Sensibly

DiPaola Consulting

Application of Machine Learning to Diagnose Benign vs. Malignant Skin Lesions

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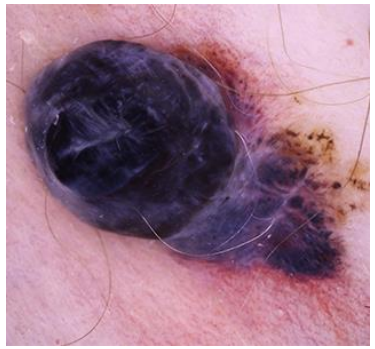
Overview

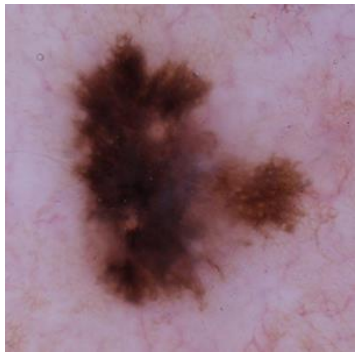
- Develop a rapid home test to properly classify benign vs. malignant skin lesions
- This method utilizes machine learning and heuristic filters to classify images as medical history provides information that may be more useful than simply optimizing the accuracy of the model (various techniques below) and will save time in development
  - Hair removal, contrast / brightness, masking skin, noise removal
  - https://pmc.ncbi.nlm.nih.gov/articles/PMC9352099/
  - https://www.frontiersin.org/journals/oncology/articles/10.3389/fonc.2022.931141/full
- Input Requirements:
  - Method to capture a picture (i.e. smart phone) and access to the internet
  - Short survey regarding history of skin lesion
- Output: Malignant vs. Benign

