Supplementary Material for: "Random Walk-steered Majority Undersampling"*

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The AUC and F1-Score results of the experiments are shown in Table 1 and 2 respectively. The values in the table are the mean AUC (Table 1) and mean F1-Score (Table 2) of the ten runs of the experiment. The values in the parentheses are the relative ranking for a sampling method and algorithm combination on the specific dataset. For example, for *ecoli4* dataset, when the proposed algorithm is used with kNN, attained an AUC value of 0.9963 and an rank of 1, when compared with kNN used with other sampling methods and original dataset. The last row of each table shows the average rank over all datasets for a specific sampling algorithm and classification algorithm pair.

Also, to further analyse the differences between the algorithms, we have performed a non-parametric statistical test for a multiple classifier comparison test. We have performed a Friedman test with Finner p-value adjustments, and the critical difference plots from the test results are shown in Figure 1. The detailed results of the statistical tests a are shown in Tables 3 to 5 for AUC scores, and Table 6 to 8 for F1 scores. The lower triangle of Tables 3 to 8 indicate the corrected p-values of the test statistical test. The upper diagonal shows a simple win/lose/tie count (algorithm on the row w.r.t. algorithm on the column).

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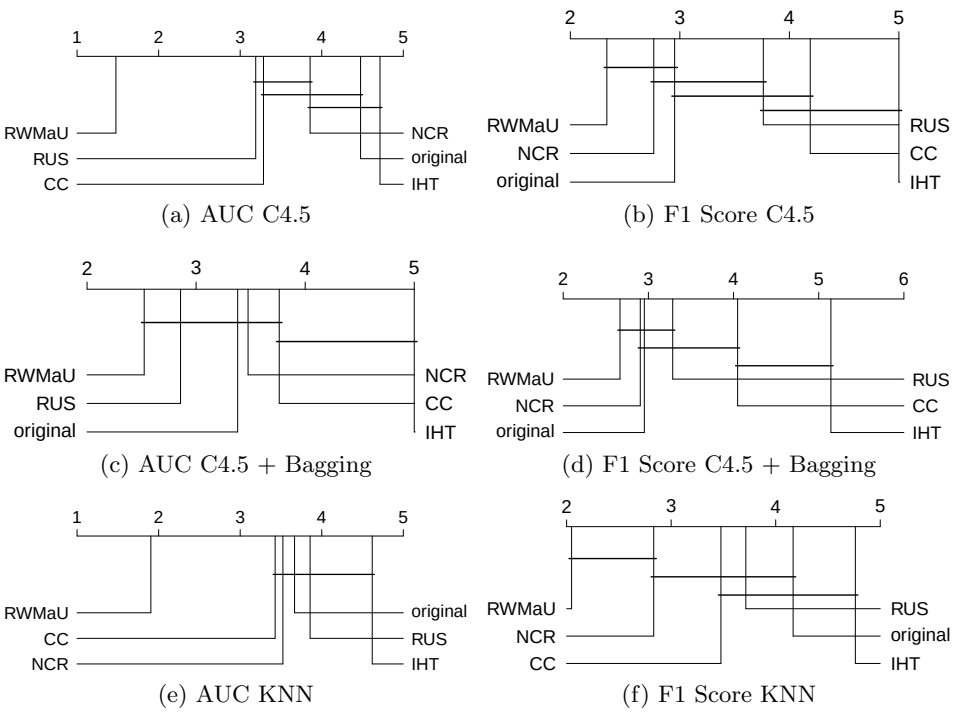
Table 1: AUC Scores

