Dimensionality-Aware Outlier Detection [Supplementary Material]

S.I. Detailed Results

Table I displays the ROC AUC of the methods over the 480 synthetic datasets. Each row is an average of 30 datasets with the same characteristics. Tables II-VII display the ROC AUC performance of the methods over the 393 real-world datasets. The highest achieved values for each data set are shown in bold.

TABLE S.I

ROC AUC VALUES FOR OUTLIER DETECTION PERFORMANCE OVER 480 SYNTHETIC DATASETS CONTAINING 2 CLUSTERS. ONE OF THE CLUSTERS (c_1) HAS INTRINSIC DIMENSION FIXED AT 8. THE INTRINSIC DIMENSION OF THE OTHER CLUSTER (c_2) VARIES ACROSS THE DATASETS (x-AXIS). THE RESULTS SHOWN ARE AVERAGES OVER 30 DATASETS WITH THE SAME CHARACTERISTICS $\pm$ THE STANDARD DEVIATION.

Intrinsic Dimension of c_2	kNN	LOF	SLOF	$\text{DAO}_{\text{LIDL(RQSNF)}}$	$\text{DAO}_{\text{LIDL(MoG)}}$	DAO_{MLE}	DAO_{TLE}	$\text{DAO}_{\text{TwoNN}}$
Intrinsic Dimension = 2	0.7617 ± 0.0017	0.9922 ± 0.0017	0.9921 ± 0.0017	0.9347 ± 0.0017	0.9957 ± 0.0017	**0.9959 ± 0.0017**	0.9956 ± 0.0017	0.9538 ± 0.0017
Intrinsic Dimension = 4	0.8634 ± 0.0008	0.9923 ± 0.0008	0.9912 ± 0.0008	0.9761 ± 0.0008	0.9947 ± 0.0008	**0.9981 ± 0.0008**	0.998 ± 0.0008	0.9838 ± 0.0008
Intrinsic Dimension = 6	0.9739 ± 0.0008	0.9973 ± 0.0008	0.9965 ± 0.0008	0.9924 ± 0.0008	0.997 ± 0.0008	**0.9982 ± 0.0008**	0.998 ± 0.0008	0.9943 ± 0.0008
Intrinsic Dimension = 8	**0.9994 ± 0.0004**	0.9985 ± 0.0004	0.9981 ± 0.0004	0.9981 ± 0.0004	0.9976 ± 0.0004	0.9987 ± 0.0004	0.9985 ± 0.0004	0.9977 ± 0.0004
Intrinsic Dimension = 10	0.9802 ± 0.0007	0.9975 ± 0.0007	0.9965 ± 0.0007	0.9952 ± 0.0007	0.9968 ± 0.0007	**0.9985 ± 0.0007**	0.9983 ± 0.0007	0.9965 ± 0.0007
Intrinsic Dimension = 12	0.919 ± 0.0005	0.9955 ± 0.0005	0.9937 ± 0.0005	0.9879 ± 0.0005	0.9937 ± 0.0005	**0.9985 ± 0.0005**	0.9984 ± 0.0005	0.9944 ± 0.0005
Intrinsic Dimension = 14	0.8352 ± 0.0011	0.9931 ± 0.001	0.9903 ± 0.0011	0.9774 ± 0.001	0.9891 ± 0.0011	**0.9983 ± 0.0011**	**0.9983 ± 0.001**	0.9907 ± 0.001
Intrinsic Dimension = 16	0.78 ± 0.0006	0.99 ± 0.0006	0.986 ± 0.0006	0.9696 ± 0.0006	0.9844 ± 0.0006	**0.9986 ± 0.0006**	**0.9986 ± 0.0006**	0.9917 ± 0.0006
Intrinsic Dimension = 18	0.7629 ± 0.0008	0.985 ± 0.0008	0.9792 ± 0.0008	0.9633 ± 0.0008	0.9748 ± 0.0008	0.9983 ± 0.0008	**0.9984 ± 0.0008**	0.9887 ± 0.0008
Intrinsic Dimension = 20	0.7567 ± 0.0006	0.9845 ± 0.0006	0.9783 ± 0.0006	0.9489 ± 0.0006	0.9721 ± 0.0006	0.9986 ± 0.0006	**0.9987 ± 0.0006**	0.9876 ± 0.0006
Intrinsic Dimension = 22	0.7511 ± 0.0008	0.979 ± 0.0007	0.9713 ± 0.0008	0.9394 ± 0.0007	0.9646 ± 0.0008	**0.9983 ± 0.0008**	**0.9983 ± 0.0007**	0.9864 ± 0.0007
Intrinsic Dimension = 24	0.7407 ± 0.001	0.9792 ± 0.001	0.971 ± 0.001	0.9263 ± 0.001	0.9626 ± 0.001	0.9981 ± 0.001	**0.9982 ± 0.001**	0.9813 ± 0.001
Intrinsic Dimension = 26	0.7619 ± 0.0005	0.9757 ± 0.0006	0.9657 ± 0.0005	0.9286 ± 0.0006	0.9525 ± 0.0005	**0.9986 ± 0.0005**	**0.9986 ± 0.0006**	0.9855 ± 0.0006
Intrinsic Dimension = 28	0.7511 ± 0.0009	0.9716 ± 0.0009	0.9616 ± 0.0009	0.9227 ± 0.0009	0.948 ± 0.0009	**0.9982 ± 0.0009**	**0.9982 ± 0.0009**	0.9851 ± 0.0009
