Appendices for "An empirical study of data sampling techniques for just-in-time software defect prediction"

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1 Comparison results of LApredict with random forest classifier

Previous defect prediction work Tan et al (2015); Ghotra et al (2015) point out random forest (RF) tends to be the top-performing classification techniques, tends to produce stable performance estimates, and is insensitive to parameter settings. Hence, we consider LApredict using the RF classifier to build JIT-SDP models.

Fig. 1 shows the absolute performance of LApredict with RF when applying data sampling techniques to defect prediction models for each of the 6 non-effort-aware measures in the context of defect classification. In this figure, a red dotted line indicates a performance difference of zero (i.e., no improvement). Fig. 2 shows the results of Scott-Knott ESD test concerning the 6 non-effort-aware performance measures. In this test, different colors denote different groups with statistical significance. The lower

the value, the better the model performance. As shown in these figures, we have the following observations:

①In terms of *Recall*, almost all the data sampling algorithms exhibit better than NONE with statistical significance, expect for the ROM algorithm, which has a performance similar to NONE. Especially, ENN achieves the best performance since it lies in the first group. Following it are NearMiss and RUM.

②With regard to *Precision* and *Pf*, NONE performs the best while NearMiss performs the worst among the data sampling algorithms, indicating that data sampling algorithms do not improve the performance in these two measures.

③Regarding *F-measure*, most of the data sampling algorithms achieve better results than NONE with statistical significance. Specifically, ENN, RUM and SMOTE+ENN outperform other algorithms in terms of *F-measure*.

④Regarding *AUC*, most of the data sampling algorithms show improvements. Among all the algorithms, RUM obtains the best performance in *AUC*.

⑤In terms of *MCC*, only several data sampling algorithms show improvements. Among them, BSMOTE and TomekLink obtain the best performance, followed by SMOTE+Tomek.

In summary, the data sampling techniques usually can produce good results in terms of *Recall*, *F-measure*, *AUC*, and *MCC*, while exhibiting poor performance in *Precision* and *Pf* in the scenario of defect classification for JIT-SDP. Among all the data sampling algorithms, the RUM and ENN emerge as the best-performing algorithms overall, particularly excelling in *Recall*, *F-measure*, and *AUC*.

The data sampling techniques demonstrate varying performance across different evaluation measures in the context of defect classification for JIT-SDP. Among them, the RUM and ENN algorithms emerge as the most favorable option for achieving superior results overall, especially in Recall, F-measure, and AUC.

Fig. 3 shows the absolute performance of LApredict with RF when applying data sampling techniques to defect prediction models for each of the 6 effort-aware measures. In this figure, a red dotted line indicates a performance difference of zero (i.e., no improvement). Fig. 4 shows the results of Scott-Knott ESD test concerning the 6 effort-aware performance measures across 10 projects in the scenario of defect ranking. From these figures, we make the following observations: ①In terms of *Popt*, all the data sampling algorithms demonstrate better performance than NONE with statistical significance which is in the last group. Especially, ENN achieves the best performance, followed by RUM. The *Recall@20%* measure shows similar results to those of *Popt*.

②With respect to *Precision@20%*, *PCI@20%*, and *IFA*, NONE exhibits the best performance with statistical significance among all the algorithms, indicting that data sampling algorithms have negative impact on these performance measures. This implies that the initial false alarms may negatively impact practitioners? patience and confidence in practice.

③Regarding *F-measure@20%*, most of the data sampling algorithms show better performance than NONE with statistical significance. The RUM and ENN algorithms achieve the best performance among all the methods since they lie in the first group.

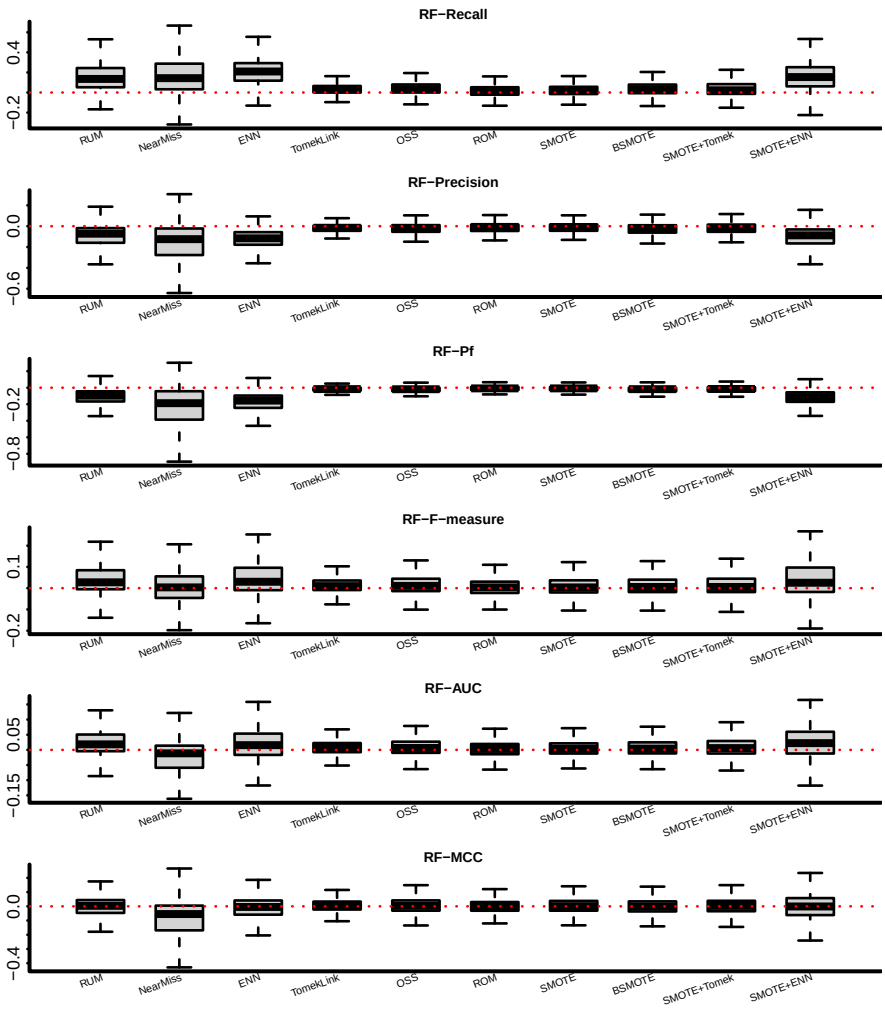

Fig. 1 The absolute performance difference of all sampling algorithms for each of the 6 non-effort-aware performance measures across 10 projects

In summary, the data sampling techniques utilized in the defect ranking for JIT-SDP demonstrate favorable results in terms of *Popt*, *Recall@20%*, and *F-measure@20%*, especially for ENN and RUM. These measures indicate that the data sampling algorithms are effective in improving the ranking performance and identifying potential defects in JIT-SDP. However, the data sampling techniques exhibit relatively poorer performance in *Precision@20%*, *PCI@20%*, and *IFA*. These measures focus on the precision of defect ranking, and the data sampling algorithms may not consistently achieve high precision or minimize the number of incorrectly ranked changes.

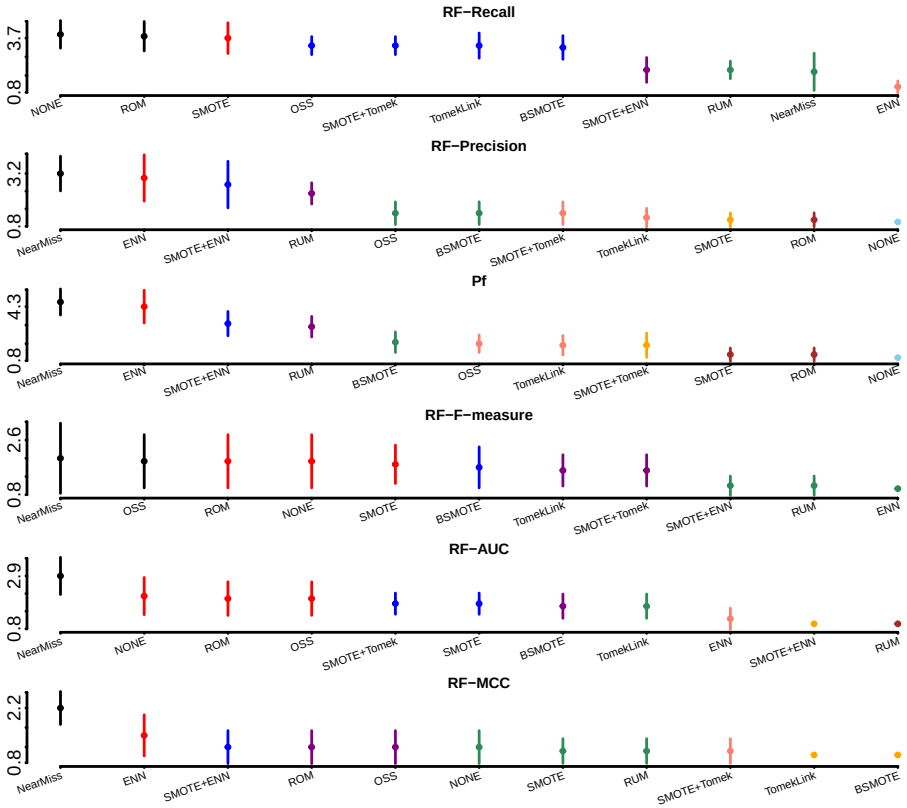

Fig. 2 The results of Scott-Knott ESD test of all sampling algorithms for each of the 6 non-effort-aware performance measures across 10 projects (the lower the better, the same below)

The effectiveness of data sampling techniques can vary depending on the specific evaluation measures in the context of defect ranking for JIT-SDP. Among them, the ENN and RUM algorithms stand out as the most favorable option for achieving superior results overall, especially in Popt, Recall@20%, and F-measure@20%.

2 Comparison results of each data sampling algorithms

Tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 present detailed Median values for *Recall, Precision, Pf, F-measure, AUC, MCC*, P_{opt}, *Recall@20%*, *Precision@20%*, *F-measure@20%*, *PCI@20%*, and *IFA* Tantithamthavorn et al (2017); Yang et al (2016); Tantithamthavorn et al (2020); Bennin et al (2022); Huang et al (2019); Han et al (2005); Chawla et al (2002); Huang et al (2017); Liu et al (2017); Bennin et al (2017) for each project on each sampling algorithm. The overall median values across all projects are also provided. Additionally, the table highlights the optimal algorithm for each project.

Table 1 Median value on *Recall* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.384	0.687	0.677	0.688	0.441	0.426	0.696	0.697	**0.721**	0.714	0.685
JGroups	0.331	0.648	0.667	0.571	0.350	0.358	0.652	0.648	**0.673**	0.652	0.577
Camel	0.442	0.733	0.691	**0.782**	0.508	0.511	0.733	0.731	0.754	0.749	0.731
Tomcat	0.529	0.672	0.677	**0.834**	0.561	0.563	0.676	0.676	0.711	0.689	0.650
Brackets	0.673	0.775	0.785	**0.879**	0.689	0.691	0.783	0.776	0.818	0.783	0.765
Neutron	0.747	0.844	0.802	**0.907**	0.764	0.819	0.844	0.844	0.883	0.852	0.849
Spring	0.599	0.774	0.677	**0.878**	0.647	0.667	0.757	0.758	0.811	0.797	0.811
Broadleaf	0.469	0.750	0.668	0.760	0.512	0.512	0.747	0.750	**0.786**	0.763	0.722
Nova	0.719	0.862	0.781	**0.919**	0.733	0.766	0.860	0.860	0.894	0.862	0.867
Npm	0.288	0.667	0.667	0.667	0.333	0.358	0.667	0.662	0.686	**0.692**	0.677
Mean	0.518	0.741	0.709	**0.788**	0.554	0.567	0.741	0.740	0.774	0.755	0.733

Table 2 Median value on *Precision* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	**0.610**	0.510	0.518	0.522	0.586	0.586	0.513	0.510	0.503	0.509	0.522
JGroups	**0.643**	0.457	0.452	0.533	0.625	0.636	0.456	0.456	0.438	0.455	0.487
Camel	**0.600**	0.507	0.507	0.494	0.593	0.590	0.508	0.504	0.497	0.496	0.508
Tomcat	**0.709**	0.641	0.638	0.564	0.689	0.690	0.641	0.641	0.624	0.638	0.665
Brackets	**0.732**	0.677	0.675	0.634	0.728	0.717	0.680	0.680	0.655	0.676	0.694
Neutron	0.759	0.731	0.753	0.689	**0.763**	0.741	0.731	0.731	0.717	0.722	0.731
Spring	**0.729**	0.681	0.700	0.642	0.714	0.707	0.677	0.682	0.667	0.679	0.667
Broadleaf	**0.661**	0.538	0.540	0.521	0.635	0.631	0.537	0.533	0.524	0.525	0.535
Nova	**0.747**	0.704	0.730	0.685	0.739	0.714	0.704	0.704	0.692	0.702	0.704
Npm	0.581	0.481	0.500	0.476	**0.586**	0.571	0.494	0.486	0.482	0.482	0.493
Mean	**0.677**	0.593	0.601	0.576	0.666	0.658	0.594	0.593	0.580	0.588	0.600