Morphological Characteristics of a Malignant Skin Lesion

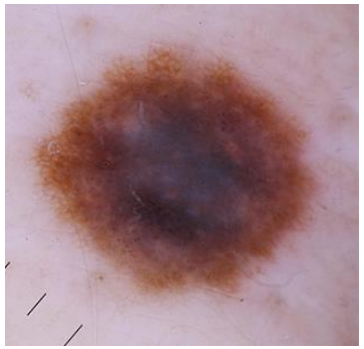
Asymmetry



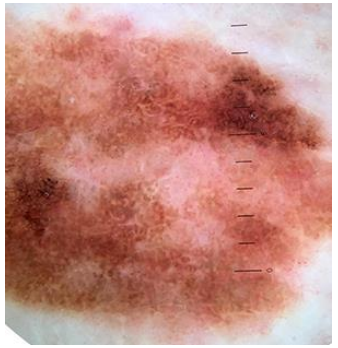
Border Irregularity



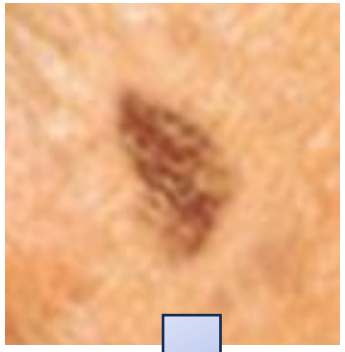
Color / Raised

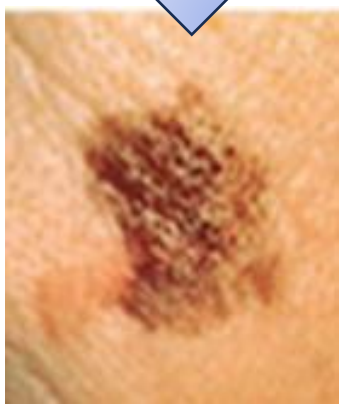


> 6 mm Diameter



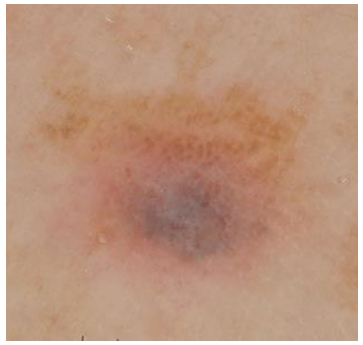
Evolution Over Time



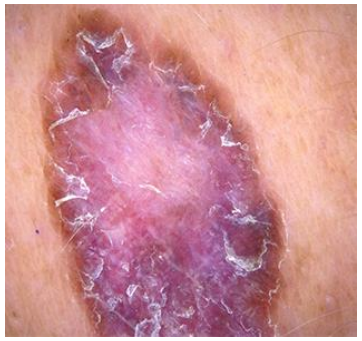


Doubled in Size

Ring or
Halo of Redness



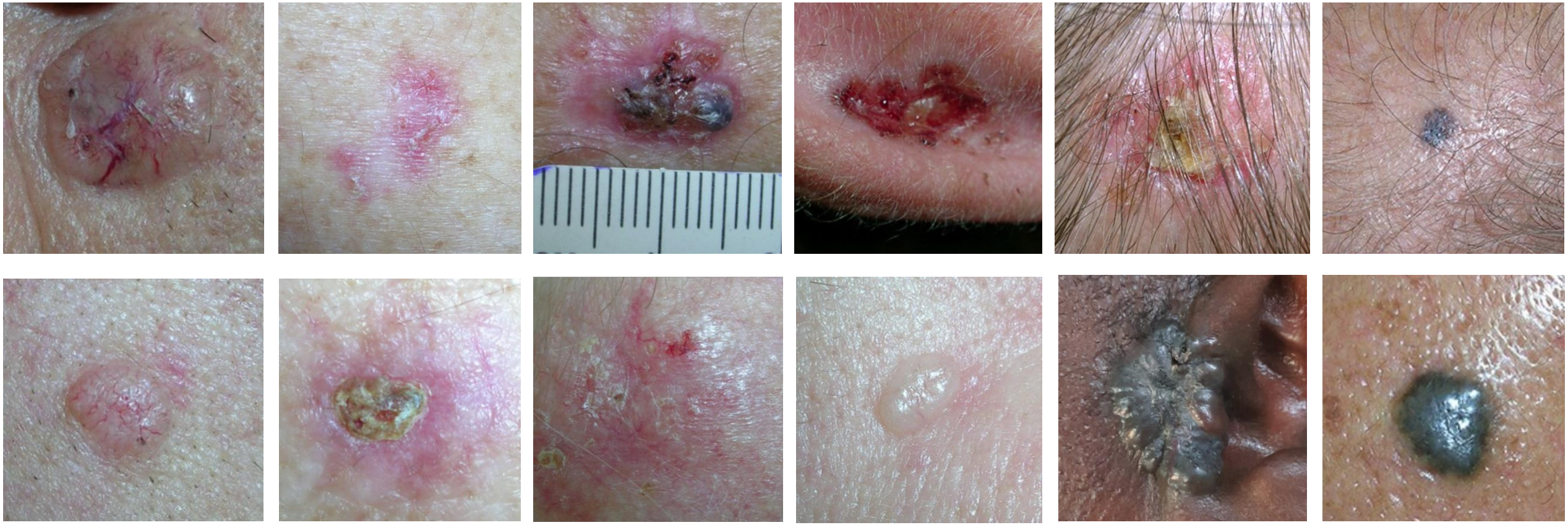
Scales



Ulcerations / Crust

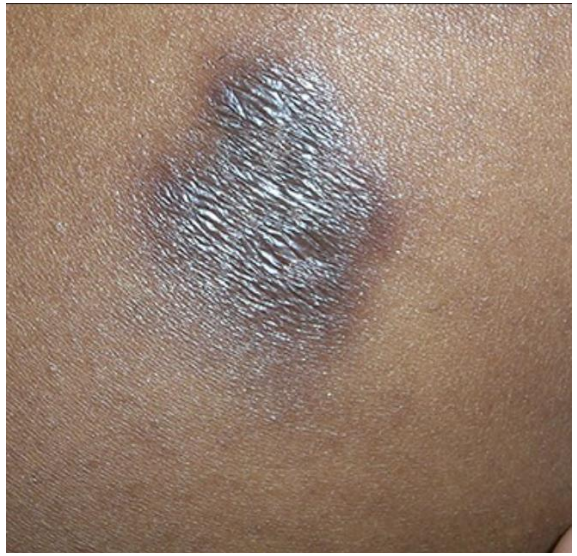
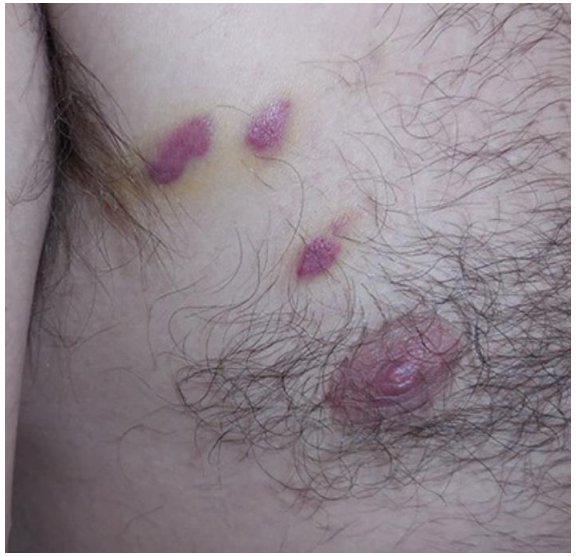
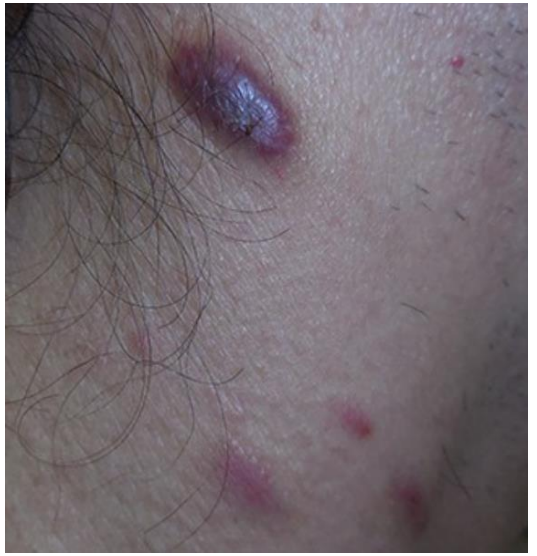
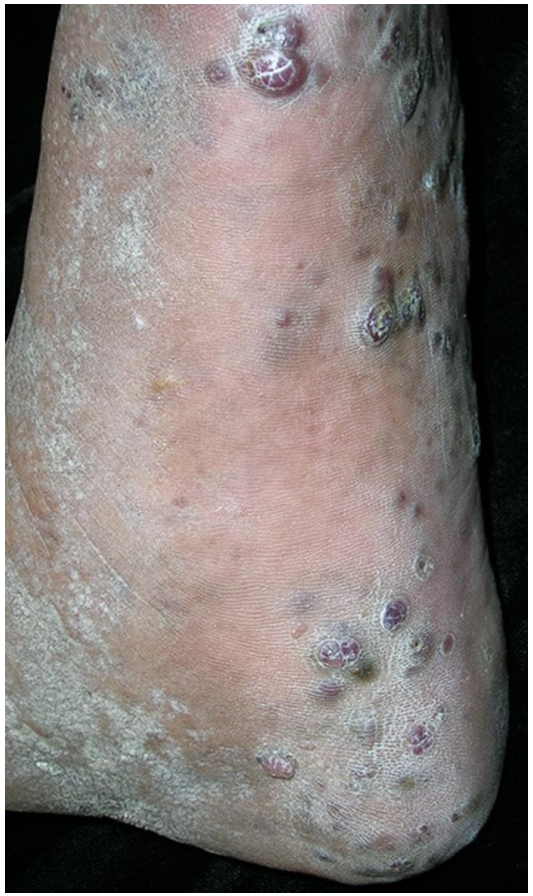
Reference: https://www.scanoma.com/blog/ and https://www.mayoclinic.org/diseases-conditions/skin-cancer/symptoms-causes/syc-20377605