Intrinsic Dimension = 30	0.7503 ± 0.0005	0.972 ± 0.0005	0.9616 ± 0.0005	0.9096 ± 0.0005	0.946 ± 0.0005	0.9983 ± 0.0005	**0.9986 ± 0.0005**	0.9815 ± 0.0005
Intrinsic Dimension = 32	0.7477 ± 0.0007	0.967 ± 0.0007	0.9554 ± 0.0007	0.9086 ± 0.0007	0.9395 ± 0.0007	0.9983 ± 0.0007	**0.9984 ± 0.0007**	0.9804 ± 0.0007
Overall	0.8207 ± 0.0946	0.9858 ± 0.0109	0.9807 ± 0.0146	0.9548 ± 0.0325	0.9757 ± 0.0216	**0.9982 ± 0.001**	**0.9982 ± 0.001**	0.9866 ± 0.0116

TABLE S.II
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
ALOI_withoutdupl_norm	0.694	0.783	0.774	**0.811**
Arrhythmia_withoutdupl_norm_05_v09	0.886	0.882	0.874	**0.893**
Glass_withoutdupl_norm	0.874	0.868	0.856	**0.884**
HeartDisease_withoutdupl_norm_05_v07	0.97	0.968	0.965	**0.971**
Hepatitis_withoutdupl_norm_05_v04	0.915	**0.935**	0.891	0.905
Ionosphere_withoutdupl_norm	0.927	0.907	0.906	**0.934**
Isolet	**1**	**1**	**1**	**1**
MultipleFeature	0.988	0.988	0.986	**0.997**
PageBlocks_withoutdupl_norm_05_v10	0.923	**0.931**	0.913	0.926
Parkinson_withoutdupl_norm_05_v02	**1**	**1**	**1**	**1**
Pima_withoutdupl_norm_05_v03	**0.804**	0.768	0.744	0.786
SpamBase_withoutdupl_norm_05_v06	0.757	0.758	0.747	**0.807**
Stamps_withoutdupl_norm_05_v05	**0.918**	0.889	0.87	0.91
Vowel	**0.989**	0.969	0.917	**0.989**
WDBC_withoutdupl_norm_v08	0.988	0.988	0.988	**0.996**
WPBC_withoutdupl_norm	**0.541**	0.525	0.5	**0.541**
Waveform_withoutdupl_norm_v05	**0.787**	0.772	0.751	0.767
Wilt_withoutdupl_norm_05	0.492	0.644	0.651	**0.662**
abalone.preproc	**0.779**	0.606	0.577	0.62
abalone_C1_P02_V01_CA0	**0.779**	0.67	0.657	0.685
abalone_C2_P02_V01_CA0	0.555	0.611	**0.625**	0.624
abalone_C3_P02_V01_CA0	**0.559**	0.469	0.458	0.462
abalone_ori_C1_P02_V01_CA0	**0.709**	0.643	0.626	0.653
aloi-unsupervised-ad	0.691	0.761	0.757	**0.796**
arrhythmia	**0.817**	0.816	0.81	**0.817**
australian_C1_P02_V01_CA0	0.243	0.348	0.457	**0.458**
australian_C2_P02_V01_CA0	0.75	**0.801**	0.77	0.797
auto2_C1_P02_V01_CA0	0.559	0.549	**0.568**	**0.568**
auto2_C2_P02_V01_CA0	0.513	0.515	0.505	**0.534**
auto4_C1_P02_V01_CA0	0.518	0.583	0.553	**0.588**
auto4_C3_P02_V01_CA0	0.496	**0.555**	0.527	0.535
auto5_C2_P02_V01_CA0	0.539	0.532	0.616	**0.632**
auto5_C3_P02_V01_CA0	0.717	0.776	0.775	**0.837**
auto5_C4_P02_V01_CA0	0.764	**0.775**	0.711	0.76
auto6_1_C1_P02_V01_CA0	0.592	0.605	0.681	**0.687**
auto6_1_C2_P02_V01_CA0	0.687	**0.692**	0.607	0.648
auto6_1_C3_P02_V01_CA0	0.611	0.65	0.662	**0.689**
auto6_1_C4_P02_V01_CA0	0.595	0.614	0.692	**0.698**
auto6_1_C5_P02_V01_CA0	0.491	0.53	0.591	**0.594**
auto6_1_C6_P02_V01_CA0	0.491	0.44	0.532	**0.541**
auto6_1_C7_P02_V01_CA0	0.556	**0.608**	0.572	0.596
auto6_1_C8_P02_V01_CA0	0.476	0.488	0.573	**0.579**
auto6_2_C1_P02_V01_CA0	**0.573**	0.49	0.507	0.547
auto6_2_C2_P02_V01_CA0	0.512	0.483	0.53	**0.572**
auto6_2_C3_P02_V01_CA0	0.552	0.549	0.585	**0.586**
auto6_2_C4_P02_V01_CA0	0.459	**0.478**	0.414	0.427
auto6_2_C5_P02_V01_CA0	0.552	**0.661**	0.614	0.635
auto6_2_C6_P02_V01_CA0	0.535	0.48	0.631	**0.641**
auto6_2_C7_P02_V01_CA0	0.52	**0.595**	0.537	0.58
