Supplementary Material for Self-Supervised Learning with Generative Adversarial Networks for Electron Microscopy

Bashir Kazimi[1], Karina Ruzaeva[1], Stefan Sandfeld[1,2]

[1]Forschungszentrum Jülich GmbH, Jülich, IAS-9, Germany

[2]RWTH Aachen University, Aachen, Germany

{b.kazimi,k.ruzaeva,s.sandfeld}@fz-juelich.de

This Supplementary Material includes example illustrations, tables and formulas that were either directly referred to in the main text or moved here due to page limits.

5.1. Objective Function for cGANs

The equation for the objective function in cGANs is as follows:

$$\mathcal{L}_{\text{cGAN}}(G, D) = \mathbb{E}_{x,y}[\log D(x, y)] + \mathbb{E}_{x,z}[\log(1 - D(x, G(x, z)))] , \tag{1}$$

where the generator G has the goal to minimize the loss and the discriminator D attempts to maximize the loss. The generator G is additionally trained to minimize the L_1 distance between its output and the original images as given by the following equation:

$$\mathcal{L}_L(G) = \mathbb{E}_{x,y,z}[\|y - G(x, z)\|_1] . \tag{2}$$

The overall objective function is

$$G^* = \arg \min_G \max_D \mathcal{L}_{\text{cGAN}}(G, D) + \lambda \mathcal{L}_L(G) \tag{3}$$

where λ controls how much weight should be given for the L_1 distance in the overall objective.

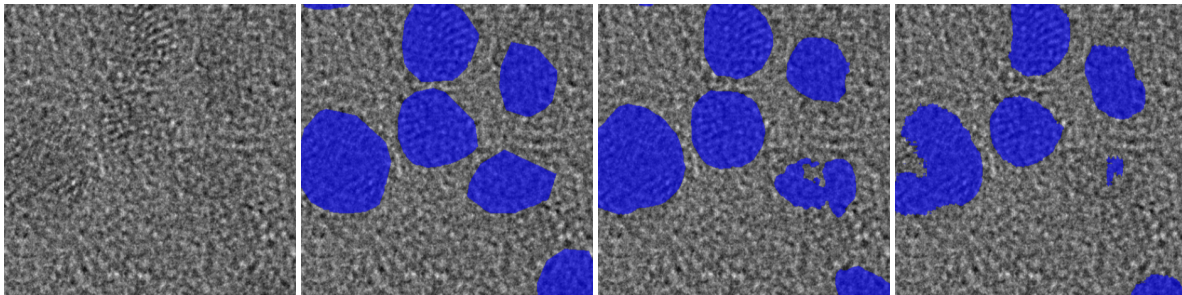## 5.2. Example Predictions for Semantic Segmentation

Figure 15. Left to write: original image, ground truth, prediction by HRNet P(100K) and U-Net_4_0 P(100K), respectively, for the Au2.2nm dataset.

Figure 16. Left to write: original image, ground truth, prediction by HRNet P(100K) and U-Net_4_0 P(100K), respectively, for the Au20nm dataset.

Figure 17. Left to write: original image, ground truth, prediction by HRNet P(100 K) and U-Net_4_0 P(100 K), respectively, for the Au5nm dataset.
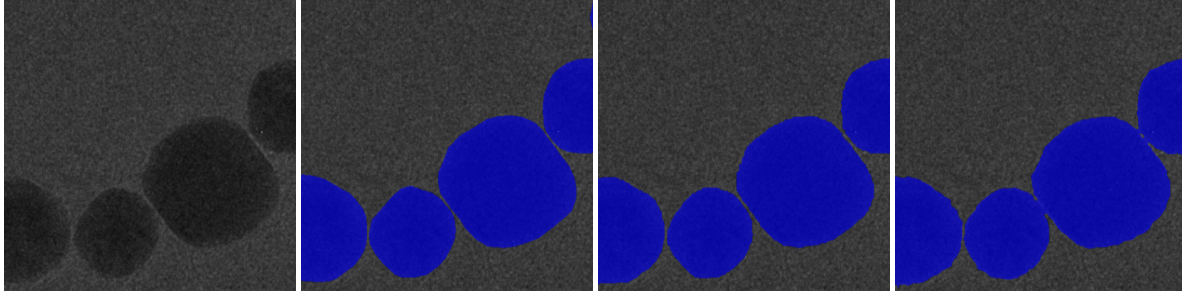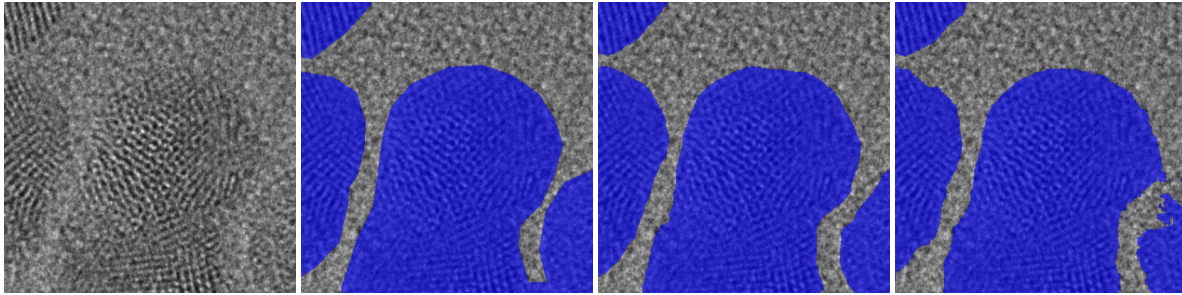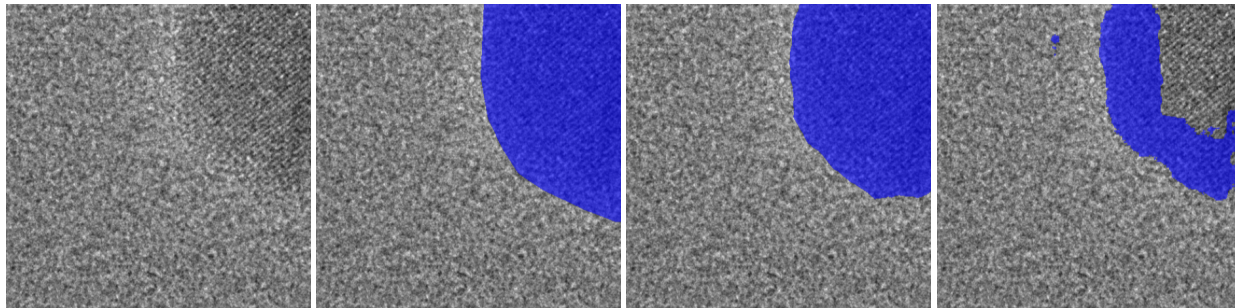

