A Novel Inspection System For Variable Data Printing Using Deep Learning

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In the following pages, we provide additional qualitative results. The samples are from the real defects test set of 80,000 image pairs (section 5.1 of the paper). It is an independent dataset of real defects (from real-world printing scenarios) that has not been used during training or validation.

Each example contains a reference image, a printed image, and a scanned image. Red bounding boxes are around the detected defects.

We compare the following methods:

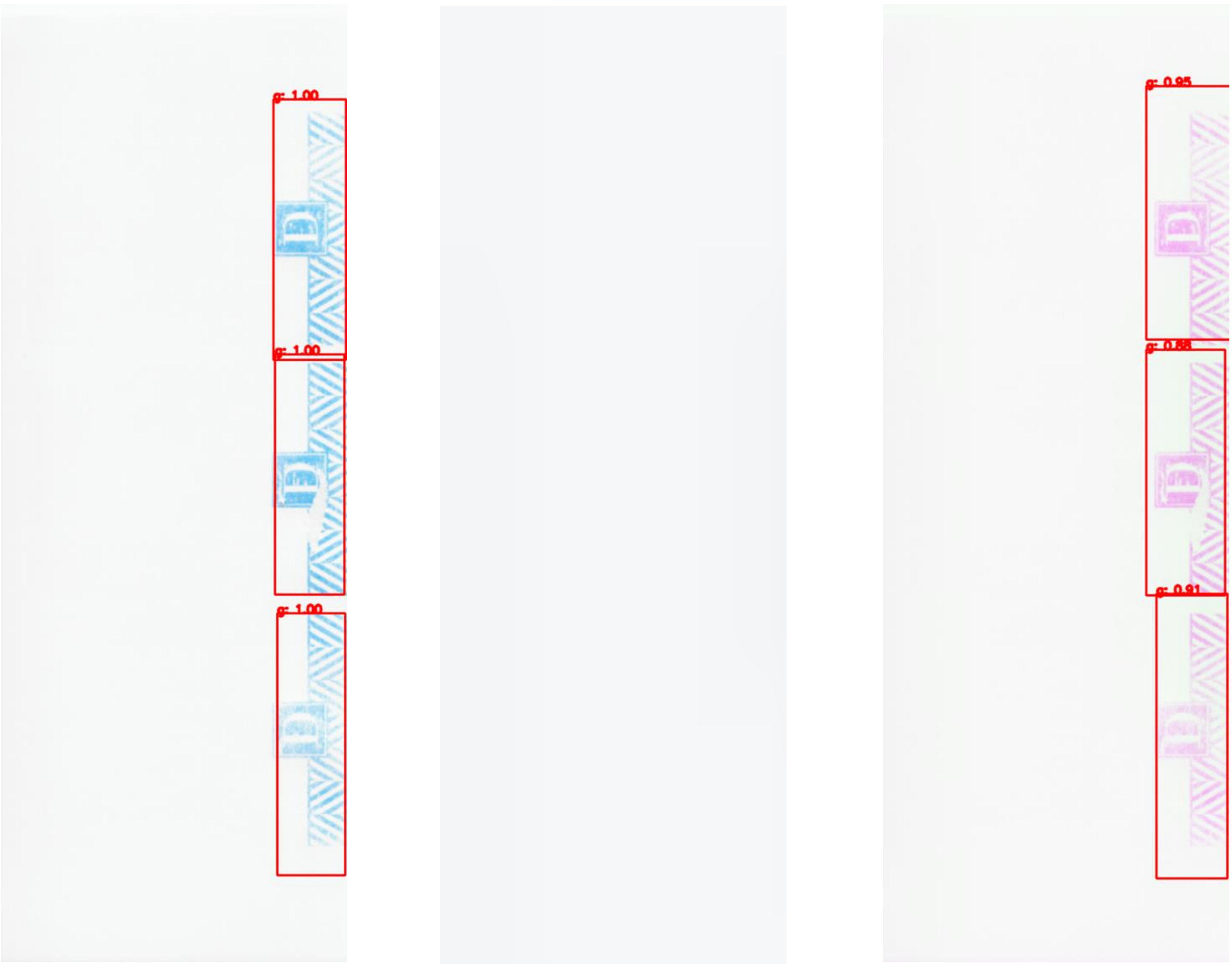
- **Pseudo-color SSD**: our novel early fusion approach (section 4.1 of the paper).
- **Change-Detection SSD (CD-SSD)** : our novel two-branch (Siamese) architecture (section 4.2 of the paper).
- **Concatenate + SSD**: a baseline (early fusion) method. It is based on concatenating the two input images (along the channel dimension) into a single 6-channel image as an input to the SSD512 model.
- **Multi-spectral SSD –** a baseline (middle fusion) method (*V. Osin et al.*; reference 28 in the paper). It has a Siamese network meta-architecture that fuses the two branches (a concatenation followed by 1x1 convolution filters for dimensionality reduction by a factor of 2) at each detection layer of the SSD. We use it with the VGG16 base network and the SSD 512 model that contains seven detection layers.

From the results, it can be noted that:

- Our CD-SSD and Pseudo-color SSD detect well a broad spectrum of defect types with different properties (e.g., size, shape, contrast, and background texture). Some of the defects (examples 1-3) are complex, difficult to define a priori, and with high variability. They are caused by erroneously printing the previous image (or some of it) on top of the current image.
- The baseline methods fail to detect (mainly) large defects with high variability (examples 1-3,8,9,11).
- All methods can detect changes of interest ('true' defects) while ignoring scanner artifacts (examples 4,5). It is probably due to the hard-negative mining employed in the single shot detector (SSD).
- Pseudo-color SSD results are quite similar to CD-SSD while it is faster and contains less trainable parameters (see paper Table 1). So, when performance limitations are an issue (speed/memory), and the data contains high variability, Pseudo-color SSD could be a good alternative.

