As demonstrated by examples in Figure APP. 9, the translation outputs of CycleGAN_40 and other models in this framework leave much to be desired regarding visual quality. None of the models before the 55th epoch learned to recreate the uncoated electrode terminals and other exposed areas of the foil, namely holes or breaks in the coating, as they appear in the TD images. The brightness distribution of translated images resembles that of the TD, only with less white and more gray, hence the taller peaks at brightness values of around 100. Moreover, models learned toward the end of this experiment put two white bands on the sides of the translated image, but they never matched the actual size of the uncoated electrode terminal in the input (SD) image. However, these models added extra texture and features to the translated image, making the outputs unusable. The model was used to translate training data for the YOLOv8x detection model and then tested on the annotated test set from the TD.

One interesting observation in this experiment is the case of CycleGAN_45. This model produced the closest pixel-value distribution to the TD by all statistical metrics across all I2I translation models in all frameworks. However, the image outputs are severely distorted and unusable as all content features are lost in translation, and the brightness values are assigned to the wrong places in the translated image. This outcome stresses once more how considering image statistics alone will be misleading.

Table 5.5 Defect detection evaluation for the YOLOv8x model trained using translated images (CycleGAN_40) and tested in the TD.

CycleGAN_YOLO (Trained on CycleGAN_40 Translations and Tested in the TD)

Class	Images	Instances	Precision	Recall	mAP50	mAP50-95
all	183	2822	0.231	0.206	0.263	0.107
Foil		369	0.014	0.005	0.155	0.088
Hole		2014	0.000	0.000	0.002	0.001
Stripe		439	0.679	0.613	0.632	0.231

Speed: 1.0ms preprocess, 154.4ms inference, 0.0ms loss, 3.6ms postprocess per image

Based on Table 5.3, CycleGAN_40 translations had the poorest performance by translation metrics. That is, these translations were the furthest of all translated images from the contents of their corresponding SD images. Although translated images closely mimic the pixel-value distribution of TD images, looking at some example translations by this model (Figure APP. 10) reveals the I2I translation model's inability to preserve the contents of the input image. Most image contents were lost in translation, creating vague images with few discernible features where the uncoated foil and coating appear identical. The only exception is the model's good performance in recreating the edges with the TD appearance.

Table 5.5 summarizes the performance of the defect detection model learned using the training dataset translated by CycleGAN_40 (CycleGAN-YOLO). Moreover, examples of this model's detection outputs can be found in Figure APP. 29. CycleGAN-YOLO is found to completely fail to detect uncoated foil, which SD-YOLO had no problem with and did not seriously challenge AdaIN-YOLO. The reason can be traced back to the I2I translation model's (CycleGAN_40) inability to recreate the uncoated electrode terminals as they would appear in the TD. Therefore, the defect detector (CycleGAN_YOLO) fails to identify uncoated-foil defects in TD images and keeps mistaking the coated areas for uncoated foil (Figure APP. 29). It must be