Table 3 Median value on *Pf* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	**0.084**	0.303	0.295	0.316	0.116	0.117	0.300	0.306	0.330	0.325	0.272
JGroups	**0.061**	0.316	0.334	0.212	0.078	0.08	0.316	0.307	0.334	0.316	0.248
Camel	**0.120**	0.306	0.290	0.332	0.137	0.137	0.306	0.306	0.325	0.318	0.296
Tomcat	**0.172**	0.263	0.269	0.465	0.186	0.186	0.263	0.263	0.295	0.272	0.243
Brackets	**0.138**	0.206	0.213	0.306	0.144	0.144	0.205	0.206	0.244	0.214	0.188
Neutron	**0.122**	0.171	0.147	0.222	0.135	0.154	0.178	0.179	0.197	0.179	0.180
Spring	**0.165**	0.279	0.228	0.349	0.193	0.220	0.272	0.284	0.292	0.283	0.298
Broadleaf	**0.088**	0.249	0.194	0.259	0.103	0.098	0.246	0.252	0.287	0.258	0.218
Nova	**0.131**	0.184	0.156	0.223	0.139	0.151	0.187	0.184	0.211	0.191	0.197
Npm	**0.087**	0.313	0.313	0.342	0.097	0.119	0.319	0.319	0.333	0.339	0.316
Mean	**0.117**	0.259	0.244	0.303	0.133	0.141	0.259	0.261	0.285	0.270	0.246

Table 4 Median value on *F-measure* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.450	0.564	0.556	0.557	0.483	0.479	0.564	**0.568**	**0.568**	0.567	0.563
JGroups	0.407	0.532	0.532	0.492	0.409	0.411	**0.533**	0.527	0.530	0.524	0.521
Camel	0.514	0.599	0.582	0.600	0.533	0.537	**0.601**	0.598	0.593	0.594	0.597
Tomcat	0.610	0.653	0.648	0.657	0.617	0.618	0.648	0.648	**0.658**	0.653	0.644
Brackets	0.691	0.724	0.714	0.712	0.693	0.697	0.723	**0.725**	0.719	**0.725**	0.717
Neutron	0.748	0.781	0.774	**0.793**	0.753	0.759	0.778	0.778	0.780	0.783	0.781
Spring	0.654	0.704	0.678	**0.713**	0.664	0.678	0.705	0.702	0.705	0.704	0.699
Broadleaf	0.527	0.600	0.598	0.592	0.549	0.553	**0.608**	**0.608**	0.604	**0.608**	0.605
Nova	0.734	0.760	0.760	**0.768**	0.741	0.745	0.760	0.760	0.759	0.760	0.752
Npm	0.349	0.538	**0.553**	0.527	0.411	0.411	0.545	0.544	0.547	0.545	0.524
Mean	0.568	0.646	0.640	0.641	0.585	0.589	**0.647**	0.646	0.646	0.646	0.640

Table 5 Median value on *AUC* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.632	0.702	0.704	0.692	0.651	0.652	0.706	0.706	0.704	0.706	**0.707**
JGroups	0.614	0.665	0.664	0.648	0.623	0.623	0.665	0.666	**0.667**	**0.667**	0.661
Camel	0.656	**0.722**	0.701	0.713	0.666	0.666	**0.722**	0.721	0.718	0.719	0.714
Tomcat	0.687	**0.701**	**0.701**	0.666	0.692	0.692	0.700	0.700	0.700	0.698	0.698
Brackets	0.771	0.789	**0.790**	0.785	0.771	0.773	0.789	0.789	0.788	0.789	0.780
Neutron	0.809	0.833	0.823	**0.840**	0.816	0.825	0.831	0.833	0.839	0.835	0.834
Spring	0.704	0.727	0.714	0.717	0.705	0.707	0.729	0.728	**0.731**	0.730	0.728
Broadleaf	0.683	0.750	0.733	0.735	0.696	0.696	0.751	**0.754**	0.747	0.751	0.748
Nova	0.796	0.834	0.818	**0.839**	0.806	0.805	0.834	0.833	0.835	0.834	0.834
Npm	0.598	0.680	0.673	0.647	0.623	0.623	0.689	0.685	0.680	**0.694**	0.669
Mean	0.695	0.740	0.732	0.728	0.705	0.706	0.741	**0.742**	0.741	**0.742**	0.737

Table 6 Median value on *MCC* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.310	0.371	0.363	0.376	0.322	0.318	0.364	0.360	0.369	0.373	**0.380**
JGroups	0.296	0.298	0.301	0.285	0.296	0.298	0.306	0.301	0.302	0.297	**0.314**
Camel	0.342	0.397	0.385	0.393	0.354	0.352	0.400	**0.401**	**0.401**	0.394	0.392
Tomcat	0.394	0.394	0.396	0.339	0.401	0.402	0.394	0.393	0.395	0.394	**0.403**
Brackets	0.544	0.558	**0.563**	0.545	0.552	0.554	**0.563**	0.561	0.557	0.56	0.554
Neutron	0.620	0.640	0.627	**0.664**	0.627	0.642	0.638	0.643	0.645	0.643	0.644
Spring	0.414	0.442	0.408	0.439	0.429	0.429	0.439	0.437	**0.453**	0.445	0.443
Broadleaf	0.403	**0.457**	0.430	0.416	0.414	0.417	0.455	**0.457**	0.448	0.456	0.452
Nova	0.590	0.622	0.598	0.622	0.592	0.579	0.613	0.613	**0.631**	0.623	0.623
Npm	0.250	0.301	0.309	0.287	0.274	0.267	**0.313**	0.308	0.299	0.308	0.288
Mean	0.416	0.448	0.438	0.436	0.426	0.426	0.448	0.447	**0.450**	0.449	0.449

Table 7 Median value on P_{opt} for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.490	0.725	0.709	0.736	0.541	0.554	0.721	0.721	**0.748**	0.744	0.736
JGroups	0.430	0.605	0.629	0.579	0.436	0.448	0.611	0.605	**0.632**	0.603	0.543
Camel	0.489	0.716	0.680	**0.773**	0.528	0.523	0.712	0.711	0.741	0.730	0.711
Tomcat	0.529	0.646	0.655	**0.804**	0.546	0.548	0.647	0.658	0.684	0.666	0.636
Brackets	0.639	0.761	0.772	**0.858**	0.655	0.663	0.766	0.761	0.808	0.771	0.749
Neutron	0.740	0.832	0.809	**0.902**	0.763	0.821	0.832	0.832	0.876	0.846	0.849
Spring	0.614	0.748	0.684	**0.851**	0.643	0.656	0.748	0.747	0.754	0.754	0.795
Broadleaf	0.488	0.748	0.670	0.752	0.521	0.513	0.740	0.748	**0.756**	0.751	0.716
Nova	0.719	0.850	0.762	**0.917**	0.732	0.770	0.850	0.850	0.888	0.857	0.856
Npm	0.434	0.652	0.655	0.681	0.461	0.463	0.653	0.649	0.667	0.670	**0.682**
Mean	0.557	0.728	0.703	**0.785**	0.583	0.596	0.728	0.728	0.755	0.739	0.727

Table 8 Median value on *Recall@20%* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.390	0.696	0.678	0.699	0.453	0.435	0.696	0.706	**0.730**	0.719	0.699
JGroups	0.303	0.548	0.562	0.492	0.319	0.327	0.556	0.550	**0.571**	0.549	0.475
Camel	0.390	0.680	0.647	**0.711**	0.452	0.452	0.678	0.678	0.690	0.685	0.677
Tomcat	0.477	0.591	0.592	**0.744**	0.494	0.494	0.597	0.592	0.624	0.613	0.577
Brackets	0.606	0.724	0.749	**0.813**	0.627	0.630	0.725	0.728	0.764	0.733	0.707
Neutron	0.733	0.816	0.790	**0.884**	0.744	0.787	0.814	0.814	0.853	0.827	0.822
Spring	0.556	0.692	0.619	**0.762**	0.592	0.600	0.692	0.692	0.700	0.700	0.721
Broadleaf	0.437	0.704	0.641	0.703	0.470	0.470	0.701	0.705	**0.735**	0.710	0.671
Nova	0.693	0.826	0.747	**0.882**	0.706	0.756	0.827	0.826	0.851	0.832	0.824
Npm	0.294	0.615	0.618	0.622	0.348	0.348	0.612	0.615	0.640	**0.654**	0.642
Mean	0.488	0.689	0.664	**0.731**	0.520	0.530	0.690	0.691	0.716	0.702	0.682

Table 9 Median value on *Precision@20%* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	**0.603**	0.479	0.495	0.488	0.585	0.585	0.484	0.484	0.465	0.476	0.493
JGroups	**0.571**	0.409	0.407	0.462	0.561	0.559	0.417	0.417	0.397	0.409	0.440
Camel	**0.583**	0.489	0.484	0.468	0.576	0.575	0.487	0.487	0.479	0.484	0.497
Tomcat	**0.684**	0.613	0.616	0.540	0.667	0.671	0.608	0.607	0.594	0.606	0.642
Brackets	**0.712**	0.643	0.643	0.588	0.697	0.696	0.653	0.652	0.628	0.646	0.662
Neutron	**0.766**	0.724	0.75	0.681	0.760	0.740	0.724	0.730	0.695	0.724	0.718
Spring	0.712	0.656	0.683	0.628	**0.718**	0.706	0.654	0.659	0.633	0.654	0.656
Broadleaf	0.631	0.525	0.529	0.508	**0.635**	**0.635**	0.525	0.519	0.506	0.511	0.523
Nova	**0.714**	0.694	0.709	0.641	**0.714**	0.707	0.695	0.699	0.676	0.695	0.676
Npm	0.569	0.448	0.484	0.467	**0.584**	0.557	0.470	0.470	0.456	0.442	0.474
Mean	**0.655**	0.568	0.580	0.547	0.650	0.643	0.572	0.572	0.553	0.565	0.578

Table 10 Median value on *F-measure@20%* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	0.453	0.558	0.556	0.553	0.485	0.479	0.558	0.562	0.561	**0.564**	0.558
JGroups	0.356	**0.471**	**0.471**	0.430	0.353	0.353	**0.471**	0.468	0.466	0.470	**0.471**
Camel	0.492	0.562	0.548	**0.563**	0.499	0.501	0.562	0.562	0.555	0.559	0.558
Tomcat	0.548	0.598	0.600	**0.614**	0.556	0.561	0.598	0.606	0.602	0.601	0.592
Brackets	0.600	0.651	0.646	0.671	0.606	0.610	0.667	0.660	0.662	0.664	**0.674**
Neutron	0.744	0.778	0.768	**0.781**	0.748	0.762	0.778	0.778	0.778	0.780	0.778
Spring	0.611	0.661	0.611	**0.676**	0.616	0.616	0.659	0.659	**0.676**	0.663	0.671
Broadleaf	0.500	0.572	0.561	0.565	0.529	0.540	**0.583**	0.577	0.570	0.576	0.576
Nova	0.699	**0.734**	0.723	0.730	0.699	0.700	**0.734**	**0.734**	0.732	**0.734**	0.725
Npm	0.340	0.511	**0.519**	0.481	0.381	0.366	0.511	0.511	0.512	0.512	0.472
Mean	0.534	0.61	0.600	0.606	0.547	0.549	**0.612**	**0.612**	0.611	**0.612**	0.608

Table 11 Median value on *PCI@20%* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	**0.182**	0.394	0.401	0.404	0.211	0.215	0.408	0.405	0.441	0.425	0.397
JGroups	**0.14**	0.364	0.384	0.313	0.158	0.158	0.370	0.370	0.392	0.373	0.315
Camel	**0.209**	0.413	0.403	0.459	0.239	0.239	0.412	0.411	0.429	0.421	0.402
Tomcat	**0.290**	0.395	0.408	0.561	0.302	0.305	0.396	0.396	0.429	0.409	0.370
Brackets	**0.293**	0.385	0.392	0.477	0.307	0.313	0.383	0.384	0.420	0.389	0.368
Neutron	**0.322**	0.396	0.364	0.449	0.339	0.366	0.394	0.394	0.422	0.399	0.399
Spring	**0.315**	0.409	0.386	0.505	0.354	0.373	0.408	0.404	0.429	0.430	0.438
Broadleaf	**0.170**	0.358	0.329	0.372	0.204	0.204	0.359	0.362	0.394	0.378	0.349
Nova	**0.366**	0.406	0.380	0.463	0.367	0.387	0.406	0.406	0.431	0.407	0.408
Npm	**0.163**	0.392	0.404	0.459	0.189	0.201	0.392	0.408	0.404	0.432	0.392
Mean	**0.245**	0.391	0.385	0.446	0.267	0.276	0.393	0.394	0.419	0.406	0.384