	KNN						C4.5						C4.5 + Bagging					
	RWMaU	Original	RUS	IHT	CC	NCR	Proposed	Original	RUS	IHT	CC	NCR	Proposed	Original	RUS	IHT	CC	NCR
yeast5	0.9871 (2)	0.9830 (4)	0.9735 (5)	0.8497 (6)	0.9868 (3)	**0.9909 (1)**	0.9489 (3)	0.8422 (5)	0.9721 (2)	0.8382 (6)	**0.9767 (1)**	0.8647 (4)	0.9837 (2)	0.9548 (4)	0.9828 (3)	0.9241 (6)	**0.9876 (1)**	0.9479 (5)
yeast1289v7	0.7214 (2)	0.6971 (3)	0.6480 (5)	0.5867 (6)	**0.7510 (1)**	0.6804 (4)	**0.6051 (1)**	0.5653 (4)	0.5441 (6)	0.5845 (3)	0.5889 (2)	0.5465 (5)	0.6894 (3)	0.6896 (2)	**0.7001** (1)	0.5799 (6)	0.6300 (5)	0.6598 (4)
wine-red-4	0.5871 (3)	0.4987 (6)	0.5765 (4)	0.6048 (2)	**0.6321 (1)**	0.5202 (5)	0.5970 (2)	0.5500 (5)	**0.6027 (1)**	0.5325 (6)	0.5902 (3)	0.5585 (4)	**0.7574 (1)**	0.6684 (5)	0.6966 (3)	0.6148 (6)	0.6816 (4)	0.7355 (2)
yeast4	0.8481 (3)	0.7755 (5)	0.8906 (2)	0.7179 (6)	**0.9094 (1)**	0.8226 (4)	0.7902 (2)	0.6505 (5)	**0.8122 (1)**	0.5825 (6)	0.7119 (3)	0.6899 (4)	**0.8900 (1)**	0.7932 (5)	0.8805 (2)	0.6552 (6)	0.8195 (4)	0.8456 (3)
yeast1458v7	**0.6934 (1)**	0.6233 (5)	0.6079 (6)	0.6479 (3)	0.6535 (2)	0.6338 (4)	**0.5645 (1)**	0.4994 (6)	0.5604 (2)	0.5352 (3)	0.5290 (4)	0.5260 (5)	0.6168 (4)	0.6719 (2)	0.6314 (3)	0.5689 (5)	0.5550 (6)	**0.7128 (1)**
abalone9-18	**0.7748 (1)**	0.7307 (3)	0.7092 (5)	0.6271 (6)	0.7131 (4)	0.7328 (2)	**0.6813 (1)**	0.6691 (3)	0.6541 (5)	0.5577 (6)	0.6667 (4)	0.6754 (2)	**0.8239 (1)**	0.8105 (3)	0.7979 (4)	0.6057 (6)	0.7787 (5)	0.8107 (2)
ecoli4	**0.9963 (1)**	0.9846 (5)	0.9899 (3)	0.9155 (6)	0.9962 (2)	0.9848 (4)	0.8440 (2)	0.8264 (5)	0.8391 (3)	0.8357 (4)	**0.8577 (1)**	0.8123 (6)	**0.9315 (1)**	0.9055 (5)	0.9228 (3)	0.9239 (2)	0.9177 (4)	0.8535 (6)
led02456789v1	0.7555 (5)	0.7635 (4)	0.8205 (2)	**0.8389 (1)**	0.7544 (6)	0.7683 (3)	**0.6924 (1)**	0.5726 (6)	0.6103 (3)	0.6277 (2)	0.6087 (4)	0.5809 (5)	0.7497 (2)	0.7206 (4)	0.7177 (6)	0.7180 (5)	**0.7712 (1)**	0.7231 (3)
page-blocks0	**0.9586 (1)**	0.9377 (4)	0.9473 (2)	0.5770 (6)	0.9132 (5)	0.9429 (3)	0.9343 (2)	0.8994 (4)	**0.9407 (1)**	0.5874 (6)	0.8752 (5)	0.9292 (3)	0.9703 (4)	0.9721 (3)	**0.9798 (1)**	0.5933 (6)	0.9348 (5)	0.9761 (2)
ecoli3	**0.9363 (1)**	0.9265 (4)	0.9301 (2)	0.8329 (6)	0.9232 (5)	0.9273 (3)	**0.8264 (1)**	0.7664 (6)	0.7957 (4)	0.7807 (5)	0.8168 (2)	0.7970 (3)	0.8878 (4)	0.8825 (6)	0.8931 (3)	0.8984 (2)	**0.9099 (1)**	0.8863 (5)