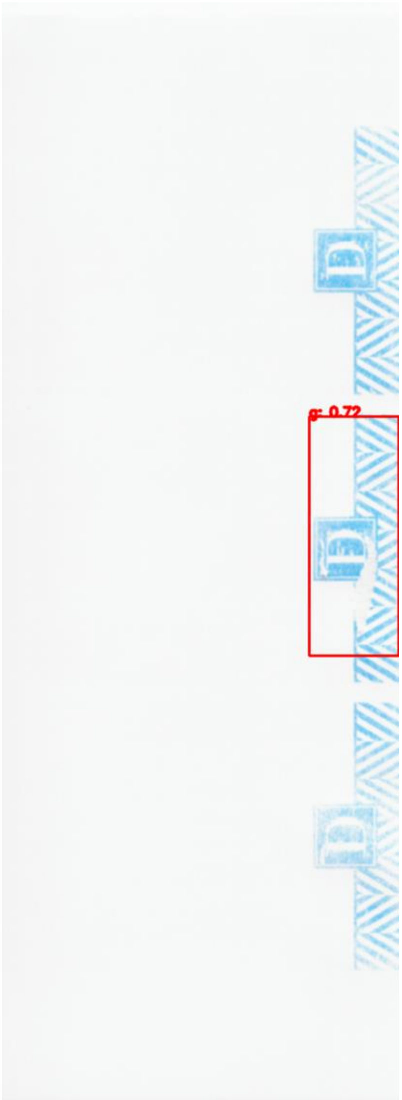
Example #1

CD-SSD **(ours)** | Reference Image | Pseudo-color SSD **(ours)**



Example #1

Multi-spectral SSD

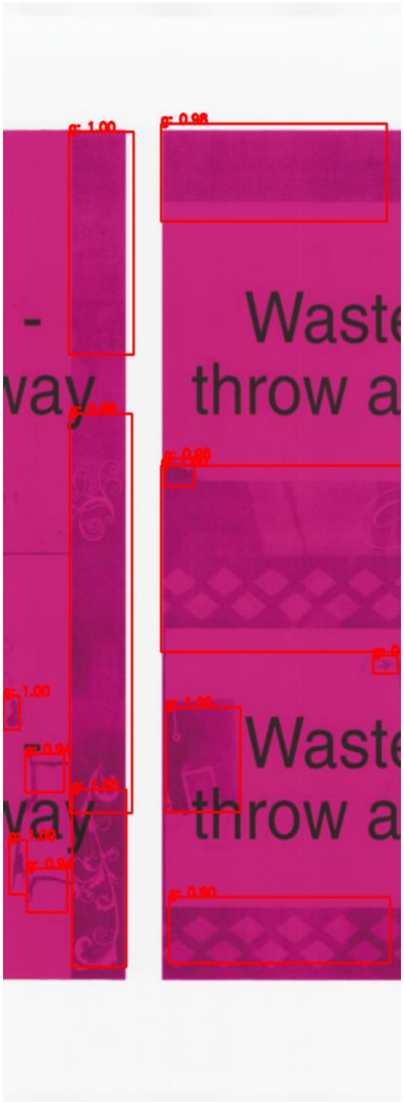


Reference Image

Concatenate + SSD

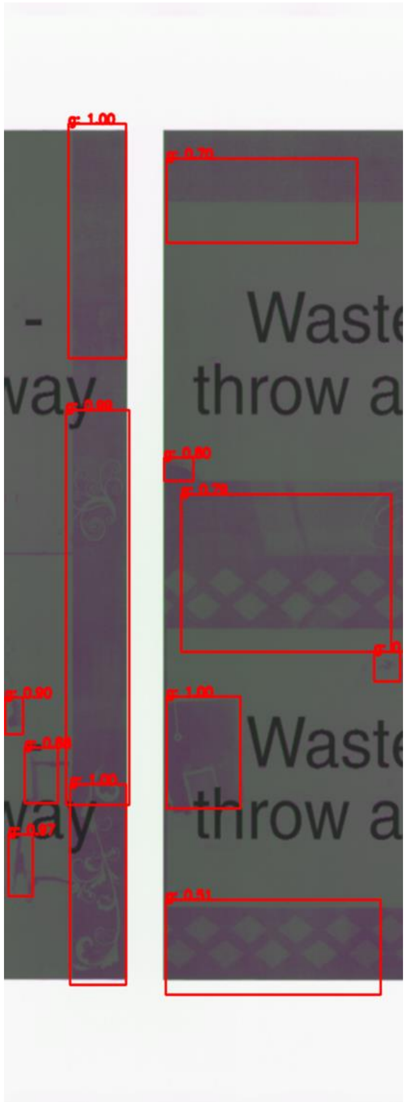
Example #2

CD-SSD **(ours)**



Reference Image

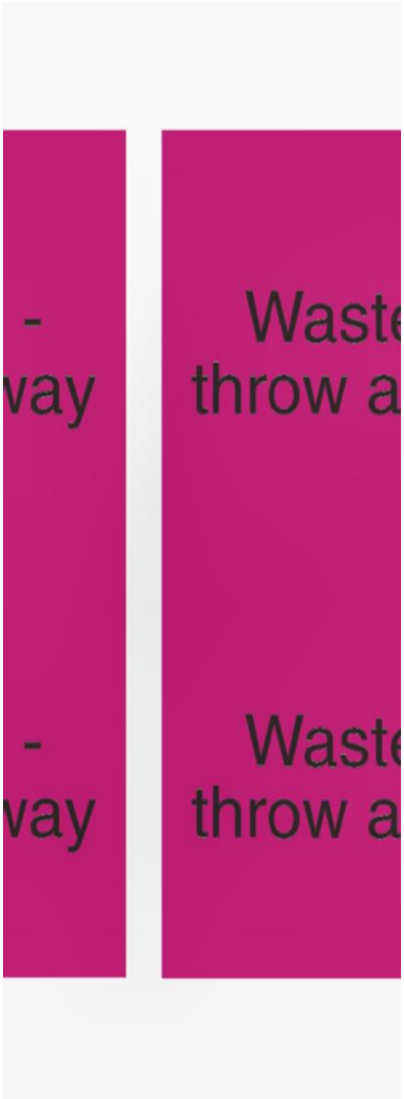
Pseudo-color SSD **(ours)**



Example #2

Multi-spectral SSD