Figure 18. Left to write: original image, ground truth, prediction by HRNet P(100 K) and U-Net_4_0 P(100 K), respectively, for the Au10nm dataset.

5.3. Validation Plots for the Pretraining
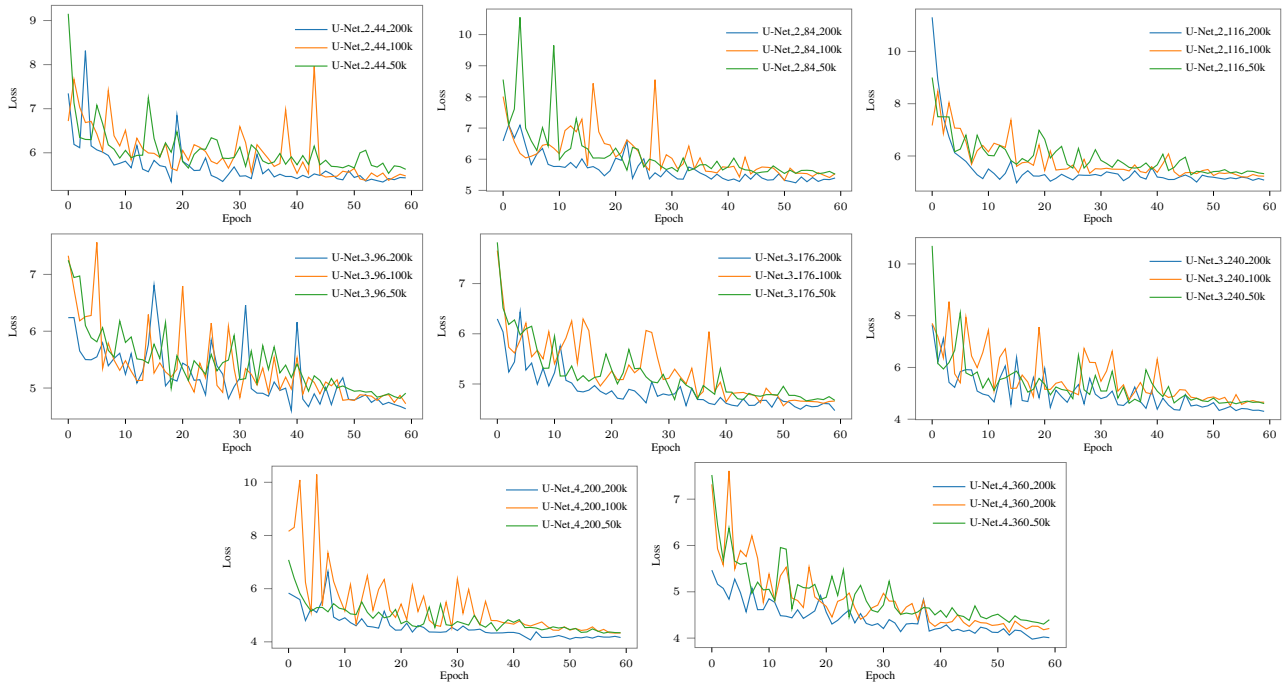
Figure 19. Validation L_1 loss for U-Nets (used as generator) of different sizes (with two, three, and four residual blocks) and receptive fields for three different dataset sizes.

5.4. Quantitative Evaluations for Semantic Segmentation

During training, the best model parameters are saved to disk after every 5 epochs. The following tables show model performance on the test datasets using the best models at the 5 epoch intervals. As observed in all tables, the higher performance is achieved in earlier epochs with fine-tuning while the random weight initialization leads to inferior performance or similar performance only towards the end of training.

Table 4. Comparison of segmentation Dice scores for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on the Au5nmV1 test dataset. The experiments were performed with UNets of different sizes (with two, three, and four residual blocks) and receptive fields (three for each U-Net size) and HRNet.

