

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

–EXTENDED RESULTS–

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This document contains extended results intended to complement the work published in the main article “Cooperative and distributed decision-making in a multi-agent perception system for improvised land mines detection” where in depth indications on how to interpret the results are given together with a thorough analysis. A brief description of tables and figures can be found in the corresponding captions.

Keywords: land mine detection, improvised explosive device, neuroevolution, genetic fuzzy systems, feature extraction, sensor fusion

This document is structured as follows:

- section 1 gives further numerical details on the GA parameter tuning phase discussed in the main article;
- section 2 shows results obtained over the validation data set;
- section 3 shows results obtained over the validation data set.

Results are produced by means of the data available in [2] with the code downloadable from [5] as a part of the project [3].

1. GAs parameter tuning

Population Size	P_M	P_m	P_C	P_{C1}	P_{C2}	P_{C3}	P_{C4}
50	0.2	0.1	0.7	0.2	0.2	0.3	0.3

Table 1: Optimal parameter setting for MGA with P_{C4} being the crossover activation probability for the added Two-Point Crossover [4] while the remaining parameters are the original ones from [1]. Optimal values were obtained empirically.

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P_C^+	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_C^-	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_N^+	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_N^-	0.3	0.2	0.1	0.3	0.2	0.1	0.3	0.2	0.1	0.1	0.4	0.7			
				0.1	0.1	0.1	0.4	0.4	0.4	0.2	0.2	0.2	0.3	0.3	0.3
				0.1	0.4	0.4	0.1	0.1	0.4	0.2	0.3	0.3	0.2	0.2	0.3
...					0.4	0.1	0.4	0.1	0.4	0.1	0.3	0.2	0.3	0.2	0.3
				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 2: NEAT GA fine-tuning process. This is the complete list of values (i.e. 24 for each parameter) tested to find the optimal parameter setting, used in the main article, for evolving the feed-forward neural networks. As indicated in the main article, different optimal configuration were found for NPDM, LDM and CDM.

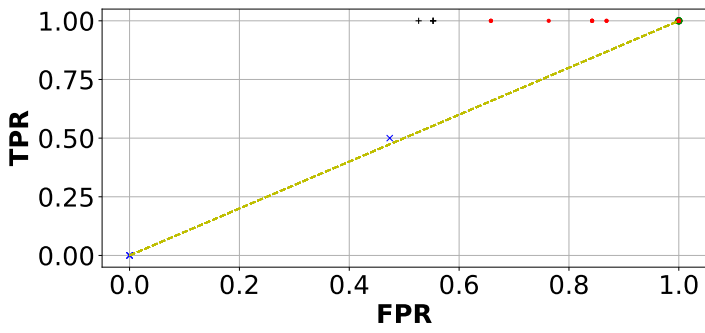
2. Training phase

Sensor	LDM (β) / NPDM (α)	TP	TN	FP	FN	ACC	RMSE	AUC
VS	ffANN / RND	18	18	20	0	0.6429	0.4737	0.5263
	ffANN / FP	18	17	21	0	0.6250	0.4615	0.5385
	ffANN / ffANN	18	17	21	0	0.6250	0.4615	0.5385
	ffANN / FDSS	18	17	21	0	0.6250	0.4615	0.5385
IR	ffANN / FP	14	17	21	4	0.5536	0.4000	0.6000
	ffANN / FDSS	14	15	23	4	0.5179	0.3784	0.6216
	ffANN / RND	14	15	23	4	0.5179	0.3784	0.6216
	ffANN / ffANN	15	13	25	3	0.5000	0.3750	0.6250
UV	ffANN / FDSS	18	10	28	0	0.5000	0.3913	0.6087
	ffANN / FP	18	9	29	0	0.4821	0.3830	0.6170
	ffANN / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	ffANN / RND	18	5	33	0	0.4107	0.3529	0.6471
TS	ffANN / FDSS	18	4	34	0	0.3929	0.3462	0.6538
	ffANN / RND	18	2	36	0	0.3571	0.3333	0.6667
	ffANN / FP	18	0	38	0	0.3214	0.3214	0.6786
	ffANN / ffANN	18	0	38	0	0.3214	0.3214	0.6786
GPR	ffANN / FDSS	16	16	22	2	0.5714	0.4211	0.5789
	ffANN / ffANN / FDSS	3	19	19	5	0.5714	0.4063	0.5938
	ffANN / FP	13	8	30	5	0.3750	0.3023	0.6977
	ffANN / RND	18	3	35	0	0.3750	0.3396	0.6604

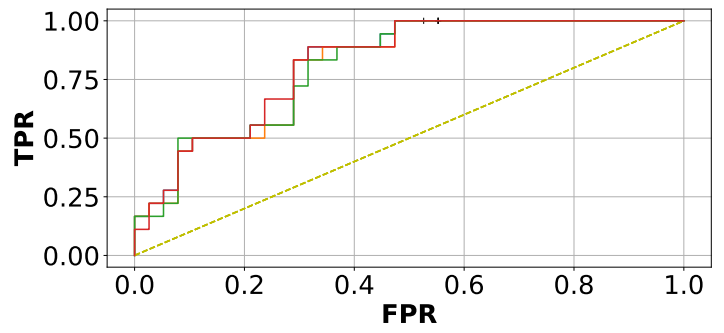
Table 3: Complete list of results obtained over the training data set, in terms of confusion matrix (TP,TN,FP,FM), accuracy (ACC), root-mean square error (RMSE) and area under the ROC curve (AUC), for each LDM (Ω) approach when combined with a given NPDM (α) method.

Sensor	CDM (Ω) / NPDM (α)	TP	TN	FP	FN	ACC	RMSE	AUC
VS	ffANN / RND	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / FP	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / FDSS	0	38	0	18	0.6786	0.0000	0.0000
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	mdn / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	VP / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	ffANN / ffANN	9	20	18	9	0.5179	0.3333	0.6667
	avg / ffANN	18	9	29	0	0.4821	0.3830	0.6170
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / RDN	18	6	32	0	0.4286	0.3600	0.6400
	mdn / FP	18	6	32	0	0.4286	0.3600	0.6400
	VP / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	VP / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	FDSS / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / RDN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FP	18	0	38	0	0.3214	0.3214	0.6786
	avg / RDN	18	0	38	0	0.3214	0.3214	0.6786
	max / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	max / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	max / RDN	18	0	38	0	0.3214	0.3214	0.6786
	VP / RDN	18	0	38	0	0.3214	0.3214	0.6786
IR	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	VP / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	ffANN / FDSS	16	12	26	2	0.5000	0.3810	0.6190
	avg / ffANN	18	9	29	0	0.4821	0.3830	0.6170
	ffANN / FP	15	12	26	3	0.4821	0.3659	0.6341
	ffANN / ffANN	16	11	27	2	0.4821	0.3721	0.6279
	ffANN / RDN	16	10	28	2	0.4643	0.3636	0.6364
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / RDN	18	6	32	0	0.4286	0.3600	0.6400
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	VP / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	VP / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	avg / RDN	18	1	37	0	0.3393	0.3273	0.6727
	VP / RDN	18	1	37	0	0.3393	0.3273	0.6727
	FDSS / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / RDN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	max / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	max / RDN	18	0	38	0	0.3214	0.3214	0.6786
UV	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	VP / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	avg / ffANN	18	9	29	0	0.4821	0.3830	0.6170
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / RDN	18	6	32	0	0.4286	0.3600	0.6400
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	VP / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	VP / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	ffANN / FP	18	2	36	0	0.3571	0.3333	0.6667
	avg / RDN	18	1	37	0	0.3393	0.3273	0.6727
	ffANN / FDSS	18	1	37	0	0.3393	0.3273	0.6727
	VP / RDN	18	1	37	0	0.3393	0.3273	0.6727
	FDSS / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / RDN	18	0	38	0	0.3214	0.3214	0.6786
	FDSS / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	max / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	max / RDN	18	0	38	0	0.3214	0.3214	0.6786
	ffANN / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	ffANN / RDN	18	0	38	0	0.3214	0.3214	0.6786
TS	ffANN / FDSS	14	27	11	4	0.7321	0.5600	0.4400
	FDSS / ffANN	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / FDSS	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / RDN	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / FP	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / RDN	14	23	15	4	0.6607	0.4828	0.5172
	ffANN / ffANN	13	23	15	5	0.6429	0.4643	0.5357
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	VP / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	ffANN / FP	8	20	18	10	0.5000	0.3077	0.6923
	avg / ffANN	18	9	29	0	0.4821	0.3830	0.6170
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / RDN	18	6	32	0	0.4286	0.3600	0.6400
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
	VP / FP	18	6	32	0	0.4286	0.3600	0.6400
	mdn / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	VP / ffANN	18	5	33	0	0.4107	0.3529	0.6471
	mdn / RDN	18	1	37	0	0.3393	0.3273	0.6727
	VP / RDN	18	1	37	0	0.3393	0.3273	0.6727
	max / FP	18	0	38	0	0.3214	0.3214	0.6786
	max / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	max / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	max / RDN	18	0	38	0	0.3214	0.3214	0.6786
GPR	ffANN / RDN	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / FP	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / FDSS	0	38	0	18	0.6786	0.0000	0.0000
	ffANN / ffANN	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / ffANN	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / RDN	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / FP	0	38	0	18	0.6786	0.0000	0.0000
	FDSS / FDSS	0	38	0	18	0.6786	0.0000	0.0000
	avg / FDSS	18	13	25	0	0.5536	0.4186	0.5814
	mdn / FDSS	18	13	25	0	0.5536	0.4186	0.5814
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	avg / ffANN	18	9	29	0	0.4821	0.3830	0.6170
	avg / FP	18	6	32	0	0.4286	0.3600	0.6400
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	VP / FP	18	6	32	0	0.4286	0.3600	0.6400
	avg / RDN	18	5	33	0	0.4107	0.3529	0.6471
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	max / FDSS	18	0	38	0	0.3214	0.3214	0.6786
	max / ffANN	18	0	38	0	0.3214	0.3214	0.6786
	max / RDN	18	0	38	0	0.3214	0.3214	0.6786
	VP / RDN	18	0	38	0	0.3214	0.3214	0.6786

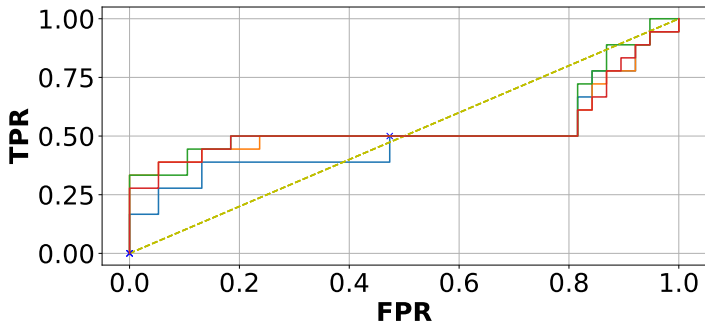
Table 4: Complete list of results obtained over the training data set, in terms of confusion matrix (TP,TN,FP,FM), accuracy (ACC), root-mean square error (RMSE) and area under the ROC curve (AUC), for each CDM (Ω) approach when combined with a given NPDM (α) method.