Table 12 Median value on *IFA* for each project

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+Tomek	SMOTE+ENN
Fabric8	**2**	4	3.5	4	**2**	**2**	4	4	4	4.5	5
JGroups	**2**	4	5	3	**2**	**2**	4	5	5	5	4
Camel	**2**	3	3	3	**2**	**2**	3	3	3	3	3
Tomcat	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
Brackets	**2**	3	3	4	**2**	**2**	3	3	3	3	**2**
Neutron	**1**	2	2	2	**1**	2	2	2	2	2	2
Spring	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Broadleaf	**2**	4	3	3	**2**	**2**	4	4	4	4	3
Nova	**2**	**2**	**2**	3	**2**	**2**	**2**	**2**	3	**2**	3
Npm	**2**	3	3	3	**2**	**2**	3	4	4	3	3
Mean	**1.8**	2.8	2.75	2.8	**1.8**	1.9	2.8	3	3.1	2.95	2.8

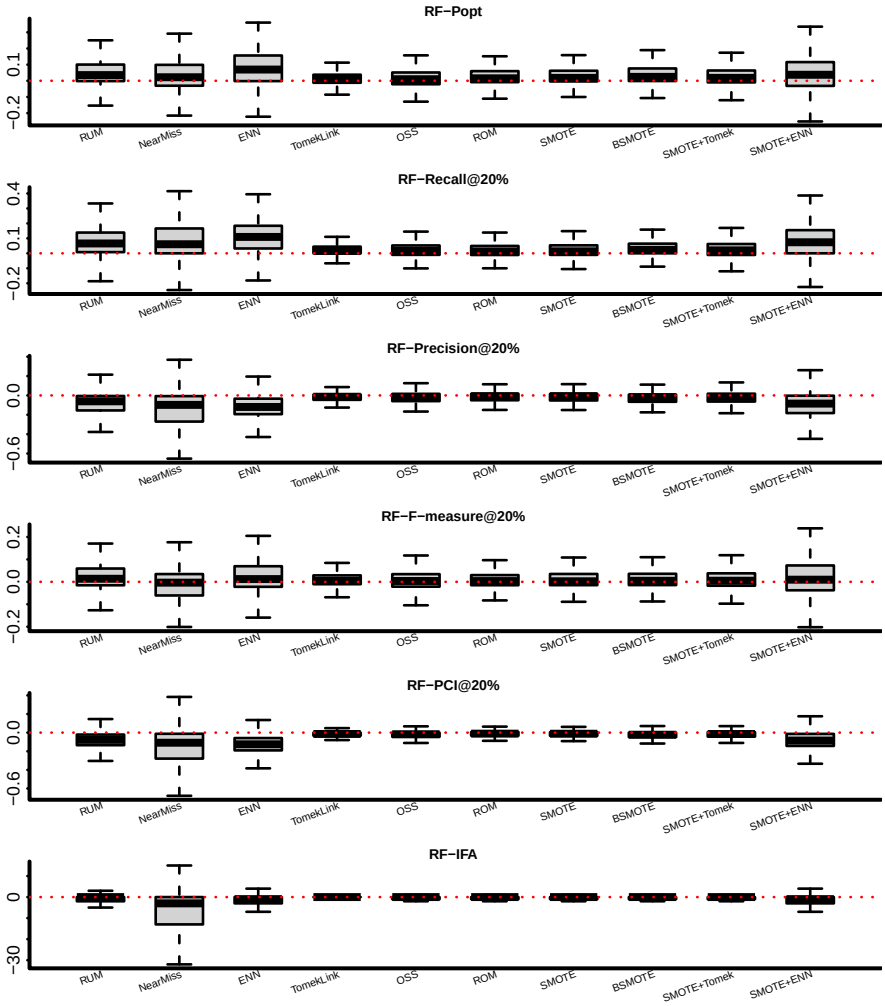

Fig. 3 The absolute performance difference of all sampling algorithms for each of the 6 effort-aware performance measures across 10 projects

3 Comparison results with different period lengths

Tables 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, and 24 present detailed Median values for *Recall, Precision, Pf, F-measure, AUC, MCC*, P_{opt}, *Recall@20%*, *Precision@20%*, *F-measure@20%*, *PCI@20%*, and *IFA* for each project on each sampling algorithm when the time period is two months and six months Tan et al (2015); Ghotra et al (2015); Cabral et al (2019). The overall mean values across all projects are also provided.

Table 13 Median value on *Recall* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.384	0.378	0.687	0.685	0.677	0.753	0.688	0.708	0.441	0.417	0.426	0.417	0.696	0.678	0.697	0.677	0.721	0.702	0.714	0.687	0.685	0.618
JGroups	0.331	0.294	0.648	0.671	0.667	0.689	0.571	0.584	0.35	0.317	0.358	0.317	0.652	0.673	0.648	0.673	0.673	0.686	0.652	0.673	0.577	0.558
Camel	0.442	0.469	0.733	0.745	0.691	0.798	0.782	0.798	0.508	0.494	0.511	0.494	0.733	0.746	0.731	0.746	0.754	0.766	0.749	0.751	0.731	0.672
Tomcat	0.529	0.591	0.672	0.688	0.677	0.697	0.834	0.848	0.561	0.596	0.563	0.596	0.676	0.686	0.676	0.686	0.711	0.715	0.689	0.696	0.65	0.624
Brackets	0.673	0.661	0.775	0.796	0.785	0.808	0.879	0.889	0.689	0.684	0.691	0.694	0.783	0.795	0.776	0.798	0.818	0.835	0.783	0.799	0.765	0.761
Neutron	0.747	0.761	0.844	0.837	0.802	0.8	0.907	0.916	0.764	0.772	0.819	0.836	0.844	0.837	0.844	0.837	0.883	0.874	0.852	0.843	0.849	0.839
Spring	0.599	0.637	0.774	0.74	0.677	0.686	0.878	0.866	0.647	0.645	0.667	0.575	0.757	0.743	0.758	0.743	0.811	0.763	0.797	0.768	0.811	0.761
Broadleaf	0.469	0.484	0.75	0.726	0.668	0.748	0.76	0.769	0.512	0.504	0.512	0.51	0.747	0.733	0.75	0.733	0.786	0.766	0.763	0.735	0.722	0.667
Nova	0.719	0.798	0.862	0.867	0.781	0.831	0.919	0.938	0.733	0.807	0.766	0.818	0.86	0.867	0.86	0.867	0.894	0.905	0.862	0.873	0.867	0.872
Npm	0.288	0.311	0.667	0.708	0.667	0.739	0.667	0.735	0.333	0.361	0.358	0.362	0.667	0.707	0.662	0.712	0.686	0.716	0.692	0.717	0.677	0.663
Mean	0.518	0.538	0.741	0.746	0.709	0.755	0.788	0.805	0.554	0.56	0.567	0.562	0.741	0.747	0.740	0.747	0.774	0.773	0.755	0.754	0.733	0.703

Table 14 Median value on *Precision* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.610	0.666	0.510	0.557	0.518	0.539	0.522	0.565	0.586	0.652	0.586	0.649	0.513	0.550	0.510	0.549	0.503	0.549	0.509	0.548	0.522	0.595
JGroups	0.643	0.627	0.457	0.447	0.452	0.433	0.533	0.478	0.625	0.620	0.636	0.611	0.456	0.443	0.456	0.447	0.438	0.441	0.455	0.444	0.487	0.478
Camel	0.600	0.570	0.507	0.507	0.507	0.481	0.494	0.477	0.593	0.557	0.590	0.557	0.508	0.510	0.504	0.509	0.497	0.502	0.496	0.507	0.508	0.529
Tomcat	0.709	0.695	0.641	0.643	0.638	0.645	0.564	0.544	0.689	0.692	0.690	0.689	0.641	0.643	0.641	0.644	0.624	0.636	0.638	0.643	0.665	0.684
Brackets	0.732	0.701	0.677	0.630	0.675	0.644	0.634	0.592	0.728	0.690	0.717	0.690	0.680	0.630	0.680	0.630	0.655	0.616	0.676	0.627	0.694	0.651
Neutron	0.759	0.726	0.731	0.699	0.753	0.717	0.689	0.639	0.763	0.717	0.741	0.663	0.731	0.699	0.731	0.699	0.717	0.681	0.722	0.691	0.731	0.677
Spring	0.729	0.770	0.681	0.702	0.700	0.729	0.642	0.672	0.714	0.760	0.707	0.757	0.677	0.702	0.682	0.702	0.667	0.688	0.679	0.692	0.667	0.705
Broadleaf	0.661	0.710	0.538	0.592	0.540	0.542	0.521	0.566	0.635	0.710	0.631	0.710	0.537	0.590	0.533	0.587	0.524	0.576	0.525	0.587	0.535	0.611
Nova	0.747	0.724	0.704	0.690	0.730	0.710	0.685	0.663	0.739	0.724	0.714	0.720	0.704	0.691	0.704	0.690	0.692	0.673	0.702	0.690	0.704	0.695
Npm	0.581	0.496	0.481	0.436	0.500	0.439	0.476	0.457	0.586	0.498	0.571	0.498	0.494	0.436	0.486	0.433	0.482	0.424	0.482	0.428	0.493	0.443
Mean	0.677	0.669	0.593	0.590	0.601	0.588	0.576	0.565	0.666	0.662	0.658	0.654	0.594	0.589	0.593	0.589	0.580	0.579	0.588	0.586	0.600	0.607

Table 15 Median value on *Pf* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.084	0.092	0.303	0.292	0.295	0.339	0.316	0.314	0.116	0.118	0.117	0.118	0.300	0.292	0.306	0.292	0.330	0.313	0.325	0.298	0.272	0.204
JGroups	0.061	0.060	0.316	0.307	0.334	0.371	0.212	0.216	0.078	0.071	0.080	0.071	0.316	0.306	0.307	0.306	0.334	0.327	0.316	0.310	0.248	0.210
Camel	0.120	0.154	0.306	0.310	0.290	0.365	0.332	0.371	0.137	0.168	0.137	0.168	0.306	0.310	0.306	0.312	0.325	0.335	0.318	0.319	0.296	0.260
Tomcat	0.172	0.177	0.263	0.270	0.269	0.289	0.465	0.489	0.186	0.186	0.186	0.189	0.263	0.270	0.263	0.269	0.295	0.304	0.272	0.276	0.243	0.199
Brackets	0.138	0.149	0.206	0.212	0.213	0.226	0.306	0.334	0.144	0.160	0.144	0.161	0.205	0.213	0.206	0.213	0.244	0.254	0.214	0.213	0.188	0.198
Neutron	0.122	0.125	0.171	0.181	0.147	0.145	0.222	0.235	0.135	0.131	0.154	0.175	0.178	0.181	0.179	0.181	0.197	0.210	0.179	0.187	0.180	0.173
Spring	0.165	0.124	0.279	0.238	0.228	0.179	0.349	0.256	0.193	0.133	0.220	0.133	0.272	0.238	0.284	0.228	0.292	0.253	0.283	0.247	0.298	0.247
Broadleaf	0.088	0.086	0.249	0.210	0.194	0.236	0.259	0.249	0.103	0.096	0.098	0.094	0.246	0.212	0.252	0.214	0.287	0.263	0.258	0.223	0.218	0.181
Nova	0.131	0.159	0.184	0.198	0.156	0.174	0.223	0.246	0.139	0.161	0.151	0.164	0.187	0.198	0.184	0.198	0.211	0.222	0.191	0.199	0.197	0.193
Npm	0.087	0.103	0.313	0.374	0.313	0.412	0.342	0.384	0.097	0.123	0.119	0.124	0.319	0.381	0.319	0.374	0.333	0.396	0.339	0.392	0.316	0.336
Mean	0.117	0.123	0.259	0.259	0.244	0.274	0.303	0.310	0.133	0.135	0.141	0.139	0.259	0.260	0.261	0.259	0.285	0.288	0.270	0.266	0.246	0.220

