

Effects of Color Calibration via ICC Profile on Inter-scanner Generalization of AI Models

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INTRODUCTION

Generalizing deep learning models to whole slide images (WSIs) from different sources is a well-known challenge in digital pathology. Scanners used for the digitization of slides usually yield images in a different color space than the standard RGB (sRGB) space, characterized by the scanner ICC profile. Further, some scanners do not apply color space transform to sRGB during WSI creation, limiting the overall utility of image-based models.

METHODS

In order to standardize images for computational workflows, the ICC profile of scanners can be used to transform the images to sRGB space. Alternatively, models can be trained via data augmentation. However, this can require retraining of deployed models as well as additional experiments. Our study evaluates the relative effect of these two options by assessing the performance of two separate deep learning models (with different architectures) that were trained to predict microsatellite instability from H&E slides with and without these procedures.

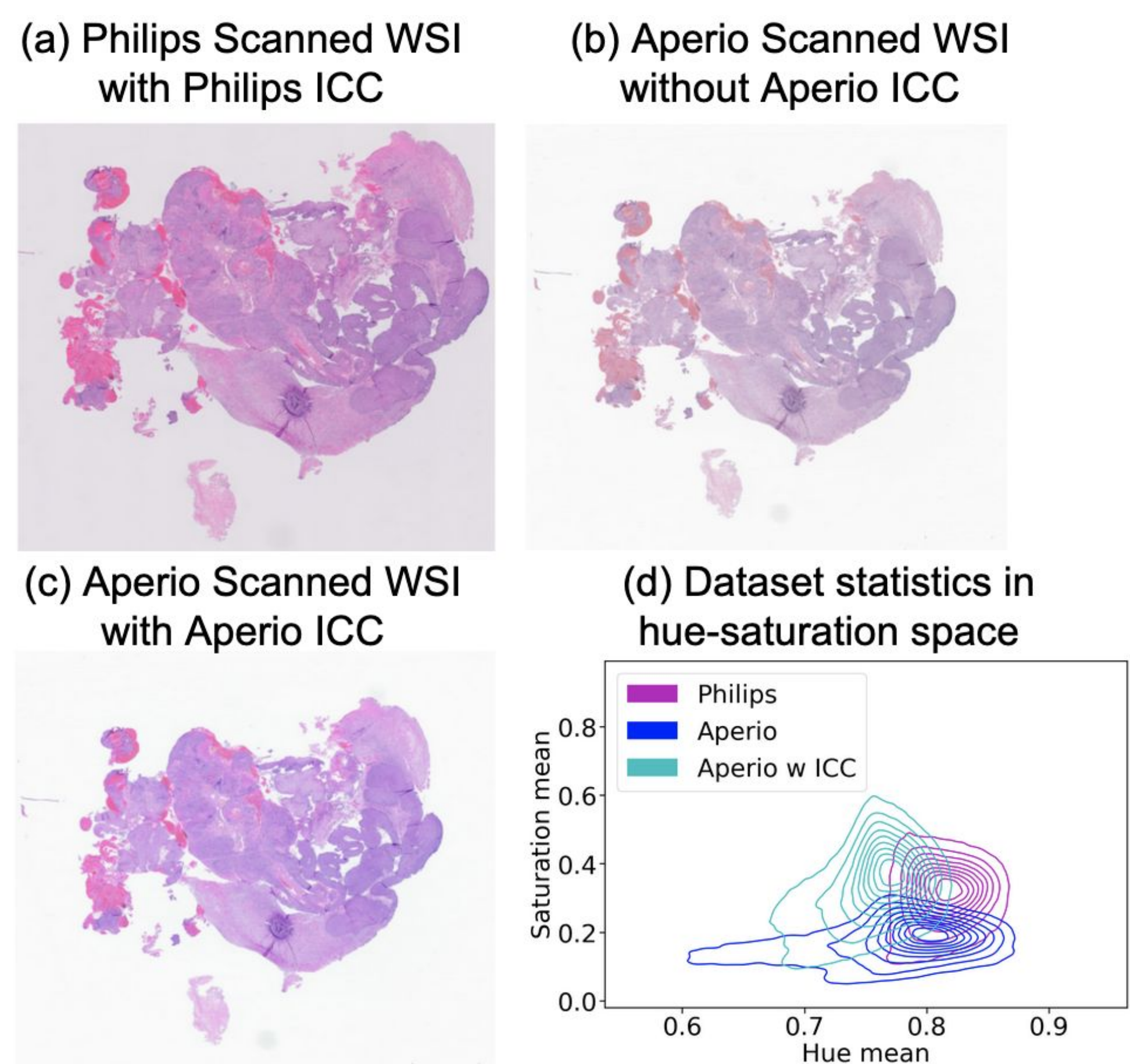


Figure 1. Whole slide images from different scanners appear visually distinct (A,B), but after mapping to the standardized color space (sRGB), they look similar (A,C). Quantitatively, these differences can be observed in the hue vs saturation space (D).

SUMMARY

ICC profile transformation yields similar or improved results on unseen scanner slides without requiring retraining of image-based models. Color normalization via ICC profile could facilitate model generalization when data is scarce and be used as a part of the standardization workflow in digital pathology.

