Cross-project online just-in-time software defect prediction

Tabassum, Sadia; Minku, Leandro; Feng, Danyi

DOI:
10.1109/TSE.2022.3150153

Document Version
Peer reviewed version

Citation for published version (Harvard):
Tabassum, S, Minku, L & Feng, D 2022, 'Cross-project online just-in-time software defect prediction', *IEEE Transactions on Software Engineering*. https://doi.org/10.1109/TSE.2022.3150153

Cross-Project Online Just-In-Time Software Defect Prediction – Supplementary Material

Sadia Tabassum, Leandro L. Minku, *Senior Member, IEEE,* Danyi Feng

This supplementary material complements the paper entitled "Cross-Project Online Just-In-Time Software Defect Prediction" authored by Sadia Tabassum, Leandro L. Minku and Danyi Feng.

1 Result Tables

This section provides all result tables, including tables for approaches based on OOB and ORB. In addition to tables depicting the initial period, periods of sudden drop in predictive performance and stable periods, there is also a table comparing all approaches across all time steps. The tables are shown from the next page onwards, to facilitate reading.

- *S. Tabassum and L.L. Minku (the corresponding author) are with the School of Computer Science, University of Birminigham, UK, emails: sxt901@cs.bham.ac.uk and L.L.Minku@bham.ac.uk.*
- *D. Feng is with Xiliu Tech, China, email: danyi@ouchteam.com.*

TABLE 1: Number of initial time steps of the initial phase, and average G-Means, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB	Filter-OOB	Ensemble-OOB	OP-AIO-OOB	OP-Filter-OOB
Tomcat	2006	50	43.62(4.84)[-b]	51.95(1.25)[b]	52.5(0.71)[b]	33.67(0.63)[-b]	53.12(3.28)[b]	52.86(1.15)[b]
JGroups	1268	50	38.6(0.83)[-b]	38.29(0.84)[-b]	39.01(0.75)[-b]	16.64(0.36)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	461	50	27.3(0.12)[-b]	24.28(0.25)[-b]	38.69(0.49)[-b]	19.48(0.22)[-b]	11.15(6.13)[-b]	29.16(6.34)[-b]
Camel	3112	50	46.82(1.71)[-b]	57.75(0.74)[b]	57.07(0.82)[b]	39.42(0.52)[-b]	47.0(1.06)[-b]	46.94(0.96)[-b]
Brackets	1569	50	21.37(0.03)[-b]	64.89(1.32)[b]	66.17(0.74)[b]	46.83(0.91)[-b]	50.46(1.05)[s]	59.45(1.33)[b]
Nova	6271	50	55.42(0.41)[b]	63.15(0.68)[b]	64.39(0.34)[b]	51.66(0.29)[b]	62.55(1.16)[b]	62.88(4.43)[b]
Fabric8	795	50	27.01(0.3)[-b]	51.51(1.42)[b]	58.63(1.57)[b]	40.3(0.69)[-b]	56.57(3.12)[b]	45.52(1.08)[-b]
Neutron	917	50	44.84(5.75)[-b]	73.55(0.99)[b]	67.29(2.45)[b]	55.07(1.1)[b]	67.03(0.41)[b]	73.15(0.7)[b]
Npm	2536	50	26.92(1.1)[-b]	48.37(1.34)[-b]	45.75(1.94)[-b]	42.02(0.34)[-b]	42.89(6.01)[-b]	15.7(1.15)[-b]
BroadleafCommerce	677	50	26.37(0.26)[-b]	50.32(1.55)[*]	53.16(1.99)[b]	37.26(1.58)[-b]	40.29(2.8)[-b]	30.63(3.6)[-b]
Ranking		2	4	**1**	**1**	4	3	3

