Optimized Image Classification Models on Dark Skin Lesions

Problem Statement

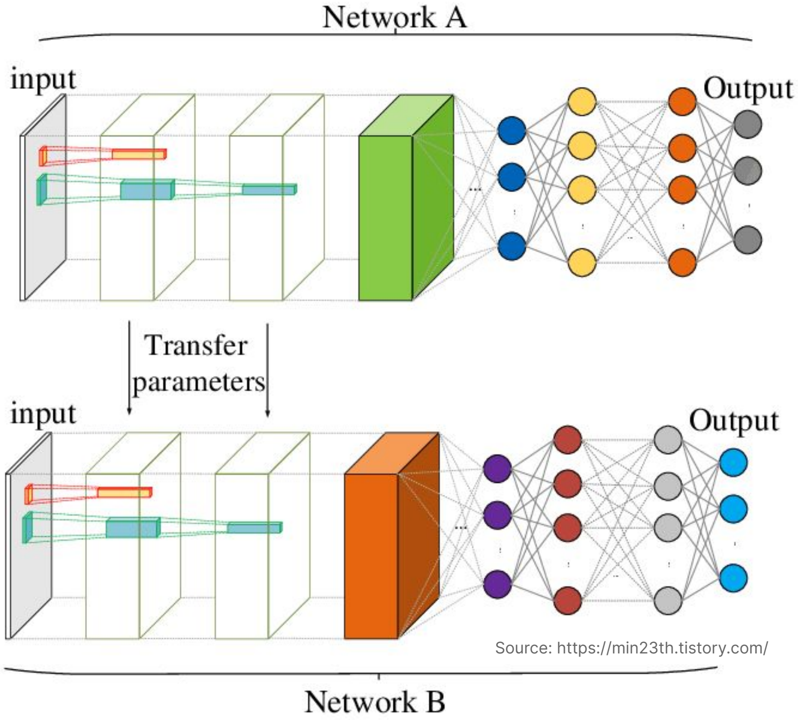
- Skin diseases
  - 1 in 4 Americans impacted by skin diseases
  - $75B USD spent annually
  - Only 1 in 3 Americans with skin diseases seen by a dermatologist
- Underserved groups, including ethnic minorities, have poorer melanoma and nonmelanoma skin cancer outcomes. This is mostly due to lack of adequate awareness and general apathy towards proactive care. Providing non-intrusive early triage could help spur them to action (seeing a dermatologist).

Background Research

- Previous research demonstrates that images of skin lesions on dark skin are a significant problem for image classifiers and publishes datasets to address that.
  - Uses various techniques to correct that bias within a single model
    - Pruning parts of the model that would only work for one skin type or another
    - Segmenting skin disease images beforehand
    - Resampling dataset to be more balanced

Materials

- Trained on Kaggle Notebooks platform
- Used Python, TensorFlow, and Keras



Source: https://min23th.tistory.com/

Design Execution

- **Independent variable:** whether or not an image modification algorithm is used
- **Dependent variable:** ROC-AUC metric
- **Controls:** dataset subsets used for trials
- Images split by their measurement on Fitzpatrick scale
  - Fitzpatrick type values 1-3 were placed in Group 1 & 4-6 in Group 2
- Optimized image modification layers:
  - focused on Group 2, fine-tuned image layers to maximize accuracy

Performed hyper-parameter optimization on the image modification layers using Optuna