Basal Cell Carcinoma Malignant Skin Lesion



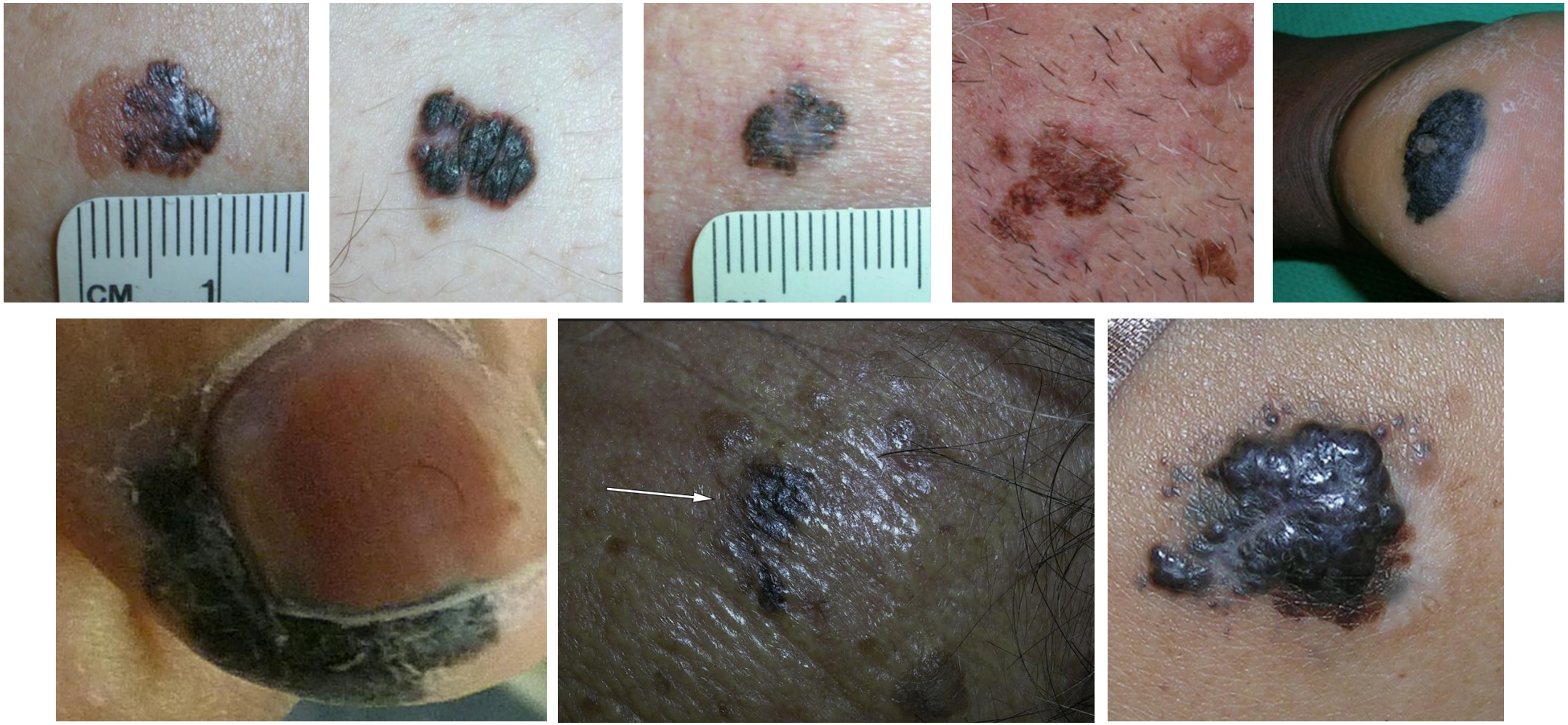
Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Kaposi Sarcoma Malignant Skin Lesion

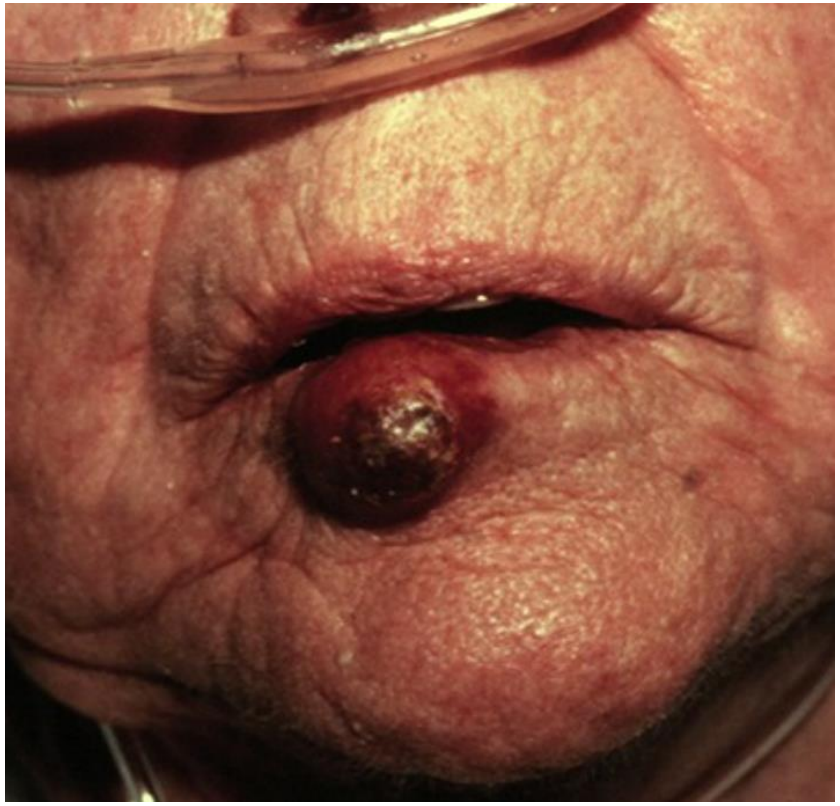
Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Melanoma Malignant Skin Lesion