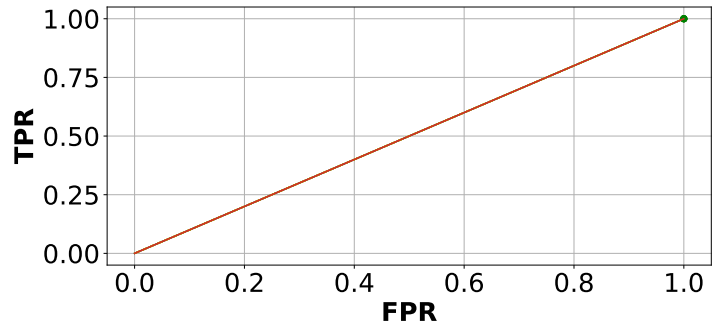
(a) LDM and CDM values in the ROC space.



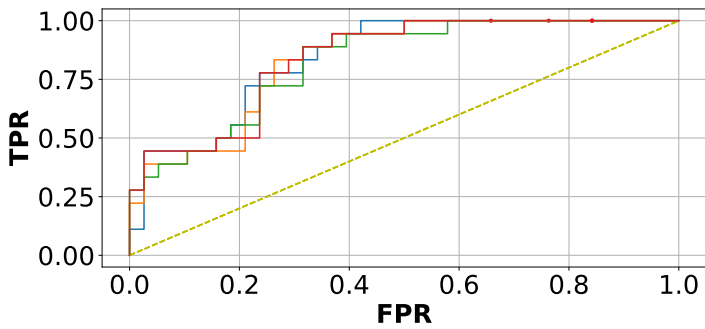
(b) LDM (fANN) ROC curves.



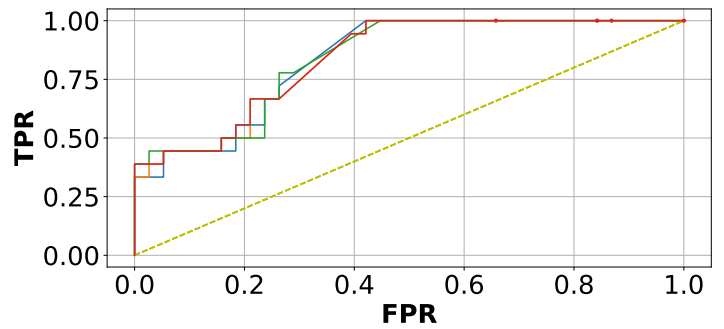
(c) CDM (fANN) ROC curves



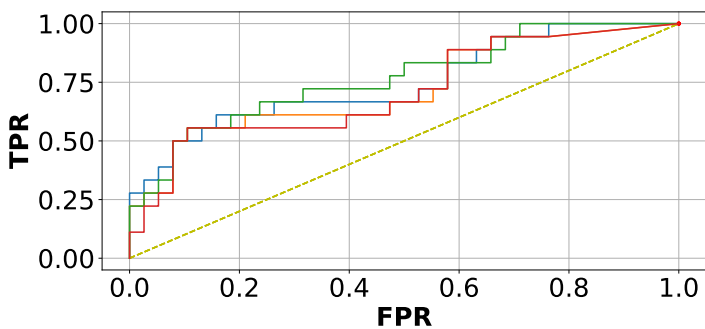
(d) CDM (FDSS) ROC curves.



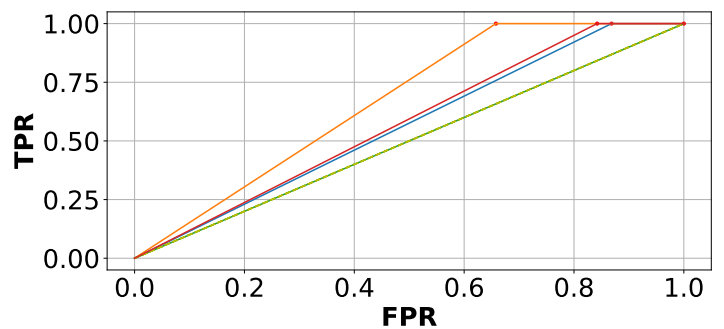
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

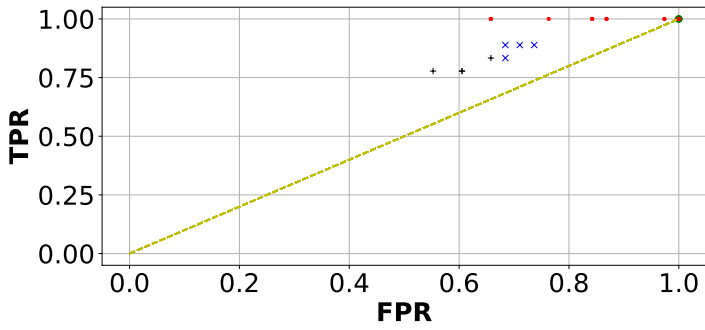


(g) CDM (max) ROC curves.

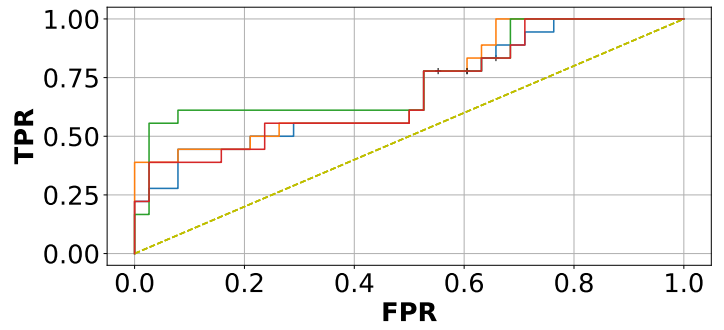


(h) CDM (VP) ROC curves.

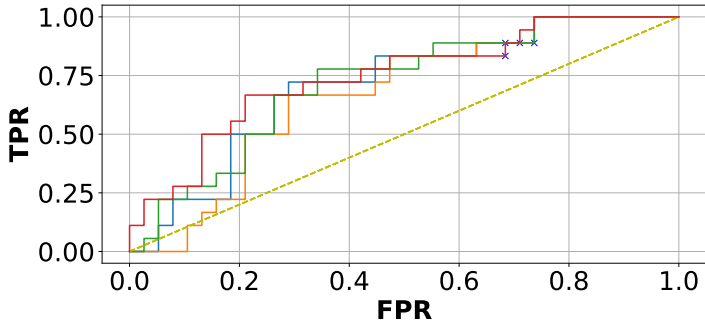
Figure 1: Results of the VS agent over the training data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (fANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a fANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



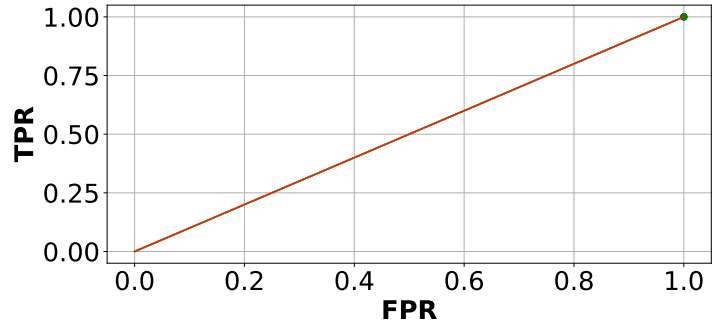
(a) LDM and CDM values in the ROC space.



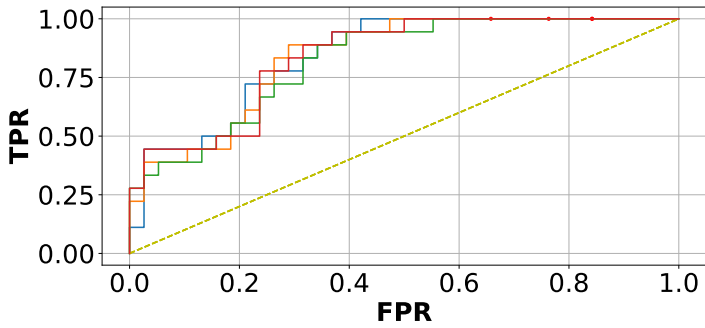
(b) LDM (ffANN) ROC curves.



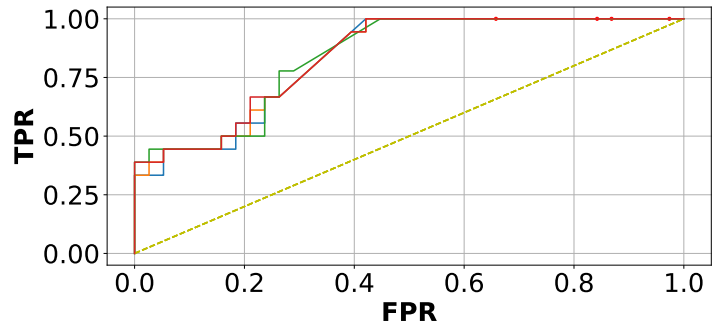
(c) CDM (ffANN) ROC curves



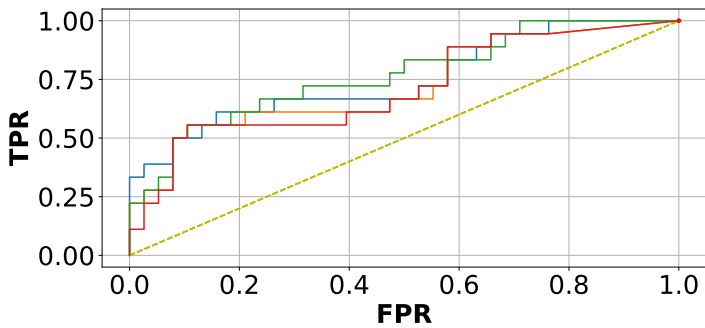
(d) CDM (FDSS) ROC curves.