Table 16 Median value on *F-measure* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.450	0.407	0.564	0.588	0.556	0.603	0.557	0.590	0.483	0.432	0.479	0.433	0.564	0.589	0.568	0.587	0.568	0.597	0.567	0.595	0.563	0.566
JGroups	0.407	0.371	0.532	0.537	0.532	0.531	0.492	0.512	0.409	0.381	0.411	0.396	0.533	0.534	0.527	0.535	0.530	0.539	0.524	0.539	0.521	0.505
Camel	0.514	0.520	0.599	0.597	0.582	0.598	0.600	0.594	0.533	0.529	0.537	0.530	0.601	0.595	0.598	0.597	0.593	0.597	0.594	0.600	0.597	0.589
Tomcat	0.610	0.635	0.653	0.660	0.648	0.663	0.657	0.663	0.617	0.637	0.618	0.637	0.648	0.660	0.648	0.660	0.658	0.663	0.653	0.661	0.644	0.650
Brackets	0.691	0.670	0.724	0.718	0.714	0.719	0.712	0.711	0.693	0.671	0.697	0.671	0.723	0.718	0.725	0.718	0.719	0.718	0.725	0.719	0.717	0.715
Neutron	0.748	0.748	0.781	0.767	0.774	0.768	0.793	0.765	0.753	0.757	0.759	0.757	0.778	0.767	0.778	0.767	0.780	0.768	0.783	0.767	0.781	0.766
Spring	0.654	0.677	0.704	0.706	0.678	0.677	0.713	0.712	0.664	0.678	0.678	0.630	0.705	0.709	0.702	0.709	0.705	0.709	0.704	0.714	0.699	0.699
Broadleaf	0.527	0.527	0.600	0.622	0.598	0.600	0.592	0.620	0.549	0.534	0.553	0.540	0.608	0.616	0.608	0.620	0.604	0.625	0.608	0.613	0.605	0.605
Nova	0.734	0.757	0.760	0.765	0.760	0.766	0.768	0.771	0.741	0.757	0.745	0.757	0.760	0.765	0.760	0.765	0.759	0.768	0.760	0.765	0.752	0.764
Npm	0.349	0.372	0.538	0.526	0.553	0.523	0.527	0.497	0.411	0.400	0.411	0.398	0.545	0.526	0.544	0.527	0.547	0.527	0.545	0.526	0.524	0.489
Mean	0.568	0.568	0.646	0.649	0.640	0.645	0.641	0.644	0.585	0.578	0.589	0.575	0.647	0.648	0.646	0.648	0.646	0.651	0.646	0.650	0.640	0.635

Table 17 Median value on *AUC* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.632	0.626	0.702	0.705	0.704	0.713	0.692	0.694	0.651	0.637	0.652	0.637	0.706	0.707	0.706	0.705	0.704	0.709	0.706	0.711	0.707	0.701
JGroups	0.614	0.607	0.665	0.675	0.664	0.666	0.648	0.656	0.623	0.611	0.623	0.613	0.665	0.68	0.666	0.678	0.667	0.682	0.667	0.675	0.661	0.671
Camel	0.656	0.664	0.722	0.721	0.701	0.718	0.713	0.71	0.666	0.668	0.666	0.667	0.722	0.721	0.721	0.721	0.718	0.72	0.719	0.72	0.714	0.711
Tomcat	0.687	0.697	0.701	0.706	0.701	0.707	0.666	0.668	0.692	0.698	0.692	0.698	0.7	0.706	0.7	0.707	0.7	0.705	0.698	0.706	0.698	0.702
Brackets	0.771	0.754	0.789	0.787	0.79	0.787	0.785	0.773	0.771	0.758	0.773	0.765	0.789	0.787	0.789	0.788	0.788	0.79	0.789	0.787	0.78	0.782
Neutron	0.809	0.807	0.833	0.83	0.823	0.828	0.84	0.838	0.816	0.811	0.825	0.832	0.831	0.83	0.833	0.83	0.839	0.834	0.835	0.833	0.834	0.832
Spring	0.704	0.681	0.727	0.732	0.714	0.714	0.717	0.723	0.705	0.684	0.707	0.69	0.729	0.733	0.728	0.733	0.731	0.732	0.73	0.734	0.728	0.733
Broadleaf	0.683	0.688	0.75	0.741	0.733	0.728	0.735	0.727	0.696	0.692	0.696	0.693	0.751	0.741	0.754	0.74	0.747	0.737	0.751	0.737	0.748	0.732
Nova	0.796	0.824	0.834	0.835	0.818	0.831	0.839	0.837	0.806	0.826	0.805	0.827	0.834	0.835	0.833	0.835	0.835	0.84	0.834	0.834	0.834	0.832
Npm	0.598	0.605	0.68	0.678	0.673	0.67	0.647	0.653	0.623	0.612	0.623	0.615	0.689	0.677	0.685	0.68	0.68	0.676	0.694	0.672	0.669	0.667
Mean	0.695	0.695	0.74	0.741	0.732	0.736	0.728	0.728	0.705	0.7	0.706	0.704	0.741	0.742	0.742	0.742	0.741	0.742	0.742	0.741	0.737	0.736

Table 18 Median value on *MCC* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.310	0.297	0.371	0.340	0.363	0.362	0.376	0.348	0.322	0.308	0.318	0.308	0.364	0.337	0.360	0.338	0.369	0.348	0.373	0.339	0.380	0.376
JGroups	0.296	0.274	0.298	0.323	0.301	0.304	0.285	0.301	0.296	0.278	0.298	0.281	0.306	0.323	0.301	0.323	0.302	0.328	0.297	0.322	0.314	0.322
Camel	0.342	0.359	0.397	0.390	0.385	0.386	0.393	0.389	0.354	0.363	0.352	0.364	0.400	0.393	0.401	0.393	0.401	0.394	0.394	0.390	0.392	0.387
Tomcat	0.394	0.402	0.394	0.410	0.396	0.405	0.339	0.352	0.401	0.402	0.402	0.402	0.394	0.409	0.393	0.411	0.395	0.405	0.394	0.411	0.403	0.405
Brackets	0.544	0.511	0.558	0.551	0.563	0.541	0.545	0.530	0.552	0.523	0.554	0.526	0.563	0.551	0.561	0.551	0.557	0.544	0.560	0.551	0.554	0.537
Neutron	0.620	0.603	0.640	0.641	0.627	0.641	0.664	0.642	0.627	0.619	0.642	0.628	0.638	0.641	0.643	0.641	0.645	0.645	0.643	0.647	0.644	0.646
Spring	0.414	0.393	0.442	0.454	0.408	0.436	0.439	0.448	0.429	0.390	0.429	0.387	0.439	0.454	0.437	0.450	0.453	0.458	0.445	0.462	0.443	0.444
Broadleaf	0.403	0.396	0.457	0.466	0.430	0.442	0.416	0.449	0.414	0.409	0.417	0.415	0.455	0.464	0.457	0.464	0.448	0.456	0.456	0.455	0.452	0.453
Nova	0.590	0.603	0.622	0.616	0.598	0.617	0.622	0.630	0.592	0.609	0.579	0.606	0.613	0.616	0.613	0.616	0.631	0.627	0.623	0.618	0.623	0.615
Npm	0.250	0.225	0.301	0.304	0.309	0.308	0.287	0.293	0.274	0.246	0.267	0.246	0.313	0.301	0.308	0.302	0.299	0.303	0.308	0.299	0.288	0.305
Mean	0.416	0.406	0.448	0.450	0.438	0.444	0.436	0.438	0.426	0.415	0.426	0.416	0.448	0.449	0.447	0.449	0.450	0.451	0.449	0.450	0.449	0.449

Table 19 Median value on P_{opt} for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.490	0.593	0.725	0.732	0.709	0.806	0.736	0.828	0.541	0.609	0.554	0.609	0.721	0.736	0.721	0.723	0.748	0.777	0.744	0.744	0.736	0.674
JGroups	0.430	0.429	0.605	0.649	0.629	0.661	0.579	0.606	0.436	0.428	0.448	0.430	0.611	0.650	0.605	0.649	0.632	0.670	0.603	0.652	0.543	0.556
Camel	0.489	0.533	0.716	0.736	0.680	0.786	0.773	0.798	0.528	0.545	0.523	0.545	0.712	0.735	0.711	0.736	0.741	0.753	0.730	0.741	0.711	0.664
Tomcat	0.529	0.592	0.646	0.677	0.655	0.689	0.804	0.830	0.546	0.597	0.548	0.604	0.647	0.675	0.658	0.677	0.684	0.706	0.666	0.680	0.636	0.621
Brackets	0.639	0.700	0.761	0.797	0.772	0.811	0.858	0.889	0.655	0.713	0.663	0.719	0.766	0.798	0.761	0.798	0.808	0.836	0.771	0.808	0.749	0.794
Neutron	0.740	0.764	0.832	0.844	0.809	0.815	0.902	0.918	0.763	0.769	0.821	0.822	0.832	0.844	0.832	0.843	0.876	0.874	0.846	0.846	0.849	0.836
Spring	0.614	0.646	0.748	0.733	0.684	0.674	0.851	0.841	0.643	0.655	0.656	0.629	0.748	0.734	0.747	0.741	0.754	0.757	0.754	0.759	0.795	0.740
Broadleaf	0.488	0.503	0.748	0.721	0.670	0.738	0.752	0.763	0.521	0.517	0.513	0.520	0.740	0.721	0.748	0.722	0.756	0.762	0.751	0.728	0.716	0.662
Nova	0.719	0.793	0.850	0.879	0.762	0.826	0.917	0.939	0.732	0.801	0.770	0.817	0.850	0.879	0.850	0.879	0.888	0.908	0.857	0.879	0.856	0.871
Npm	0.434	0.410	0.652	0.706	0.655	0.736	0.681	0.741	0.461	0.427	0.463	0.427	0.653	0.701	0.649	0.705	0.667	0.712	0.670	0.707	0.682	0.671
Mean	0.557	0.596	0.728	0.747	0.703	0.754	0.785	0.815	0.583	0.606	0.596	0.612	0.728	0.747	0.728	0.747	0.755	0.776	0.739	0.754	0.727	0.709

Table 20 Median value on *Recall@20%* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.390	0.537	0.696	0.690	0.678	0.759	0.699	0.774	0.453	0.524	0.435	0.524	0.696	0.678	0.706	0.683	0.730	0.718	0.719	0.700	0.699	0.645
JGroups	0.303	0.286	0.548	0.600	0.562	0.627	0.492	0.548	0.319	0.310	0.327	0.302	0.556	0.600	0.550	0.600	0.571	0.630	0.549	0.606	0.475	0.533
Camel	0.390	0.433	0.680	0.701	0.647	0.759	0.711	0.739	0.452	0.461	0.452	0.461	0.678	0.701	0.678	0.701	0.690	0.722	0.685	0.706	0.677	0.618
Tomcat	0.477	0.535	0.591	0.645	0.592	0.651	0.744	0.783	0.494	0.550	0.494	0.550	0.597	0.644	0.592	0.644	0.624	0.666	0.613	0.646	0.577	0.569
Brackets	0.606	0.684	0.724	0.790	0.749	0.801	0.813	0.876	0.627	0.684	0.630	0.684	0.725	0.790	0.728	0.791	0.764	0.817	0.733	0.791	0.707	0.753
Neutron	0.733	0.742	0.816	0.815	0.790	0.786	0.884	0.898	0.744	0.758	0.787	0.809	0.814	0.815	0.814	0.815	0.853	0.860	0.827	0.830	0.822	0.830
Spring	0.556	0.612	0.692	0.693	0.619	0.647	0.762	0.796	0.592	0.615	0.600	0.543	0.692	0.696	0.692	0.696	0.700	0.717	0.700	0.713	0.721	0.695
Broadleaf	0.437	0.475	0.704	0.713	0.641	0.723	0.703	0.742	0.470	0.497	0.470	0.498	0.701	0.713	0.705	0.711	0.735	0.752	0.710	0.723	0.671	0.648
Nova	0.693	0.786	0.826	0.855	0.747	0.822	0.882	0.930	0.706	0.791	0.756	0.812	0.827	0.855	0.826	0.855	0.851	0.884	0.832	0.855	0.824	0.855
Npm	0.294	0.302	0.615	0.691	0.618	0.729	0.622	0.720	0.348	0.346	0.348	0.346	0.612	0.692	0.615	0.693	0.640	0.704	0.654	0.701	0.642	0.626
Mean	0.488	0.539	0.689	0.719	0.664	0.730	0.731	0.781	0.520	0.554	0.530	0.553	0.690	0.718	0.691	0.719	0.716	0.747	0.702	0.727	0.682	0.677

Table 21 Median value on *Precision@20%* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.603	0.593	0.479	0.510	0.495	0.499	0.488	0.511	0.585	0.594	0.585	0.590	0.484	0.507	0.484	0.505	0.465	0.506	0.476	0.506	0.493	0.528
JGroups	0.571	0.571	0.409	0.407	0.407	0.412	0.462	0.424	0.561	0.571	0.559	0.571	0.417	0.407	0.417	0.406	0.397	0.398	0.409	0.407	0.440	0.430
Camel	0.583	0.550	0.489	0.498	0.484	0.467	0.468	0.466	0.576	0.547	0.575	0.547	0.487	0.498	0.487	0.498	0.479	0.489	0.484	0.499	0.497	0.514
Tomcat	0.684	0.684	0.613	0.635	0.616	0.631	0.540	0.528	0.667	0.679	0.671	0.676	0.608	0.635	0.607	0.632	0.594	0.625	0.606	0.631	0.642	0.672
Brackets	0.712	0.673	0.643	0.620	0.643	0.609	0.588	0.552	0.697	0.660	0.696	0.660	0.653	0.619	0.652	0.619	0.628	0.591	0.646	0.618	0.662	0.626
Neutron	0.766	0.715	0.724	0.692	0.750	0.713	0.681	0.628	0.760	0.713	0.740	0.669	0.724	0.692	0.730	0.692	0.695	0.674	0.724	0.683	0.718	0.674
Spring	0.712	0.766	0.656	0.699	0.683	0.739	0.628	0.674	0.718	0.756	0.706	0.754	0.654	0.707	0.659	0.699	0.633	0.687	0.654	0.694	0.656	0.696
Broadleaf	0.631	0.706	0.525	0.585	0.529	0.541	0.508	0.557	0.635	0.707	0.635	0.707	0.525	0.586	0.519	0.584	0.506	0.573	0.511	0.584	0.523	0.597
Nova	0.714	0.720	0.694	0.691	0.709	0.709	0.641	0.663	0.714	0.719	0.707	0.713	0.695	0.692	0.699	0.691	0.676	0.674	0.695	0.691	0.676	0.695
Npm	0.569	0.500	0.448	0.447	0.484	0.447	0.467	0.452	0.584	0.487	0.557	0.483	0.470	0.449	0.470	0.449	0.456	0.437	0.442	0.440	0.474	0.465
Mean	0.655	0.648	0.568	0.578	0.580	0.577	0.547	0.546	0.650	0.643	0.643	0.637	0.572	0.579	0.572	0.577	0.553	0.565	0.565	0.575	0.578	0.590