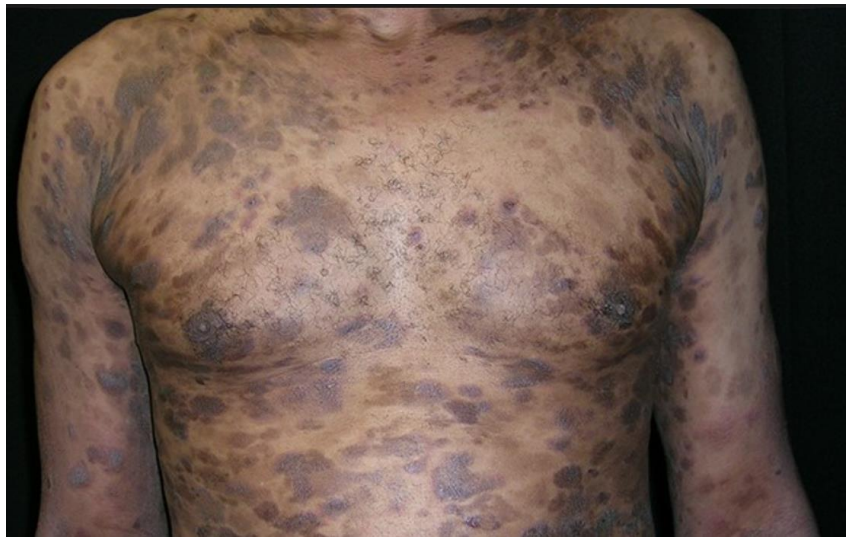
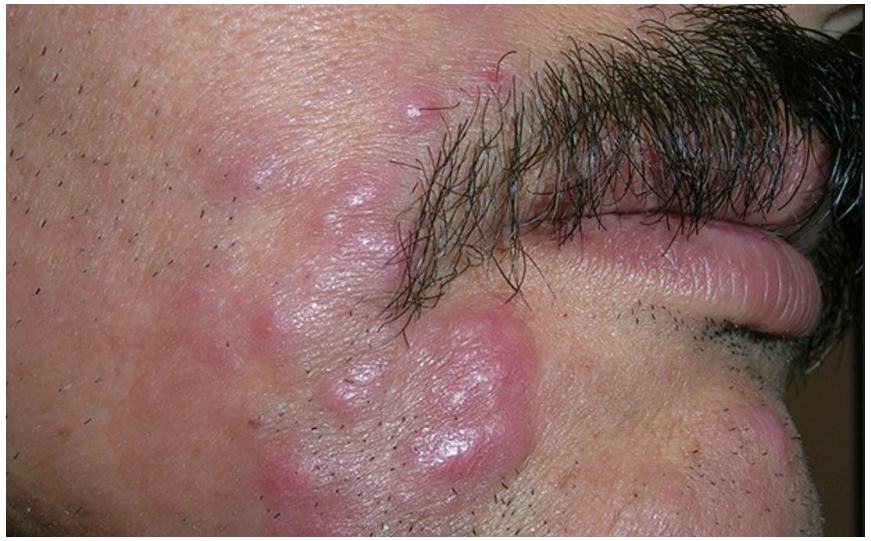
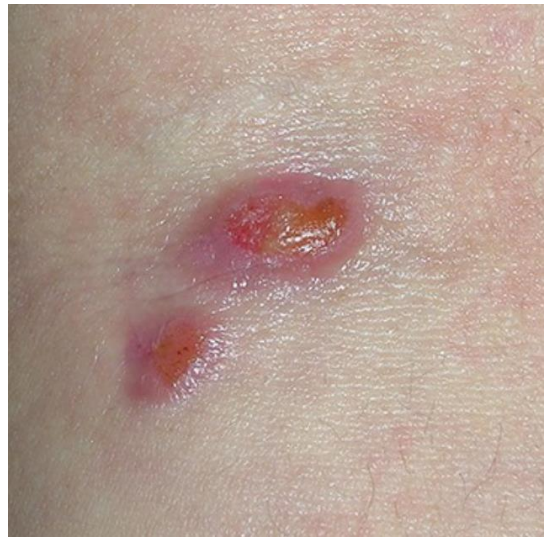
Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Merkel Cell Carcinoma Malignant Skin Lesion – One of most dangerous types



