Supplementary material to our paper submitted to IVC: Artificial Immune Systems for data augmentation

This document contains supplementary materials to the main paper. In Section 1, we show the stability analysis of our method using YOLOv4. Section 2 analyses how various distortions affect object detection using YOLOv4. Section 3 offers a detailed breakdown of the simulation results presented in the main paper using YOLOv4. Lastly, Section 4 presents the visual results demonstrating the effectiveness of our method in enhancing object detection using Faster RCNN.

1 Stability analysis

For this study, we conducted five experiments (i.e., we trained and validated each model five times) of YOLOv4 under PASCAL using our method (AISbod) and Stylize. We then calculated their mean and standard deviation. Table 1 shows that YOLOv4 appears to be the most stable under clean samples. However, under distortion, YOLOv4+AISbod appears to be the most stable. Both mPC and rPC consistently confirm this observation. Using AISbod seems to provide the best compromise (stability-wise) under both clean and distorted samples.

Table 1: Stability analysis using YOLOv4, using mean and standard deviation. (The most stable results are in red and second in blue.)

Model	YOLOv4	+ AISbod (our)	+ Stylize
mAP_{org}	83.39(±0.1559)	83.45(±0.1838)	83.80(±0.1753)
mPC	52.20(±0.4739)	58.57(±0.2637)	61.11(±0.5129)
rPC	0.6259(±0.0058)	0.7024(±0.0030)	0.7328(±0.0065)

2 Distortion-specific Analysis

Table 2 shows which of the 15 distortions make YOLOv4 less robust for PASCAL and COCO validation datasets. We use an $IOU = 0.5$ to calculate mAP_{org} and mPC for a fair comparison of both datasets; the mPC for each distortion is the average of all its corresponding five severity levels. The model is most susceptible to blur (glass, zoom, motion, and defocus) and noise (impulse, Gaussian, and shot). Both categories significantly reduce the accuracy of YOLOv4. Comparatively, the model is more robust to weather conditions like brightness, fog, frost, and snow. Our method helps the model under all 15 distortions but mostly under noise (impulse, Gaussian, and shot on average by 17.96%), blur (on average by 3.67%), and compression (by 4.84%), as shown in Table 3.

Table 2: Susceptibility of YOLOv4 to type of distortions arranged from most to least using PASCAL and COCO. ($IOU = 0.5$ is used in the calculation of all metrics. The mPC reported per distortion is the average for all 5 severity levels; the -() indicates the deterioration per distortion.)

PASCAL ($mAP_{org} = 83.31$)		COCO ($mAP_{org} = 62.07$)	
Distortion	mPC	Distortion	mPC
glass blur	34.36 (-48.95)	zoom blur	18.43 (-43.64)
zoom blur	38.09 (-45.22)	glass blur	27.19 (-34.88)
pixelate	38.90 (-44.41)	impulse noise	29.25 (-32.82)
motion blur	41.09 (-42.22)	motion blur	31.75 (-30.32)
impulse noise	42.15 (-41.16)	pixelate	33.26 (-28.81)
Gaussian noise	48.44 (-34.87)	Gaussian noise	34.80 (-27.27)
defocus blur	48.57 (-34.74)	shot noise	35.48 (-26.59)
jpeg compression	49.96 (-33.35)	snow	36.05 (-26.02)
shot noise	51.25 (-32.06)	defocus blur	36.72 (-25.35)
elastic transform	53.03 (-30.28)	jpeg compression	37.16 (-24.91)
snow	56.76 (-26.55)	elastic transform	39.42 (-22.65)
frost	63.11 (-20.20)	frost	44.57 (-17.50)
contrast	66.92 (-16.39)	contrast	48.70 (-13.37)
fog	75.54 (-7.77)	fog	56.43 (-5.64)
brightness	78.98 (-4.33)	brightness	59.29 (-2.78)

Table 3: Gain introduced by YOLOv4+AISbod on type of distortion arranged from most to least using COCO. ($IOU = 0.5$ is used in the calculation of all metrics. The best results are red in each row; the mPC reported per distortion is the average for all 5 severity levels.)