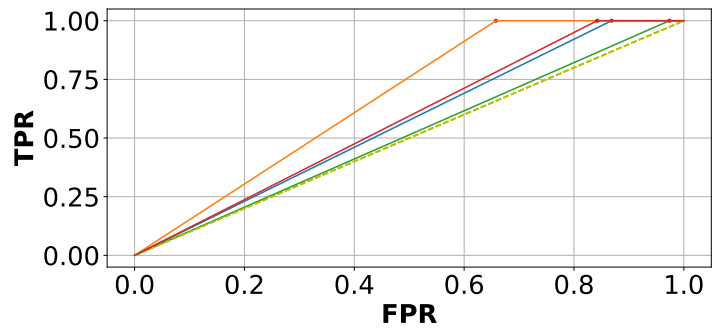
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

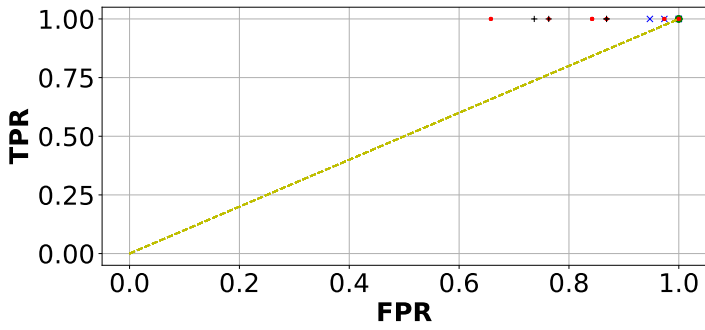


(g) CDM (max) ROC curves.

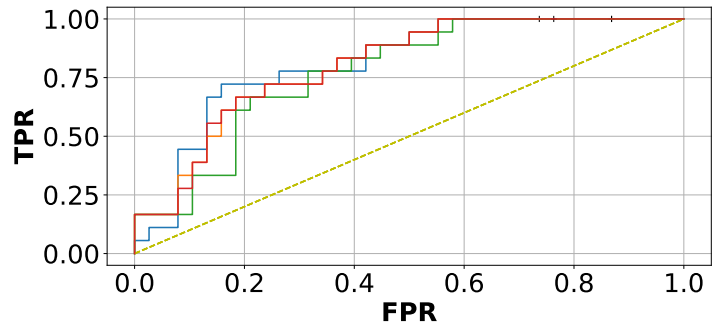


(h) CDM (VP) ROC curves.

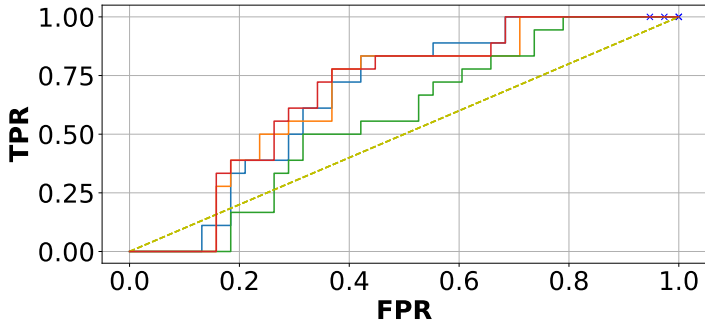
Figure 2: Results of the IR agent over the training data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



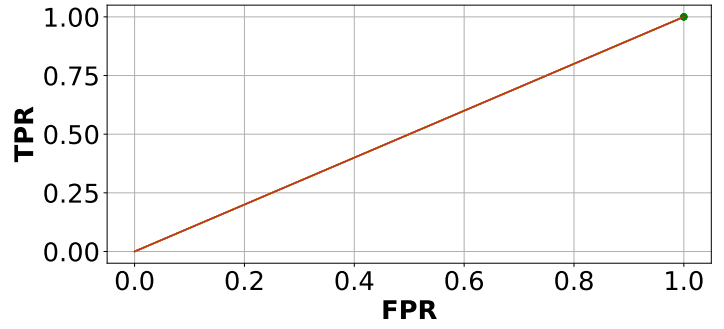
(a) LDM and CDM values in the ROC space.



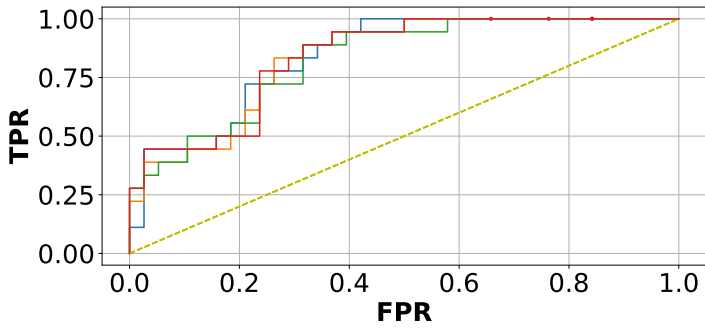
(b) LDM (ffANN) ROC curves.



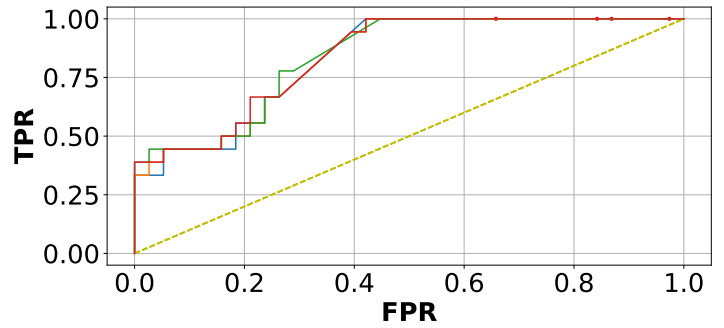
(c) CDM (ffANN) ROC curves



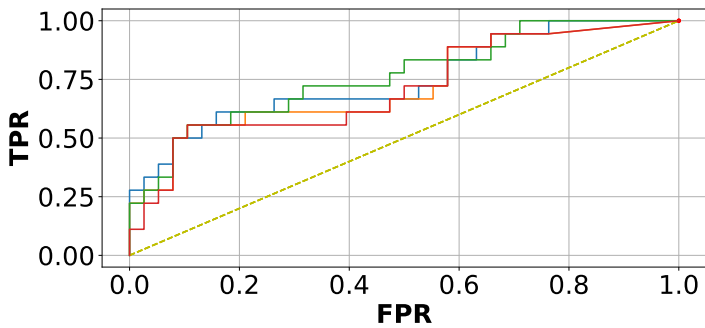
(d) CDM (FDSS) ROC curves.



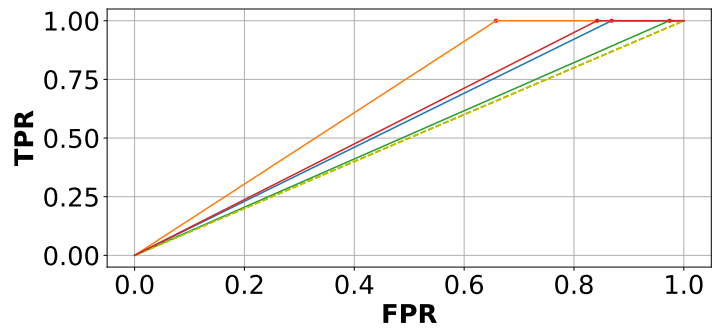
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

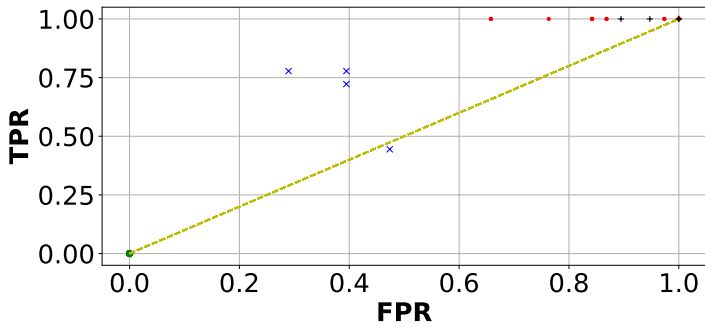


(g) CDM (max) ROC curves.

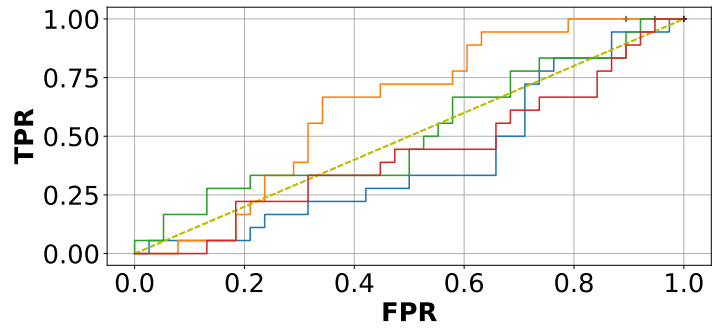


(h) CDM (VP) ROC curves.

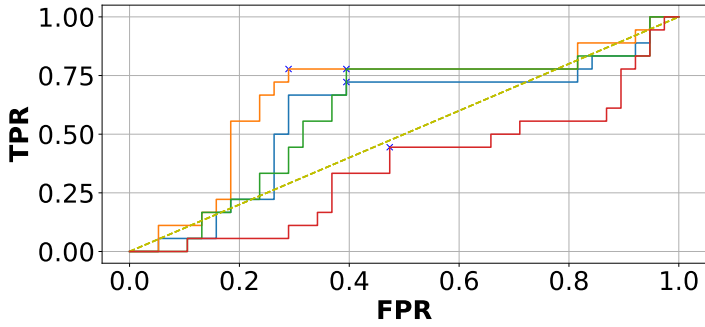
Figure 3: Results of the UV agent over the training data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



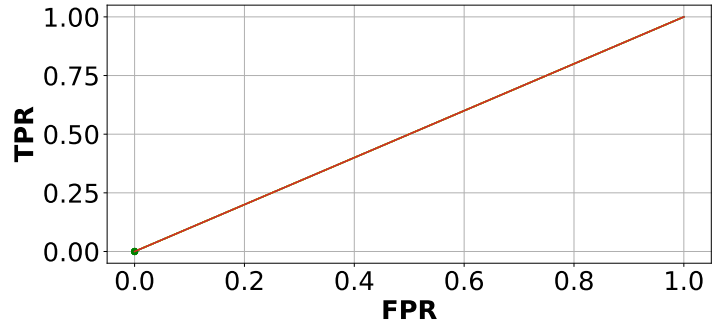
(a) LDM and CDM values in the ROC space.



