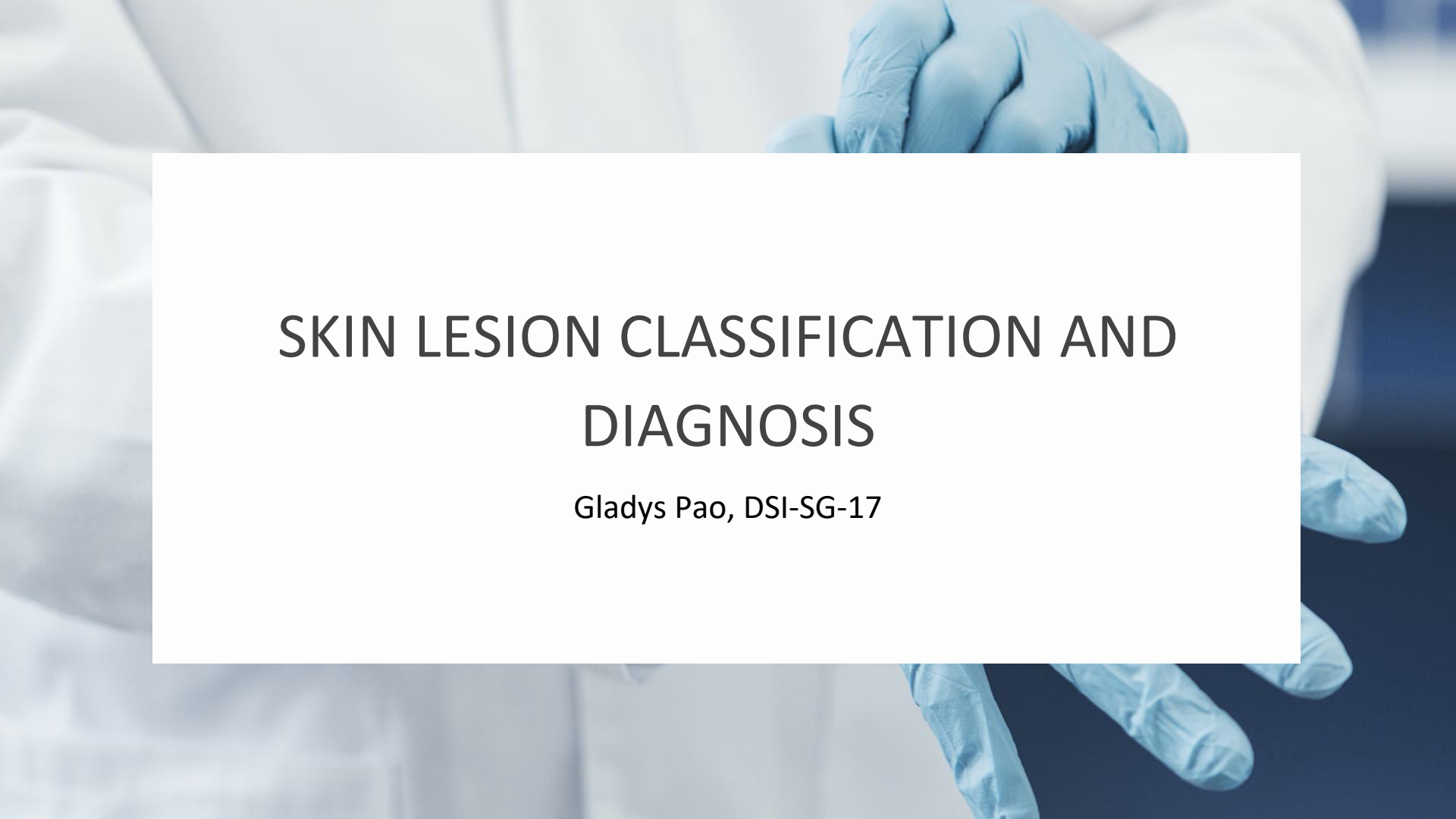


SKIN LESION CLASSIFICATION AND DIAGNOSIS

Gladys Pao, DSI-SG-17

PROBLEM STATEMENT

01 THE PROBLEM

- Skin cancer is the most common cancer globally
- Numerous lesions being misdiagnosed despite usage of dermoscopy
- $673 million in overall cost

02 THE STAKEHOLDERS

- Dermatologists
- Hospitals and skin cancer clinics in Singapore

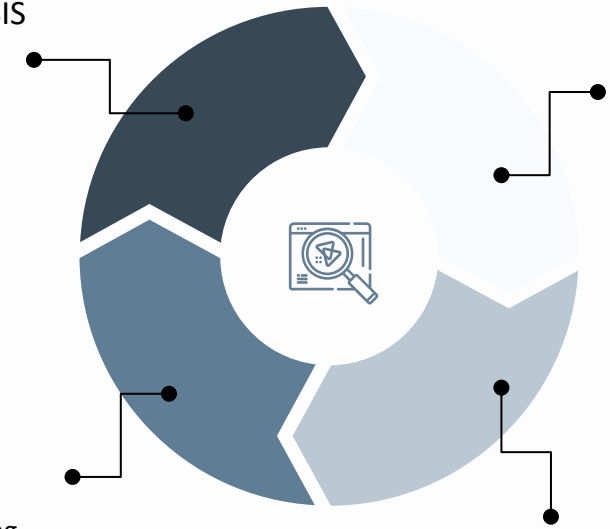
03 THE PURPOSE

- Improve diagnostic rate of skin lesions and cancer
- 2 classification tasks using Convolutional Neural Networks:
    - **Specific skin lesion diagnosis**
    - **Malignant, benign, or precancerous**
- Appropriate treatments for patients