Created 3 subsets for cross-validating the data

Ran 24 trials, models trained and tested for each subset

Used a model based on EfficientNet-B1

Modification Layers Deployed

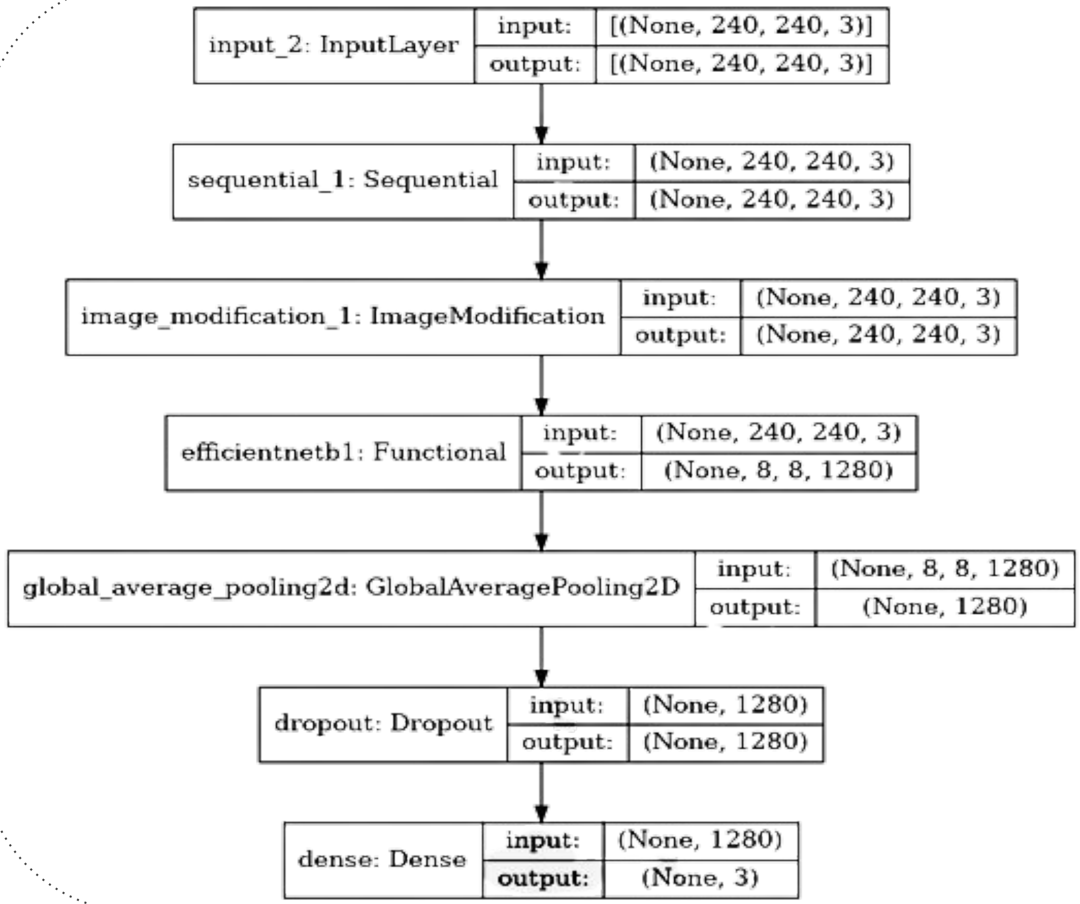


Image Modification Layer

- Contrast Modifier
- Brightness Modifier
- Image Saturation Modifier

Findings

	Control	With Image Modifications
Trial 0	0.791	0.907
Trial 1	0.818	0.913
Trial 2	0.832	0.852
Average	0.814	0.891
Standard Deviation	0.021	0.034

