Cooperative and distributed decision-making in a multi-agent perception system for improvised landmines detection

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This document contains the full set of results complementing the work published in [2]. Indications on how to interpret the results are given in this document. However, the full details of experimental pre-requisites, motivation, and setup are available in the main article.

Results as grouped as follow. the configuration details of the ffANN (feed-forward artificial neural networks) and FDSS (fuzzy decision support system) training stage and the results of each stage. training and validation. The results are shown in two tables. first the values obtained from the artificial neural network as the local uncertainty measure. and second the outcomes of a set of decision-making methods as cooperative uncertainty measure. These tables use the nomenclature detailed in table 1. have four decimal digits per value. present all the test cases. and each one has three performance metrics (accuracy – ACC. root mean square error – RMSE. and area under the ROC curve – AUC). Besides. each result section has a group of ROC curves per sensor.

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Nomenclature	Name	Value
U	Uncertainty Measure	See Table 2
N	Next Position	See Table 3
S	Sensor	See Table 4
TP	True-Positive	0-100
TN	True-Negative	0-100
FP	False-Positive	0-100
FN	False-Negative	0-100
ACC	Accuracy	[0.1]. best case ACC = 1
RMSE	Root mean square error	[0.1]. best case RMSE = 0
AUC	Area under the ROC curve	[0.1]. best case AUC = 1

Table 1: Global nomenclature of the tables results in this document.

Uncertainty Measure		
Number	Decision Making Method	ROC space position (row.column)
0	NEAT	(2.1)
1	GFS/FDSS	(2.2)
2	MEAN	(3.1)
3	MEDIAN	(3.2)
4	MAX	(4.1)
5	VOTING	(4.2)

Table 2: Uncertainty measure column nomenclature and position of the ROC space in each figure

Next Position	
Number	Decision Making Method
0	NEAT
1	GFS
2	Random Position
3	Fixed Position

Table 3: Next position column nomenclature

Sensor		
Number	Type	Figures (training and evaluation)
0	Visual spectrum camera (VS)	1 and 6
1	Infrared spectrum camera (IR)	2 and 7
2	Ultraviolet spectrum camera (UV)	3 and 8
3	Single beam thermal sensor (TM)	4 and 9
4	Ground penetrating radar (GP)	5 and 10

Table 4: Sensor column nomenclature and figures with the ROC curves per every stage. training and evaluation

The decision-making systems evaluated in the main paper has an uncertainty measure as output. and they were considered as a binary classifier assuming a threshold value. Each threshold value produces a different point in ROC space. and a set of threshold values generates a two-dimensional curve. The ROC space has an x-axis referenced to the false-positive rates (FPR). and a y-axis related to the true-positive rates (TPR). per threshold value. Besides. every ROC space in this paper has drawn the diagonal line. $x = y$ because a classifier under this curve performs worse than random guessing.

Each figure belongs to a specific sensor (see Table 4) and has eight ROC spaces. Any ROC space represents the results of the performance of decision-making methods. The ROC space in the first row and column has the ROC points of the 0.5 threshold value from all the decision-making methods. The ROC space in the first row and the second column has the ROC curve of the local uncertainty measure. and the other ROC spaces have cooperative decision-making methods (see Table 2). On the other hand. every ROC space of a decision-making method has four curves. and they are respectively linked to

P_{NMC+}	0.1	0.4	0.7	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1
P_{NMC-}	0.3	0.2	0.1	0.1	0.4	0.7	0.3	0.2	0.1	0.3	0.2	0.1
P_{NMN+}	0.3	0.2	0.1	0.3	0.2	0.1	0.1	0.4	0.7	0.3	0.2	0.1
P_{NMN-}	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1	0.1	0.4	0.7

P_{NMC+}	0.1	0.1	0.1	0.4	0.4	0.4	0.2	0.2	0.2	0.3	0.3	0.3
P_{NMC-}	0.1	0.4	0.4	0.1	0.1	0.4	0.2	0.3	0.3	0.2	0.2	0.3
P_{NMN+}	0.4	0.1	0.4	0.1	0.4	0.1	0.3	0.2	0.3	0.2	0.3	0.2
P_{NMN-}	0.4	0.4	0.1	0.4	0.1	0.1	0.3	0.3	0.3	0.3	0.2	0.2

Table 5: This table contains the 24 cases of probability mutation operators evaluated per artificial neural network trained with NEAT

a decision-making method of next position (NEAT. GFS. random angle. or fixed/static position).

1. Training setup

According to the guidelines in [3, 4]. this is done by specifying a starting configuration. i.e. we fixed three admissible values for hidden layers (0.1 and 2) as well as for connections ("unconnected". "no direct" and "direct"). before starting the optimisation process. GA parameters. have also to be set-up after fine tuning. In particular. the NEAT algorithm requires the probability of adding a connection. referred to as P_{NMC+}[1]. the probability of removing a connection. referred to as P_{NMC-}. and similarly. the probabilities of adding and removing a neuron. referred to as P_{NMN+}[2] and P_{NMN-} respectively. Their optimal value was found by means of a thorough empirical process. in which 24 configurations of admissible values were checked for each case. i.e. LDM. CDM. NPDM respectively (see table 5).

2. Results from the training process

Table 6: Results of the training process of the local decision-making method.

N	S	TP	TN	FP	FN	ACC	RMSE	AUC
2	0	18	18	20	0	0.6429	0.4737	0.5263
3	0	18	17	21	0	0.6250	0.4615	0.5385
0	0	18	17	21	0	0.6250	0.4615	0.5385

[1] NMC stands for NEAT-Mutation for Connection.
[2] NMN stands for NEAT-Mutation for Neuron.

1	0	18	17	21	0	0.6250	0.4615	0.5385
3	1	14	17	21	4	0.5536	0.4000	0.6000
1	1	14	15	23	4	0.5179	0.3784	0.6216
2	1	14	15	23	4	0.5179	0.3784	0.6216
0	1	15	13	25	3	0.5000	0.3750	0.6250
1	2	18	10	28	0	0.5000	0.3913	0.6087
3	2	18	9	29	0	0.4821	0.3830	0.6170
0	2	18	5	33	0	0.4107	0.3529	0.6471
2	2	18	5	33	0	0.4107	0.3529	0.6471
1	3	18	4	34	0	0.3929	0.3462	0.6538
2	3	18	2	36	0	0.3571	0.3333	0.6667
3	3	18	0	38	0	0.3214	0.3214	0.6786
0	3	18	0	38	0	0.3214	0.3214	0.6786
1	4	16	16	22	2	0.5714	0.4211	0.5789
0	4	13	19	19	5	0.5714	0.4063	0.5938
3	4	13	8	30	5	0.3750	0.3023	0.6977
2	4	18	3	35	0	0.3750	0.3396	0.6604

Table 7: Results of the training process of the cooperative decision-making methods.

U	N	S	TP	TN	FP	FN	ACC	RMSE	AUC
0	2	0	0	38	0	18	0.6786	0.0000	0.0000
0	3	0	0	38	0	18	0.6786	0.0000	0.0000
0	1	0	0	38	0	18	0.6786	0.0000	0.0000
2	1	0	18	13	25	0	0.5536	0.4186	0.5814
3	1	0	18	13	25	0	0.5536	0.4186	0.5814
5	1	0	18	13	25	0	0.5536	0.4186	0.5814
0	0	0	9	20	18	9	0.5179	0.3333	0.6667
2	0	0	18	9	29	0	0.4821	0.3830	0.6170
2	3	0	18	6	32	0	0.4286	0.3600	0.6400
2	2	0	18	6	32	0	0.4286	0.3600	0.6400
3	3	0	18	6	32	0	0.4286	0.3600	0.6400
5	3	0	18	6	32	0	0.4286	0.3600	0.6400