	YOLOv4: $mAP_{org} = 62.07$	YOLOv4+AISbod: $mAP_{org} = 62.31$
Distortion	mPC: YOLOv4	mPC: YOLOv4+AISbod
impulse noise	29.25	57.36 (+28.11)
Gaussian noise	34.80	53.79 (+18.99)
shot noise	35.48	42.27 (+6.79)
glass blur	27.19	32.78 (+5.59)
jpeg compression	37.16	41.99 (+4.84)
snow	36.05	40.11 (+4.06)
defocus blur	36.72	40.53 (+3.81)
pixelate	33.26	36.78 (+3.53)
motion blur	31.75	34.74 (+2.99)
elastic transform	39.42	42.07 (+2.65)
zoom blur	18.43	20.72 (+2.29)
frost	44.57	46.19 (+1.62)
contrast	48.70	49.74 (+1.04)
fog	56.43	57.17 (+0.74)
brightness	59.29	59.83 (+0.54)

3 Detailed breakdown of simulation results

We provide a detailed breakdown of the performance of our method and related works here using YOLOv4 for both PASCAL and COCO. We show the accuracy of each of the 15 distortions and their corresponding severity level from 1 to 5, with level 1 being the lowest and 5 the highest severity. As shown in Table 4 and 5, the results affirm our analysis in the main paper.

Table 4: PASCAL validation set: Detailed comparison of our method (AISbod) with related works on YOLOv4. The best results are in red and second in blue in each row; the +() indicates gain, that is, the difference between the original and defence method.)