Dataset

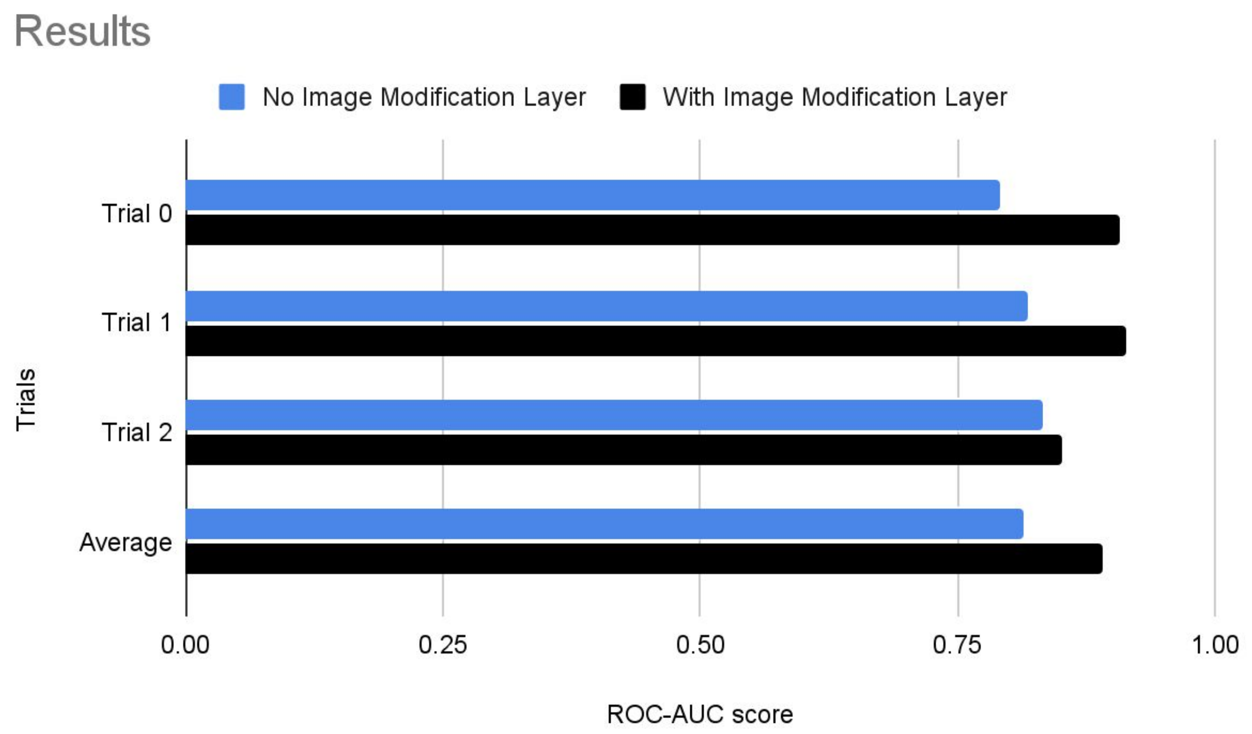
- Fitzpatrick 17k dataset has 17000 images from 2 datasets
- Fitzpatrick describes skin tones: 1 lightest & 6 darkest
- Skin type assessed through human annotation
- It has three classifications:
  - Non-neoplastic growth
    (growth or changes in tissue not caused by abnormal cell growth)
  - Benign growth
    (non-cancerous growths or changes in tissue)
  - Malignant growth
    (cancerous growths or changes in tissue)

	Non-Neoplastic	Benign	Malignant
# Images	12,080	2,234	2,263
Type 1	17.0%	19.9%	20.2%
Type 2	28.1%	30.0%	32.8%
Type 3	19.7%	21.2%	20.2%
Type 4	17.5%	16.4%	13.3%
Type 5	10.1%	7.1%	6.5%
Type 6	4.4%	2.0%	2.7%
Unknown	3.2%	3.3%	4.6%

Table 1. Distribution of skin conditions in *Fitzpatrick 17k* by Fitzpatrick skin type and high level skin condition categorization.

The Fitzpatrick Scale

Performance Overview



This graph shows a comparison of the performance of the models depending on whether or not there is an image modification layer.

Conclusions

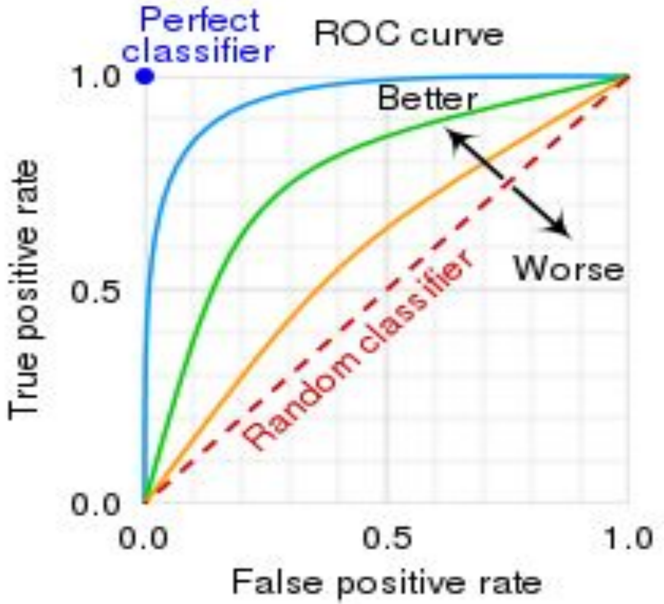
- Image classifier model accuracy can be enhanced by segmenting data based on visual aspects and using image modification layers
    - Multiple similar models can be combined to create highly accurate ensemble-based classifications tailored for an individual.
- Can be used by medical professionals with limited experience with certain disease pairs, especially in diverse countries where training materials are comparatively homogeneous.