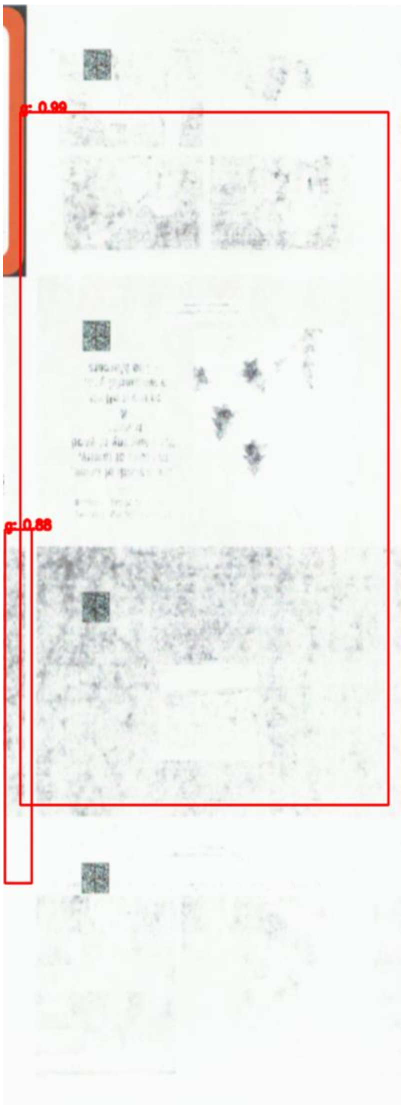
Reference Image



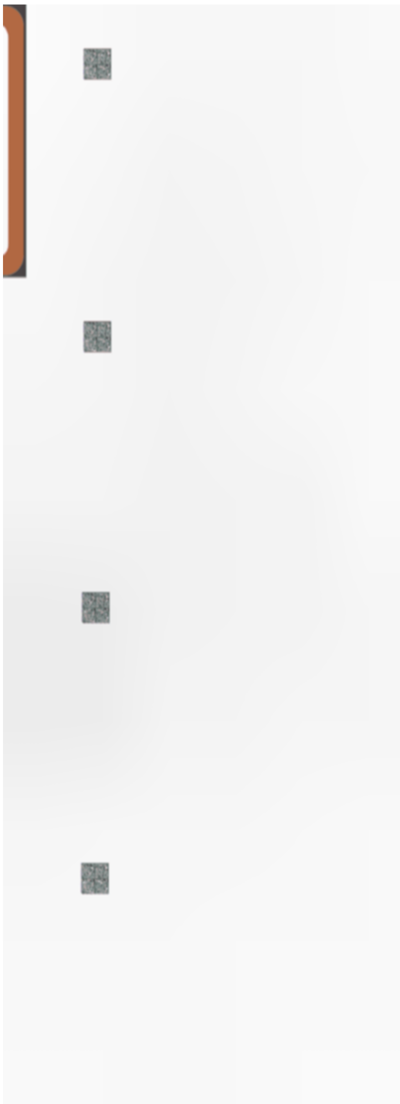
Concatenate + SSD

Example #3

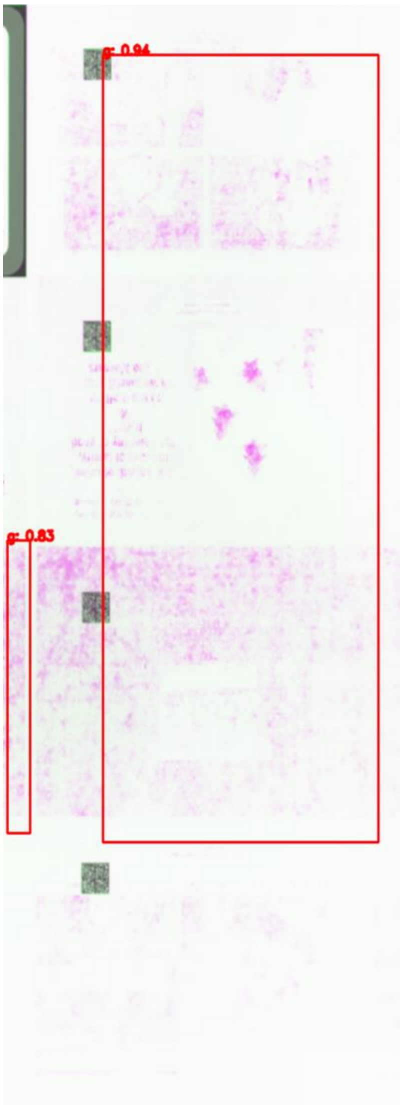
CD-SSD **(ours)**



Reference Image

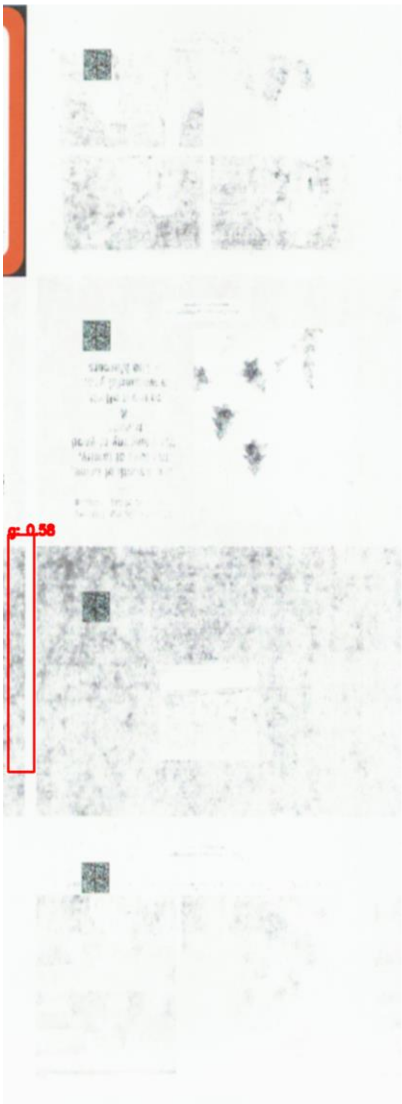


Pseudo-color SSD **(ours)**

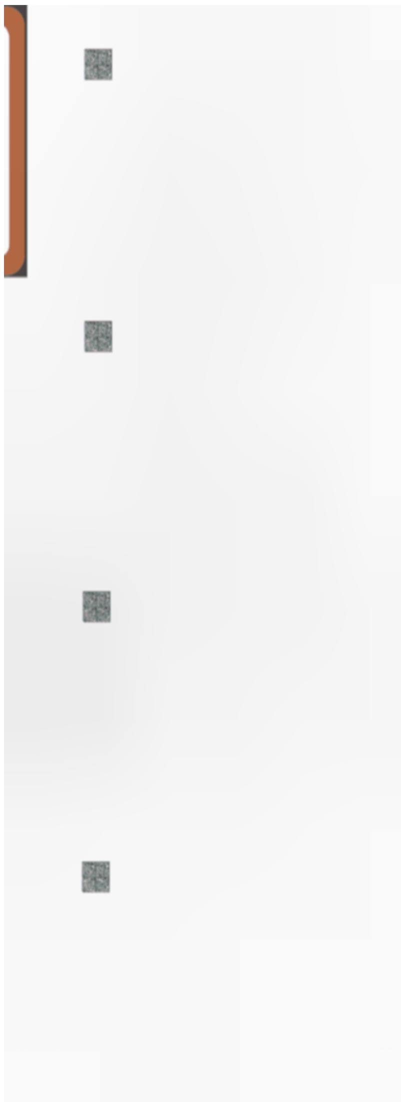


Example #3

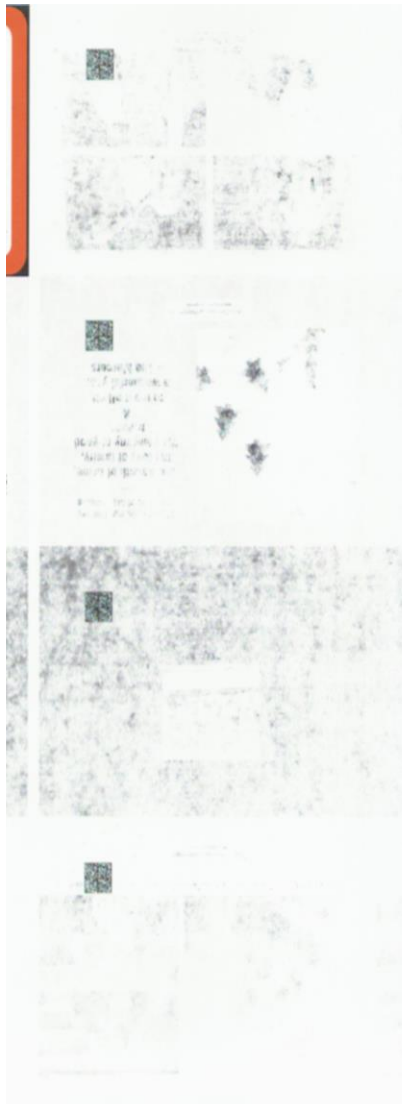
Multi-spectral SSD



Reference Image

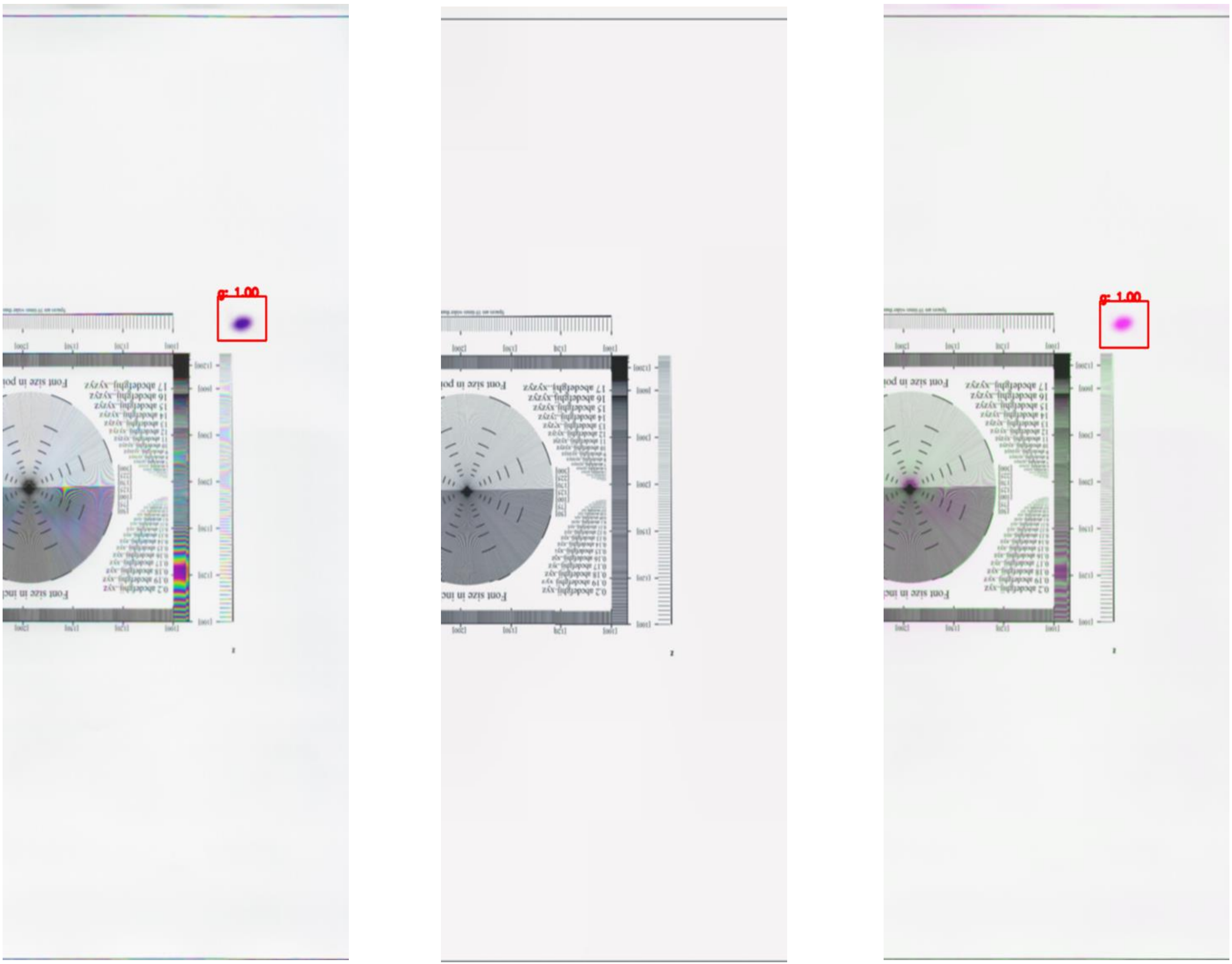


