Evaluation of Image Pre-processing Techniques for Improved Rice Leaf Disease Detection

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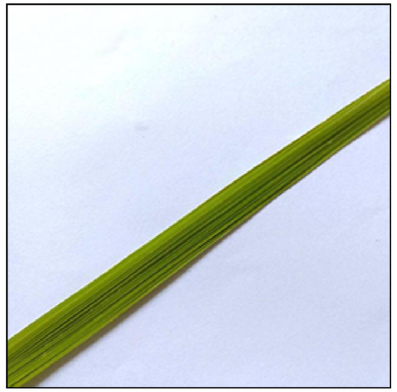
Introduction

- Rice
- Crop Loss
- Disease Management
- Image pre-processing



Oryza sativa L.
(Healthy)

Xanthomonas oryzae pv. oryzae
(Bacterial Leaf Blight)

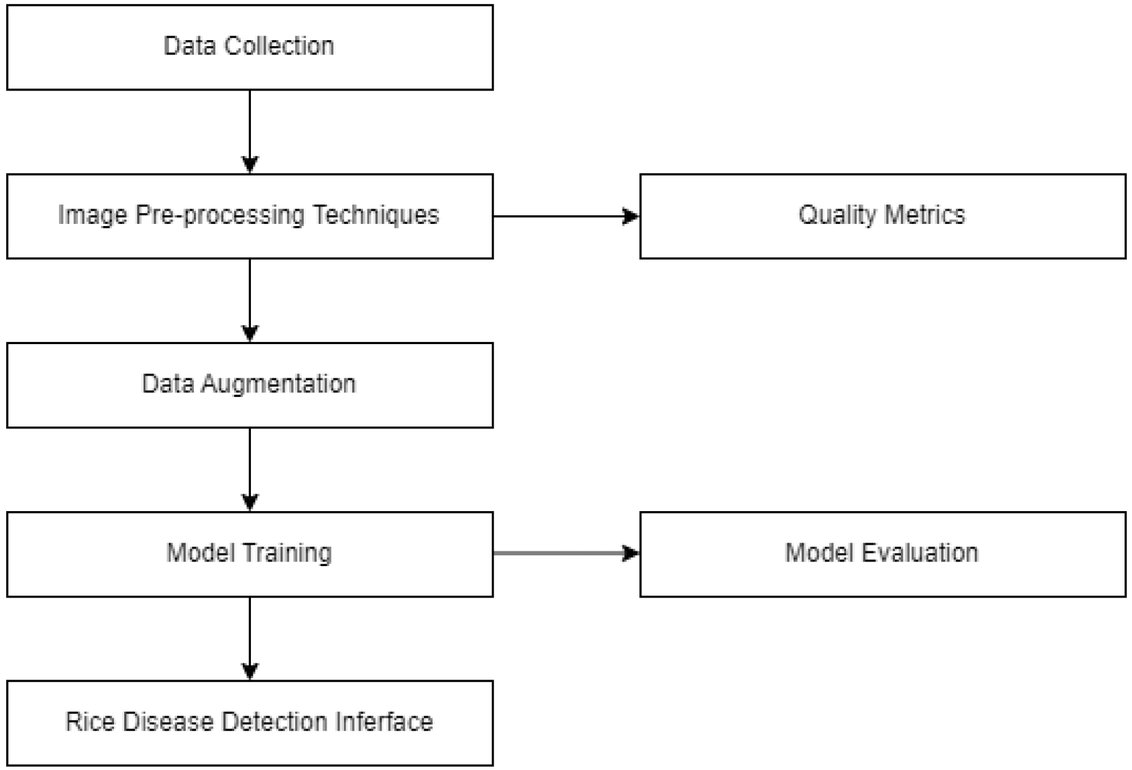
Cochliobolus miyabeanus
(Brown Spot)

Magnaporthe grisea
(Leaf Blast)

Cercospora oryzae
(Narrow Brown Spot)

Microdochium oryzae
(Leaf Scald)

Methodology



- The chosen dataset of rice leaf disease images used were from Roboflow Universe entitled ”Rice Leaf Disease detection obj Computer Vision Project”
- Image pre-processing techniques used are Histogram Equalization and Contrast Stretching
- Images were evaluated using quality metrics specifically Peak Signal-to-Noise Ratio, Normalized Root Mean Square Error, and Structural Similarity Index
- Data Augmentation and Model Training were done using using ConvXT, a convolutional neural network (CNN) development tool, available at CINTERLABS
- The web application was built using HTML5, JS, CSS and Flask.

Results

Original Image

Histogram Equalization

Contrast Stretching 1

Contrast Stretching 2

PSNR

- tells you how much noise or distortion is present in the reconstructed image
- Higher PSNR indicates better quality

	HE	CS	CS2
brown spot	11.06969543	20.29281726	18.64096447
healthy	9.855276498	19.41013825	17.7859447
leaf blast	11.20461905	20.18447619	18.07047619
leaf blight	14.28692521	19.38709141	17.18451524
leaf scald	14.59628492	24.3503352	23.51162011
narrow brown spot	14.50629902	22.50928922	22.16166667
MEAN	**12.58651669**	**21.02235792**	**19.5591979**

NRMSE

- similar to PSNR; calculates the average squared difference between the intensity values of each pixel in the reconstructed image.
- Lower NRMSE indicates better quality