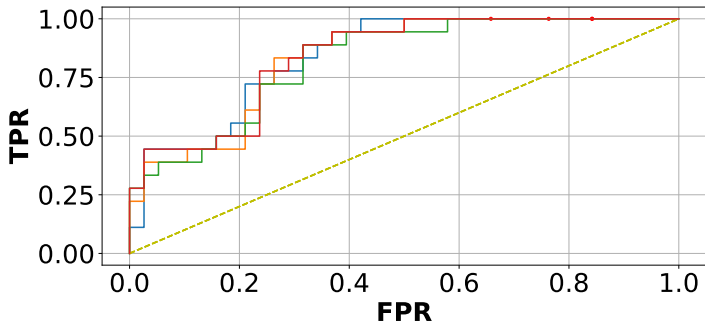
(b) LDM (ffANN) ROC curves.



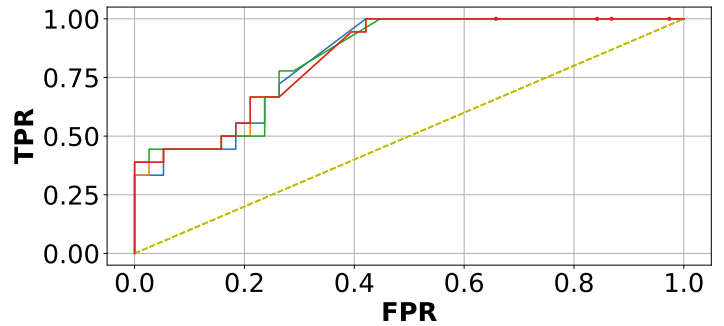
(c) CDM (ffANN) ROC curves



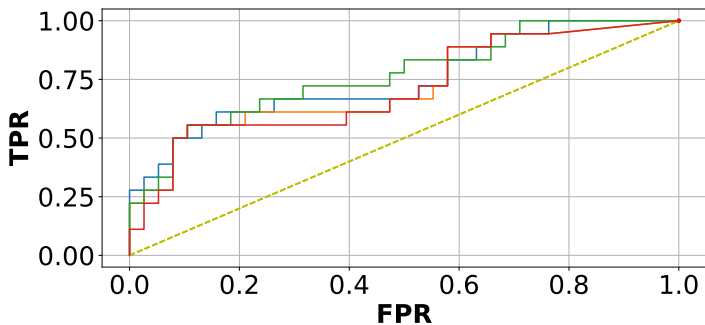
(d) CDM (FDSS) ROC curves.



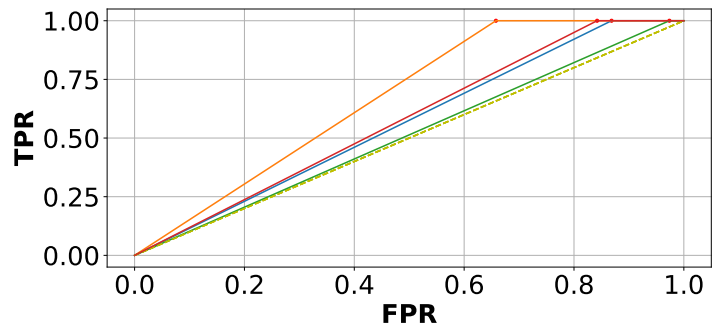
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

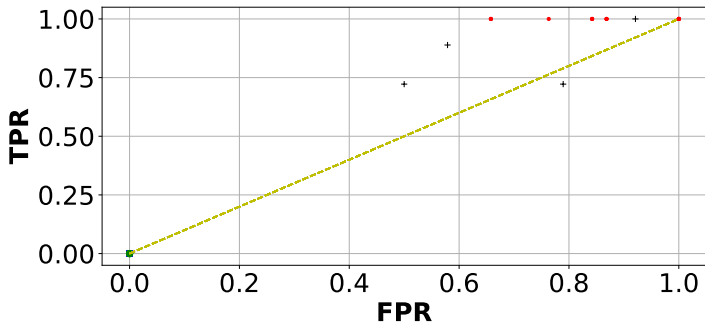


(g) CDM (max) ROC curves.

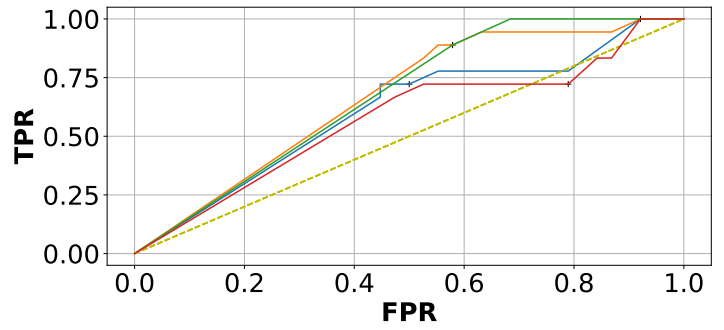


(h) CDM (VP) ROC curves.

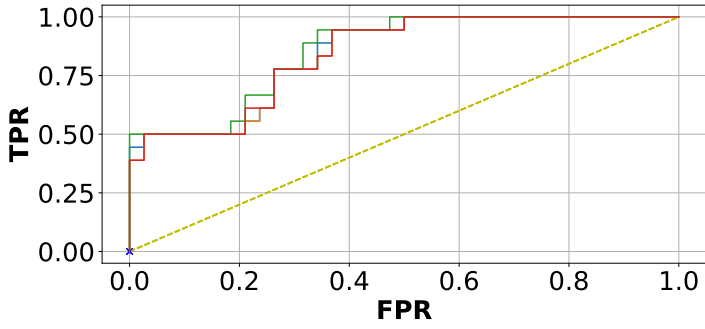
Figure 4: Results of the TS agent over the training data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



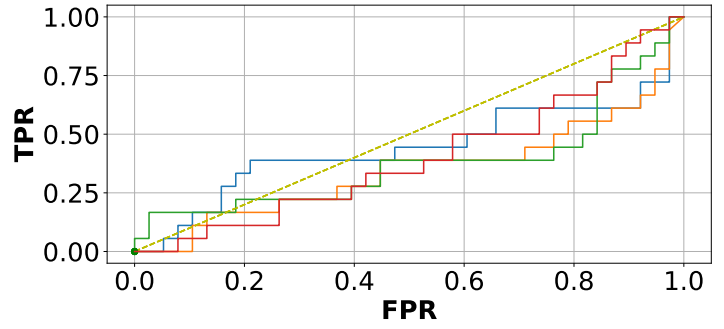
(a) LDM and CDM values in the ROC space.



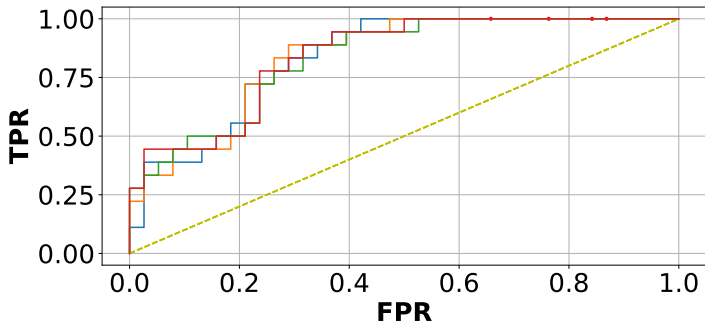
(b) LDM (ffANN) ROC curves.



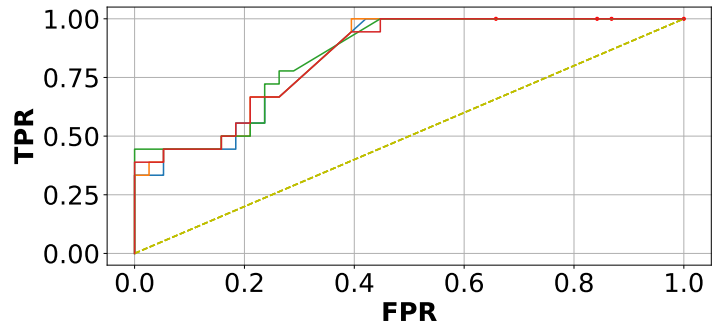
(c) CDM (ffANN) ROC curves



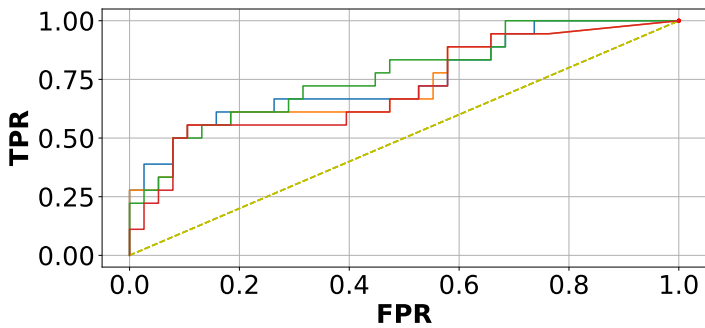
(d) CDM (FDSS) ROC curves.



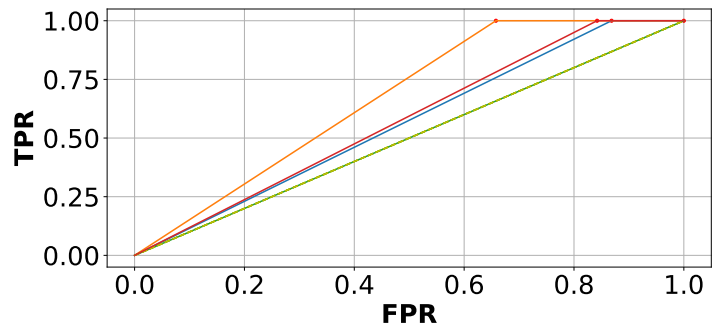
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.



