



JOINT MASTER IN MEDICAL IMAGING AND APPLICATIONS



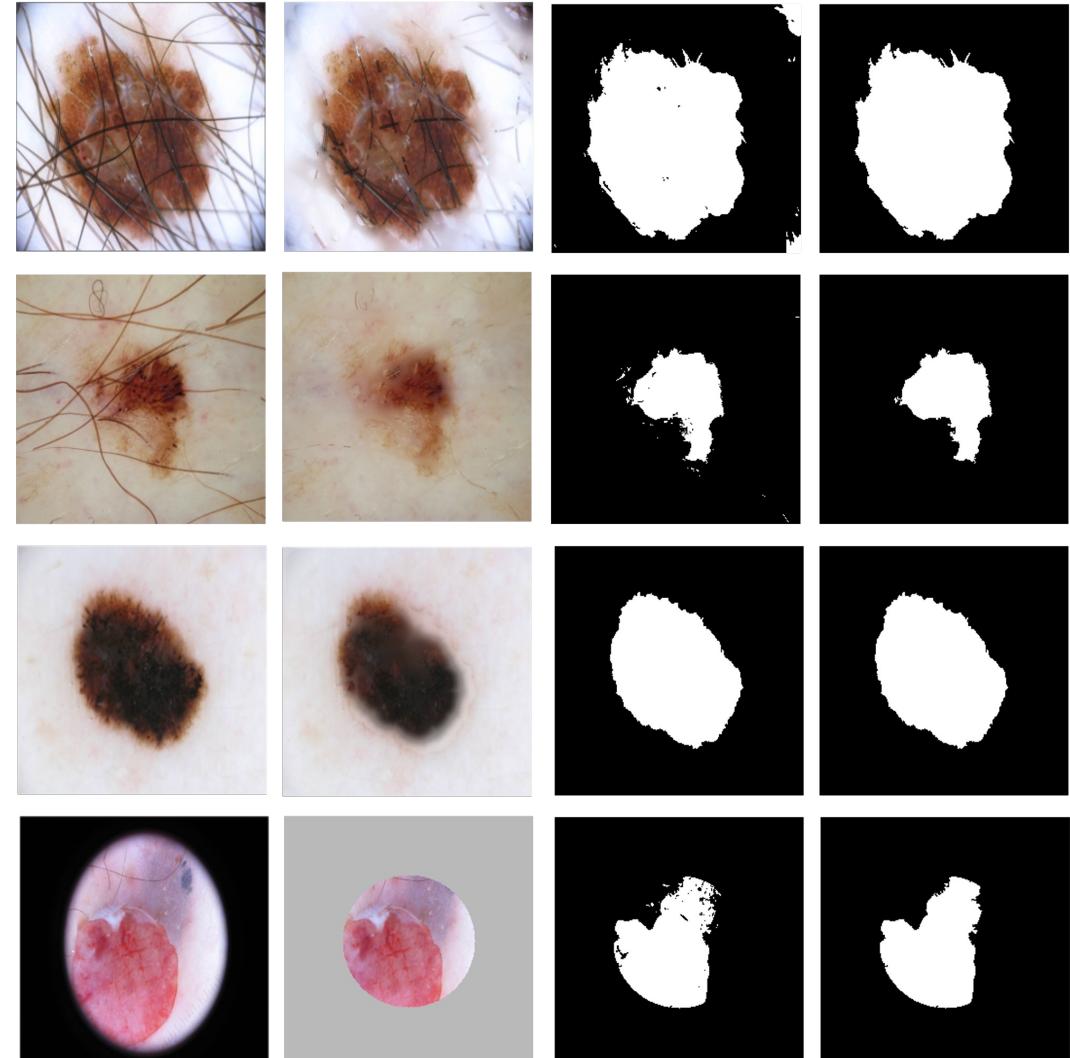
SKIN LESION SEGMENTATION AND CLASSIFICATION WITH IMAGE PROCESSING, MACHINE LEARNING AND DEEP LEARNING APPROACHES

ADVANCED IMAGE ANALYSIS
MACHINE AND DEEP LEARNING

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JOSÉ CARLOS REYES HERNÁNDEZ

UNIVERSITY OF CASSINO AND SOUTHERN LAZIO

Resized image Pre-processing Segmentation Final mask

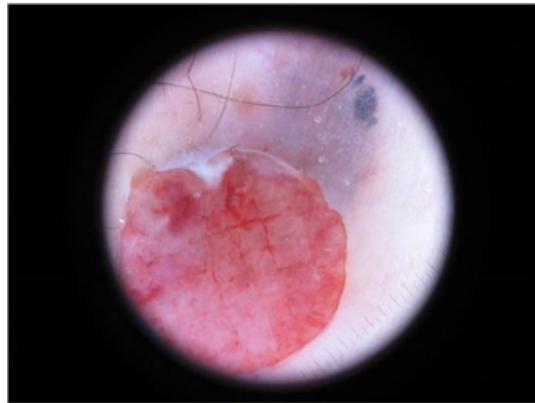


EXAMPLES OF ARTIFACTS IN THE SKIN LESION IMAGES

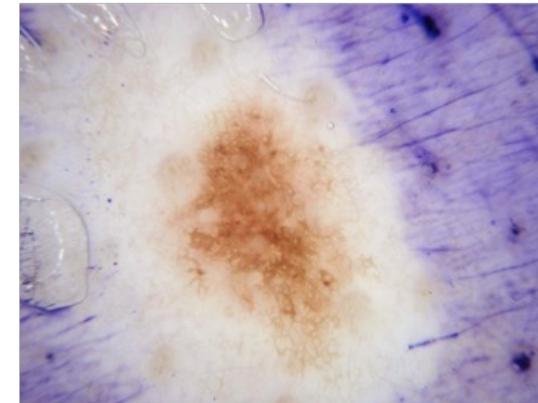
(a)



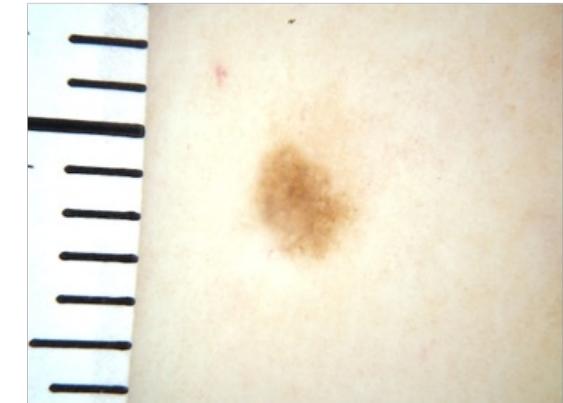
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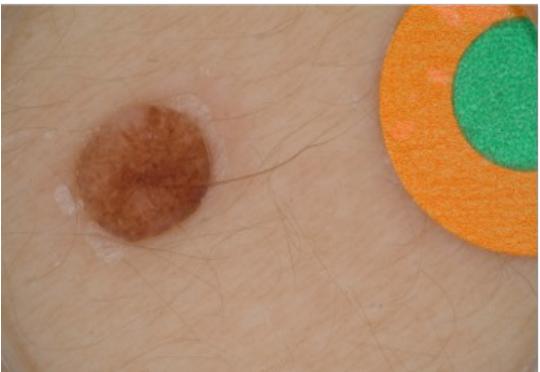
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(d)



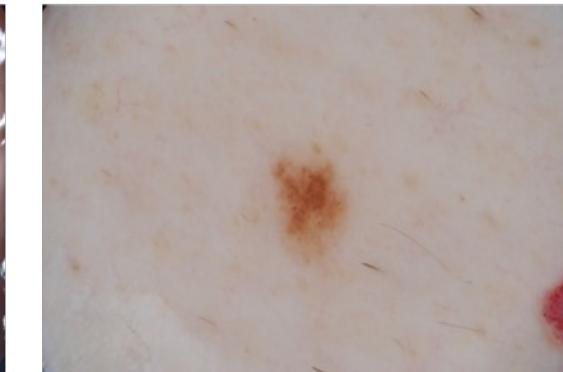
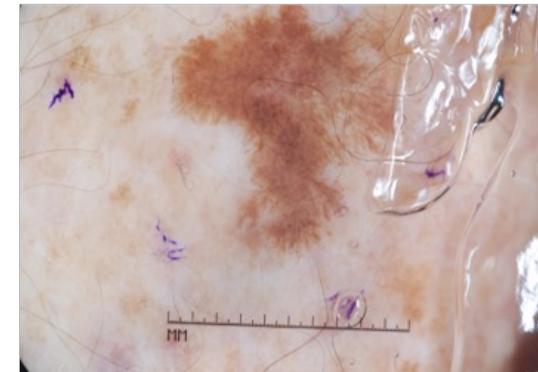
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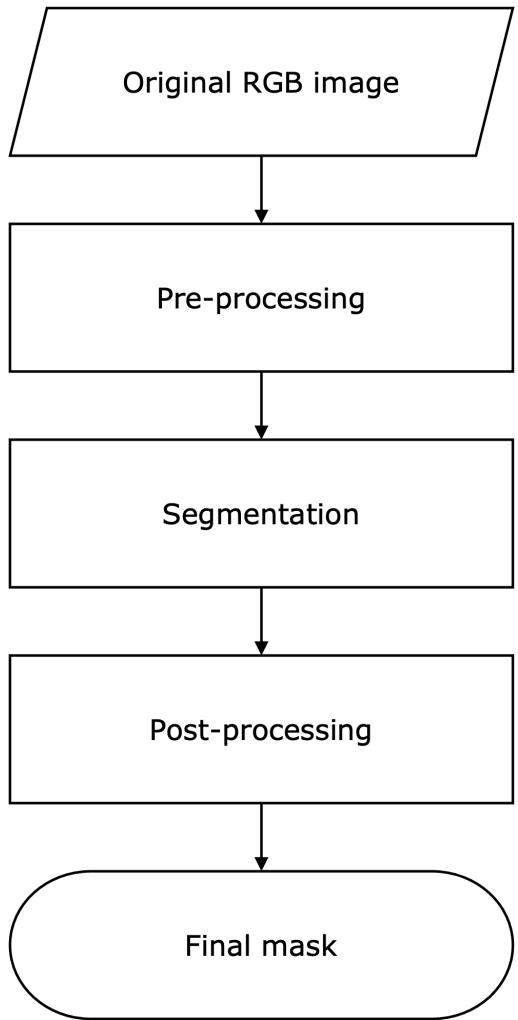
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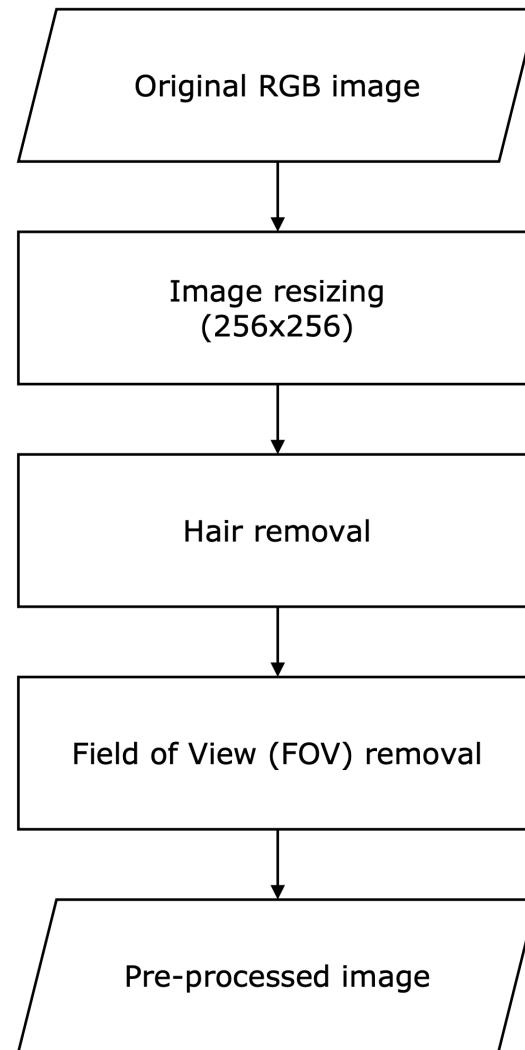
(g)



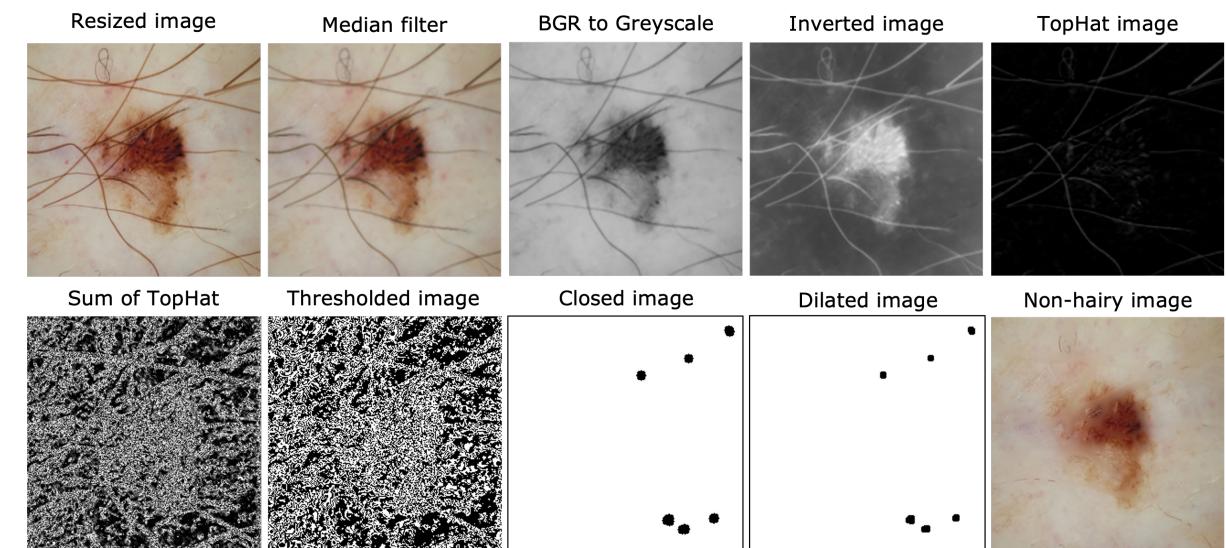
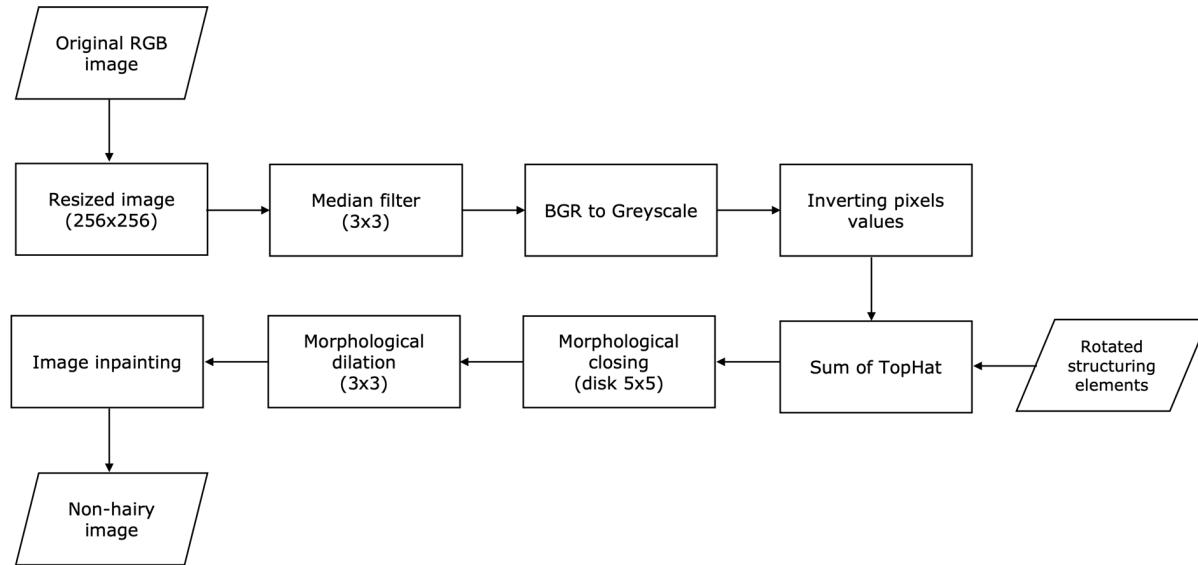
ADVANCED IMAGE ANALYSIS (AIA): SEGMENTATION WORKFLOW