yeast3	**0.9586 (1)**	0.9407 (5)	0.9463 (3)	0.8716 (6)	0.9574 (2)	0.9462 (4)	**0.8969** (1)	0.8223 (6)	0.8931 (3)	0.8268 (5)	0.8966 (2)	0.8852 (4)	0.9588 (2)	0.9410 (5)	**0.9608 (1)**	0.9021 (6)	0.9557 (3)	0.9522 (4)
new-thyroid1	0.9897 (3)	0.9927 (2)	0.9866 (4)	0.9109 (6)	0.9845 (5)	**0.9966 (1)**	0.9462 (2)	0.8857 (4)	0.9461 (3)	0.8418 (6)	**0.9474 (1)**	0.8856 (5)	0.9854 (3)	0.9814 (4)	**0.9904 (1)**	0.9624 (5)	0.9882 (2)	0.9436 (6)
new-thyroid2	0.9724 (5)	**0.9977 (1)**	0.9808 (4)	0.8940 (6)	0.9858 (3)	0.9919 (2)	**0.9593 (1)**	0.9158 (4)	0.9172 (3)	0.8751 (6)	0.9420 (2)	0.8920 (5)	0.9955 (2)	**0.9965 (1)**	0.9886 (3)	0.9785 (6)	0.9877 (4)	0.9814 (5)
vehicle3	**0.7816 (1)**	0.7742 (4)	0.7653 (5)	0.7758 (3)	0.7578 (6)	0.7788 (2)	0.7446 (2)	0.6855 (6)	0.7046 (3)	**0.7514 (1)**	0.6882 (5)	0.7024 (4)	0.8110 (4)	0.8180 (2)	0.8043 (6)	0.8107 (5)	0.8143 (3)	**0.8278 (1)**
vehicle1	**0.7735 (1)**	0.7578 (4)	0.7458 (6)	0.7679 (2)	0.7469 (5)	0.7621 (3)	**0.7673** (1)	0.6668 (6)	0.6998 (4)	0.7427 (3)	0.6777 (5)	**0.7432 (2)**	0.8310 (2)	0.8191 (5)	0.8214 (4)	**0.8325** (1)	0.8052 (6)	0.8272 (3)
vehicle2	0.9485 (2)	**0.9600 (1)**	0.9307 (5)	0.9120 (6)	0.9468 (3)	0.9460 (4)	**0.9413 (1)**	0.9286 (4)	0.9213 (5)	0.8945 (6)	0.9385 (2)	0.9340 (3)	0.9861 (4)	0.9862 (3)	**0.9884 (1)**	0.9494 (6)	0.9779 (5)	0.9868 (2)
glass0	**0.8682 (1)**	0.8491 (3)	0.8539 (2)	0.7704 (6)	0.8463 (4)	0.8423 (5)	0.8094 (2)	**0.8373 (1)**	0.7931 (4)	0.7386 (6)	0.7392 (5)	0.8060 (3)	0.8795 (3)	**0.9239 (1)**	0.8894 (2)	0.7866 (6)	0.8531 (5)	0.8672 (4)
pima	0.7632 (2)	0.7288 (6)	0.7604 (3)	**0.7822 (1)**	0.7451 (5)	0.7598 (4)	0.6114 (2)	0.5606 (5)	0.5659 (4)	**0.6217 (1)**	0.5461 (6)	0.6036 (3)	**0.6820 (1)**	0.6404 (5)	0.6476 (4)	0.6728 (2)	0.5624 (6)	0.6650 (3)
glass1	0.8702 (2)	**0.8844 (1)**	0.8417 (5)	0.7988 (6)	0.8607 (3)	0.8521 (4)	**0.7365 (1)**	0.6946 (5)	0.7054 (2)	0.6258 (6)	0.6966 (4)	0.7006 (3)	0.8392 (2)	**0.8404 (1)**	0.8119 (4)	0.6814 (6)	0.8082 (5)	0.8139 (3)
wdbc	0.9519 (1)	0.9454 (5)	0.9497 (4)	0.9504 (2)	0.9500 (3)	0.9431 (6)	**0.9372 (1)**	0.9291 (2)	0.9239 (4)	0.9087 (6)	0.9189 (5)	0.9276 (3)	0.9803 (5)	**0.9855 (1)**	0.9840 (2)	0.9712 (6)	0.9826 (3)	0.9809 (4)
spam	**0.8630 (1)**	0.8580 (2)	0.8503 (4)	0.8499 (5)	0.8510 (3)	0.8458 (6)	**0.9069 (1)**	0.9011 (2)	0.8927 (4)	0.8672 (6)	0.8964 (3)	0.8885 (5)	0.9712 (2)	0.9692 (4)	0.9694 (3)	0.9539 (6)	**0.9724 (1)**	0.9644 (5)
Avg. rank	1.90	3.67	3.86	4.62	3.43	3.52	1.48	4.48	3.19	4.71	3.29	3.86	2.52	3.38	2.86	5.00	3.76	3.48