Dataset	#Time Periods	Dummy	WP-ORB	AIO-ORB	Filter-ORB	Ensemble-ORB	OP-AIO-ORB	OP-Filter-ORB
Tomcat	926	50	40.45(1.39)[-b]	45.83(1.39)[-b]	48.13(1.58)[-b]	35.32(0.46)[-b]	27.73(6.1)[-b]	32.87(8.82)[-b]
JGroups	1412	50	30.72(1.55)[-b]	31.48(1.31)[-b]	33.48(1.44)[-b]	15.14(0.79)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	900	50	25.7(0.8)[-b]	60.47(3.09)[b]	63.43(3.06)[b]	42.17(1.25)[-b]	62.77(2.92)[b]	48.32(2.29)[-b]
Camel	5111	50	49.69(1.59)[-s]	57.94(0.92)[b]	57.64(1.3)[b]	41.38(0.74)[-b]	50.32(4.15)[-s]	49.76(4.08)[-s]
Brackets	1721	50	13.5(0.32)[-b]	67.39(1.42)[b]	67.21(0.75)[b]	50.46(0.9)[b]	65.23(1.32)[b]	59.26(2.72)[b]
Nova	6271	50	52.8(1.78)[b]	66.44(0.37)[b]	65.0(0.78)[b]	51.85(0.88)[b]	34.29(14.0)[-b]	56.84(6.67)[b]
Fabric8	1613	50	29.97(0.45)[-b]	63.34(1.84)[b]	62.9(1.09)[b]	45.2(1.01)[-b]	56.59(4.16)[b]	55.11(3.05)[b]
Neutron	3304	50	71.78(1.03)[b]	75.09(1.11)[b]	74.98(1.42)[b]	71.04(1.0)[b]	63.71(13.18)[b]	70.28(4.96)[b]
Npm	1494	50	30.12(2.16)[-b]	40.07(2.86)[-b]	43.49(4.92)[-b]	43.53(1.45)[-b]	39.02(19.3)[-m]	0.0(0.0)[-b]
BroadleafCommerce	950	50	27.68(0.25)[-b]	51.82(3.62)[m]	52.41(4.96)[s]	41.69(0.85)[-b]	58.34(4.49)[b]	44.01(2.49)[-b]
Ranking		2	4	**1**	**1**	3	2	3

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 2: Number of initial time steps of the initial phase, and average G-Means, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB combined	AIO-OOB proprietary	Filter-OOB combined	OP-AIO-OOB combined	OP-AIO-OOB proprietary	OP-Filter-OOB combined
C1	284	50	15.76(4.12)[-b]	35.07(3.74)[-b]	15.97(3.9)[-b]	42.5(2.11)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	581	50	24.62(0.37)[-b]	31.03(0.43)[-b]	32.71(5.38)[-b]	46.82(0.76)[-b]	43.84(1.9)[-b]	5.62(6.26)[-b]	45.33(2.97)[-b]
C3	82	50	8.48(0.0)[-b]	23.36(0.0)[-b]	35.9(0.0)[-b]	8.62(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	24	50	7.59(0.13)[-b]	18.93(2.73)[-b]	18.63(3.19)[-b]	0.0(0.0)[-b]	20.1(0.14)[-b]	14.47(0.39)[-b]	0.0(0.0)[-b]
C5	8	50	11.62(0.0)[-b]	1.69(2.63)[-b]	31.66(4.57)[-b]	10.14(3.89)[-b]	5.16(6.01)[-b]	1.99(4.52)[-b]	39.83(0.0)[-b]
C6	20	50	3.6(0.0)[-b]	1.8(0.0)[-b]	1.8(0.0)[-b]	1.38(0.77)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C7	29	50	1.17(0.0)[-b]	42.76(2.42)[-b]	50.92(3.65)[-s]	0.0(0.0)[-b]	40.61(8.02)[-b]	23.0(10.38)[-b]	0.0(0.0)[-b]
C8	39	50	0.76(0.0)[-b]	5.87(4.91)[-b]	40.16(8.41)[-b]	0.66(0.26)[-b]	16.56(8.28)[-b]	37.57(6.39)[-b]	0.0(0.0)[-b]
C9	62	50	10.44(1.43)[-b]	15.4(6.94)[-b]	25.12(2.67)[-b]	0.55(0.0)[-b]	21.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Ranking		**1**	4	3	2	4	4	4	4