auto6_2_C8_P02_V01_CA0	0.589	0.613	0.573	**0.629**
auto6_3_C1_P02_V01_CA0	0.754	0.821	0.842	**0.861**
auto6_3_C2_P02_V01_CA0	0.642	**0.708**	0.663	0.701
auto6_3_C4_P02_V01_CA0	0.598	0.717	0.674	**0.775**
auto6_3_C5_P02_V01_CA0	0.391	0.653	0.66	**0.68**
auto6_3_C7_P02_V01_CA0	0.544	0.648	0.679	**0.798**
auto6_3_C8_P02_V01_CA0	**0.657**	0.619	0.52	0.571
auto7_1_C1_P02_V01_CA0	0.277	0.504	0.538	**0.553**
auto7_1_C2_P02_V01_CA0	0.598	0.601	0.578	**0.615**
auto7_1_C3_P02_V01_CA0	0.534	0.568	0.605	**0.628**
auto7_1_C4_P02_V01_CA0	0.604	0.57	0.642	**0.68**
auto7_1_C5_P02_V01_CA0	**0.659**	0.58	0.61	0.64
auto7_2_C1_P02_V01_CA0	0.456	0.645	0.645	**0.677**
auto7_2_C2_P02_V01_CA0	**0.623**	0.554	0.523	0.587
auto7_2_C3_P02_V01_CA0	0.835	0.733	0.741	**0.86**
auto7_3_C1_P02_V01_CA0	0.574	0.608	**0.742**	0.721
auto7_3_C2_P02_V01_CA0	0.727	0.634	0.751	**0.759**
auto7_3_C3_P02_V01_CA0	0.64	**0.716**	0.696	0.687

TABLE S.III
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
auto7_3_C4_P02_V01_CA0	0.657	0.619	0.631	**0.675**
auto7_3_C5_P02_V01_CA0	0.591	0.747	0.774	**0.835**
auto8_C10_P02_V01_CA0	0.576	**0.606**	0.577	0.583
auto8_C1_P02_V01_CA0	0.568	0.656	**0.685**	0.679
auto8_C3_P02_V01_CA0	0.522	0.501	0.486	**0.569**
auto8_C4_P02_V01_CA0	0.451	**0.581**	0.484	0.495
auto8_C5_P02_V01_CA0	0.544	0.533	0.561	**0.658**
auto8_C6_P02_V01_CA0	0.521	**0.581**	0.524	0.538
auto8_C7_P02_V01_CA0	0.613	0.611	0.625	**0.65**
auto8_C8_P02_V01_CA0	0.444	0.509	0.477	**0.556**
auto8_C9_P02_V01_CA0	0.663	0.693	**0.697**	0.694
automobile_C1_P02_V01_CA0	0.801	0.79	0.801	**0.836**
automobile_C2_P02_V01_CA0	0.904	0.962	0.938	**0.973**
automobile_C3_P02_V01_CA0	0.477	0.613	0.581	**0.671**
automobile_C4_P02_V01_CA0	0.535	0.404	0.546	**0.55**
automobile_C5_P02_V01_CA0	0.849	0.759	0.791	**0.856**
automobile_C6_P02_V01_CA0	0.846	0.842	0.795	**0.874**
banana_C1_P02_V01_CNA	0.934	**0.943**	0.931	0.939
banana_C2_P02_V01_CNA	0.943	0.945	0.949	**0.953**
banknote_C1_P02_V01_CNA	**1**	**1**	**1**	**1**
banknote_C2_P02_V01_CNA	0.999	**1**	0.999	**1**
blood_C2_P02_V01_CNA	0.866	**0.98**	0.933	**0.98**
breast-cancer-unsupervised-ad	0.982	0.992	0.99	**0.993**
breast_cancer_wis_ori_C1_P02_V01_CNA	0.972	0.972	0.968	**0.974**
breast_cancer_wis_ori_C2_P02_V01_CNA	0.692	0.803	**0.895**	0.887
breast_cancer_wis_pro2_C2_P02_V01_CA0	0.689	0.678	0.751	**0.773**
breast_cancer_wis_pro_C2_P02_V01_CA0	0.722	**0.889**	0.865	0.874
bupa_C1_P02_V01_CNA	0.452	0.661	0.644	**0.697**
bupa_C2_P02_V01_CNA	0.539	0.553	0.542	**0.556**
cardio	**0.91**	0.854	0.786	0.851
cardio3_C2_P02_V01_CNA	0.752	0.86	0.894	**0.928**
chronic_kidney_disease_C1_P02_V01_CA0	**1**	**1**	**1**	**1**
chronic_kidney_disease_C2_P02_V01_CA0	0.44	0.593	0.584	**0.597**
chronic_kidney_disease_full_C1_P02_V01_CA0	0.833	0.907	0.863	**0.963**
chronic_kidney_disease_full_C2_P02_V01_CA0	0.457	0.723	0.635	**0.859**
cilinder_C2_P02_V01_CA0	0.614	0.665	0.686	**0.785**
climate_C1_P02_V01_CA0	**0.694**	0.637	0.679	0.686
concrete.preproc	**0.714**	0.687	0.636	0.665
connectionist_sonar_C1_P02_V01_CNA	0.95	0.955	0.959	**1**