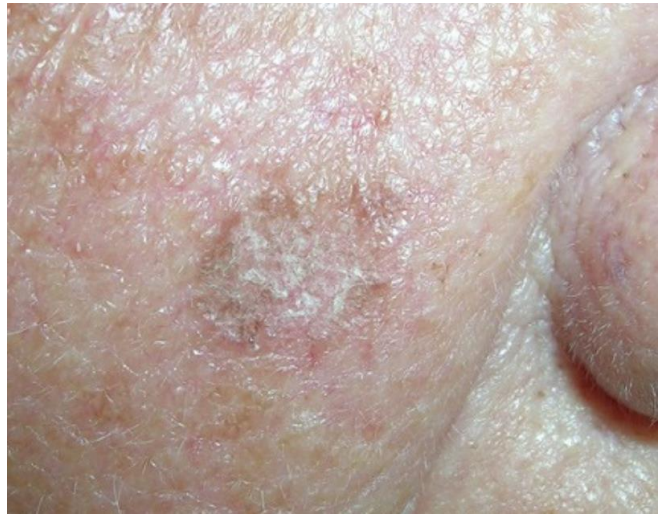
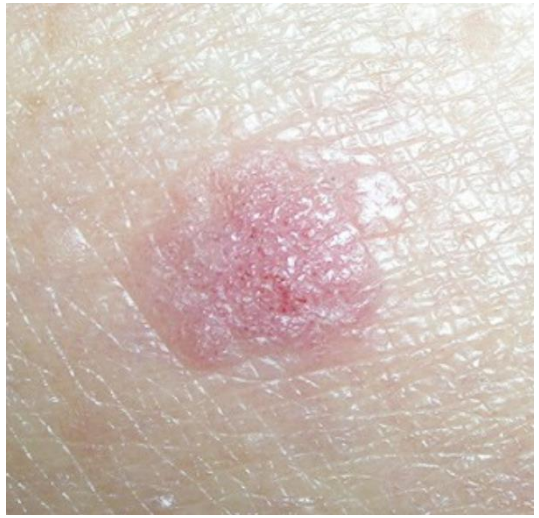
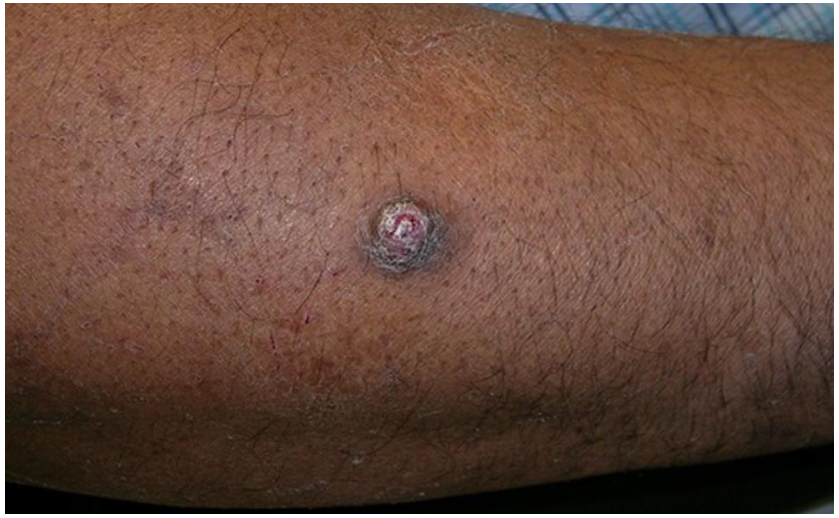
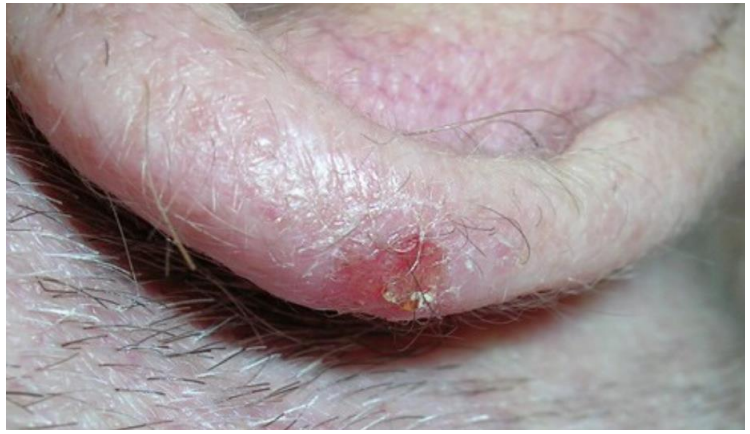
Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Skin Lymphoma Malignant Skin Lesion

Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Squamous Cell Carcinoma Malignant Skin Lesion

Reference: https://www.cancer.org/cancer/types/skin-cancer/skin-cancer-image-gallery.html

Methods

- Random images from the ISIC 2020 Dataset (The International Skin Imaging Collaboration) with varied participants (sex, age, nationality – white skin tone)
- Training set of 457 benign and 457 malignant (total: 914) and test set of 125 benign and 125 malignant (total: 250)
- Images in JPG format were processed (square cropping and scaling) from various landscape pixel widths and heights to square 299 X 299-pixel RGB images
  - The most relevant portion of the image was maintained during cropping
  - Hair was not removed and in some cases scale measurement marks were left in the image
- Various supervised, convolutional neural network (CNN) computer vision models were evaluated:
  - Custom Encoder / Decoder Model
  - Inception V3
  - Xception
  - ResNet18
  - ResNet50
  - ResNet152
  - VGG16, VGG19
- Hyperparameters were tuned, data normalized, and training data was randomly horizontally flipped

