Impact of Quality of Image Database on AI Performance in Skin Cancer Detection

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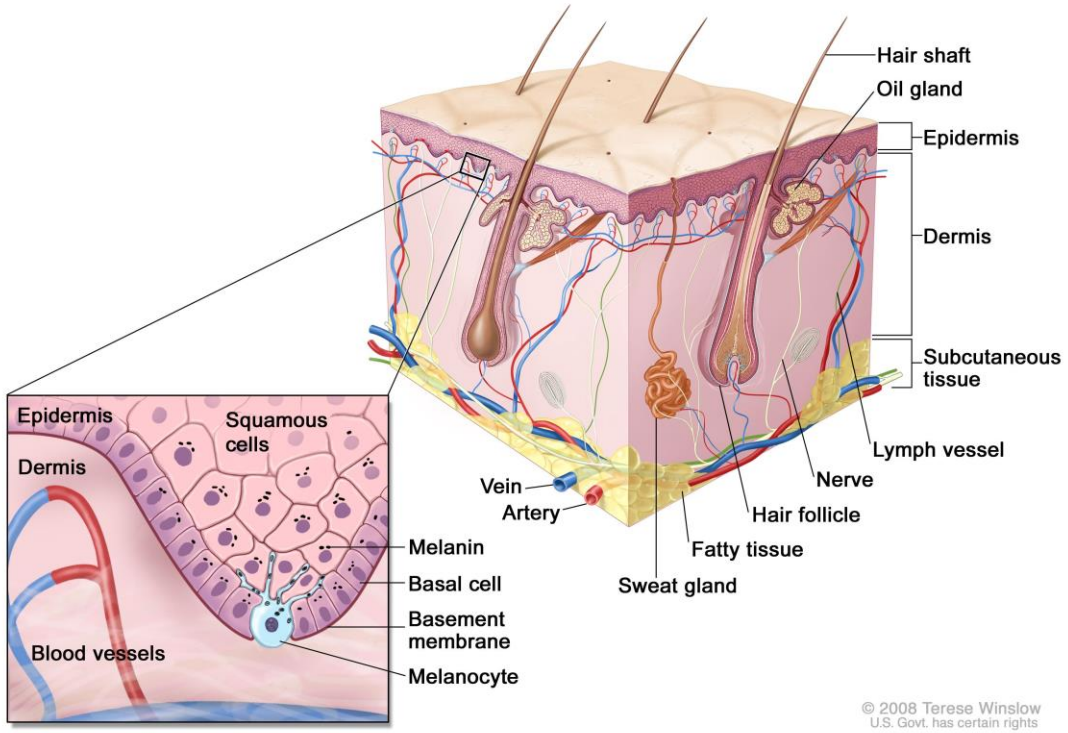
Motivation

- > 82,000 New Zealanders get skin cancer every year
- Due to depletion of ozone layer, this number is increasing 10-20% annually, accounting 80% of all new cancers in NZ.
- Melanoma is the most deadly one in all skin cancers, accounting <5% of all skin cancers, but responsible for >75% of total death.
- the highest incidence rate from melanoma NZ > Australia > European countries.
- Most skin cancers can be prevented if detected early.