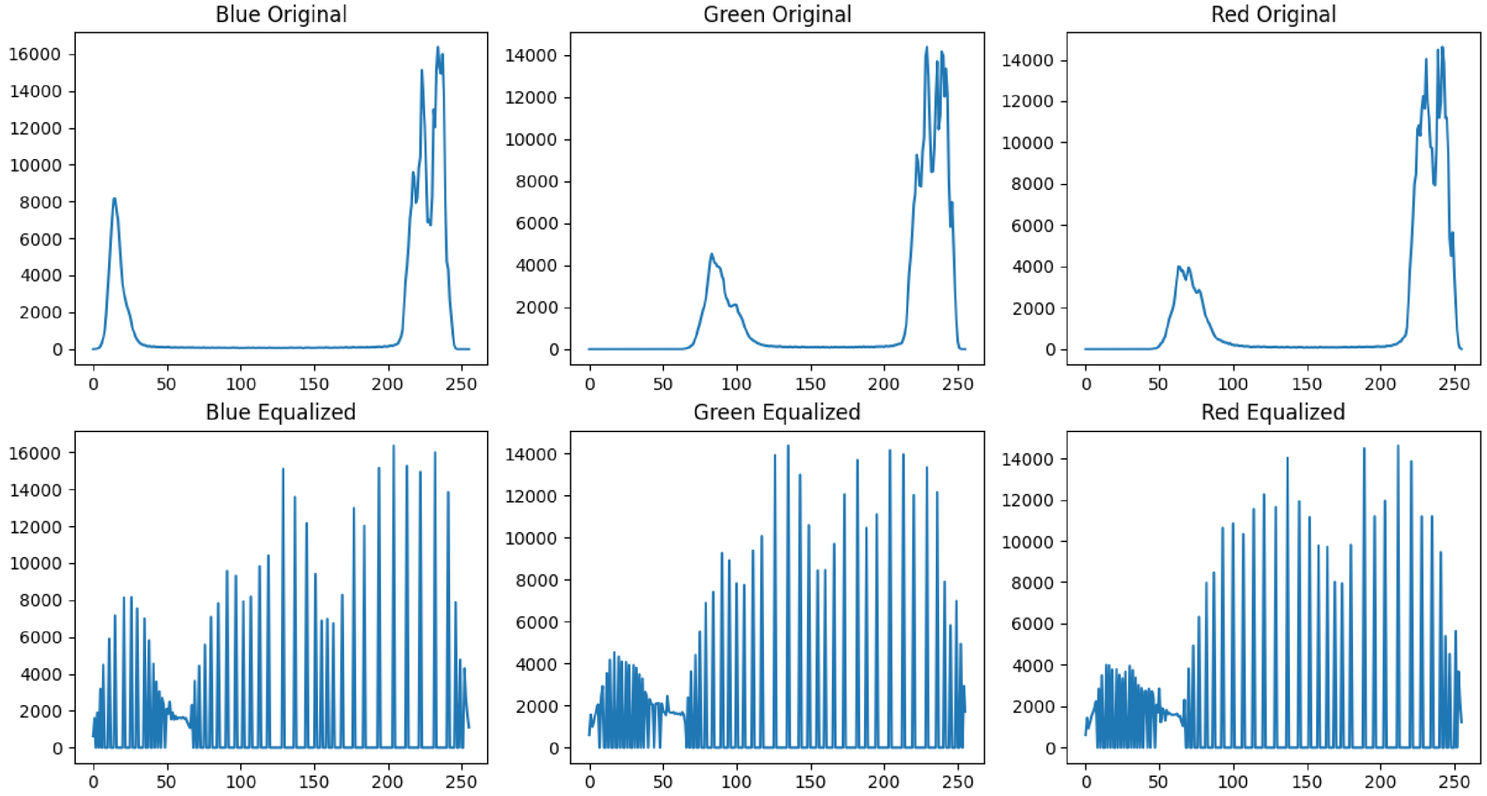
	HE	CS	CS2
brown spot	0.2932424365	0.1009069289	0.1237681472
healthy	0.3269909677	0.1089079263	0.1314761751
leaf blast	0.2973081905	0.1083819286	0.1410157143
leaf blight	0.2025302493	0.1120404432	0.1440661773
leaf scald	0.1920848045	0.06319452514	0.06930268156
narrow brown spot	0.192079951	0.07652509804	0.0794732598
MEAN	**0.2507060999**	**0.09499280836**	**0.1148503592**

