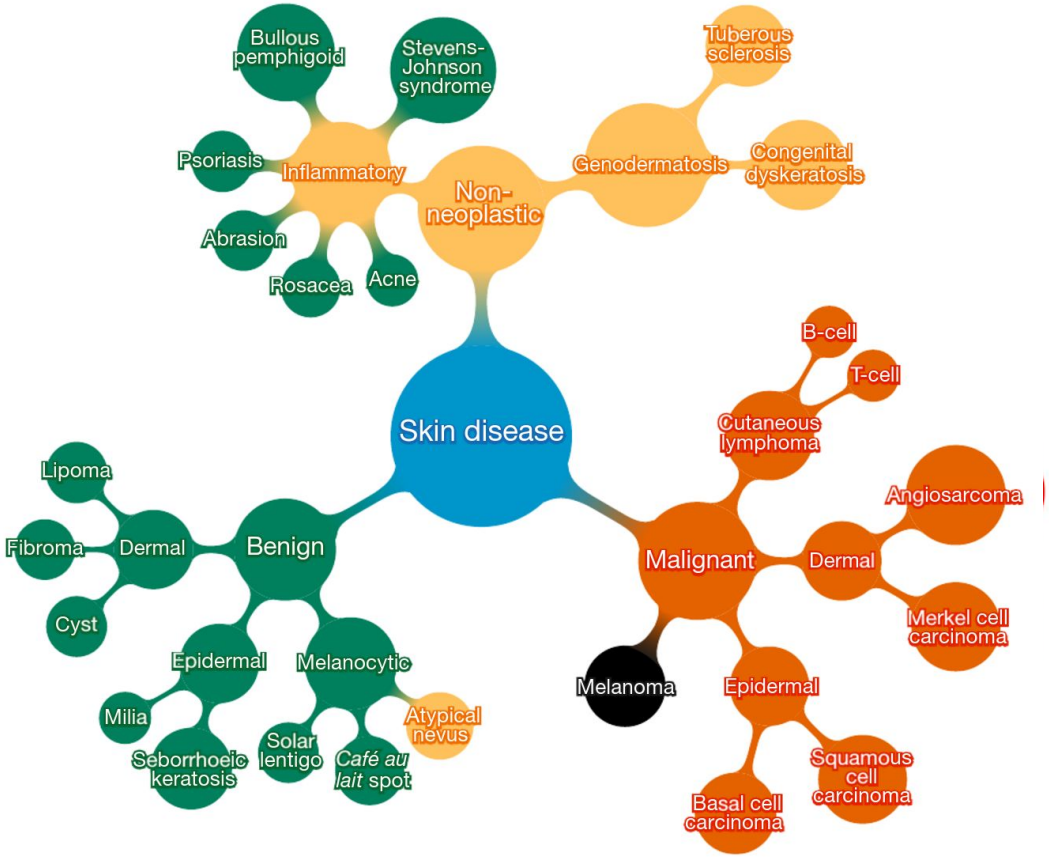
Skin Cancer Classification

Skin Cancer Classification

~130,000 images of skin

2000 diseases

Skin Cancer Classification



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