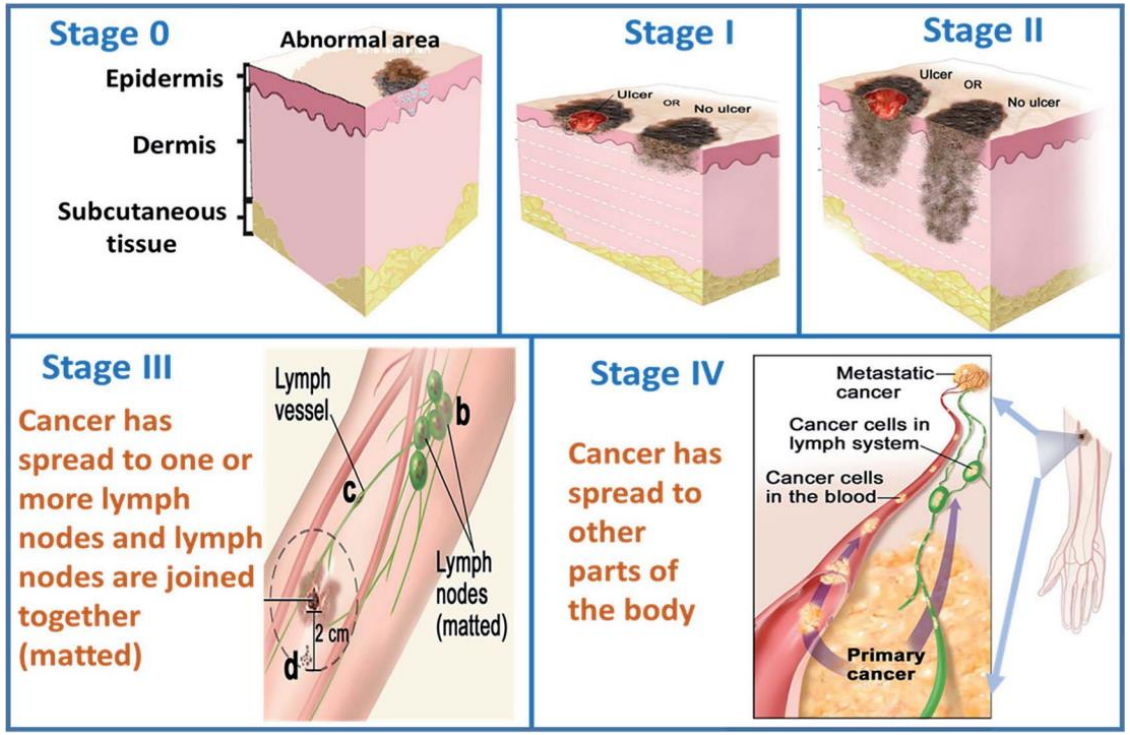
Major cause : Over-exposure of UV rays

Introduction

- Early detection would increase Melanoma 5 years' survival rate from 15% to 99%.