METHODOLOGY

STEP 1:
EXPLORATORY DATA ANALYSIS

- Analyse trends in labelled and image data



STEP 2: IMAGE PREPROCESSING

- Standardise images (size, colour etc.)
- Data augmentation

STEP 3: MODELLING AND EVALUATION

- Convolutional Neural Networks
- Evaluation metrics (Accuracy and Recall)

STEP 4: CONCLUSION

- Recommendations moving forward

THE DATASET

DATA SOURCES

TOTAL NUMBER OF IMAGES

10,276

3 MAIN DATASETS

International Skin Imaging Collaboration (ISIC):

- 2018, 2019 and 2020 datasets

3 EXTERNAL DATASETS

- DermNet NZ
- Dermoscopedia
- 7-point Criteria Evaluation Database

TARGET VARIABLES

7 SKIN LESIONS

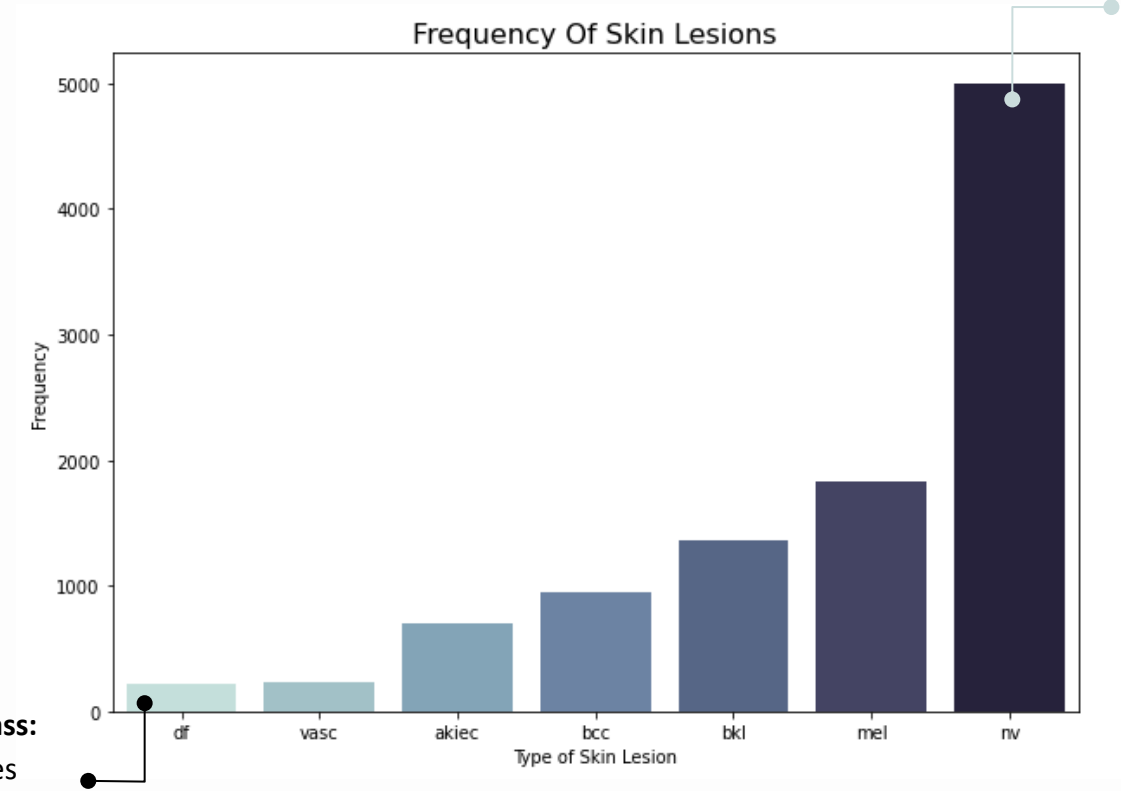
- Melanocytic Nevi (NV)
- Benign keratoses (BKL)
- Vascular lesions (VASC)
- Dermatofibroma (DF)
- Melanoma (MEL)
- Basal cell carcinoma (BCC)
- Actinic Keratoses (AKIEC)

3 TYPES OF DIAGNOSIS

- Benign
  - NV, BKL, VASC, DF
- Malignant
  - MEL, BCC
- Precancerous
  - AKIEC

EXPLORATORY DATA ANALYSIS

CLASS IMBALANCE



Majority class:
NV with
4992 images;