Dataset	#Time Steps	Dummy	WP-ORB	AIO-ORB combined	AIO-ORB proprietary	Filter-ORB combined	OP-AIO-ORB combined	OP-AIO-ORB proprietary	OP-Filter-ORB combined
C1	671	50	25.54(2.04)[-b]	30.77(1.43)[-b]	25.34(1.12)[-b]	35.03(2.64)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	582	50	16.67(0.51)[-b]	38.71(3.98)[-b]	39.32(3.38)[-b]	28.6(0.76)[-b]	41.93(2.97)[-b]	30.43(12.08)[-b]	40.93(5.07)[-b]
C3	396	50	38.67(0.64)[-b]	38.19(0.45)[-b]	39.31(1.26)[-b]	40.62(0.93)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	93	50	4.44(0.2)[-b]	35.18(3.62)[-b]	43.86(1.29)[-b]	23.17(4.39)[-b]	41.81(3.75)[-b]	42.81(0.97)[-b]	19.07(0.73)[-b]
C5	297	50	9.53(1.07)[-b]	23.72(4.03)[-b]	25.43(3.96)[-b]	35.72(3.56)[-b]	52.41(3.99)[s]	47.88(4.29)[-s]	54.87(2.63)[b]
C6	210	50	2.08(0.0)[-b]	31.87(0.96)[-b]	31.45(2.3)[-b]	29.12(1.21)[-b]	30.05(2.19)[-b]	11.88(0.89)[-b]	21.61(1.45)[-b]
C7	62	50	1.76(0.4)[-b]	45.34(6.83)[-b]	43.59(2.0)[-b]	14.65(1.7)[-b]	35.82(14.86)[-b]	29.86(12.14)[-b]	0.0(0.0)[-b]
C8	232	50	1.55(0.1)[-b]	48.68(5.87)[-s]	50.06(5.09)[*]	35.23(2.99)[-b]	50.43(5.74)[-s]	54.31(2.16)[b]	40.83(2.08)[-b]
C9	198	50	1.04(0.0)[-b]	29.05(2.79)[-b]	36.29(1.78)[-b]	21.21(0.02)[-b]	19.25(0.22)[-b]	1.27(4.7)[-b]	5.23(0.0)[-b]
Ranking		**1**	6	3	2	4	3	5	5

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 3: Total number of time steps of the performance drop periods, average G-Means, A12 effect sizes against the Dummy approach and Scott-Knott.BA12 to compare approaches using OOB and ORB for open source data during the drop periods

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB	Filter-OOB	Ensemble-OOB	OP-AIO-OOB	OP-Filter-OOB
Tomcat	3855	50	48.52(1.17)[-b]	58.86(0.72)[b]	60.22(1.0)[b]	52.26(0.32)[b]	36.58(6.17)[-b]	43.78(1.42)[-b]
JGroups	4353	50	43.95(1.44)[-b]	48.01(1.05)[-b]	48.08(0.89)[-b]	31.41(0.5)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	3973	50	32.98(0.7)[-b]	59.01(0.53)[b]	60.15(0.97)[b]	45.68(0.43)[-b]	52.2(5.28)[s]	34.89(4.74)[-b]
Camel	6009	50	53.15(1.68)[b]	56.17(0.98)[b]	57.0(0.92)[b]	52.4(0.41)[b]	50.16(1.49)[*]	50.67(0.69)[b]
Nova	4427	50	66.99(0.06)[b]	66.99(0.18)[b]	66.85(0.26)[b]	57.19(0.66)[b]	65.4(3.73)[b]	67.03(6.47)[b]
Fabric8	3443	50	53.79(2.18)[b]	56.34(0.76)[b]	65.57(1.04)[b]	53.98(0.4)[b]	22.94(6.32)[-b]	24.49(6.65)[-b]
Npm	1202	50	38.64(1.95)[-b]	62.97(1.47)[b]	65.37(1.25)[b]	51.13(0.62)[b]	44.21(7.42)[-s]	17.21(3.51)[-b]
BroadleafCommerce	3579	50	50.18(0.55)[s]	67.39(1.05)[b]	66.05(0.66)[b]	54.38(0.25)[b]	52.72(1.17)[b]	56.02(2.4)[b]
Ranking		3	3	2	**1**	3	4	4

Dataset	#Time Steps	Dummy	WP-ORB	AIO-ORB	Filter-ORB	Ensemble-ORB	OP-AIO-ORB	OP-Filter-ORB
Tomcat	2265	50	47.34(1.72)[-b]	56.29(1.15)[b]	56.23(1.22)[b]	51.1(0.46)[b]	25.76(8.05)[-b]	25.53(11.14)[-b]
JGroups	2066	50	52.94(1.49)[b]	53.93(1.37)[b]	55.36(1.45)[b]	34.42(0.45)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	2319	50	36.48(1.38)[-b]	64.14(0.86)[b]	65.49(1.07)[b]	47.13(0.72)[-b]	66.62(1.78)[b]	54.96(3.64)[b]
Camel	1105	50	48.98(3.85)[-m]	55.46(1.7)[b]	55.21(2.74)[b]	56.61(0.92)[b]	56.9(6.38)[b]	55.88(5.57)[b]
Nova	4408	50	67.29(0.57)[b]	67.48(0.56)[b]	66.65(0.25)[b]	61.5(0.62)[b]	20.38(18.77)[-b]	60.54(8.49)[b]
Fabric8	1473	50	55.13(5.87)[b]	57.2(1.9)[b]	63.55(0.94)[b]	55.15(1.05)[b]	51.26(6.09)[m]	44.7(4.8)[-b]
Npm	936	50	44.07(4.78)[-b]	46.78(4.55)[-b]	46.11(9.12)[-s]	50.03(0.65)[-s]	40.28(19.24)[-m]	0.0(0.0)[-b]
BroadleafCommerce	2703	50	51.72(2.03)[b]	67.03(1.11)[b]	66.98(0.98)[b]	54.38(0.65)[b]	49.33(5.1)[*]	58.01(2.88)[b]
Ranking		2	2	**1**	**1**	2	3	3