3	0	0	18	5	33	0	0.4107	0.3529	0.6471
5	0	0	18	5	33	0	0.4107	0.3529	0.6471
1	0	0	18	0	38	0	0.3214	0.3214	0.6786
1	1	0	18	0	38	0	0.3214	0.3214	0.6786
1	2	0	18	0	38	0	0.3214	0.3214	0.6786
1	3	0	18	0	38	0	0.3214	0.3214	0.6786
3	2	0	18	0	38	0	0.3214	0.3214	0.6786
4	3	0	18	0	38	0	0.3214	0.3214	0.6786
4	1	0	18	0	38	0	0.3214	0.3214	0.6786
4	0	0	18	0	38	0	0.3214	0.3214	0.6786
4	2	0	18	0	38	0	0.3214	0.3214	0.6786
5	2	0	18	0	38	0	0.3214	0.3214	0.6786
2	1	1	18	13	25	0	0.5536	0.4186	0.5814
3	1	1	18	13	25	0	0.5536	0.4186	0.5814
5	1	1	18	13	25	0	0.5536	0.4186	0.5814
0	1	1	16	12	26	2	0.5000	0.3810	0.6190
2	0	1	18	9	29	0	0.4821	0.3830	0.6170
0	3	1	15	12	26	3	0.4821	0.3659	0.6341
0	0	1	16	11	27	2	0.4821	0.3721	0.6279
0	2	1	16	10	28	2	0.4643	0.3636	0.6364
2	3	1	18	6	32	0	0.4286	0.3600	0.6400
2	2	1	18	6	32	0	0.4286	0.3600	0.6400
3	3	1	18	6	32	0	0.4286	0.3600	0.6400
5	3	1	18	6	32	0	0.4286	0.3600	0.6400
3	0	1	18	5	33	0	0.4107	0.3529	0.6471
5	0	1	18	5	33	0	0.4107	0.3529	0.6471
3	2	1	18	1	37	0	0.3393	0.3273	0.6727
5	2	1	18	1	37	0	0.3393	0.3273	0.6727
1	0	1	18	0	38	0	0.3214	0.3214	0.6786
1	1	1	18	0	38	0	0.3214	0.3214	0.6786
1	2	1	18	0	38	0	0.3214	0.3214	0.6786
1	3	1	18	0	38	0	0.3214	0.3214	0.6786

4	3	1	18	0	38	0	0.3214	0.3214	0.6786
4	1	1	18	0	38	0	0.3214	0.3214	0.6786
4	0	1	18	0	38	0	0.3214	0.3214	0.6786
4	2	1	18	0	38	0	0.3214	0.3214	0.6786
2	1	2	18	13	25	0	0.5536	0.4186	0.5814
3	1	2	18	13	25	0	0.5536	0.4186	0.5814
5	1	2	18	13	25	0	0.5536	0.4186	0.5814
2	0	2	18	9	29	0	0.4821	0.3830	0.6170
2	3	2	18	6	32	0	0.4286	0.3600	0.6400
2	2	2	18	6	32	0	0.4286	0.3600	0.6400
3	3	2	18	6	32	0	0.4286	0.3600	0.6400
5	3	2	18	6	32	0	0.4286	0.3600	0.6400
3	0	2	18	5	33	0	0.4107	0.3529	0.6471
5	0	2	18	5	33	0	0.4107	0.3529	0.6471
0	3	2	18	2	36	0	0.3571	0.3333	0.6667
3	2	2	18	1	37	0	0.3393	0.3273	0.6727
0	1	2	18	1	37	0	0.3393	0.3273	0.6727
5	2	2	18	1	37	0	0.3393	0.3273	0.6727
1	0	2	18	0	38	0	0.3214	0.3214	0.6786
1	1	2	18	0	38	0	0.3214	0.3214	0.6786
1	2	2	18	0	38	0	0.3214	0.3214	0.6786
1	3	2	18	0	38	0	0.3214	0.3214	0.6786
4	3	2	18	0	38	0	0.3214	0.3214	0.6786
4	1	2	18	0	38	0	0.3214	0.3214	0.6786
4	0	2	18	0	38	0	0.3214	0.3214	0.6786
4	2	2	18	0	38	0	0.3214	0.3214	0.6786
0	0	2	18	0	38	0	0.3214	0.3214	0.6786
0	2	2	18	0	38	0	0.3214	0.3214	0.6786
0	1	3	14	27	11	4	0.7321	0.5600	0.4400
1	0	3	0	38	0	18	0.6786	0.0000	0.0000
1	1	3	0	38	0	18	0.6786	0.0000	0.0000
1	2	3	0	38	0	18	0.6786	0.0000	0.0000

1	3	3	0	38	0	18	0.6786	0.0000	0.0000
0	2	3	14	23	15	4	0.6607	0.4828	0.5172
0	0	3	13	23	15	5	0.6429	0.4643	0.5357
2	1	3	18	13	25	0	0.5536	0.4186	0.5814
3	1	3	18	13	25	0	0.5536	0.4186	0.5814
5	1	3	18	13	25	0	0.5536	0.4186	0.5814
0	3	3	8	20	18	10	0.5000	0.3077	0.6923
2	0	3	18	9	29	0	0.4821	0.3830	0.6170
2	3	3	18	6	32	0	0.4286	0.3600	0.6400
2	2	3	18	6	32	0	0.4286	0.3600	0.6400
3	3	3	18	6	32	0	0.4286	0.3600	0.6400
5	3	3	18	6	32	0	0.4286	0.3600	0.6400
3	0	3	18	5	33	0	0.4107	0.3529	0.6471
5	0	3	18	5	33	0	0.4107	0.3529	0.6471
3	2	3	18	1	37	0	0.3393	0.3273	0.6727
5	2	3	18	1	37	0	0.3393	0.3273	0.6727
4	3	3	18	0	38	0	0.3214	0.3214	0.6786
4	1	3	18	0	38	0	0.3214	0.3214	0.6786
4	0	3	18	0	38	0	0.3214	0.3214	0.6786
4	2	3	18	0	38	0	0.3214	0.3214	0.6786
0	2	4	0	38	0	18	0.6786	0.0000	0.0000
0	3	4	0	38	0	18	0.6786	0.0000	0.0000
0	1	4	0	38	0	18	0.6786	0.0000	0.0000
0	0	4	0	38	0	18	0.6786	0.0000	0.0000
1	0	4	0	38	0	18	0.6786	0.0000	0.0000
1	2	4	0	38	0	18	0.6786	0.0000	0.0000
1	3	4	0	38	0	18	0.6786	0.0000	0.0000
1	1	4	0	38	0	18	0.6786	0.0000	0.0000
2	1	4	18	13	25	0	0.5536	0.4186	0.5814
3	1	4	18	13	25	0	0.5536	0.4186	0.5814
5	1	4	18	13	25	0	0.5536	0.4186	0.5814
2	0	4	18	9	29	0	0.4821	0.3830	0.6170

2	3	4	18	6	32	0	0.4286	0.3600	0.6400
3	3	4	18	6	32	0	0.4286	0.3600	0.6400
5	3	4	18	6	32	0	0.4286	0.3600	0.6400
2	2	4	18	5	33	0	0.4107	0.3529	0.6471
3	0	4	18	5	33	0	0.4107	0.3529	0.6471
5	0	4	18	5	33	0	0.4107	0.3529	0.6471
3	2	4	18	0	38	0	0.3214	0.3214	0.6786
4	3	4	18	0	38	0	0.3214	0.3214	0.6786
4	1	4	18	0	38	0	0.3214	0.3214	0.6786
4	0	4	18	0	38	0	0.3214	0.3214	0.6786
4	2	4	18	0	38	0	0.3214	0.3214	0.6786
5	2	4	18	0	38	0	0.3214	0.3214	0.6786