Methods

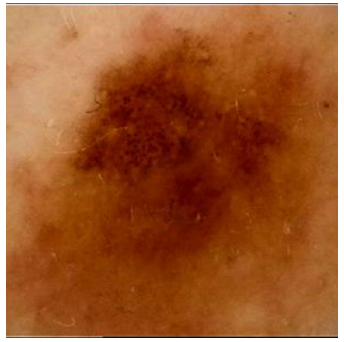
- A short survey was given to learn the history of the skin legion (case studies)
  - How long was the skin legion present? < 3 months, < 6 months, < 1 year, < 5 years, lifetime
  - Is skin legion greater than size of a single standard No 2 pencil end eraser (6 mm)? Yes or no
  - Has the skin legion increased in size over time? Yes or No
  - How much as the skin legion increased in size? < Doubled in size, Doubled in size, > Doubled in size
  - How long ago did it start growing? 3 months, 6 months, 1 year, 5 years, slowly over lifetime
  - Does it bleed on it's own (without picking, squeezing)? Yes or No
  - Has it significantly changed in appearance? Yes or No
  - Have you had a previous malignant skin lesion(s) (skin cancer) removed? Yes or no
  - Does lesion itch, burn or cause pain? Yes or No

- This information is not available from ISIC database

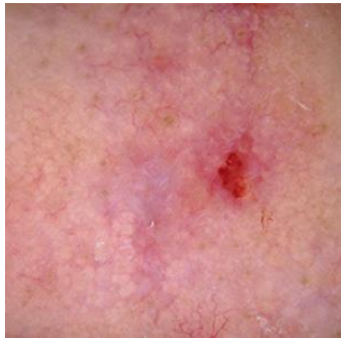
Results

- ResNet18 was chosen for its balance of training speed (< 50 secs) and accuracy 86%
  - Training accuracy was 88% with further training resulting in over training and lower test accuracy
  - Number of epochs was 5
  - This test accuracy will likely increase with much larger sample size
- Results of image analysis alone (no health history information)
  - False positives: 10% (cautious approach, high likelihood of biopsy)
  - False negatives: 4% (risk of not being treated resulting in high potential for adverse outcome)
- Most false positives very difficult to determine from image alone
- 80% of false negatives I would have gotten biopsied from image alone hence accuracy improvement in model warranted with more training images
- Adding health history has potential to increase accuracy to > 95% and significantly reduce false negatives (very limited sample size) – much larger dataset needed to confirm hypothesis
- Results from this development were quite consistent with this research published in nature
  - https://www.nature.com/articles/s41598-024-59783

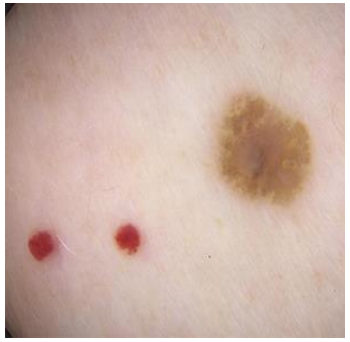
Results: False Positives



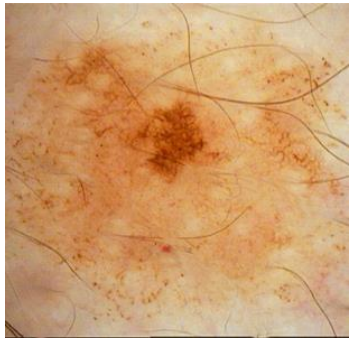
Border Irregularity



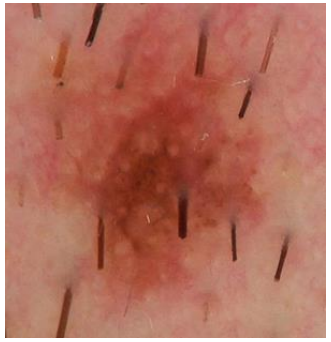
Ulceration



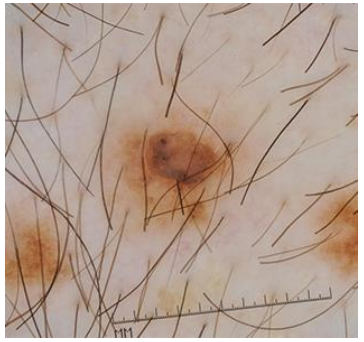
Raised Color



Size / Irregularity



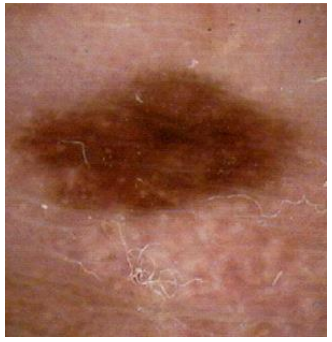
Red Halo



Size / Irregularity

Looks Normal

Unsure



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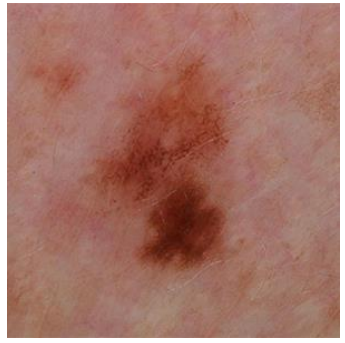
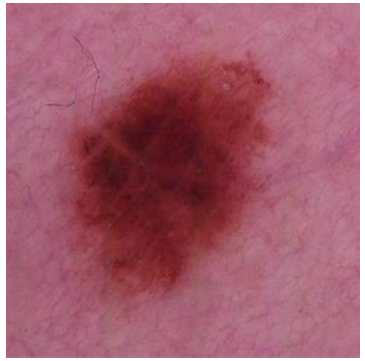