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 4: Total number of time steps of the performance drop periods, average G-Means, A12 effect sizes against the Dummy approach and Scott-Knott.BA12 to compare approaches using OOB and ORB for proprietary data during the drop periods

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB combined	AIO-OOB proprietary	Filter-OOB combined	OP-AIO-OOB combined	OP-AIO-OOB proprietary	OP-Filter-OOB combined
C1	452	50	32.27(4.27)[-b]	41.37(1.45)[-b]	43.4(4.45)[-b]	46.66(1.08)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C3	210	50	42.79(1.72)[-b]	47.75(1.31)[-b]	39.1(1.42)[-b]	52.17(1.3)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	249	50	33.0(0.95)[-b]	51.47(1.74)[b]	60.05(2.89)[b]	56.78(1.76)[b]	57.74(1.11)[b]	47.1(1.74)[-b]	51.35(0.0)[b]
C6	466	50	21.34(1.35)[-b]	43.64(1.49)[-b]	45.89(5.02)[-b]	44.32(1.98)[-b]	43.53(0.41)[-b]	37.47(0.18)[-b]	45.1(0.47)[-b]
C7	255	50	25.74(1.19)[-b]	41.5(5.94)[-b]	32.34(1.51)[-b]	40.34(1.02)[-b]	50.43(2.6)[-*]	36.26(0.52)[-b]	30.73(0.4)[-b]
C8	287	50	7.3(0.89)[-b]	44.65(0.96)[-b]	34.6(5.43)[-b]	40.14(1.82)[-b]	44.3(1.81)[-b]	45.49(9.63)[*]	25.57(8.7)[-b]
C9	541	50	31.75(1.77)[-b]	51.34(1.76)[b]	50.08(2.77)[s]	53.25(1.58)[b]	40.3(5.22)[-b]	34.92(3.87)[-b]	34.36(0.55)[-b]
Ranking		**1**	5	3	4	2	4	5	5

Dataset	#Time Steps	Dummy	WP-ORB	AIO-ORB combined	AIO-ORB proprietary	Filter-ORB combined	OP-AIO-ORB combined	OP-AIO-ORB proprietary	OP-Filter-ORB combined
C1	238	50	41.17(6.37)[-b]	37.26(5.59)[-b]	28.75(3.01)[-b]	47.3(6.34)[-s]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C6	64	50	35.38(0.91)[-b]	50.99(7.22)[m]	35.67(9.61)[-b]	44.61(5.36)[-b]	61.13(3.51)[b]	46.51(5.76)[-m]	42.82(5.16)[-b]
C7	85	50	31.09(4.47)[-b]	32.33(10.88)[-b]	50.09(13.02)[m]	59.45(6.92)[b]	35.64(17.93)[-s]	41.39(2.73)[-b]	0.0(0.0)[-b]
C8	80	50	20.25(1.22)[-b]	39.45(14.5)[-s]	37.97(14.69)[-s]	50.59(6.1)[b]	47.77(6.08)[-s]	32.34(8.23)[-b]	45.77(2.75)[-b]
C9	23	50	23.59(1.26)[-b]	39.88(7.47)[-b]	25.48(4.84)[-b]	20.64(1.48)[-b]	43.2(8.64)[-b]	1.64(3.75)[-b]	17.96(0.0)[-b]
Ranking		**1**	4	3	3	2	3	4	4

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 5: Number of time steps of the stable periods, and average G-Means, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this stable periods for OOB and ORB for open source data