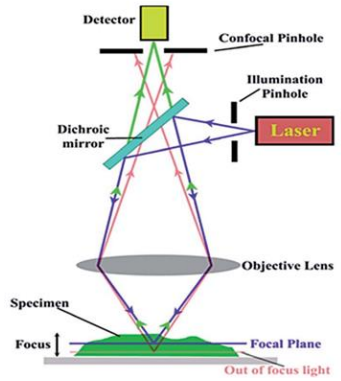


Normal Skin



Five Stages of Skin Cancer

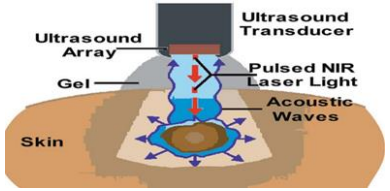
Non-Invasive Detection of Skin Cancer



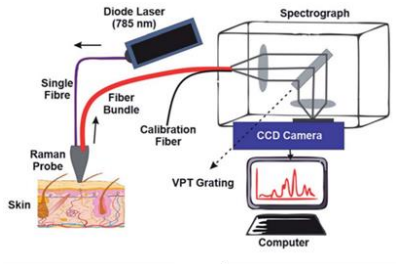
Reflectance Confocal Microscopy

Dermatoscopy

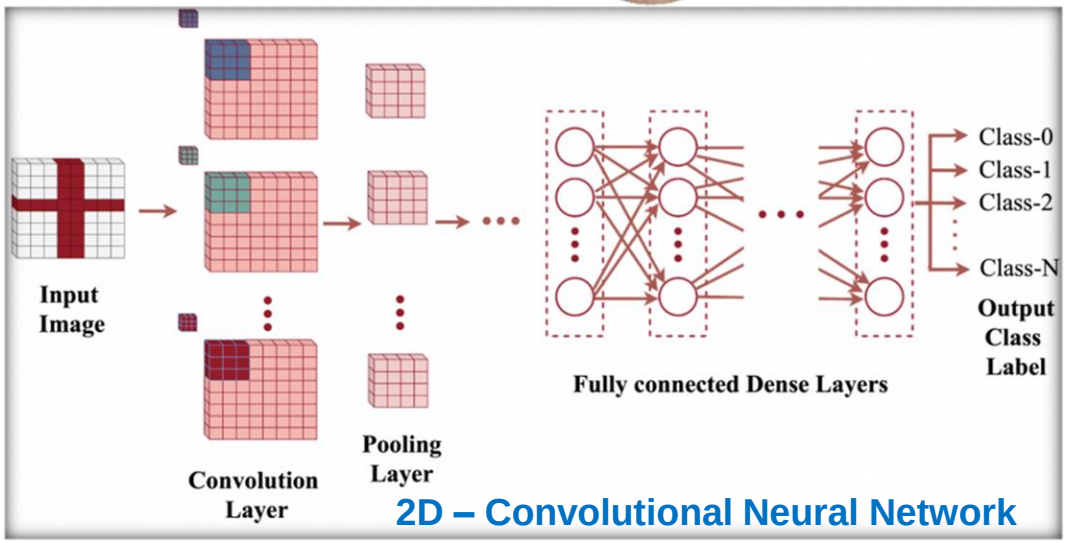
Fast, Easy Accessible, Low-cost,



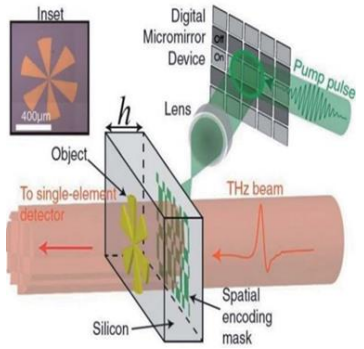
High-frequency ultrasound



Raman spectroscopy



2D – Convolutional Neural Network



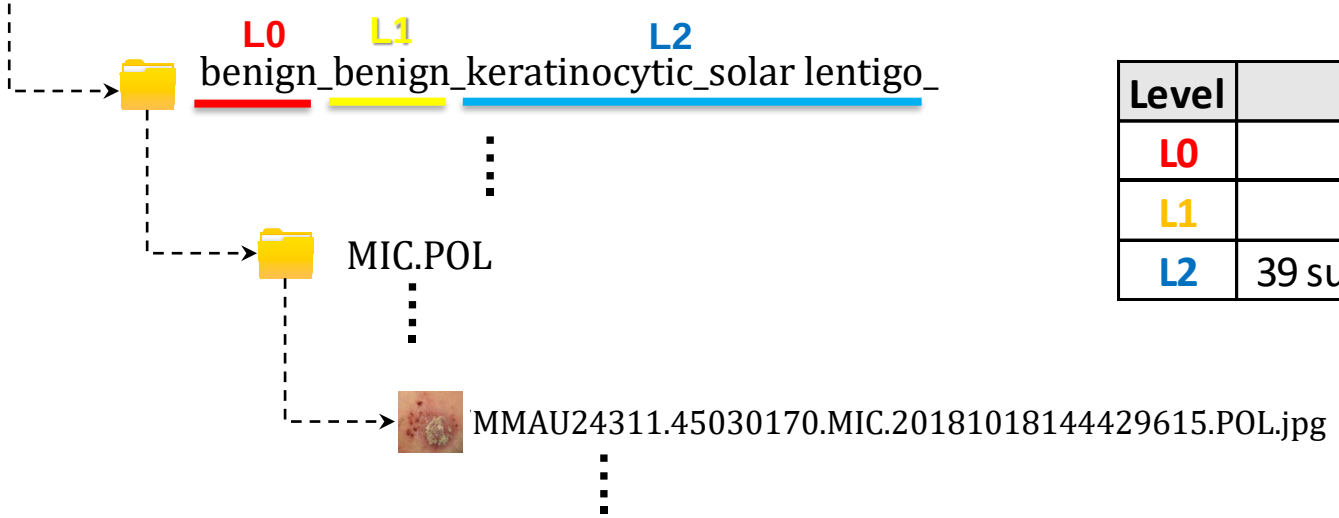
Tetrahertz Spectroscopy

Research Questions

- How to track, analyze, manage image database modification
- How to track uniqueness of image files and archive them in SQL database
- What is the relationship of the quality of AI Database to the model performance

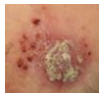
Methods

- Structure of AI database: three-level labeling system



Level	Classes
L0	Benign , Malignant
L1	Benign, IEC, Melanoma, NMSC
L2	39 subclasses, e.g.,Dermatofibroma, Keratinocytic

- Image-hashing to track uniqueness of images



SHA256 →

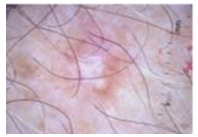
Hash Code (256 bits)

44f3142b5c659e96ca4557b5d45f061e3479ca49aa3e0ed4a27fcb412502d88f

Statistical Analysis on AI database

Three kinds of errors in AI database:

1, 0.15% Redundancy due to multi-upload error



ASP305456.31550590.MIC.20140428080042946.POL.jpg
ASP701991.31550590.MIC.20140428080042946.POL.jpg
ASPH03700.31550590.MIC.20140428080042946.POL.jpg