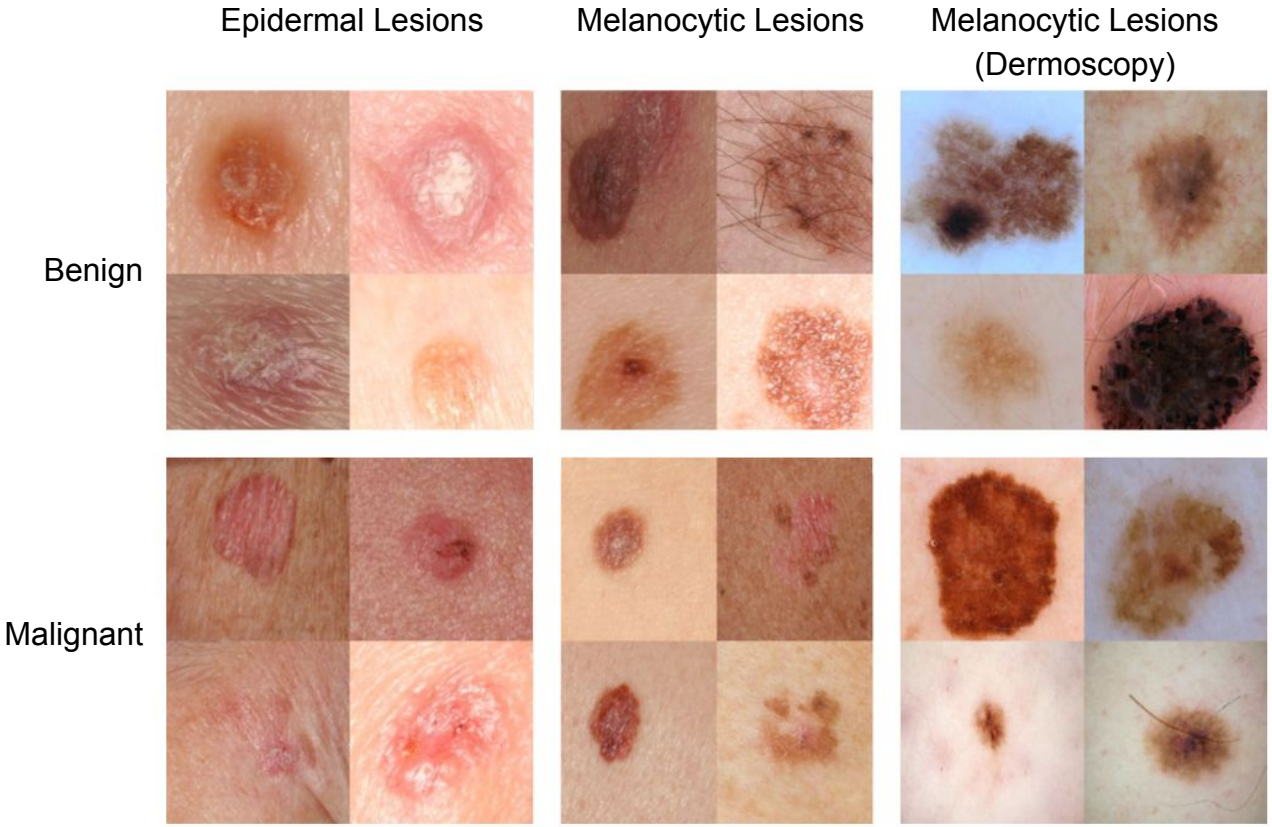
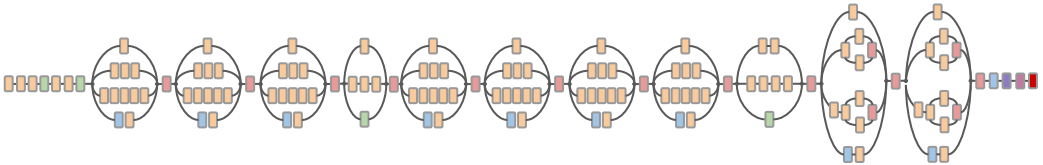


Skin Cancer Classification

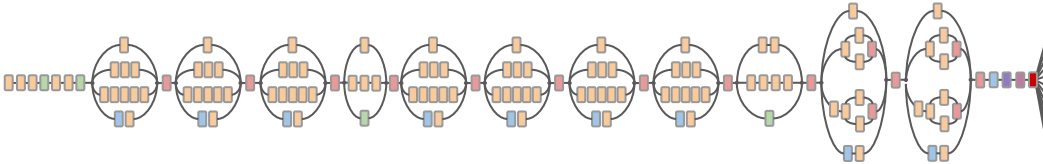
Deep Convolutional Neural Network (Inception-v3)