Border Irregularity

Results: False Positives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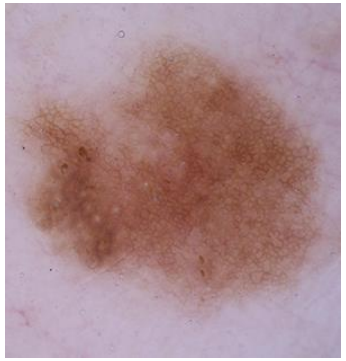
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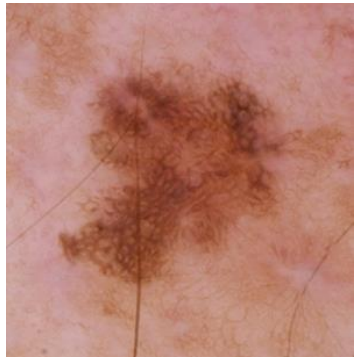
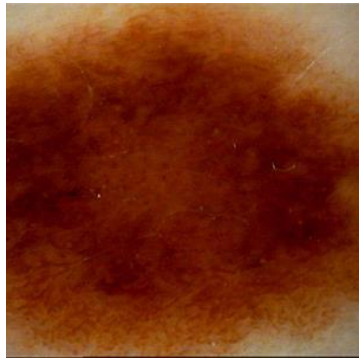
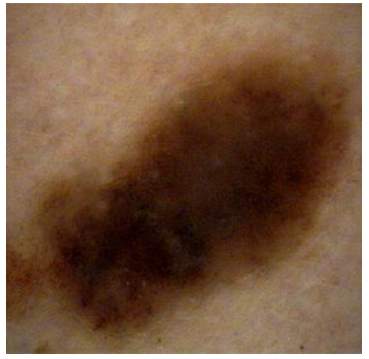
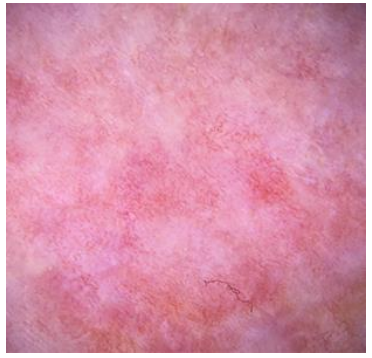

Irregularity
Color


Size / Irregularity
Color


Size / Asymmetry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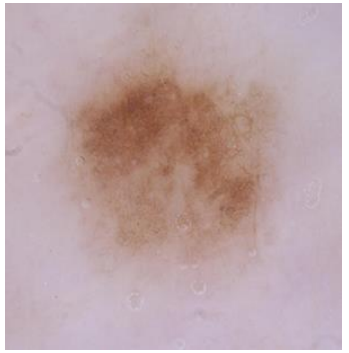
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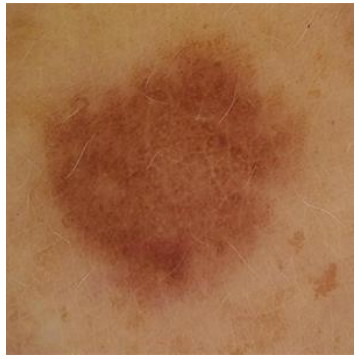
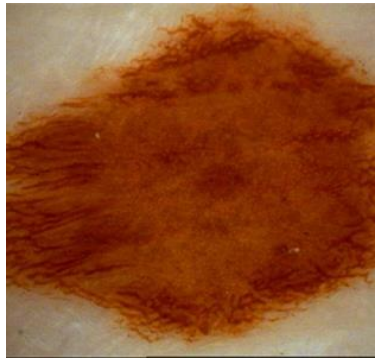

Unsure


Size / Color


Size / Color

Results: False Positives

Unsure

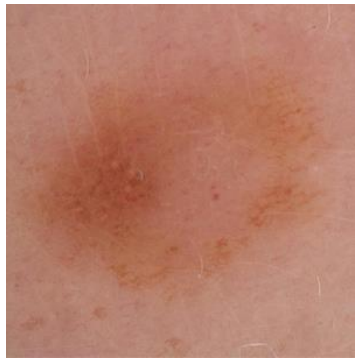


Size / Color

Unsure

Maybe Size

Results: False Negatives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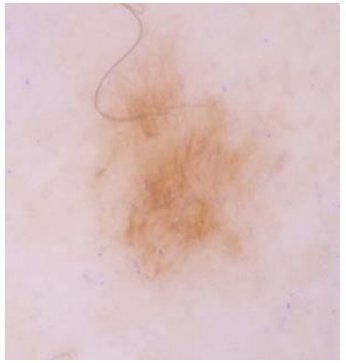
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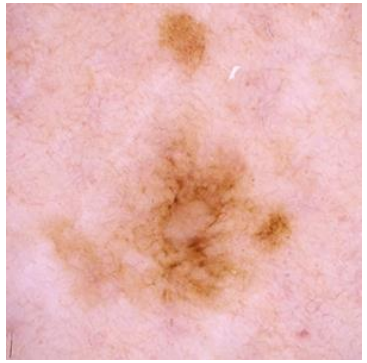
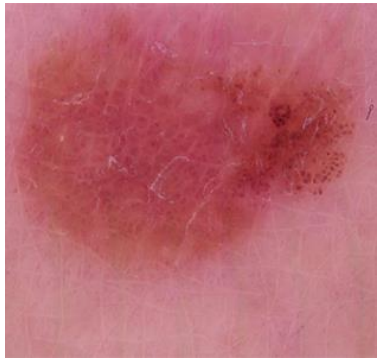
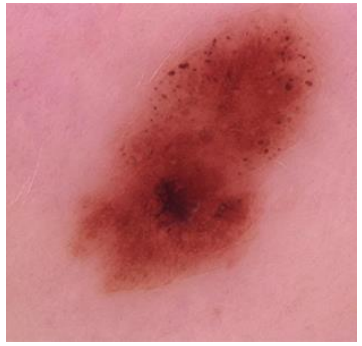
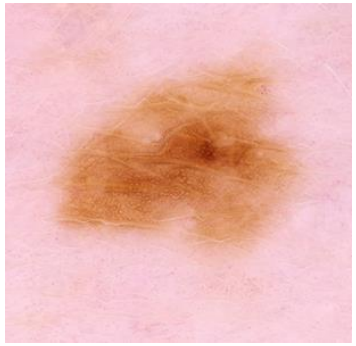
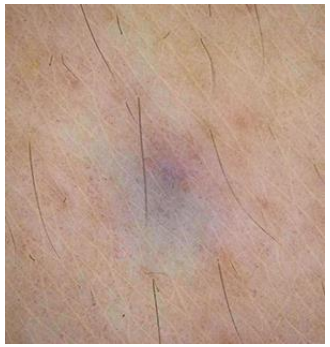