Table 22 Median value on *F-measure@20%* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.453	0.500	0.558	0.584	0.556	0.591	0.553	0.589	0.485	0.510	0.479	0.515	0.558	0.584	0.562	0.584	0.561	0.587	0.564	0.584	0.558	0.581
JGroups	0.356	0.366	0.471	0.488	0.471	0.487	0.430	0.464	0.353	0.374	0.353	0.378	0.471	0.486	0.468	0.486	0.466	0.485	0.470	0.488	0.471	0.465
Camel	0.492	0.481	0.562	0.568	0.548	0.564	0.563	0.560	0.499	0.489	0.501	0.489	0.562	0.566	0.562	0.568	0.555	0.567	0.559	0.568	0.558	0.554
Tomcat	0.548	0.596	0.598	0.627	0.600	0.631	0.614	0.638	0.556	0.599	0.561	0.599	0.598	0.626	0.606	0.625	0.602	0.632	0.601	0.630	0.592	0.612
Brackets	0.600	0.655	0.651	0.681	0.646	0.681	0.671	0.673	0.606	0.659	0.610	0.659	0.667	0.684	0.660	0.681	0.662	0.688	0.664	0.682	0.674	0.675
Neutron	0.744	0.747	0.778	0.761	0.768	0.765	0.781	0.751	0.748	0.754	0.762	0.756	0.778	0.761	0.778	0.761	0.778	0.766	0.780	0.764	0.778	0.764
Spring	0.611	0.645	0.661	0.681	0.611	0.641	0.676	0.692	0.616	0.647	0.616	0.592	0.659	0.683	0.659	0.683	0.676	0.688	0.663	0.686	0.671	0.667
Broadleaf	0.500	0.509	0.572	0.614	0.561	0.592	0.565	0.612	0.529	0.525	0.540	0.531	0.583	0.609	0.577	0.614	0.570	0.621	0.576	0.608	0.576	0.599
Nova	0.699	0.751	0.734	0.765	0.723	0.763	0.730	0.771	0.699	0.751	0.700	0.751	0.734	0.765	0.734	0.765	0.732	0.768	0.734	0.765	0.725	0.762
Npm	0.340	0.359	0.511	0.525	0.519	0.524	0.481	0.497	0.381	0.389	0.366	0.385	0.511	0.526	0.511	0.527	0.512	0.528	0.512	0.526	0.472	0.491
Mean	0.534	0.561	0.610	0.629	0.600	0.624	0.606	0.625	0.547	0.570	0.549	0.566	0.612	0.629	0.612	0.629	0.611	0.633	0.612	0.630	0.608	0.617

Table 23 Median value on *PCI@20%* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	0.182	0.252	0.394	0.446	0.401	0.499	0.404	0.499	0.211	0.274	0.215	0.274	0.408	0.440	0.405	0.439	0.441	0.468	0.425	0.454	0.379	0.397
JGroups	0.140	0.109	0.364	0.375	0.384	0.439	0.313	0.301	0.158	0.126	0.158	0.131	0.370	0.378	0.370	0.379	0.392	0.397	0.373	0.384	0.296	0.315
Camel	0.209	0.230	0.413	0.406	0.403	0.467	0.459	0.463	0.239	0.242	0.239	0.242	0.412	0.407	0.411	0.410	0.429	0.437	0.421	0.413	0.354	0.402
Tomcat	0.290	0.319	0.395	0.422	0.408	0.434	0.561	0.598	0.302	0.329	0.305	0.329	0.396	0.419	0.396	0.422	0.429	0.444	0.409	0.423	0.349	0.370
Brackets	0.293	0.321	0.385	0.422	0.392	0.432	0.477	0.528	0.307	0.345	0.313	0.345	0.383	0.422	0.384	0.423	0.420	0.448	0.389	0.423	0.397	0.368
Neutron	0.322	0.345	0.396	0.393	0.364	0.379	0.449	0.460	0.339	0.353	0.366	0.357	0.394	0.393	0.394	0.393	0.422	0.423	0.399	0.400	0.401	0.399
Spring	0.315	0.332	0.409	0.408	0.386	0.360	0.505	0.470	0.354	0.337	0.373	0.329	0.408	0.409	0.404	0.409	0.429	0.425	0.430	0.421	0.397	0.438
Broadleaf	0.170	0.210	0.358	0.362	0.329	0.377	0.372	0.387	0.204	0.223	0.204	0.225	0.359	0.363	0.362	0.359	0.394	0.398	0.378	0.370	0.305	0.349
Nova	0.366	0.383	0.406	0.421	0.380	0.397	0.463	0.479	0.367	0.383	0.387	0.389	0.406	0.421	0.406	0.421	0.431	0.441	0.407	0.421	0.405	0.408
Npm	0.163	0.147	0.392	0.467	0.404	0.495	0.459	0.486	0.189	0.179	0.201	0.180	0.392	0.467	0.408	0.463	0.404	0.477	0.432	0.475	0.406	0.392
Mean	0.245	0.265	0.391	0.412	0.385	0.428	0.446	0.467	0.267	0.279	0.276	0.280	0.393	0.412	0.394	0.412	0.419	0.436	0.406	0.418	0.369	0.384

Table 24 Median value on *IFA* for each project when the time period is two months and six months

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six	two	six
Fabric8	2.0	3.0	4.0	4.0	3.5	5.0	4.0	4.0	2.0	4.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5	5.0	5.0	3.0
JGroups	2.0	2.0	4.0	5.0	5.0	4.0	3.0	4.0	2.0	2.0	2.0	2.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	4.0
Camel	2.0	2.0	3.0	3.0	3.0	4.0	3.0	4.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	4.0
Tomcat	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0
Brackets	2.0	3.0	3.0	4.0	3.0	4.0	4.0	6.0	2.0	3.0	2.0	3.0	3.0	4.0	3.0	4.0	3.0	5.0	3.0	4.0	2.0	4.0
Neutron	1.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	2.0	2.0	3.0
Spring	1.0	1.0	1.0	2.0	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	2.0
Broadleaf	2.0	3.0	4.0	4.0	3.0	4.0	3.0	5.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	3.0
Nova	2.0	2.0	2.0	3.0	2.0	2.0	3.0	5.0	2.0	2.0	2.0	2.5	2.0	3.0	2.0	3.0	3.0	3.0	2.0	3.0	3.0	3.0
Npm	2.0	3.0	3.0	5.0	3.0	5.0	3.0	4.0	2.0	3.0	2.0	3.0	3.0	5.0	4.0	5.0	4.0	5.0	3.0	4.5	3.0	4.0
Mean	1.8	2.4	2.8	3.5	2.8	3.4	2.8	4.0	1.8	2.4	1.9	2.5	2.8	3.5	3.0	3.5	3.1	3.7	3.0	3.6	2.8	3.3

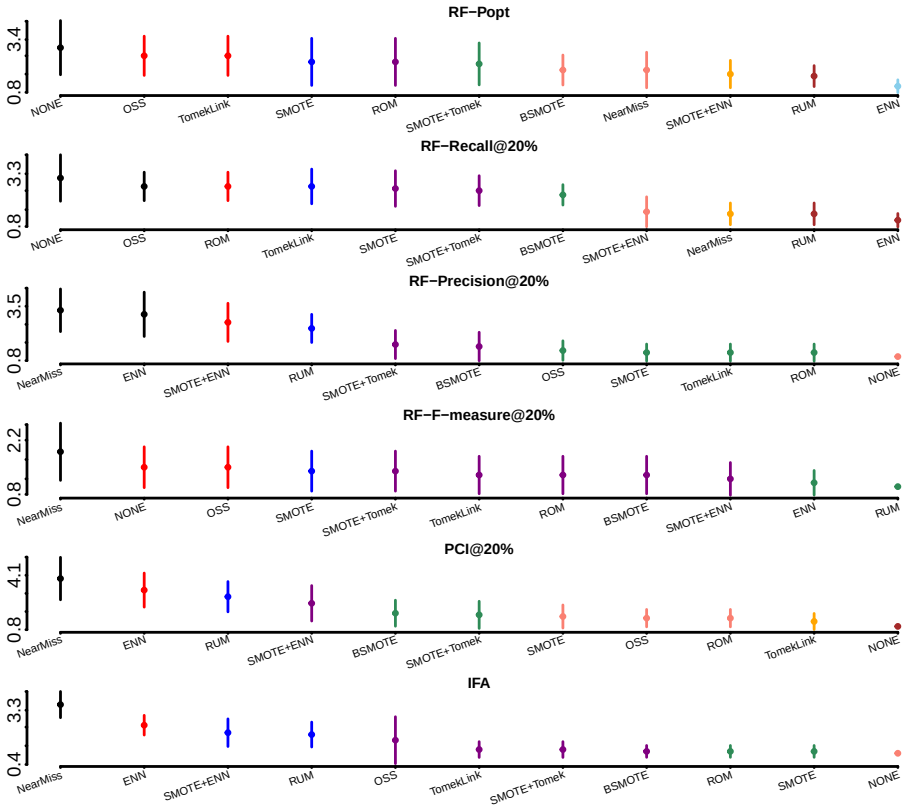

Fig. 4 The results of Scott-Knott ESD test of all sampling algorithms for each of the 6 effort-aware performance measures across 10 projects

4 Comparison results with optimized classifiers

Tables 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, and 36 present detailed Median values for *Recall, Precision, Pf, F-measure, AUC, MCC*, P_{opt}, *Recall@20%*, *Precision@20%*, *F-measure@20%*, *PCI@20%*, and *IFA* for each project on each sampling algorithm when applying the default LR classifier and the LR classifier with optimized parameter settings Fu et al (2016); Tantithamthavorn et al (2019). The overall mean values across all projects are also provided.

5 Comparison results for the 6 newly added projects

Tables 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, and 48 present detailed Median values for *Recall, Precision, Pf, F-measure, AUC, MCC*, P_{opt}, *Recall@20%*, *Precision@20%*, *F-measure@20%*, *PCI@20%*, and *IFA* for each project on each sampling algorithm The overall median values across all projects are also provided.

Table 25 Median value on *Recall* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.384	0.350	0.687	0.817	0.677	0.831	0.688	0.828	0.441	0.412	0.426	0.412	0.696	0.808	0.697	0.817	0.721	0.885	0.714	0.810	0.685	0.744
JGroups	0.331	0.250	0.648	0.722	0.667	0.753	0.571	0.573	0.350	0.283	0.358	0.294	0.652	0.709	0.648	0.706	0.673	0.786	0.652	0.709	0.577	0.629
Camel	0.442	0.426	0.733	0.801	0.691	0.858	0.782	0.827	0.508	0.477	0.511	0.484	0.733	0.807	0.731	0.808	0.754	0.860	0.749	0.814	0.731	0.785
Tomcat	0.529	0.540	0.672	0.726	0.677	0.735	0.834	0.861	0.561	0.600	0.563	0.578	0.676	0.720	0.676	0.724	0.711	0.778	0.689	0.727	0.650	0.709
Brackets	0.673	0.737	0.775	0.849	0.785	0.829	0.879	0.923	0.689	0.748	0.691	0.756	0.783	0.842	0.776	0.849	0.818	0.923	0.783	0.843	0.765	0.791
Neutron	0.747	0.890	0.844	0.956	0.802	0.890	0.907	0.960	0.764	0.891	0.819	0.879	0.844	0.959	0.844	0.974	0.883	0.987	0.852	0.968	0.849	0.891
Spring	0.599	0.693	0.774	0.883	0.677	0.779	0.878	0.892	0.647	0.714	0.667	0.739	0.757	0.855	0.758	0.862	0.811	0.894	0.797	0.836	0.811	0.833
Broadleaf	0.469	0.441	0.750	0.795	0.668	0.760	0.760	0.821	0.512	0.477	0.512	0.500	0.747	0.786	0.750	0.795	0.786	0.888	0.763	0.791	0.722	0.750
Nova	0.719	0.828	0.862	0.958	0.781	0.844	0.919	0.950	0.733	0.849	0.766	0.834	0.860	0.947	0.860	0.947	0.894	0.981	0.862	0.954	0.867	0.898
Npm	0.288	0.304	0.667	0.833	0.667	0.706	0.667	0.788	0.333	0.333	0.358	0.351	0.667	0.824	0.662	0.833	0.686	0.851	0.692	0.827	0.677	0.735
Mean	0.518	0.546	0.741	0.834	0.709	0.798	0.788	0.843	0.554	0.579	0.567	0.583	0.741	0.826	0.740	0.832	0.774	0.885	0.755	0.828	0.733	0.777