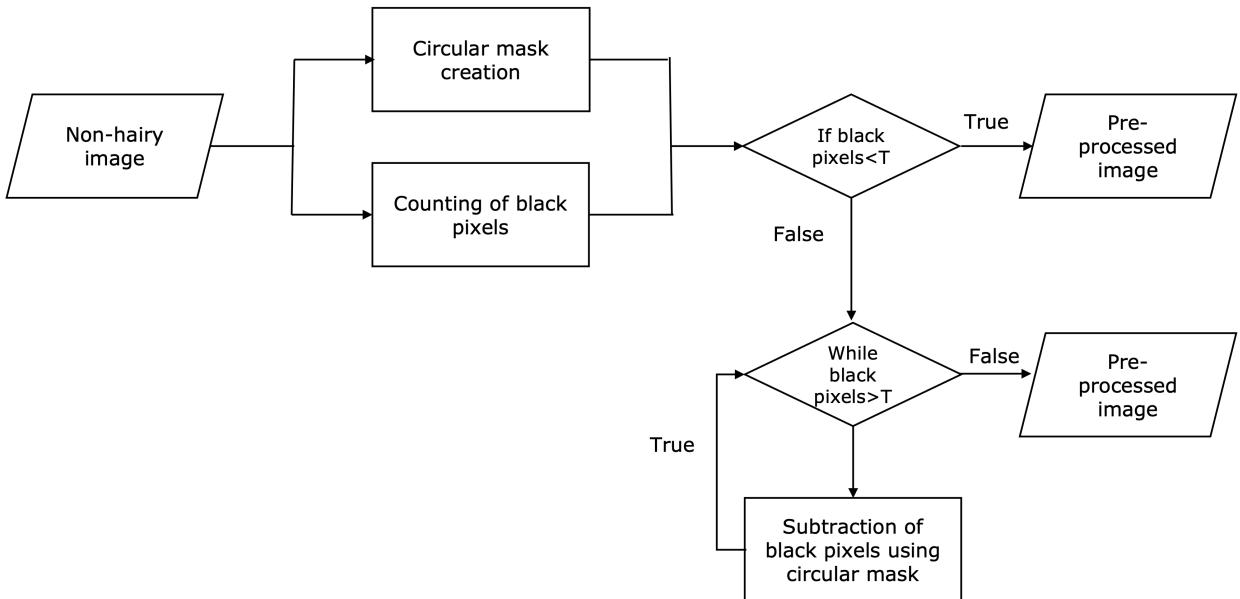
WORKFLOW: PRE-PROCESSING (AIA)



PRE-PROCESSING: HAIR REMOVAL



PRE-PROCESSING: FOV REMOVAL



Non-hairy image

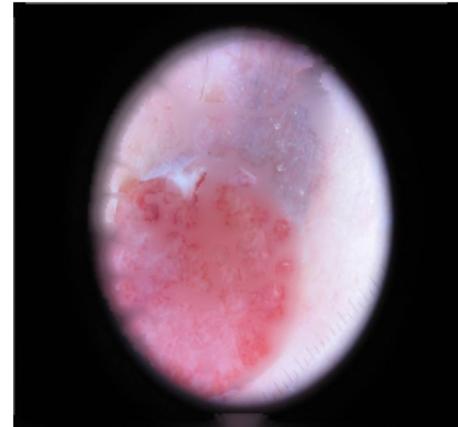
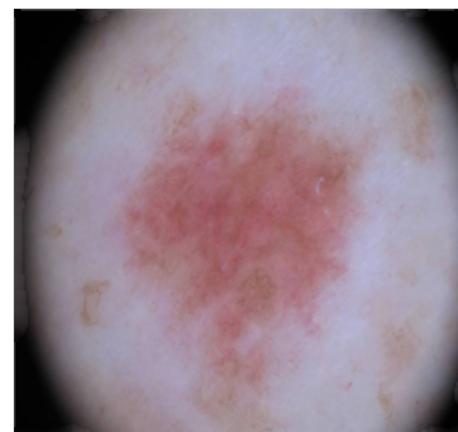
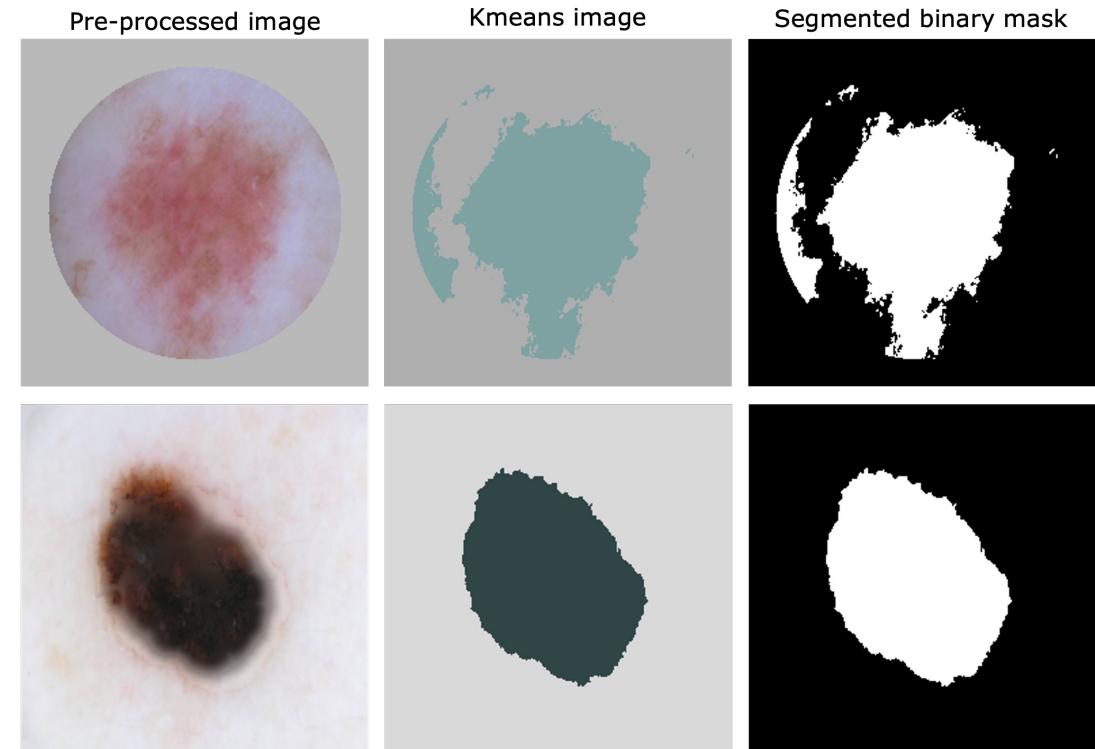
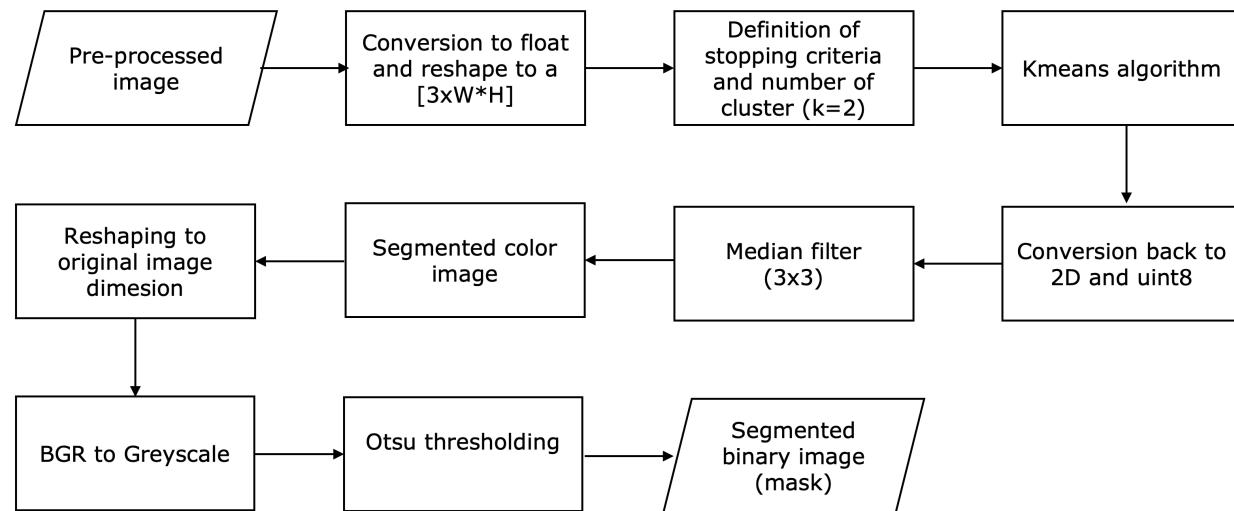


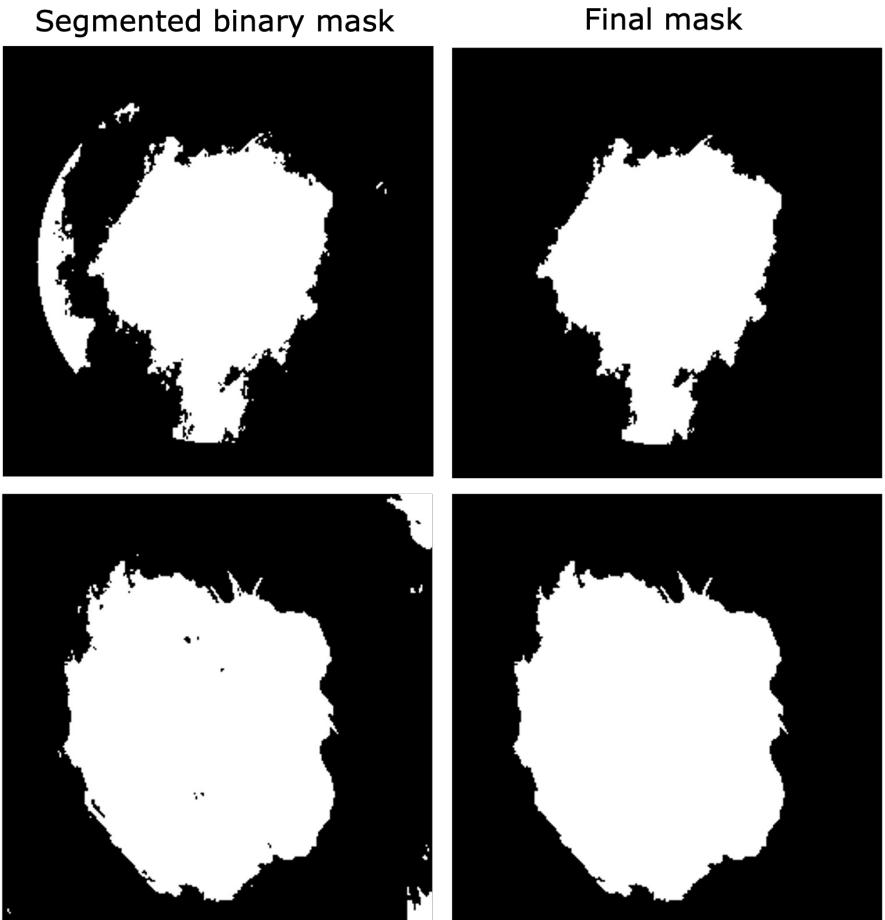
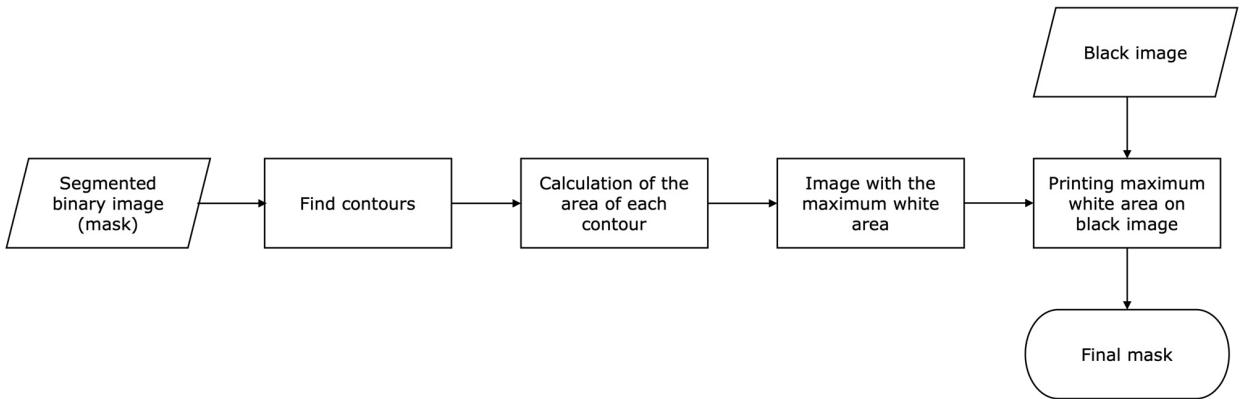
Image without FOV



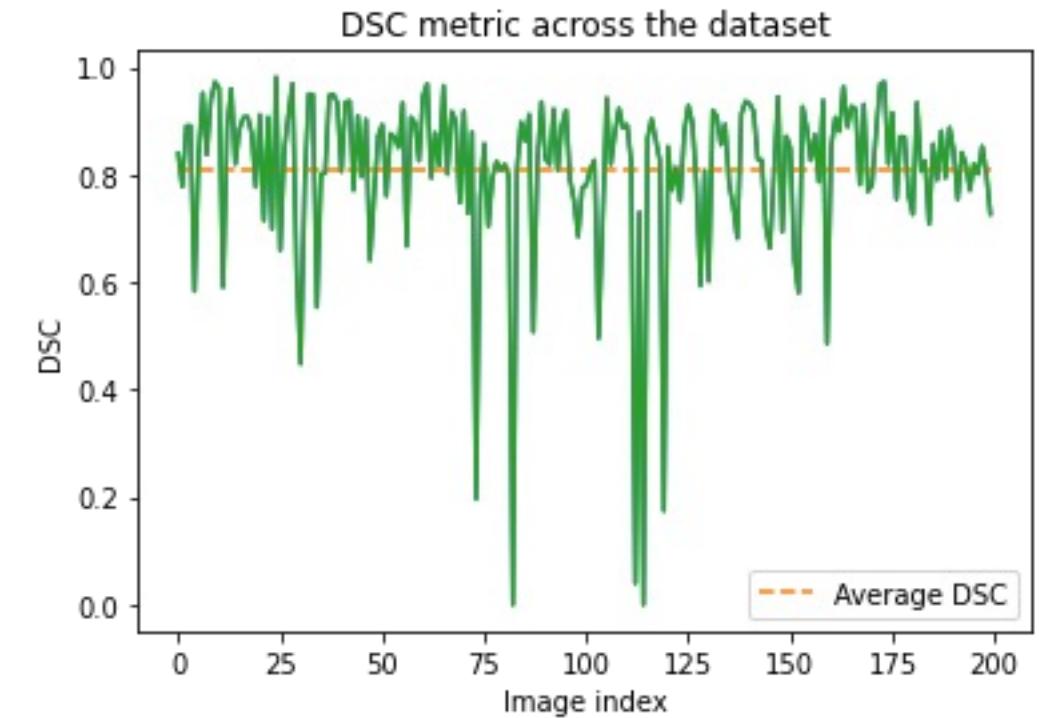
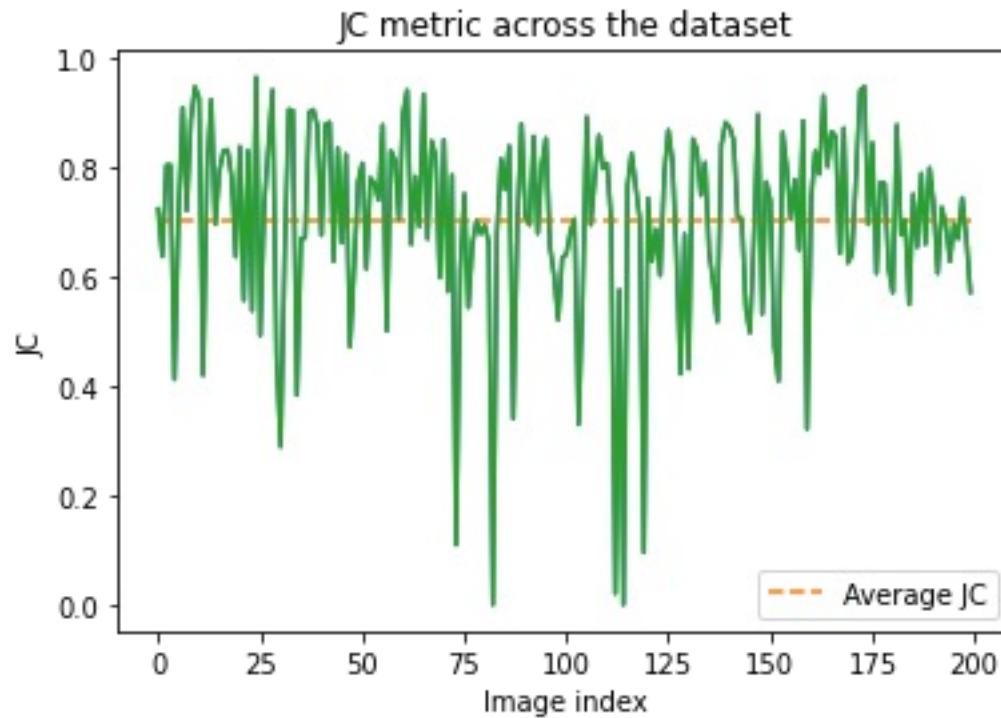
SEGMENTATION: K-MEANS