Skin Cancer Classification

Skin Lesion Image

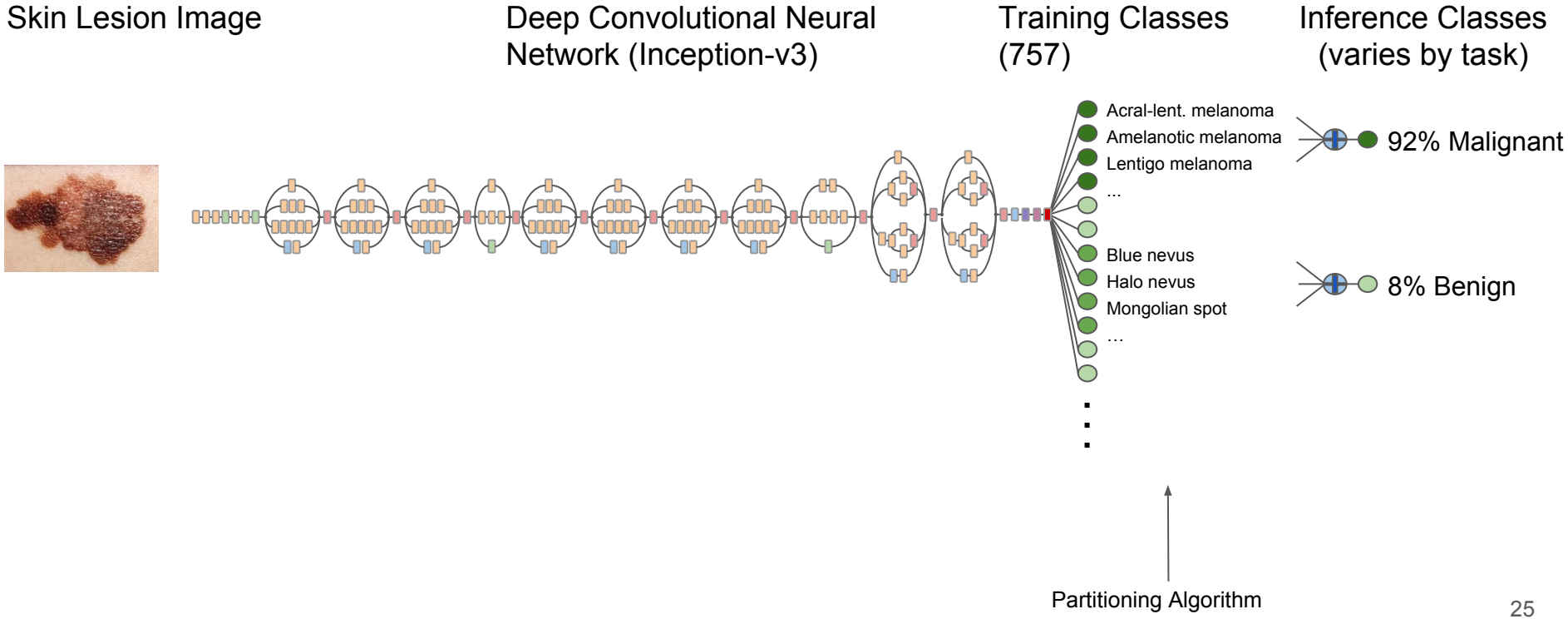
Deep Convolutional Neural Network (Inception-v3)



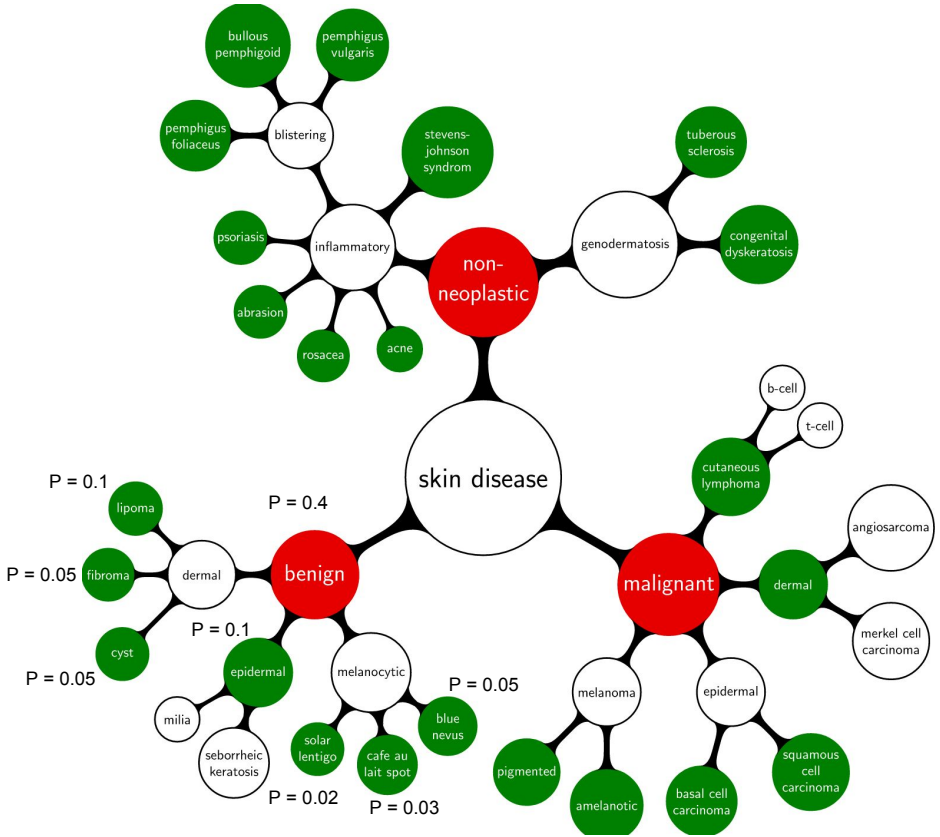
Training Classes (757)

