Supplementary Information

Entropy-driven adaptive knowledge distillation with reliable candidate fusion for imbalanced binary classification

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Supplementary Table S1. Dataset-wise performance of the compared methods on the nine imbalanced binary classification datasets.

Each value is the mean over 25 outer test evaluations (five folds × five repetitions) for the corresponding dataset. All values are reported as percentages. Higher values are better for MCC, F1-score, and G-Mean; lower values are better for ECE and Brier score.

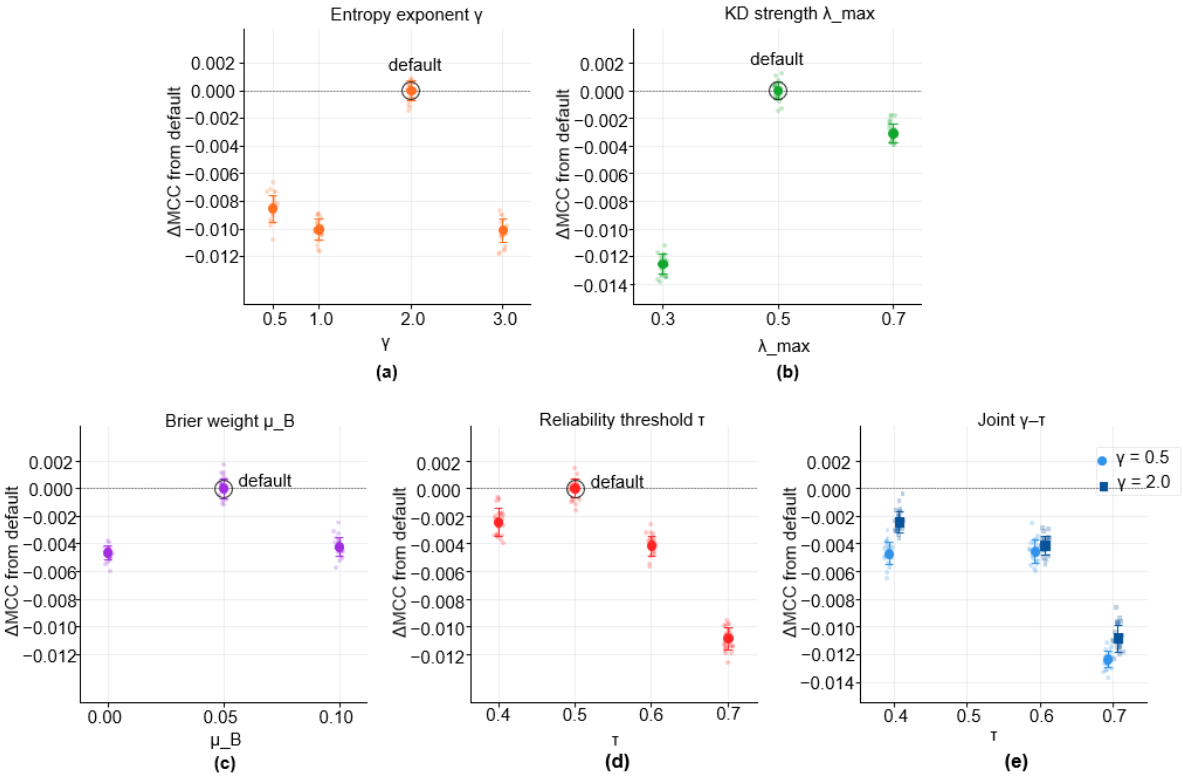
Indicator	Method	BCWO	Haberman	WDBC	WPBC	Pima	Sick	Mammographic	Heart	Hepatitis
MCC	LR	92.49	27.82	94.30	36.04	47.14	64.23	64.31	64.95	43.26
	RF	92.15	17.05	88.93	32.41	46.29	84.14	55.25	62.41	47.08
	XGBoost	91.60	6.72	91.37	34.20	43.86	86.00	62.43	60.00	39.44
	BalancedRF	92.67	21.62	89.72	29.47	46.21	82.07	55.72	64.42	47.09
	EasyEnsemble	90.54	22.63	92.17	23.28	47.54	74.59	64.79	64.78	43.60
	KD	92.00	23.62	94.25	36.61	45.97	77.03	64.42	63.65	51.56
	Yang-ATD	92.78	19.89	91.35	34.63	47.82	76.58	63.36	63.76	53.48
	BKD	92.11	24.31	94.32	36.16	48.51	76.24	64.38	64.73	54.65
	CBD	92.36	20.21	94.40	36.45	47.48	80.10	64.78	63.15	58.06
	CalibKD	92.82	18.08	91.66	35.77	47.83	74.88	63.54	64.69	52.66
	CCKD	92.63	21.20	94.08	35.85	48.44	77.79	64.10	62.98	56.12
	SRW-KD	92.24	21.66	93.65	38.58	47.22	78.55	65.07	63.13	55.15
	UMKD-UDD	92.28	23.34	94.49	36.32	43.88	77.31	62.63	60.15	49.95
	CB-DistillGrad	90.85	8.57	92.16	22.64	34.55	81.13	60.26	54.02	39.94
	EAKD-RCF	**92.42**	**22.94**	**94.66**	**34.86**	**47.60**	**84.97**	**64.87**	**64.60**	**50.76**
F1	LR	95.05	44.08	96.35	49.63	65.45	65.78	80.87	78.80	52.56
	RF	94.83	42.82	92.72	40.63	65.43	84.82	75.55	77.71	56.07
	XGBoost	94.47	35.42	94.30	42.95	64.06	86.51	79.96	76.24	49.71
	BalancedRF	95.18	45.17	93.24	37.58	65.01	82.95	76.16	79.35	54.23
	EasyEnsemble	93.76	43.20	94.85	34.94	66.10	75.20	80.73	79.62	51.68
	KD	94.70	41.06	96.24	47.71	65.07	77.71	81.37	78.36	60.05
	Yang-ATD	95.24	38.83	94.35	46.00	66.64	77.49	80.56	77.84	61.80
	BKD	94.75	44.29	96.33	45.34	66.62	77.02	81.31	79.05	63.04
	CBD	94.97	39.21	96.39	47.57	66.07	80.68	81.59	78.37	65.25
	CalibKD	95.27	36.19	94.59	46.85	66.31	75.55	80.45	78.67	61.29
	CCKD	95.15	41.43	96.15	45.82	66.68	78.45	81.04	78.26	63.62
	SRW-KD	94.87	40.86	95.87	48.57	65.20	79.15	81.68	77.67	63.21