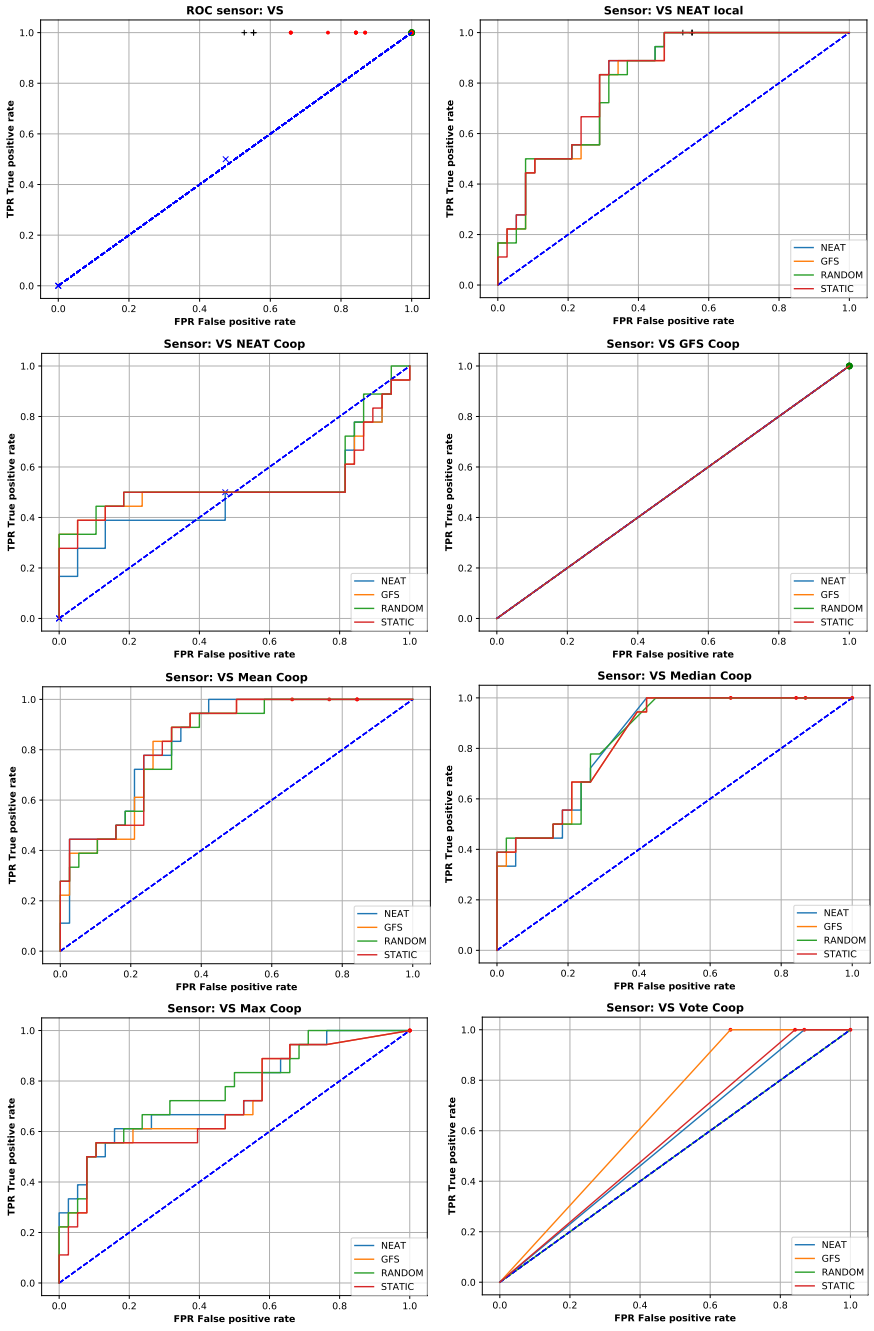

Figure 1: Results of the camera in the visual spectrum (VS) in the training stage.

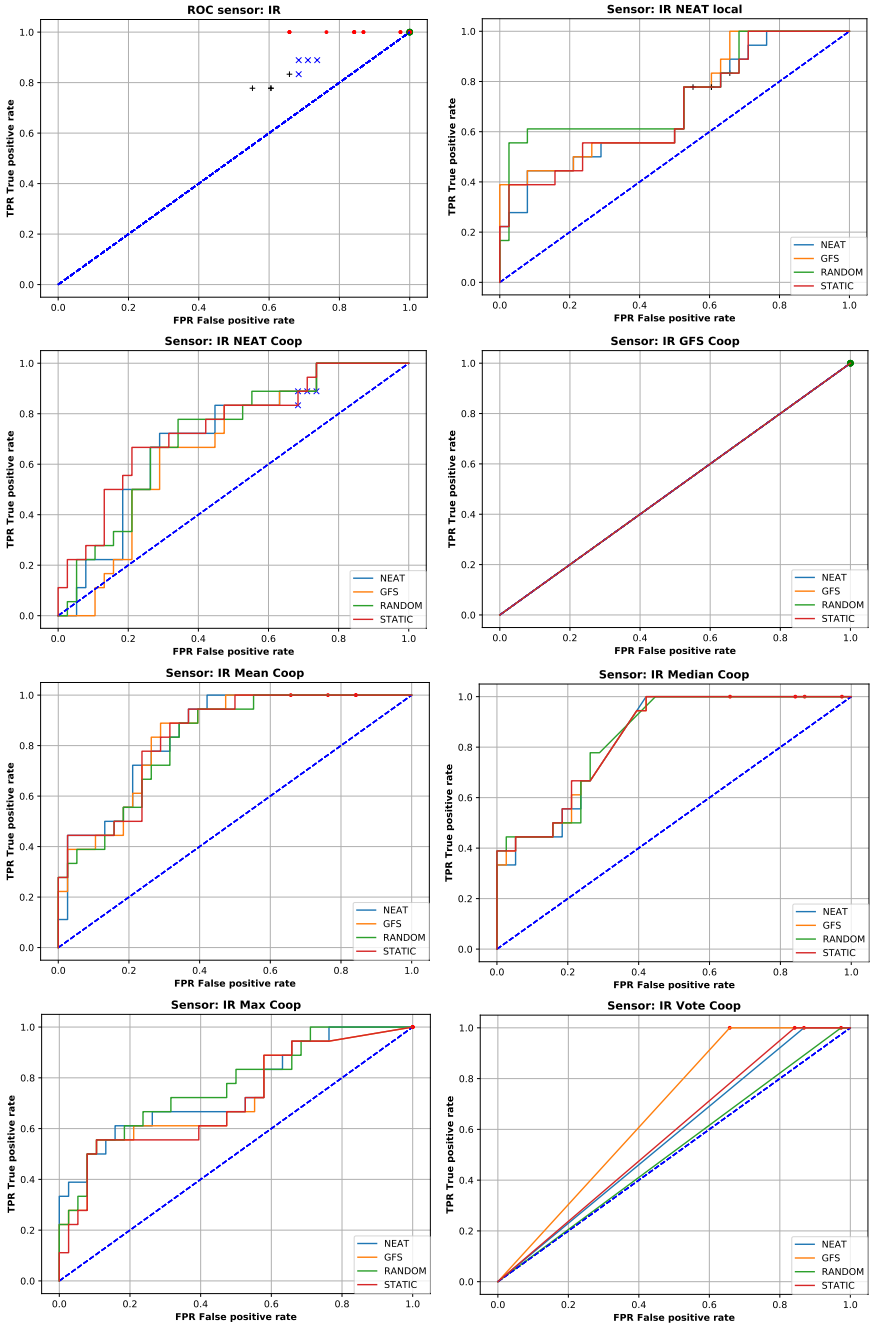

Figure 2: Results of the camera in the infrared spectrum (IR) in the training stage.