Partitioning Algorithm

Skin Cancer Classification



Skin Cancer Classification



$$P[u] = \sum_{v \in C(u)} P[v]$$

- Training Classes
- Inference Classes

Dermatologist-level performance

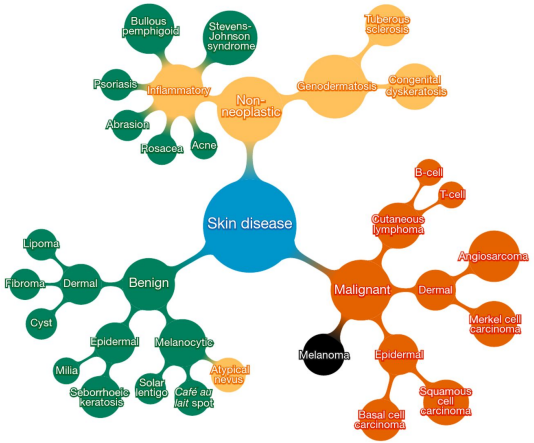
Skin Cancer Classification

Validation set

Skin Cancer Classification

Validation set

Classifier	Three-way accuracy
Dermatologist 1	65.6%
Dermatologist 2	66.0%
CNN	69.5%
CNN - PA	**72.0%**

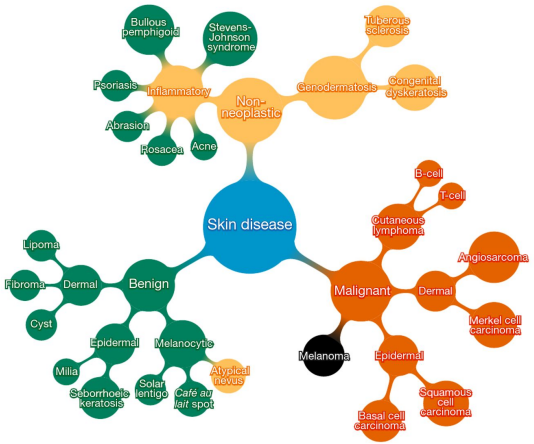


Disease classes:
three-way classification

0. Benign single lesions
1. Malignant single lesions
2. Non-neoplastic lesions

Skin Cancer Classification

Validation set



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Disease classes:
three-way classification

0. Benign single lesions
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2. Non-neoplastic lesions

Classifier	Nine-way accuracy
Dermatologist 1	53.3%
Dermatologist 2	55.0%
CNN	48.9%
CNN - PA	**55.3%**

Disease classes:
nine-way classification

0. Cutaneous lymphoma and lymphoid infiltrates
1. Benign dermal tumors, cysts, sinuses
2. Malignant dermal tumor
3. Benign epidermal tumors, hamartomas, milia, and growths
4. Malignant and premalignant epidermal tumors
5. Genodermatoses and supernumerary growths
6. Inflammatory conditions
7. Benign melanocytic lesions
8. Malignant Melanoma

Skin Cancer Classification

Test set

Skin Cancer Classification

Test set: Dermatologist Comparison (376 images)

Skin Cancer Classification

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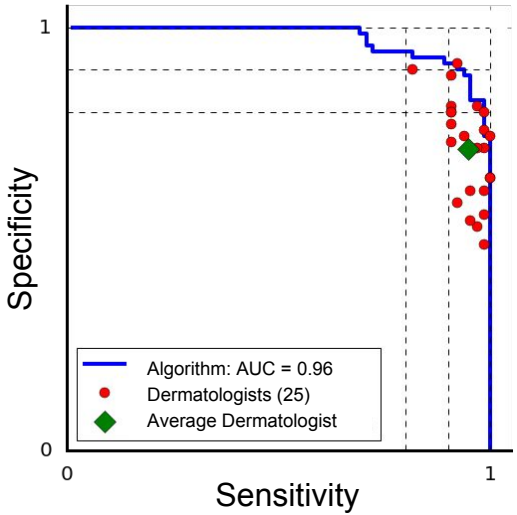
Carcinoma: 135 images