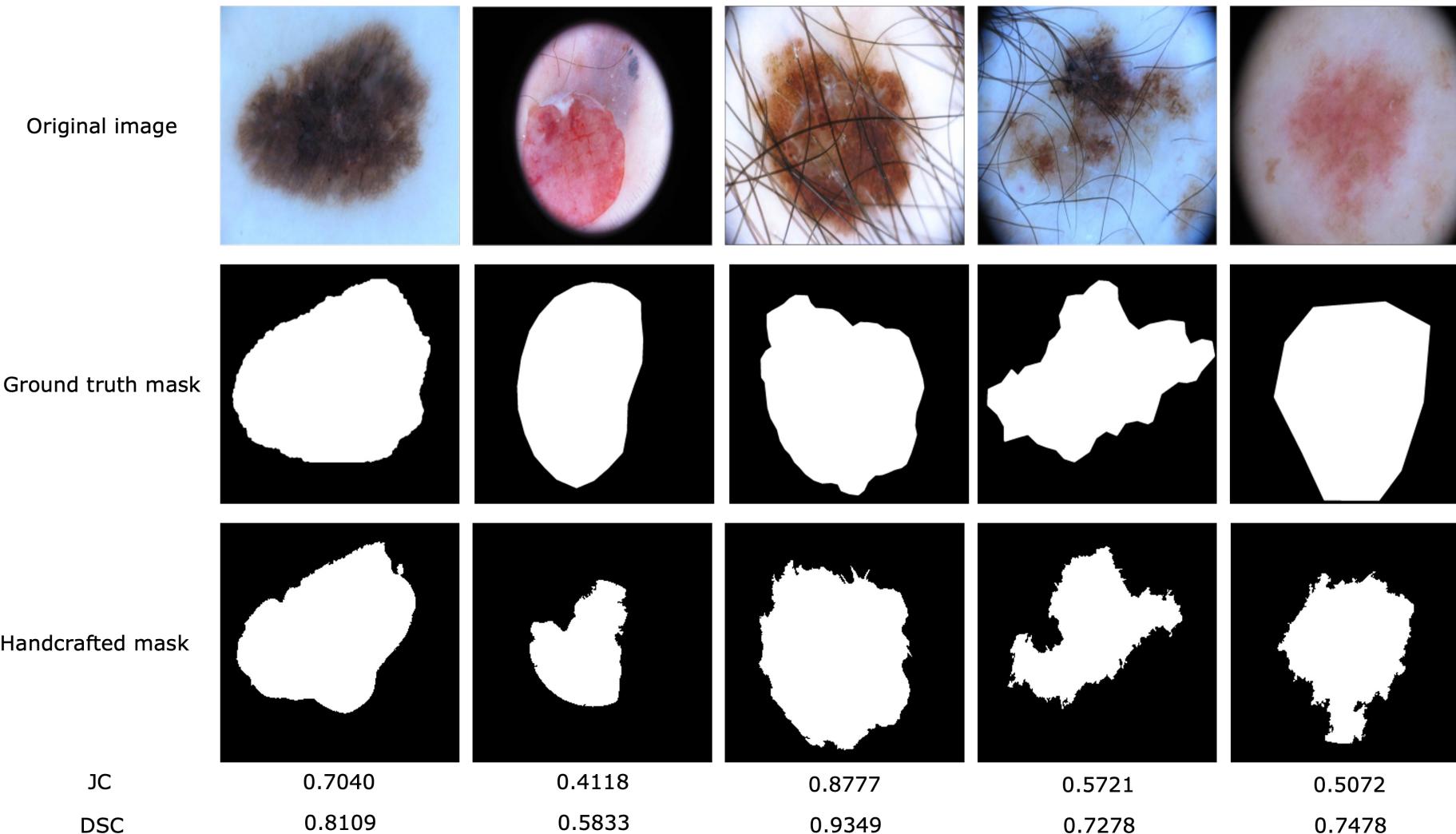
POST-PROCESSING: EXTRACTING LARGEST CONNECTED COMPONENTS



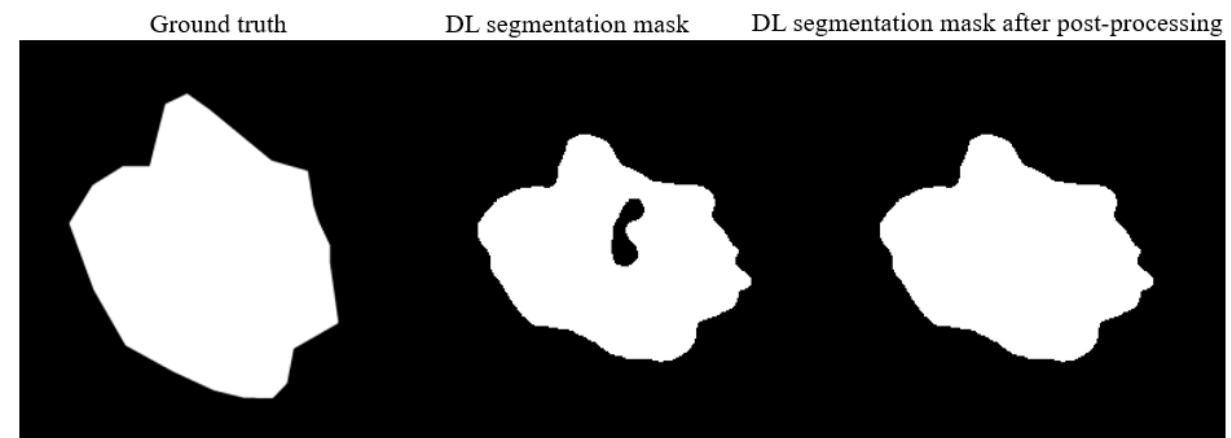
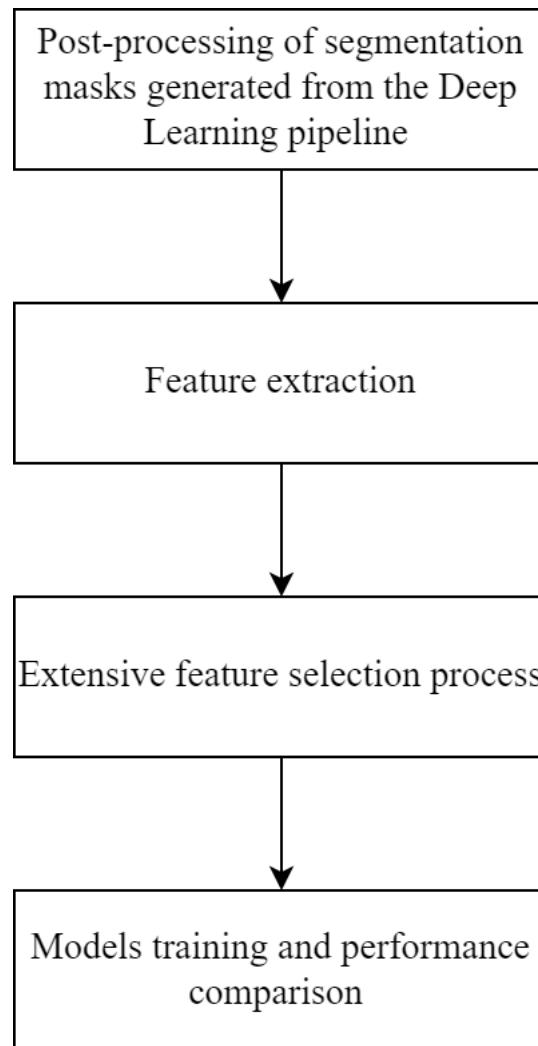
RESULTS (AIA): JACCARD AND DSC METRICS



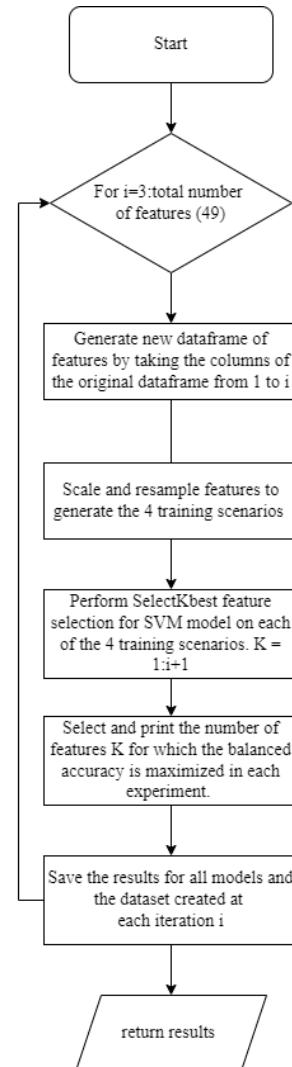
RESULTS (AIA): QUALITATIVE AND QUANTITAVE



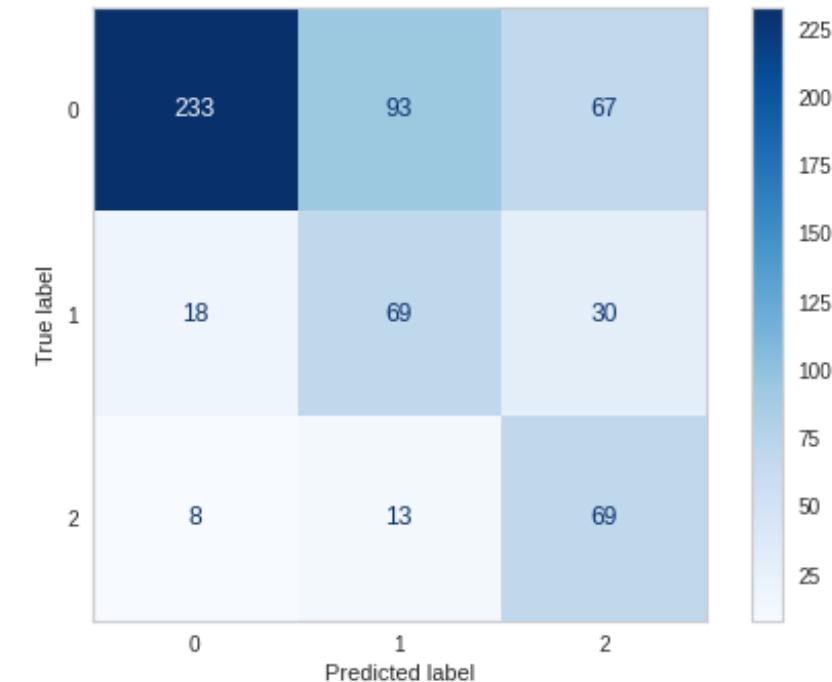
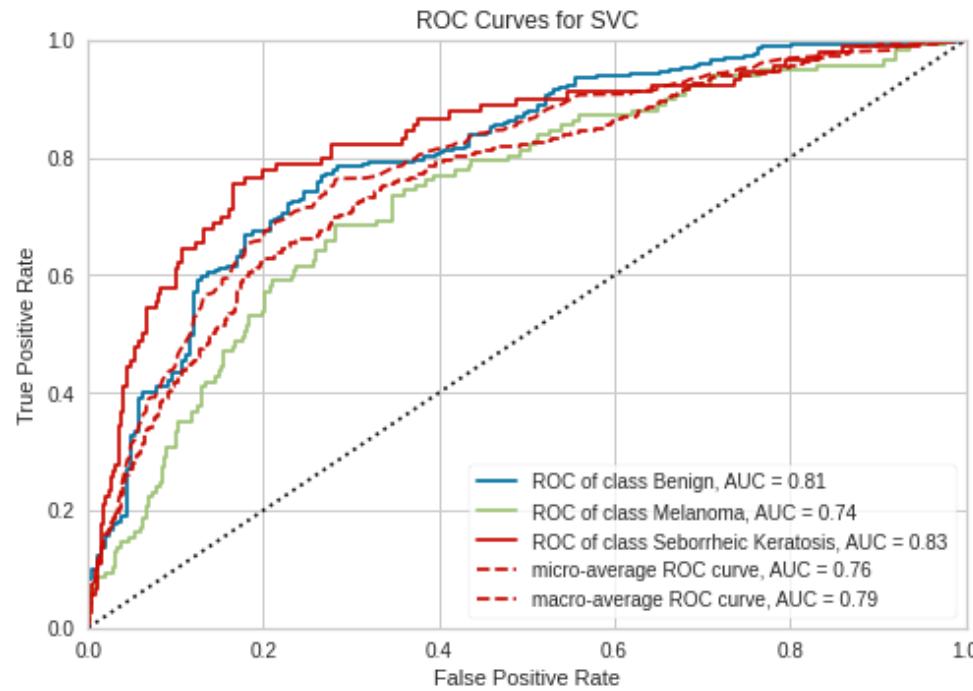
MACHINE LEARNING: CLASSIFICATION WORKFLOW