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB	Filter-OOB	Ensemble-OOB	OP-AIO-OOB	OP-Filter-OOB
Tomcat	13046	50	62.69(0.81)[b]	61.36(0.5)[b]	63.36(0.64)[b]	50.57(0.22)[b]	39.85(6.0)[-b]	45.14(1.49)[-b]
JGroups	12704	50	60.08(0.66)[b]	58.74(0.72)[b]	58.51(0.54)[b]	38.8(0.3)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	4316	50	64.86(1.01)[b]	65.99(0.35)[b]	66.96(0.77)[b]	56.02(0.33)[b]	55.71(8.02)[b]	45.38(8.91)[-*]
Camel	21454	50	67.33(0.56)[b]	64.48(0.67)[b]	65.05(0.62)[b]	54.61(0.35)[b]	41.5(1.52)[-b]	41.54(1.25)[-b]
Brackets	15795	50	68.27(0.12)[b]	71.44(0.48)[b]	71.38(0.42)[b]	64.25(0.54)[b]	39.05(12.78)[-b]	66.69(0.34)[b]
Nova	38291	50	79.84(0.26)[b]	82.03(0.21)[b]	81.54(0.2)[b]	68.72(0.79)[b]	73.83(16.61)[b]	75.2(0.5)[b]
Fabric8	8868	50	65.0(0.77)[b]	63.53(0.62)[b]	67.64(0.64)[b]	54.15(0.4)[b]	25.97(4.87)[-b]	28.17(4.46)[-b]
Neutron	18605	50	81.13(0.27)[b]	81.87(0.23)[b]	82.22(0.25)[b]	68.93(1.5)[b]	74.49(1.77)[b]	71.43(3.91)[b]
Npm	4182	50	59.52(1.71)[b]	64.96(0.63)[b]	66.49(0.99)[b]	55.3(0.46)[b]	29.41(2.02)[-b]	40.07(1.13)[-b]
BroadleafCommerce	10754	50	65.96(1.12)[b]	70.73(0.62)[b]	70.13(0.55)[b]	59.55(0.2)[b]	54.3(0.78)[b]	60.4(1.06)[b]
Ranking		4	2	**1**	**1**	3	5	4

Dataset	#Time Steps	Dummy	WP-ORB	AIO-ORB	Filter-ORB	Ensemble-ORB	OP-AIO-ORB	OP-Filter-ORB
Tomcat	15716	50	62.71(0.97)[b]	63.44(0.86)[b]	62.74(0.57)[b]	51.69(0.43)[b]	45.39(1.76)[-b]	37.75(2.12)[-b]
JGroups	14847	50	60.31(0.8)[b]	60.99(0.67)[b]	61.06(0.74)[b]	39.88(0.34)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	5531	50	62.36(0.94)[b]	70.48(0.7)[b]	70.75(0.41)[b]	56.27(0.61)[b]	68.57(2.2)[b]	58.38(4.57)[b]
Camel	24359	50	66.33(1.02)[b]	66.92(0.39)[b]	66.34(0.34)[b]	56.85(0.55)[b]	51.0(3.63)[b]	45.33(4.33)[-b]
Brackets	15643	50	68.79(0.53)[b]	70.26(1.01)[b]	70.07(0.83)[b]	66.28(0.79)[b]	64.33(0.62)[b]	64.42(1.56)[b]
Nova	38310	50	80.06(0.81)[b]	80.18(0.41)[b]	79.94(0.38)[b]	76.12(0.68)[b]	38.93(30.48)[*]	76.85(2.32)[b]
Fabric8	10020	50	67.41(0.81)[b]	64.72(1.01)[b]	68.72(0.59)[b]	57.74(0.6)[b]	49.22(6.71)[-s]	38.08(5.44)[-b]
Neutron	16218	50	81.09(0.63)[b]	81.87(0.39)[b]	81.83(0.51)[b]	74.93(1.23)[b]	67.06(12.37)[b]	70.65(7.2)[b]
Npm	5490	50	61.92(0.9)[b]	67.72(0.88)[b]	65.63(1.3)[b]	55.23(0.64)[b]	51.29(19.52)[b]	0.0(0.0)[-b]
BroadleafCommerce	11357	50	64.31(1.34)[b]	69.39(0.6)[b]	68.9(0.78)[b]	61.46(0.49)[b]	41.81(8.62)[-b]	49.32(2.91)[-s]
Ranking		4	2	**1**	**1**	3	4	4

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 6: Number of time steps of the stable periods, and average G-Means, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this stable periods for OOB and ORB for proprietary data