(g) CDM (max) ROC curves.



(h) CDM (VP) ROC curves.

Figure 5: Results of the GPR agent over the training data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.

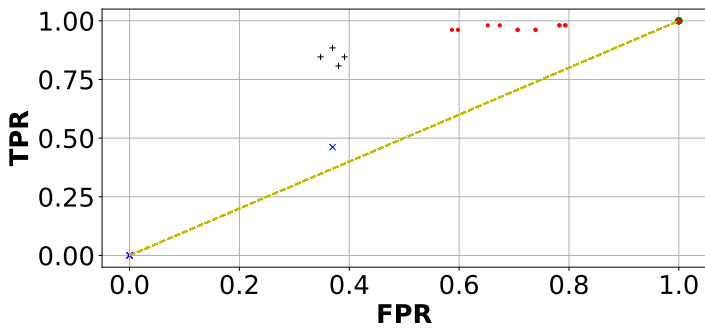
3. Validation phase

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

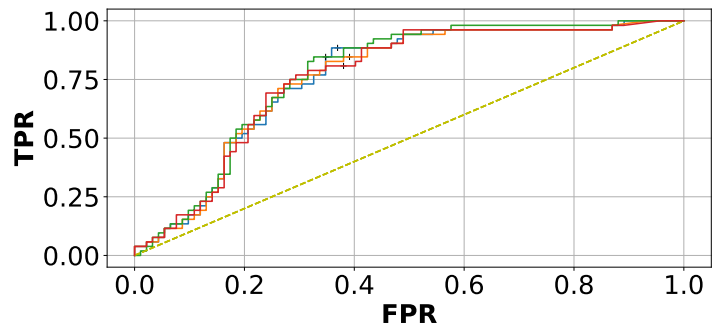
Table 5: Complete list of results obtained over the validation data set, in terms of confusion matrix (TP,TN,FP,FM), accuracy (ACC), root-mean square error (RMSE) and area under the ROC curve (AUC), for each LDM (Ω) approach when combined with a given NPDM (α) method.

Sensor	CDM (ω) / NPDM (α)	TP	TN	FP	FN	ACC	RMSE	AUC
VS	ffANN / RND	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / FP	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / FDSS	0	92	0	52	0.6389	0.0000	0.0000
	avg / FP	50	38	54	2	0.6111	0.4808	0.5192
	avg / FDSS	50	37	55	2	0.6042	0.4762	0.5238
	avg / ffANN	51	32	60	1	0.5764	0.4595	0.5405
	ffANN / ffANN	24	58	34	28	0.5694	0.4138	0.5862
	avg / RND	51	30	62	1	0.5625	0.4513	0.5487
	mdn / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	VP / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	mdn / FP	50	24	68	2	0.5139	0.4237	0.5763
	VP / FP	50	24	68	2	0.5139	0.4237	0.5763
	mdn / RND	51	20	72	1	0.4931	0.4146	0.5854
	VP / RND	51	20	72	1	0.4931	0.4146	0.5854
	mdn / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	VP / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	FDSS / ffANN	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FDSS	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / RND	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FP	52	0	92	0	0.3611	0.3611	0.6389
max / FP	52	0	92	0	0.3611	0.3611	0.6389	
max / FDSS	52	0	92	0	0.3611	0.3611	0.6389	
max / ffANN	52	0	92	0	0.3611	0.3611	0.6389	
max / RND	52	0	92	0	0.3611	0.3611	0.6389	
IR	ffANN / ffANN	48	41	51	4	0.6181	0.4848	0.5152
	avg / FP	50	38	54	2	0.6111	0.4808	0.5192
	ffANN / FDSS	48	40	52	4	0.6111	0.4800	0.5200
	avg / FDSS	50	37	55	2	0.6042	0.4762	0.5238
	ffANN / RND	48	38	54	4	0.5972	0.4706	0.5294
	ffANN / FP	47	37	55	5	0.5833	0.4608	0.5392
	avg / ffANN	51	32	60	1	0.5764	0.4595	0.5405
	avg / RND	51	31	61	1	0.5694	0.4554	0.5446
	mdn / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	VP / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	mdn / FP	50	23	69	2	0.5069	0.4202	0.5798
	VP / FP	50	23	69	2	0.5069	0.4202	0.5798
	mdn / RND	51	20	72	1	0.4931	0.4146	0.5854
	VP / RND	51	20	72	1	0.4931	0.4146	0.5854
	mdn / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	VP / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	FDSS / ffANN	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FDSS	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / RND	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FP	52	0	92	0	0.3611	0.3611	0.6389
max / FDSS	52	0	92	0	0.3611	0.3611	0.6389	
max / FP	52	0	92	0	0.3611	0.3611	0.6389	
max / ffANN	52	0	92	0	0.3611	0.3611	0.6389	
max / RND	52	0	92	0	0.3611	0.3611	0.6389	
UV	avg / FP	50	38	54	2	0.6111	0.4808	0.5192
	avg / FDSS	50	37	55	2	0.6042	0.4762	0.5238
	avg / ffANN	51	32	60	1	0.5764	0.4595	0.5405
	ffANN / FDSS	52	30	62	0	0.5694	0.4561	0.5439
	ffANN / FP	52	28	64	0	0.5556	0.4483	0.5517
	avg / RND	51	28	64	1	0.5486	0.4435	0.5565
	mdn / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	ffANN / ffANN	52	25	67	0	0.5347	0.4370	0.5630
	VP / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	ffANN / RND	52	24	68	0	0.5278	0.4333	0.5667
	mdn / FP	50	23	69	2	0.5069	0.4202	0.5798
	VP / FP	50	23	69	2	0.5069	0.4202	0.5798
	mdn / RND	51	20	72	1	0.4931	0.4146	0.5854
	VP / RND	51	20	72	1	0.4931	0.4146	0.5854
	mdn / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	VP / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	FDSS / ffANN	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FDSS	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / RND	52	0	92	0	0.3611	0.3611	0.6389
	FDSS / FP	52	0	92	0	0.3611	0.3611	0.6389
max / FP	52	0	92	0	0.3611	0.3611	0.6389	
max / FDSS	52	0	92	0	0.3611	0.3611	0.6389	
max / ffANN	52	0	92	0	0.3611	0.3611	0.6389	
max / RND	52	0	92	0	0.3611	0.3611	0.6389	
TS	ffANN / RND	40	57	35	12	0.6736	0.5333	0.4667
	FDSS / ffANN	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / FDSS	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / RND	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / FP	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / FDSS	39	53	39	13	0.6389	0.5000	0.5000
	avg / FP	50	38	54	2	0.6111	0.4808	0.5192
	ffANN / ffANN	38	50	42	14	0.6111	0.4750	0.5250
	avg / FDSS	50	37	55	2	0.6042	0.4762	0.5238
	avg / ffANN	51	32	60	1	0.5764	0.4595	0.5405
	avg / RND	51	32	60	1	0.5764	0.4595	0.5405
	mdn / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	VP / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	mdn / FP	50	23	69	2	0.5069	0.4202	0.5798
	VP / FP	50	23	69	2	0.5069	0.4202	0.5798
	mdn / RND	51	20	72	1	0.4931	0.4146	0.5854
	VP / RND	51	20	72	1	0.4931	0.4146	0.5854
	mdn / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	VP / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	ffANN / FP	16	49	43	36	0.4514	0.2712	0.7288
max / FP	52	0	92	0	0.3611	0.3611	0.6389	
max / FDSS	52	0	92	0	0.3611	0.3611	0.6389	
max / ffANN	52	0	92	0	0.3611	0.3611	0.6389	
max / RND	52	0	92	0	0.3611	0.3611	0.6389	
GPR	ffANN / FDSS	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / FP	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / ffANN	0	92	0	52	0.6389	0.0000	0.0000
	ffANN / RND	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / FP	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / FDSS	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / ffANN	0	92	0	52	0.6389	0.0000	0.0000
	FDSS / RND	0	92	0	52	0.6389	0.0000	0.0000
	avg / FP	50	38	54	2	0.6111	0.4808	0.5192
	avg / FDSS	50	37	55	2	0.6042	0.4762	0.5238
	avg / ffANN	51	32	60	1	0.5764	0.4595	0.5405
	avg / RND	51	30	62	1	0.5625	0.4513	0.5487
	mdn / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	VP / FDSS	50	27	65	2	0.5347	0.4348	0.5652
	mdn / FP	50	23	69	2	0.5069	0.4202	0.5798
	VP / FP	50	23	69	2	0.5069	0.4202	0.5798
	mdn / RND	51	21	71	1	0.5000	0.4180	0.5820
	VP / RND	51	21	71	1	0.5000	0.4180	0.5820
	mdn / ffANN	51	19	73	1	0.4861	0.4113	0.5887
	VP / ffANN	51	19	73	1	0.4861	0.4113	0.5887
max / FDSS	52	0	92	0	0.3611	0.3611	0.6389	
max / FP	52	0	92	0	0.3611	0.3611	0.6389	
max / ffANN	52	0	92	0	0.3611	0.3611	0.6389	
max / RND	52	0	92	0	0.3611	0.3611	0.6389	

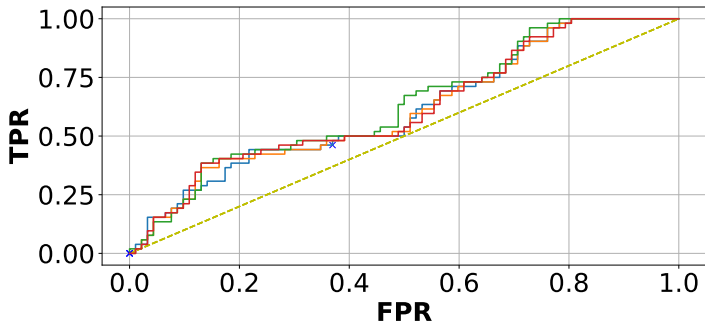
Table 6: Complete list of results obtained over the validation data set, in terms of confusion matrix (TP,TN,FP,FM), accuracy (ACC), root-mean square error (RMSE) and area under the ROC curve (AUC), for each CDM (Ω) approach when combined with a given NPDM (α) method.