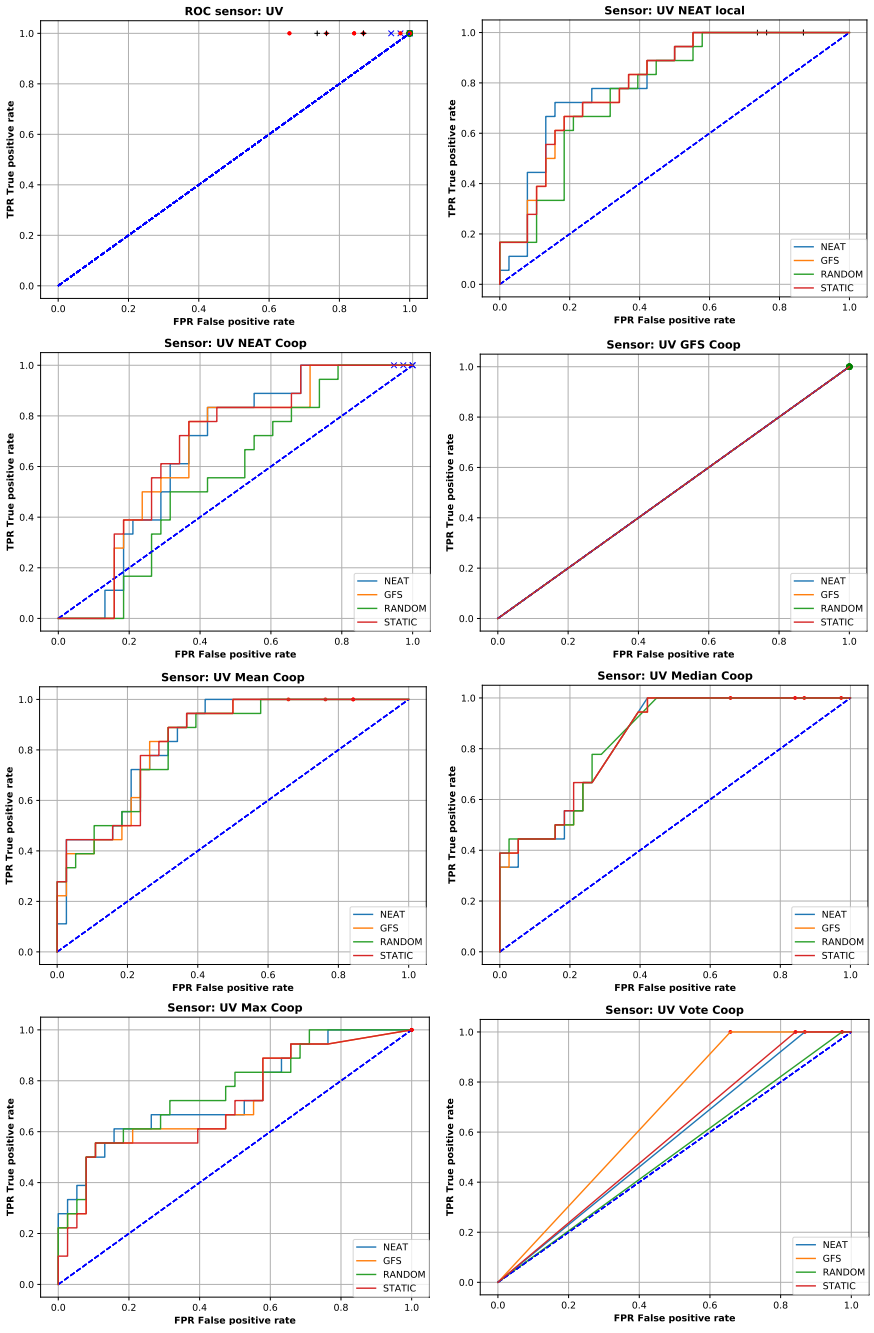

Figure 3: Results of the camera in the ultraviolet spectrum (UV) in the training stage.

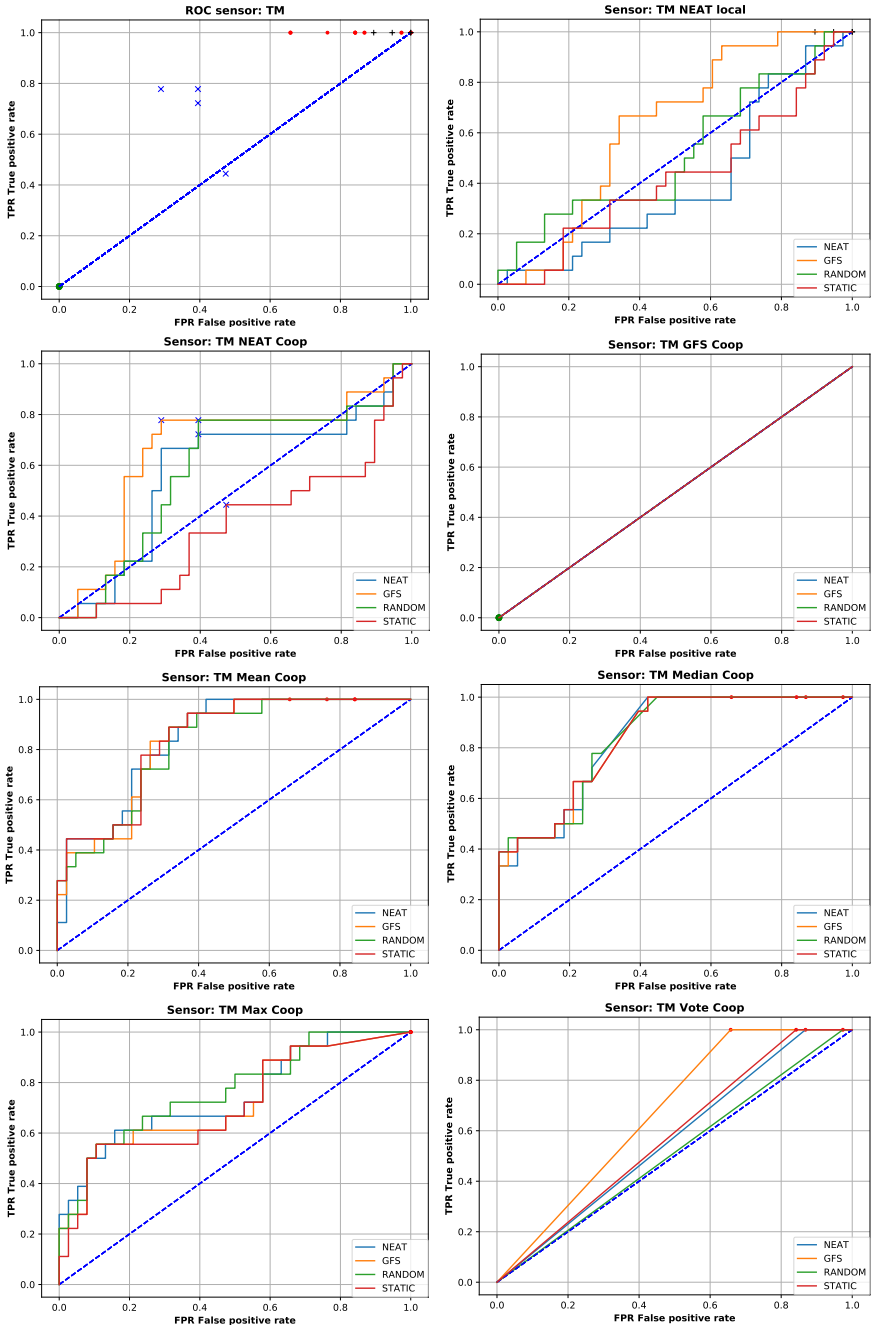

Figure 4: Results of the single beam thermal sensor (TM) in the training stage.