EPOCHS			5	10	15	20	25	30	35	40	45	50	55	60
HRNET		R	41.05	82.65	82.65	80.41	86.15	86.55	86.55	86.55	86.55	90.24	90.24	90.24
		P(50K)	86.37	91.03	91.41	91.41	91	91	92.2	91.97	91.97	91.97	91.97	91.97
		P(100K)	88.49	90.57	90.57	92.14	92.14	92.14	92.14	92.14	92.54	92.54	92.54	92.38
		P(200K)	83.86	89.71	89.71	91.41	91.41	91.41	91.41	91.41	92.3	92.3	92.3	92.07
U-NET 4 BLOCKS	424	R	7.8	81.04	81.66	86.03	86.03	86.03	86.03	86.03	89.47	89.47	89.95	89.95
		P(50K)	72.78	84.47	86.92	89.81	89.81	89.81	89.81	88.87	90.73	91.16	91.16	91.16
		P(100K)	71.8	78.68	81.52	85.9	85.9	89	88.46	88.72	88.72	88.72	89.72	89.72
		P(200K)	75.46	83.33	84.44	85.28	87.72	87.34	89.34	89.34	89.34	90.21	90.21	90.21
	360	R	0.01	84.65	84.65	84.65	84.65	84.65	84.65	84.65	84.65	91.07	91.07	91.07
		P(50K)	68.33	78.12	83.2	84.48	85.83	85.83	85.83	85.83	85.83	89.09	90.08	90.08
		P(100K)	71	78.74	81.66	86.07	86.07	86.07	88.11	88.11	89.21	90.41	90.41	90.41
		P(200K)	70.97	81.86	78.92	87.15	88.79	89.45	89.45	89.45	89.45	89.45	89.45	90.86
	200	R	0.25	81.59	81.59	80.69	80.69	80.69	85.89	85.89	85.73	85.73	83.61	83.61
		P(50K)	82.03	81.54	84.55	85.71	87.05	87.05	87.28	85.68	85.68	85.68	85.68	85.68
		P(100K)	83	80.81	84.14	84.14	86.7	86.7	86.7	88.37	88.46	88.53	88.53	88.53
		P(200K)	55.75	78.31	77.4	86.74	86.74	86.56	86.56	86.91	88.42	89.4	89	89
U-NET 3 BLOCKS	240	R	0	72.59	69.97	69.97	82.7	84.41	84.41	84.41	84.41	86.82	86.76	89.82
		P(50K)	57.2	81.81	85.23	87.38	87.38	87.38	87.9	87.9	87.9	87.94	87.94	87.94
		P(100K)	50.9	77.5	77.5	85.12	85.12	85.96	85.96	84.85	86.79	86.79	86.79	86.79
		P(200K)	49.13	75.12	84.69	84.69	86.08	88.4	89.08	89.08	89.08	89.13	89.13	89.73
	176	R	0	78.03	80.43	83.43	83.43	83.43	83.43	87.13	87.13	87.13	87.13	87.13
		P(50K)	72.57	78.64	78.64	82.47	84.31	84.31	84.76	84.76	84.76	86.81	86.32	86.76
		P(100K)	67.55	68.8	77.69	79.57	83.58	83.58	83.58	83.58	84.41	86.38	86.38	88.22
		P(200K)	58.44	73.82	82.95	82.95	83.4	83.4	83.28	83.28	83.62	83.62	83.62	83.62
	96	R	0	67.22	75.79	80.41	80.41	82.8	82.8	82.8	84.41	84.41	84.41	84.41
		P(50K)	65.65	76.38	81.28	81.3	82.5	82.86	84.69	84.69	84.69	83.96	83.96	83.96
		P(100K)	74.22	76.38	80.19	82.1	82.73	83.31	83.85	83.85	83.85	83.85	83.85	84.37
		P(200K)	71.55	81.88	82.04	82.04	81.5	81.62	83.65	83.65	83.65	84.59	84.59	84.27
U-NET 2 BLOCKS	116	R	0	66.26	80.06	79.17	80.81	80.81	81.86	81.86	81.86	82.49	82.49	82.49
		P(50K)	61.99	65.27	79.92	82.3	82.3	82.3	82.86	82.86	82.86	84.72	84.72	84.72
		P(100K)	51.97	65.61	76.3	80.16	80.16	80.16	80.16	81.55	80.71	82.64	83.47	83.47
		P(200K)	67.87	74.51	80.48	80.48	80.48	80.48	81.98	81.98	81.98	81.98	81.98	83.18
	84	R	0	73.4	75.97	75.97	78.77	80.77	80.77	82.82	82.41	82.41	82.41	81.76
		P(50K)	66.69	75.04	77.83	82.53	83.05	83.75	83.75	83.75	83.72	83.26	83.18	83.99
		P(100K)	70.28	76.14	78.62	81.33	81.44	81.44	81.44	81.44	81.44	82.52	82.52	82.63
		P(200K)	63.88	77.09	79.08	82.87	82.87	82.73	82.73	83.6	83.6	83.6	83.6	83.6
	44	R	0	73.58	74.87	74.87	74.87	74.87	78	78	80.03	80.03	80.03	79.75
		P(50K)	65.89	72.27	72.27	72.47	72.47	76.9	76.9	78.59	78.59	78.59	78.59	78.59
		P(100K)	58.62	72.77	75.47	76.14	75.67	75.67	78.17	78.17	79.92	79.92	79.92	79.92
		P(200K)	53.15	72.76	73.5	75.45	75.45	75.45	75.45	75.45	75.45	76.99	76.99	76.99

5.5. Quantitative Evaluation on TEMImageNet datasets

Similar to experiments on semantic segmentation, during training, the best model parameters are saved to disk after every 5 epochs. The following tables show model performance on the test datasets using the best models at the 5 epoch intervals. As observed in all tables, the higher performance is achieved in earlier epochs with fine-tuning while the random weight initialization leads to inferior performance or similar performance only towards the end of training.