2, 0.22% Cross-labelling

name	path	hashcode
@POD00004.14970729.MIC.20140503120707252.POL.jpg	malignant_melanoma_melanoma_/MIC	30fa4765b3cd19236d59cfef45faf25d01ecd4d15e95c3f41887e997d10bb846
@POD00004.14970729.MIC.20140503120707252.POL.jpg	benign_benign_vascular_telangiectasia_/benign_benign_nevus benign_/MIC.POL	30fa4765b3cd19236d59cfef45faf25d01ecd4d15e95c3f41887e997d10bb846

3, 22.56% Repetitive - labelling

Deleted + some re-labellings

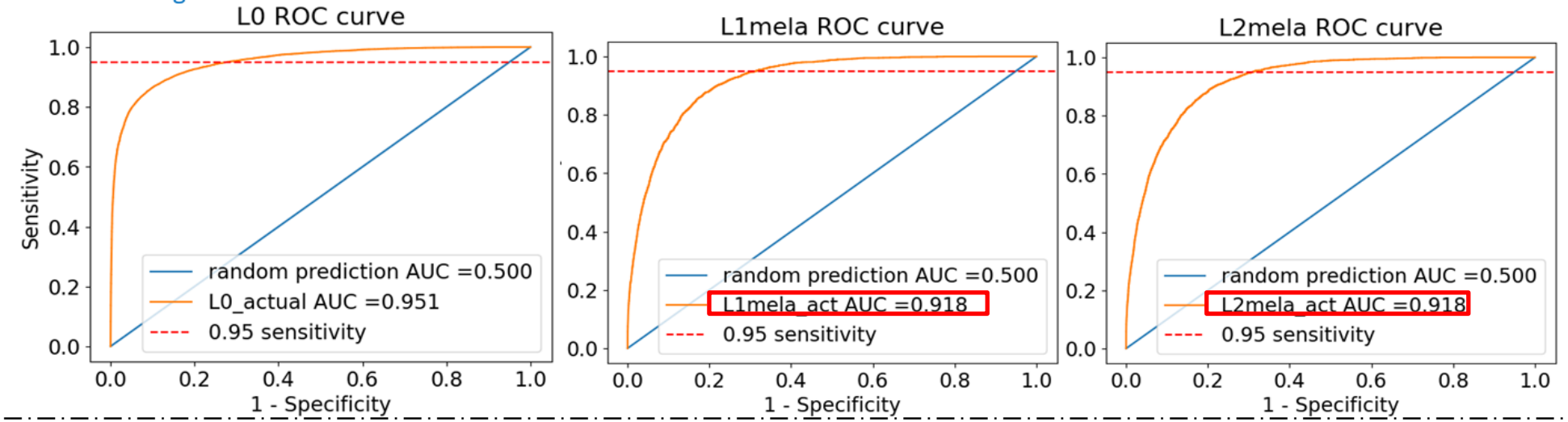
Derivations	L0	L1 melanoma	L2 melanoma
Sensitivity(TPR)	0.95	0.95	0.95
Specificity(TNR)	0.72	0.69	0.69
Precision (PPV)	0.74	0.17	0.18
Distribuion of lesion(1/PPV)	1.36	5.77	5.70
Negative predictive value NPV	0.95	1.00	1.00
pevalence threshold(PT)	0.35	0.37	0.36
F1-score	0.83	0.29	0.30
Accuracy(ACC)	0.82	0.70	0.71
After cleaning			
Sensitivity(TPR)	0.95	0.95	0.95
Specificity(TNR)	0.72	0.69	0.70
Precision (PPV)	0.74	0.20	0.21
Distribuion of lesion(1/PPV)	1.36	4.93	4.86
Negative predictive value NPV	0.95	0.99	0.99
pevalence threshold(PT)	0.35	0.36	0.36
F1-score	0.83	0.34	0.34
Accuracy(ACC)	0.82	0.71	0.72