Table 2: F1 Scores

	KNN						C4.5						C4.5 + Bagging					
	RWMaU	Original	RUS	IHT	CC	NCR	Proposed	Original	RUS	IHT	CC	NCR	Proposed	Original	RUS	IHT	CC	NCR
yeast5	0.6200 (3)	0.6606 (2.0)	0.3978 (5)	0.1420 (6)	0.4052 (4)	**0.7540 (1.0)**	0.4662 (5)	**0.6995 (1)**	0.5478 (4)	0.1726 (6)	0.6000 (3)	0.6470 (2)	0.4699 (5)	0.6760 (2)	0.5128 (4)	0.1972 (6)	0.5647 (3)	**0.7272 (1)**
yeast1289v7	**0.1938 (1)**	0.0000 (5.5)	0.0930 (3)	0.0760 (4)	0.1064 (2)	0.0000 (5.5)	**0.1953 (1)**	0.1680 (2)	0.0795 (6)	0.0856 (5)	0.0886 (4)	0.1316 (3)	0.1688 (3)	**0.2052 (1)**	0.1274 (4)	0.0786 (6)	0.0904 (5)	0.1821 (2)
wine-red-4	**0.1345 (1)**	0.0000 (6.0)	0.0898 (4)	0.0924 (3)	0.0952 (2)	0.0787 (5.0)	**0.1652 (1)**	0.1235 (3)	0.1023 (4)	0.0782 (6)	0.0897 (5)	0.1246 (2)	**0.1452 (1)**	0.0897 (4)	0.1318 (2)	0.0791 (5)	0.1004 (3)	0.0438 (6)
yeast4	**0.4530 (1)**	0.1616 (5.0)	0.2824 (4)	0.1148 (6)	0.3137 (3)	0.4200 (2.0)	0.1943 (4)	0.2751 (2)	0.2164 (3)	0.0771 (6)	0.1245 (5)	**0.2847 (1)**	0.2132 (4)	0.2570 (2)	0.2140 (3)	0.0761 (6)	0.1472 (5)	**0.3013 (1)**
yeast1458v7	**0.1433 (1)**	0.0250 (6.0)	0.1123 (3)	0.1033 (4)	0.1189 (2)	0.0450 (5.0)	0.0947 (2)	0.0461 (6)	**0.0992 (1)**	0.0861 (3)	0.0793 (4)	0.0769 (5)	0.1045 (2)	0.0250 (5)	**0.1193 (1)**	0.0891 (3)	0.0863 (4)	0.0200 (6)
abalone9-18	**0.3203 (1)**	0.0836 (6.0)	0.1978 (3)	0.1339 (5)	0.2223 (2)	0.1479 (4.0)	0.2978 (3)	**0.3540 (1)**	0.1945 (5)	0.1307 (6)	0.2055 (4)	0.3460 (2)	0.3650 (3)	**0.4101 (1)**	0.2316 (5)	0.1323 (6)	0.2968 (4)	0.3882 (2)
ecoli4	**0.8770 (1)**	0.8571 (3.0)	0.5377 (5)	0.3148 (6)	0.5533 (4)	0.8587 (2.0)	0.4124 (5)	**0.6760 (1)**	0.4292 (3)	0.3160 (6)	0.4177 (4)	0.6419 (2)	0.4898 (3)	**0.6698 (1)**	0.4739 (4)	0.3405 (6)	0.4362 (5)	0.6664 (2)