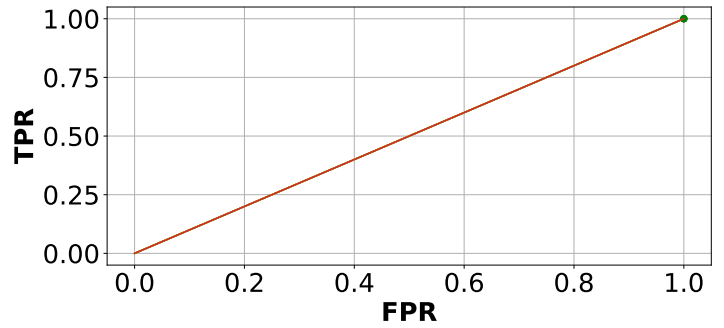
(a) LDM and CDM values in the ROC space.



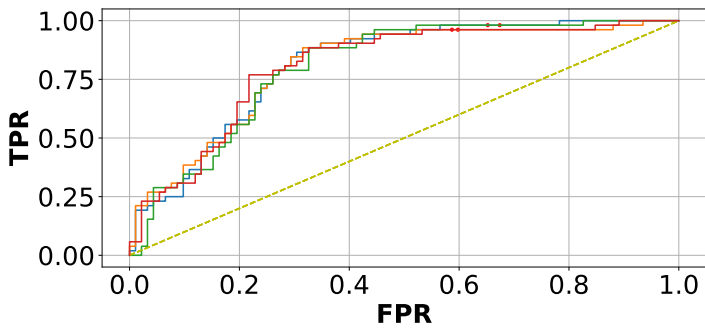
(b) LDM (ffANN) ROC curves.



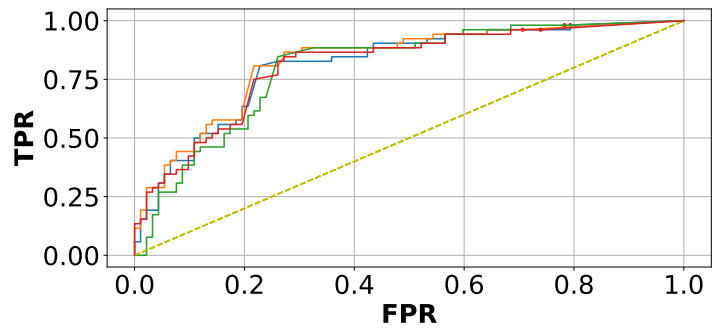
(c) CDM (ffANN) ROC curves



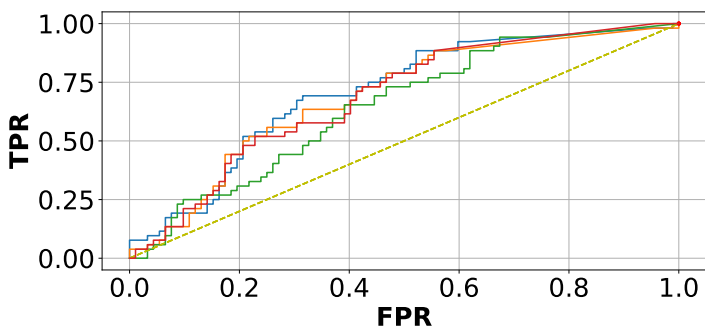
(d) CDM (FDSS) ROC curves.



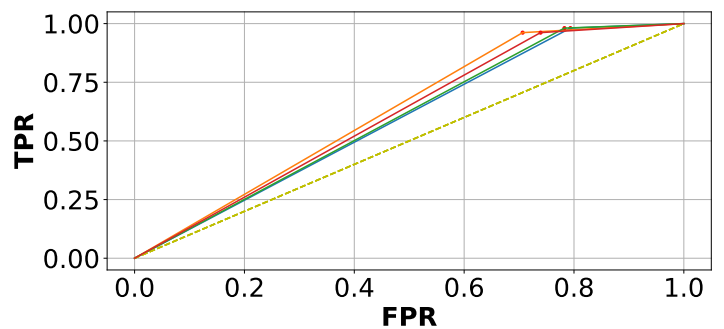
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

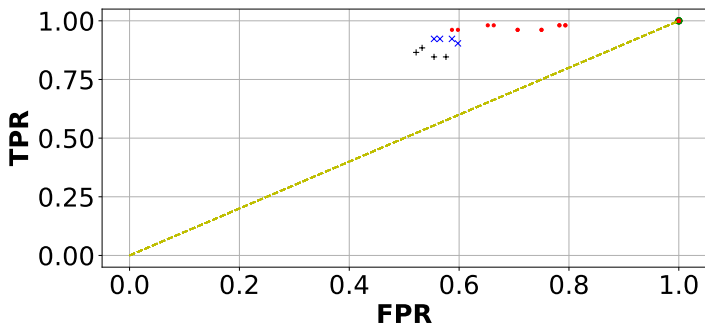


(g) CDM (max) ROC curves.

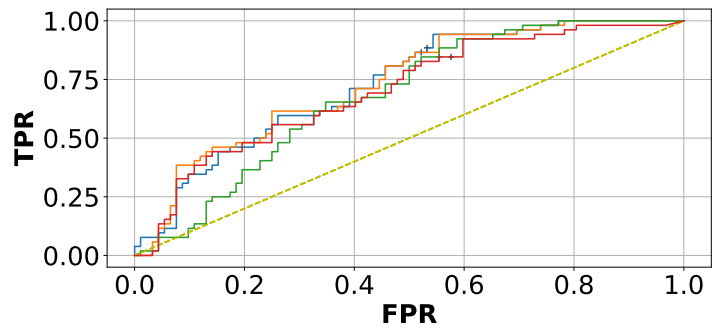


(h) CDM (VP) ROC curves.

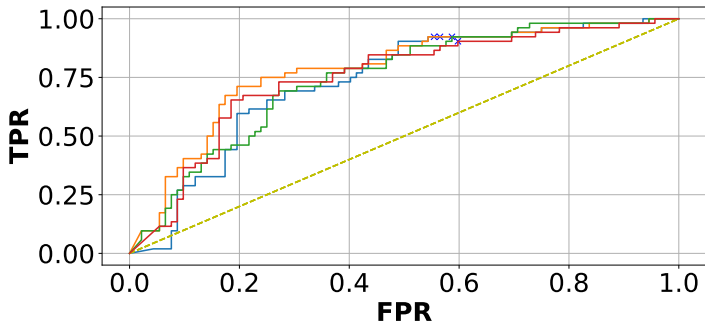
Figure 6: Results of the VS agent over the validation data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



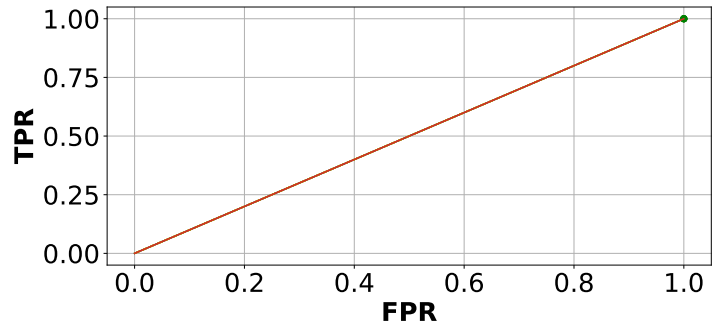
(a) LDM and CDM values in the ROC space.



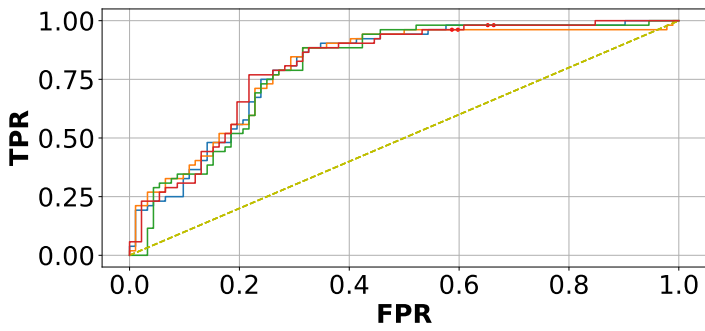
(b) LDM (ffANN) ROC curves.



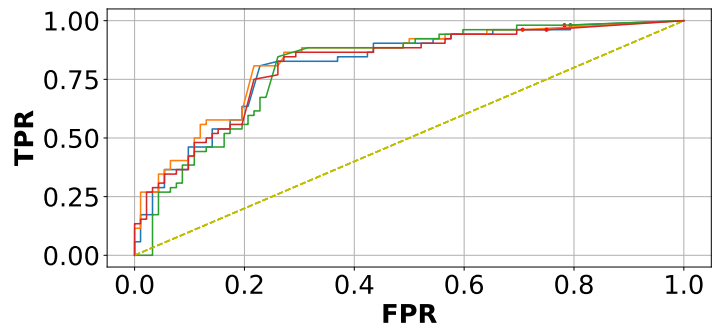
(c) CDM (ffANN) ROC curves



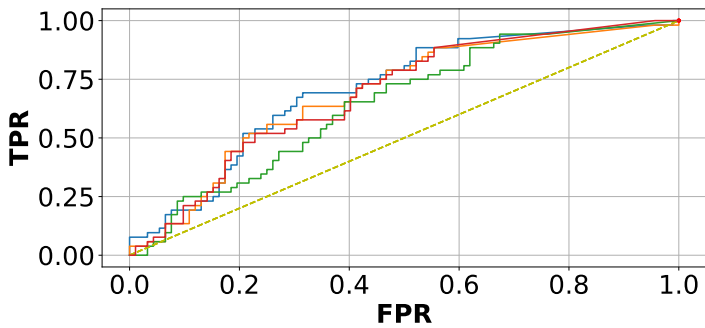
(d) CDM (FDSS) ROC curves.