Table 5. Comparison of segmentation Dice scores for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on the Au2.2nm test dataset. The experiments were performed with UNets of different sizes (with two, three, and four residual blocks) and receptive fields (three for each U-Net size) and HRNet.

		EPOCHS	5	10	15	20	25	30	35	40	45	50	55	60
HRNet		R	79.24	82.02	82.36	81.36	82.55	82.45	82.45	82.45	82.45	82.45	82.45	82.45
		P(50K)	81.57	82.16	83.1	83.1	83.94	83.94	83.94	83.94	83.94	83.94	83.94	83.94
		P(100K)	81.54	82.65	81.61	81.61	83.3	82.73	82.73	82.73	83.43	83.23	83.23	83.23
		P(200K)	81.14	82.11	82.11	82.11	82.11	82.11	82.11	82.11	82.11	82.11	82.11	82.11
U-Net 4 blocks	424	R	74.14	77.92	80.55	80.34	80.34	81.7	81.7	81.7	82.4	82.24	82.24	82.24
		P(50K)	68.23	75.26	77.73	77.73	78.19	79.26	79.26	79.26	80.57	81.28	81.28	81.66
		P(100K)	69.49	77.72	78.36	79.76	81.68	81.68	81.68	80.78	81.31	81.36	81.36	81.36
		P(200K)	74.66	74.64	79.13	79.13	79.13	80.88	80.12	80.12	80.59	81.31	81.87	81.87
	360	R	0	77.17	80.42	80.42	80.42	80.73	81.41	81.41	81.36	81.94	81.94	82.81
		P(50K)	73.96	77.54	77.54	79.01	81.16	81.16	81.65	81.65	81.36	80.94	81.89	81.89
		P(100K)	73.47	74.21	77.43	81.3	79.15	82.05	82.05	82.05	82.05	81.55	81.55	81.55
		P(200K)	67.11	79.06	79.28	79.28	80.1	80.1	81.18	79.69	79.69	79.69	81.39	80.98
	200	R	72.09	71.7	79.23	79.23	79.23	79.5	79.5	79.5	81.18	81.18	81.18	81.18
		P(50K)	64.22	75.3	75.3	75.3	78.23	78.15	79.5	80.43	81.21	81.21	81.21	81.21
		P(100K)	69.28	74.78	75.95	79.53	75.12	77.54	77.54	77.54	77.54	77.54	80.73	81.62
		P(200K)	69.44	75.38	77.06	78.99	75.99	79.33	79.33	79.42	79.42	79.42	77.51	79.21
U-Net 3 blocks	240	R	0	70.35	77.22	79.21	79.63	79.63	79.63	81.18	81.08	82.07	82.07	82.07
		P(50K)	73.25	71.77	75.24	78.41	78.41	78.41	78.87	81.36	79.65	79.65	79.65	79.65
		P(100K)	71.05	69.95	73.86	77.06	79.4	79.4	79.4	80.82	80.9	80.9	80.9	81.81
		P(200K)	66.61	70.65	73.29	74.62	75.53	76.75	78.01	78.83	78.83	78.83	78.83	78.16
	176	R	61.15	77.56	76.31	76.31	77.53	77.53	77.53	79.03	79.03	79.03	79.03	79.03
		P(50K)	62.51	70.33	72.44	72.44	76.19	76.19	78.98	78.98	78.98	79.7	79.94	79.94
		P(100K)	63.84	72.93	74.54	74.65	74.89	74.65	77.77	77.77	77.77	77.77	77.77	79.97
		P(200K)	57.69	70.35	73.25	73.25	73.25	77.79	78.25	78.25	78.25	79.26	79.26	79.26
	96	R	0	66.01	68.19	68.19	67.04	67.97	67.97	67.97	69.94	69.94	70.2	70.2
		P(50K)	57.88	65.46	67.07	67.07	69.48	69.48	69.48	67.67	67.67	67.67	71.09	71.09
		P(100K)	58.8	58.8	64.66	64.66	64.66	64.66	64.66	69.28	69.28	69.28	70.25	70.25
		P(200K)	54.24	62.23	62.23	67.87	67.87	64.66	64.66	66.3	68.44	68.26	68.26	67.95
U-Net 2 blocks	116	R	58.77	64.79	64.79	66.9	67.98	67.98	69.95	72.88	72.88	72.2	72.2	72.2
		P(50K)	55.45	63.64	67.37	67.37	67.37	70.6	70.6	71.98	70.01	70.01	70.01	70.01
		P(100K)	64.2	64.99	66.35	66.35	66.35	71.95	71.95	70.92	68.67	72.86	72.86	72.86
		P(200K)	56.97	62.14	63.06	66.4	67.59	66.49	66.49	66.49	67.76	67.76	68.35	68.35
	84	R	0	0	57.5	64.67	64.67	64.67	68.2	68.2	68.29	68.29	68.29	67.8
		P(50K)	58.08	65.29	63.2	65.06	64.9	65.23	66.48	66.48	66.48	66.48	66.96	66.96
		P(100K)	52.37	61.42	62.52	62.52	62.52	66.07	66.07	66.07	66.07	66.07	66.07	66.07
		P(200K)	53.46	62.37	62.37	62.37	62.37	65.81	64.07	66.83	64.97	64.97	64.97	64.97
	84	R	0	0	0	51.89	59.29	60.1	59.4	59.4	59.4	59.4	61.18	61.18
		P(50K)	46.56	46.56	48.67	56.55	53.71	53.71	53.71	53.71	53.71	57.93	59.3	59.3
		P(100K)	47.67	55.09	55.86	55.86	57.37	57.37	57.37	57.37	57.37	59.96	59.96	59.96
		P(200K)	41.06	47.32	50.83	50.92	52.07	52.38	56.32	56.63	58.46	58.46	58.46	58.46