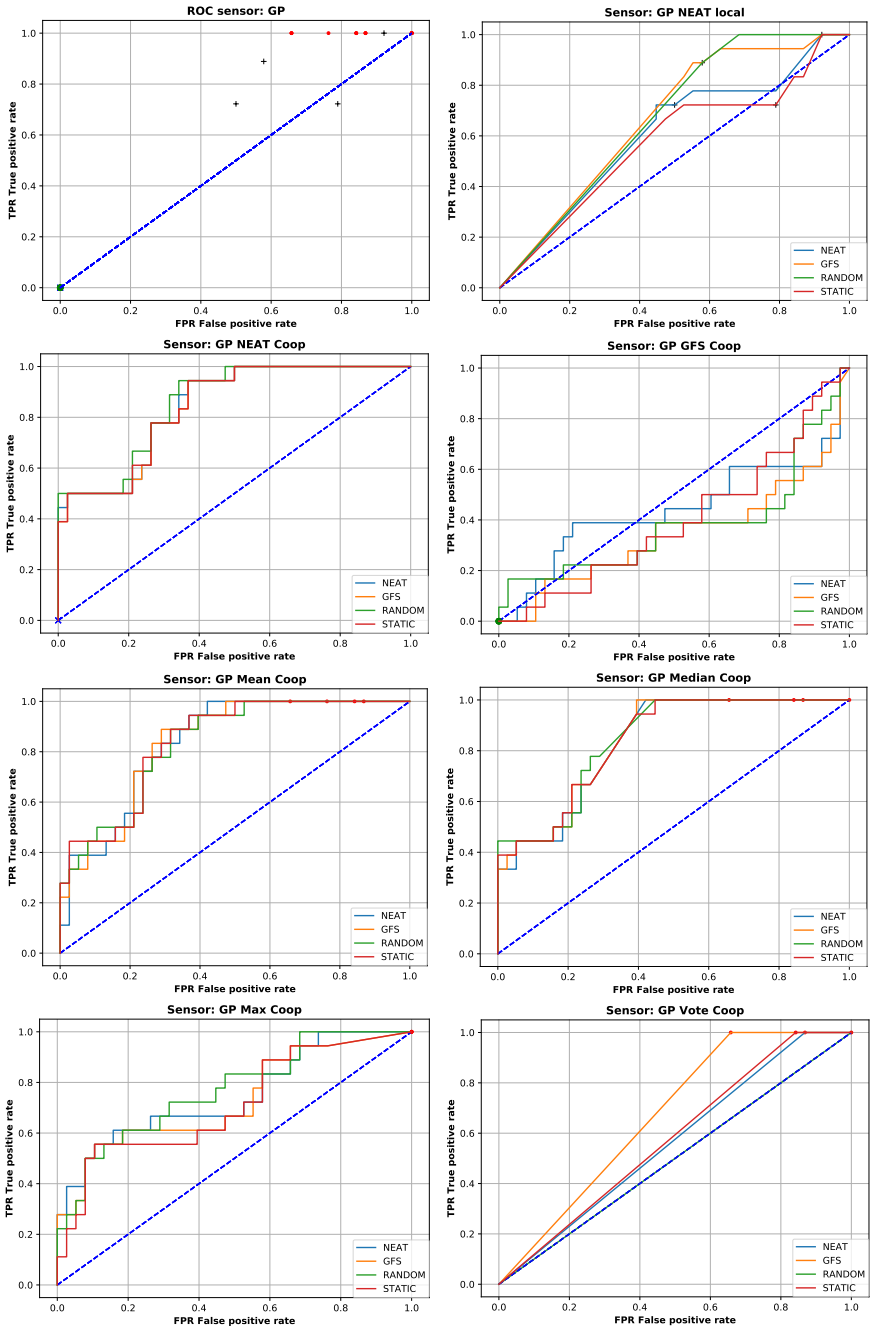

Figure 5: Results of the GPR sensor in the training stage.

3. Results from evaluation process

Table 8: Results of the evaluation process of the local decision-making method.

N	S	TP	TN	FP	FN	ACC	RMSE	AUC
2	0	44	60	32	8	0.7222	0.5789	0.4211
0	0	46	58	34	6	0.7222	0.5750	0.4250
1	0	44	56	36	8	0.6944	0.5500	0.4500
3	0	42	57	35	10	0.6875	0.5455	0.4545
1	1	45	44	48	7	0.6181	0.4839	0.5161
0	1	46	43	49	6	0.6181	0.4842	0.5158
2	1	44	41	51	8	0.5903	0.4632	0.5368
3	1	44	39	53	8	0.5764	0.4536	0.5464
3	2	51	39	53	1	0.6250	0.4904	0.5096
1	2	51	35	57	1	0.5972	0.4722	0.5278
2	2	51	26	66	1	0.5347	0.4359	0.5641
0	2	51	25	67	1	0.5278	0.4322	0.5678
0	3	52	1	91	0	0.3681	0.3636	0.6364
1	3	49	4	88	3	0.3681	0.3577	0.6423
3	3	52	0	92	0	0.3611	0.3611	0.6389
2	3	46	5	87	6	0.3542	0.3459	0.6541
1	4	40	20	72	12	0.4167	0.3571	0.6429
2	4	45	14	78	7	0.4097	0.3659	0.6341
3	4	38	19	73	14	0.3958	0.3423	0.6577
0	4	35	21	71	17	0.3889	0.3302	0.6698

Table 9: Results of the evaluation process of the cooperative decision-making methods.

U	N	S	TP	TN	FP	FN	ACC	RMSE	AUC
0	2	0	0	92	0	52	0.6389	0.0000	0.0000
0	3	0	0	92	0	52	0.6389	0.0000	0.0000
0	1	0	0	92	0	52	0.6389	0.0000	0.0000
2	3	0	50	38	54	2	0.6111	0.4808	0.5192

2	1	0	50	37	55	2	0.6042	0.4762	0.5238
2	0	0	51	32	60	1	0.5764	0.4595	0.5405
0	0	0	24	58	34	28	0.5694	0.4138	0.5862
2	2	0	51	30	62	1	0.5625	0.4513	0.5487
3	1	0	50	27	65	2	0.5347	0.4348	0.5652
5	1	0	50	27	65	2	0.5347	0.4348	0.5652
3	3	0	50	24	68	2	0.5139	0.4237	0.5763
5	3	0	50	24	68	2	0.5139	0.4237	0.5763
3	2	0	51	20	72	1	0.4931	0.4146	0.5854
5	2	0	51	20	72	1	0.4931	0.4146	0.5854
3	0	0	51	19	73	1	0.4861	0.4113	0.5887
5	0	0	51	19	73	1	0.4861	0.4113	0.5887
1	0	0	52	0	92	0	0.3611	0.3611	0.6389
1	1	0	52	0	92	0	0.3611	0.3611	0.6389
1	2	0	52	0	92	0	0.3611	0.3611	0.6389
1	3	0	52	0	92	0	0.3611	0.3611	0.6389
4	3	0	52	0	92	0	0.3611	0.3611	0.6389
4	1	0	52	0	92	0	0.3611	0.3611	0.6389
4	0	0	52	0	92	0	0.3611	0.3611	0.6389
4	2	0	52	0	92	0	0.3611	0.3611	0.6389
0	0	1	48	41	51	4	0.6181	0.4848	0.5152
2	3	1	50	38	54	2	0.6111	0.4808	0.5192
0	1	1	48	40	52	4	0.6111	0.4800	0.5200
2	1	1	50	37	55	2	0.6042	0.4762	0.5238
0	2	1	48	38	54	4	0.5972	0.4706	0.5294
0	3	1	47	37	55	5	0.5833	0.4608	0.5392
2	0	1	51	32	60	1	0.5764	0.4595	0.5405
2	2	1	51	31	61	1	0.5694	0.4554	0.5446
3	1	1	50	27	65	2	0.5347	0.4348	0.5652
5	1	1	50	27	65	2	0.5347	0.4348	0.5652
3	3	1	50	23	69	2	0.5069	0.4202	0.5798
5	3	1	50	23	69	2	0.5069	0.4202	0.5798

3	2	1	51	20	72	1	0.4931	0.4146	0.5854
5	2	1	51	20	72	1	0.4931	0.4146	0.5854
3	0	1	51	19	73	1	0.4861	0.4113	0.5887
5	0	1	51	19	73	1	0.4861	0.4113	0.5887
1	0	1	52	0	92	0	0.3611	0.3611	0.6389
1	1	1	52	0	92	0	0.3611	0.3611	0.6389
1	2	1	52	0	92	0	0.3611	0.3611	0.6389
1	3	1	52	0	92	0	0.3611	0.3611	0.6389
4	1	1	52	0	92	0	0.3611	0.3611	0.6389
4	3	1	52	0	92	0	0.3611	0.3611	0.6389
4	0	1	52	0	92	0	0.3611	0.3611	0.6389
4	2	1	52	0	92	0	0.3611	0.3611	0.6389
2	3	2	50	38	54	2	0.6111	0.4808	0.5192
2	1	2	50	37	55	2	0.6042	0.4762	0.5238
2	0	2	51	32	60	1	0.5764	0.4595	0.5405
0	1	2	52	30	62	0	0.5694	0.4561	0.5439
0	3	2	52	28	64	0	0.5556	0.4483	0.5517
2	2	2	51	28	64	1	0.5486	0.4435	0.5565
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0	2	2	52	24	68	0	0.5278	0.4333	0.5667
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5	2	2	51	20	72	1	0.4931	0.4146	0.5854
3	0	2	51	19	73	1	0.4861	0.4113	0.5887
5	0	2	51	19	73	1	0.4861	0.4113	0.5887
1	0	2	52	0	92	0	0.3611	0.3611	0.6389
1	1	2	52	0	92	0	0.3611	0.3611	0.6389
1	2	2	52	0	92	0	0.3611	0.3611	0.6389
1	3	2	52	0	92	0	0.3611	0.3611	0.6389