Concatenate + SSD



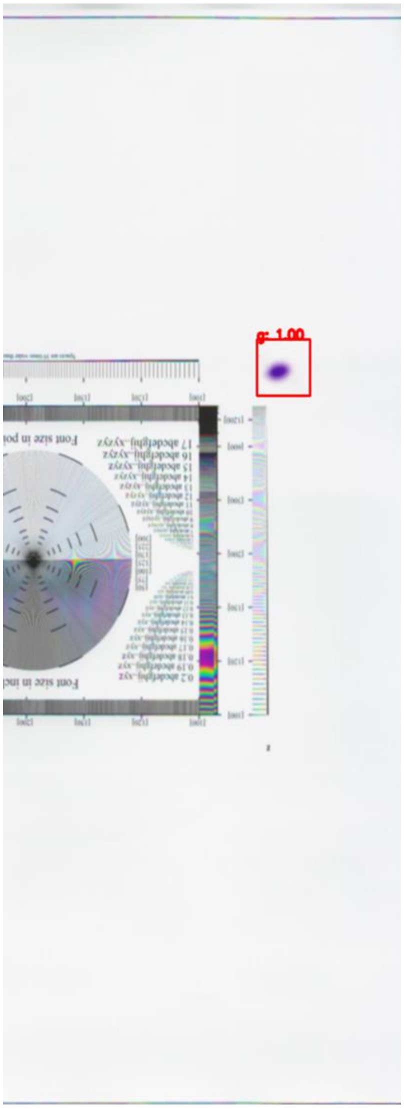
Example #4

CD-SSD **(ours)** | Reference Image | Pseudo-color SSD **(ours)**

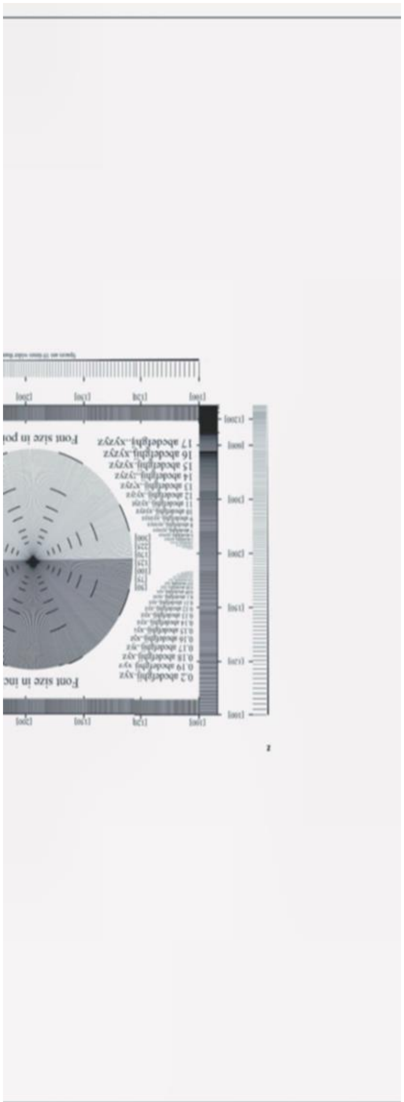


Example #4

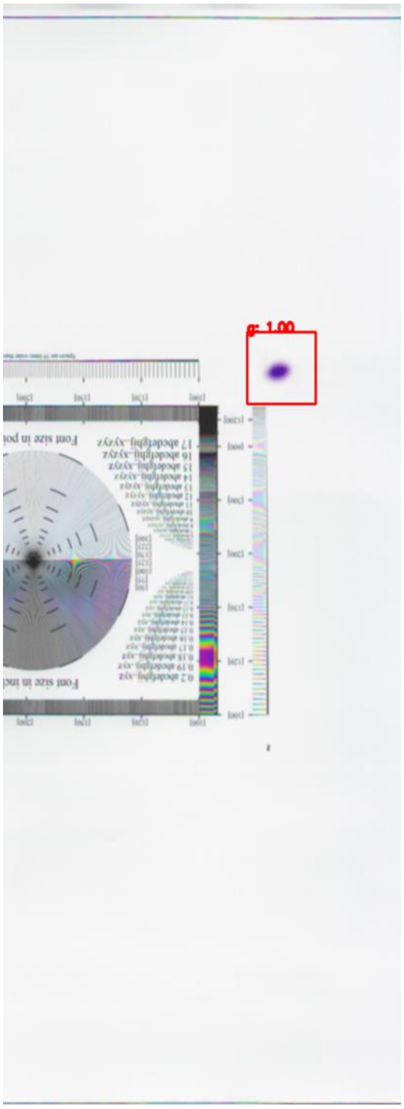
Multi-spectral SSD



Reference Image

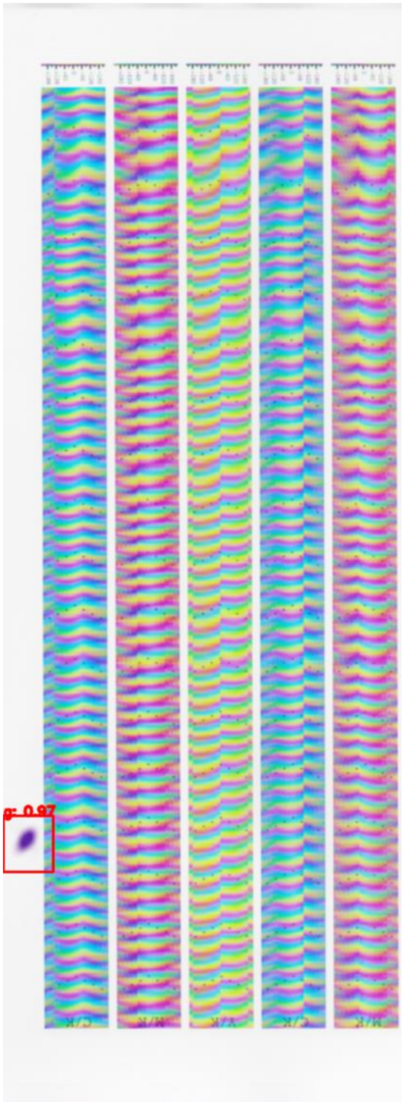


Concatenate + SSD

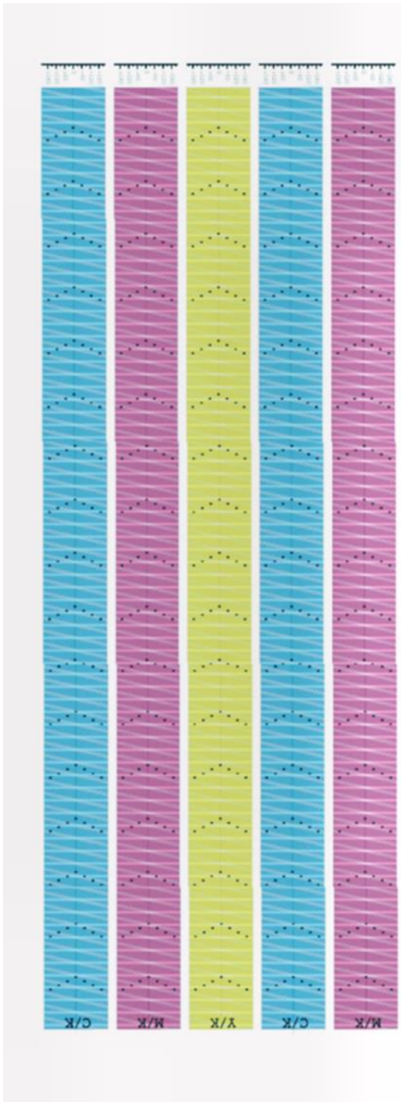


Example #5

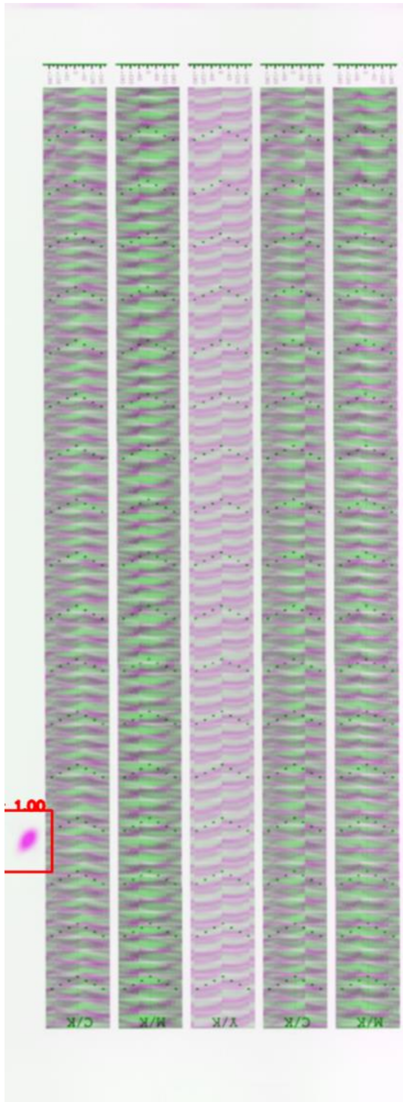