Indicator	Method	BCWO	Haberman	WDBC	WPBC	Pima	Sick	Mammographic	Heart	Hepatitis
	UMKD-UDD	94.92	43.74	96.49	49.69	63.76	78.05	80.34	76.92	57.17
	CB-DistillGrad	93.96	31.10	94.91	39.52	58.46	81.82	78.00	74.12	49.68
	EAKD-RCF	**95.01**	**44.28**	**96.57**	**46.26**	**66.76**	**85.64**	**81.68**	**79.50**	**57.28**
G-Mean	LR	96.80	57.48	96.93	64.42	72.46	81.05	81.67	80.66	65.86
	RF	96.69	55.33	93.89	51.94	72.38	92.37	76.42	79.05	71.23
	XGBoost	96.46	43.62	95.02	54.08	70.01	92.04	80.70	77.60	66.21
	BalancedRF	97.00	57.07	94.27	49.59	72.11	91.94	76.75	80.87	66.52
	EasyEnsemble	95.83	57.47	95.48	42.45	72.95	92.84	81.94	80.90	65.23
	KD	96.45	54.90	96.70	59.89	72.09	88.41	81.75	80.30	74.15
	Yang-ATD	97.04	49.93	95.17	58.90	73.40	87.59	80.55	79.58	75.61
	BKD	96.49	57.93	96.86	57.71	73.65	87.42	81.55	80.56	76.10
	CBD	96.74	51.55	96.93	60.68	72.95	88.23	81.95	79.13	76.65
	CalibKD	97.07	47.37	95.51	59.60	73.06	86.75	80.81	80.62	74.31
	CCKD	96.93	52.80	96.67	58.26	73.49	87.09	81.26	79.77	76.08
	SRW-KD	96.67	55.20	96.44	60.49	72.21	87.31	82.09	79.68	76.50
	UMKD-UDD	96.68	56.33	97.10	63.44	70.19	86.74	80.32	77.84	70.03
	CB-DistillGrad	95.86	38.02	95.67	51.66	66.06	91.83	78.56	74.92	64.45
	EAKD-RCF	**96.72**	**58.12**	**97.10**	**60.36**	**73.70**	**91.76**	**82.07**	**81.09**	**70.74**
ECE	LR	3.85	9.24	3.39	13.33	8.27	2.41	7.58	11.51	14.73
	RF	3.69	8.69	4.79	12.19	7.98	1.30	9.46	12.76	13.08
	XGBoost	3.49	7.83	3.59	12.25	7.85	1.25	7.41	12.08	14.96
	BalancedRF	3.83	9.51	4.87	9.56	7.37	1.56	9.45	12.37	12.88
	EasyEnsemble	7.32	7.20	8.10	6.39	8.97	4.05	7.22	15.31	14.46
	KD	3.39	8.71	3.63	11.50	8.31	1.89	7.24	13.20	13.89
	Yang-ATD	3.13	8.96	3.78	11.13	8.36	1.77	6.82	12.51	12.94
	BKD	3.43	9.82	3.51	11.90	9.04	1.64	7.09	13.09	13.51
	CBD	3.46	8.78	3.54	11.83	8.58	1.57	7.17	12.43	13.35
	CalibKD	3.18	8.34	3.81	12.44	8.93	1.91	6.99	12.46	13.55
	CCKD	3.50	9.44	3.36	11.56	9.65	1.66	7.08	13.25	13.71
	SRW-KD	3.28	9.81	3.46	12.68	8.89	1.74	7.06	12.61	13.61
	UMKD-UDD	3.36	9.86	2.99	11.20	9.08	1.57	8.16	12.01	13.39
	CB-DistillGrad	3.66	5.48	4.00	11.03	9.99	1.70	10.84	14.43	13.35
	EAKD-RCF	**3.40**	**9.21**	**3.34**	**12.31**	**8.96**	**1.36**	**7.45**	**12.15**	**13.57**
Brier	LR	2.82	18.48	2.17	15.39	15.80	3.14	12.93	12.70	13.19
	RF	2.81	18.66	3.18	16.25	16.25	1.22	15.75	12.81	11.51
	XGBoost	2.90	19.52	2.56	15.45	16.53	1.07	13.29	13.90	13.21
	BalancedRF	2.79	18.41	3.19	16.46	16.09	1.64	15.64	12.79	11.33
	EasyEnsemble	3.39	18.62	3.32	17.28	15.96	2.81	12.65	13.93	13.80
	KD	2.61	18.04	2.11	14.96	15.96	1.88	12.47	12.72	11.36
	Yang-ATD	2.55	18.35	2.61	15.52	16.04	1.91	12.66	12.69	11.08