4	3	2	52	0	92	0	0.3611	0.3611	0.6389
4	1	2	52	0	92	0	0.3611	0.3611	0.6389
4	0	2	52	0	92	0	0.3611	0.3611	0.6389
4	2	2	52	0	92	0	0.3611	0.3611	0.6389
0	2	3	40	57	35	12	0.6736	0.5333	0.4667
1	0	3	0	92	0	52	0.6389	0.0000	0.0000
1	1	3	0	92	0	52	0.6389	0.0000	0.0000
1	2	3	0	92	0	52	0.6389	0.0000	0.0000
1	3	3	0	92	0	52	0.6389	0.0000	0.0000
0	1	3	39	53	39	13	0.6389	0.5000	0.5000
2	3	3	50	38	54	2	0.6111	0.4808	0.5192
0	0	3	38	50	42	14	0.6111	0.4750	0.5250
2	1	3	50	37	55	2	0.6042	0.4762	0.5238
2	0	3	51	32	60	1	0.5764	0.4595	0.5405
2	2	3	51	32	60	1	0.5764	0.4595	0.5405
3	1	3	50	27	65	2	0.5347	0.4348	0.5652
5	1	3	50	27	65	2	0.5347	0.4348	0.5652
3	3	3	50	23	69	2	0.5069	0.4202	0.5798
5	3	3	50	23	69	2	0.5069	0.4202	0.5798
3	2	3	51	20	72	1	0.4931	0.4146	0.5854
5	2	3	51	20	72	1	0.4931	0.4146	0.5854
3	0	3	51	19	73	1	0.4861	0.4113	0.5887
5	0	3	51	19	73	1	0.4861	0.4113	0.5887
0	3	3	16	49	43	36	0.4514	0.2712	0.7288
4	3	3	52	0	92	0	0.3611	0.3611	0.6389
4	1	3	52	0	92	0	0.3611	0.3611	0.6389
4	0	3	52	0	92	0	0.3611	0.3611	0.6389
4	2	3	52	0	92	0	0.3611	0.3611	0.6389
0	1	4	0	92	0	52	0.6389	0.0000	0.0000
0	3	4	0	92	0	52	0.6389	0.0000	0.0000
0	0	4	0	92	0	52	0.6389	0.0000	0.0000
0	2	4	0	92	0	52	0.6389	0.0000	0.0000

1	3	4	0	92	0	52	0.6389	0.0000	0.0000
1	1	4	0	92	0	52	0.6389	0.0000	0.0000
1	0	4	0	92	0	52	0.6389	0.0000	0.0000
1	2	4	0	92	0	52	0.6389	0.0000	0.0000
2	3	4	50	38	54	2	0.6111	0.4808	0.5192
2	1	4	50	37	55	2	0.6042	0.4762	0.5238
2	0	4	51	32	60	1	0.5764	0.4595	0.5405
2	2	4	51	30	62	1	0.5625	0.4513	0.5487
3	1	4	50	27	65	2	0.5347	0.4348	0.5652
5	1	4	50	27	65	2	0.5347	0.4348	0.5652
3	3	4	50	23	69	2	0.5069	0.4202	0.5798
5	3	4	50	23	69	2	0.5069	0.4202	0.5798
3	2	4	51	21	71	1	0.5000	0.4180	0.5820
5	2	4	51	21	71	1	0.5000	0.4180	0.5820
3	0	4	51	19	73	1	0.4861	0.4113	0.5887
5	0	4	51	19	73	1	0.4861	0.4113	0.5887
4	1	4	52	0	92	0	0.3611	0.3611	0.6389
4	3	4	52	0	92	0	0.3611	0.3611	0.6389
4	0	4	52	0	92	0	0.3611	0.3611	0.6389
4	2	4	52	0	92	0	0.3611	0.3611	0.6389

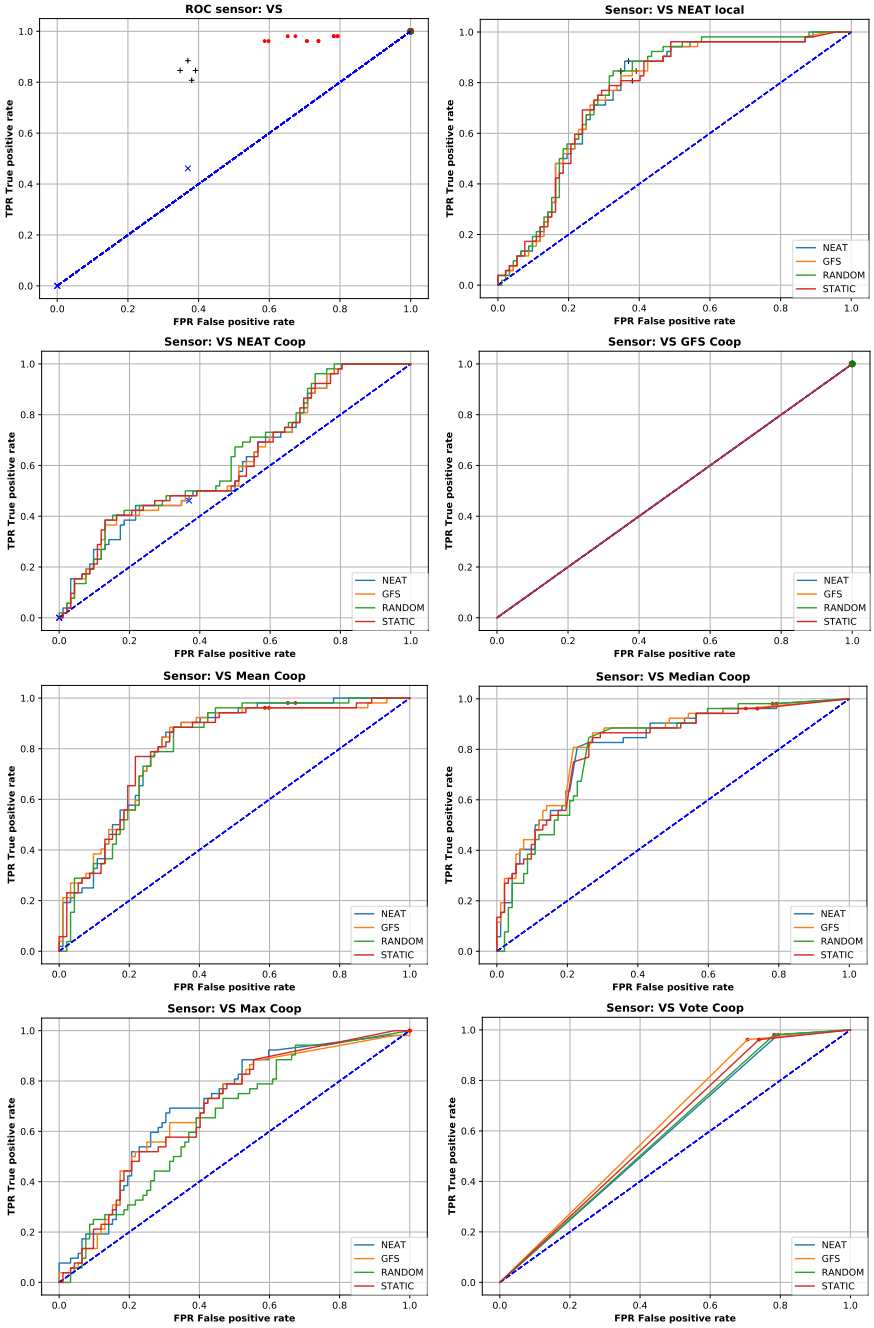

Figure 6: Results of the camera in the visual spectrum (VS) in the evaluation stage.