48.6%

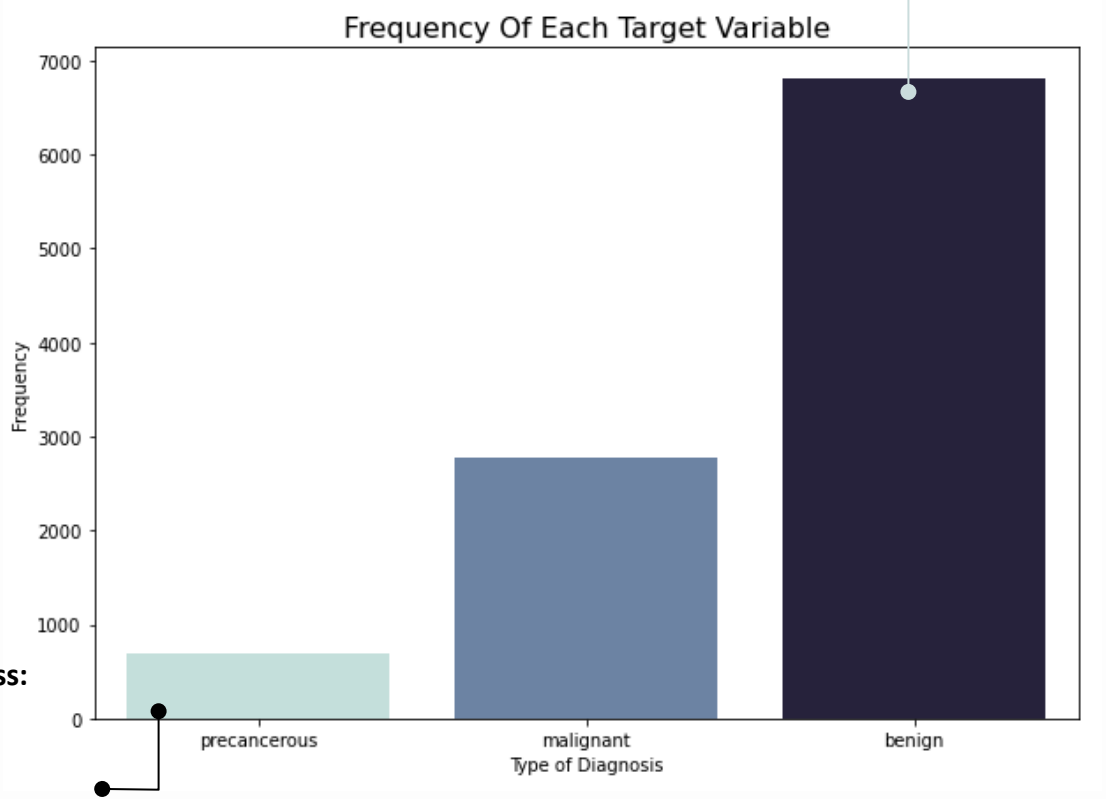
Lowest minority class:
DF with 217 images

2.1%

CLASS IMBALANCE

Majority class:
Benign with 6801 images

66.2%



Lowest minority class:
Precancerous with
696 images

6.8%

IMAGE SIZES

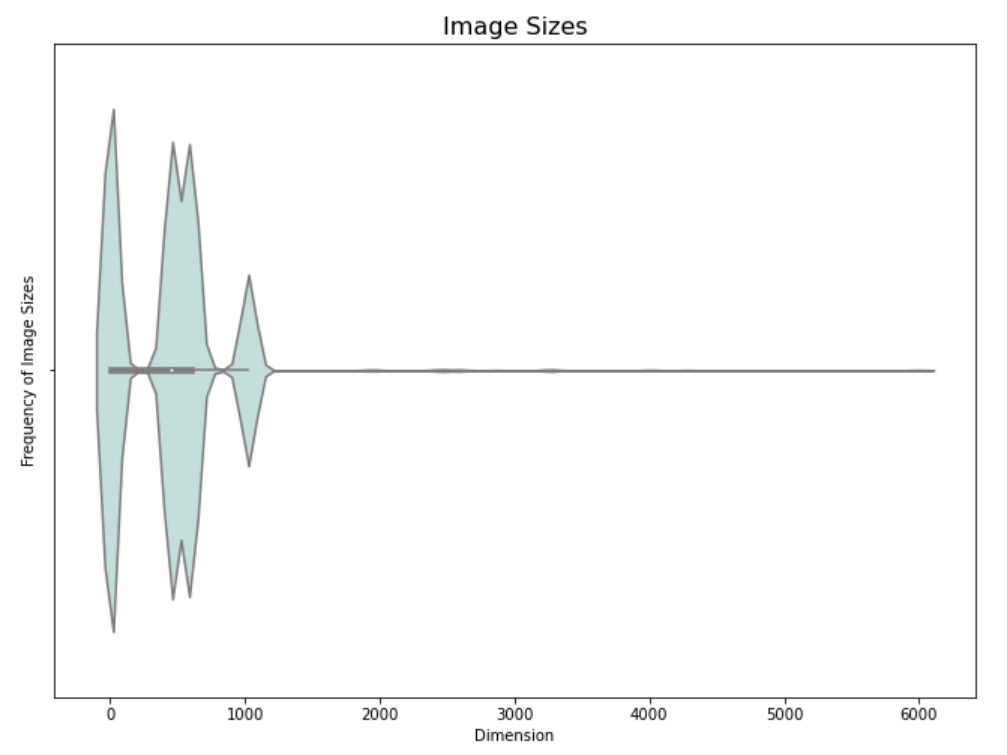
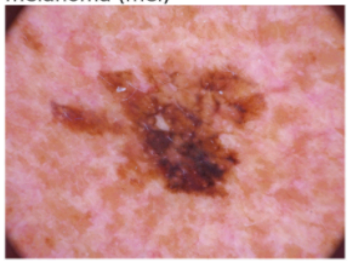