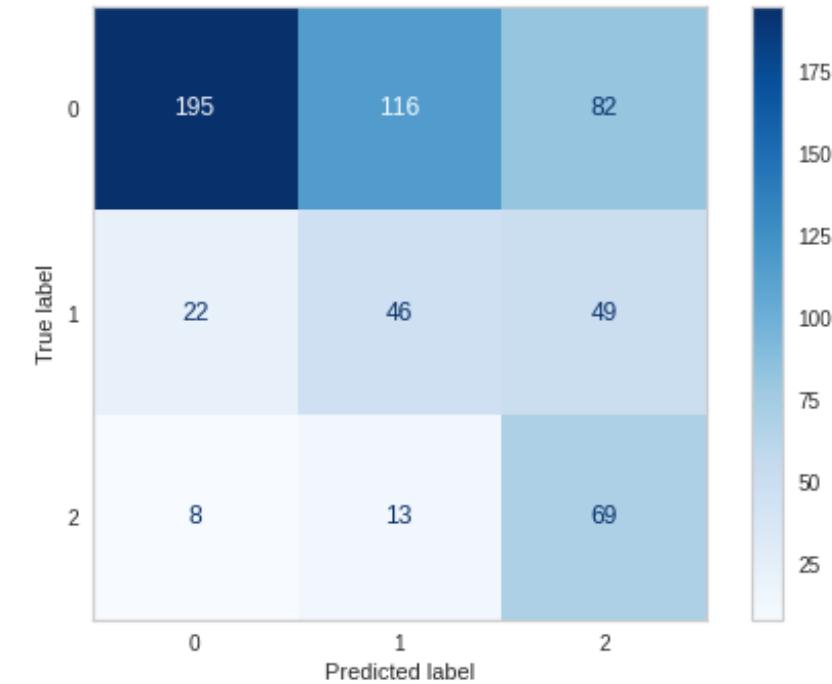
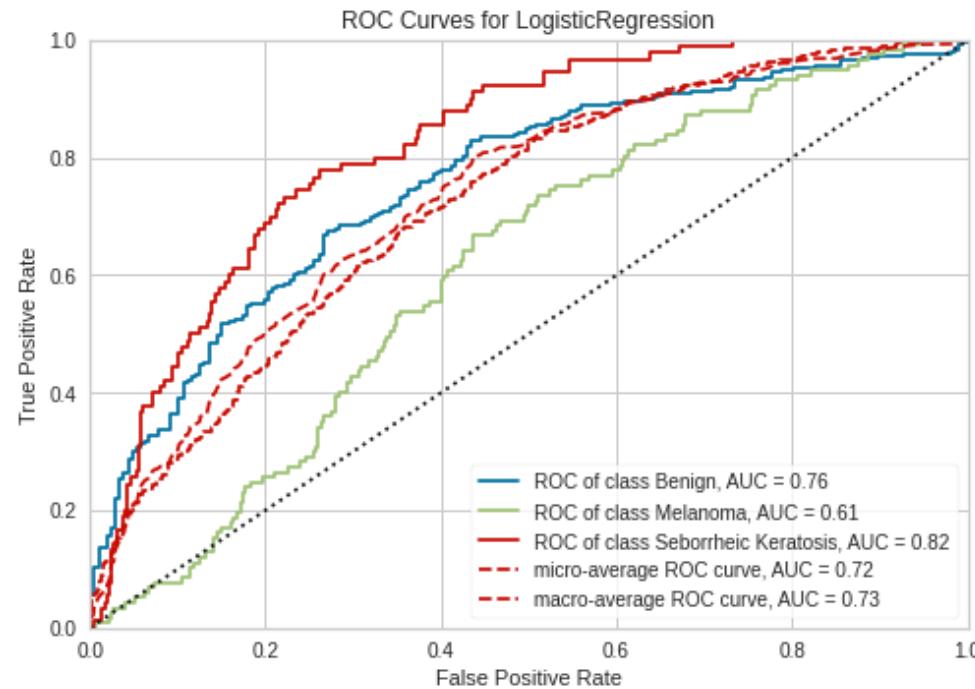
MACHINE LEARNING: FEATURE SEARCH ALGORITHM



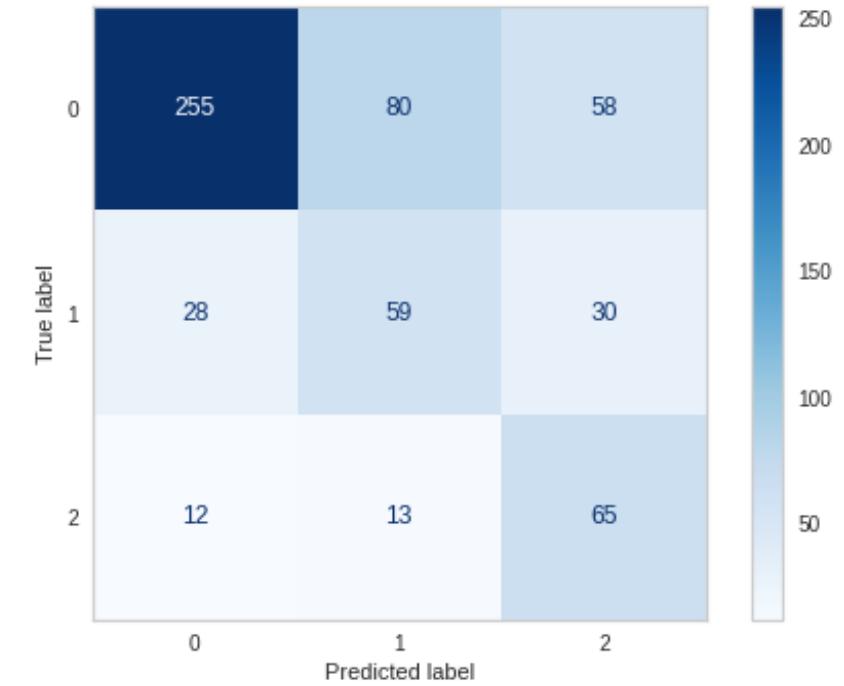
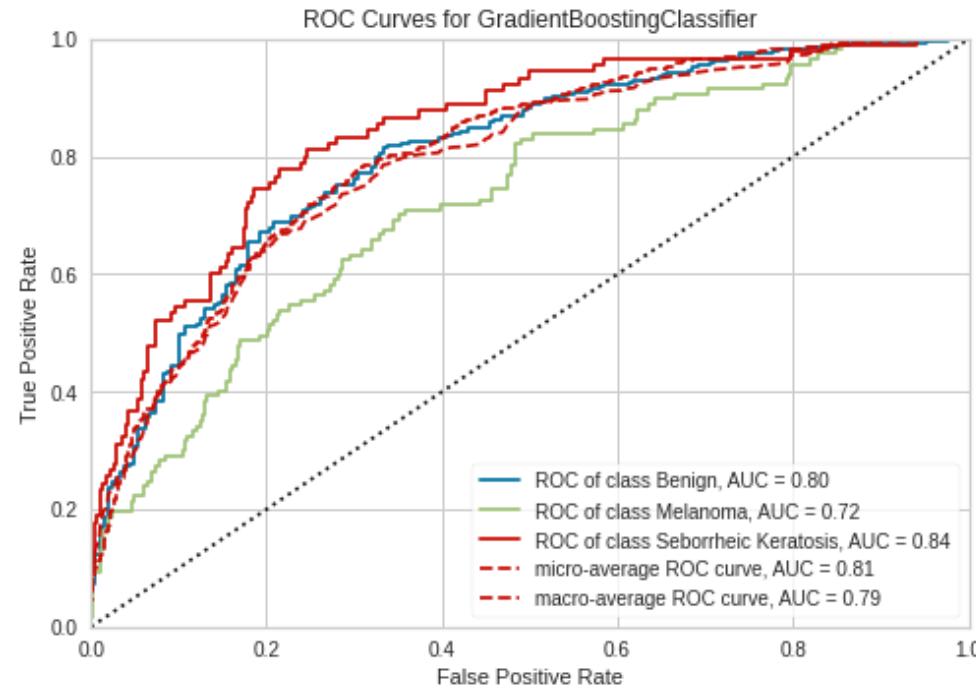
RESULTS (ML): SVC METRICS



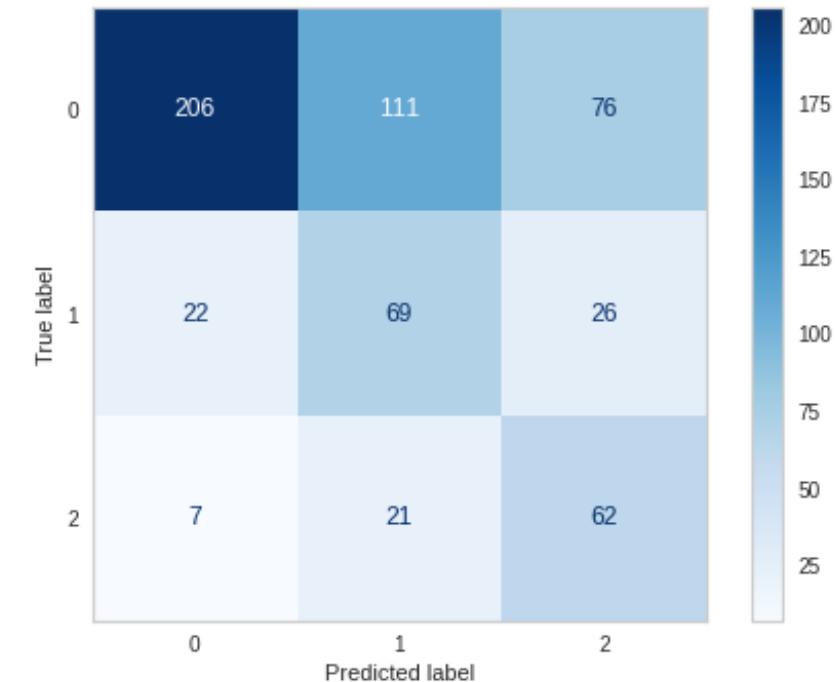
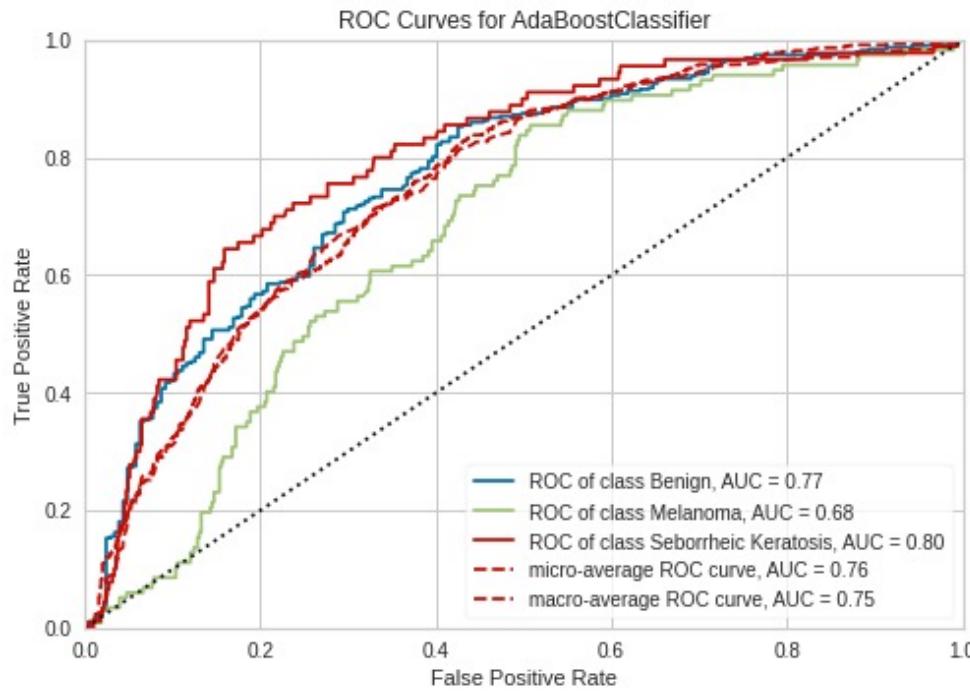
RESULTS (ML): LOGISTIC REGRESSION METRICS



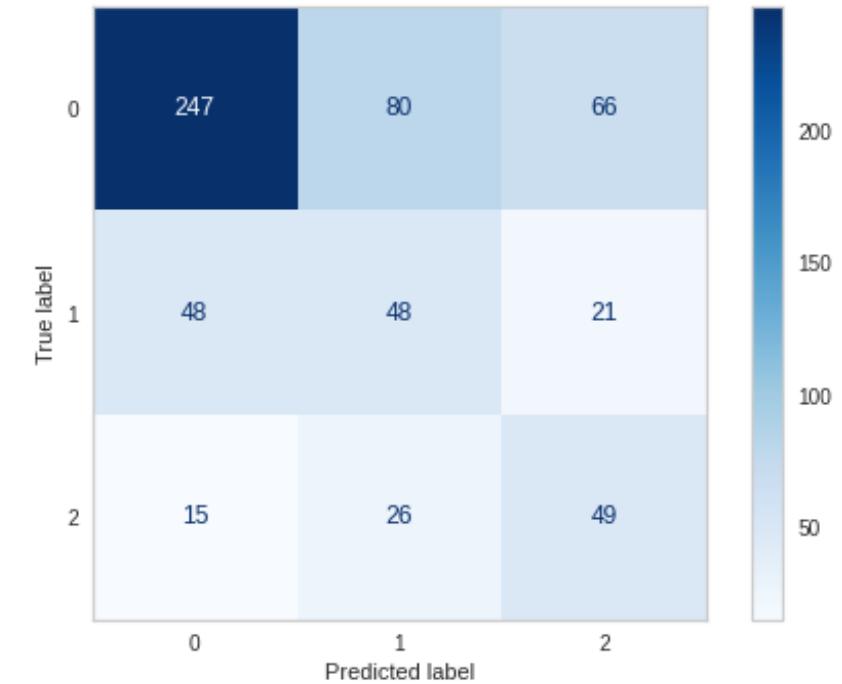
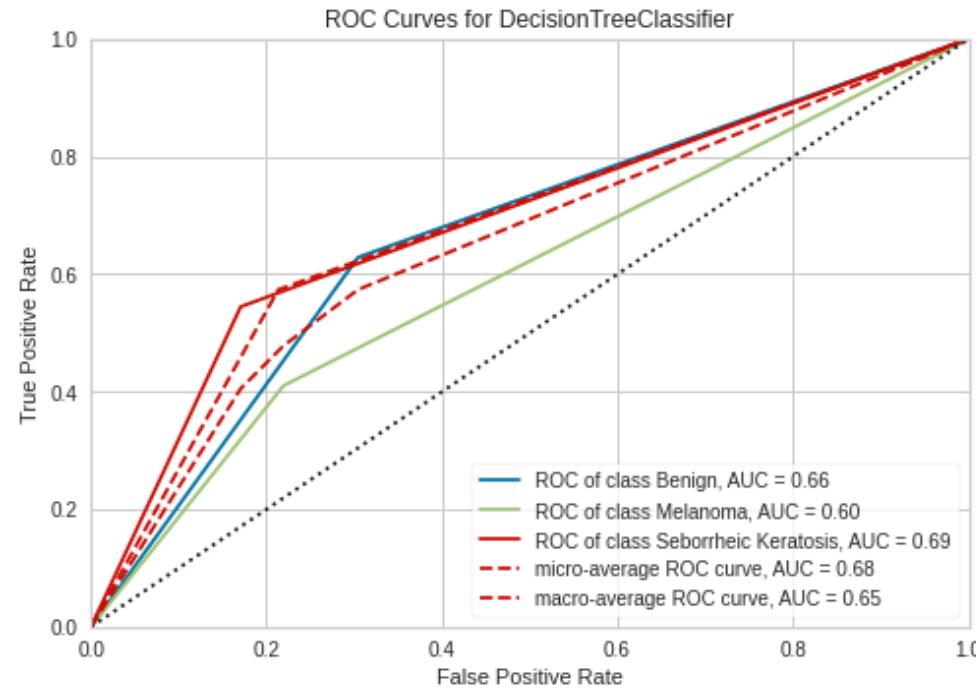
RESULTS (ML): GRADIENT BOOSTING METRICS