SSIM

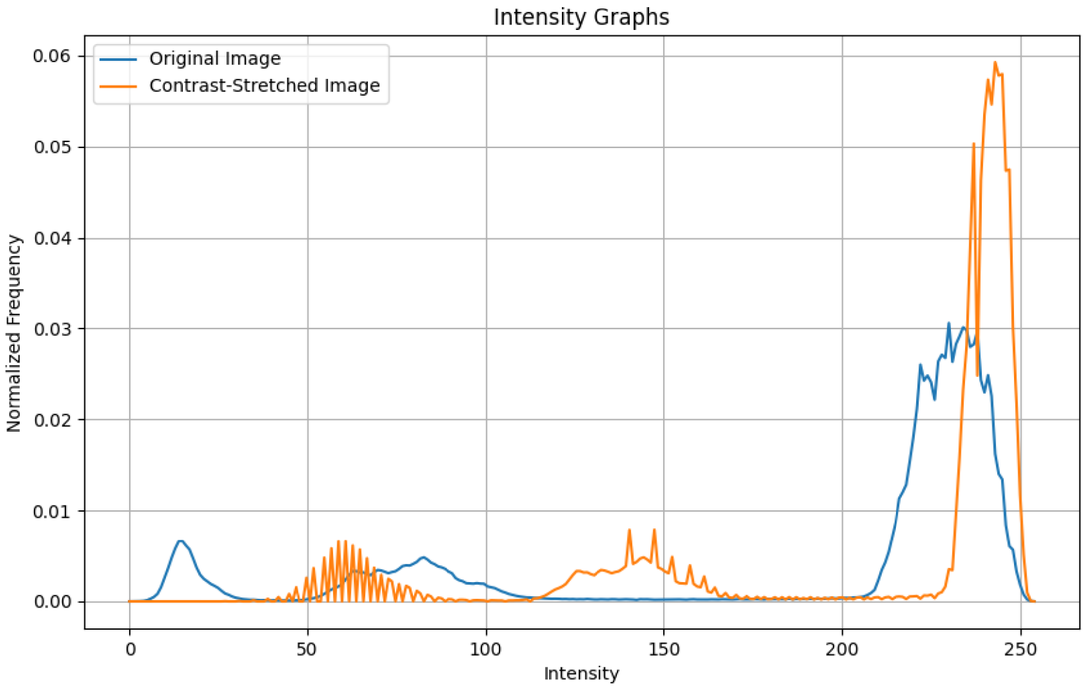
- It takes into account factors like luminance (brightness), contrast, and structural information (arrangement of pixels).
- SSIM index value ranging from 0 to 1. A value of 1 indicates perfect structural similarity.

	HE	CS	CS2
brown spot	0.635893401	0.950969797	0.950969797
healthy	0.4198165899	0.9343087558	0.9343087558
leaf blast	0.5236040476	0.9503161905	0.9503161905
leaf blight	0.7003955679	0.9534382271	0.9534382271
leaf scald	0.865427933	0.9812175978	0.9812175978
narrow brown spot	0.8522588235	0.9694323529	0.9694323529
MEAN	**0.6662327271**	**0.9566138202**	**0.9566138202**