connectionist_vowel_C10_P02_V01_CA0	0.972	**0.979**	0.964	**0.979**
connectionist_vowel_C11_P02_V01_CA0	0.849	0.837	0.845	**0.878**
connectionist_vowel_C1_P02_V01_CA0	**0.969**	0.95	0.936	0.946
connectionist_vowel_C2_P02_V01_CA0	0.832	0.915	0.919	**0.938**
connectionist_vowel_C3_P02_V01_CA0	0.878	**0.91**	0.856	0.883
connectionist_vowel_C4_P02_V01_CA0	0.701	**0.814**	0.769	0.786
connectionist_vowel_C5_P02_V01_CA0	0.833	0.88	0.824	**0.899**
connectionist_vowel_C6_P02_V01_CA0	0.732	**0.878**	0.858	0.867
connectionist_vowel_C7_P02_V01_CA0	0.855	**0.905**	0.819	0.848
connectionist_vowel_C8_P02_V01_CA0	**0.922**	0.868	0.739	0.786
connectionist_vowel_C9_P02_V01_CA0	0.896	0.879	0.862	**0.908**
credit_C1_P02_V01_CA0	0.837	0.846	0.821	**0.863**
credit_C2_P02_V01_CA0	0.309	0.727	0.734	**0.77**
crx_C1_P02_V01_CA0	0.636	0.677	0.714	**0.727**
crx_C2_P02_V01_CA0	0.37	0.484	0.471	**0.571**
diabetic_C1_P02_V01_CNA	0.516	0.534	**0.626**	0.612
diabetic_C2_P02_V01_CNA	0.575	0.598	0.698	**0.702**
ecoli_C1_P02_V01_CNA	0.883	0.912	0.915	**0.934**
ecoli_C2_P02_V01_CNA	0.898	0.906	0.839	**0.915**
fault.preproc	**0.738**	0.606	0.589	0.644
first_C1_P02_V01_CA0	0.666	0.708	0.695	**0.718**
first_C2_P02_V01_CA0	0.548	0.588	0.591	**0.596**
forest_C1_P02_V01_CNA	0.827	0.942	0.928	**0.956**
forest_C2_P02_V01_CNA	0.778	0.96	0.954	**0.963**
forest_C3_P02_V01_CNA	0.544	0.78	0.753	**0.791**
forest_C4_P02_V01_CNA	**0.978**	0.965	0.956	0.964
fourclass_C1_P02_V01_CNA	**1**	**1**	**1**	**1**
fourclass_C2_P02_V01_CNA	**1**	**1**	0.999	**1**

TABLE S.IV
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
gas.preproc	0.469	**0.543**	0.524	0.537
gesture_raw_C1_P02_V01_CNA	**0.999**	**0.999**	0.997	**0.999**
gesture_raw_C2_P02_V01_CNA	**0.991**	0.989	0.973	0.977
gesture_raw_C3_P02_V01_CNA	**0.998**	0.997	0.996	0.997
gesture_raw_C4_P02_V01_CNA	**0.986**	0.981	0.95	0.952
gesture_raw_C5_P02_V01_CNA	**0.994**	0.993	0.973	0.976
gesture_va_C1_P02_V01_CNA	0.239	0.7	**0.706**	0.667
gesture_va_C2_P02_V01_CNA	**0.631**	0.549	0.558	0.575
gesture_va_C4_P02_V01_CNA	0.384	0.644	0.637	**0.661**
gesture_va_C5_P02_V01_CNA	**0.668**	0.576	0.58	0.584
glass	**0.869**	0.842	0.797	**0.869**
glass_C1_P02_V01_CNA	0.382	0.642	0.712	**0.719**
glass_C2_P02_V01_CNA	0.606	0.828	0.777	**0.861**
glass_C3_P02_V01_CNA	0.333	0.5	0.493	**0.563**
glass_C4_P02_V01_CNA	0.919	0.859	0.834	**0.951**
glass_C5_P02_V01_CNA	0.863	0.828	0.766	**0.864**
grammatical_a1_C1_P02_V01_CNA	**0.808**	0.626	0.617	0.774
grammatical_a1_C2_P02_V01_CNA	0.654	**0.77**	0.768	0.75
grammatical_a2_C1_P02_V01_CNA	**0.769**	0.664	0.678	0.768
grammatical_a2_C2_P02_V01_CNA	0.781	0.766	0.804	**0.827**
grammatical_a3_C1_P02_V01_CNA	0.758	0.692	0.691	**0.786**
grammatical_a3_C2_P02_V01_CNA	**0.872**	0.724	0.716	0.786
grammatical_a4_C1_P02_V01_CNA	0.422	0.507	**0.601**	0.596
grammatical_a4_C2_P02_V01_CNA	0.793	0.798	0.8	**0.83**
grammatical_a5_C1_P02_V01_CNA	0.53	0.604	0.648	**0.683**
grammatical_a5_C2_P02_V01_CNA	0.737	0.727	0.691	**0.772**
grammatical_a6_C1_P02_V01_CNA	**0.765**	0.661	0.694	0.754
grammatical_a6_C2_P02_V01_CNA	0.834	0.662	0.659	**0.843**