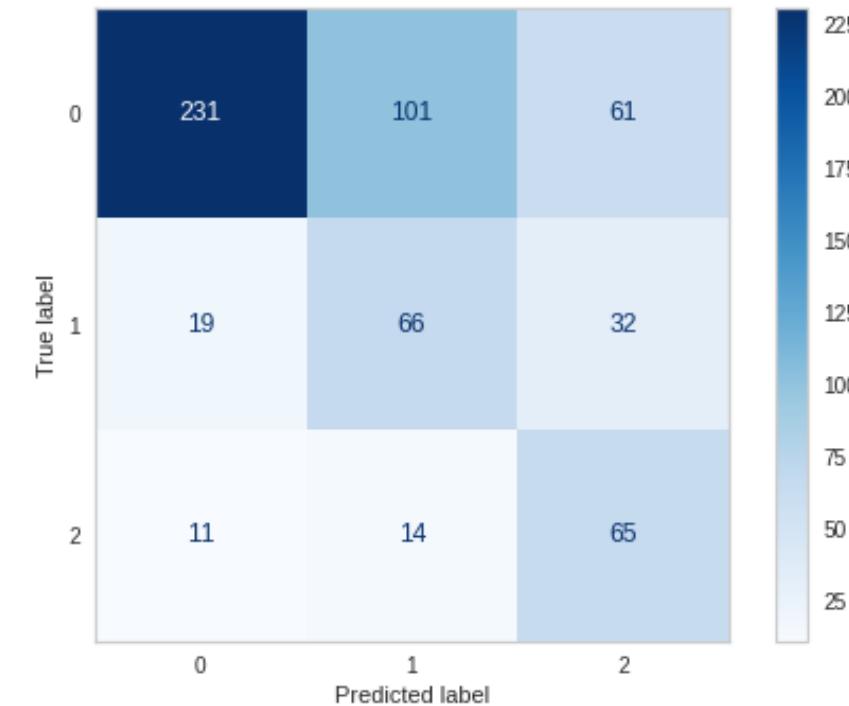
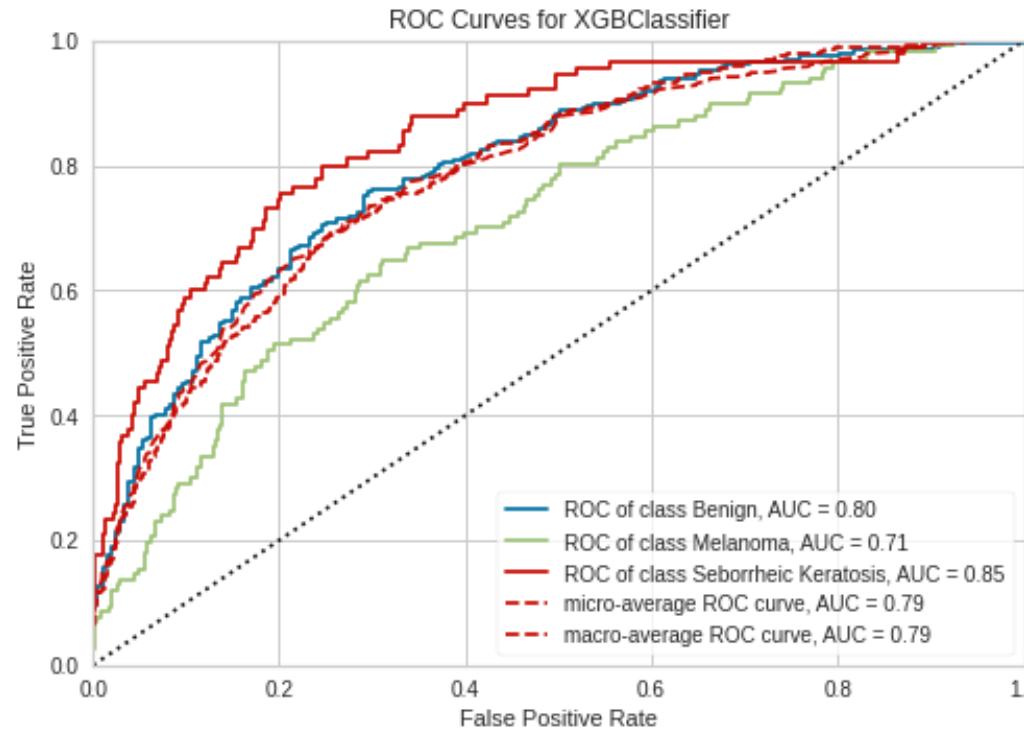
RESULTS (ML): ADABOOST METRICS



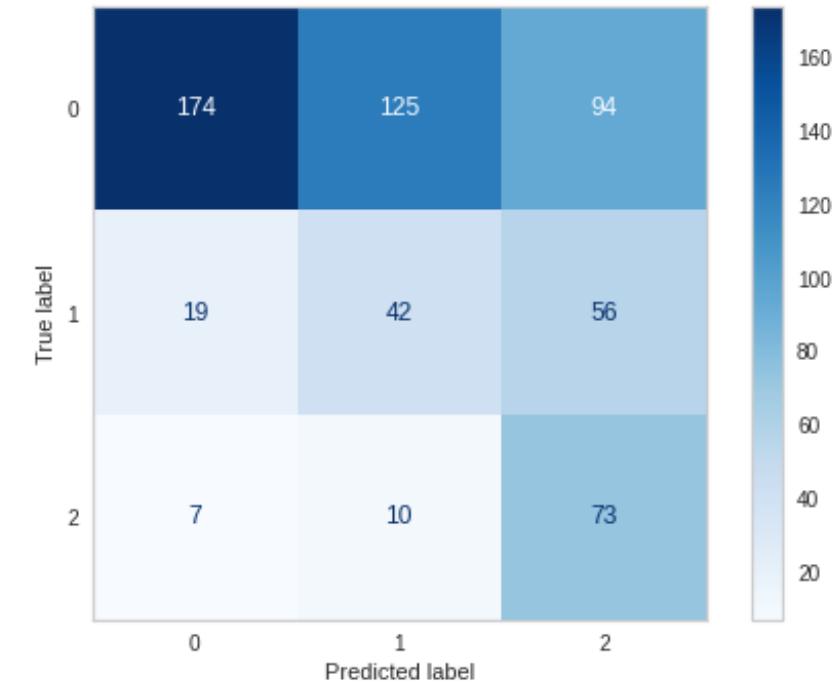
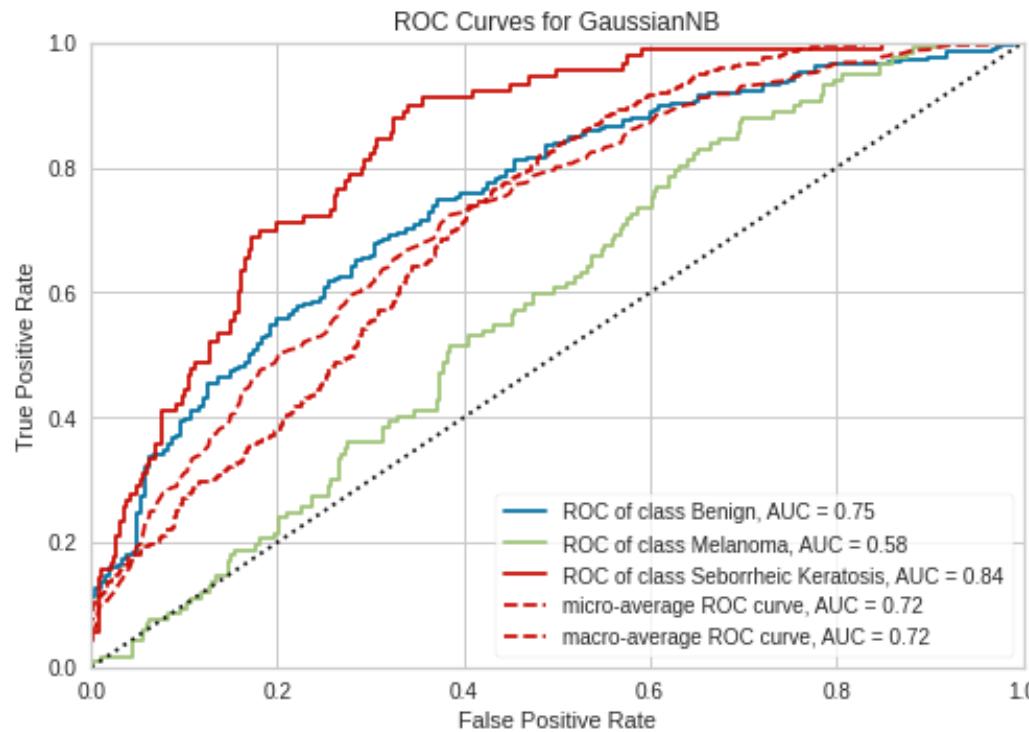
RESULTS (ML): DECISION TREE METRICS



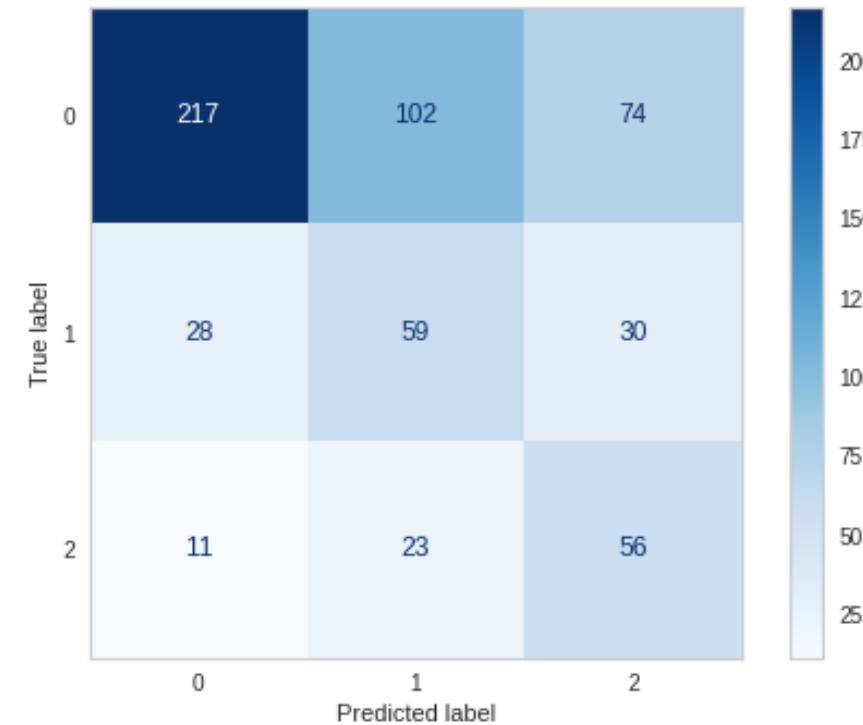
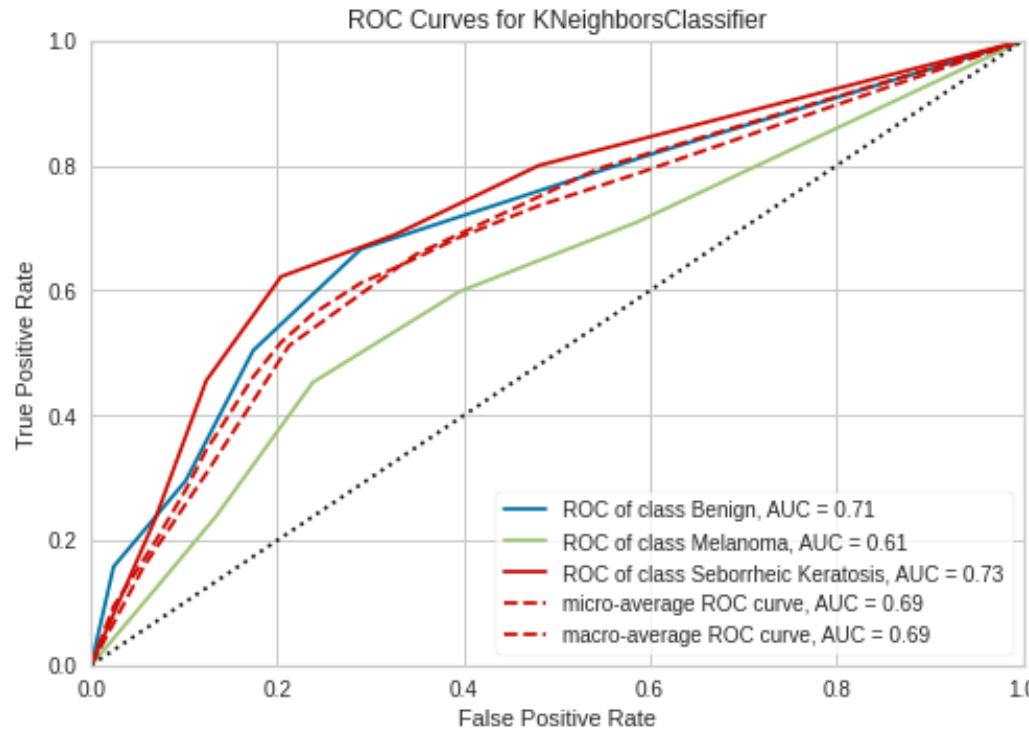
RESULTS (ML): XGBCCLASSIFIER METRICS



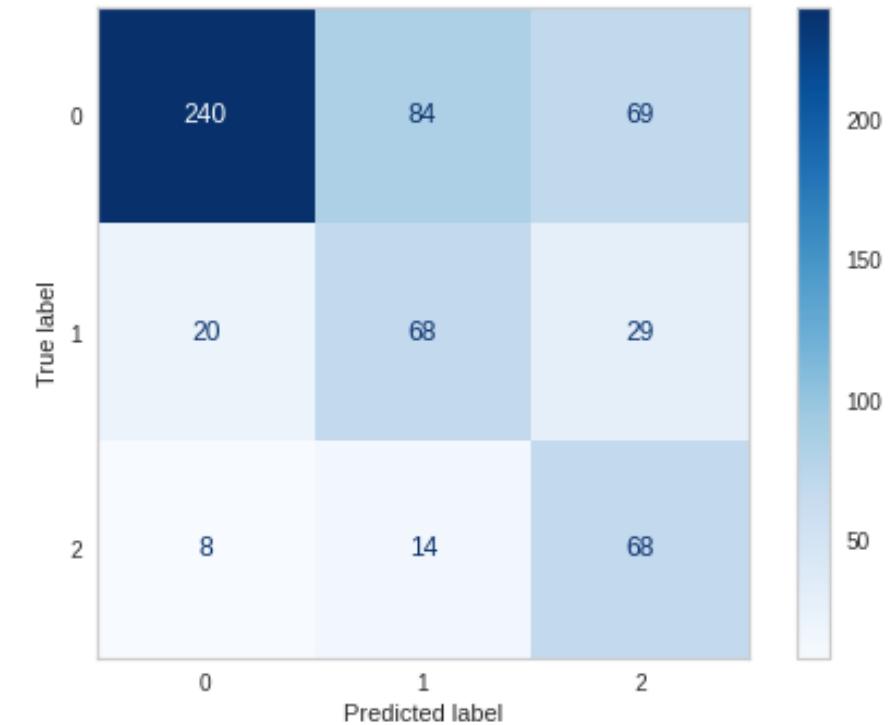
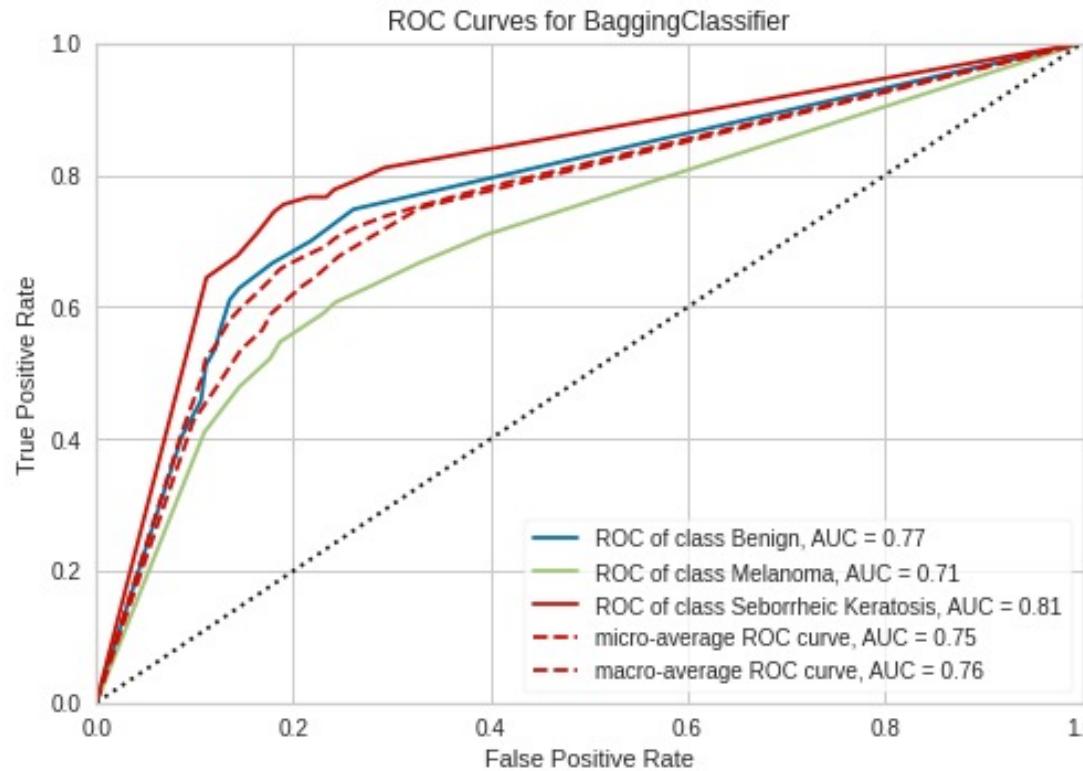
RESULTS (ML): GAUSSIAN NAÏVE-BAYES METRICS