Table 6. Comparison of segmentation Dice scores (in %) for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on the Au5nm test datasets. The experiments were performed with UNets of different sizes (with two, three, and four residual blocks) and receptive fields (three for each U-Net size) and HRNet.

		EPOCHS	5	10	15	20	25	30	35	40	45	50	55	60
HRNET		R	86.29	91.12	92.61	93.29	93.72	94.43	94.12	94.12	94.44	94.68	94.72	94.76
		P(50K)	92.51	94.46	94.35	94.56	94.56	94.54	94.6	94.6	94.62	94.62	94.56	94.56
		P(100K)	93.74	94.24	94.24	94.24	94.25	94.4	94.4	94.4	94.53	94.53	94.79	94.6
		P(200K)	93.27	93.9	94.05	94.5	94.63	94.63	94.63	94.63	94.57	94.57	94.57	94.57
U-NET 4 BLOCKS	**424**	R	88.69	91.98	92.55	93.67	93.11	93.81	94.16	94.16	94.21	94.21	94.21	94.36
		P(50K)	88.29	90.08	92.16	92.13	93.34	93.34	93.78	93.78	93.78	93.74	93.81	93.81
		P(100K)	83.95	90.59	91.31	87.77	92.8	93.7	93.7	93.72	93.67	93.67	94.18	94.18
		P(200K)	79.55	89.32	91.88	92.26	90.47	92.94	93.26	93.35	92.15	92.15	93.68	93.72
	360	R	86.82	91.67	92.99	93.63	93.83	94.16	94.29	93.87	93.87	94.19	94.19	94.19
		P(50K)	83.64	89.7	89.7	92.39	92.67	92.67	92.82	93.9	93.9	93.9	93.79	94.28
		P(100K)	87.61	90.61	90.61	92.22	92.22	92.22	92.22	93.56	93.56	93.56	94.08	94.08
		P(200K)	88.58	90.44	91.02	92.62	92.62	93.47	93.47	94.07	94.07	94.07	94.07	94.07
	200	R	80.25	78.81	82.84	82.84	87.28	87.04	83.93	84.18	84.18	84.18	84.18	90.53
		P(50K)	78.6	86.96	89.26	91.27	91.27	92.18	92.18	91.45	92.85	92.2	92.2	93.16
		P(100K)	80.63	86.14	73.63	75.68	75.68	91.96	91.96	91.96	91.32	91.82	91.82	91.82
		P(200K)	81.92	85.52	88.2	91.22	91.34	92.19	92.19	93.16	93.16	93.16	93.34	93.34
U-NET 3 BLOCKS	**240**	R	0	87.23	84.49	90.06	89.14	90.35	89.05	88.55	88.55	87.3	87.3	87.3
		P(50K)	77.28	83.27	86.52	90.3	90.9	90.9	90.9	90.9	92.79	92.79	92.1	92.1
		P(100K)	77.26	81.34	85.51	85.51	85.53	85.53	85.53	85.53	85.53	92.41	92.63	89.37
		P(200K)	79.95	81.54	81.54	81.54	89.23	89.23	89.92	89.92	91.87	91.87	91.87	92.64
	176	R	71.12	62.29	82.12	82.12	77.2	72.48	72.48	72.48	72.48	72.48	72.48	74.18
		P(50K)	77.35	77.35	81.69	84.35	84.35	88.77	88.77	81.7	81.7	81.7	83.43	83.43
		P(100K)	74.26	84.6	84.6	88.68	89.31	87.76	88.43	88.43	88.43	88.43	88.43	91.3
		P(200K)	77.37	83.23	85.75	87.47	89.38	89.37	89.37	89.37	88.33	91.4	91.4	91.4
	96	R	75.95	82.46	79.72	79.72	78.78	78.78	78.78	78.78	85.45	87.21	87.21	82.6
		P(50K)	80.55	82.35	82.76	82.76	82.76	83.91	83.13	83.13	83.13	83.13	85.67	84.31
		P(100K)	73.9	79.13	79.13	78.79	78.79	78.79	78.79	78.79	80.35	80.35	80.35	80.35
		P(200K)	78.6	75.64	76.25	76.25	76.25	76.25	76.25	84.86	84.13	84.13	84.13	84.13
U-NET 2 BLOCKS	**116**	R	80.66	74.92	74.49	74.49	74.49	74.49	82.26	82.26	76.51	76.51	76.51	76.51
		P(50K)	79.88	79.88	78.52	78.52	78.52	78.52	77.69	77.69	77.69	77.69	77.69	77.69
		P(100K)	73.76	78.17	78.17	82.27	81.74	81.74	82.46	71.87	71.87	71.87	71.87	71.87
		P(200K)	76.25	79.29	82.11	81.23	81.23	81.23	81.23	81.23	81.23	81.23	84.09	84.09
	84	R	67.13	80.18	78.57	78.57	78.57	78.57	76.39	76.39	76.39	76.39	78.6	78.6
		P(50K)	80.19	80.19	80.19	80.19	75.73	78.29	78.29	76.89	76.89	76.89	76.89	76.89
		P(100K)	77.4	80.85	80.85	81.67	81.67	82.81	82.81	82.81	83.03	83.03	83.03	81.76
		P(200K)	64.98	79.31	79.31	79.31	79.31	81.26	81.26	81.26	82.14	82.14	82.14	82.45
	84	R	70.5	75.06	75.06	76.63	76.1	76.1	76.1	76.1	76.1	76.1	77.83	77.83
		P(50K)	65.87	72.88	72.88	70.8	70.8	70.8	70.8	70.8	70.8	70.8	74.39	74.39
		P(100K)	68.77	70.86	73	75.13	76.49	76.47	76.47	76.47	76.13	77.11	77.11	77.11
		P(200K)	60.94	63.7	69.83	73.56	73.56	73.66	73.66	73.66	73.66	73.66	75.25	76.72