CD-SSD **(ours)**



Reference Image

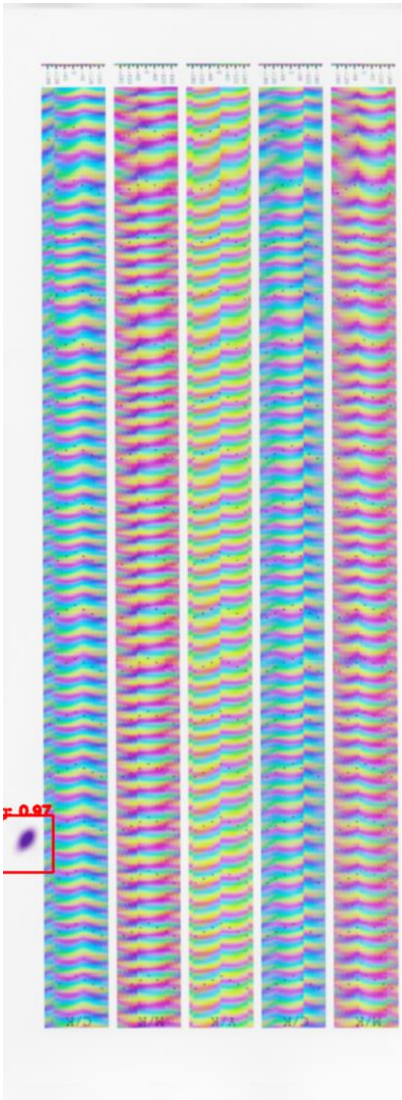


Pseudo-color SSD **(ours)**

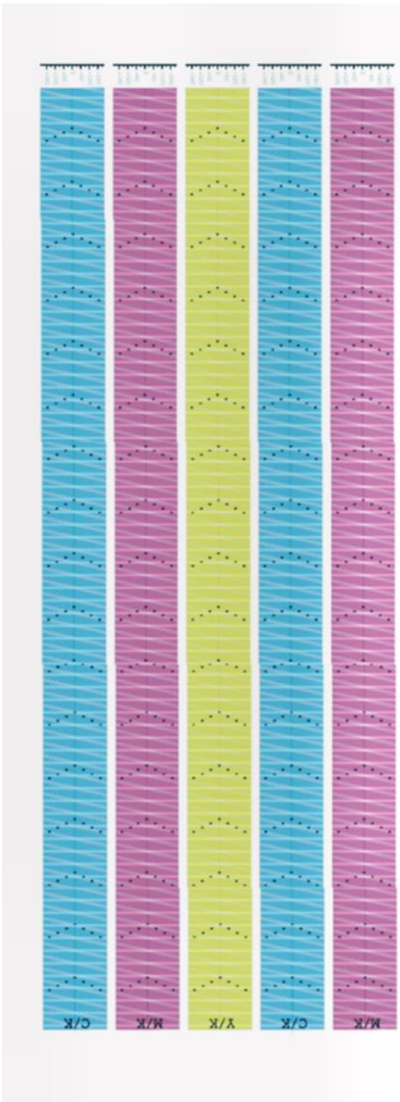


Example #5

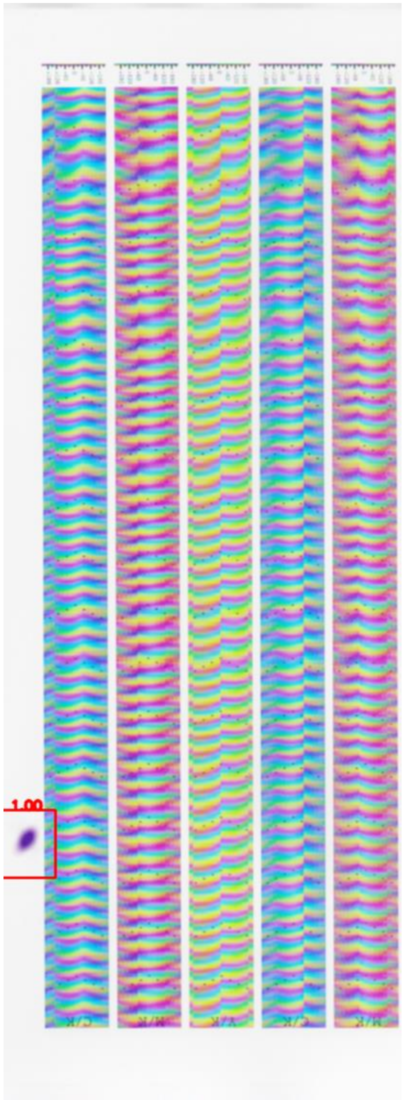
Multi-spectral SSD



Reference Image



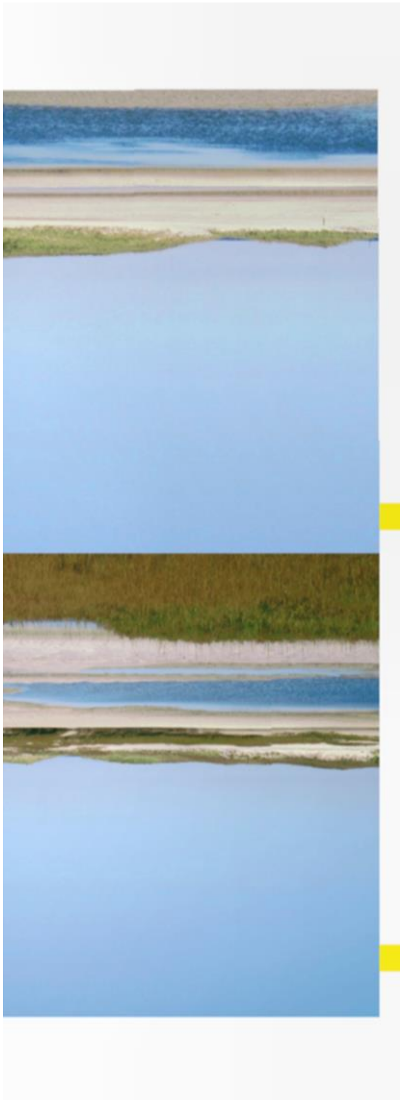
Concatenate + SSD



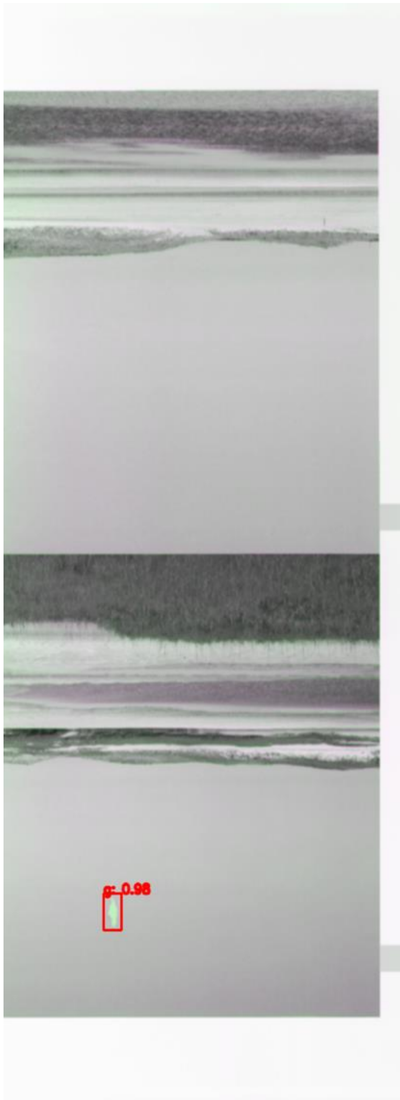
Example #6

CD-SSD **(ours)**

Reference Image



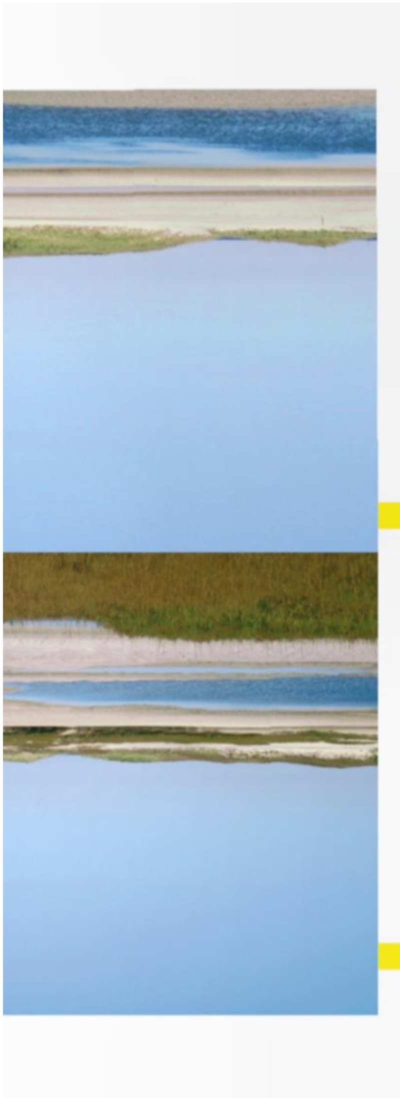