led02456789v1	**0.5000 (1)**	0.4300 (4.0)	0.4402 (3)	0.4072 (6)	0.4249 (5)	0.4467 (2.0)	**0.4065 (1)**	0.1675 (6)	0.2702 (5)	0.3102 (2)	0.2803 (3)	0.2758 (4)	**0.4325 (1)**	0.1286 (6)	0.3180 (4)	0.3141 (5)	0.3794 (2)	0.3397 (3)
page-blocks0	0.7229 (3)	**0.7586 (1.0)**	0.6823 (4)	0.1968 (6)	0.4094 (5)	0.7542 (2.0)	0.7600 (3)	0.8123 (2)	0.7456 (4)	0.2099 (6)	0.5047 (5)	**0.8248 (1)**	0.7943 (3)	**0.8584 (1)**	0.7534 (4)	0.2101 (6)	0.5066 (5)	0.8499 (2)
ecoli3	0.6205 (2)	0.5905 (3.0)	0.5540 (5)	0.3670 (6)	0.5748 (4)	**0.6305 (1.0)**	0.5047 (4)	**0.5728 (1)**	0.4843 (5)	0.3971 (6)	0.5471 (3)	0.5644 (2)	0.5464 (4)	0.5821 (3)	0.5441 (5)	0.4164 (6)	0.5914 (2)	**0.6206 (1)**
yeast3	0.7140 (3)	0.7225 (2.0)	0.6569 (4)	0.3550 (6)	0.6568 (5)	**0.7378 (1.0)**	0.6148 (5)	0.6872 (2)	0.6608 (3)	0.4316 (6)	0.6257 (4)	**0.7277 (1)**	0.6855 (5)	0.7107 (3)	0.7175 (2)	0.4518 (6)	0.6897 (4)	**0.7673 (1)**
new-thyroid1	**0.8712 (1)**	0.8147 (5.0)	0.8635 (3)	0.5276 (6)	0.8268 (4)	0.8672 (2.0)	0.8669 (2)	0.8228 (4)	**0.8692 (1)**	0.6110 (6)	0.8448 (3)	0.8226 (5)	0.8571 (3)	0.8511 (4)	**0.8922 (1)**	0.6222 (6)	0.8608 (2)	0.8340 (5)
new-thyroid2	0.7783 (5)	0.7934 (4.0)	0.8041 (2)	0.5129 (6)	0.7953 (3)	**0.8154 (1.0)**	0.8346 (2)	**0.8669 (1)**	0.7964 (4)	0.6337 (6)	0.7924 (5)	0.8325 (3)	0.8651 (4)	**0.9003 (1)**	0.8795 (3)	0.6328 (6)	0.7877 (5)	0.8931 (2)
vehicle3	0.5162 (4)	0.4233 (6.0)	0.5309 (3)	**0.5576 (1)**	0.5099 (5)	0.5455 (2.0)	0.6088 (2)	0.5411 (6)	0.5668 (3)	**0.6097 (1)**	0.5499 (5)	0.5653 (4)	**0.6303 (1)**	0.4735 (6)	0.5870 (5)	0.6302 (2)	0.5890 (4)	0.6249 (3)