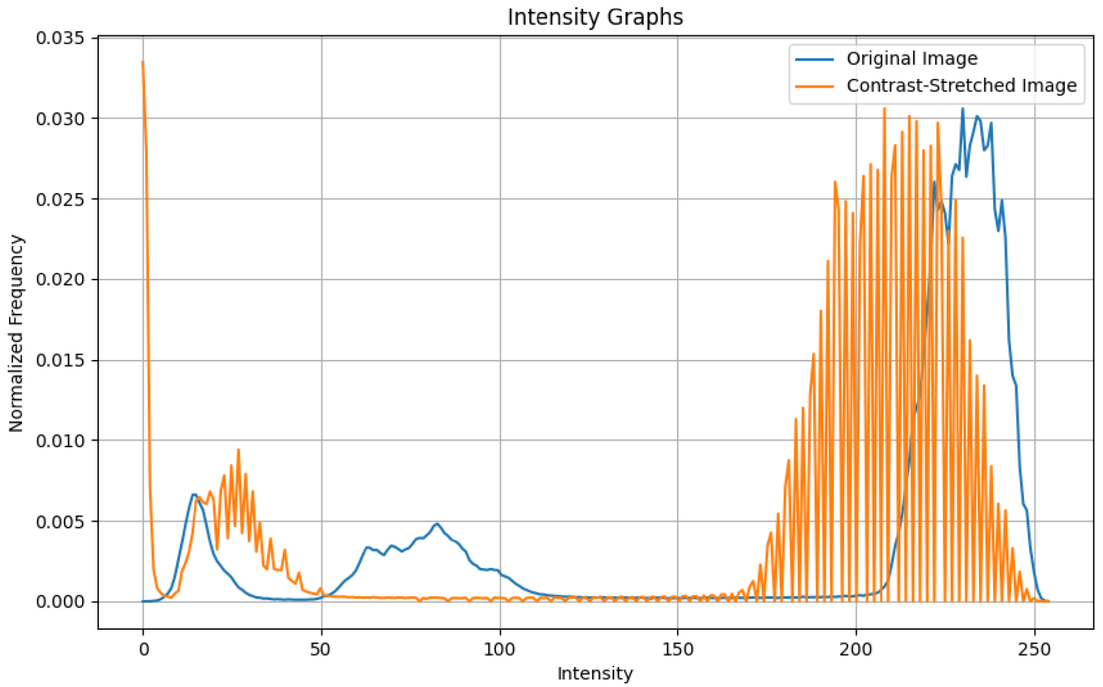
Histogram Equalization



Contrast Stretching



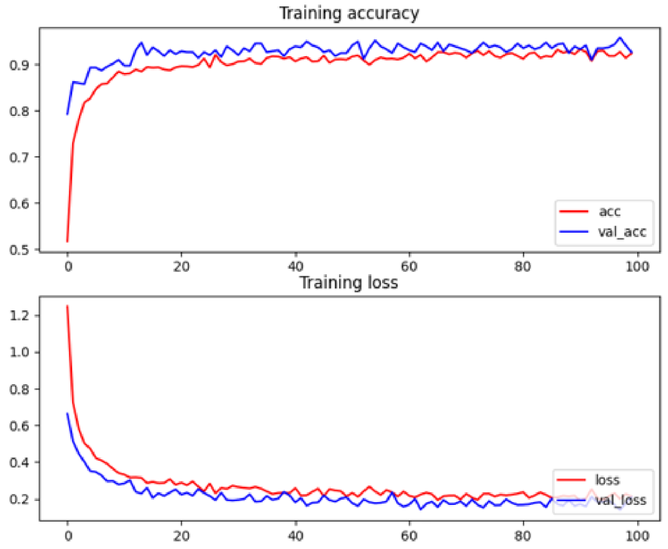
0.5



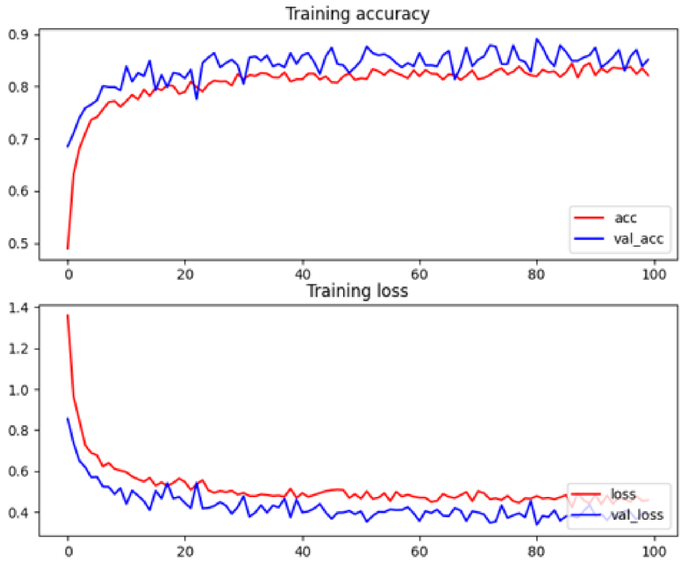
2

Model Evaluation

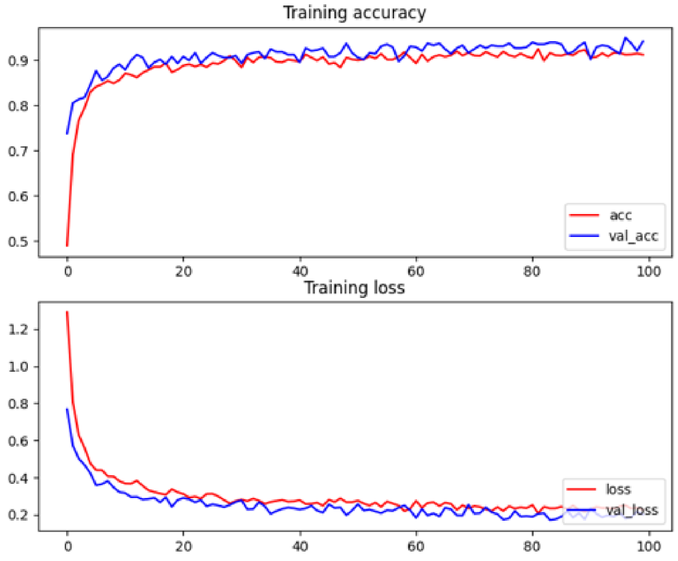
raw



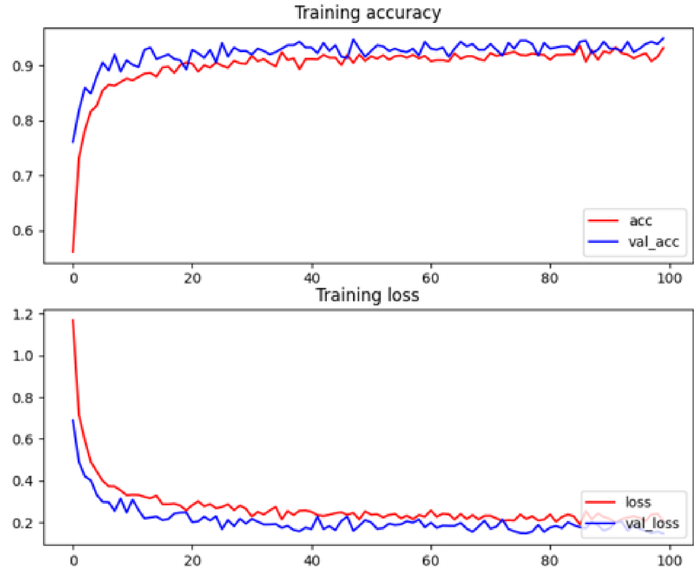
he



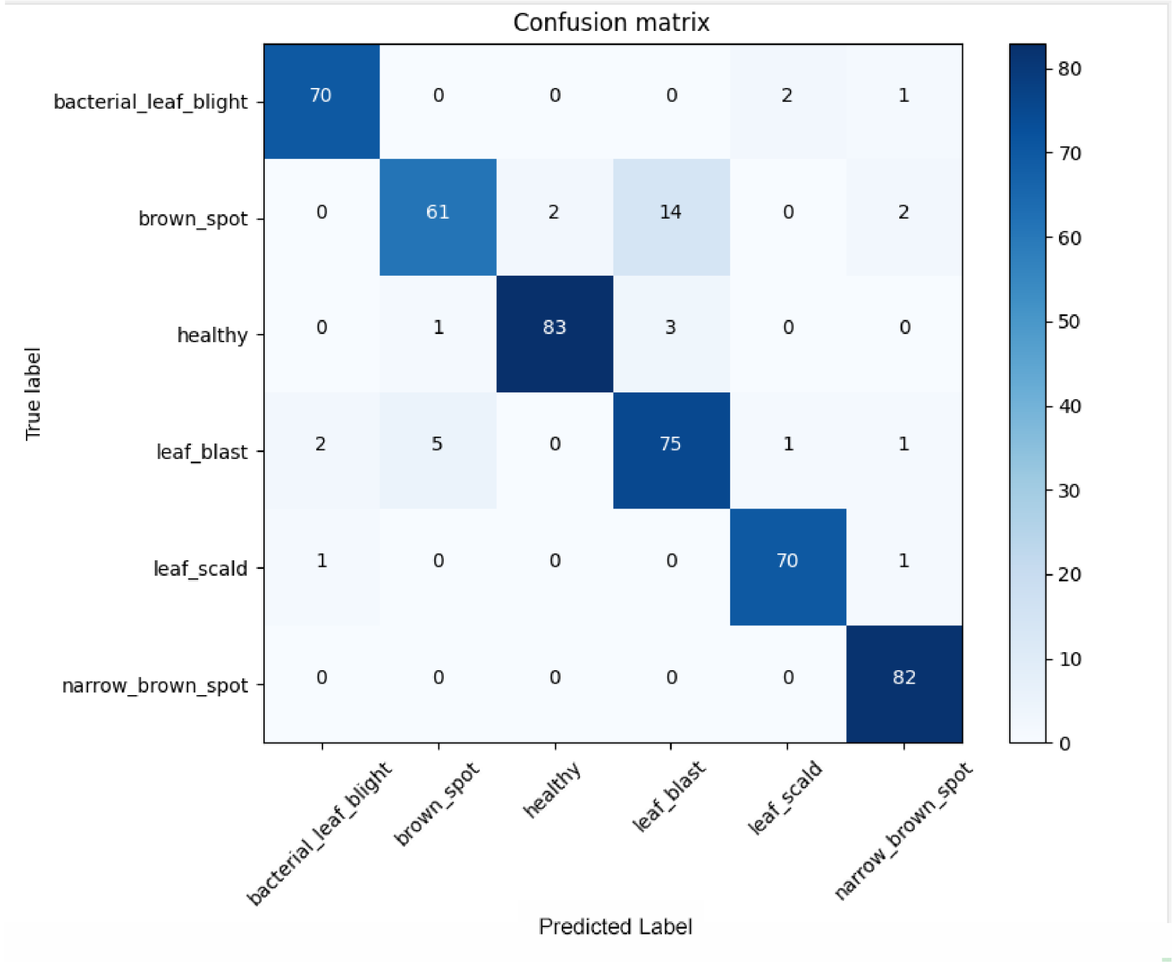
cs