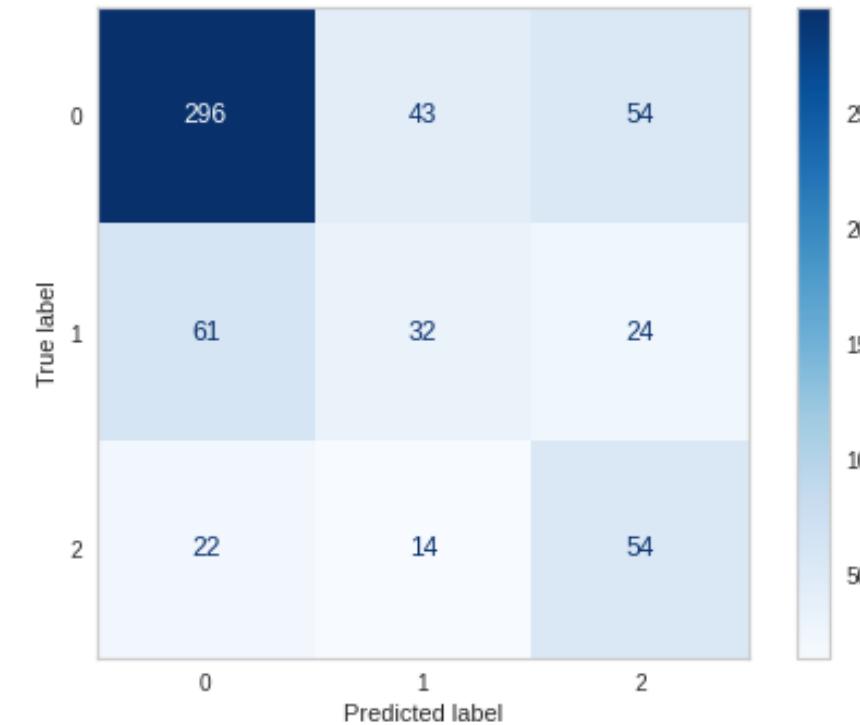
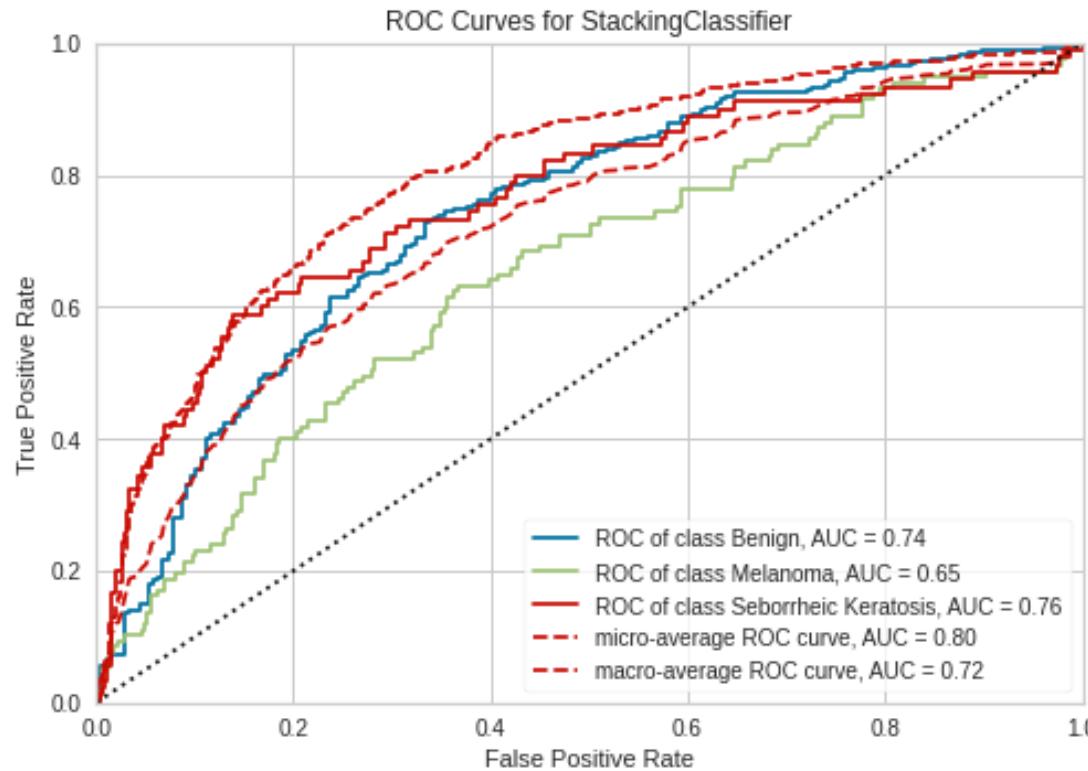
RESULTS (ML): KNN METRICS



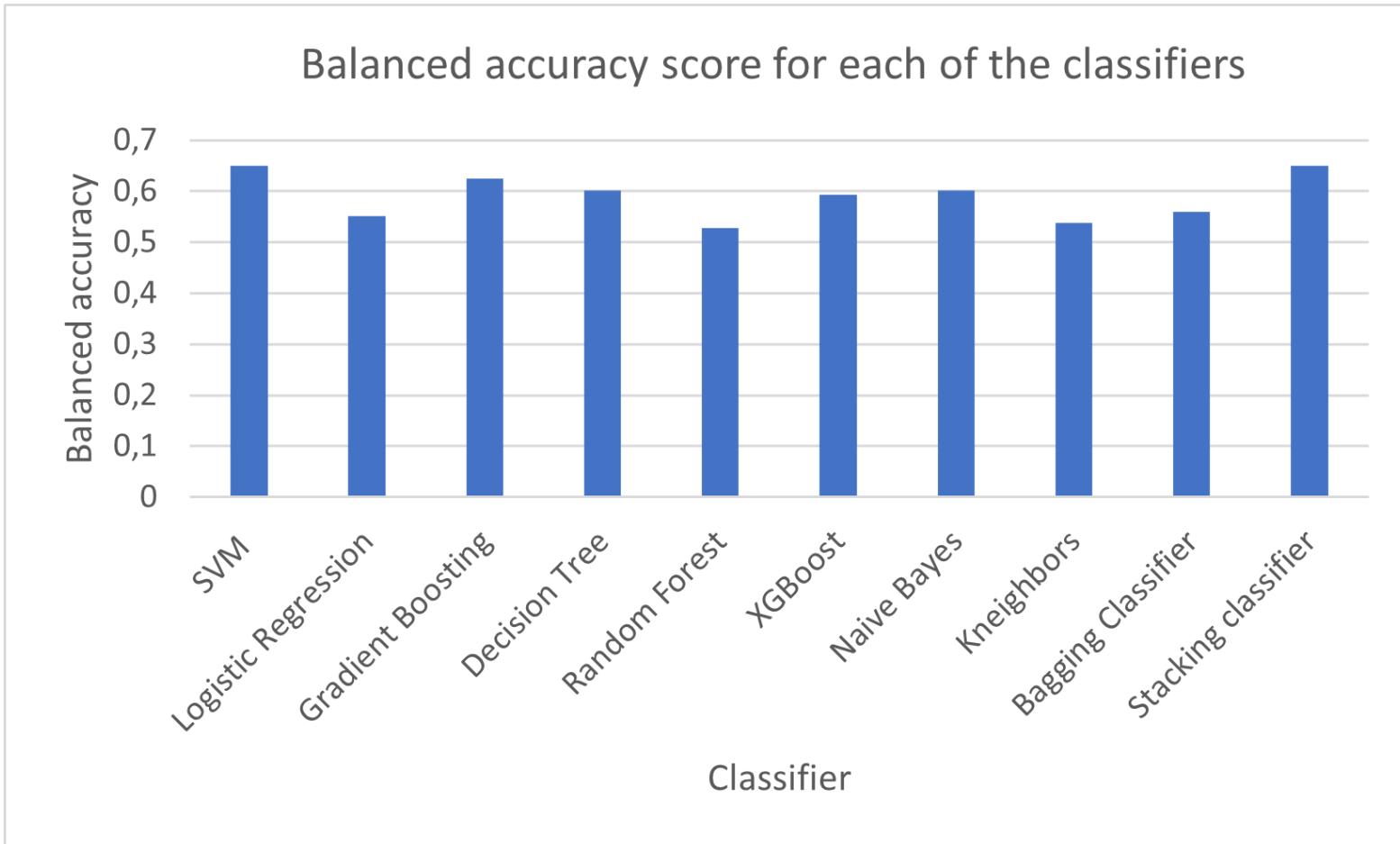
RESULTS (ML): BAGGING CLASSIFIER METRICS



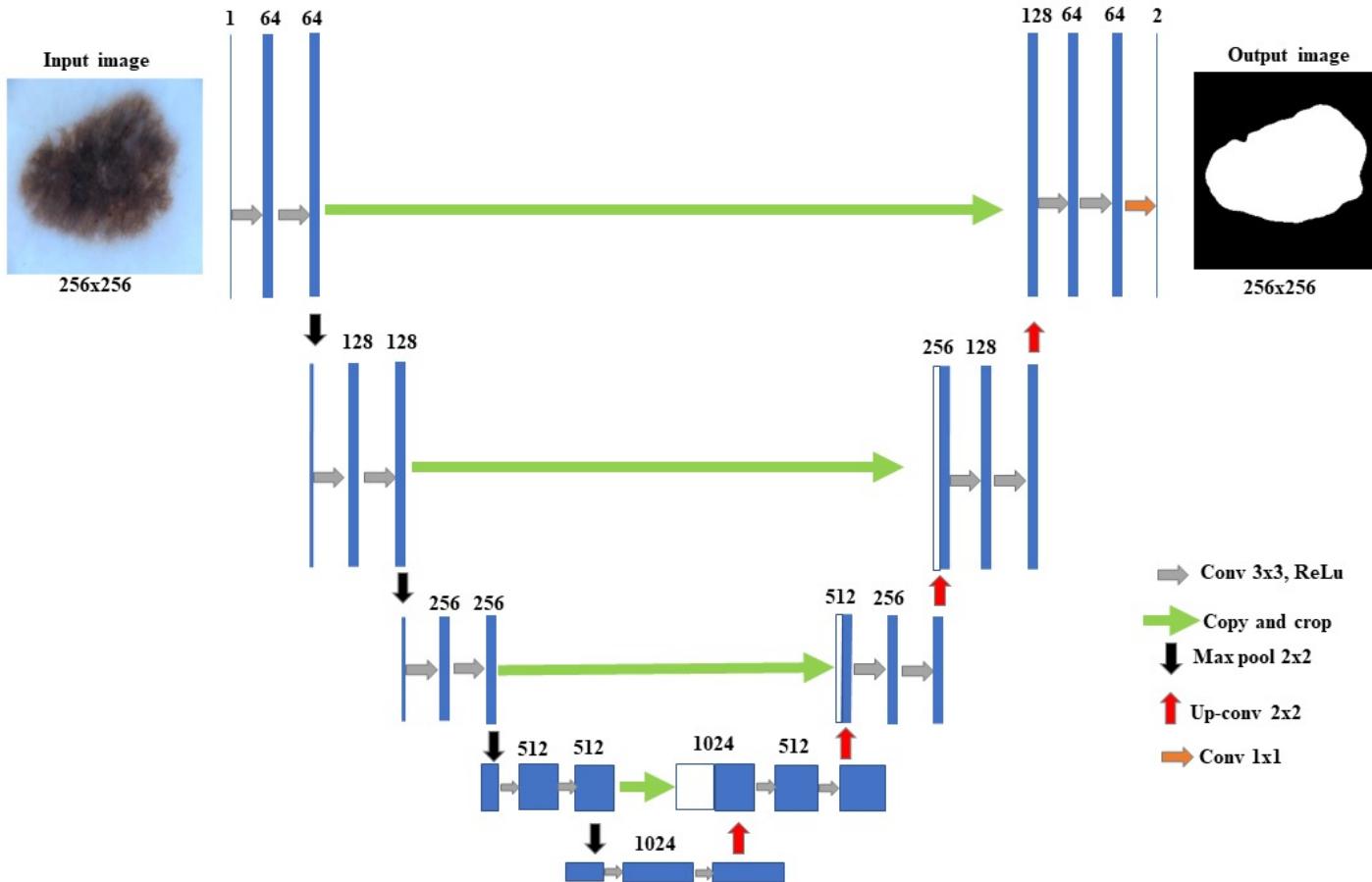
RESULTS (ML): STACKING CLASSIFIER METRICS



RESULTS (ML): OVERALL CLASSIFIERS PERFORMANCE



DEEP LEARNING-SEGMENTATION (DL): UNET ARCHITECTURE



RESULTS (DL): HYPER-PARAMETERS TUNING

TABLE I
HYPERPARAMETER VALUES FOR SEGMENTATION TASK

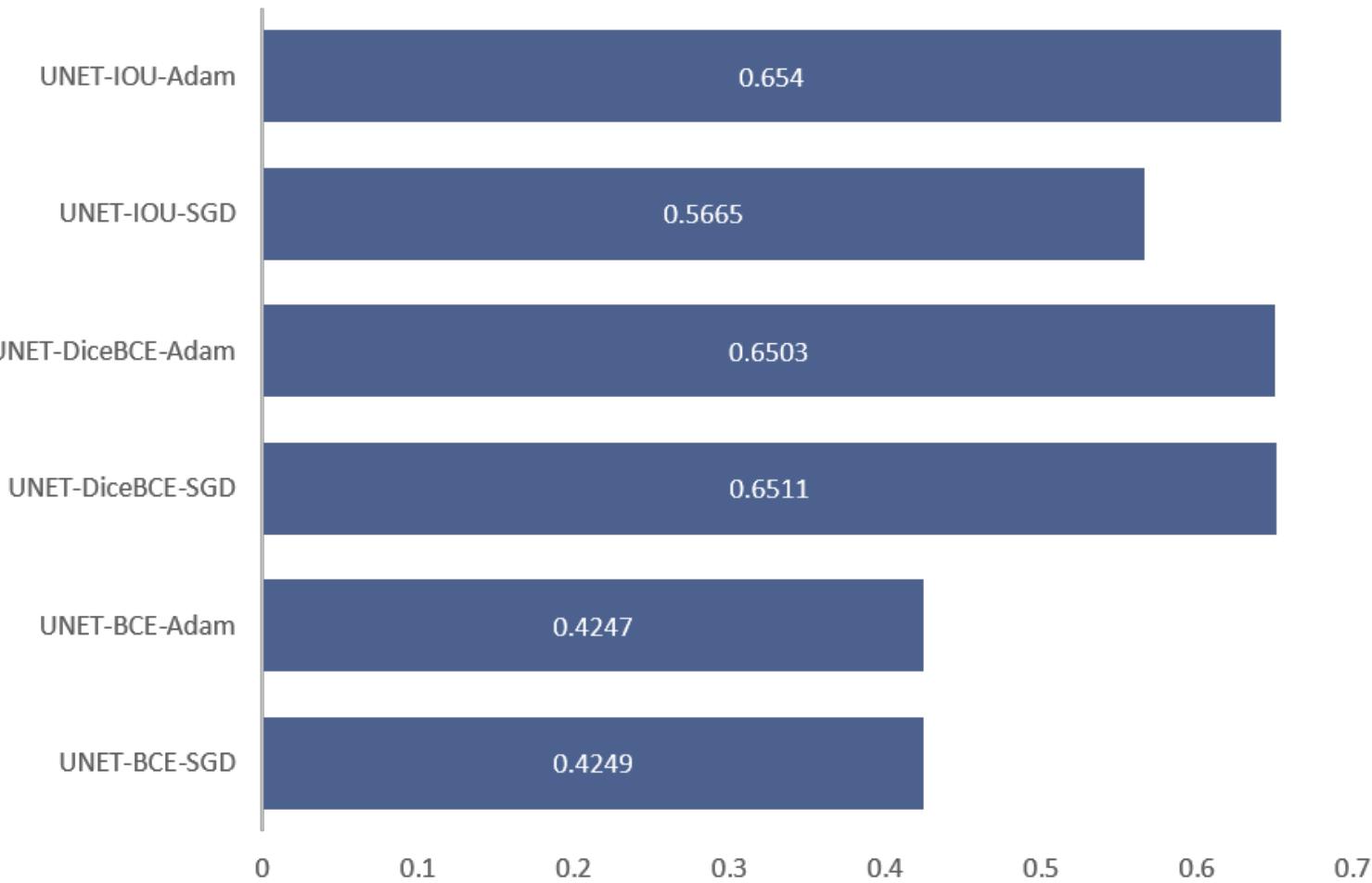
Hyperparameters	Value
Image Dimension	256*256
Batch Size	10
Learning Rate	1.00E-05
Number Of Epochs	100
Leraning Rate Patience	5
Early Stopping Patience	10
Weight Decay	1.00E-08
Momentum	0.9