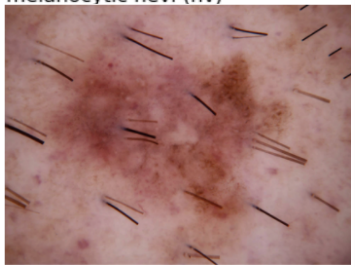
Image size	(1983, 1983)	(1775, 1775)	(4288, 2848)	(3024, 4032)	(2592, 3888)	(2317, 2317)	(511, 768)	(3456, 5184)	(2848, 4288)	(222, 294)	(4000, 6000)	(1936, 2592)	(2448, 3264)	(512, 768)	(1024, 1024)	(450, 600)
frequency	1	1	1	1	1	2	3	6	13	20	20	32	41	61	1770	8303

IMAGE ANALYSIS

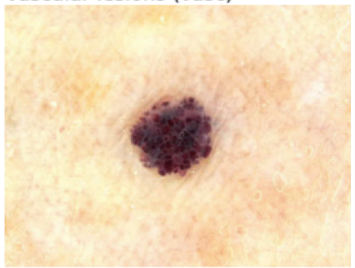
melanoma (mel)



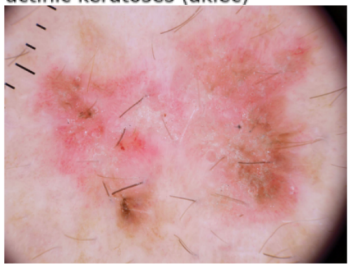
melanocytic nevi (nv)



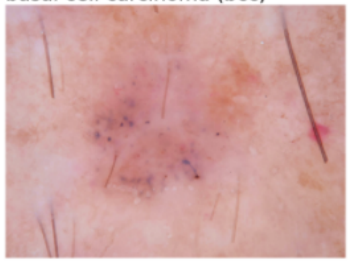
vascular lesions (vasc)



actinic keratoses (akiec)



basal cell carcinoma (bcc)



benign keratosis-like lesions (bkl)

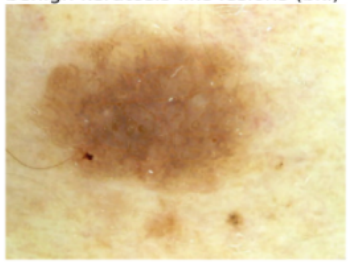


IMAGE PREPROCESSING

HAIR REMOVAL

ORIGINAL IMAGE

GREYSCALED IMAGE

BLACK TOP-HAT
TRANFORMATION

INCREASING THRESHOLD

INPAINTING
(image interpolation)

BLACK TOP-HAT TRANSFORMATION

- Enhance dark objects of interest in a bright background

HAIR REMOVAL

ORIGINAL IMAGE

GREYSCALED IMAGE

BLACK TOP-HAT TRANFORMATION
(morphological filtering)

INCREASING THRESHOLD

INPAINTING
(image interpolation)

INPAINTING

- Form of image interpolation
- Reconstruct missing parts of an image
- Replacing areas with pixels similar to the neighbouring ones

HAIR REMOVAL

ORIGINAL IMAGE

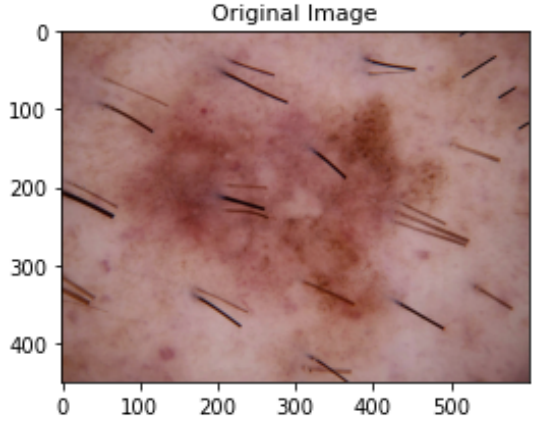
GREYSCALED IMAGE

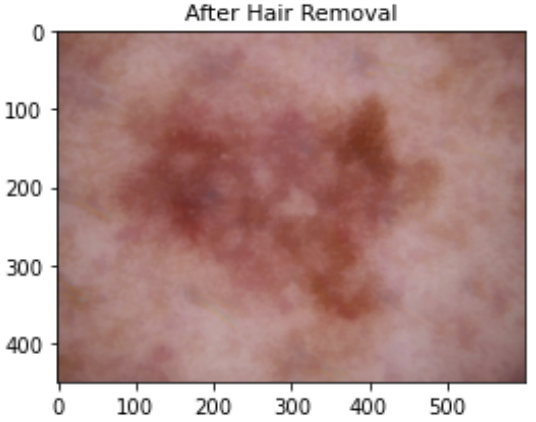
BLACK TOP-HAT TRANFORMATION
(morphological filtering)