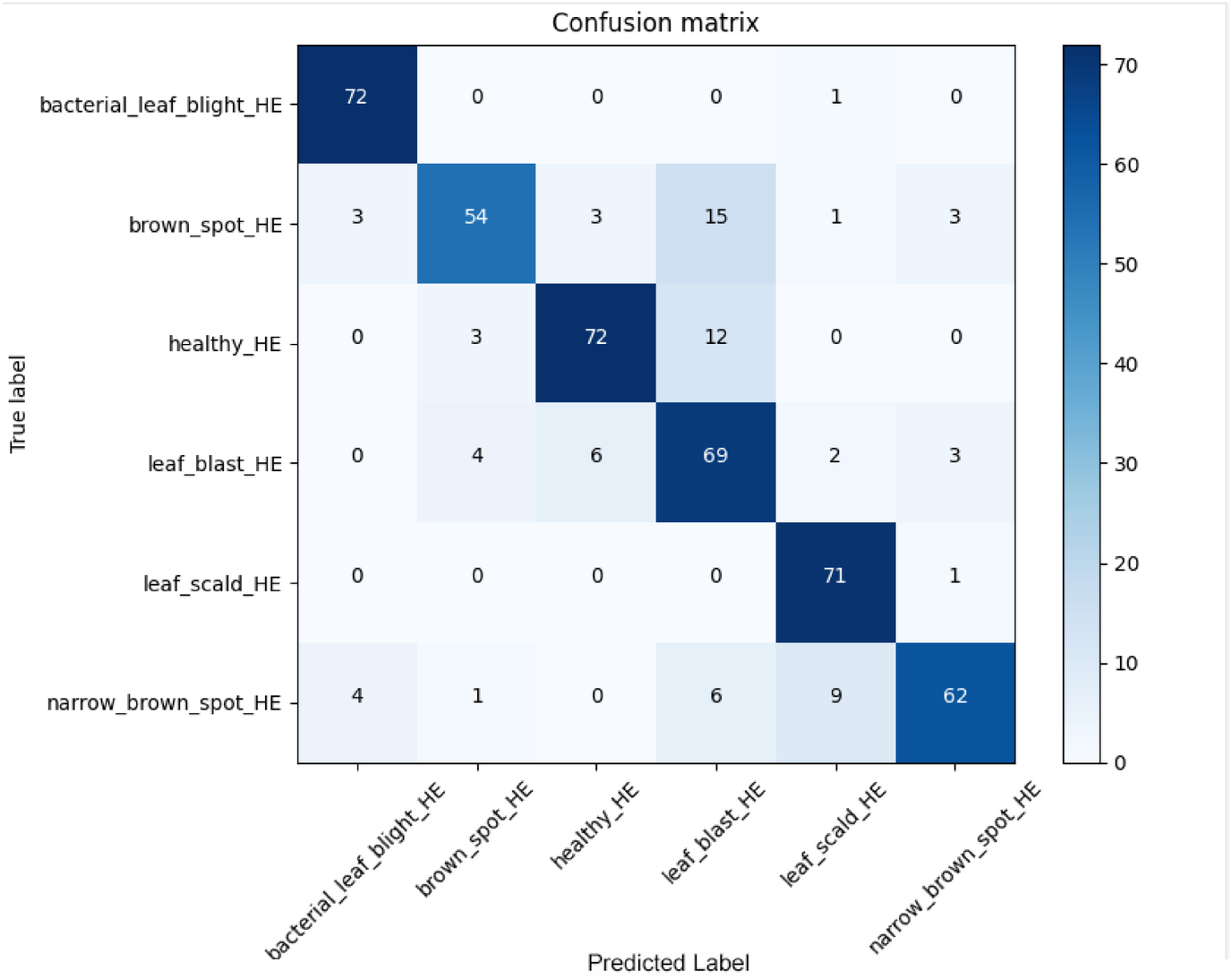


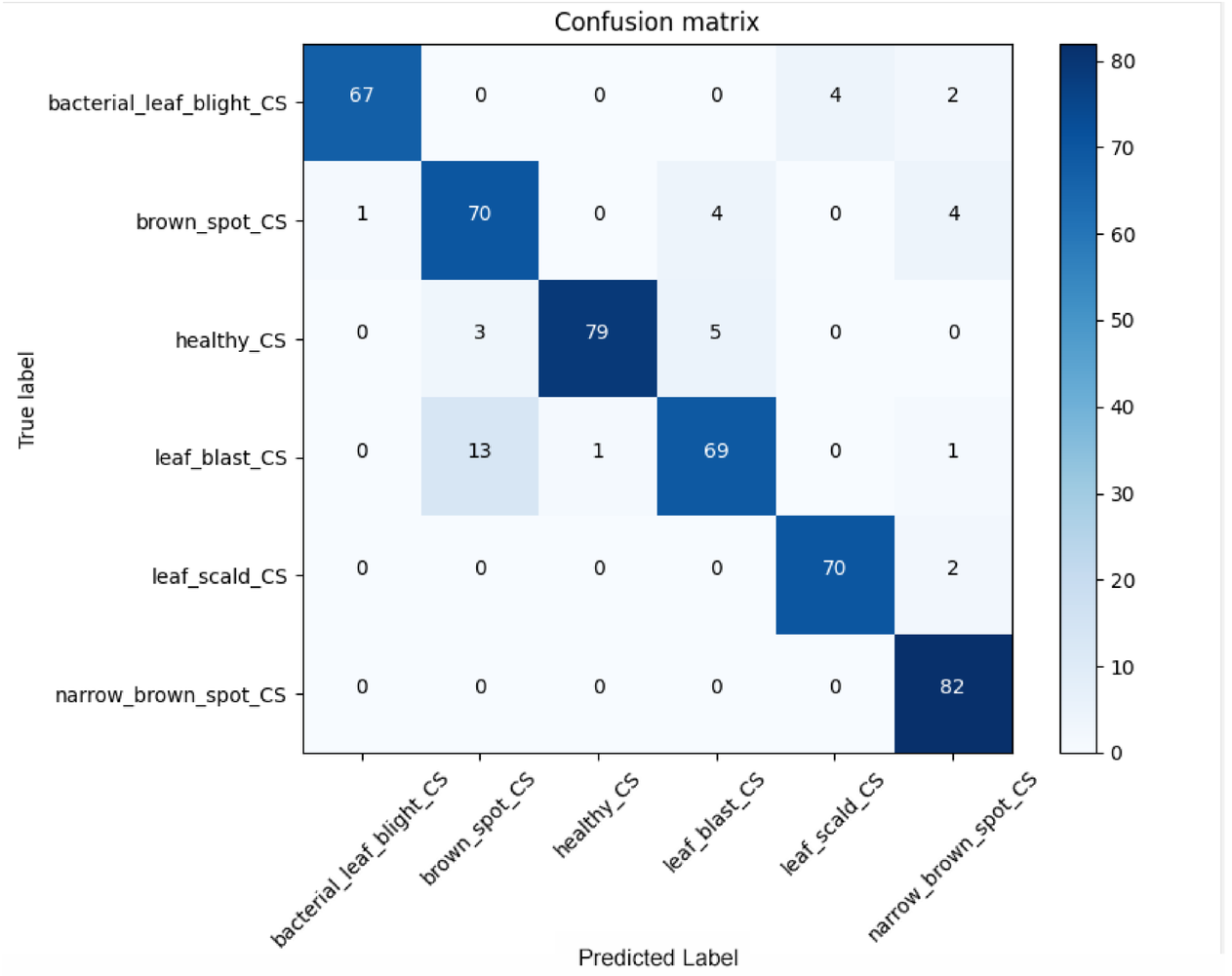
cs2

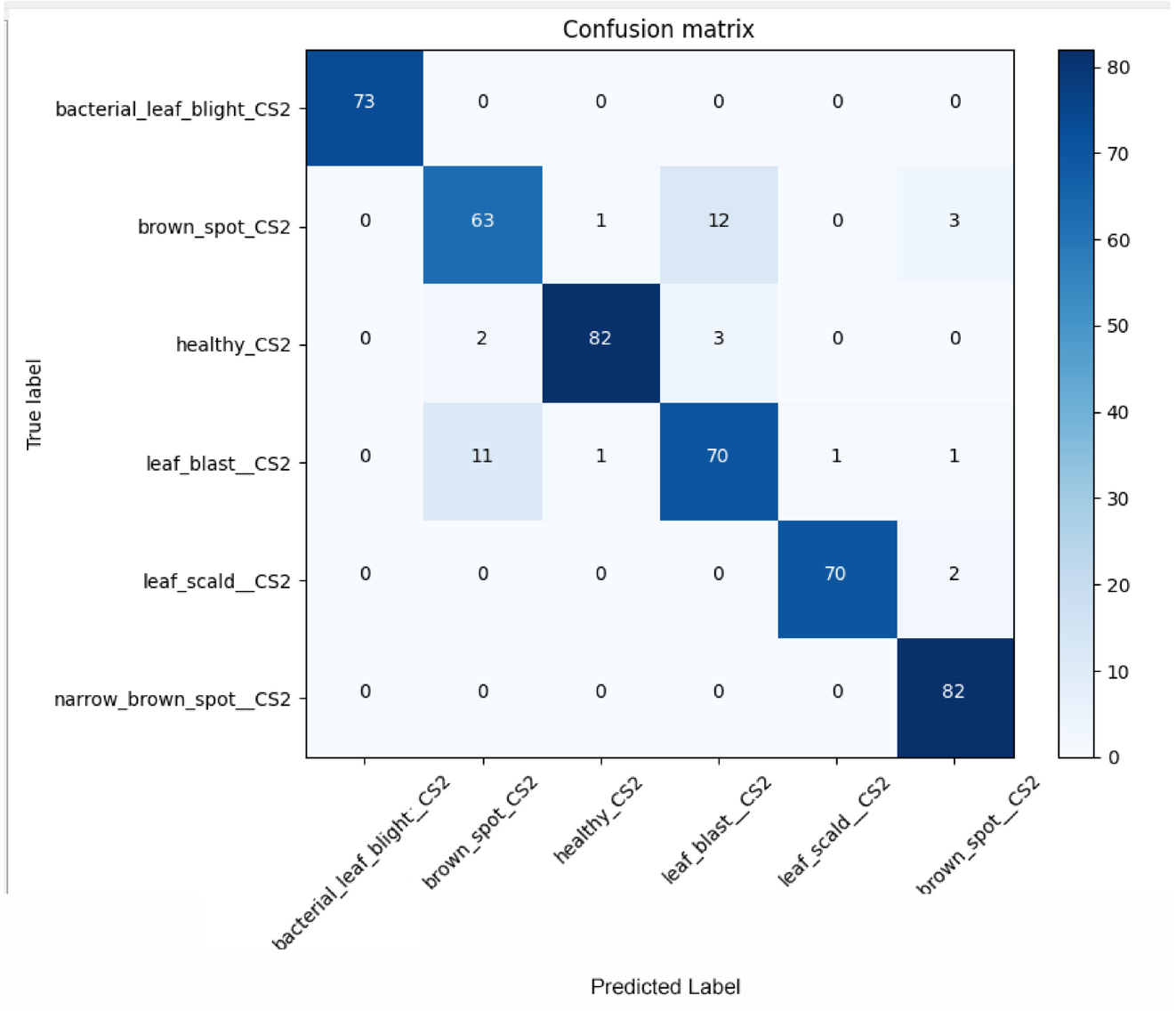


Classification Results




Confusion matrix
bacterial_leaf_blight_HE
brown_spot_HE
healthy_HE
leaf_blast_HE
leaf_scald_HE
narrow_brown_spot_HE
True label
Predicted Label
72 0 0 0 1 0
3 54 3 15 1 3
0 3 72 12 0 0
0 4 6 69 2 3
0 0 0 0 71 1
4 1 0 6 9 62
70
60
50
40
30
20
10
0


Confusion matrix
bacterial_leaf_blight_CS
brown_spot_CS
healthy_CS
leaf_blast_CS
leaf_scald_CS
narrow_brown_spot_CS
True label
Predicted Label
67 0 0 0 4 2
1 70 0 4 0 4
0 3 79 5 0 0
0 13 1 69 0 1
0 0 0 0 70 2
0 0 0 0 0 82
80
70
60
50
40
30
20
10
0


Confusion matrix
bacterial_leaf_blight_CS2
brown_spot_CS2
healthy_CS2
leaf_blast__CS2
leaf_scald__CS2
narrow_brown_spot__CS2
True label
73 0 0 0 0 0
0 63 1 12 0 3
0 2 82 3 0 0
0 11 1 70 1 1
0 0 0 0 70 2
0 0 0 0 0 82
bacterial_leaf_blight_CS2
brown_spot_CS2
healthy_CS2
leaf_blast__CS2
leaf_scald__CS2
brown_spot__CS2
Predicted Label
80
70
60
50
40
30
20
10
0