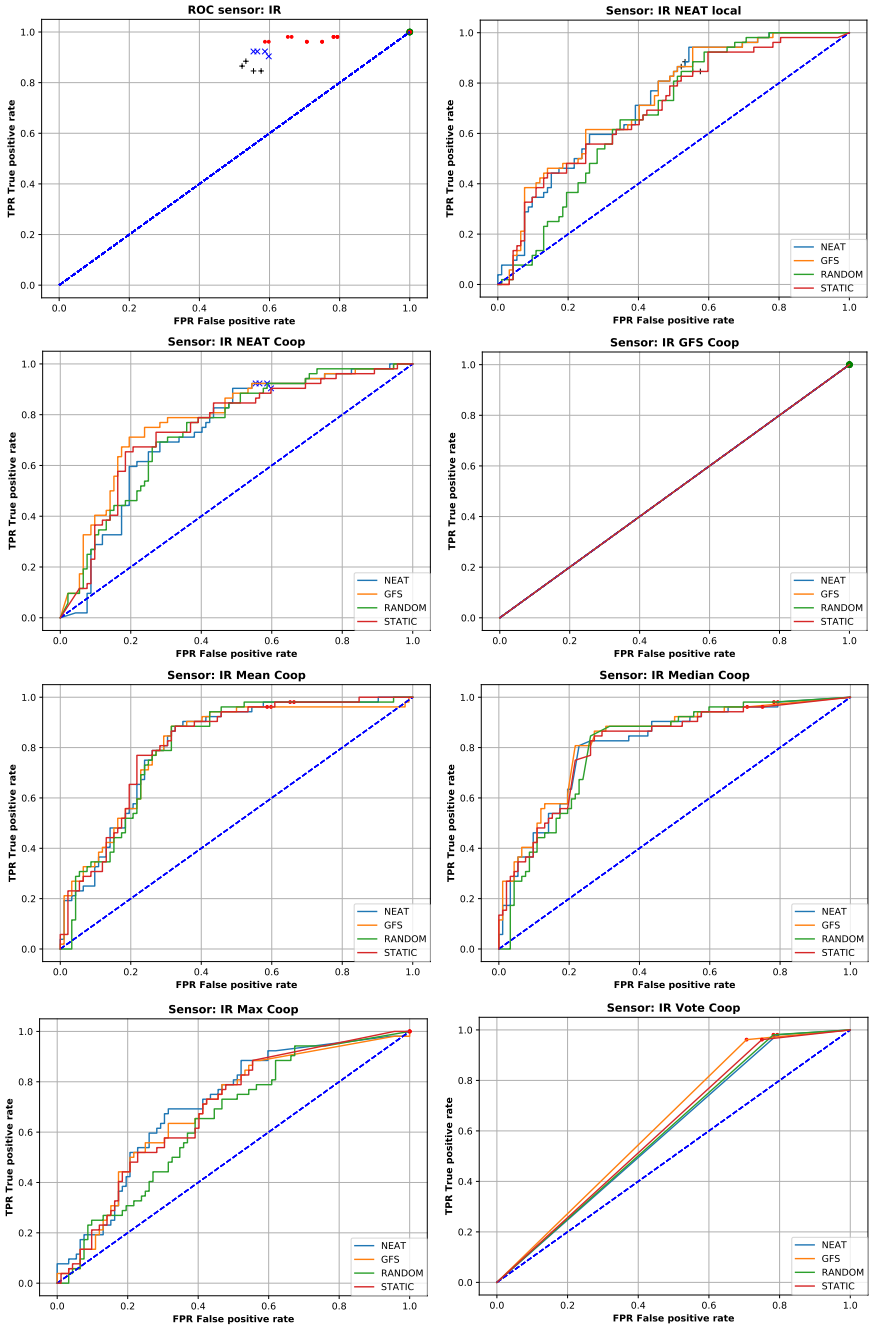

Figure 7: Results of the camera in the infrared spectrum (IR) in the evaluation stage.

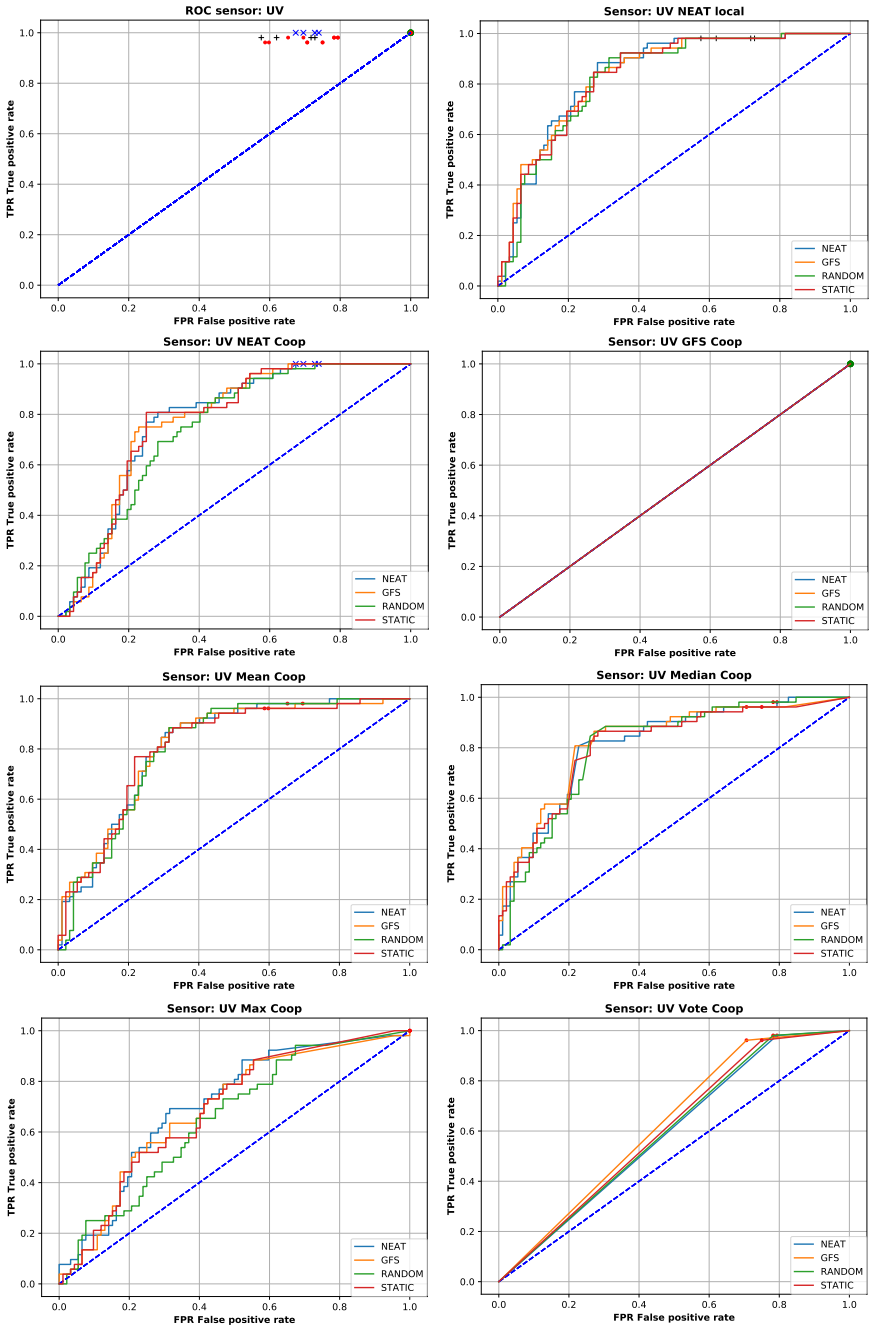

Figure 8: Results of the camera in the ultraviolet spectrum (UV) in the evaluation stage.