Skin Cancer Classification

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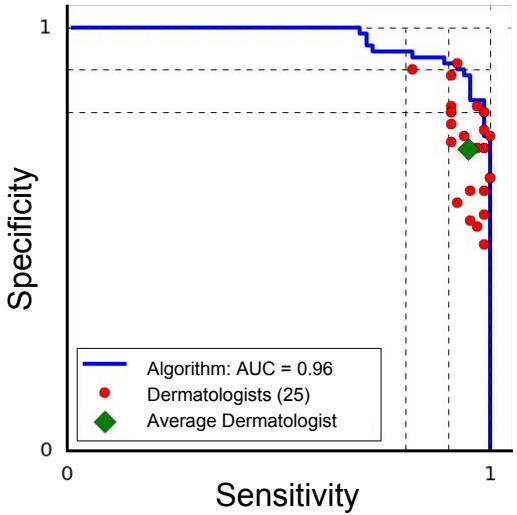
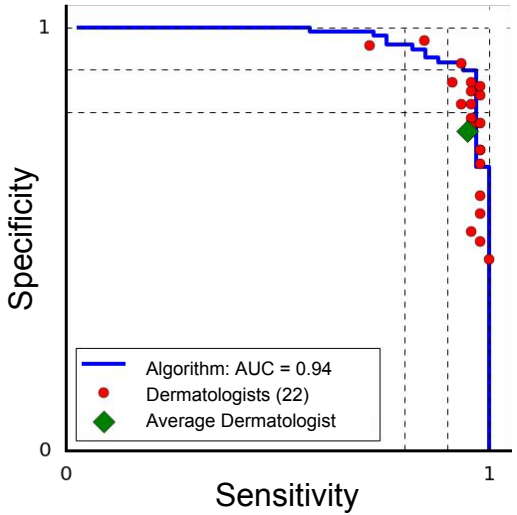
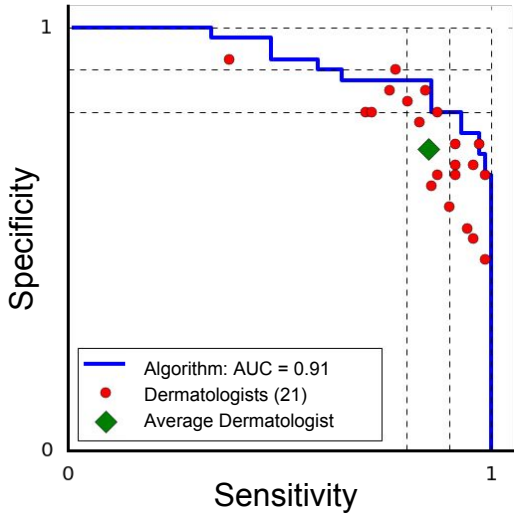


Melanoma: 130 images



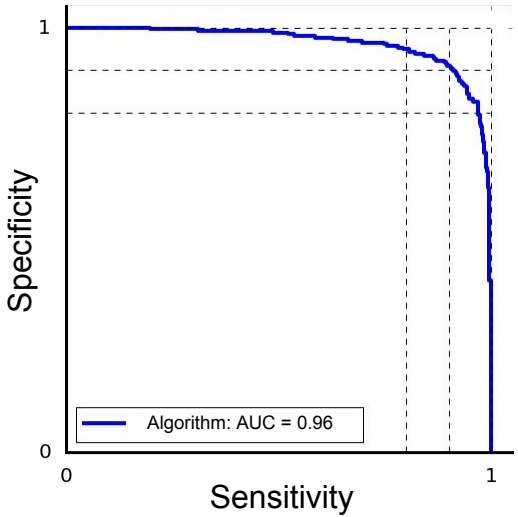
Melanoma: 111 dermoscopy images



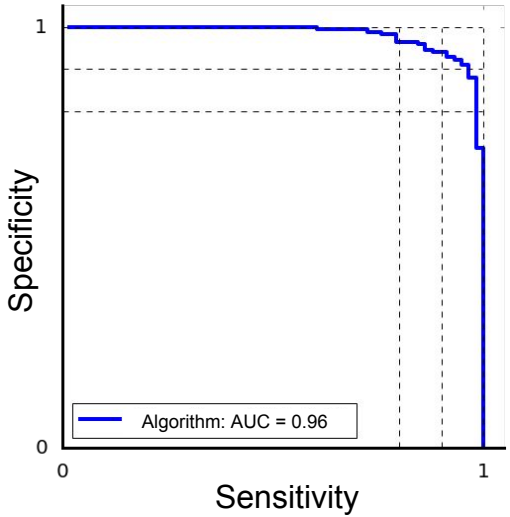
Skin Cancer Classification

Test set: Total (1942 images)