		YOLOv4	+ AISbod (our)	+ Stylize	+ SMIX	+ URIE
	clean	83.31	83.50 (+0.19)	83.90 (+0.59)	83.65 (+0.34)	
Gaussian noise	severity 1	74.06	78.69 (+4.63)	76.41 (+2.35)	73.86 (-0.20)	68.56 (-5.50)
	severity 2	66.34	76.55 (+10.21)	70.47 (+4.13)	64.43 (-1.91)	64.88 (-1.46)
	severity 3	52.83	72.49 (+19.66)	60.74 (+7.91)	47.08 (-5.75)	59.13 (+6.30)
	severity 4	34.37	65.93 (+31.56)	46.90 (+12.53)	27.19 (-7.18)	52.44 (+18.07)
	severity 5	14.62	55.82 (+41.20)	27.33 (+12.71)	12.00 (-2.62)	41.04 (+26.42)
shot noise	severity 1	74.89	79.07 (+4.18)	76.92 (+2.03)	74.70 (-0.19)	69.24 (-5.65)
	severity 2	66.98	77.01 (+10.03)	69.83 (+2.85)	64.27 (-2.71)	65.60 (-1.38)
	severity 3	56.36	73.98 (+17.62)	62.12 (+5.76)	50.60 (-5.76)	60.59 (+4.23)
	severity 4	35.69	65.87 (+30.18)	46.69 (+11.00)	28.09 (-7.60)	52.15 (+16.46)
	severity 5	22.34	58.79 (+36.45)	33.86 (+11.52)	16.86 (-5.48)	45.89 (+23.55)
impulse noise	severity 1	61.09	76.38 (+15.29)	70.35 (+9.26)	63.55 (+2.46)	66.64 (+5.55)
	severity 2	54.40	75.24 (+20.84)	66.63 (+12.23)	57.27 (+2.87)	62.58 (+8.18)
	severity 3	48.48	73.56 (+25.08)	61.73 (+13.25)	48.77 (+0.29)	58.99 (+10.51)
	severity 4	31.68	67.76 (+36.08)	46.50 (+14.82)	25.92 (-5.76)	51.12 (+19.44)
	severity 5	15.12	59.24 (+44.12)	28.22 (+13.10)	10.93 (-4.19)	41.50 (+26.38)
motion blur	severity 1	70.50	72.16 (+1.66)	70.64 (+0.14)	70.42 (-0.08)	65.65 (-4.85)
	severity 2	57.25	60.62 (+3.37)	60.36 (+3.11)	57.08 (-0.17)	61.39 (+4.14)
	severity 3	37.72	42.62 (+4.90)	45.91 (+8.19)	39.88 (+2.16)	54.03 (+16.31)
	severity 4	22.87	26.56 (+3.69)	30.72 (+7.85)	26.69 (+3.82)	45.32 (+22.45)
	severity 5	17.13	19.32 (+2.19)	23.72 (+6.59)	19.97 (+2.84)	39.87 (+22.74)
zoom blur	severity 1	53.81	55.22 (+1.41)	57.32 (+3.51)	53.75 (-0.06)	55.96 (+2.15)
	severity 2	43.78	44.99 (+1.21)	46.77 (+2.99)	43.71 (-0.07)	50.74 (+6.96)
	severity 3	37.72	38.23 (+0.51)	43.13 (+5.41)	39.69 (+1.97)	45.21 (+7.49)
	severity 4	30.22	30.23 (+0.01)	34.34 (+4.12)	32.76 (+2.54)	40.39 (+10.17)
	severity 5	24.92	23.91 (-1.01)	28.83 (+3.91)	28.62 (+3.70)	35.02 (+10.10)
glass blur	severity 1	69.08	71.01 (+1.93)	71.82 (+2.74)	68.98 (-0.10)	63.89 (-5.19)
	severity 2	55.68	59.46 (+3.78)	63.44 (+7.76)	55.74 (+0.06)	58.55 (+2.87)
	severity 3	20.12	25.14 (+5.02)	36.61 (+16.49)	21.26 (+1.14)	45.68 (+25.56)
	severity 4	15.32	18.74 (+3.42)	29.13 (+13.81)	14.58 (-0.74)	39.85 (+24.53)
	severity 5	11.61	12.99 (+1.38)	26.16 (+14.55)	11.32 (-0.29)	31.31 (+19.70)
defocus blur	severity 1	70.21	70.81 (+0.60)	71.00 (+0.79)	67.18 (-3.03)	62.53 (-7.68)
	severity 2	61.94	63.83 (+1.89)	64.16 (+2.22)	56.13 (-5.81)	58.54 (-3.40)
	severity 3	47.84	51.12 (+3.28)	52.74 (+4.90)	41.67 (-6.17)	49.12 (+1.28)
	severity 4	36.33	39.46 (+3.13)	42.65 (+6.32)	29.88 (-6.45)	40.09 (+3.76)
	severity 5	26.53	28.67 (+2.14)	33.49 (+6.96)	21.59 (-4.94)	34.18 (+7.65)
contrast	severity 1	78.89	79.11 (+0.22)	81.09 (+2.20)	80.59 (+1.70)	73.75 (-5.14)
	severity 2	77.67	77.29 (-0.38)	79.93 (+2.26)	79.70 (+2.03)	73.56 (-4.11)