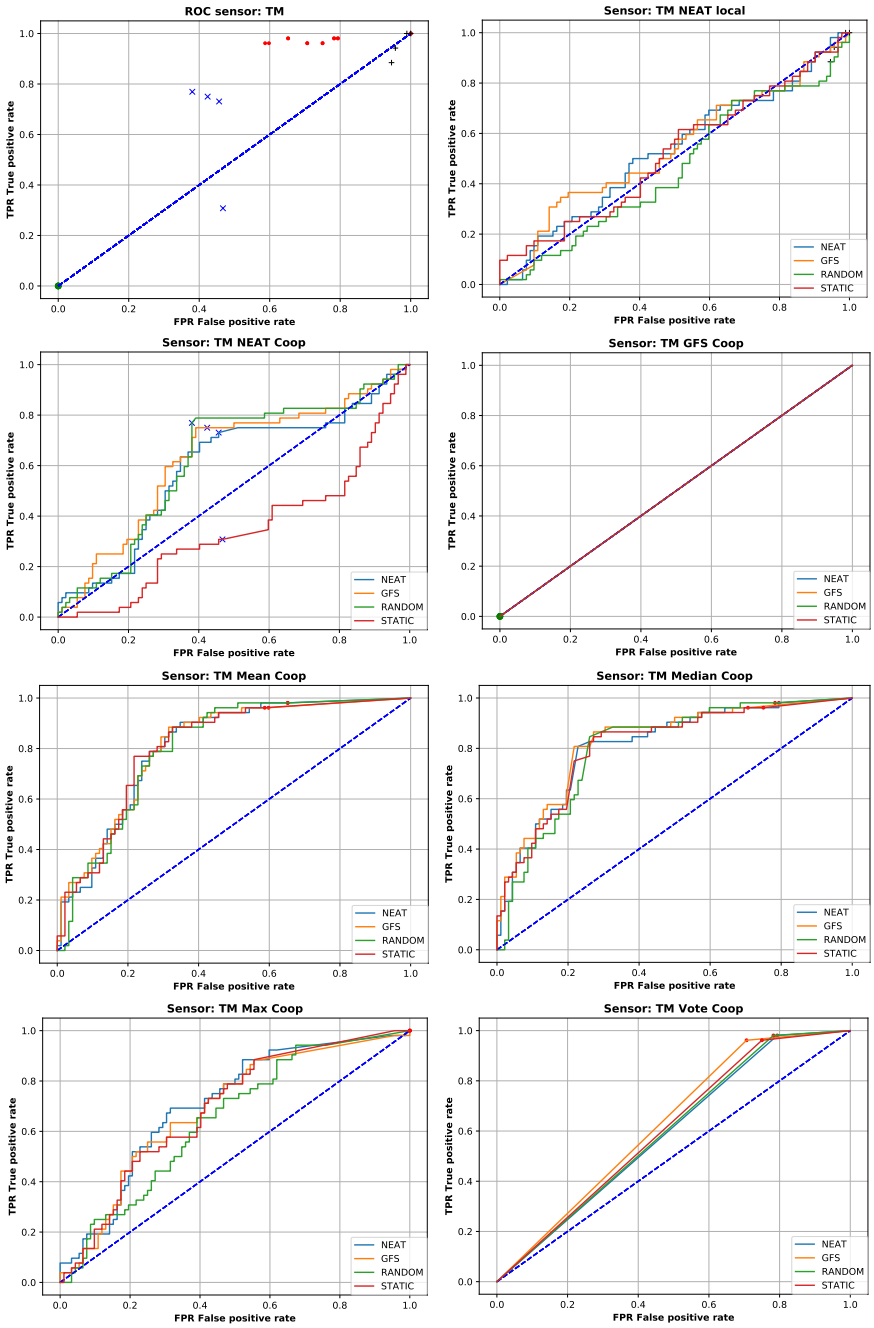

Figure 9: Results of the single beam thermal sensor (TM) in the evaluation stage.

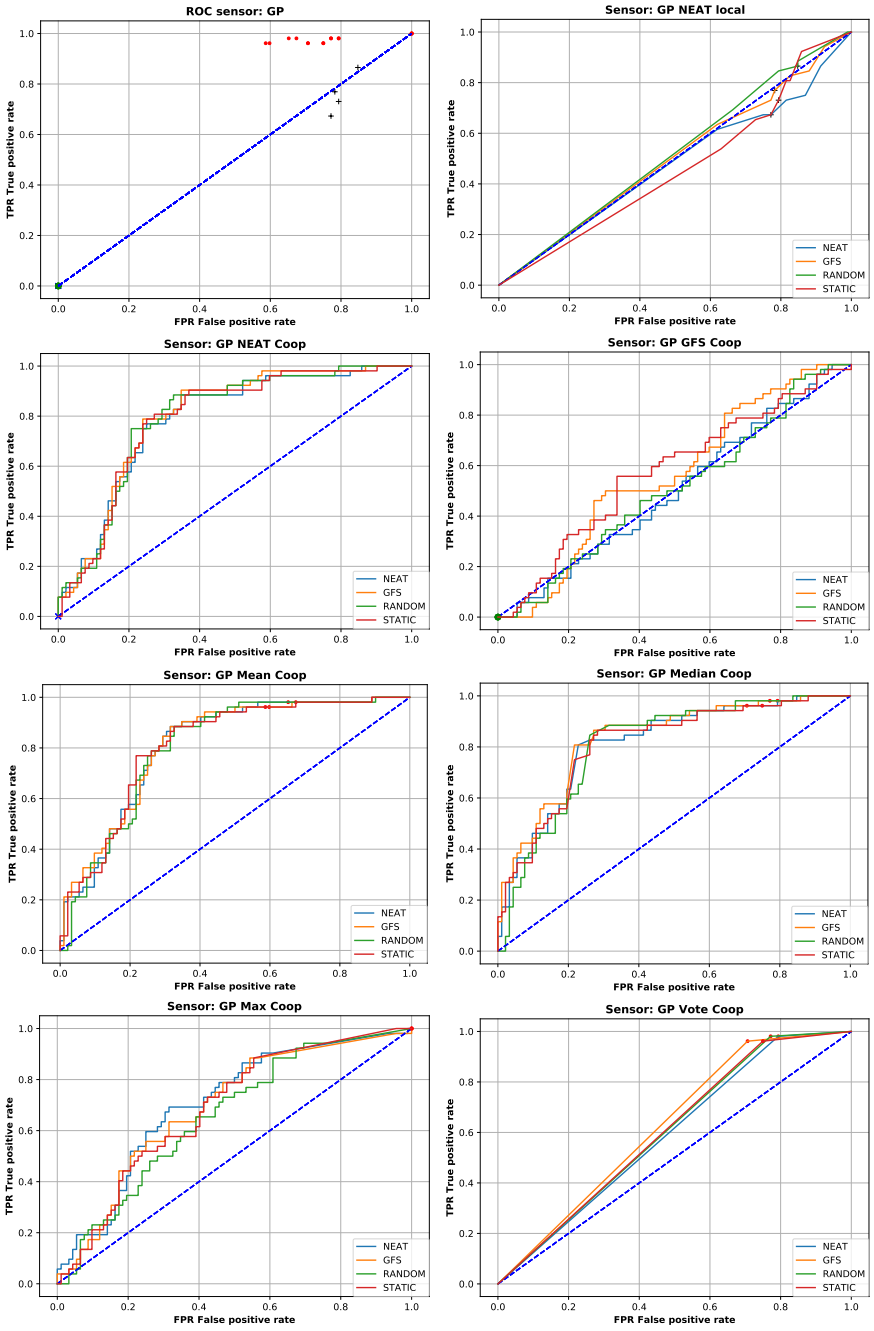

Figure 10: Results of the ground penetrating radar (GPR) sensor in the evaluation stage.

Acknowledgements

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