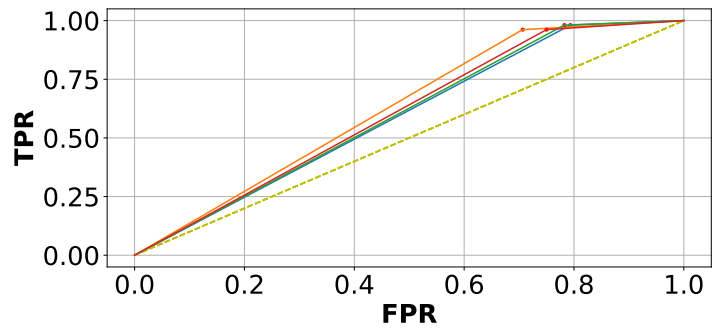
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

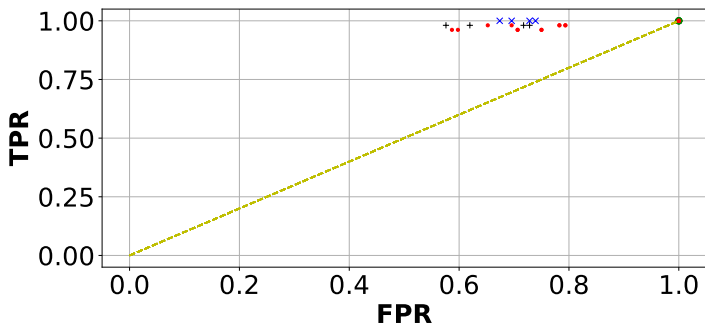


(g) CDM (max) ROC curves.

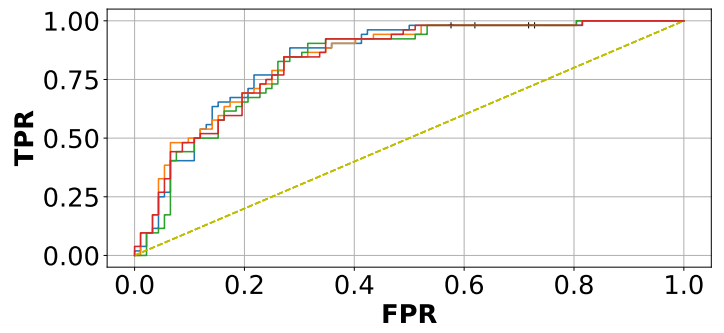


(h) CDM (VP) ROC curves.

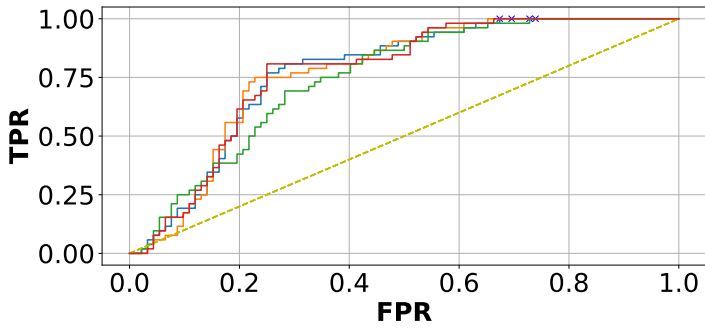
Figure 7: Results of the IR agent over the validation data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



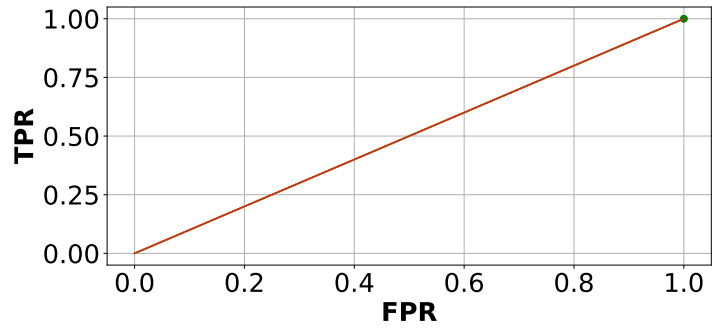
(a) LDM and CDM values in the ROC space.



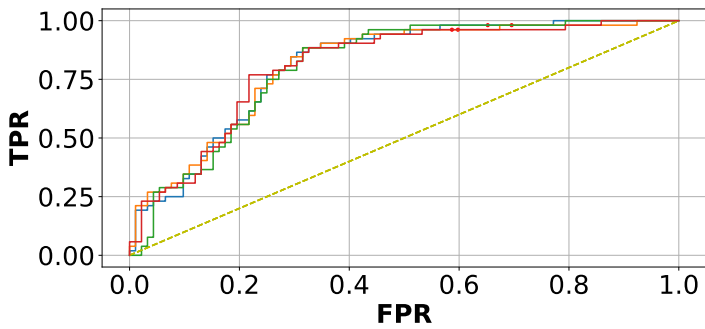
(b) LDM (ffANN) ROC curves.



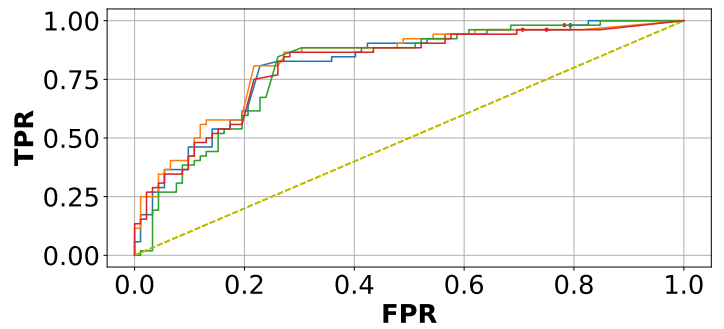
(c) CDM (ffANN) ROC curves



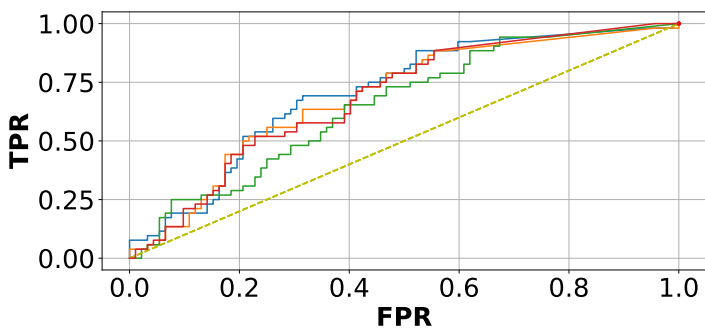
(d) CDM (FDSS) ROC curves.



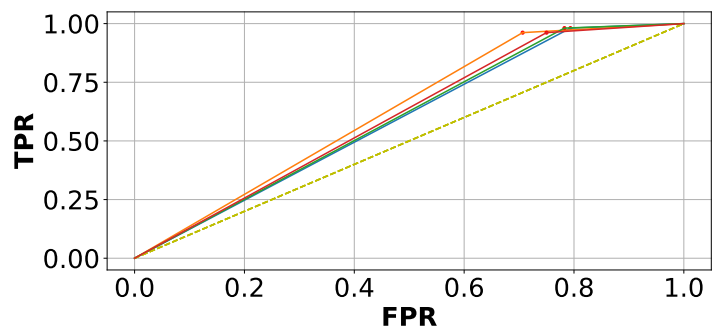
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

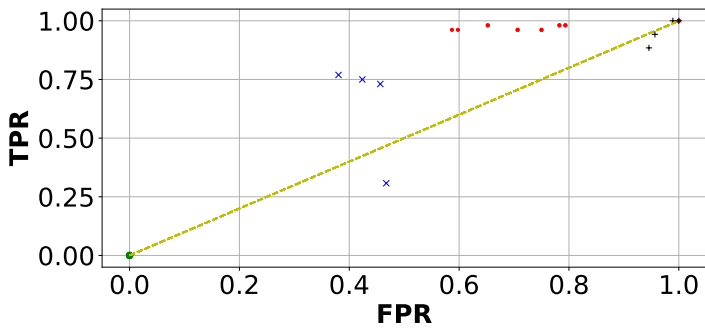


(g) CDM (max) ROC curves.

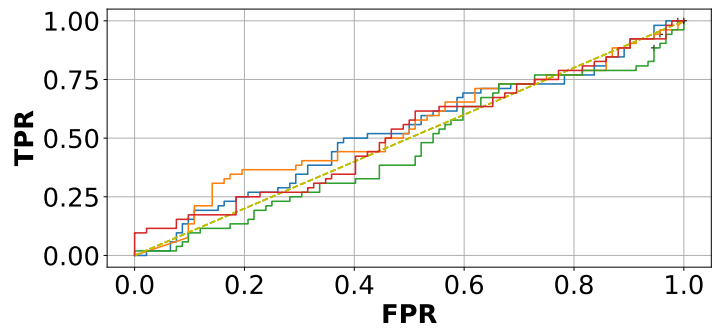


(h) CDM (VP) ROC curves.

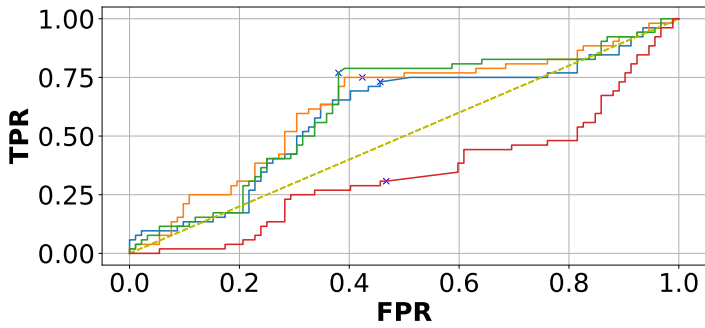
Figure 8: Results of the UV agent over the validation data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method



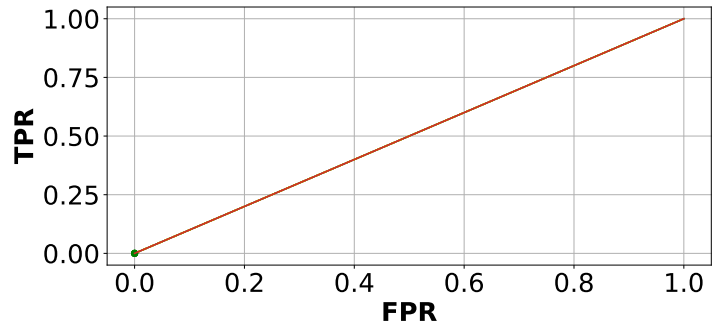
(a) LDM and CDM values in the ROC space.