Results

- This novel approach of optimizing image preprocessing is an effective way to increase model performance for datasets with similar types of images.

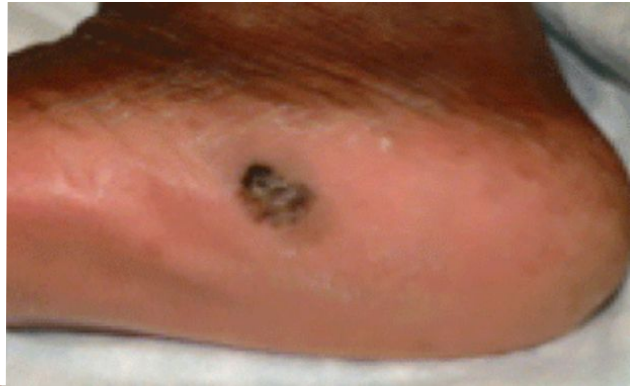
7.7%

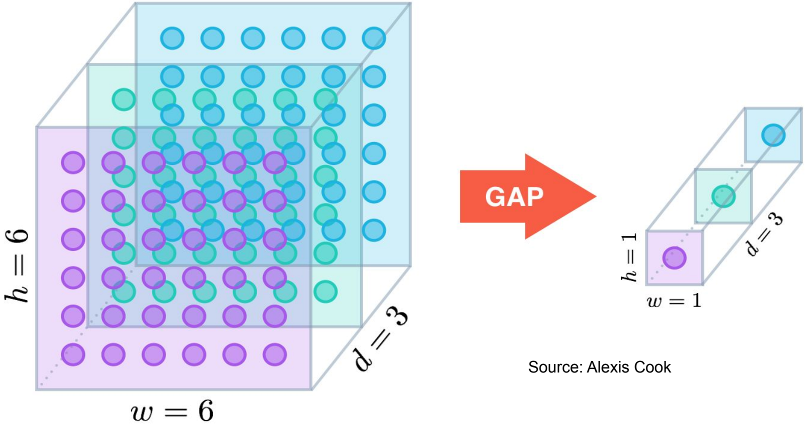
increase in ROC-AUC score, on average



Skin Cancer on Lighter Skin Tones

Skin Cancer on Darker Skin Tones

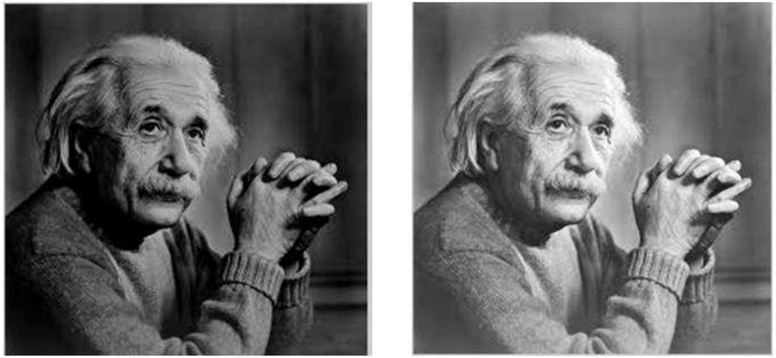




Source: Alexis Cook

-80 +80

Saturation example - Adobe Support



Brightness example - Tutorialspoint

OPTUNA

TensorFlow

Keras

The Fitzpatrick Scale

TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TYPE VI
Light, pale white	**White, fair**	**Medium, white to olive**	**Olive, moderate brown**	**Brown, dark brown**	**Black, very dark brown to black**
Always burns, never tans	Usually burns, tans with difficulty	Sometimes mild burn, gradually tans to olive	Rarely burns, tans with ease to a moderate brown	Very rarely burns, tans very easily	Never burns, tans very easily, deeply pigmented