RESULTS (DL): AUTOMATIC SEGMENTATION (U-NET)

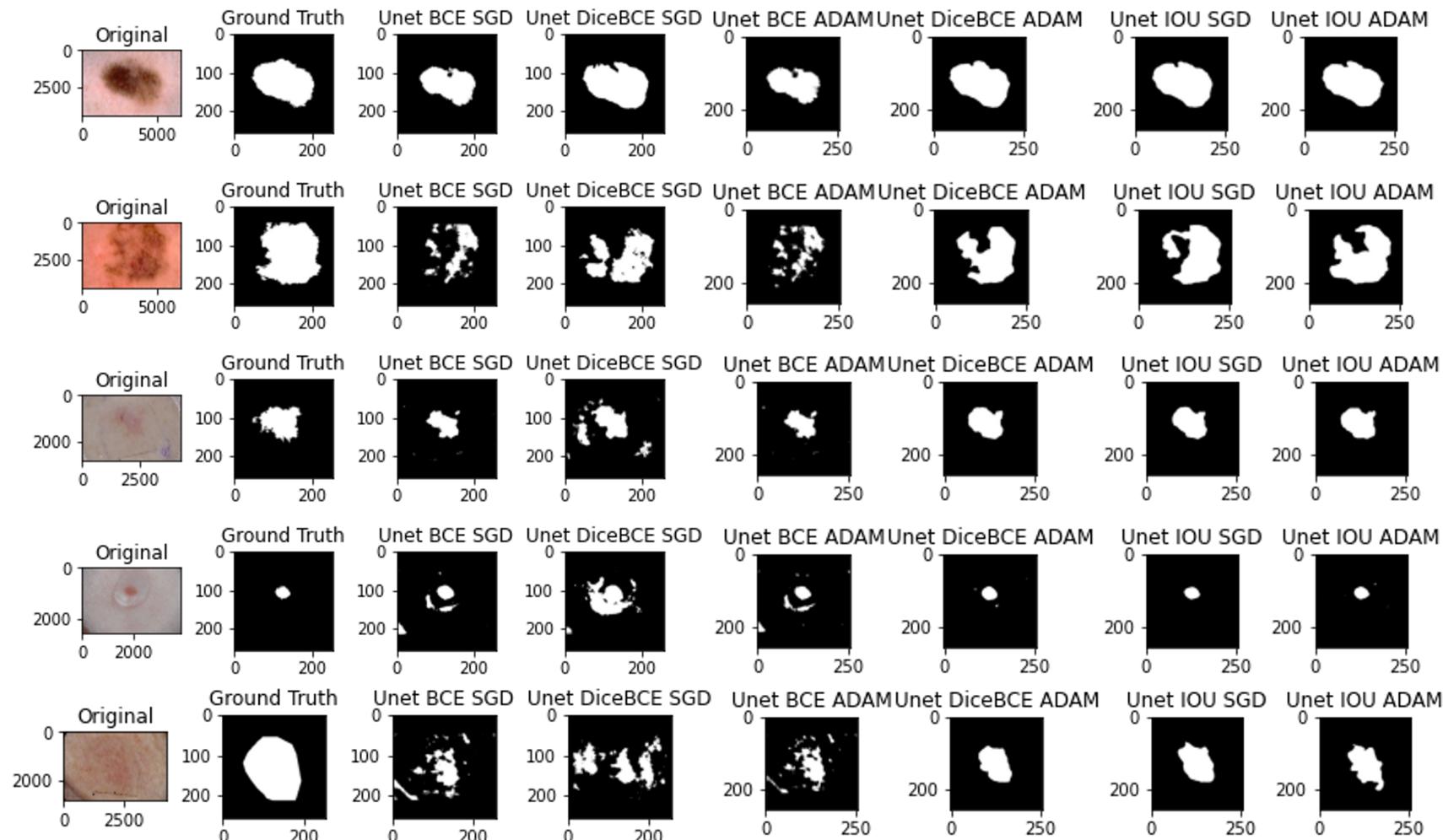
TABLE II
COMPARISON TABLE FOR SEGMENTATION RESULTS

Model	Loss Function	Optimizer	Test Loss	Test Dice	Test Jaccard
UNET	BCE Loss	SGD	0.8359	0.431	0.4249
		Adam	0.8825	0.4175	0.4247
	IOU Loss	SGD	0.5389	0.7461	0.6511
		Adam	0.5713	0.7575	0.6503
	Dice-BCE Loss	SGD	0.5794	0.6272	0.5665
		Adam	0.5052	0.7428	0.654

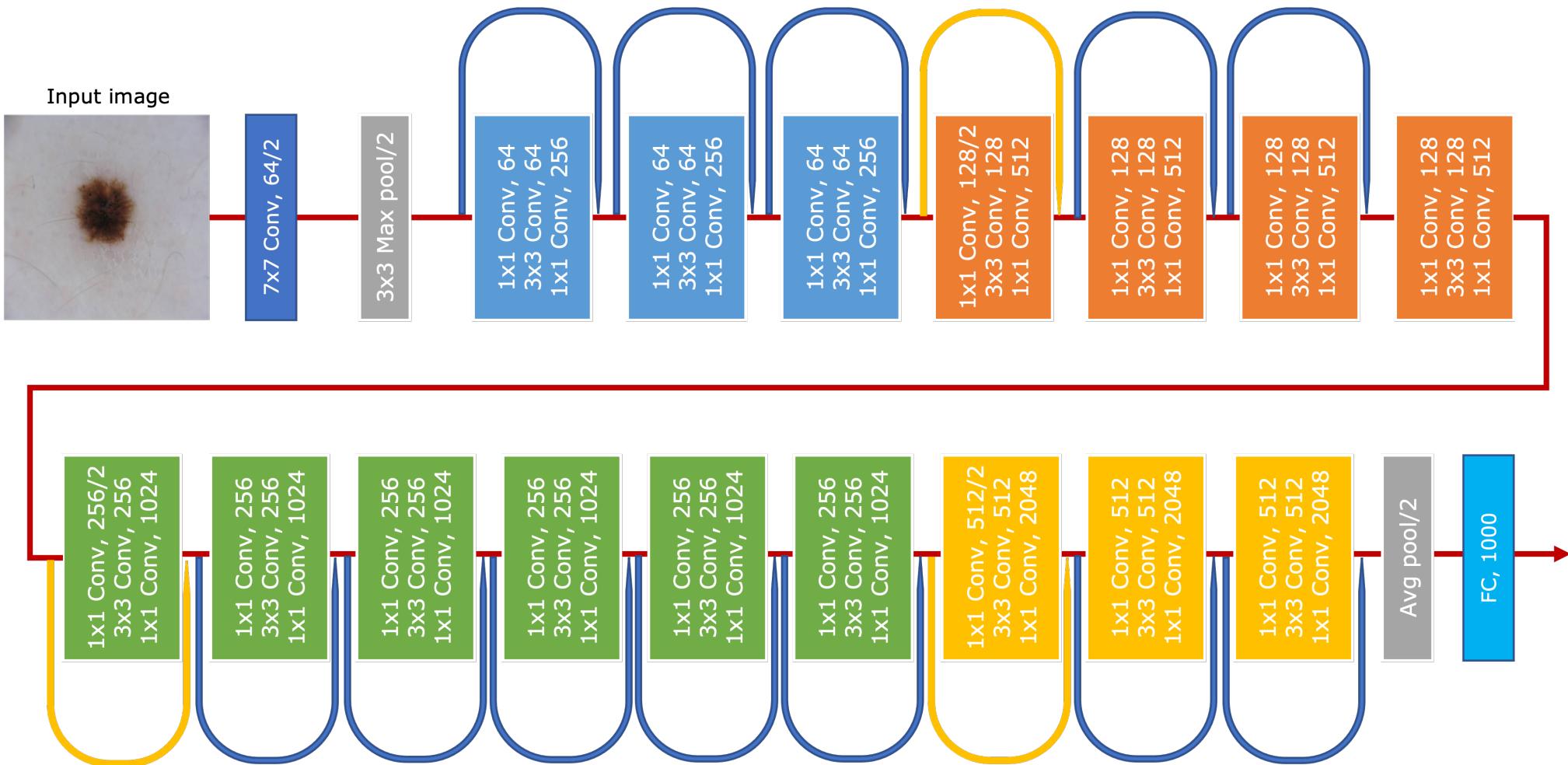
RESULTS (DL): MODELS JACCARD SCORE



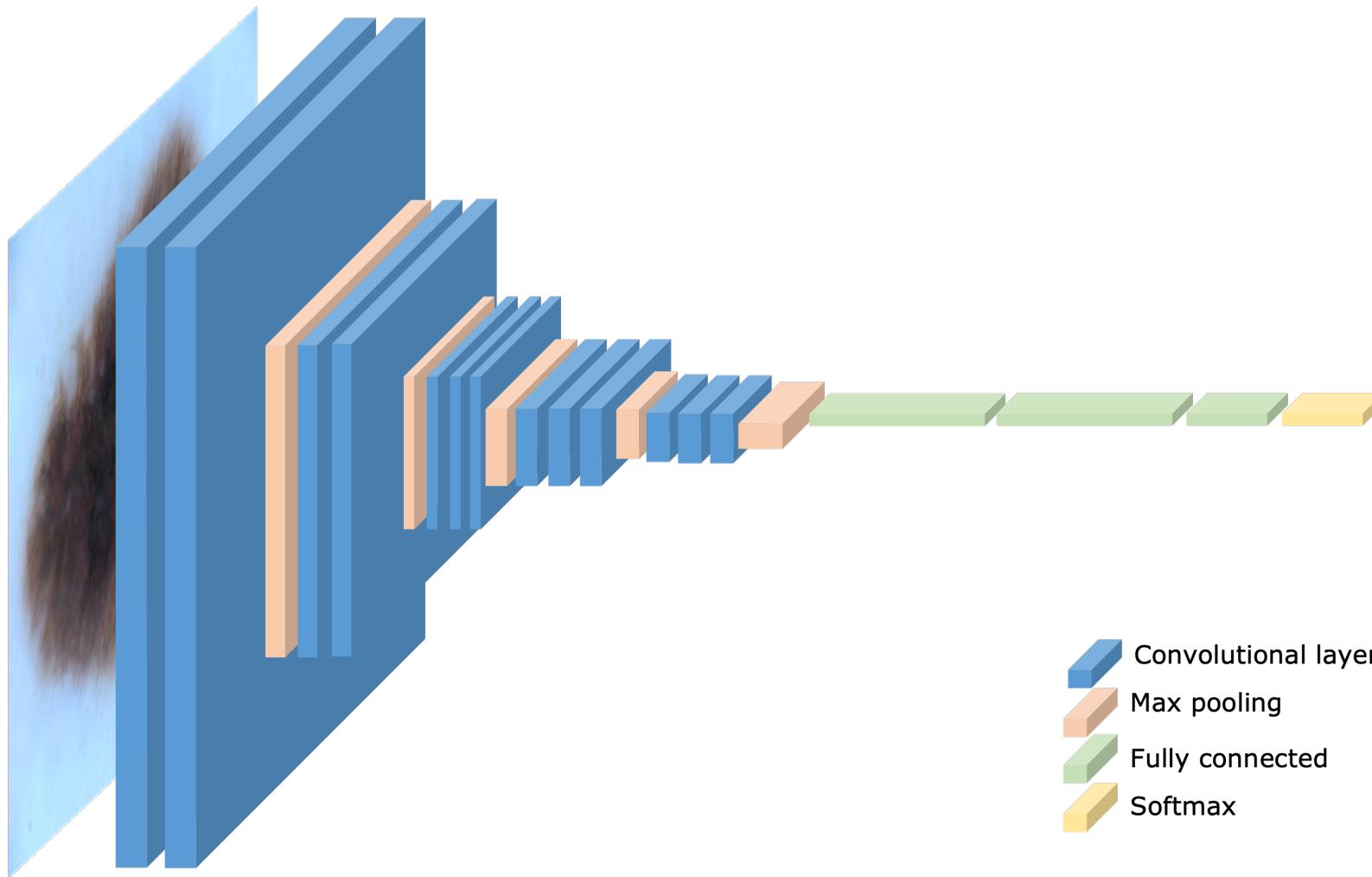
RESULTS (DL): QUALITATIVE RESULTS



CLASSIFICATION (DL): RESNET50 ARCHITECTURE

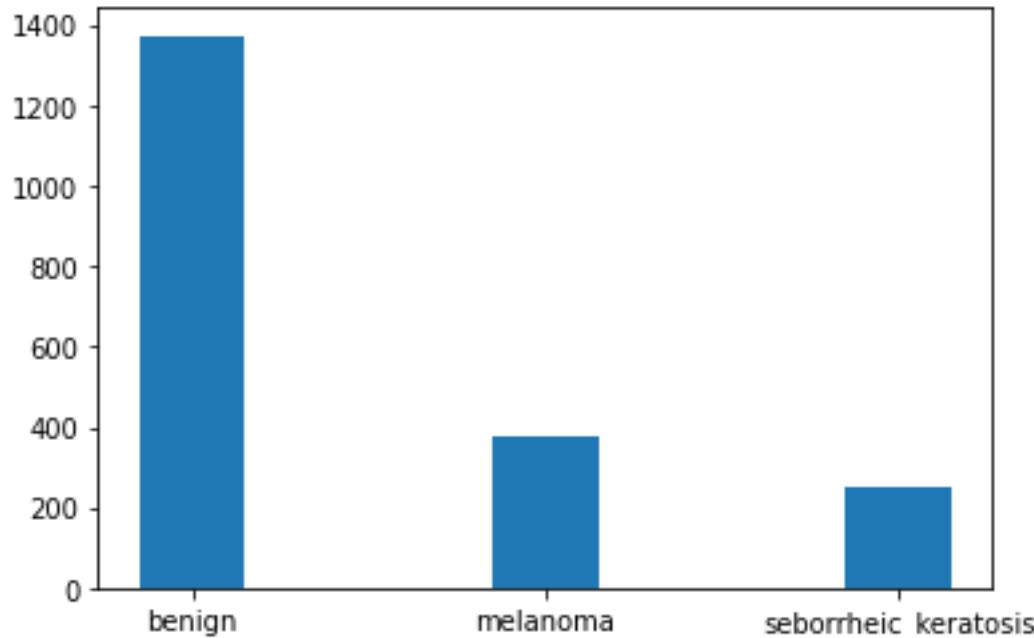


CLASSIFICATION (DL): VGG16 ARCHITECTURE

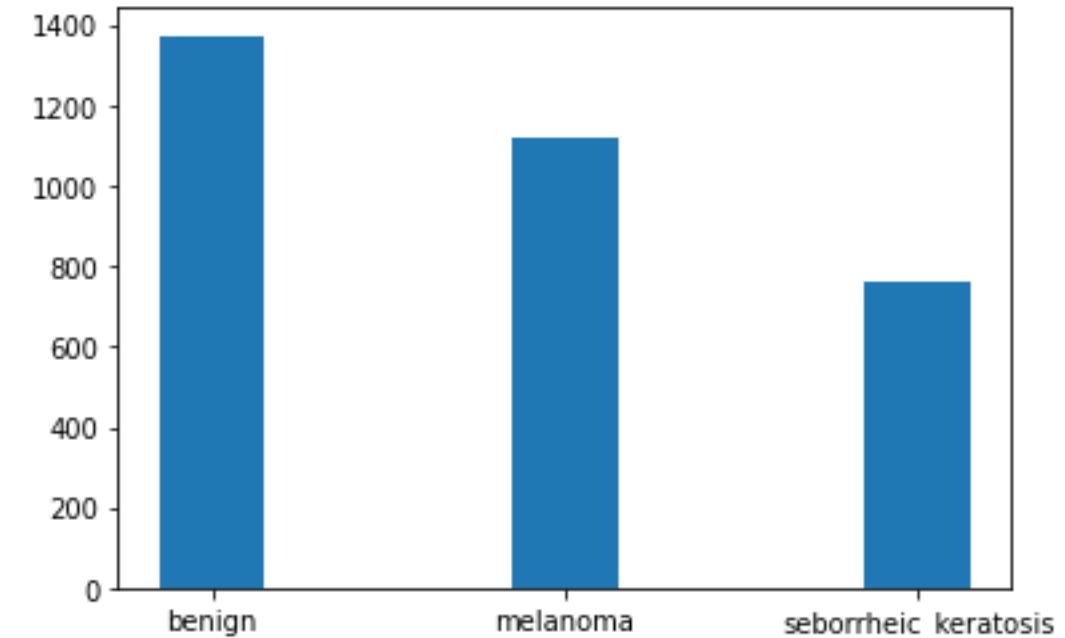


CLASSIFICATION (DL): VISUALIZATION OF DATA

INITIAL DISTRIBUTION OF TRAINING DATA



DISTRIBUTION AFTER DATA AUGMENTATION



RESULTS (DL): HYPER-PARAMETERS TUNNING

TABLE III
HYPERPARAMETER VALUES FOR CLASSIFICATION TASK

Hyperparameters	Value
Image Dimension	224*224
Batch Size	10
Learning Rate	1.00E-05
Number of Epochs	15
Learning Rate Patience	2
beta1 (Adam)	0.9
beta2(Adam)	9.99E-01
Momentum	0.9
Weight Decay	1.00E-06