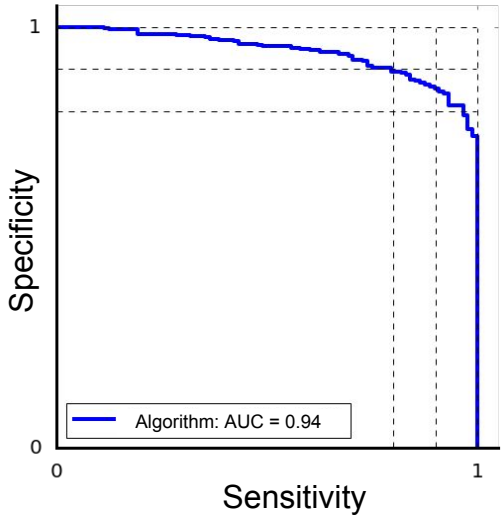
Carcinoma: 707 images



Melanoma: 225 images



Melanoma: 1010 dermoscopy images

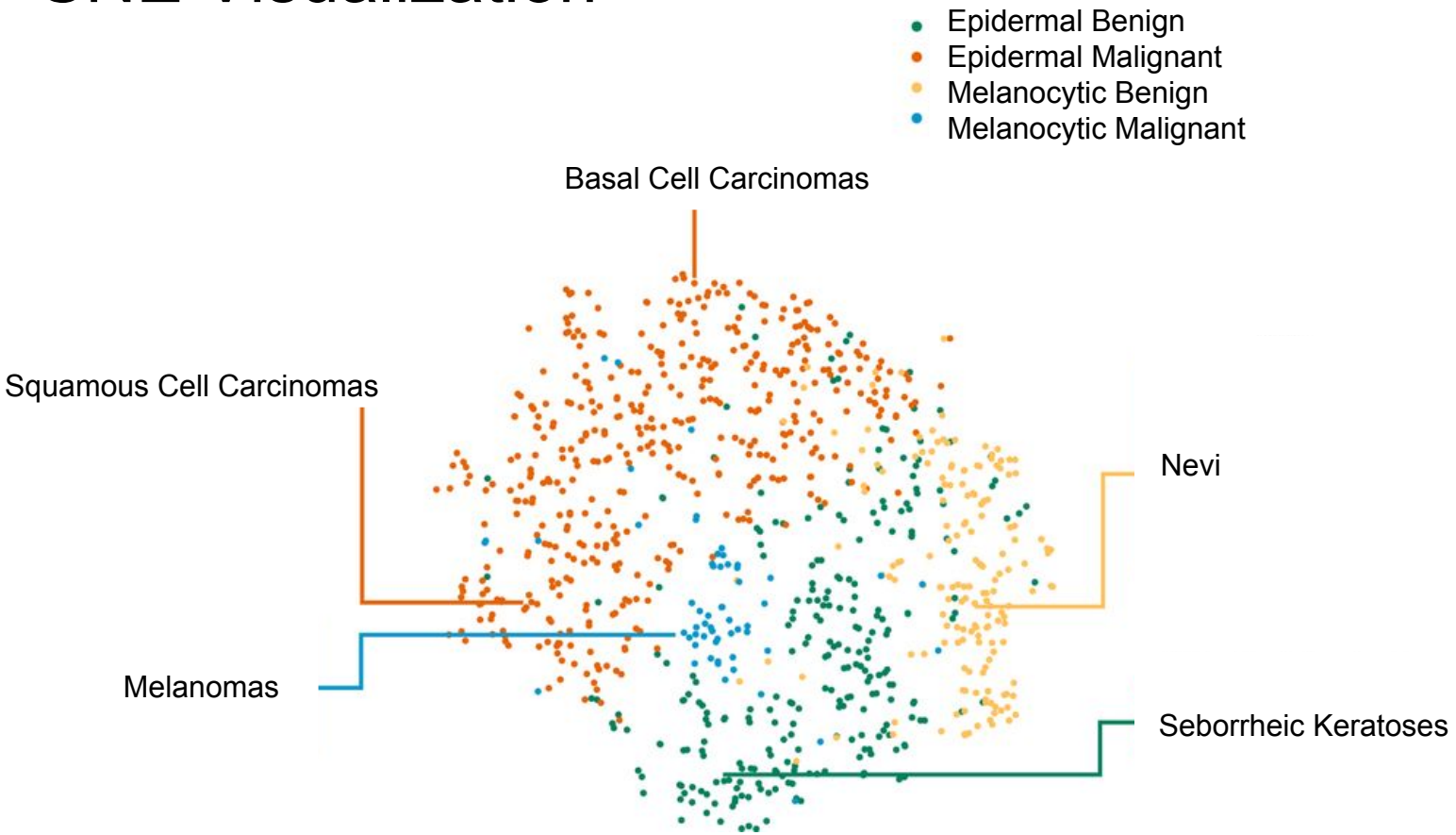


How does the algorithm work?