Table 7. Comparison of segmentation Dice scores (in %) for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on the Au10nm test dataset. The experiments were performed with UNets of different sizes (with two, three, and four residual blocks) and receptive fields (three for each U-Net size) and HRNet.

EPOCHS		5	10	15	20	25	30	35	40	45	50	55	60
HRNET	R	82.66	92.47	92.36	95.13	95.13	95.29	95.7	95.7	95.7	95.7	95.7	96.38
	P(50K)	94.66	95.17	96.53	96.39	96.79	96.96	96.91	97.19	97.19	97.28	97.34	97.25
	P(100K)	94.82	96.74	96.74	97.08	97.08	97.08	97.08	97.08	97.08	97.08	97.08	97.08
	P(200K)	94.33	96.07	96.07	96.56	96.56	96.56	96.99	97.43	97.43	97.32	97.36	97.36
U-NET 4 BLOCKS 424	R	86.01	90.11	92.37	94.45	94.61	95.93	95.93	95.82	95.82	96.5	96.5	96.6
	P(50K)	89.89	92	92.52	94.05	94.41	95.07	95.07	95.25	95.88	96.09	96.09	96.27
	P(100K)	86.18	90.24	92.06	92.06	93.68	93.2	93.83	94.62	94.74	95.15	95.36	95.36
	P(200K)	85.56	90.86	91.47	92.45	93.78	93.78	93.78	94.12	94.12	95.31	95.06	95.06
360	R	83.15	90.79	90.79	93.14	92.67	93.53	94.92	94.92	94.92	95.37	95.37	96.02
	P(50K)	83.66	90.32	85.78	93.26	94.12	94.12	94.17	95.14	95.96	95.74	95.74	95.74
	P(100K)	86.72	91.33	91.89	93.7	94.29	94.29	94.29	94.29	94.62	95.6	95.6	95.6
	P(200K)	85.99	90.75	92.05	92.52	93.68	93.68	94.15	94.31	94.31	94.31	94.9	94.62
200	R	78.11	84.92	91.39	94.36	94.16	94.32	94.32	95.83	95.83	95.83	95.26	96.04
	P(50K)	82.69	89.68	91.5	92.08	93.42	94.61	94.86	95	95	95	95	95
	P(100K)	90.1	90.64	92.12	92.12	94.07	94.07	93.79	93.79	94.93	94.93	95.78	94.11
	P(200K)	89.46	90.59	90.59	92.56	92.56	93.06	93.06	93.82	93.82	93.82	93.82	94.74
U-NET 3 BLOCKS 240	R	78.95	84.47	89.45	88.39	91.73	91.73	93.79	94.16	94.16	94.16	94.16	94.16
	P(50K)	89.67	87.54	89.51	89.51	91.54	92.5	93.31	93.31	93.83	93.83	93.83	94.8
	P(100K)	77.97	88.65	88.65	88.42	93.28	93.28	92.82	92.82	92.82	93.91	93.91	93.91
	P(200K)	84.82	88.71	89.47	91.25	91.25	91.25	92.44	93.23	93.23	93.23	93.23	93.23
176	R	80.21	88.64	90.48	92.11	92.11	94.28	93.97	93.97	93.97	94.95	94.95	95.44
	P(50K)	80.09	87.77	87.77	91.06	91.06	91.7	93.42	92.95	92.43	92.43	92.43	92.43
	P(100K)	80.63	85.92	89.67	90.96	91.17	92.16	92.16	92.16	92.16	93.24	93	93.98
	P(200K)	83.75	86.88	91.33	91.92	91.9	91.9	92.86	92.86	92.86	93.91	93.91	94.58
96	R	74.58	87.31	90.56	90.56	91.12	92.12	92.12	92.12	92.12	92.7	92.99	92.99
	P(50K)	86.37	86.37	86.37	86.37	89.31	90.6	90.6	90.6	91.01	90.21	90.21	91.35
	P(100K)	82.64	82.95	86.43	88.35	88.45	88.45	88.45	89.22	90.65	90.65	90.65	90.77
	P(200K)	80.26	84.84	84.84	88.34	88.34	88.34	89.89	89.89	89.49	89.6	91.31	91.6
U-NET 2 BLOCKS 116	R	77.99	88.37	88.87	88.87	88.87	90.74	90.74	90.74	90.74	90.74	92.62	91.97
	P(50K)	84.63	88.12	89.26	89.26	89.26	89.26	91.23	91.23	91.23	91.23	91.23	91.23
	P(100K)	81.11	89.75	89.75	89.75	89.75	89.75	89.75	89.75	91.26	91.26	90.52	90.52
	P(200K)	74.59	83.77	85.98	87.29	87.29	89.49	89.49	90.05	90.05	90.05	90.54	91.53
84	R	67.42	79.87	83.86	89.3	89.03	89.97	89.97	91.03	91.12	91.12	91.12	90.93
	P(50K)	84.9	84.41	84.41	84.41	86.84	86.84	86.84	86.84	86.84	89.53	89.53	89.53
	P(100K)	83.1	83.1	83.1	88.26	88.26	87.07	87.07	87.07	89.7	89.7	89.7	91.31
	P(200K)	77.11	83.31	83.31	83.31	83.31	83.31	88.58	89.34	89.34	89.34	89.34	89.34
84	R	68.75	71.89	77.94	80.52	84.14	84.14	84.14	85.66	85.66	86.39	86.39	86.68
	P(50K)	75.08	75.08	75.08	77.74	77.74	77.74	77.74	77.74	83.8	83.8	83.8	83.8
	P(100K)	79.16	79.16	79.16	79.16	79.16	83.66	83.66	83.66	83.66	83.66	83.66	83.66
	P(200K)	67.11	71.81	71.81	74.74	75.45	75.45	75.45	78.73	78.73	78.36	78.36	78.36