grammatical_a7_C1_P02_V01_CNA	0.758	0.79	0.727	**0.796**
grammatical_a7_C2_P02_V01_CNA	**0.891**	0.789	0.782	0.842
grammatical_a8_C1_P02_V01_CNA	**0.815**	0.759	0.758	0.796
grammatical_a8_C2_P02_V01_CNA	0.681	0.694	0.67	**0.708**
grammatical_a9_C1_P02_V01_CNA	**0.818**	0.747	0.736	0.776
grammatical_a9_C2_P02_V01_CNA	**0.698**	0.629	0.597	0.65
grammatical_b1_C1_P02_V01_CNA	0.726	0.696	0.752	**0.784**
grammatical_b1_C2_P02_V01_CNA	0.658	0.741	**0.776**	0.766
grammatical_b2_C1_P02_V01_CNA	0.598	0.69	0.717	**0.806**
grammatical_b2_C2_P02_V01_CNA	0.596	0.706	0.693	**0.713**
grammatical_b3_C1_P02_V01_CNA	0.758	0.709	0.732	**0.814**
grammatical_b3_C2_P02_V01_CNA	0.439	0.637	**0.715**	0.687
grammatical_b4_C1_P02_V01_CNA	0.561	0.678	**0.732**	0.724
grammatical_b4_C2_P02_V01_CNA	**0.8**	0.727	0.678	0.76
grammatical_b5_C1_P02_V01_CNA	0.392	0.534	0.566	**0.667**
grammatical_b5_C2_P02_V01_CNA	0.692	0.667	0.685	**0.718**
grammatical_b6_C1_P02_V01_CNA	0.694	0.67	0.67	**0.716**
grammatical_b6_C2_P02_V01_CNA	0.425	**0.608**	0.584	0.572
grammatical_b7_C1_P02_V01_CNA	0.829	0.816	0.808	**0.888**
grammatical_b7_C2_P02_V01_CNA	0.373	0.474	0.525	**0.566**
grammatical_b8_C2_P02_V01_CNA	**0.948**	0.921	0.92	0.924
grammatical_b9_C1_P02_V01_CNA	0.69	0.696	0.725	**0.738**
grammatical_b9_C2_P02_V01_CNA	0.512	**0.708**	0.703	0.703
haberman_C2_P02_V01_CNA	0.738	0.711	0.807	**0.824**
heart_cleverland_C1_P02_V01_CA0	0.624	0.69	0.704	**0.763**
heart_cleverland_C2_P02_V01_CA0	0.815	0.8	0.776	**0.856**
heart_cleverland_C5_P02_V01_CA0	0.628	0.625	0.603	**0.654**
heart_hungarian_C2_P02_V01_CA0	0.391	0.436	0.45	**0.487**
heart_switzerland_C3_P02_V01_CA0	0.819	0.81	0.782	**0.935**
heart_switzerland_C5_P02_V01_CA0	0.664	0.617	0.739	**0.761**
heart_va_C1_P02_V01_CA0	0.708	**0.725**	0.679	0.679
heart_va_C2_P02_V01_CA0	0.95	0.971	0.975	**0.992**
heart_va_C3_P02_V01_CA0	0.857	0.899	0.887	**0.945**
heart_va_C4_P02_V01_CA0	0.83	0.908	0.94	**0.956**
heart_va_C5_P02_V01_CA0	**0.686**	0.618	0.598	0.641
hepatitis_C2_P02_V01_CA0	0.556	**0.721**	0.568	0.581
horse_colic_lesion_C1_P02_V01_CA0	0.512	0.5	0.495	**0.546**
horse_colic_lesion_C2_P02_V01_CA0	0.821	0.854	**0.874**	0.862
horse_colic_outcome_C1_P02_V01_CA0	0.787	0.741	0.797	**0.848**
horse_colic_outcome_C2_P02_V01_CA0	0.545	**0.55**	0.519	**0.55**
horse_colic_outcome_C3_P02_V01_CA0	0.521	0.685	0.79	**0.861**
human_C1_P02_V01_CNA	0.599	0.807	0.777	**0.826**

TABLE S.V
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
human_C4_P02_V01_CNA	**0.841**	0.73	0.677	0.698
hv_no_noise_C1_P02_V01_CNA	0.723	0.721	0.686	**0.776**
hv_no_noise_C2_P02_V01_CNA	0.538	0.53	0.574	**0.629**
hv_noise_C2_P02_V01_CNA	0.496	0.614	0.604	**0.657**
ilpd_C2_P02_V01_CA0	0.349	0.496	0.531	**0.562**
image_C1_P02_V01_CA0	0.571	0.695	0.714	**0.745**
image_C3_P02_V01_CA0	0.606	**0.806**	0.74	0.773
image_C4_P02_V01_CA0	0.945	0.943	0.932	**0.953**
image_C5_P02_V01_CA0	0.638	**0.786**	0.772	0.776
image_C6_P02_V01_CA0	0.969	0.963	0.938	**0.971**
image_C7_P02_V01_CA0	0.956	**0.975**	0.973	0.974
imgseg.preproc	**0.525**	0.52	0.494	0.5