vehicle1	**0.5680 (1)**	0.4669 (6.0)	0.5483 (5)	0.5632 (2)	0.5588 (3)	0.5582 (4.0)	**0.5990 (1)**	0.5031 (6)	0.5469 (4)	0.5834 (3)	0.5205 (5)	0.5953 (2)	**0.6161 (1)**	0.4964 (6)	0.6014 (4)	0.6151 (2)	0.5838 (5)	0.6083 (3)
vehicle2	0.7883 (2)	**0.8132 (1.0)**	0.7390 (5)	0.6918 (6)	0.7738 (4)	0.7852 (3.0)	**0.9095 (1)**	0.9020 (2)	0.8567 (5)	0.7732 (6)	0.8700 (4)	0.8994 (3)	0.9217 (2)	**0.9261 (1)**	0.9125 (4)	0.7849 (6)	0.8861 (5)	0.9142 (3)
glass0	**0.7113 (1)**	0.6806 (4.0)	0.6920 (3)	0.6527 (6)	0.6549 (5)	0.7071 (2.0)	0.7282 (2)	**0.7732 (1)**	0.7087 (4)	0.6519 (6)	0.6533 (5)	0.7202 (3)	0.7331 (3)	0.7682 (2)	**0.7776 (1)**	0.6477 (6)	0.6928 (5)	0.7302 (4)
pima	**0.6527 (1)**	0.5541 (6.0)	0.6318 (4)	0.6508 (2)	0.6284 (5)	0.6505 (3.0)	0.4567 (2)	0.3497 (6)	0.3978 (4)	**0.4764 (1)**	0.3869 (5)	0.4476 (3)	0.4675 (2)	0.2823 (6)	0.4309 (4)	**0.4735 (1)**	0.4006 (5)	0.4646 (3)
glass1	0.7112 (5)	0.7208 (3.0)	0.7143 (4)	0.7039 (6)	**0.7489 (1)**	0.7298 (2.0)	**0.6650 (1)**	0.5956 (5)	0.6308 (3)	0.5683 (6)	0.6251 (4)	0.6320 (2)	**0.6676 (1)**	0.6617 (2)	0.6560 (5)	0.5856 (6)	0.6562 (4)	0.6579 (3)
wdbc	0.8816 (4)	0.8875 (3.0)	**0.8927 (1)**	0.8775 (5)	0.8901 (2)	0.8756 (6.0)	**0.9118 (1)**	0.9081 (2)	0.8952 (4)	0.8660 (6)	0.8939 (5)	0.9035 (3)	0.9248 (4)	**0.9369 (1)**	0.9302 (2)	0.8898 (6)	0.9209 (5)	0.9260 (3)
spam	**0.7497 (1)**	0.7391 (6.0)	0.7406 (5)	0.7471 (2)	0.7436 (3)	0.7430 (4.0)	**0.8842 (1)**	0.8799 (2)	0.8681 (4)	0.8333 (6)	0.8714 (3)	0.8600 (5)	**0.9229 (1)**	0.9118 (4)	0.9194 (2)	0.8692 (6)	0.9158 (3)	0.8963 (5)
Avg. rank	2.05	4.17	3.71	4.76	3.48	2.83	2.33	2.95	3.76	5.00	4.19	2.76	2.67	2.95	3.29	5.14	4.05	2.90