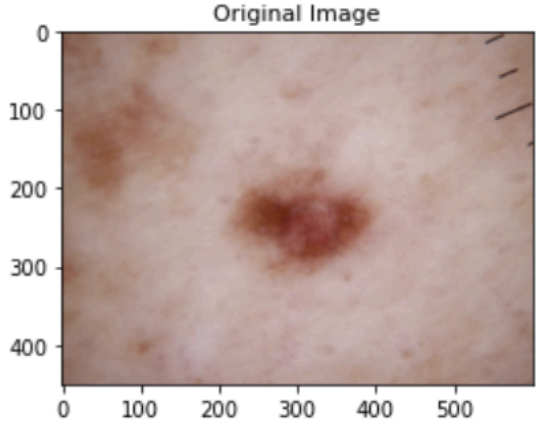
INCREASING THRESHOLD

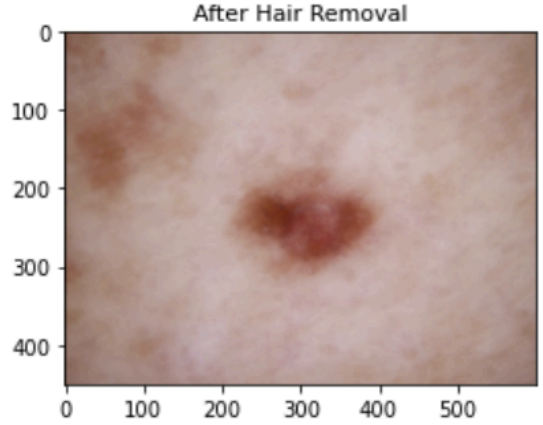
INPAINTING
(image interpolation)