	severity 3	73.69	74.08 (+0.39)	77.55 (+3.86)	78.04 (+4.35)	72.97 (-0.72)
	severity 4	63.15	63.69 (+0.54)	72.23 (+9.08)	72.60 (+9.45)	71.08 (+7.93)
	severity 5	41.18	42.32 (+1.14)	63.27 (+22.09)	61.66 (+20.48)	66.40 (+25.22)
jpeg compression	severity 1	72.71	76.92 (+4.21)	76.56 (+3.85)	76.11 (+3.40)	68.52 (-4.19)
	severity 2	63.79	72.86 (+9.07)	72.17 (+8.38)	69.63 (+5.84)	66.88 (+3.09)
	severity 3	55.76	69.38 (+13.62)	69.54 (+13.78)	64.03 (+8.27)	65.38 (+9.62)
	severity 4	35.47	54.17 (+18.70)	59.04 (+23.57)	46.41 (+10.94)	60.75 (+25.28)
	severity 5	22.08	35.12 (+13.04)	44.02 (+21.94)	30.45 (+8.37)	54.92 (+32.84)
pixelate	severity 1	75.02	77.95 (+2.93)	79.95 (+4.93)	74.93 (-0.09)	70.47 (-4.55)
	severity 2	69.89	74.67 (+4.78)	77.34 (+7.45)	70.03 (+0.14)	69.56 (-0.33)
	severity 3	31.76	43.94 (+12.18)	68.42 (+36.66)	33.51 (+1.75)	65.71 (+33.95)
	severity 4	12.02	15.95 (+3.93)	50.15 (+38.13)	12.78 (+0.76)	61.09 (+49.07)
	severity 5	5.82	7.85 (+2.03)	31.90 (+26.08)	5.49 (-0.33)	55.35 (+49.53)
elastic transform	severity 1	73.23	73.62 (+0.39)	78.62 (+5.39)	71.91 (-1.32)	64.04 (-9.19)
	severity 2	66.21	66.59 (+0.38)	73.35 (+7.14)	62.93 (-3.28)	59.65 (-6.56)
	severity 3	53.11	53.96 (+0.85)	65.29 (+12.18)	47.44 (-5.67)	51.99 (-1.12)
	severity 4	42.41	43.78 (+1.37)	57.94 (+15.53)	36.39 (-6.02)	47.30 (+4.89)
	severity 5	30.18	30.88 (+0.70)	45.76 (+15.58)	24.17 (-6.01)	40.20 (+10.02)
frost	severity 1	76.27	76.03 (-0.24)	76.77 (+0.50)	77.51 (+1.24)	65.38 (-10.89)
	severity 2	66.79	66.45 (-0.34)	68.90 (+2.11)	70.09 (+3.30)	59.03 (-7.76)
	severity 3	60.64	59.99 (-0.65)	63.25 (+2.61)	64.67 (+4.03)	53.60 (-7.04)
	severity 4	58.76	58.36 (-0.40)	61.78 (+3.02)	62.61 (+3.85)	53.10 (-5.66)
	severity 5	53.10	52.24 (-0.86)	57.04 (+3.94)	58.69 (+5.59)	49.28 (-3.82)
fog	severity 1	78.53	78.51 (-0.02)	81.10 (+2.57)	80.47 (+1.94)	71.58 (-6.95)
	severity 2	77.43	77.39 (-0.04)	80.58 (+3.15)	79.99 (+2.56)	70.79 (-6.64)
	severity 3	75.76	76.02 (+0.26)	80.00 (+4.24)	79.22 (+3.46)	69.57 (-6.19)
	severity 4	75.00	74.57 (-0.43)	78.97 (+3.97)	78.54 (+3.54)	68.34 (-6.66)
	severity 5	70.98	69.95 (-1.03)	75.79 (+4.81)	76.04 (+5.06)	64.47 (-6.51)
snow	severity 1	72.13	70.55 (-1.58)	73.68 (+1.55)	70.11 (-2.02)	63.34 (-8.79)
	severity 2	59.74	61.25 (+1.51)	62.65 (+2.91)	59.34 (-0.40)	59.23 (-0.51)
	severity 3	57.37	56.88 (-0.49)	61.69 (+4.32)	57.48 (+0.11)	57.39 (+0.02)
	severity 4	47.90	46.70 (-1.20)	54.16 (+6.26)	48.65 (+0.75)	50.73 (+2.83)
	severity 5	46.64	48.78 (+2.14)	51.48 (+4.84)	49.98 (+3.34)	53.79 (+7.15)
brightness	severity 1	81.39	80.98 (-0.41)	82.24 (+0.85)	81.98 (+0.59)	72.48 (-8.91)
	severity 2	80.01	80.42 (+0.41)	81.53 (+1.52)	81.26 (+1.25)	71.61 (-8.40)
	severity 3	79.27	79.70 (+0.43)	80.93 (+1.66)	80.54 (+1.27)	70.08 (-9.19)
	severity 4	78.12	78.40 (+0.28)	79.92 (+1.80)	79.16 (+1.04)	67.80 (-10.32)
	severity 5	76.11	76.83 (+0.72)	78.42 (+2.31)	76.52 (+0.41)	64.99 (-11.12)
Overall summary	mPC	52.48	58.87 (+6.40)	60.44 (+7.96)	53.04 (+0.56)	58.05 (+5.57)
	rPC	0.6299	0.7067	0.7254	0.6367	0.6968