RESULTS

Guide to experimental results

	Scanner type		ICC profile transform?	Color augmentation?
	Philips	Aperio		
Experiment 1	✓	-	✓	-
Experiment 2	-	✓	-	-
Experiment 3	-	✓	✓	-
Experiment 4	✓	-	✓	✓
Experiment 5	-	✓	-	✓
Experiment 6	-	✓	✓	✓

Table 1. The various experiments we performed to assess the impact of both ICC profile transformation and color augmentation across two different scanners. Colors correspond to line colors shown in Figure 2.

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Demonstrating improved model performance using ICC profile transform and color augmentation

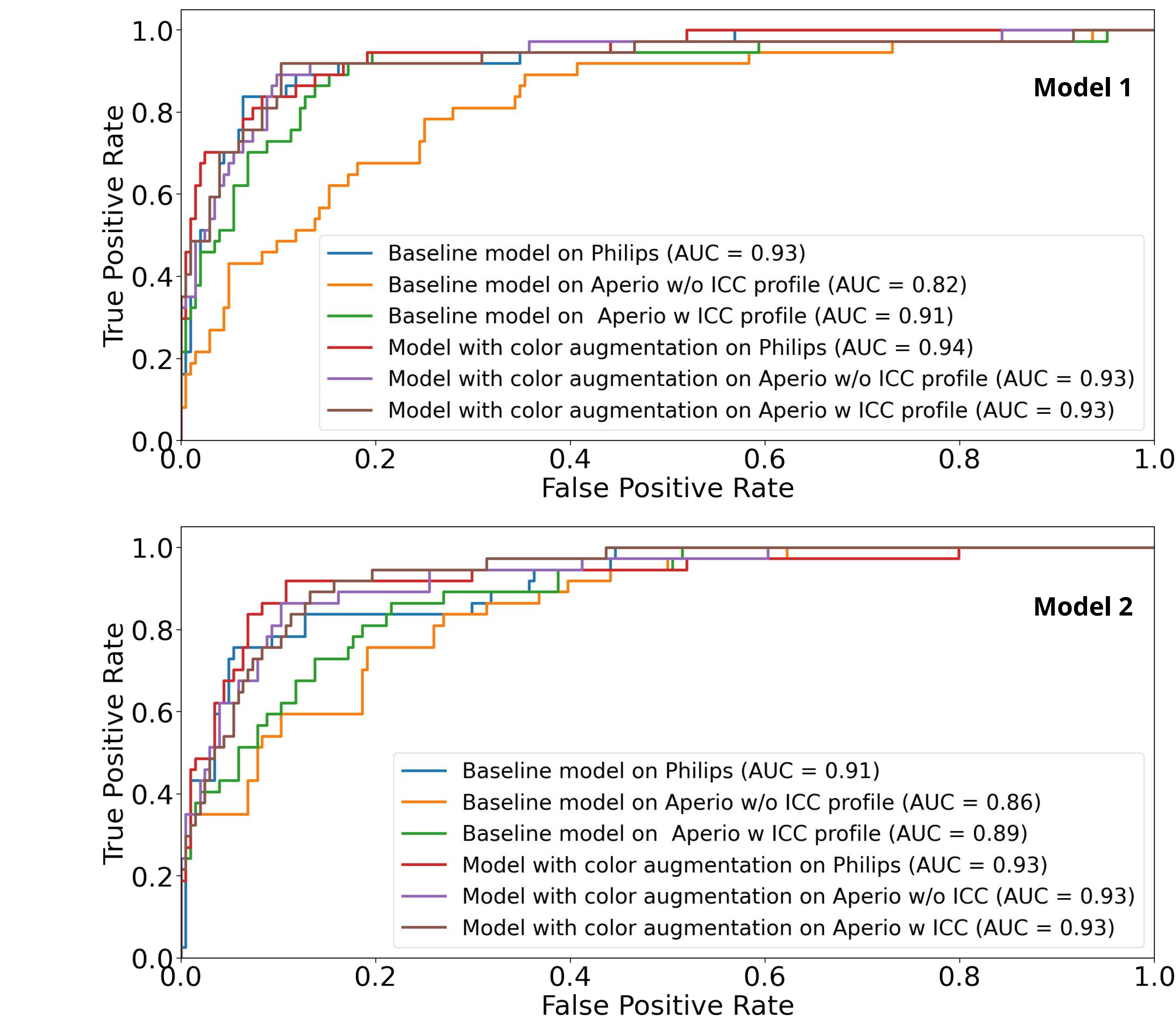


Figure 2. Comparing the effect of ICC profile transform and color augmentation on two models: model 1 (top) and model 2 (bottom). Model performance is improved or similar by applying ICC profile transformation (compare blue [baseline] against orange [no ICC] and green [w/ICC] lines). The use of color augmentation can improve model performance regardless of ICC profile transformation (compare red [baseline] against purple [no ICC] and brown [w/ICC] lines). Note that ICC profile transform improves performance when used without color augmentation and does not negatively impact performance when used with color augmentation.