ionosphere	0.929	0.909	0.907	**0.937**
ionosphere_C1_P02_V01_CNA	0.292	**0.472**	0.224	0.264
ionosphere_C2_P02_V01_CNA	0.979	0.95	0.949	**0.992**
iris_C1_P02_V01_CNA	**1**	**1**	**1**	**1**
iris_C2_P02_V01_CNA	0.959	**0.995**	0.938	0.985
iris_C3_P02_V01_CNA	**0.98**	0.969	**0.98**	**0.98**
isolet_C1_P02_V01_CNA	0.465	**0.686**	0.588	0.672
japanese_C1_P02_V01_CA0	0.663	0.627	0.655	**0.711**
japanese_C2_P02_V01_CA0	0.387	0.689	0.732	**0.738**
leaf_C1_P02_V01_CA0	0.373	0.535	**0.537**	0.535
libras_C11_P02_V01_CNA	0.491	0.537	0.613	**0.679**
libras_C12_P02_V01_CNA	0.611	0.837	0.813	**0.842**
libras_C13_P02_V01_CNA	0.408	0.642	0.632	**0.684**
libras_C14_P02_V01_CNA	**0.869**	0.806	0.645	0.764
libras_C15_P02_V01_CNA	0.919	0.924	0.912	**0.985**
libras_C1_P02_V01_CNA	0.866	0.832	0.883	**0.933**
libras_C2_P02_V01_CNA	0.838	**0.853**	0.695	0.743
libras_C3_P02_V01_CNA	0.863	**0.901**	0.857	0.897
libras_C4_P02_V01_CNA	**0.947**	0.893	0.811	0.891
libras_C6_P02_V01_CNA	**0.828**	0.768	0.685	0.772
libras_C7_P02_V01_CNA	0.314	**0.501**	0.439	0.464
libras_C9_P02_V01_CNA	0.454	0.468	0.531	**0.548**
madelon_C1_P02_V01_CNA	0.478	0.464	0.502	**0.531**
madelon_C2_P02_V01_CNA	0.585	0.591	0.608	**0.669**
magic.gamma.preproc	**0.815**	0.733	0.706	0.738
mammography	**0.816**	0.76	0.73	0.769
mice_C1_P02_V01_CA0	**0.88**	0.792	0.776	0.802
mice_C2_P02_V01_CA0	0.624	0.797	0.789	**0.832**
mice_C3_P02_V01_CA0	0.902	0.961	0.956	**0.968**
mice_C4_P02_V01_CA0	0.786	0.802	0.745	**0.805**
mice_C5_P02_V01_CA0	**0.882**	0.87	0.861	0.87
mice_C6_P02_V01_CA0	0.708	0.872	0.825	**0.877**
mice_C7_P02_V01_CA0	0.841	0.852	0.805	**0.87**
mice_C8_P02_V01_CA0	0.935	**0.948**	0.915	0.937
multiple_C10_P02_V01_CNA	0.86	0.883	0.817	**0.902**
multiple_C2_P02_V01_CNA	0.903	0.968	0.944	**0.972**
multiple_C3_P02_V01_CNA	**0.874**	0.687	0.621	0.675
multiple_C5_P02_V01_CNA	**0.975**	0.942	0.915	0.923
multiple_C7_P02_V01_CNA	**0.955**	0.935	0.886	0.947
multiple_C8_P02_V01_CNA	**0.927**	0.776	0.697	0.771
ozone1_C2_P02_V01_CNA	0.358	0.583	0.602	**0.616**
ozone8_C1_P02_V01_CNA	0.508	**0.562**	0.492	0.523
ozone8_C2_P02_V01_CNA	0.429	0.661	0.688	**0.706**
page_C1_P02_V01_CNA	0.694	0.73	0.634	**0.754**
page_C2_P02_V01_CNA	0.585	0.945	0.941	**0.958**
pageb.preproc	**0.921**	0.914	0.884	0.911
parkinson_speech_C1_P02_V01_CNA	0.556	0.632	0.662	**0.713**
parkinson_speech_C2_P02_V01_CNA	0.672	0.747	0.757	**0.769**
parkinsons_C2_P02_V01_CNA	**0.891**	0.884	0.847	0.874
particle.preproc	**0.613**	0.47	0.484	0.455
pendigits	**0.955**	0.551	0.563	0.665
phoneme_C1_P02_V01_CNA	**0.846**	0.779	0.751	0.792
phoneme_C2_P02_V01_CNA	**0.833**	0.758	0.757	0.789
pima	0.646	**0.653**	0.608	0.625
pima_C2_P02_V01_CNA	0.61	0.61	0.544	**0.62**
planning_C2_P02_V01_CNA	0.659	0.679	0.659	**0.71**
qsar_C1_P02_V01_CNA	**0.613**	0.515	0.477	0.56
qsar_C2_P02_V01_CNA	0.843	0.862	0.839	**0.88**

TABLE S.VI
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
ring_C1_P02_V01_CNA	**0.992**	**0.992**	**0.992**	**0.992**
robot1_C1_P02_V01_CNA	0.27	0.651	0.646	**0.764**
robot1_C2_P02_V01_CNA	0.586	0.951	0.954	**0.98**