Table 8. Comparison of segmentation Dice scores (in %) for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on the Au20nm test dataset. The experiments were performed with UNets of different sizes (with two, three, and four residual blocks) and receptive fields (three for each U-Net size) and HRNet.

	EPOCHS		5	10	15	20	25	30	35	40	45	50	55	60
HRNET		R	89.27	92.19	95.61	96.65	97.37	97.69	97.69	97.69	97.87	98.11	98.3	98.37
		P(50K)	97.8	98.17	98.45	98.48	98.56	98.5	98.61	98.63	98.65	98.67	98.65	98.67
		P(100K)	97.88	98.24	98.35	98.48	98.52	98.56	98.59	98.64	98.67	98.7	98.67	98.71
		P(200K)	98.08	98.39	98.53	98.53	98.53	98.53	98.6	98.6	98.62	98.62	98.67	98.69
U-NET 4 BLOCKS	424	R	92.18	92.18	96.12	96.99	97.34	97.58	97.64	97.64	97.87	97.87	97.87	97.97
		P(50K)	95.19	96.79	97.44	97.7	97.89	98.02	98.12	98.12	98.06	98.27	98.27	98.27
		P(100K)	96.06	97.05	97.51	97.63	97.73	97.87	98.01	98.06	98.17	98.22	98.26	98.26
		P(200K)	94.14	96.22	97.4	97.84	97.92	98.01	98	98.13	98.1	98.23	98.27	98.27
	360	R	76.57	91.93	94.55	95.1	96.7	97.26	97.26	97.26	97.26	97.45	97.69	97.7
		P(50K)	95.43	96.78	97.4	97.76	97.88	98.01	98.01	98.13	98.13	98.13	98.13	98.11
		P(100K)	94.58	96.78	97.2	97.72	97.87	97.91	98.02	98.11	98.14	98.17	98.18	98.26
		P(200K)	95.24	96.92	97.56	97.78	97.94	97.94	97.99	98.14	98.14	98.25	98.25	98.25
	200	R	0	0	0	96.58	97.56	97.56	97.56	97.72	97.95	98.06	98.1	98.13
		P(50K)	95.23	95.98	97.55	97.35	97.61	97.61	98.03	98.14	98.23	98.27	98.27	98.27
		P(100K)	93.89	96.21	97.66	97.71	97.89	98.09	98.09	98.13	98.18	98.18	98.23	98.3
		P(200K)	94.6	96.53	97.21	97.63	97.84	97.84	98.08	98.14	98.14	98.14	98.25	98.31
U-NET 3 BLOCKS	240	R	93.82	95.65	96.49	97.25	97.57	97.76	97.91	97.93	98.14	98.23	98.23	98.32
		P(50K)	95.82	96.38	96.95	97.37	97.71	97.68	97.88	97.88	97.88	98.04	98.04	98.14
		P(100K)	93.26	95.84	97.13	97.39	97.41	97.63	97.72	97.82	97.82	97.88	97.88	98.01
		P(200K)	91.91	95.42	96.97	96.97	97.12	97.7	97.73	97.78	97.94	98	98	98.04
	176	R	93.25	93.25	96.39	96.88	97.14	97.51	97.77	97.7	97.67	97.97	98.06	98.13
		P(50K)	93.55	94.81	96.28	96.81	96.93	97.39	97.4	97.75	97.9	97.9	97.81	97.91
		P(100K)	82.97	94.61	95.73	96.46	97.04	97.31	97.55	97.54	97.69	97.85	97.83	97.95
		P(200K)	92.36	95.83	96.66	97.39	97.45	97.45	97.82	97.82	98.01	97.99	98.11	98.12
	96	R	62.53	76.4	86.28	90.83	94.25	94.25	95.86	95.86	95.86	96.21	96.49	96.78
		P(50K)	90.5	90.5	93.87	93.87	94.5	95.57	95.96	95.96	95.96	96.82	96.82	96.82
		P(100K)	70.31	91.09	94.87	94.73	94.73	94.57	96.18	96.45	96.45	96.77	96.77	96.77
		P(200K)	87.83	91.26	93.18	93.58	94.86	95.28	96.02	96.02	95.98	95.98	95.98	95.98