Table 26 Median value on *Precision* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.610	0.606	0.510	0.468	0.461	0.539	0.522	0.457	0.586	0.585	0.586	0.585	0.513	0.466	0.510	0.457	0.503	0.438	0.509	0.497	0.522	0.500
JGroups	0.643	0.648	0.457	0.399	0.403	0.433	0.533	0.500	0.625	0.667	0.636	0.674	0.456	0.404	0.456	0.417	0.438	0.384	0.455	0.404	0.487	0.427
Camel	0.600	0.586	0.507	0.470	0.457	0.481	0.494	0.454	0.593	0.589	0.590	0.585	0.508	0.474	0.504	0.470	0.497	0.436	0.496	0.474	0.508	0.482
Tomcat	0.709	0.683	0.641	0.609	0.619	0.645	0.564	0.535	0.689	0.670	0.690	0.682	0.641	0.610	0.641	0.603	0.624	0.584	0.638	0.608	0.665	0.625
Brackets	0.732	0.694	0.677	0.637	0.648	0.644	0.634	0.590	0.728	0.698	0.717	0.697	0.680	0.631	0.680	0.644	0.655	0.577	0.676	0.635	0.694	0.669
Neutron	0.759	0.696	0.731	0.671	0.692	0.717	0.689	0.671	0.763	0.696	0.741	0.702	0.731	0.692	0.731	0.692	0.717	0.682	0.722	0.674	0.731	0.695
Spring	0.729	0.679	0.681	0.612	0.653	0.729	0.642	0.591	0.714	0.678	0.707	0.682	0.677	0.620	0.682	0.620	0.667	0.555	0.679	0.607	0.667	0.613
Broadleaf	0.661	0.652	0.538	0.483	0.471	0.542	0.521	0.500	0.635	0.636	0.631	0.625	0.537	0.500	0.533	0.494	0.524	0.429	0.525	0.471	0.535	0.494
Nova	0.747	0.708	0.704	0.634	0.711	0.710	0.685	0.628	0.739	0.697	0.714	0.711	0.704	0.634	0.704	0.671	0.692	0.658	0.702	0.634	0.704	0.669
Npm	0.581	0.583	0.481	0.433	0.494	0.439	0.476	0.468	0.586	0.587	0.571	0.588	0.494	0.465	0.486	0.465	0.482	0.441	0.482	0.457	0.493	0.476
Mean	0.677	0.654	0.593	0.542	0.561	0.588	0.576	0.539	0.666	0.650	0.658	0.653	0.594	0.550	0.593	0.553	0.580	0.519	0.588	0.546	0.600	0.565

Table 27 Median value on *Pf* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.084	0.075	0.303	0.398	0.295	0.433	0.316	0.372	0.116	0.093	0.117	0.093	0.300	0.352	0.306	0.376	0.330	0.444	0.325	0.355	0.272	0.321
JGroups	0.061	0.057	0.316	0.401	0.334	0.431	0.212	0.212	0.078	0.056	0.080	0.060	0.316	0.372	0.307	0.396	0.334	0.463	0.316	0.391	0.248	0.330
Camel	0.120	0.112	0.306	0.375	0.290	0.420	0.332	0.413	0.137	0.139	0.137	0.132	0.306	0.373	0.306	0.367	0.325	0.471	0.318	0.373	0.296	0.344
Tomcat	0.172	0.189	0.263	0.329	0.269	0.330	0.465	0.498	0.186	0.219	0.186	0.211	0.263	0.320	0.263	0.318	0.295	0.382	0.272	0.331	0.243	0.307
Brackets	0.138	0.190	0.206	0.265	0.213	0.245	0.306	0.378	0.144	0.198	0.144	0.203	0.205	0.251	0.206	0.265	0.244	0.378	0.214	0.268	0.188	0.213
Neutron	0.122	0.191	0.171	0.263	0.147	0.214	0.222	0.267	0.135	0.198	0.154	0.198	0.178	0.265	0.179	0.277	0.197	0.328	0.179	0.256	0.180	0.205
Spring	0.165	0.198	0.279	0.327	0.228	0.278	0.349	0.362	0.193	0.223	0.220	0.215	0.272	0.335	0.284	0.334	0.292	0.402	0.283	0.339	0.298	0.322
Broadleaf	0.088	0.070	0.249	0.283	0.194	0.295	0.259	0.301	0.103	0.090	0.098	0.093	0.246	0.280	0.252	0.283	0.287	0.426	0.258	0.288	0.218	0.250
Nova	0.131	0.194	0.184	0.262	0.156	0.195	0.223	0.261	0.139	0.199	0.151	0.181	0.187	0.262	0.184	0.253	0.211	0.310	0.191	0.266	0.197	0.221
Npm	0.087	0.089	0.313	0.437	0.313	0.374	0.342	0.427	0.097	0.095	0.119	0.097	0.319	0.419	0.319	0.455	0.333	0.489	0.339	0.438	0.316	0.376
Mean	0.117	0.137	0.259	0.334	0.244	0.322	0.303	0.349	0.133	0.151	0.141	0.148	0.259	0.323	0.261	0.332	0.285	0.409	0.270	0.330	0.246	0.289

Table 28 Median value on *F-measure* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.450	0.448	0.564	0.566	0.556	0.568	0.557	0.557	0.483	0.463	0.479	0.459	0.564	0.575	0.568	0.563	0.568	0.568	0.567	0.569	0.563	0.562
JGroups	0.407	0.341	0.532	0.512	0.532	0.523	0.492	0.456	0.409	0.378	0.411	0.374	0.533	0.520	0.527	0.522	0.530	0.507	0.524	0.521	0.521	0.493
Camel	0.514	0.500	0.599	0.584	0.582	0.580	0.600	0.582	0.533	0.528	0.537	0.530	0.601	0.593	0.598	0.590	0.593	0.574	0.594	0.593	0.597	0.586
Tomcat	0.610	0.601	0.653	0.649	0.648	0.655	0.657	0.642	0.617	0.623	0.618	0.619	0.648	0.644	0.648	0.651	0.658	0.653	0.653	0.653	0.644	0.653
Brackets	0.691	0.705	0.724	0.719	0.714	0.714	0.712	0.710	0.693	0.702	0.697	0.705	0.723	0.719	0.725	0.722	0.719	0.705	0.725	0.714	0.717	0.711
Neutron	0.748	0.774	0.781	0.798	0.774	0.780	0.793	0.780	0.753	0.774	0.759	0.774	0.778	0.780	0.778	0.806	0.780	0.810	0.783	0.775	0.781	0.776
Spring	0.654	0.676	0.704	0.696	0.678	0.698	0.713	0.698	0.664	0.697	0.678	0.698	0.705	0.691	0.702	0.697	0.705	0.682	0.704	0.694	0.699	0.686
Broadleaf	0.527	0.504	0.600	0.602	0.598	0.583	0.592	0.583	0.549	0.524	0.553	0.533	0.608	0.606	0.608	0.596	0.604	0.557	0.608	0.598	0.605	0.590
Nova	0.734	0.749	0.760	0.755	0.760	0.770	0.768	0.754	0.741	0.750	0.745	0.763	0.760	0.750	0.760	0.763	0.759	0.764	0.760	0.750	0.752	0.752
Npm	0.349	0.350	0.538	0.575	0.553	0.564	0.527	0.538	0.411	0.400	0.411	0.414	0.545	0.571	0.544	0.577	0.547	0.574	0.545	0.575	0.524	0.551
Mean	0.568	0.565	0.646	0.645	0.640	0.643	0.641	0.630	0.585	0.584	0.589	0.587	0.647	0.645	0.646	0.649	0.646	0.639	0.646	0.644	0.640	0.636

Table 29 Median value on *AUC* for each projectwhen applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.632	0.639	0.702	0.711	0.704	0.700	0.692	0.689	0.651	0.649	0.652	0.647	0.706	0.716	0.706	0.706	0.704	0.707	0.706	0.706	0.707	0.706
JGroups	0.614	0.596	0.665	0.650	0.664	0.640	0.648	0.633	0.623	0.603	0.623	0.605	0.665	0.655	0.666	0.656	0.667	0.629	0.667	0.655	0.661	0.651
Camel	0.656	0.653	0.722	0.705	0.701	0.693	0.713	0.702	0.666	0.663	0.666	0.661	0.722	0.713	0.721	0.709	0.718	0.700	0.719	0.715	0.714	0.718
Tomcat	0.687	0.680	0.701	0.691	0.701	0.694	0.666	0.642	0.692	0.685	0.692	0.684	0.700	0.691	0.700	0.691	0.700	0.680	0.698	0.694	0.698	0.692
Brackets	0.771	0.781	0.789	0.789	0.790	0.793	0.785	0.770	0.771	0.782	0.773	0.782	0.789	0.786	0.789	0.790	0.788	0.776	0.789	0.787	0.780	0.784
Neutron	0.809	0.839	0.833	0.843	0.823	0.839	0.840	0.832	0.816	0.839	0.825	0.830	0.831	0.838	0.833	0.842	0.839	0.825	0.835	0.842	0.834	0.839
Spring	0.704	0.714	0.727	0.730	0.714	0.731	0.717	0.712	0.705	0.703	0.707	0.726	0.729	0.733	0.728	0.733	0.731	0.728	0.730	0.736	0.728	0.733
Broadleaf	0.683	0.682	0.750	0.743	0.733	0.726	0.735	0.720	0.696	0.686	0.696	0.691	0.751	0.745	0.754	0.744	0.747	0.721	0.751	0.743	0.748	0.744
Nova	0.796	0.814	0.834	0.841	0.818	0.834	0.839	0.836	0.806	0.828	0.805	0.814	0.834	0.841	0.833	0.836	0.835	0.828	0.834	0.841	0.834	0.838
Npm	0.598	0.602	0.680	0.662	0.673	0.663	0.647	0.647	0.623	0.602	0.623	0.613	0.689	0.669	0.685	0.667	0.680	0.668	0.694	0.659	0.669	0.665
Mean	0.695	0.700	0.740	0.737	0.732	0.731	0.728	0.718	0.705	0.704	0.706	0.705	0.741	0.739	0.742	0.737	0.741	0.726	0.742	0.738	0.737	0.737

Table 30 Median value on *MCC* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.310	0.324	0.371	0.387	0.363	0.363	0.376	0.372	0.322	0.338	0.318	0.336	0.364	0.395	0.360	0.380	0.369	0.369	0.373	0.386	0.380	0.378
JGroups	0.296	0.261	0.298	0.270	0.301	0.263	0.285	0.276	0.296	0.286	0.298	0.288	0.306	0.273	0.301	0.274	0.302	0.247	0.297	0.273	0.314	0.279
Camel	0.342	0.339	0.397	0.372	0.385	0.361	0.393	0.380	0.354	0.349	0.352	0.349	0.400	0.375	0.401	0.379	0.401	0.355	0.394	0.379	0.392	0.393
Tomcat	0.394	0.383	0.394	0.383	0.396	0.381	0.339	0.309	0.401	0.389	0.402	0.388	0.394	0.383	0.393	0.381	0.395	0.358	0.394	0.386	0.403	0.389
Brackets	0.544	0.543	0.558	0.551	0.563	0.557	0.545	0.522	0.552	0.543	0.554	0.551	0.563	0.551	0.561	0.557	0.557	0.522	0.560	0.550	0.554	0.558
Neutron	0.620	0.649	0.640	0.667	0.627	0.655	0.664	0.650	0.627	0.655	0.642	0.649	0.638	0.649	0.643	0.663	0.645	0.683	0.643	0.656	0.644	0.646
Spring	0.414	0.419	0.442	0.465	0.408	0.455	0.439	0.445	0.429	0.442	0.429	0.454	0.439	0.465	0.437	0.452	0.453	0.433	0.445	0.461	0.443	0.449
Broadleaf	0.403	0.396	0.457	0.437	0.430	0.423	0.416	0.408	0.414	0.405	0.417	0.398	0.455	0.444	0.457	0.448	0.448	0.380	0.456	0.442	0.452	0.458
Nova	0.590	0.596	0.622	0.612	0.598	0.609	0.622	0.621	0.592	0.599	0.579	0.596	0.613	0.618	0.613	0.587	0.631	0.590	0.623	0.613	0.623	0.633
Npm	0.250	0.260	0.301	0.295	0.309	0.311	0.287	0.295	0.274	0.267	0.267	0.275	0.313	0.313	0.308	0.316	0.299	0.284	0.308	0.302	0.288	0.296
Mean	0.416	0.417	0.448	0.444	0.438	0.438	0.436	0.428	0.426	0.427	0.426	0.428	0.448	0.447	0.447	0.444	0.450	0.422	0.449	0.445	0.449	0.448