robot1_C4_P02_V01_CNA	0.698	0.866	0.866	**0.892**
robot2_C1_P02_V01_CNA	0.652	0.833	0.842	**0.88**
robot3_C1_P02_V01_CNA	0.553	0.773	0.786	**0.829**
robot4_C1_P02_V01_CNA	0.527	0.631	0.628	**0.83**
robot4_C2_P02_V01_CNA	0.685	0.824	0.835	**0.843**
robot5_C1_P02_V01_CNA	0.514	0.653	0.656	**0.72**
robot5_C3_P02_V01_CNA	0.722	0.86	0.861	**0.863**
saheart_C1_P02_V01_CA0	0.876	0.879	0.868	**0.914**
saheart_C2_P02_V01_CA0	0.607	0.648	0.69	**0.808**
secom_C1_P02_V01_CNA	0.768	0.737	0.768	**0.803**
secom_C2_P02_V01_CNA	0.512	0.512	0.57	**0.574**
seeds_C1_P02_V01_CNA	0.982	**1**	0.996	**1**
seeds_C2_P02_V01_CNA	0.946	0.95	0.95	**0.964**
seeds_C3_P02_V01_CNA	0.929	0.911	0.932	**0.982**
seismic_C1_P02_V01_CA0	0.494	0.567	0.633	**0.731**
seismic_C2_P02_V01_CA0	**0.723**	0.638	0.628	0.642
spambase.preproc	**0.574**	0.476	0.473	0.555
spambase_C1_P02_V01_CA0	**0.732**	0.681	0.681	0.696
spectf_heart_C2_P02_V01_CNA	0.177	0.173	0.212	**0.308**
speech-unsupervised-ad	0.486	0.625	**0.629**	0.615
statlog_australian_C1_P02_V01_CA0	0.454	0.64	0.711	**0.718**
statlog_australian_C2_P02_V01_CA0	0.7	0.696	0.714	**0.727**
statlog_german_C1_P02_V01_CA0	0.6	**0.785**	0.723	0.764
statlog_german_C2_P02_V01_CA0	0.718	0.701	0.762	**0.788**
statlog_heart_C1_P02_V01_CA0	0.651	0.633	0.653	**0.664**
statlog_heart_C2_P02_V01_CA0	0.354	**0.729**	0.633	0.708
statlog_is_C1_P02_V01_CNA	0.966	0.957	0.928	**0.967**
statlog_is_C2_P02_V01_CNA	0.604	**0.862**	0.798	0.811
statlog_is_C3_P02_V01_CNA	**0.986**	0.972	0.964	0.976
statlog_is_C4_P02_V01_CNA	0.95	**0.972**	0.968	**0.972**
statlog_is_C5_P02_V01_CNA	0.604	0.771	0.75	**0.776**
statlog_is_C6_P02_V01_CNA	0.941	0.925	0.914	**0.944**
statlog_is_C7_P02_V01_CNA	0.638	**0.818**	0.79	0.802
statlog_vehicle_C1_P02_V01_CNA	0.685	**0.864**	0.807	0.857
statlog_vehicle_C2_P02_V01_CNA	**0.675**	0.629	0.617	0.656
statlog_vehicle_C3_P02_V01_CNA	0.777	0.744	0.784	**0.793**
statlog_vehicle_C4_P02_V01_CNA	**0.756**	0.614	0.642	0.667
synthetic.preproc	**0.999**	0.987	0.977	**0.999**
tae_C1_P02_V01_CA0	0.479	**0.929**	0.6	0.586
tae_C2_P02_V01_CA0	0.972	**1**	**1**	**1**
tae_C3_P02_V01_CA0	0.95	0.95	0.95	**0.971**
texture_C10_P02_V01_CNA	**0.988**	0.929	0.832	0.98
texture_C11_P02_V01_CNA	0.901	0.947	0.908	**0.958**
texture_C2_P02_V01_CNA	**0.769**	0.657	0.58	0.649
texture_C3_P02_V01_CNA	**0.88**	0.673	0.573	0.644
texture_C4_P02_V01_CNA	**0.842**	0.828	0.758	0.841
texture_C5_P02_V01_CNA	**0.788**	0.737	0.665	0.741
texture_C6_P02_V01_CNA	**0.96**	0.491	0.525	0.647
texture_C7_P02_V01_CNA	0.739	0.868	0.799	**0.888**
texture_C8_P02_V01_CNA	0.866	0.864	0.792	**0.878**
thyroid_allbp_C1_P02_V01_CA0	0.776	0.795	0.649	**0.971**
thyroid_allhypo_C1_P02_V01_CA0	0.599	0.659	0.8	**0.811**
thyroid_allrep_C1_P02_V01_CA0	0.547	0.491	0.551	**0.564**
thyroid_ann_C1_P02_V01_CA0	0.518	0.547	**0.619**	0.604
thyroid_hypothyroid_C2_P02_V01_CA0	0.985	0.985	0.985	**0.993**
thyroid_new_thyroid_C2_P02_V01_CNA	0.915	0.998	**1**	**1**
thyroid_new_thyroid_C3_P02_V01_CNA	0.987	0.998	0.998	**1**

TABLE S.VII
ROC AUC PERFORMANCE OF THE METHODS OVER 393 REAL DATASETS.