Pseudo-color SSD **(ours)**



Example #6

Multi-spectral SSD

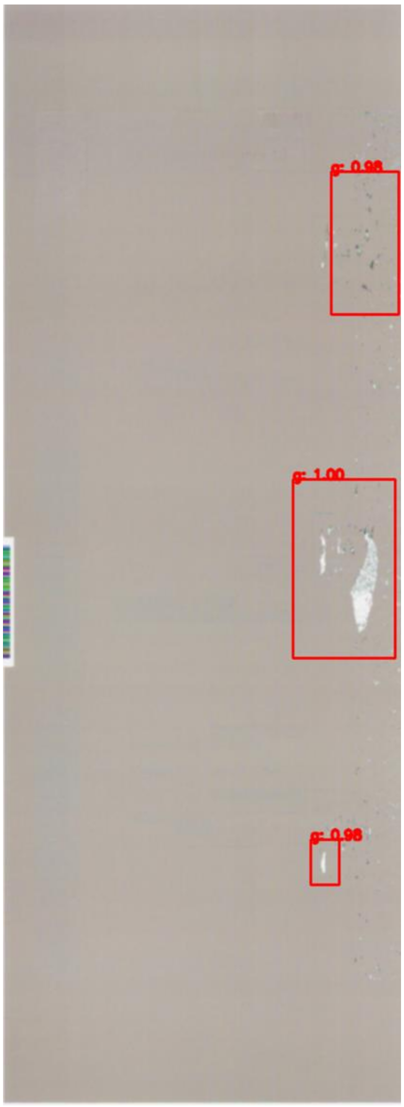
Reference Image



Concatenate + SSD

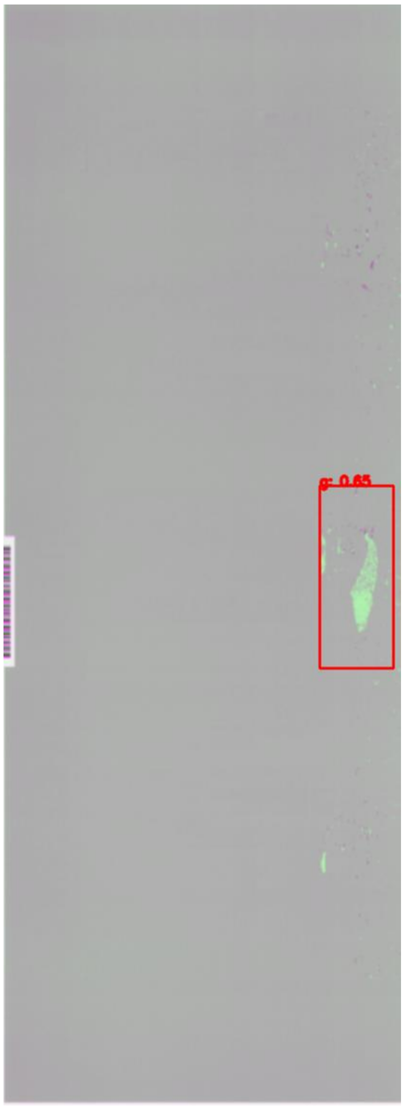
Example #7

CD-SSD **(ours)**



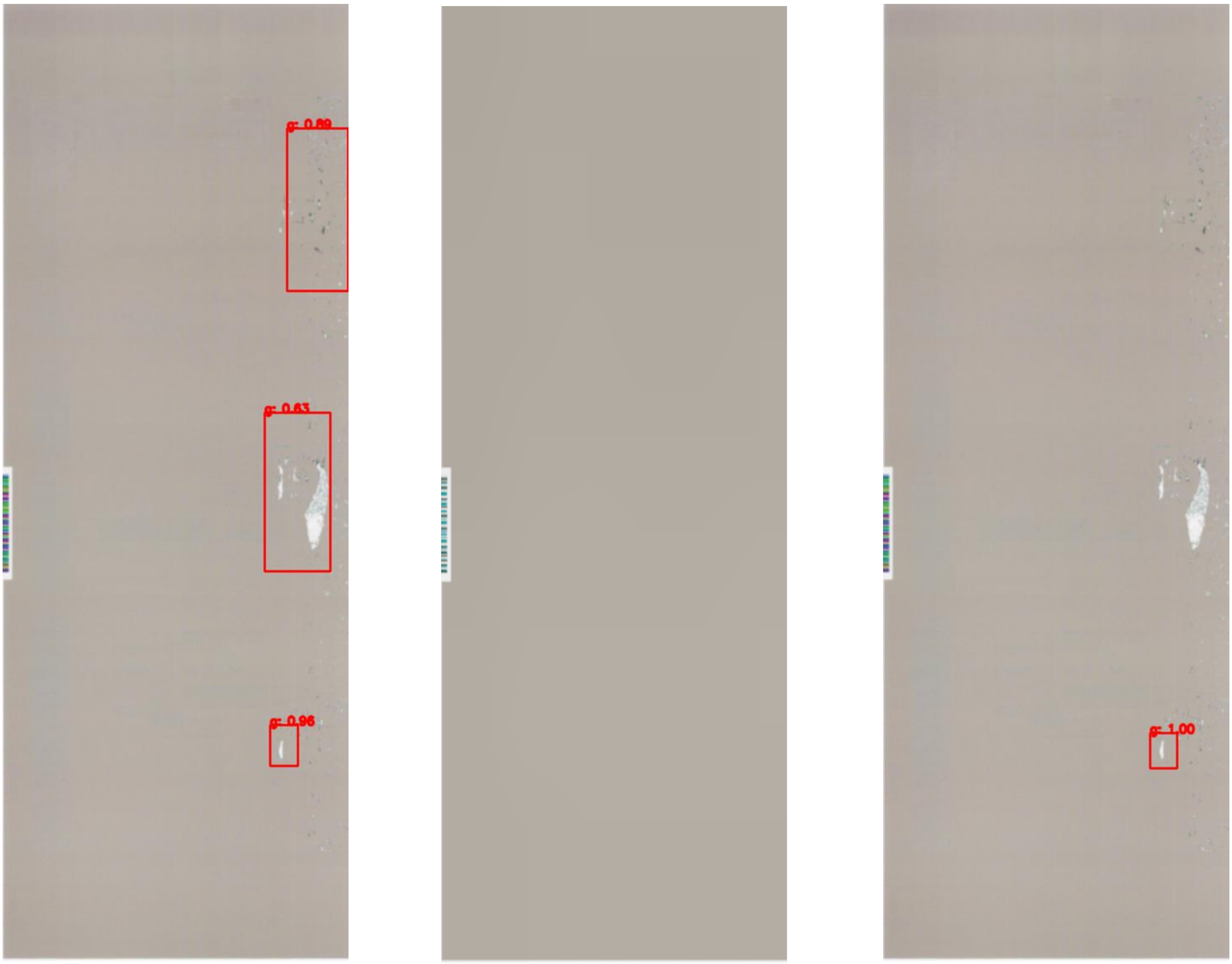
Reference Image

Pseudo-color SSD **(ours)**



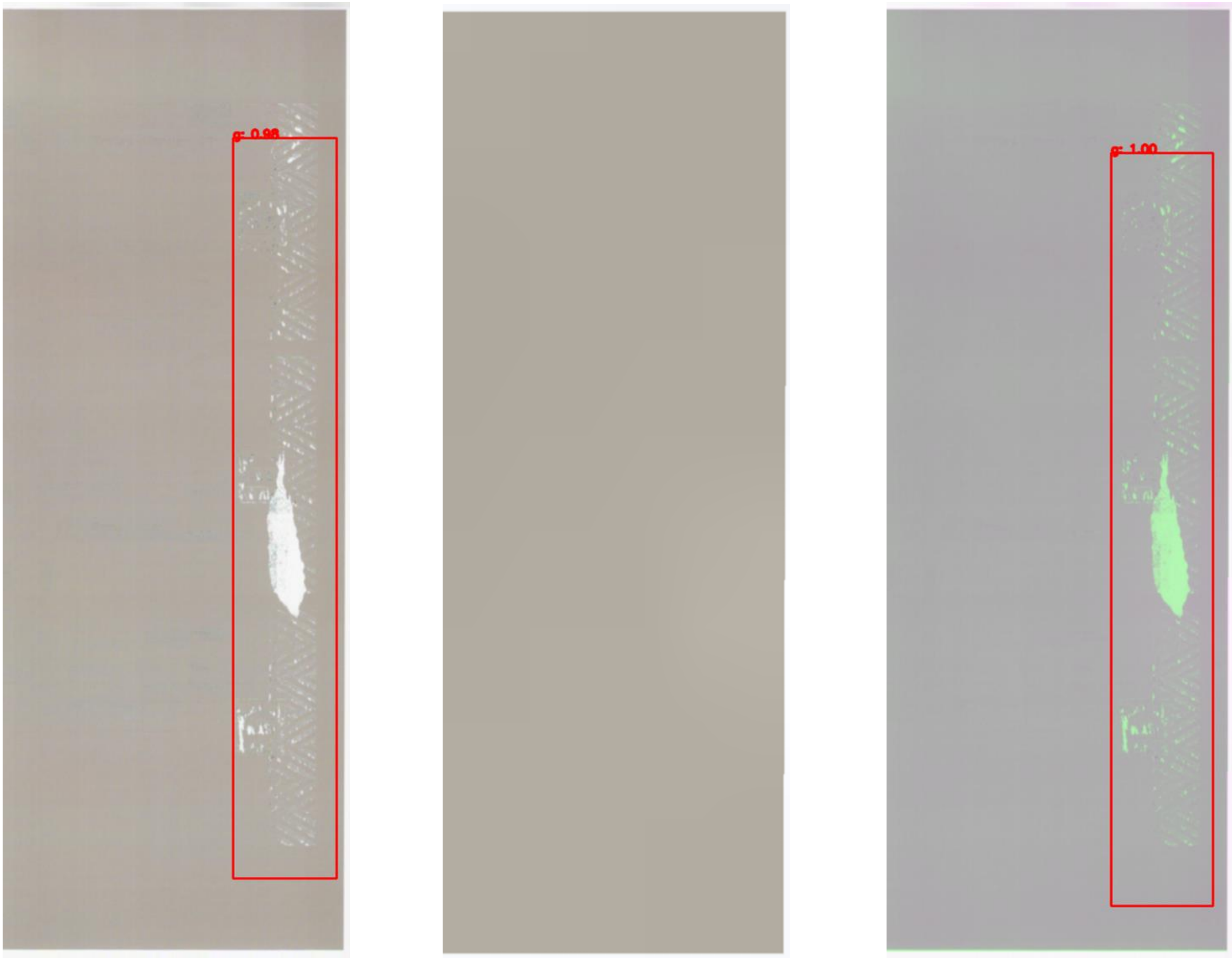
Example #7

Multi-spectral SSD | Reference Image | Concatenate + SSD



Example #8