U-NET 2 BLOCKS	116	R	72.73	81.99	87.09	91.99	93.76	93.76	94.35	94.93	95.17	95.39	95.48	96.27
		P(50K)	70.81	70.81	91.02	91.02	91.57	91.57	91.57	92.67	92.67	95.32	95.32	95.32
		P(100K)	85.85	89.29	89.79	90.89	91.73	94.34	94.34	95.14	95.14	95.87	95.71	95.78
		P(200K)	33.71	78.82	87.84	89.83	92.54	93.56	93.93	94.73	95.05	95.72	95.72	96.14
	84	R	71.23	66.65	88.39	88.39	91.5	91.5	92.9	93.42	94.1	94.07	92.15	92.15
		P(50K)	68.8	68.8	78.39	78.39	88.28	88.28	88.28	90.64	90.64	90.1	90.1	93.04
		P(100K)	83.48	84.8	84.28	89.55	91.64	91.64	91.64	92.63	93.23	92.04	92.04	92.04
		P(200K)	78.24	78.24	85.15	87.72	89.22	89.22	89.22	90.36	90.74	91.94	91.94	91.94
	84	R	35.85	35.85	61.46	74.07	74.07	74.07	81.69	81.69	83.14	84.11	83.34	86.63
		P(50K)	60.74	60.74	60.74	60.74	74.61	74.61	78.49	78.49	79.22	81.94	81.94	84.28
		P(100K)	56.68	56.68	62.47	69.56	69.56	69.56	69.56	77.4	77.4	80.89	81.49	82.2
		P(200K)	32.64	67.93	73.62	74.74	74.74	77.25	77.25	77.25	80.08	83.64	83.64	83.64

Table 9. Comparison of the L_1 metric for different training methods (randomly initialized weights (R) and pretrained (P) with GANs on CEM500K using 50 K, 100 K, 200 K images) on each of the downstream tasks: Super-resolution (SR), Noise & Background Removal (N&BGR) and Denoising (DN). The experiments were performed with HRNet.

EPOCHS		5	10	15	20	25	30	35	40	45	50	55	60
SR	R	0.01972	0.01731	0.01469	0.01636	0.01513	0.01524	0.01338	0.01208	0.01212	0.0113	0.01244	0.01122
	P(50K)	0.01688	0.01557	0.0177	0.01373	0.0139	0.01359	0.01239	0.01307	0.01137	0.01113	0.01155	0.0112
	P(100K)	0.02105	0.01685	0.01645	0.01451	0.0188	0.01465	0.01368	0.01357	0.01234	0.01231	0.01229	0.01142
	P(200K)	0.01639	0.01617	0.01544	0.01503	0.01428	0.01371	0.01249	0.01186	0.01222	0.01246	0.01159	0.01156
N&BGR	R	0.06391	0.04049	0.03073	0.0432	0.03312	0.03438	0.02974	0.03098	0.02102	0.01918	0.01905	0.0176
	P(50K)	0.03332	0.02916	0.03479	0.02494	0.03002	0.02257	0.02877	0.02326	0.0196	0.02056	0.01812	0.01776
	P(100K)	0.03268	0.04262	0.02986	0.03289	0.02772	0.02913	0.02307	0.02077	0.02126	0.01904	0.01973	0.01766
	P(200K)	0.03323	0.03545	0.02541	0.03602	0.02424	0.0224	0.02861	0.02136	0.02139	0.01851	0.01867	0.01792
DN	R	0.04732	0.02965	0.03173	0.02433	0.02658	0.02996	0.03735	0.02042	0.02012	0.01982	0.01714	0.01541
	P(50K)	0.03287	0.0263	0.02193	0.02918	0.0212	0.02169	0.02778	0.01932	0.01727	0.01672	0.01613	0.01542
	P(100K)	0.03693	0.02867	0.02607	0.02381	0.01953	0.03708	0.02121	0.02148	0.01798	0.01751	0.01635	0.01555
	P(200K)	0.02657	0.02408	0.0212	0.02536	0.02489	0.01907	0.02233	0.01782	0.01674	0.01695	0.01638	0.01586