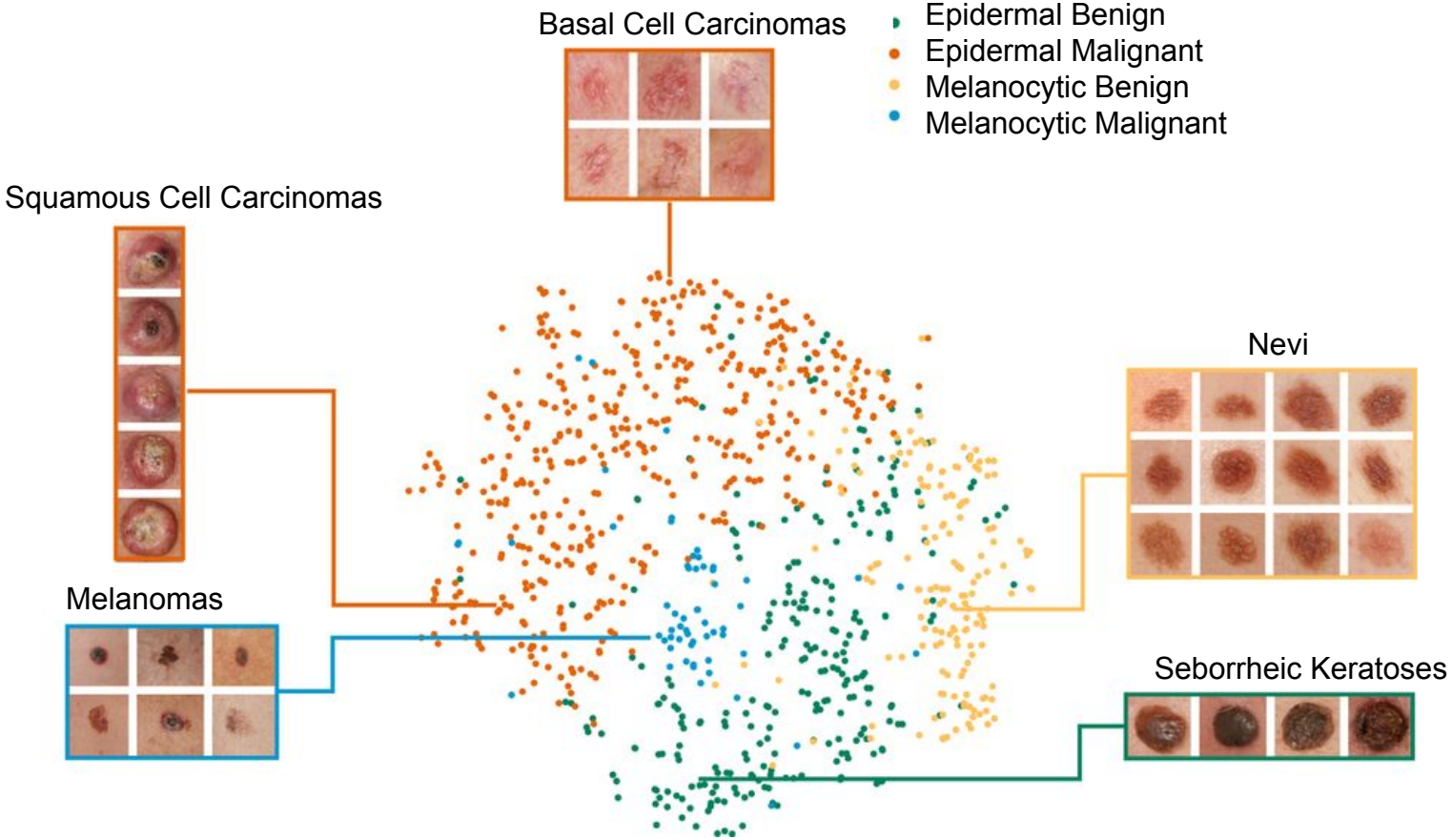
T-SNE Visualization

Van der Maaten & Hinton, 2008

T-SNE Visualization



T-SNE Visualization



What is the network fixating on?

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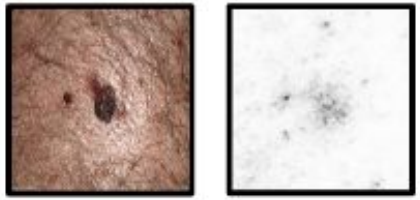
Malignant Melanocytic Lesion



Simonyan, Zisserman, 2014

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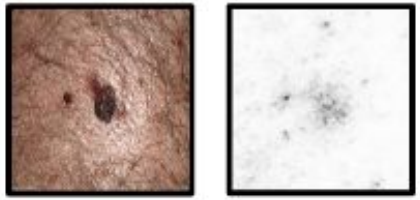
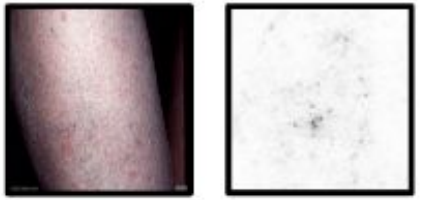
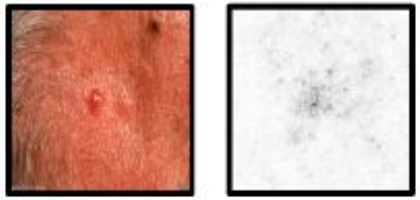