CD-SSD **(ours)** | Reference Image | Pseudo-color SSD **(ours)**



Example #8

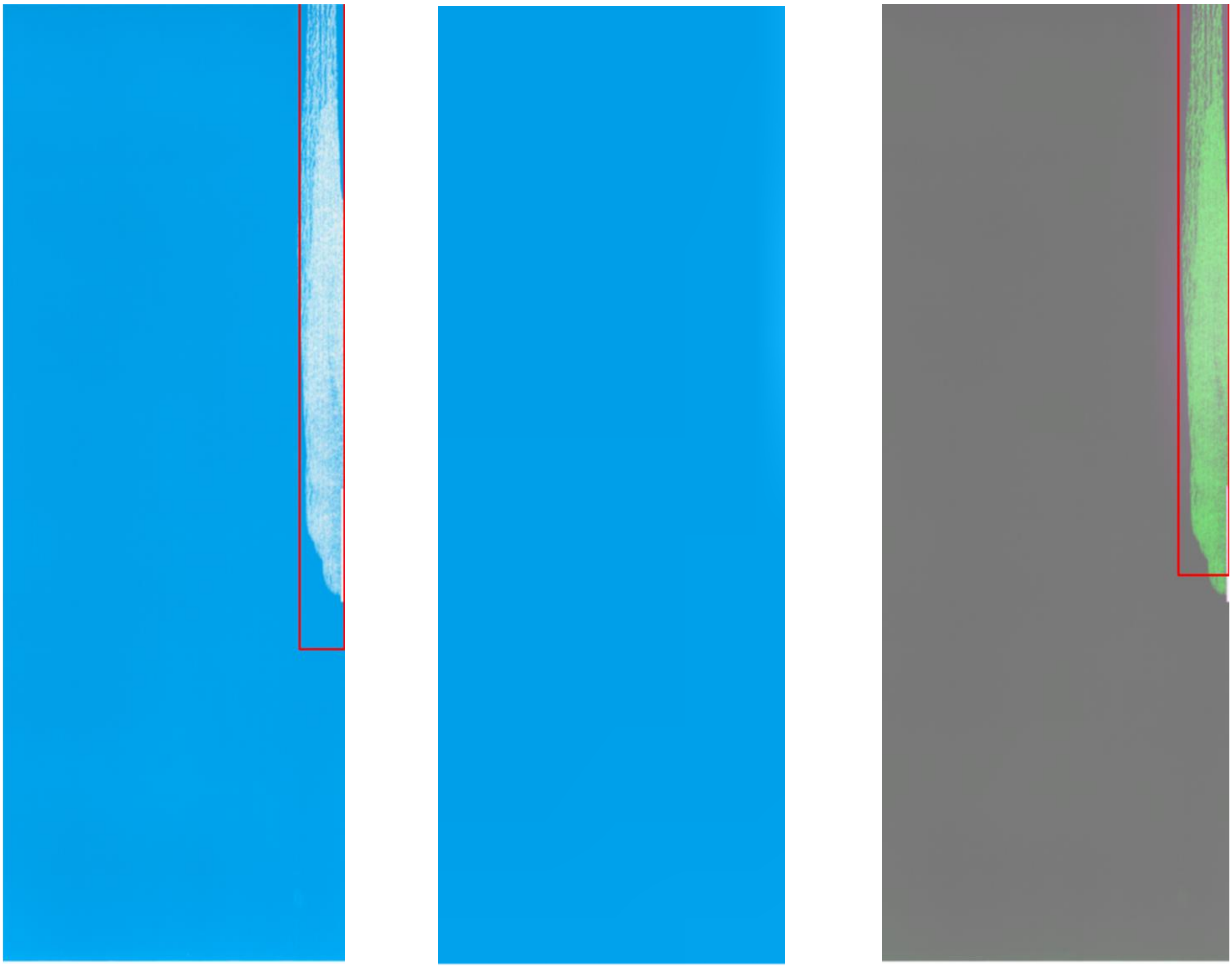
Multi-spectral SSD

Reference Image

Concatenate + SSD

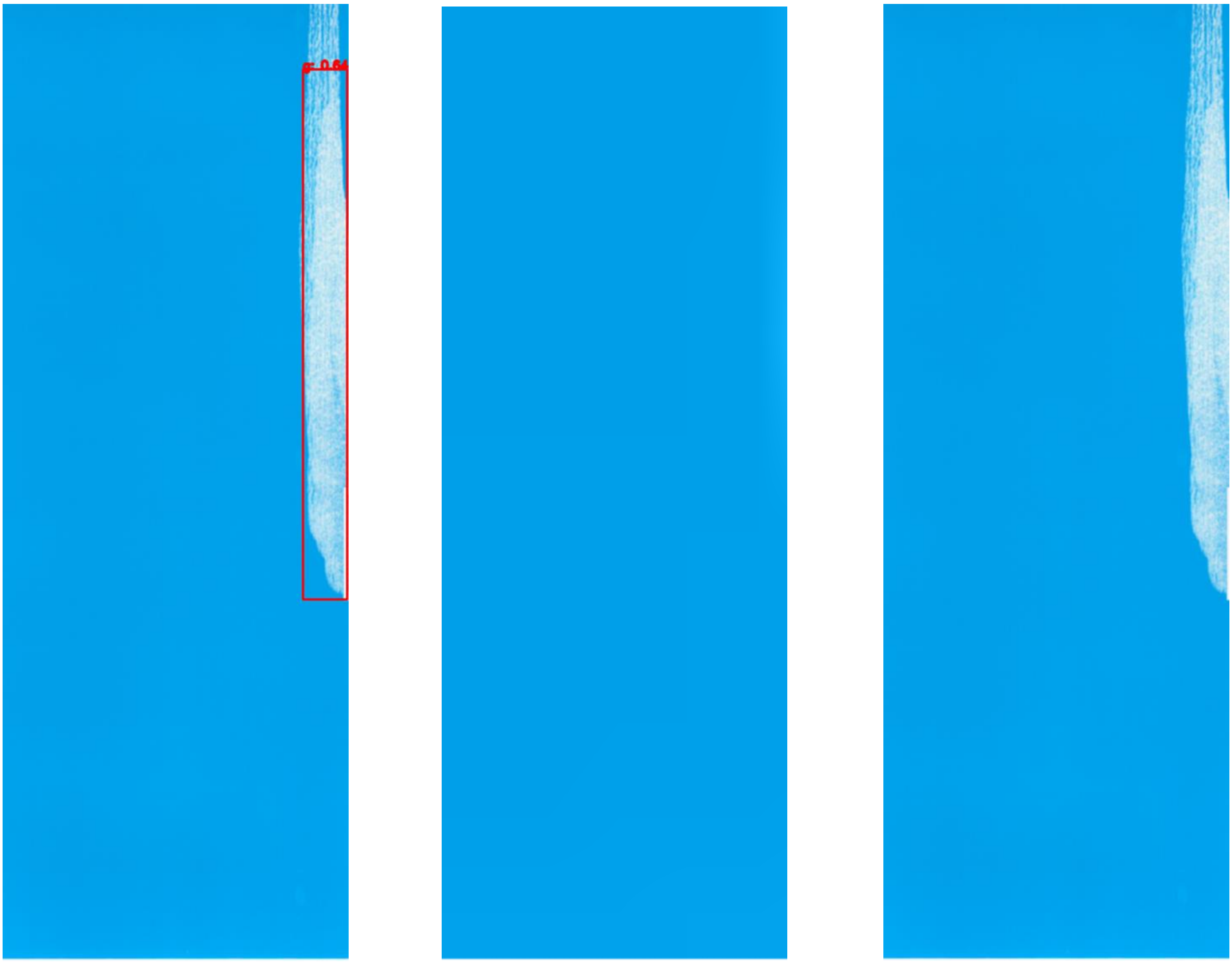
Example #9

CD-SSD **(ours)** Reference Image Pseudo-color SSD **(ours)**



Example #9

Multi-spectral SSD | Reference Image | Concatenate + SSD

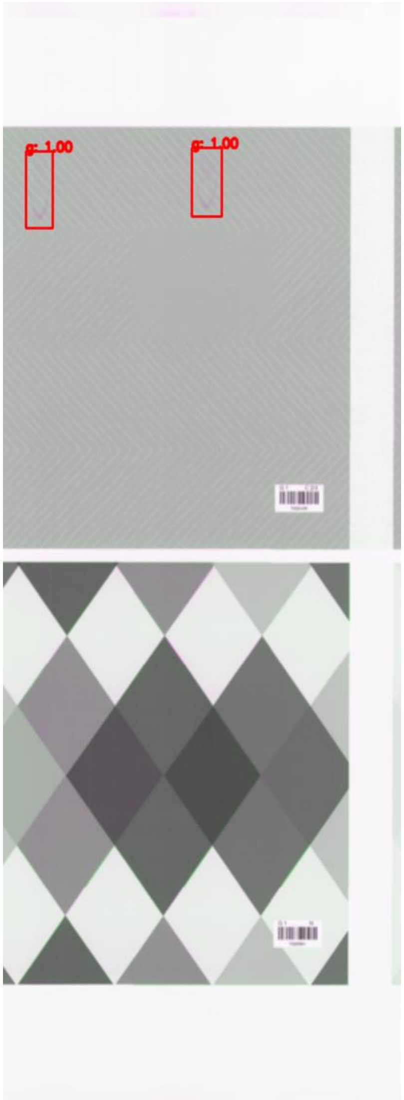


Example #10

CD-SSD **(ours)**

Reference Image