Table 5: COCO validation set: Detailed comparison of our method (AISbod) with related works on YOLOv4. The best results are in red and second in blue in each row; the +() indicates gain, that is, the difference between the original and defence method.)

		YOLOv4	+ AISbod (our)	+ Stylize	+ URIE
	clean	40.67	40.87 (+0.20)	38.95 (-1.73)	
Gaussian noise	severity 1	35.02	37.85 (+2.83)	34.55 (-0.47)	30.55 (-4.47)
	severity 2	30.20	36.85 (+6.65)	31.04 (+0.83)	28.32 (-1.88)
	severity 3	22.72	35.51 (+12.79)	26.47 (+3.75)	24.96 (+2.24)
	severity 4	14.35	31.29 (+16.94)	20.09 (+5.74)	20.60 (+6.25)
	severity 5	5.56	24.51 (+18.95)	11.55 (+5.99)	15.49 (+9.93)
shot noise	severity 1	35.00	38.03 (+3.03)	34.49 (-0.51)	30.49 (-4.51)
	severity 2	29.68	35.90 (+6.22)	30.73 (+1.05)	28.12 (-1.56)
	severity 3	23.29	32.64 (+9.35)	26.68 (+3.39)	25.38 (+2.09)
	severity 4	13.73	25.30 (+11.57)	19.21 (+5.48)	20.40 (+6.67)
	severity 5	8.00	18.74 (+10.74)	14.01 (+6.01)	16.95 (+8.95)
impulse noise	severity 1	26.03	39.34 (+13.31)	31.47 (+5.44)	29.41 (+3.39)
	severity 2	23.49	38.44 (+14.95)	29.03 (+5.54)	27.01 (+3.53)
	severity 3	20.98	37.68 (+16.70)	26.74 (+5.76)	24.77 (+3.79)
	severity 4	13.08	35.26 (+22.19)	19.77 (+6.70)	20.12 (+7.04)
	severity 5	5.79	30.98 (+25.19)	12.50 (+6.71)	15.45 (+9.66)
motion blur	severity 1	33.71	33.98 (+0.26)	32.43 (-1.29)	29.12 (-4.59)
	severity 2	26.46	27.86 (+1.40)	27.48 (+1.02)	26.24 (-0.23)
	severity 3	17.70	19.95 (+2.25)	21.17 (+3.47)	22.43 (+4.73)
	severity 4	10.06	12.27 (+2.20)	14.93 (+4.87)	17.73 (+7.67)
	severity 5	6.49	8.60 (+2.11)	11.51 (+5.02)	14.93 (+8.44)
zoom blur	severity 1	16.13	17.45 (+1.32)	18.06 (+1.93)	16.84 (+0.72)
	severity 2	10.60	11.66 (+1.06)	12.52 (+1.91)	12.83 (+2.23)
	severity 3	7.81	8.61 (+0.80)	9.90 (+2.09)	10.26 (+2.45)
	severity 4	5.37	6.11 (+0.74)	7.13 (+1.76)	8.01 (+2.64)
	severity 5	4.12	4.86 (+0.74)	5.77 (+1.65)	6.70 (+2.58)
glass blur	severity 1	33.19	34.82 (+1.63)	33.38 (+0.19)	28.55 (-4.64)
	severity 2	26.91	30.12 (+3.20)	29.49 (+2.57)	25.76 (-1.16)
	severity 3	10.61	15.48 (+4.87)	17.29 (+6.68)	19.20 (+8.59)
	severity 4	8.04	12.29 (+4.26)	14.41 (+6.37)	16.90 (+8.87)
	severity 5	5.53	8.74 (+3.21)	10.77 (+5.24)	12.59 (+7.06)
defocus blur	severity 1	33.98	35.04 (+1.06)	33.53 (-0.45)	27.65 (-6.32)
	severity 2	29.79	31.34 (+1.55)	30.39 (+0.59)	25.51 (-4.28)
	severity 3	22.56	24.87 (+2.32)	24.67 (+2.12)	21.11 (-1.44)
	severity 4	16.50	19.63 (+3.12)	19.75 (+3.25)	17.01 (+0.51)
	severity 5	11.27	14.78 (+3.51)	15.65 (+4.37)	13.24 (+1.97)
contrast	severity 1	38.71	38.87 (+0.16)	37.78 (-0.93)	34.13 (-4.58)
	severity 2	37.54	37.81 (+0.26)	37.11 (-0.44)	34.09 (-3.46)
	severity 3	35.14	35.46 (+0.33)	35.75 (+0.61)	33.73 (-1.41)
	severity 4	28.65	29.11 (+0.46)	32.23 (+3.58)	32.67 (+4.02)
	severity 5	17.80	19.12 (+1.32)	26.21 (+8.41)	29.71 (+11.91)
jpeg compression	severity 1	34.02	35.61 (+1.59)	33.82 (-0.20)	30.34 (-3.69)
	severity 2	29.07	31.76 (+2.69)	30.67 (+1.60)	29.34 (+0.28)
	severity 3	25.47	29.07 (+3.60)	28.39 (+2.92)	28.58 (+3.11)
	severity 4	15.90	20.31 (+4.42)	21.17 (+5.28)	26.14 (+10.24)
	severity 5	8.60	12.28 (+3.69)	14.66 (+6.07)	22.64 (+14.04)