Asymmetry

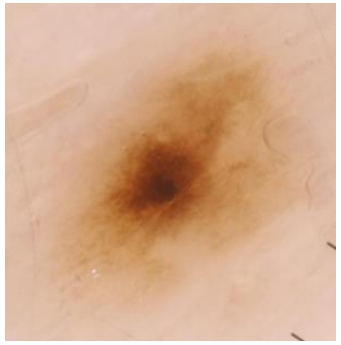

Maybe Size

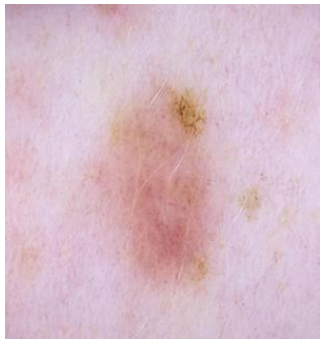

Size / Asymmetry


Asymmetry
Color

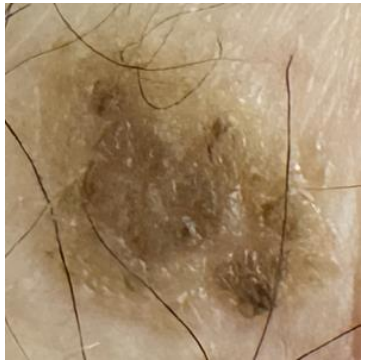

Asymmetry
Color


Color

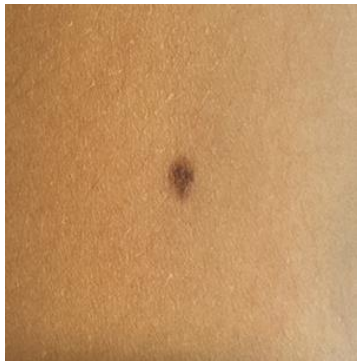

Asymmetry
Color


Asymmetry
Color

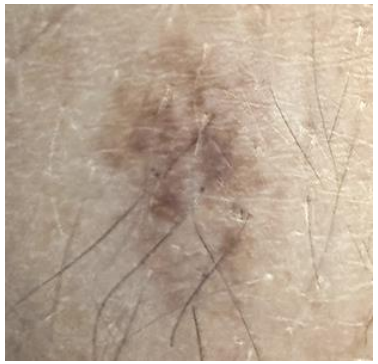
Results: Case Studies



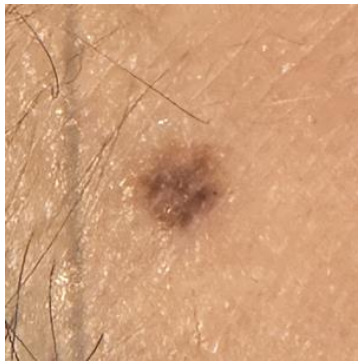
Asymmetry
Color / Size



Looks Normal

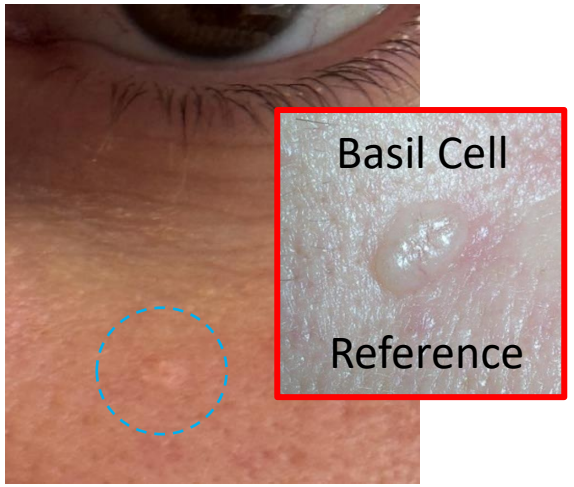


Asymmetry
Color



Looks Normal

Resembles Basil Cell



- Case Study 1: Model stated malignant, increasing in size, > 6 mm in size, previous history of skin cancer, getting biopsied
- Case Study 2: Model stated normal, present since birth, no history of skin cancer, < 6 mm in size
- Case Study 3: Model 50 / 50 (Inception vs. ResNet18) Normal vs. Malignant, present since birth, size not changing, > 6 mm (birth mark) – Low risk not getting evaluated
- Case Study 4: Model 50 / 50 (Inception vs. ResNet18) Malignant vs. Normal, present > 10 years, size not changing, < 6 mm – Low risk may have dermatologist evaluate in next visit (sometimes moles can develop malignancy)
- Case Study 5: Model stated malignant, high sun area on cheek, history of skin cancer, present < 5 years, itches, changing size growing – making an appointment to get removed and biopsied

Conclusions

- Improvement in machine learning model has merit (goal > 92%)
- Image analysis using machine learning for skin lesion diagnosis of benign vs. malignant can likely be enhanced with evaluating health history as part of the model
- A risk factor scale can be added to model to strongly encourage close cases to be evaluated by biopsy at a dermatologist's office

PRACTICAL APPLICATION: This approach has the potential to be a home screening test (with refinement) to encourage close cases to be evaluated while minimizing unnecessary trips to the dermatologist that usually have 2 – 3 month waiting periods