Table 31 Median value on P_{opt} for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.490	0.489	0.725	0.859	0.709	0.852	0.736	0.812	0.541	0.531	0.554	0.545	0.721	0.815	0.721	0.839	0.748	0.886	0.744	0.814	0.736	0.777
JGroups	0.430	0.436	0.605	0.656	0.629	0.725	0.579	0.578	0.436	0.434	0.448	0.443	0.611	0.655	0.605	0.656	0.632	0.735	0.603	0.659	0.543	0.579
Camel	0.489	0.474	0.716	0.812	0.680	0.839	0.773	0.819	0.528	0.500	0.523	0.509	0.712	0.811	0.711	0.801	0.741	0.863	0.730	0.823	0.711	0.762
Tomcat	0.529	0.546	0.646	0.695	0.655	0.716	0.804	0.844	0.546	0.568	0.548	0.564	0.647	0.684	0.658	0.688	0.684	0.745	0.666	0.704	0.636	0.675
Brackets	0.639	0.745	0.761	0.846	0.772	0.818	0.858	0.913	0.655	0.745	0.663	0.745	0.766	0.831	0.761	0.839	0.808	0.912	0.771	0.825	0.749	0.783
Neutron	0.740	0.890	0.832	0.952	0.809	0.887	0.902	0.959	0.763	0.890	0.821	0.874	0.832	0.953	0.832	0.965	0.876	0.995	0.846	0.959	0.849	0.892
Spring	0.614	0.693	0.748	0.839	0.684	0.767	0.851	0.870	0.643	0.727	0.656	0.739	0.748	0.828	0.747	0.834	0.754	0.849	0.754	0.804	0.795	0.816
Broadleaf	0.488	0.459	0.748	0.777	0.670	0.775	0.752	0.796	0.521	0.502	0.513	0.513	0.740	0.779	0.748	0.774	0.756	0.890	0.751	0.763	0.716	0.739
Nova	0.719	0.839	0.850	0.955	0.762	0.867	0.917	0.946	0.732	0.869	0.770	0.835	0.850	0.944	0.850	0.931	0.888	0.974	0.857	0.947	0.856	0.885
Npm	0.434	0.446	0.652	0.817	0.655	0.700	0.681	0.795	0.461	0.501	0.463	0.469	0.653	0.802	0.649	0.811	0.667	0.835	0.670	0.809	0.682	0.742
Mean	0.557	0.602	0.728	0.821	0.703	0.795	0.785	0.833	0.583	0.627	0.596	0.624	0.728	0.810	0.728	0.814	0.755	0.868	0.739	0.811	0.727	0.765

Table 32 Median value on *Recall@20%* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.390	0.370	0.696	0.811	0.678	0.819	0.699	0.806	0.453	0.400	0.435	0.400	0.696	0.787	0.706	0.798	0.730	0.875	0.719	0.788	0.699	0.738
JGroups	0.303	0.263	0.548	0.600	0.562	0.634	0.492	0.492	0.319	0.263	0.327	0.273	0.556	0.608	0.550	0.606	0.571	0.667	0.549	0.605	0.475	0.531
Camel	0.390	0.363	0.680	0.770	0.647	0.779	0.711	0.767	0.452	0.417	0.452	0.417	0.678	0.750	0.678	0.745	0.690	0.816	0.685	0.750	0.677	0.718
Tomcat	0.477	0.495	0.591	0.643	0.592	0.641	0.744	0.772	0.494	0.518	0.494	0.518	0.597	0.637	0.592	0.621	0.624	0.691	0.613	0.647	0.577	0.629
Brackets	0.606	0.682	0.724	0.791	0.749	0.773	0.813	0.902	0.627	0.695	0.630	0.667	0.725	0.785	0.728	0.793	0.764	0.886	0.733	0.793	0.707	0.741
Neutron	0.733	0.882	0.816	0.934	0.790	0.865	0.884	0.938	0.744	0.865	0.787	0.837	0.814	0.917	0.814	0.934	0.853	0.981	0.827	0.931	0.822	0.868
Spring	0.556	0.605	0.692	0.768	0.619	0.707	0.762	0.785	0.592	0.618	0.600	0.634	0.692	0.758	0.692	0.756	0.700	0.780	0.700	0.760	0.721	0.750
Broadleaf	0.437	0.417	0.704	0.755	0.641	0.723	0.703	0.782	0.470	0.444	0.470	0.458	0.701	0.752	0.705	0.739	0.735	0.830	0.710	0.739	0.671	0.705
Nova	0.693	0.810	0.826	0.932	0.747	0.818	0.882	0.935	0.706	0.841	0.756	0.810	0.827	0.927	0.826	0.904	0.851	0.946	0.832	0.927	0.824	0.867
Npm	0.294	0.304	0.615	0.789	0.618	0.667	0.622	0.710	0.348	0.353	0.348	0.353	0.612	0.765	0.615	0.797	0.640	0.808	0.654	0.776	0.642	0.706
Mean	0.488	0.519	0.689	0.779	0.664	0.743	0.731	0.789	0.520	0.542	0.530	0.537	0.690	0.768	0.691	0.769	0.716	0.828	0.702	0.771	0.682	0.725

Table 33 Median value on *Precision@20%* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.603	0.582	0.479	0.434	0.495	0.441	0.488	0.435	0.585	0.571	0.585	0.574	0.484	0.447	0.484	0.434	0.465	0.426	0.476	0.438	0.493	0.474
JGroups	0.571	0.571	0.409	0.369	0.407	0.370	0.462	0.440	0.561	0.615	0.559	0.600	0.417	0.378	0.417	0.381	0.397	0.336	0.409	0.378	0.440	0.387
Camel	0.583	0.554	0.489	0.443	0.484	0.435	0.468	0.446	0.576	0.571	0.575	0.564	0.487	0.451	0.487	0.453	0.479	0.412	0.484	0.451	0.497	0.467
Tomcat	0.684	0.657	0.613	0.585	0.616	0.589	0.540	0.508	0.667	0.654	0.671	0.658	0.608	0.590	0.607	0.590	0.594	0.557	0.606	0.588	0.642	0.600
Brackets	0.712	0.666	0.643	0.605	0.643	0.609	0.588	0.562	0.697	0.668	0.696	0.668	0.653	0.599	0.652	0.612	0.628	0.555	0.646	0.605	0.662	0.617
Neutron	0.766	0.702	0.724	0.658	0.750	0.692	0.681	0.664	0.760	0.698	0.740	0.716	0.724	0.690	0.730	0.695	0.695	0.696	0.724	0.653	0.718	0.691
Spring	0.712	0.679	0.656	0.594	0.683	0.631	0.628	0.579	0.718	0.687	0.706	0.690	0.654	0.594	0.659	0.594	0.633	0.538	0.654	0.590	0.656	0.587
Broadleaf	0.631	0.627	0.525	0.473	0.529	0.453	0.508	0.497	0.635	0.635	0.635	0.632	0.525	0.497	0.519	0.485	0.506	0.398	0.511	0.466	0.523	0.486
Nova	0.714	0.682	0.694	0.616	0.709	0.681	0.641	0.612	0.714	0.671	0.707	0.691	0.695	0.626	0.699	0.633	0.676	0.593	0.695	0.633	0.676	0.663
Npm	0.569	0.583	0.448	0.425	0.484	0.484	0.467	0.462	0.584	0.571	0.557	0.586	0.470	0.442	0.470	0.446	0.456	0.427	0.442	0.438	0.474	0.474
Mean	0.655	0.630	0.568	0.520	0.580	0.538	0.547	0.521	0.650	0.634	0.643	0.638	0.572	0.531	0.572	0.532	0.553	0.494	0.565	0.524	0.578	0.545

Table 34 Median value on *F-measure@20%* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.453	0.429	0.558	0.552	0.556	0.565	0.553	0.545	0.485	0.449	0.479	0.454	0.558	0.557	0.562	0.550	0.561	0.548	0.564	0.557	0.558	0.557
JGroups	0.356	0.333	0.471	0.452	0.471	0.480	0.430	0.407	0.353	0.333	0.353	0.337	0.471	0.469	0.468	0.465	0.466	0.446	0.470	0.459	0.471	0.436
Camel	0.492	0.470	0.562	0.541	0.548	0.538	0.563	0.550	0.499	0.488	0.501	0.494	0.562	0.550	0.562	0.552	0.555	0.537	0.559	0.552	0.558	0.562
Tomcat	0.548	0.545	0.598	0.607	0.600	0.607	0.614	0.586	0.556	0.560	0.561	0.558	0.598	0.610	0.606	0.610	0.602	0.610	0.601	0.609	0.592	0.610
Brackets	0.600	0.634	0.651	0.679	0.646	0.644	0.671	0.683	0.606	0.626	0.610	0.626	0.667	0.660	0.660	0.653	0.662	0.665	0.664	0.667	0.674	0.657
Neutron	0.744	0.766	0.778	0.772	0.768	0.766	0.781	0.761	0.748	0.766	0.762	0.769	0.778	0.780	0.778	0.783	0.778	0.821	0.780	0.763	0.778	0.771
Spring	0.611	0.624	0.661	0.663	0.611	0.626	0.676	0.658	0.616	0.627	0.616	0.629	0.659	0.628	0.659	0.638	0.676	0.625	0.663	0.627	0.671	0.632
Broadleaf	0.500	0.497	0.572	0.567	0.561	0.556	0.565	0.559	0.529	0.491	0.540	0.500	0.583	0.573	0.577	0.577	0.570	0.535	0.576	0.571	0.576	0.571
Nova	0.699	0.722	0.734	0.714	0.723	0.722	0.730	0.723	0.699	0.720	0.700	0.722	0.734	0.714	0.734	0.710	0.732	0.702	0.734	0.714	0.725	0.734
Npm	0.340	0.345	0.511	0.539	0.519	0.544	0.481	0.526	0.381	0.400	0.366	0.405	0.511	0.552	0.511	0.532	0.512	0.532	0.512	0.536	0.472	0.521
Mean	0.534	0.537	0.610	0.609	0.600	0.605	0.606	0.600	0.547	0.546	0.549	0.549	0.612	0.609	0.612	0.607	0.611	0.602	0.612	0.605	0.608	0.605

Table 35 Median value on *PCI@20%* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	0.182	0.149	0.394	0.525	0.401	0.537	0.404	0.472	0.211	0.172	0.215	0.174	0.408	0.497	0.405	0.523	0.441	0.554	0.425	0.503	0.379	0.445
JGroups	0.140	0.121	0.364	0.452	0.384	0.481	0.313	0.321	0.158	0.131	0.158	0.139	0.370	0.444	0.370	0.444	0.392	0.537	0.373	0.445	0.296	0.375
Camel	0.209	0.200	0.413	0.498	0.403	0.534	0.459	0.512	0.239	0.233	0.239	0.224	0.412	0.497	0.411	0.489	0.429	0.563	0.421	0.492	0.354	0.452
Tomcat	0.290	0.311	0.395	0.437	0.408	0.465	0.561	0.631	0.302	0.335	0.305	0.337	0.396	0.434	0.396	0.431	0.429	0.507	0.409	0.444	0.349	0.435
Brackets	0.293	0.373	0.385	0.470	0.392	0.431	0.477	0.571	0.307	0.373	0.313	0.367	0.383	0.456	0.384	0.470	0.420	0.574	0.389	0.460	0.397	0.397
Neutron	0.322	0.436	0.396	0.507	0.364	0.431	0.449	0.506	0.339	0.436	0.366	0.405	0.394	0.492	0.394	0.509	0.422	0.553	0.399	0.506	0.401	0.426
Spring	0.315	0.407	0.409	0.491	0.386	0.458	0.505	0.522	0.354	0.407	0.373	0.402	0.408	0.474	0.404	0.506	0.429	0.534	0.430	0.475	0.397	0.455
Broadleaf	0.170	0.153	0.358	0.420	0.329	0.454	0.372	0.468	0.204	0.177	0.204	0.186	0.359	0.403	0.362	0.411	0.394	0.543	0.378	0.424	0.305	0.368
Nova	0.366	0.421	0.406	0.481	0.380	0.421	0.463	0.490	0.367	0.429	0.387	0.421	0.406	0.478	0.406	0.470	0.431	0.506	0.407	0.481	0.405	0.428
Npm	0.163	0.157	0.392	0.525	0.404	0.469	0.459	0.545	0.189	0.189	0.201	0.201	0.392	0.500	0.408	0.549	0.404	0.563	0.432	0.536	0.406	0.473
Mean	0.245	0.273	0.391	0.481	0.385	0.468	0.446	0.504	0.267	0.288	0.276	0.285	0.393	0.468	0.394	0.480	0.419	0.543	0.406	0.477	0.369	0.425

Table 36 Median value on *IFA* for each project when applying the default LR classifier and the LR classifier with optimized parameter settings