Statistical Analysis on AI database

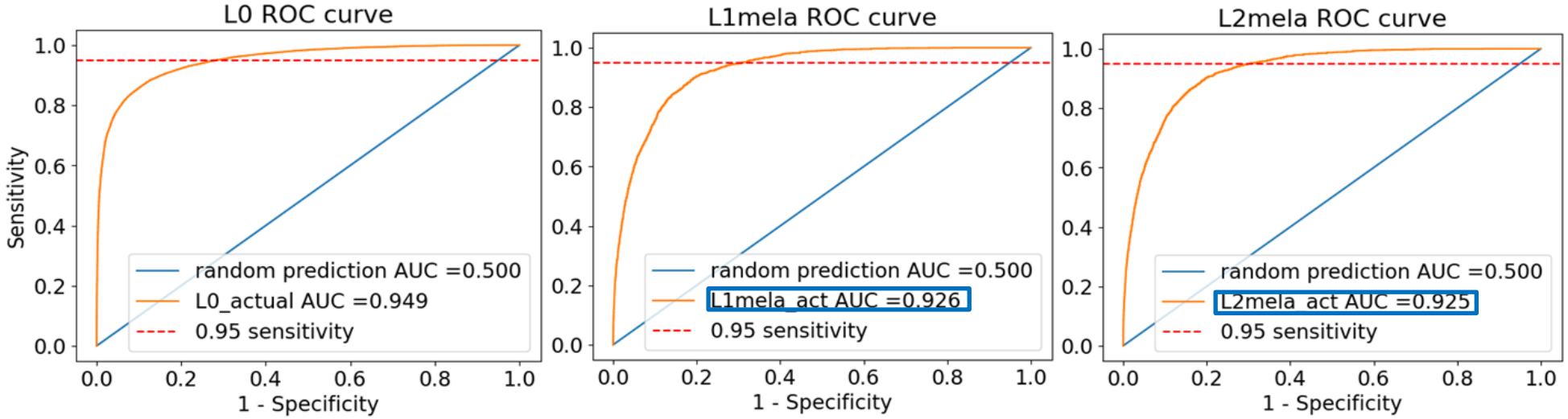
Description	Total image with labels	% in Total
Total	835,214	100.00%
Unique file name + labels	835,214	100.00%
No pure duplicates exist		
Duplicated image names	190,218	22.77%
Duplicated hash codes	191,448	22.92%
Difference: same images named with different filenames	1,230	0.15%
Unique images names	644,996	77.23%
Unique hashcode (absolute unique images)	643,766	77.08%
L0 labels analysis in duplicated filenames		
L0 - cross labelling of malignant and benign	1820	0.22%
L0 - repeative labelling of malignant or benign	188398	22.56%
subtotal:	190218	22.77%
L1 labels analysis in duplicated filenames		
L1 - cross labelling of benign:benign and malignant:iec	256	0.03%
L1 - cross labelling of benign:benign and malignant: melanom	1137	0.14%
L1 - cross labelling of benign:benign and malignant:nmsc	427	0.05%
L1 - cross labelling of malignant:iec and malignant:melanoma	16	0.00%
L1 - cross labelling of malignant:iec and malignant:nmsc	448	0.05%
L1 - cross labelling of malignant:melanoma and malignant:nm	66	0.01%
L1 - repeative labelling of benign:benign	187483	22.45%
L1 - repeative labelling of malignant:iec	177	0.02%
L1 - repeative labelling of malignant:melanoma	54	0.01%
L1 - repeative labelling of malignant:nmsc	154	0.02%
subtotal:	190218	22.77%