Dataset	kNN	LOF	SLOF	DAO
thyroid_sick_C1_P02_V01_CA0	0.836	0.832	0.823	**0.876**
twonorm_C1_P02_V01_CNA	0.917	0.906	0.876	**0.94**
twonorm_C2_P02_V01_CNA	**0.92**	0.901	0.865	0.896
urban_C1_P02_V01_CNA	0.681	0.899	0.914	**0.917**
urban_C2_P02_V01_CNA	0.802	0.734	0.733	**0.804**
urban_C3_P02_V01_CNA	0.392	0.579	0.593	**0.637**
urban_C4_P02_V01_CNA	0.656	**0.731**	0.698	0.716
urban_C5_P02_V01_CNA	0.488	0.506	0.501	**0.507**
urban_C6_P02_V01_CNA	0.458	**0.478**	0.436	0.474
urban_C7_P02_V01_CNA	0.38	0.554	**0.674**	0.652
urban_C8_P02_V01_CNA	**0.63**	0.575	0.569	**0.63**
urban_C9_P02_V01_CNA	0.314	0.652	**0.684**	0.643
user_C1_P02_V01_CNA	0.733	0.775	0.929	**0.935**
user_C2_P02_V01_CNA	0.899	**0.973**	0.962	0.952
user_C3_P02_V01_CNA	0.773	**0.8**	0.735	0.787
user_C4_P02_V01_CNA	0.71	0.92	**0.955**	0.949
vert2_C1_P02_V01_CNA	0.855	0.77	0.855	**0.955**
vert2_C2_P02_V01_CNA	0.43	0.554	**0.608**	0.593
vert3_C1_P02_V01_CNA	0.38	0.584	0.568	**0.606**
vert3_C2_P02_V01_CNA	**0.99**	0.985	0.983	**0.99**
vert3_C3_P02_V01_CNA	0.529	0.562	0.639	**0.719**
vertebral	0.325	0.531	0.526	**0.536**
vowels	**0.975**	0.949	0.924	0.967
wall24_C1_P02_V01_CNA	0.539	0.526	0.534	**0.547**
wall24_C2_P02_V01_CNA	**0.827**	0.773	0.784	0.821
wall24_C3_P02_V01_CNA	0.674	0.693	0.729	**0.758**
wall24_C4_P02_V01_CNA	0.703	0.674	0.651	**0.737**
wall2_C1_P02_V01_CNA	**0.92**	0.894	0.867	0.894
wall2_C2_P02_V01_CNA	0.906	0.943	0.924	**0.947**
wall2_C3_P02_V01_CNA	**0.961**	0.938	0.934	0.953
wall2_C4_P02_V01_CNA	0.991	0.979	0.977	**0.994**
wall4_C1_P02_V01_CNA	**0.869**	0.728	0.704	0.759
wall4_C2_P02_V01_CNA	0.877	0.851	0.851	**0.89**
wall4_C3_P02_V01_CNA	**0.942**	0.868	0.852	0.906
wall4_C4_P02_V01_CNA	**0.944**	0.883	0.839	0.928
wave2_C1_P02_V01_CNA	**0.77**	0.672	0.635	0.678
wave2_C2_P02_V01_CNA	**0.752**	0.715	0.69	0.691
wave2_C3_P02_V01_CNA	**0.755**	0.7	0.673	0.712
wave_C1_P02_V01_CNA	**0.788**	0.668	0.631	0.708
wave_C2_P02_V01_CNA	**0.813**	0.733	0.693	0.705
wave_C3_P02_V01_CNA	**0.768**	0.752	0.736	0.751
wbc	0.954	0.954	0.954	**0.965**
weight_C1_P02_V01_CA0	**0.829**	0.764	0.775	0.776
weight_C2_P02_V01_CA0	0.555	0.592	0.594	**0.601**
weight_C3_P02_V01_CA0	**0.642**	0.627	0.579	0.581
weight_C5_P02_V01_CA0	**0.626**	0.557	0.593	0.613
wholesale_C1_P02_V01_CNA	0.817	0.851	0.844	**0.898**
wholesale_C2_P02_V01_CNA	0.694	0.771	0.831	**0.908**
wilt_C1_P02_V01_CNA	0.76	0.859	0.852	**0.874**
wilt_C2_P02_V01_CNA	0.932	0.967	0.97	**0.98**
wine	0.999	**1**	**1**	**1**
wine_C1_P02_V01_CNA	0.987	0.987	0.992	**1**
wine_C2_P02_V01_CNA	0.757	0.72	0.818	**0.864**
wine_C3_P02_V01_CNA	0.783	0.696	0.854	**0.896**
wine_quality_C1_P02_V01_CA0	**0.653**	0.63	0.629	0.633
wine_quality_C2_P02_V01_CA0	0.517	**0.534**	0.517	0.524
wine_quality_C3_P02_V01_CA0	0.498	0.556	0.55	**0.561**
wpbc_C2_P02_V01_CNA	0.563	0.601	0.727	**0.73**
yearp.preproc	0.523	**0.536**	0.535	0.535
Overall	0.71	0.741	0.736	**0.773**