RESULTS (DL): AUTOMATIC SEGMENTATION (U-NET)

TABLE IV
ACCURACY COMPARISON TABLE FOR CLASSIFICATION TASK

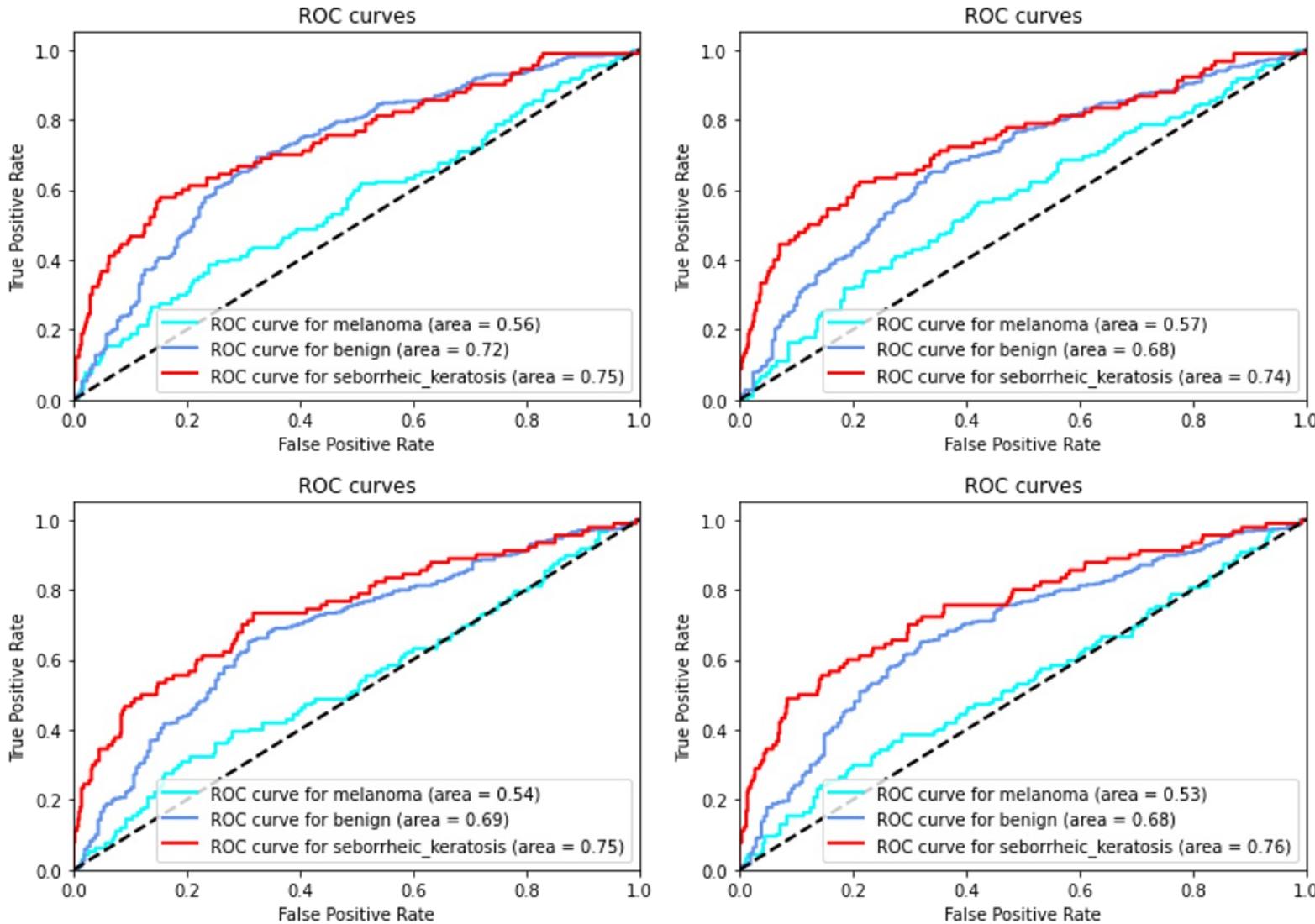
Model	Loss Function	Optimizer	Accuracy(Melanoma)	Accuracy(Benign)	Accuracy(Seborrheic)	Overall Accuracy
VGG-16	Cross-Entropy	ADAM	0.41	0.65	0.66	0.6
		SGD	0.42	0.64	0.68	0.6
	Focal-Loss	ADAM	0.28	0.65	0.71	0.59
		SGD	0.38	0.65	0.69	0.6
ResNet50	Cross-Entropy	ADAM	0.68	0.71	0.73	0.7
		SGD	0.6	0.78	0.71	0.73
	Focal-Loss	ADAM	0.41	0.8	0.73	0.72
		SGD	0.56	0.74	0.74	0.7

RESULTS (DL): AUC COMPARISON

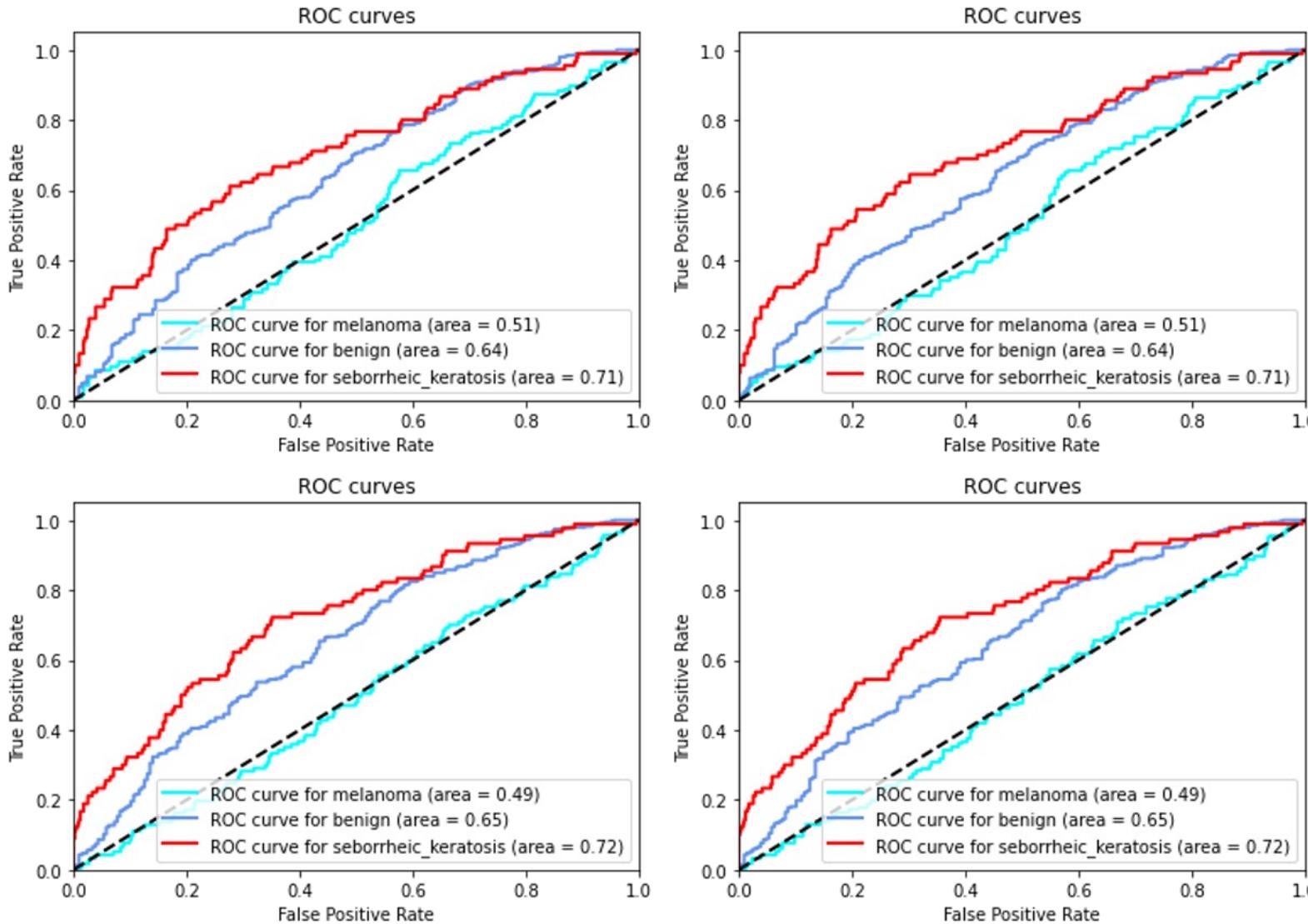
TABLE V
AUC COMPARISON FOR CLASSIFICATION TASK

Model	Loss Function	Optimizer	AUC(Melanoma)	AUC(Benign)	AUC(Seborrheic)
VGG-16	Cross-Entropy	ADAM	0.509	0.642	0.709
		SGD	0.506	0.639	0.711
	Focal-Loss	ADAM	0.49	0.651	0.723
		SGD	0.38	0.65	0.69
ResNet50	Cross-Entropy	ADAM	0.562	0.716	0.747
		SGD	0.572	0.68	0.739
	Focal-Loss	ADAM	0.535	0.686	0.746
		SGD	0.534	0.685	0.757

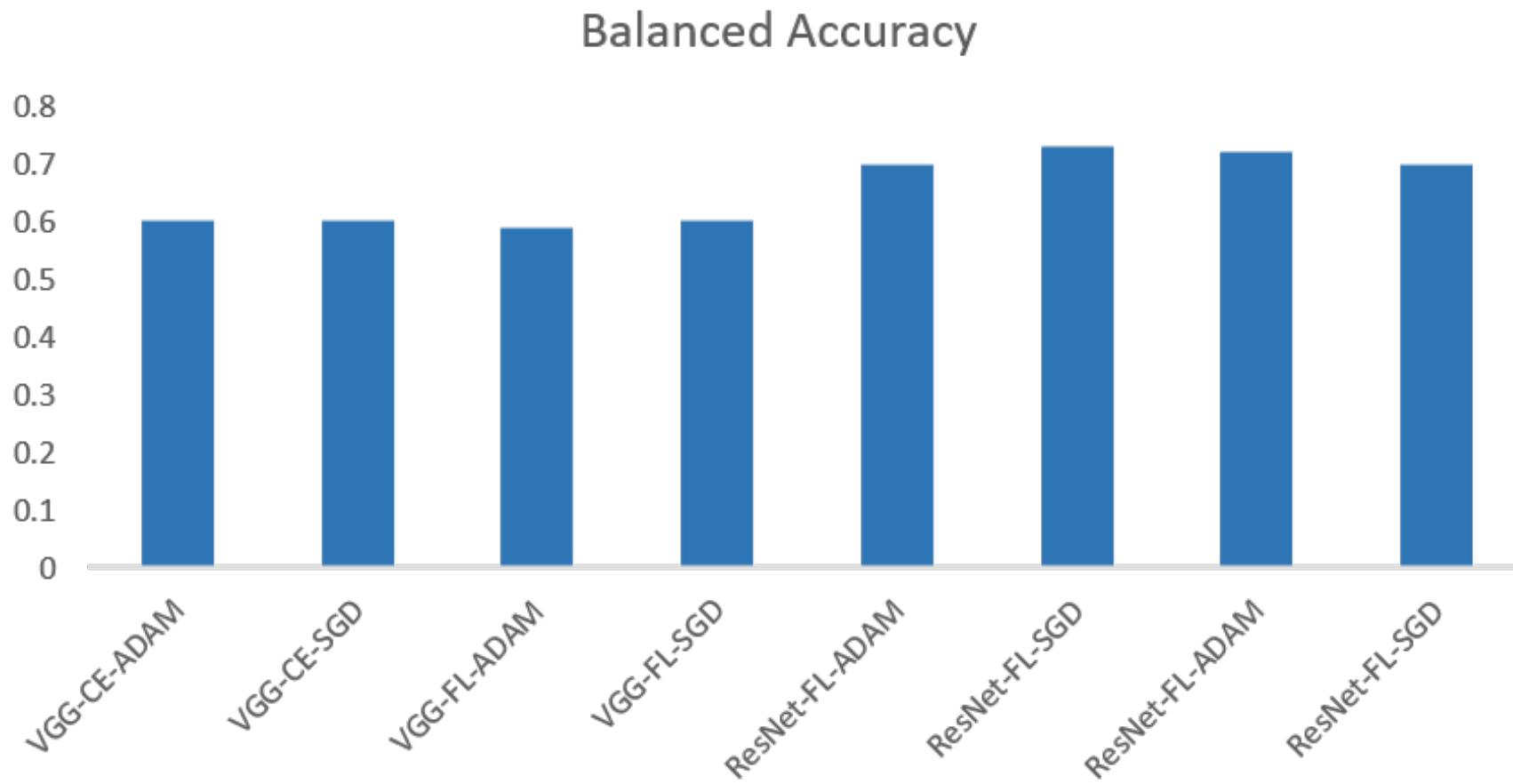
RESULTS (DL): ROCs FOR RESNET50 MODELS



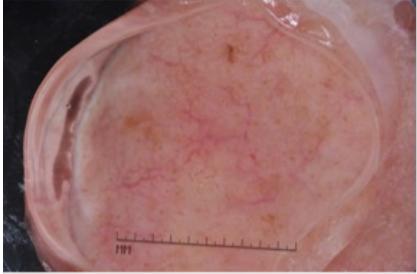
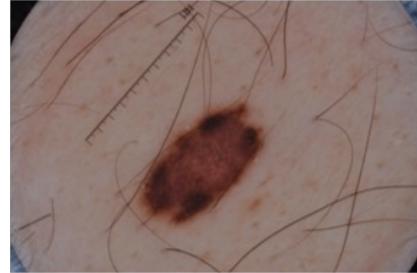
RESULTS (DL): ROCs FOR VGG16 MODELS



RESULTS (DL): COMPARISON FOR CLASSIFICATION MODELS



RESULTS (DL): CLASSIFICATION

Ground Truth	VGG16 (SGD/CE)	VGG16 (Adam/CE)	ResNet50 (SGD/CE)	ResNet50 (Adam/CE)
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	{"benign": 2}	{"benign": 2}	{"benign": 2}	{"benign": 2}
	{"melanoma": 1}	{"benign": 2}	{"seborrheic": 2}	{"melanoma": 1}