ROC curve comparison of binary classification

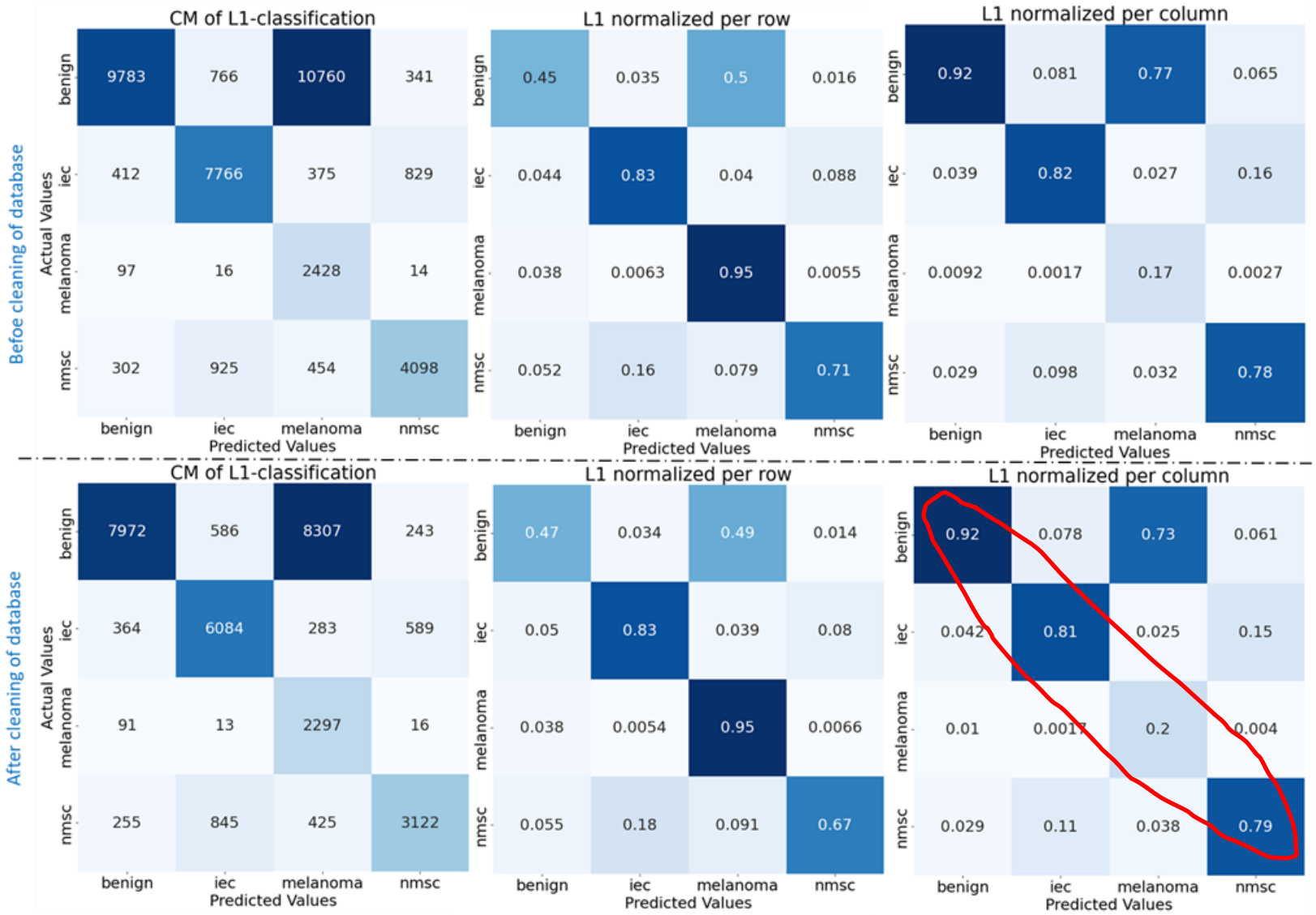
Before cleaning of database



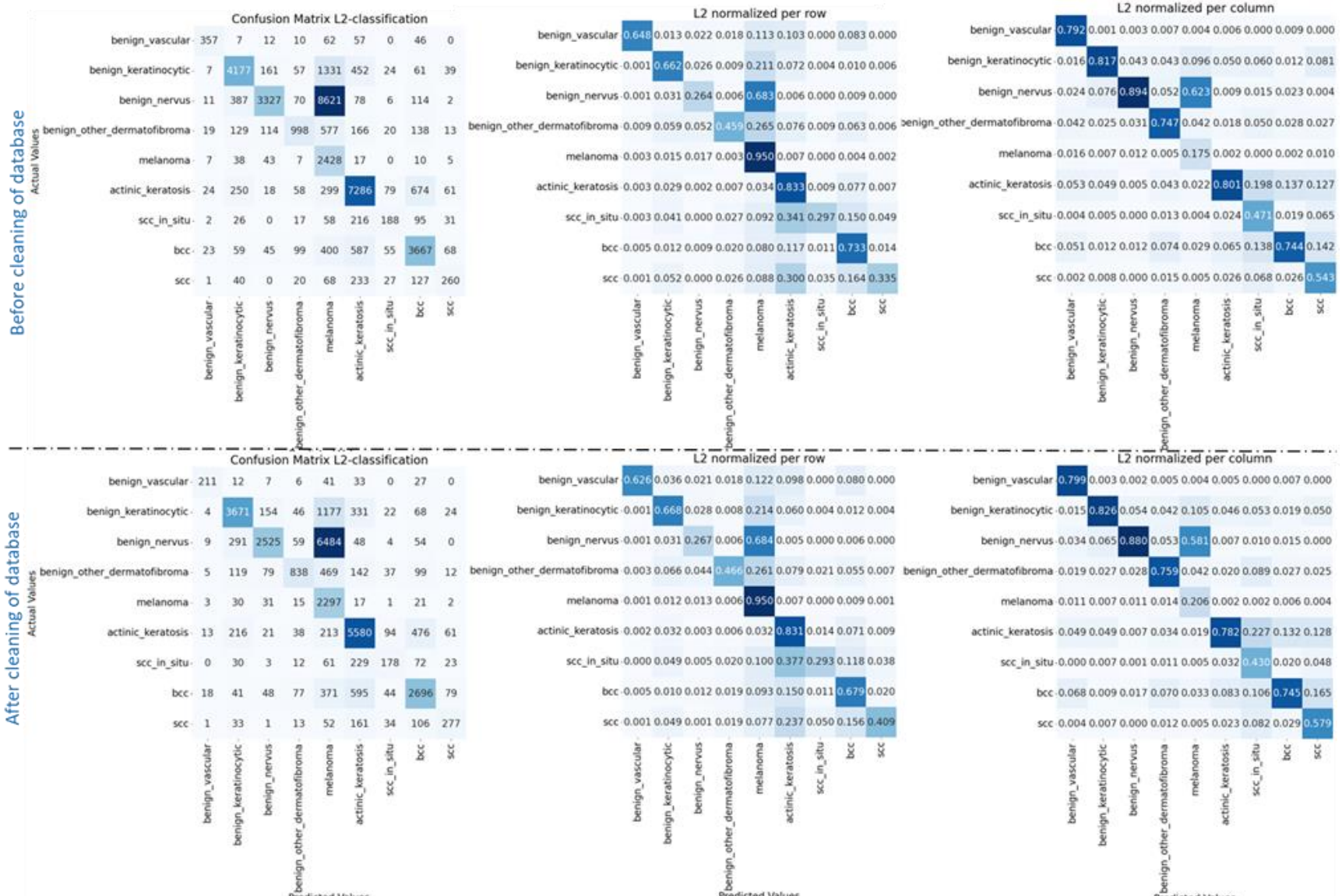
After cleaning of database



Confusion matrix of 4-class classification



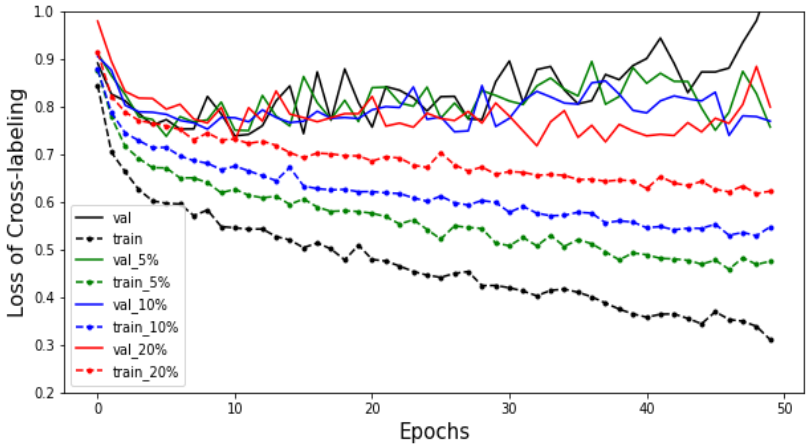
Confusion matrix of 9-class classification