(a) AUC C4.5 (b) F1 Score C4.5

(c) AUC C4.5 + Bagging (d) F1 Score C4.5 + Bagging

(e) AUC KNN (f) F1 Score KNN

Fig. 1: Critical difference plots of the post-hoc Friedman multiple classifier comparison test with significance level $\alpha = 0.05$ for AUC and F1 Score for the KNN, C4.5 and C4.5 + Bagging experiments.

Table 3: AUC C4.5 post-hoc Friedman p-values and win/lose/tie counts

	RWMaU	original	RUS	IHT	CC	NCR
RWMaU		20/1/0	17/4/0	19/2/0	18/3/0	21/0/0
original	0.0000 ***		6/15/0	12/9/0	6/15/0	7/14/0
RUS	0.0089 ***	0.0481 **		16/5/0	11/10/0	13/8/0
IHT	0.0000 ***	0.7051	0.0206 **		5/16/0	6/15/0
CC	0.0064 ***	0.0645 *	0.8690	0.0284 **		13/8/0
NCR	0.0002 ***	0.3409	0.3223	0.1992	0.3617	

Table 4: AUC C4.5 + Bagging post-hoc Friedman p-values and win/lose/tie counts

	RWMaU	original	RUS	IHT	CC	NCR
RWMaU		12/9/0	12/9/0	19/2/0	14/7/0	16/5/0
original	0.2187		8/13/0	17/4/0	12/9/0	9/12/0
RUS	0.6160	0.4608		15/6/0	16/5/0	13/8/0
IHT	0.0003 ***	0.0250 **	0.0015 ***		4/17/0	5/16/0
CC	0.0930 *	0.5894	0.2082	0.0930 *		9/12/0
NCR	0.2003	0.8690	0.3937	0.0308 **	0.6461	

Table 5: AUC KNN post-hoc Friedman p-values and win/lose/tie counts

	RWMaU	original	RUS	IHT	CC	NCR
RWMaU		16/5/0	18/3/0	18/3/0	17/4/0	17/4/0
original	0.0113 **		11/10/0	14/7/0	12/9/0	7/14/0
RUS	0.0054 ***	0.7900		14/7/0	7/14/0	11/10/0
IHT	0.0000 ***	0.1776	0.2917		5/16/0	7/14/0
CC	0.0247 **	0.7594	0.6009	0.0952 *		11/10/0
NCR	0.0188 **	0.8261	0.6773	0.1198	0.8690	

Table 6: F1 Score C4.5 post-hoc Friedman p-values and win/lose/tie counts

	RWMaU	original	RUS	IHT	CC	NCR
RWMaU		12/9/0	15/6/0	19/2/0	17/4/0	14/7/0
original	0.3409		14/7/0	16/5/0	14/7/0	11/10/0
RUS	0.0395 **	0.2313		16/5/0	14/7/0	4/17/0
IHT	0.0001 ***	0.0019 ***	0.0673 *		5/16/0	4/17/0
CC	0.0049 ***	0.0673 *	0.5066	0.2313		4/17/0
NCR	0.5066	0.7415	0.1349	0.0008 ***	0.0395 **	

Table 7: F1 Score C4.5 + Bagging post-hoc Friedman p-values and win/lose/tie counts

	RWMaU	original	RUS	IHT	CC	NCR
RWMaU		9/12/0	13/8/0	20/1/0	17/4/0	11/10/0
original	0.6732		11/10/0	16/5/0	12/9/0	13/8/0
RUS	0.3937	0.6454		18/3/0	15/6/0	6/15/0
IHT	0.0003 ***	0.0008 ***	0.0049 ***		4/17/0	5/16/0
CC	0.0494 **	0.1198	0.2917	0.1198		5/16/0
NCR	0.7051	0.9343	0.6213	0.0008 ***	0.1152	

Table 8: F1 Score KNN post-hoc Friedman p-values and win/lose/tie counts

	proposed	original	RUS	IHT	CC	NCR
proposed		14/7/0	17/4/0	20/1/0	18/3/0	14/7/0
original	0.0018 ***		7/14/0	13/8/0	8/13/0	3/17/1
RUS	0.0145 **	0.4558		16/5/0	9/12/0	5/16/0
IHT	0.0000 ***	0.3402	0.1265		4/17/0	8/13/0
CC	0.0395 **	0.3019	0.6801	0.0548 *		8/13/0
NCR	0.2487	0.0515 *	0.2026	0.0042 ***	0.3200	