Benign Melanocytic Lesion

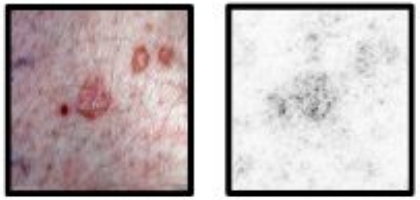
Inflammatory Condition



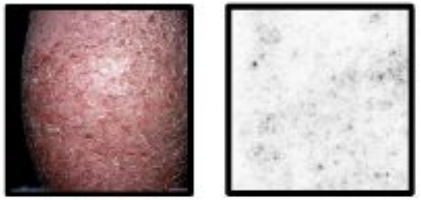
Malignant Epidermal Lesion



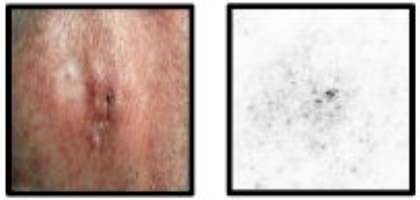
Benign Epidermal Lesion



Genodermatosis

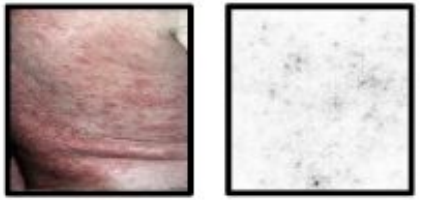


Malignant Dermal Lesion



Benign Dermal Lesion

Cutaneous Lymphoma



What does the network misclassify?

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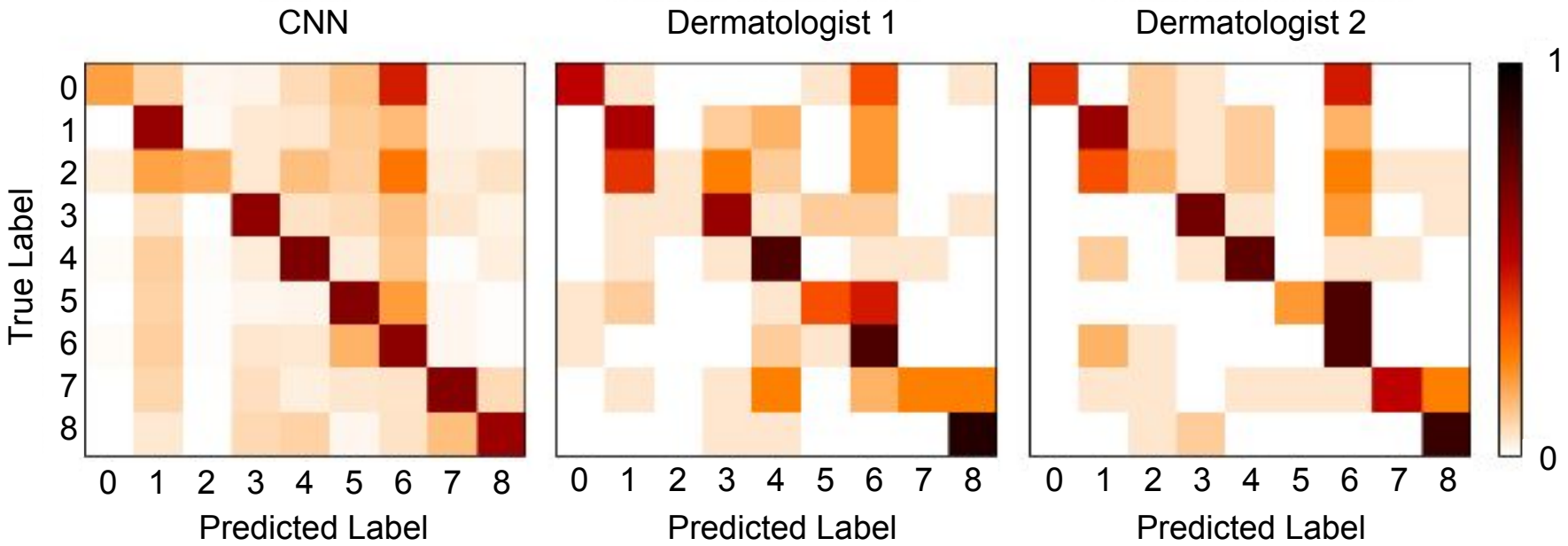

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Andre Esteva*, Brett Kuprel*, Rob Novoa, Justin Ko, Susan Swetter, Helen Blau, Sebastian Thrun

Nature, 2017

(Equal contribution authors*)


How can AI assist a dermatologist?

Community

Questions?

esteva@cs.stanford.edu
@andreesteva
cs.stanford.edu/people/esteva