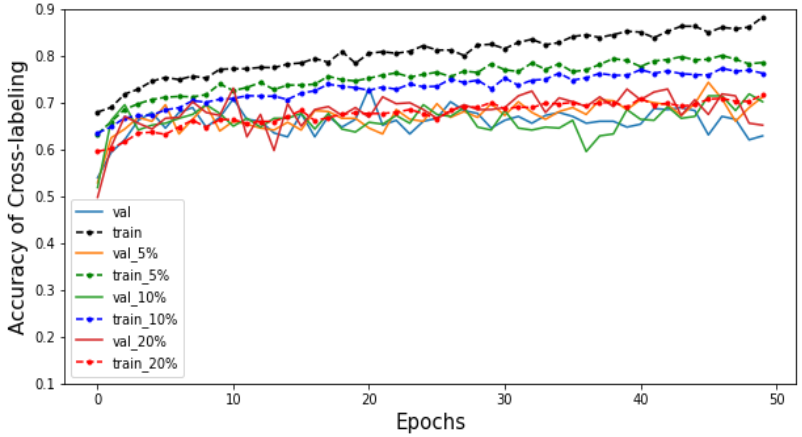


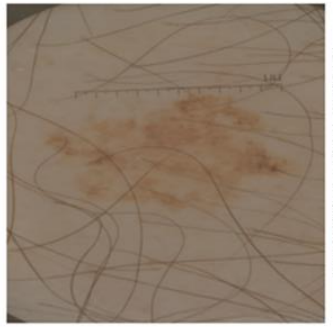
Simulation with Melanoma Dataset

Use EfficientNet CNN model on ISIC Melanoma Detection Dataset with 5%, 10% and 20% redundancy of both

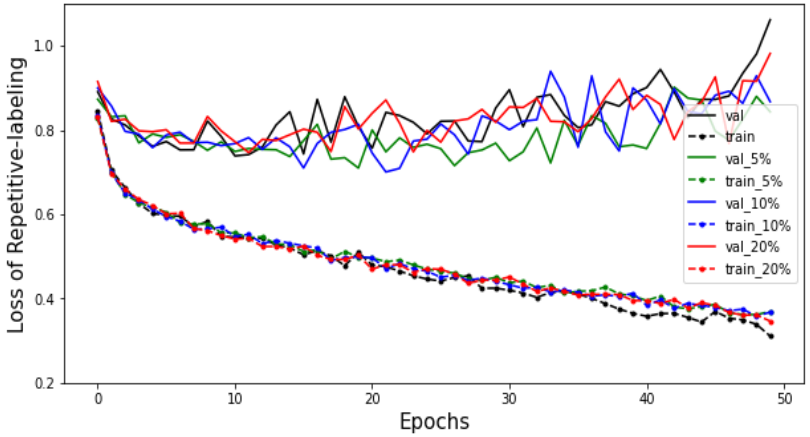
Cross-labelling

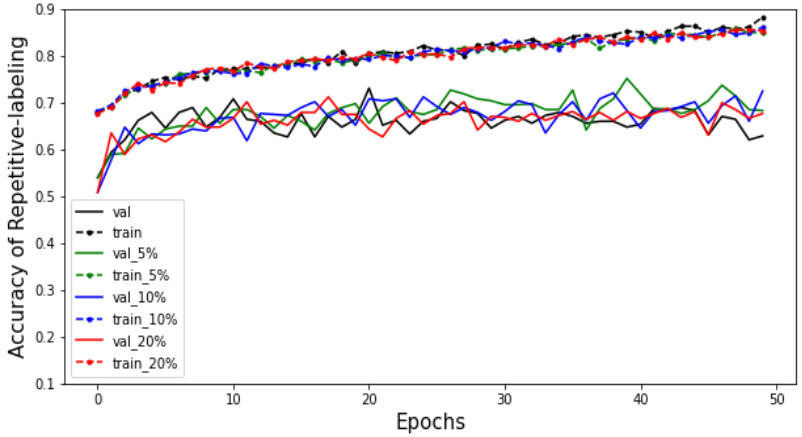


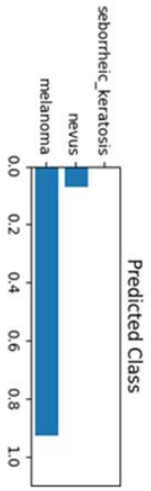




Repetitive-labelling







Cross-labelling would potentially damage AI performance, while unclear in repetitive-labelling.

Future Prospects

- Boost accuracy via pre-processing (e.g., ESRGAN) and post-processing (e.g., Xgboost)
- Manage class imbalance and skin-color bias of AI database and their connection to AI performance
- Incorporate CNN model with metadata ML models

Selected References:

- “New Zealand skin cancer statistics,” Science Learning Hub, https://www.sciencelearn.org.nz/resources/1329-new-zealand-skin-cancer-statistics (accessed Nov. 18, 2022)
- Narayanamurthy, Vigneswaran et.al., "Skin cancer detection using non-invasive techniques, "*RSC Adv.,* Vol.8, issue 49, pp. 28095-28130, 2018. doi : 10.1039/C8RA04164D.
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- Esteva, A., et al., “Dermatologist-level classification of skin cancer with deep neural networks,” *Nature*, vol. 542, pp. 115–118, 2017, https://doi.org/10.1038/nature21056

Thank you!

Questions?