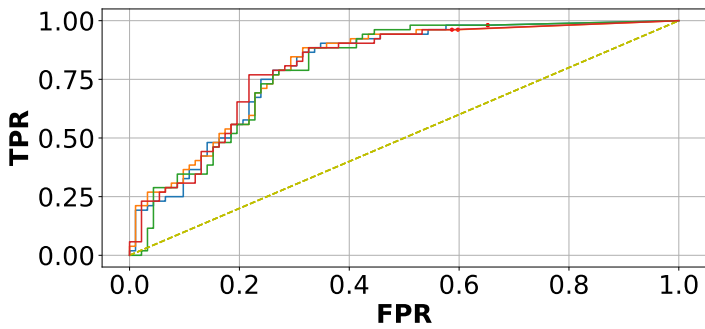
(b) LDM (ffANN) ROC curves.



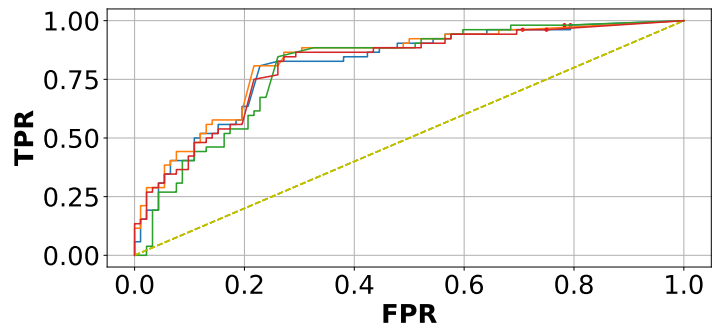
(c) CDM (ffANN) ROC curves



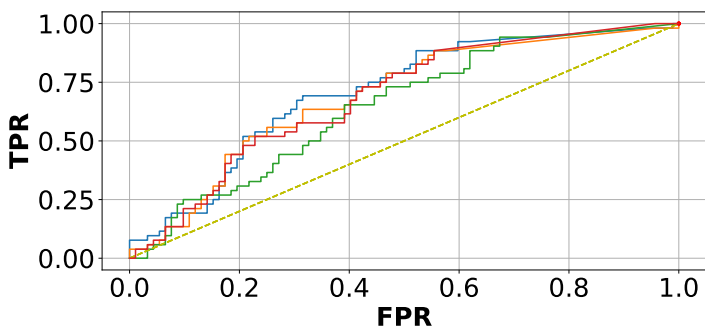
(d) CDM (FDSS) ROC curves.



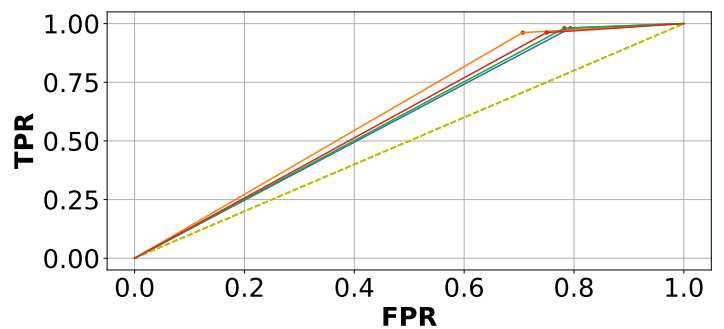
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.

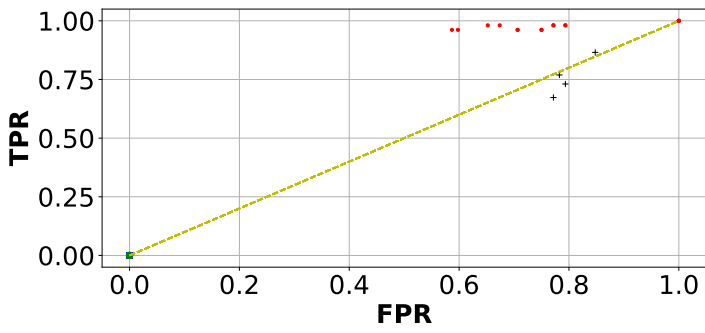


(g) CDM (max) ROC curves.

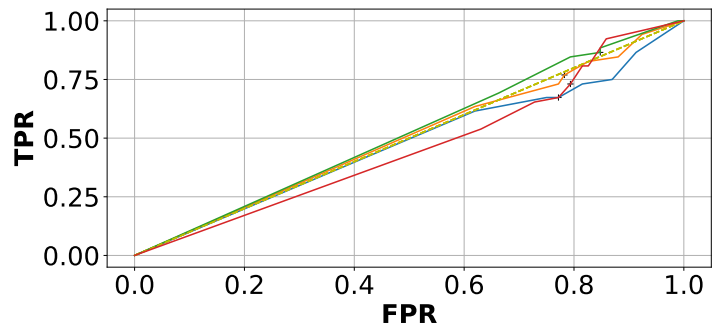


(h) CDM (VP) ROC curves.

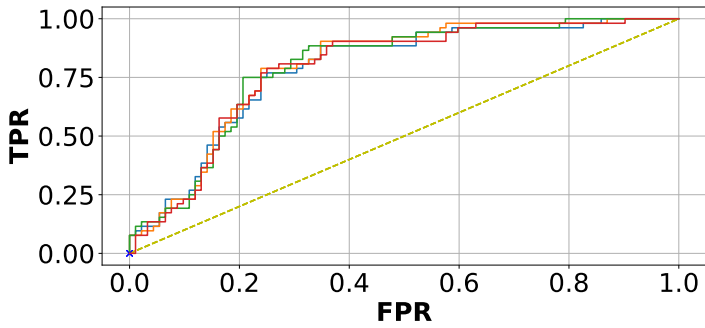
Figure 9: Results of the TS agent over the validation data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.



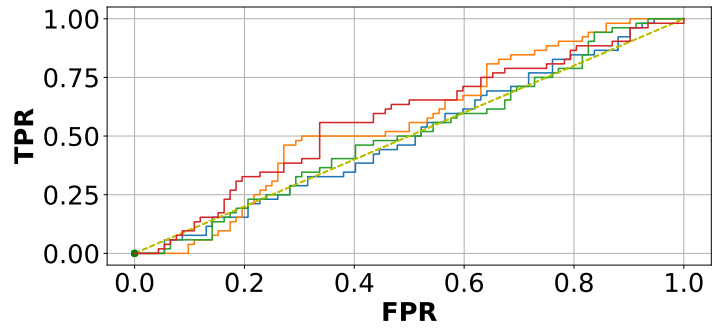
(a) LDM and CDM values in the ROC space.



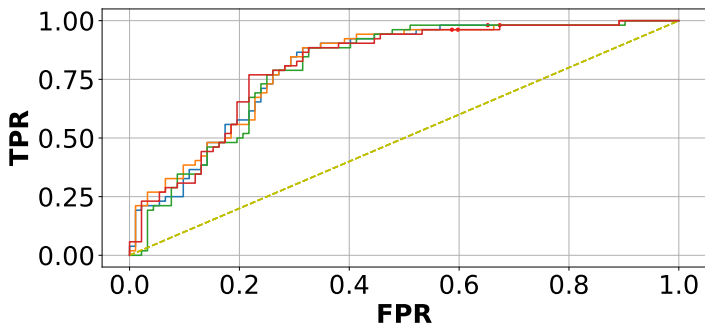
(b) LDM (ffANN) ROC curves.



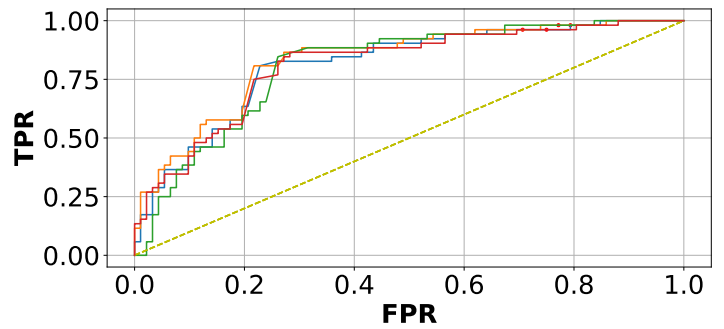
(c) CDM (ffANN) ROC curves



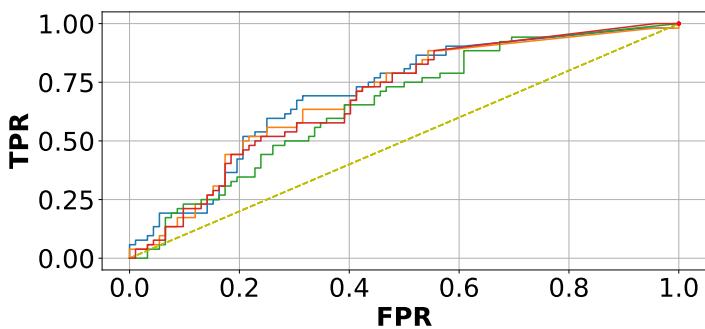
(d) CDM (FDSS) ROC curves.



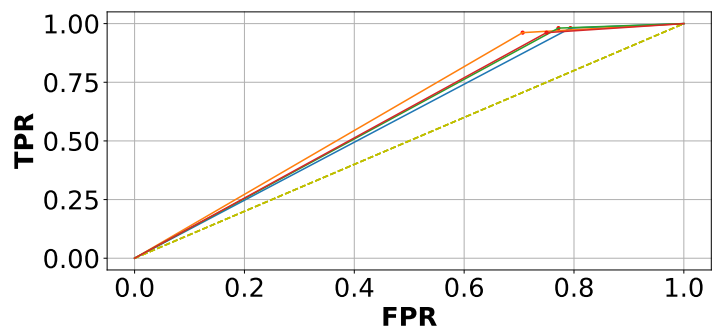
(e) CDM (avg) ROC curves.



(f) CDM (mdn) ROC curves.



(g) CDM (max) ROC curves.



(h) CDM (VP) ROC curves.

Figure 10: Results of the GPR agent over the validation data set. In (a) black points refer to LDM. As for CDM, the red points indicate the FPR-TPR values obtained via the aggregation methods, blue points those with a neural system (ffANN) and green ones those with a genetic fuzzy system (FDSS). The ROC curves in the other diagrams refer to the four possible NPDM systems used in conjunction with an indicated LDM or CDM system, i.e. the light-blue curve is obtained by means a ffANN, the green curve by means of the random (RDN) method, the orange curve with a FDSS and the red one with the fixed position (FP) method.

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