HAIR REMOVAL



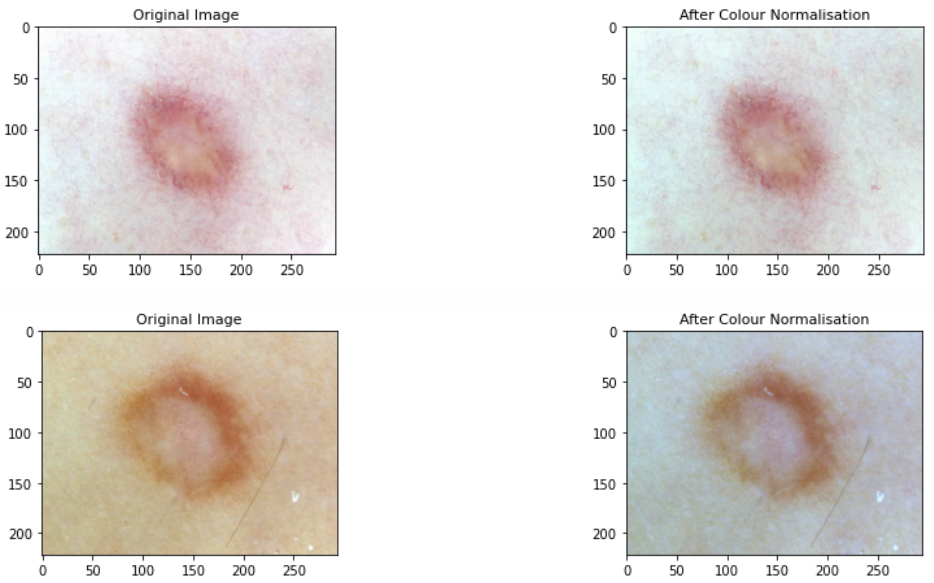




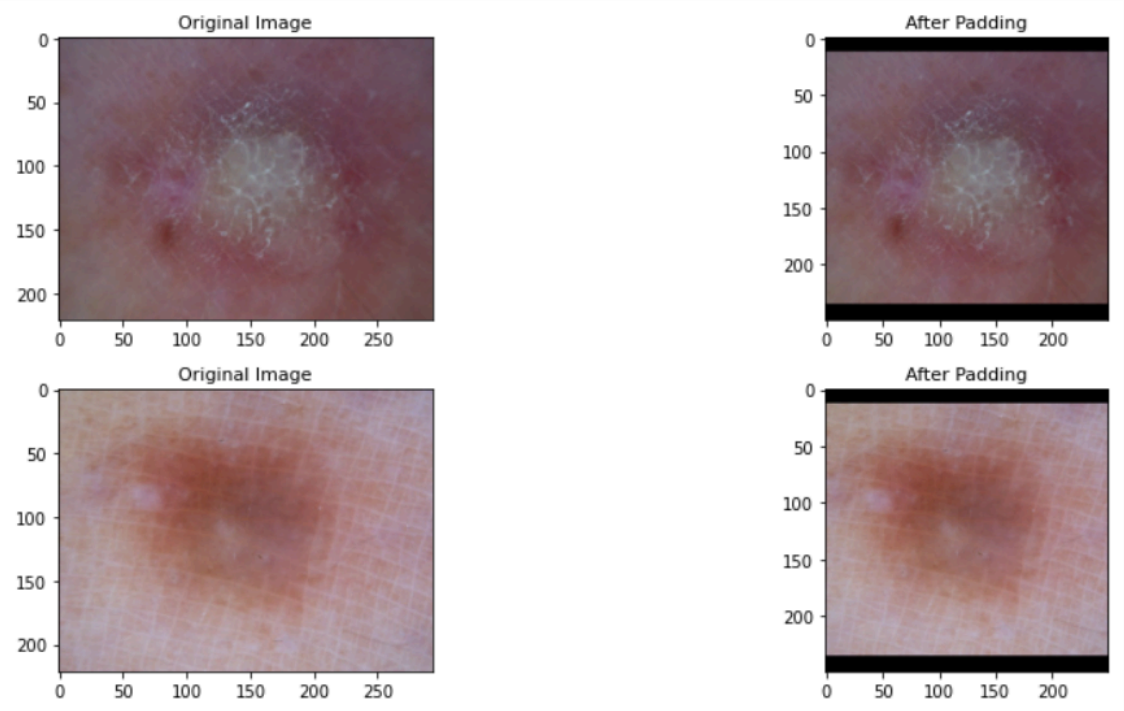


COLOUR NORMALISATION

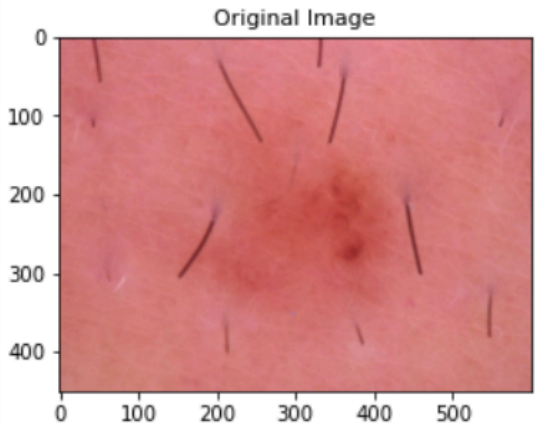
- **White-balancing Grey World Algorithm**
- Assumes equal average intensities of R, G, B channels
- R and B channels are multiplied by their respective gains
    - Gains = Average of G channel ÷ Average of respective channel

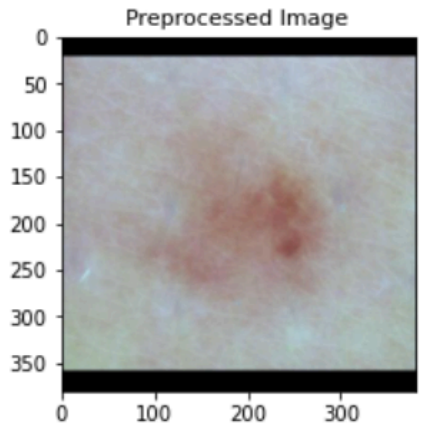


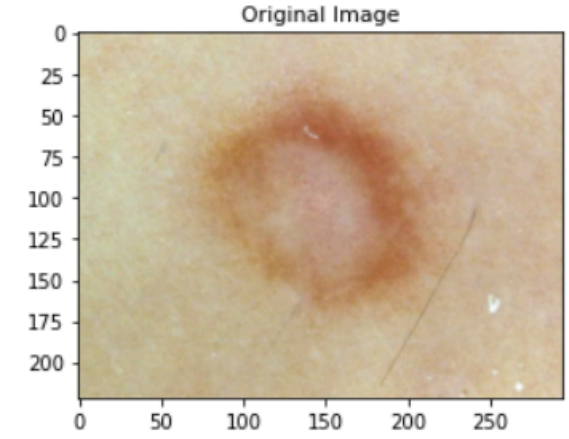
PADDING, CROPPING AND RESIZING

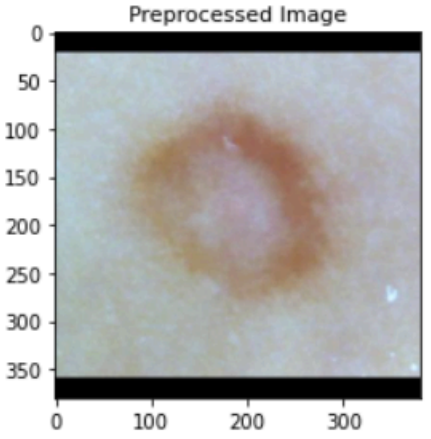


ORIGINAL VERSUS PREPROCESSED









SYNTHETIC MINORITY OVERSAMPLING TECHNIQUE (SMOTE)