Indicator	Method	BCWO	Haberman	WDBC	WPBC	Pima	Sick	Mammographic	Heart	Hepatitis
	BKD	2.64	18.10	2.05	15.20	15.85	1.88	12.45	12.72	11.38
	CBD	2.70	18.39	1.99	15.27	15.88	1.51	12.59	12.67	10.74
	CalibKD	2.59	18.44	2.58	15.51	16.22	1.94	12.68	12.67	11.00
	CCKD	2.69	18.39	2.02	15.18	16.01	1.82	12.50	12.75	11.35
	SRW-KD	2.60	18.11	2.00	15.09	15.86	1.81	12.43	12.69	11.29
	UMKD-UDD	2.79	18.40	1.88	14.85	17.12	1.82	12.97	13.32	12.41
	CB-DistillGrad	3.33	19.13	2.64	16.90	20.04	1.68	14.63	17.10	14.48
	EAKD-RCF	**2.68**	**18.66**	**2.03**	**14.91**	**16.06**	**1.27**	**12.80**	**12.84**	**11.44**

Supplementary parameter sensitivity analysis

Additional sensitivity analyses were conducted for the distillation-related parameters that are not shown in the main manuscript. Performance is expressed as the change in MCC relative to the predefined default configuration, so a value of zero denotes the default setting.



Supplementary Fig. S1. Sensitivity of EAKD-RCF to additional distillation-related parameter settings. (a) Entropy exponent γ; (b) maximum knowledge-distillation strength λ_max; (c) Brier regularization weight μ_B; (d) reliability threshold τ; and (e) joint γ–τ analysis. ΔMCC denotes the change in MCC relative to the predefined default configuration; values closer to zero indicate performance closer to the default result.

The default settings generally lie near the best-performing region of the tested ranges. Larger deviations are observed when γ, λ_{max}, or τ move farther from their predefined values, whereas the Brier regularization weight shows a comparatively moderate effect. The joint γ–τ analysis exhibits a similar pattern, indicating that appropriate distillation settings remain important while the reported performance is not tied to an isolated parameter value.