pixelate	severity 1	37.45	38.44 (+0.99)	36.90 (-0.55)	31.83 (-5.62)
	severity 2	35.60	36.98 (+1.38)	36.12 (+0.52)	31.67 (-3.93)
	severity 3	22.01	26.08 (+4.07)	31.14 (+9.13)	30.00 (+7.99)
	severity 4	8.04	11.40 (+3.37)	24.41 (+16.37)	28.04 (+20.01)
	severity 5	3.24	5.28 (+2.04)	18.25 (+15.01)	25.80 (+22.56)
elastic transform	severity 1	34.25	35.02 (+0.76)	35.54 (+1.28)	28.06 (-6.20)
	severity 2	29.90	31.27 (+1.36)	32.82 (+2.91)	25.29 (-4.62)
	severity 3	23.55	25.36 (+1.81)	28.02 (+4.48)	21.51 (-2.04)
	severity 4	19.48	21.57 (+2.09)	24.34 (+4.86)	18.88 (-0.61)
	severity 5	14.19	16.50 (+2.30)	19.39 (+5.19)	15.76 (+1.57)
frost	severity 1	35.73	36.03 (+0.31)	35.18 (-0.55)	29.46 (-6.27)
	severity 2	30.38	31.32 (+0.94)	30.98 (+0.60)	25.13 (-5.25)
	severity 3	26.45	27.36 (+0.91)	28.01 (+1.55)	22.11 (-4.35)
	severity 4	25.26	26.25 (+1.00)	27.12 (+1.86)	21.31 (-3.94)
	severity 5	22.98	24.30 (+1.32)	25.46 (+2.48)	19.37 (-3.61)
fog	severity 1	m38.40	38.68 (+0.28)	37.61 (-0.79)	33.16 (-5.24)
	severity 2	37.69	37.94 (+0.25)	37.14 (-0.55)	32.91 (-4.78)
	severity 3	36.71	37.10 (+0.40)	36.62 (-0.09)	32.20 (-4.50)
	severity 4	36.25	36.82 (+0.57)	36.48 (+0.23)	31.89 (-4.36)
	severity 5	34.55	35.07 (+0.52)	35.37 (+0.82)	30.51 (-4.04)
snow	severity 1	30.48	32.93 (+2.46)	32.63 (+2.16)	27.28 (-3.20)
	severity 2	23.57	27.21 (+3.64)	27.99 (+4.43)	23.78 (+0.22)
	severity 3	22.35	24.37 (+2.02)	27.20 (+4.85)	22.57 (+0.23)
	severity 4	17.54	19.60 (+2.06)	23.53 (+5.99)	18.32 (+0.78)
	severity 5	17.85	20.30 (+2.46)	23.22 (+5.37)	19.57 (+1.73)
brightness	severity 1	40.38	40.45 (+0.06)	38.63 (-1.75)	33.46 (-6.93)
	severity 2	39.64	39.71 (+0.07)	38.01 (-1.63)	33.32 (-6.32)
	severity 3	38.77	38.95 (+0.19)	37.44 (-1.33)	32.72 (-6.05)
	severity 4	37.54	37.90 (+0.36)	36.61 (-0.94)	31.49 (-6.06)
	severity 5	36.14	36.83 (+0.69)	35.54 (-0.60)	29.74 (-6.40)
Overall summary	mPC	23.61	27.51 (+3.90)	26.59 (+2.97)	24.52 (+0.91)
	rPC	0.5806	0.6764	0.6537	0.6029

4 Visual Results

Subjectively, Fig. 1 and 2 show the accuracy of the Faster RCNN model for a Gaussian noise level of 27 dB and impulse density of 0.25% on some samples, respectively. The model is easily tricked by adding noise, as seen in the first row. Objects are wrongly classified in some instances, and in others, the detection is missed. These vulnerabilities are mitigated with our method (as shown in their respective rows in the Figures).

Figure 1: Comparison of Faster RCNN and Faster RCNN+AISbod on 27 dB Gaussian noisy samples. For instance, the *Aeroplane* correctly detected in the original image (row 1, column 6) is missed in its noisy version (row 2, column 6). This error is corrected in AISbod (row 2, column 6). (Points of interest indicated by blue arrows are better viewed by zooming in).

Figure 2: Comparison of Faster RCNN and Faster RCNN+AISbod on 0.25% impulse noisy samples. For instance, the *Train* correctly detected in the original image (row 1, column 1) is missed in the noisy version (row 2, column 1). This error is corrected in AIS (row 4, column 1). (Points of interest indicated by blue arrows are better viewed by zooming in).