Pseudo-color SSD **(ours)**



Example #10

Multi-spectral SSD

Reference Image

Concatenate + SSD

Example #11

CD-SSD **(ours)** | Reference Image | Pseudo-color SSD **(ours)**

Example #11

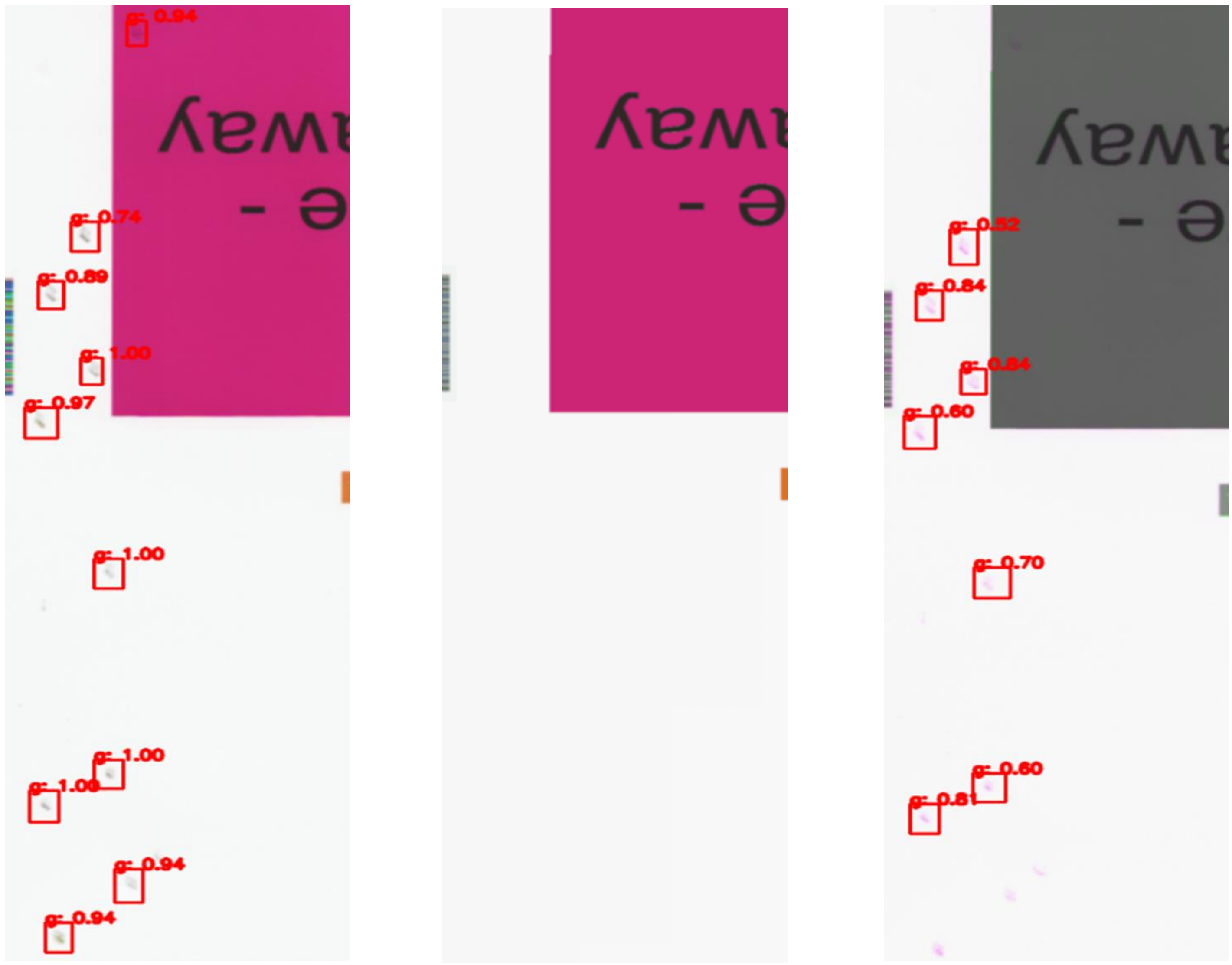
Multi-spectral SSD

Reference Image

Concatenate + SSD

Example #12

CD-SSD **(ours)** | Reference Image | Pseudo-color SSD **(ours)**



Example #12

Multi-spectral SSD | Reference Image | Concatenate + SSD