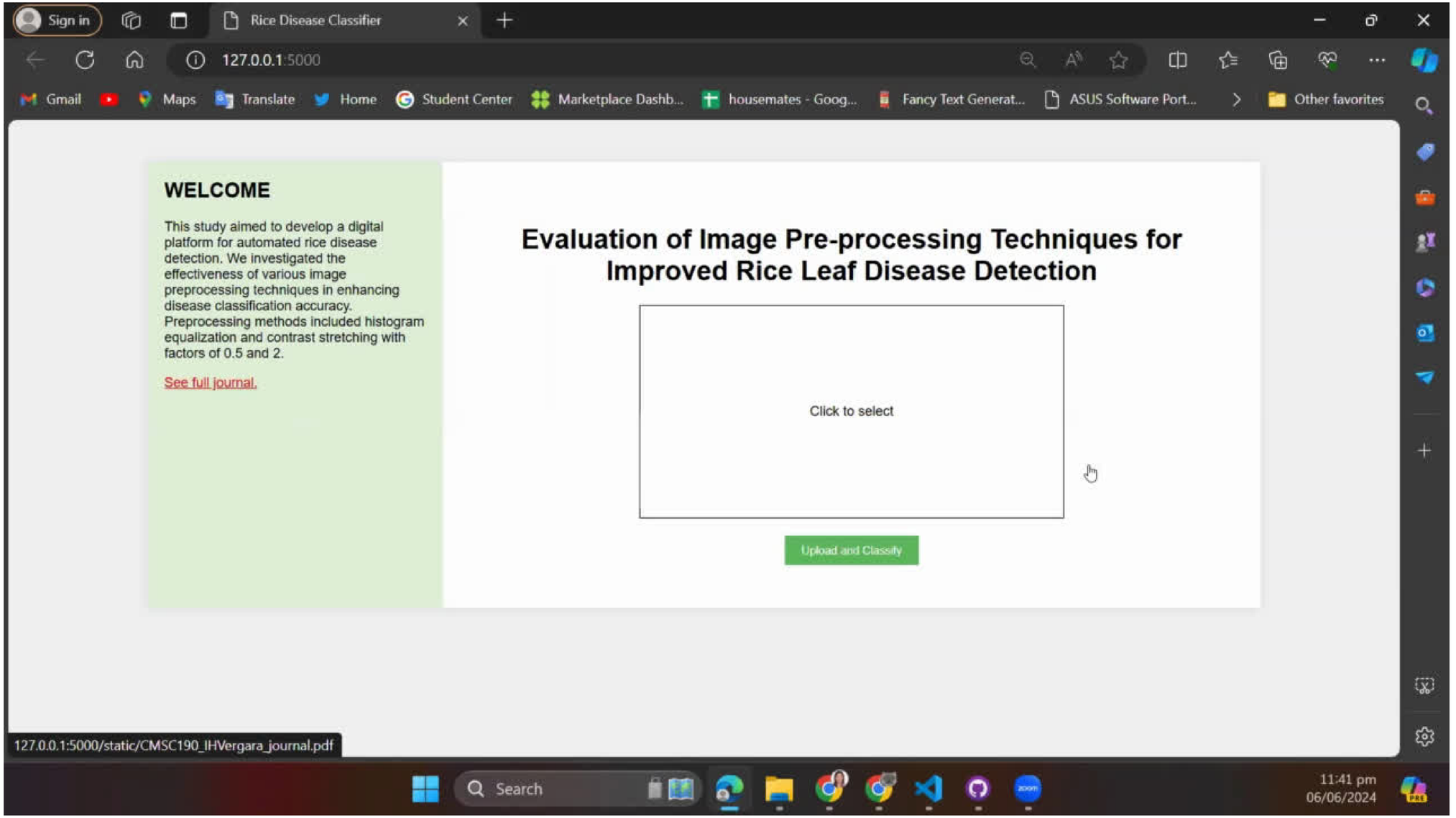
Classification Results

		precision	recall	f1-score
Orginal Image	bacterial_leaf_blight	1.0000	0.9726	0.9861
	brown_spot	0.8846	0.8734	0.8790
	healthy	0.9880	0.9425	0.9647
	leaf_blast	0.8929	0.8929	0.8929
	leaf_scald	0.9726	0.9861	0.9793
	narrow_brown_spot	0.9318	1.0000	0.9647
HE-processed Image	bacterial_leaf_blight_HE	0.9114	0.9863	0.9474
	brown_spot_HE	0.8710	0.6835	0.7660
	healthy_HE	0.8889	0.8276	0.8571
	leaf_blast_HE	0.6765	0.8214	0.7419
	leaf_scald_HE	0.8452	0.9861	0.9103
	narrow_brown_spot_HE	0.8986	0.7561	0.8212
CS-processed Image (0.5)	bacterial_leaf_blight_CS	0.9853	0.9178	0.9504
	brown_spot_CS	0.8140	0.8861	0.8485
	healthy_CS	0.9875	0.9080	0.9461
	leaf_blast_CS	0.8846	0.8214	0.8519
	leaf_scald_CS	0.9459	0.9722	0.9589
	narrow_brown_spot_CS	0.9011	1.0000	0.9480
CS- processed Image (2)	bacterial_leaf_blight_CS2	1.0000	1.0000	1.0000
	brown_spot_CS2	0.8289	0.7975	0.8129
	healthy_CS2	0.9762	0.9425	0.9591
	leaf_blast__CS2	0.8235	0.8333	0.8284
	leaf_scald__CS2	0.9859	0.9722	0.9790
	narrow_brown_spot__CS2	0.9318	1.0000	0.9647

Overall Accuracy

Method	Accuracy
Original	94.34%
Contrast Stretching (2)	92.24%
Contrast Stretching (0.5)	91.61%
Histogram Equalization	83.86%

Web Application



Conclusion

- Image quality metrics (PSNR, NRMSE, SSIM) and classification accuracy measure different things.
  - Image quality metrics focus on noise, sharpness, and structural similarity.
  - Classification accuracy focuses on a classifier's ability to categorize images correctly.
- High image quality metrics don't guarantee optimal classification accuracy.
  - Classification algorithms' complexity and robustness play a role.
- Preprocessing can be beneficial for specific diseases (e.g., contrast stretching for bacterial leaf blight).
- Not all diseases benefit from preprocessing techniques, as shown by the original image achieving higher accuracy for some diseases.

Future Works

- Investigate how these findings apply to other CNN models (architecture's impact on image quality-accuracy relationship).
- Explore alternative preprocessing techniques for a deeper understanding of image enhancement and classification performance.
- Utilize validated datasets from different organisms/tissues requiring image quality improvement to broaden platform applicability.
- Develop a mobile application to enable real-time disease detection in the field, improving accessibility for a wider user base.

Thank you!