- Generates synthetic samples for the minority classes
- Obtain a synthetically class-balanced training set
- Split data into a 60-20-20 ratio and used SMOTE on the training set

TASK 1:
SKIN LESION CLASSIFICATION

20,965

images

TASK 2:
DIAGNOSIS CLASSIFICATION

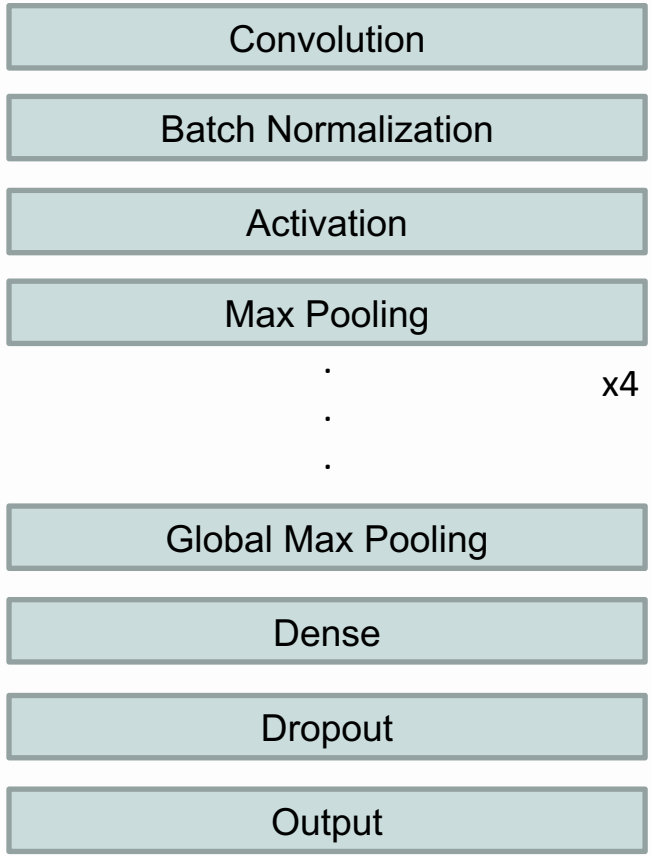
12,240

images

MODELLING AND EVALUATION

CONVOLUTIONAL NEURAL NETWORKS

- Similar model architecture for both tasks
- **Batch Normalization**
  - Standardize inputs of each layer
  - Faster training times
  - Better model performance
  - Better regularization effect (compared to Dropout)



TASK 01

SKIN LESION CLASSIFICATION

7-way Classification

BASELINE MODEL:

Artificial Neural Networks

56.8%

ACCURACY RATE

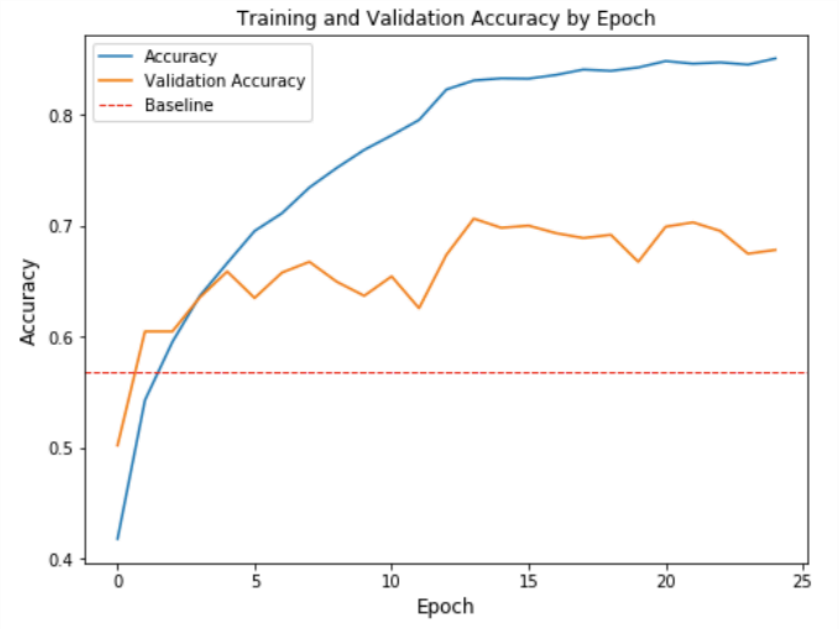
75.6%

TOP 2
ACCURACY RATE

38.4%

AVERAGE
RECALL RATE

CONVOLUTIONAL NEURAL NETWORKS



70.7% > **56.8%**

ACCURACY RATE

BASELINE ACCURACY

86.2% > **75.6%**

TOP 2
ACCURACY RATE

BASELINE TOP 2
ACCURACY

57.7% > **38.4%**

AVERAGE
RECALL RATE

BASELINE RECALL

MODEL EVALUATION

70.5%

TEST
ACCURACY RATE

0.1%
DIFFERENCE

86.2%

TEST TOP 2
ACCURACY RATE

0%
DIFFERENCE

60.7%

TEST AVERAGE
RECALL RATE

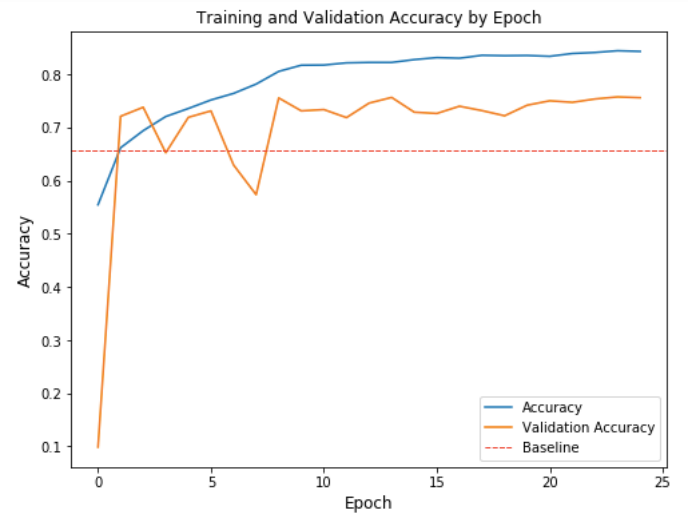
3%
DIFFERENCE

TASK 02

DIAGNOSIS CLASSIFICATION

3-way Classification: Benign, Malignant or Precancerous

CONVOLUTIONAL NEURAL NETWORKS



75.8%

ACCURACY RATE

>

65.8%

DERMATOLOGISTS' ACCURACY RATE

63.6%

AVERAGE RECALL RATE

>

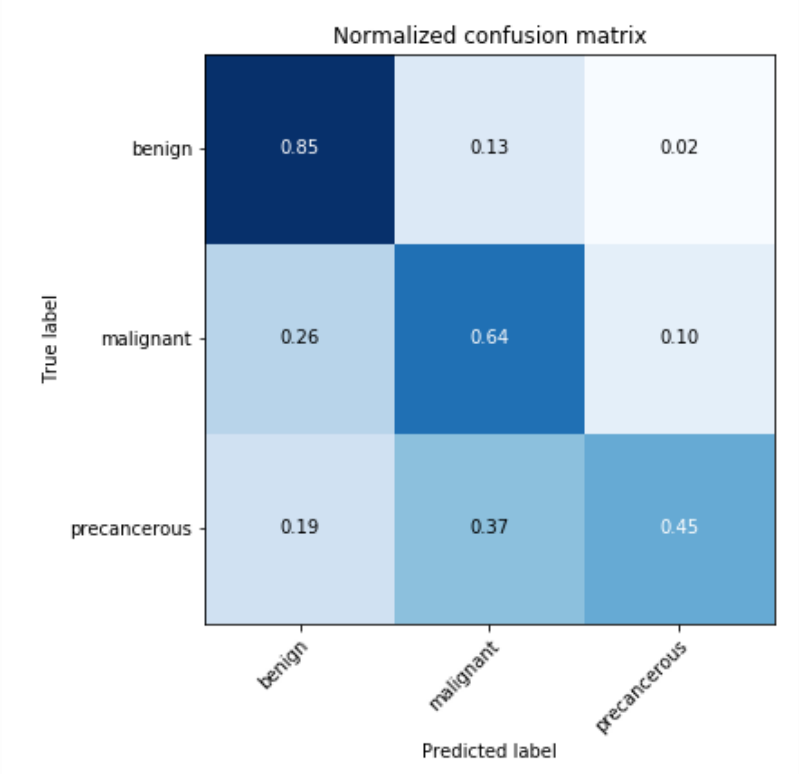
49.2%

DERMATOLOGISTS' AVERAGE RECALL RATE

MODEL EVALUATION

	Accuracy	Average Recall Rate
Validation	75.8%	63.6%
Test	76.4%	64.4%
Difference	**0.6%**	**0.8%**

MODEL EVALUATION



MODEL EVALUATION

76.4%

ACCURACY RATE

64.4%

AVERAGE
RECALL RATE

63.5%

AVERAGE
PRECISION RATE

64.0%

AVERAGE
F1 SCORE

CONCLUSION

CONCLUSION

- Moderately high accuracy at 70.5% for the skin lesion classification task, and 76.4% for the diagnosis classification task
- Recall rates surpassed baseline scores
- Performed well for most benign skin lesions (especially for diagnosis classification)
    - Serve as great models specifically for benign skin lesions in the future

RECOMMENDATIONS

1. Collect more data for minority classes
2. Build a web application for secure in-house usage at hospitals and skin cancer clinics
3. Add additional clinical data (demographic data of patients, and characteristics of lesions)
    - Feed into fully connected network
    - Merging outputs
4. Expand classification task to include other type of lesions
    - Non-neoplastic lesions (diagnosis classification)
    - Cystic lesions (skin lesion classification)

THANK YOU