Projects	NONE		RUM		NearMiss		ENN		TomekLink		OSS		ROM		SMOTE		BSMOTE		SMOTE+ Tomek		SMOTE+ ENN	
	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt	default	opt
Fabric8	2.0	2.0	4.0	5.0	3.5	5.0	4.0	4.0	2.0	2.0	2.0	2.0	4.0	5.0	4.0	5.0	4.0	6.0	4.5	5.0	5.0	4.0
JGroups	2.0	1.0	4.0	5.0	5.0	5.0	3.0	3.0	2.0	1.0	2.0	2.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.0	5.0
Camel	2.0	2.0	3.0	4.0	3.0	4.0	3.0	3.0	2.0	2.0	2.0	2.0	3.0	3.0	3.0	4.0	3.0	4.0	3.0	3.0	3.0	3.0
Tomcat	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Brackets	2.0	3.0	3.0	3.0	3.0	3.0	4.0	6.0	2.0	3.0	2.0	3.0	3.0	3.0	3.0	3.0	3.0	5.0	3.0	3.0	2.0	3.0
Neutron	1.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	4.0	2.0	3.0	2.0	2.0
Spring	1.0	1.0	1.0	2.0	1.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	3.0	1.0	2.5	1.0	3.0	1.0	2.0	1.0	2.5
Broadleaf	2.0	2.0	4.0	4.0	3.0	4.0	3.0	4.0	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0
Nova	2.0	2.0	2.0	3.0	2.0	3.0	3.0	4.0	2.0	2.0	2.0	2.0	2.0	3.0	2.0	4.0	3.0	4.0	2.0	4.0	3.0	3.0
Npm	2.0	2.0	3.0	4.0	3.0	4.0	3.0	3.0	2.0	2.0	2.0	2.0	3.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	3.0	3.0
Mean	1.8	1.9	2.8	3.4	2.8	3.4	2.8	3.4	1.8	1.9	1.9	2.0	2.8	3.4	3.0	3.7	3.1	4.1	3.0	3.5	2.8	3.2

Table 37 Median value on *Recall* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.09	0.4	0.4	**1**	1	0.581	0.378	0.4	0.437	0.383	0.952
Columba	0.113	0.481	0.551	**0.868**	0.073	0.09	0.467	0.489	0.469	0.471	0.378
Jdt	0.007	0.344	0.472	0.029	0.016	0.016	0.345	0.349	0.336	0.352	**0.237**
Mozilla	0	0.343	0.43	0	0	0	0.315	0.315	0.3	0.327	**0.097**
Platform	0.003	0.318	0.491	0.03	0.005	0.006	0.318	0.324	0.305	0.335	**0.219**
Postgres	0.018	0.349	0.433	0.976	0.033	0.03	0.34	0.338	0.348	0.345	**0.921**
Mean	0.038	0.372	0.463	0.484	0.188	0.12	0.361	0.369	0.366	0.369	**0.467**

Table 38 Median value on *Precision* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	**0.5**	**0.5**	0.6	0.405	0.457	0.409	0.472	0.494	0.472	0.452	0.4
Columba	**0.53**	0.346	0.35	0.327	0.442	0.455	0.354	0.348	0.35	0.338	0.325
Jdt	**0.562**	0.212	0.195	0.235	0.2	0.2	0.213	0.212	0.212	0.208	0.212
Mozilla	0	0.073	**0.096**	0	0	0	0.073	0.069	0.077	0.069	0.07
Platform	**0.292**	0.197	0.203	0.196	0.191	0.182	0.201	0.194	0.2	0.196	0.184
Postgres	0.45	0.34	0.371	0.312	**0.5**	0.425	0.364	0.357	0.357	0.345	0.286
Mean	**0.389**	0.278	0.302	0.246	0.298	0.278	0.279	0.279	0.278	0.268	0.246

Table 39 Median value on *Pf* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.029	0.2	0.2	**1**	0.185	0.395	0.195	0.19	0.267	0.237	**1**
Columba	0.025	0.241	0.333	**1**	0.054	0.052	0.243	0.275	0.26	0.277	0.184
Jdt	0.002	0.21	0.299	0.009	0.003	0.003	0.205	0.208	0.204	0.213	**0.131**
Mozilla	0.001	0.176	0.235	0.001	0.001	0.001	0.166	0.171	0.159	0.175	**0.061**
Platform	0.003	0.189	0.311	0.018	0.004	0.004	0.189	0.192	0.181	0.2	**0.12**
Postgres	0.008	0.195	0.246	0.17	0.01	0.01	0.184	0.19	0.194	0.192	**0.798**
Mean	0.011	0.202	0.271	0.366	0.043	0.077	0.197	0.204	0.211	0.216	**0.382**

Table 40 Median value on *F-measure* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Fabric8	0.450	0.564	0.556	0.557	0.483	0.479	0.564	**0.568**	**0.568**	0.567	0.563
JGroups	0.407	0.532	0.532	0.492	0.409	0.411	**0.533**	0.527	0.530	0.524	0.521
Camel	0.514	0.599	0.582	0.600	0.533	0.537	**0.601**	0.598	0.593	0.594	0.597
Tomcat	0.610	0.653	0.648	0.657	0.617	0.618	0.648	0.648	**0.658**	0.653	0.644
Brackets	0.691	0.724	0.714	0.712	0.693	0.697	0.723	**0.725**	0.719	**0.725**	0.717
Neutron	0.748	0.781	0.774	**0.793**	0.753	0.759	0.778	0.778	0.780	0.783	0.781
Spring	0.654	0.704	0.678	**0.713**	0.664	0.678	0.705	0.702	0.705	0.704	0.699
Broadleaf	0.527	0.600	0.598	0.592	0.549	0.553	**0.608**	**0.608**	0.604	**0.608**	0.605
Nova	0.734	0.760	0.760	**0.768**	0.741	0.745	0.760	0.760	0.759	0.760	0.752
Npm	0.349	0.538	**0.553**	0.527	0.411	0.411	0.545	0.544	0.547	0.545	0.524
Mean	0.568	0.646	0.640	0.641	0.585	0.589	**0.647**	0.646	0.646	0.646	0.640

Table 41 Median value on *AUC* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.5	0.539	**0.598**	0.5	0.5	0.5	0.537	0.537	0.531	0.535	0.5
Columba	0.5	0.585	**0.613**	0.5	0.5	0.5	0.59	0.59	0.589	0.598	0.502
Jdt	0.5	0.567	**0.579**	0.5	0.5	0.5	0.567	0.567	0.565	0.566	0.533
Mozilla	0.5	0.544	**0.598**	0.5	0.5	0.5	0.546	0.547	0.547	0.547	0.5
Platform	0.5	0.562	**0.598**	0.5	0.5	0.5	0.562	0.562	0.56	0.565	0.537
Postgres	0.5	0.555	**0.586**	0.5	0.5	0.5	0.56	0.561	0.56	0.557	0.5
Mean	0.5	0.559	**0.595**	0.5	0.5	0.5	0.56	0.561	0.559	0.561	0.512

Table 42 Median value on *MCC* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.024	0.108	**0.207**	-0.031	0.079	-0.004	0.114	0.122	0.094	0.111	0.048
Columba	-0.026	0.160	0.205	0.140	0.017	0.050	0.172	0.160	0.171	**0.181**	0.093
Jdt	-0.016	0.114	0.119	-0.009	-0.017	-0.017	0.115	0.116	0.114	**0.116**	0.085
Mozilla	-0.007	0.055	0.093	-0.006	-0.006	-0.007	0.049	0.047	0.056	0.053	**0.016**
Platform	-0.019	0.096	**0.139**	-0.004	-0.013	-0.013	0.100	0.100	0.094	0.103	0.076
Postgres	-0.040	0.120	**0.158**	0.032	-0.029	-0.029	0.134	0.129	0.134	0.126	0.084
Mean	-0.014	0.109	**0.154**	0.020	0.005	-0.003	0.114	0.112	0.110	0.115	0.067

Table 43 Median value on P_{opt} for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.433	0.466	**0.485**	0.44	0.428	0.39	0.463	0.486	0.48	0.464	0.448
Columba	0.489	0.52	0.549	**0.553**	0.459	0.457	0.514	0.515	0.511	0.52	0.484
Jdt	0.478	0.515	0.569	0.499	0.478	0.476	0.517	0.526	0.521	**0.528**	0.522
Mozilla	0.519	0.506	**0.572**	0.523	0.519	0.519	0.506	0.506	0.503	0.508	0.512
Platform	0.5	0.489	**0.589**	0.495	0.495	0.495	0.484	0.486	0.483	0.492	0.532
Postgres	0.436	0.494	**0.545**	0.444	0.439	0.438	0.497	0.496	0.497	0.495	0.457
Mean	0.476	0.498	**0.552**	0.492	0.47	0.463	0.497	0.502	0.499	0.501	0.493

Table 44 Median value on *Recall@20%* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.158	**0.283**	0.28	0.15	0.146	0.148	0.27	0.277	0.267	0.267	0.182
Columba	0.15	0.256	**0.258**	0.244	0.169	0.169	0.246	0.246	0.252	0.243	0.176
Jdt	0.181	0.274	0.269	0.19	0.181	0.178	**0.273**	0.272	0.269	0.271	0.225
Mozilla	0.139	0.273	**0.4**	0.14	0.139	0.14	0.283	0.284	0.273	0.288	0.139
Platform	0.158	0.271	**0.301**	0.162	0.164	0.164	0.272	0.273	0.264	0.279	0.21
Postgres	0.145	0.262	**0.288**	0.154	0.146	0.144	0.265	0.258	0.265	0.258	0.169
Mean	0.155	0.27	**0.299**	0.173	0.157	0.157	0.268	0.268	0.265	0.268	0.184

Table 45 Median value on *Precision@20%* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.289	0.455	**0.595**	0.265	0.269	0.269	0.455	0.455	0.455	0.444	0.286
Columba	0.222	0.347	0.347	0.287	0.266	0.288	**0.358**	0.368	0.354	0.36	0.316
Jdt	0.112	0.214	0.192	0.141	0.111	0.109	0.212	0.21	0.214	0.209	**0.183**
Mozilla	0.029	0.059	**0.098**	0.03	0.03	0.03	0.056	0.055	0.071	0.057	0.037
Platform	0.093	0.19	**0.198**	0.118	0.106	0.106	0.195	0.194	0.198	0.192	0.17
Postgres	0.162	0.34	**0.369**	0.185	0.163	0.163	0.355	0.352	0.347	0.329	0.205
Mean	0.151	0.268	**0.3**	0.171	0.158	0.161	0.272	0.272	0.273	0.265	0.199

Table 46 Median value on *F-measure@20%* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.2	0.359	**0.385**	0.18	0.176	0.176	0.359	0.359	0.333	0.357	0.2
Columba	0.173	0.3	**0.3**	0.257	0.208	0.213	0.287	0.288	0.286	0.293	0.222
Jdt	0.139	0.235	**0.241**	0.154	0.138	0.138	0.24	0.241	0.24	0.237	0.209
Mozilla	0.049	0.098	**0.152**	0.05	0.049	0.049	0.096	0.094	0.113	0.095	0.061
Platform	0.115	0.224	**0.252**	0.124	0.121	0.12	0.226	0.226	0.226	0.228	0.194
Postgres	0.156	0.3	**0.322**	0.167	0.156	0.158	0.302	0.304	0.301	0.304	0.176
Mean	0.139	0.253	**0.273**	0.155	0.141	0.142	0.251	0.252	0.25	0.252	0.177

Table 47 Median value on *PCI@20%* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	0.218	0.208	0.203	**0.228**	0.223	0.223	0.204	0.204	0.21	0.205	0.224
Columba	**0.245**	0.194	0.21	0.251	0.204	0.186	0.189	0.202	0.202	0.202	0.163
Jdt	0.225	0.184	0.192	0.21	0.224	**0.224**	0.183	0.184	0.181	0.184	0.161
Mozilla	**0.265**	0.181	0.217	0.265	0.265	0.265	0.176	0.175	0.166	0.18	0.185
Platform	0.246	0.177	0.198	0.243	**0.246**	0.246	0.176	0.176	0.173	0.18	0.17
Postgres	0.219	0.192	0.202	0.216	0.218	**0.218**	0.19	0.191	0.193	0.191	0.215
Mean	0.236	0.189	0.203	**0.235**	0.23	0.227	0.186	0.189	0.187	0.19	0.186

Table 48 Median value on *IFA* for added 6 projects

Project	NONE	RUM	NearMiss	ENN	TomekLink	OSS	ROM	SMOTE	BSMOTE	SMOTE+ Tomek	SMOTE+ ENN
Bugzilla	2	2	**1**	2	2	2	2	2	**1**	2	2
Columba	3.5	3	3	3.5	2.5	2.5	3	3	3	**3.5**	3
Jdt	5	6	6	4	5	5	5	**7**	5	**7**	4
Mozilla	13	11	14	13	12	13	10	10	11	10	**14**
Platform	6	5	5	**7**	6	6	5	5	5	5	6
Postgres	2	2	**3**	2	2	2	2	2	2	2	2
Mean	5.25	4.833	5.333	5.25	4.917	5.083	4.5	4.833	4.5	4.917	**5.167**

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