Dataset	#Time Steps	Dummy	WP-OOB	AIO-OOB combined	AIO-OOB proprietary	Filter-OOB combined	OP-AIO-OOB combined	OP-AIO-OOB proprietary	OP-Filter-OOB combined
C1	294	50	49.55(1.47)[-*]	43.65(2.33)[-b]	43.4(6.94)[-b]	45.75(2.02)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	20	50	64.59(0.23)[b]	52.86(1.75)[b]	55.58(2.72)[b]	59.42(0.62)[b]	36.49(0.93)[-b]	2.8(3.22)[-b]	37.36(1.46)[-b]
C3	125	50	54.54(1.05)[b]	54.01(0.43)[b]	33.69(2.6)[-b]	57.0(0.61)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	68	50	45.72(1.21)[-b]	53.4(1.23)[b]	56.98(4.85)[b]	27.16(8.92)[-b]	46.76(0.61)[-b]	44.62(2.6)[-b]	21.15(0.0)[-b]
C5	315	50	23.2(0.43)[-b]	46.55(1.35)[-b]	42.6(0.99)[-b]	49.93(1.71)[-s]	44.14(5.2)[-b]	49.53(2.92)[-s]	41.15(4.14)[-b]
C6	69	50	41.71(0.64)[-b]	43.05(0.65)[-b]	49.84(2.73)[-*]	41.83(3.36)[-b]	24.67(0.34)[-b]	14.76(0.07)[-b]	21.1(0.26)[-b]
C7	262	50	45.55(1.0)[-b]	52.02(5.6)[s]	52.62(2.11)[b]	52.35(2.27)[b]	57.67(1.5)[b]	52.6(1.18)[b]	40.38(0.7)[-b]
C8	472	50	26.13(0.22)[-b]	55.16(0.91)[b]	47.01(3.71)[-b]	40.38(1.65)[-b]	45.29(1.94)[-b]	48.99(5.2)[s]	41.14(2.6)[-b]
C9	91	50	49.63(1.59)[-b]	56.46(2.26)[b]	59.12(6.12)[b]	46.6(2.06)[-b]	29.03(2.98)[-b]	8.62(1.08)[-b]	14.33(2.11)[-b]
Ranking		2	3	**1**	2	3	4	5	5

Dataset	#Time Steps	Dummy	WP-ORB	AIO-ORB combined	AIO-ORB proprietary	Filter-ORB combined	OP-AIO-ORB combined	OP-AIO-ORB proprietary	OP-Filter-ORB combined
C1	121	50	48.52(2.36)[-b]	46.19(4.31)[-b]	37.82(3.52)[-b]	54.01(3.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	19	50	49.05(1.07)[-b]	61.06(1.23)[b]	47.53(6.61)[-b]	58.16(0.66)[b]	36.04(3.44)[-b]	35.0(13.46)[-b]	37.85(3.21)[-b]
C3	21	50	61.11(1.36)[b]	60.52(1.53)[b]	62.7(1.89)[b]	61.9(1.38)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	248	50	52.68(1.35)[b]	41.8(5.78)[-b]	46.85(3.7)[-b]	56.44(1.82)[b]	53.88(2.62)[b]	43.79(1.04)[-b]	66.78(4.59)[b]
C5	26	50	42.31(8.55)[-b]	56.2(1.44)[b]	56.09(1.8)[b]	54.92(3.15)[b]	57.76(7.76)[b]	47.64(4.51)[-b]	53.59(5.68)[m]
C6	281	50	51.77(0.51)[b]	53.76(2.24)[b]	52.25(3.62)[b]	51.32(1.58)[b]	62.91(2.09)[b]	49.96(2.24)[s]	54.29(1.24)[b]
C7	399	50	46.48(2.58)[-b]	47.52(8.24)[-s]	56.43(6.65)[b]	60.96(2.67)[b]	31.51(15.32)[-b]	35.19(10.53)[-b]	0.0(0.0)[-b]
C8	486	50	32.08(0.62)[-b]	45.61(11.25)[*]	42.57(13.67)[*]	48.0(2.75)[-b]	49.95(5.09)[-s]	40.18(6.55)[-b]	48.24(2.34)[-b]
C9	473	50	34.92(0.48)[-b]	38.53(2.39)[-b]	40.0(4.65)[-b]	34.07(1.49)[-b]	36.98(6.48)[-b]	2.06(4.74)[-b]	18.38(0.0)[-b]
Ranking		2	3	2	2	**1**	4	4	4

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the corresponding Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Smaller Scott-Knott.BA12 rankings are better rankings.

TABLE 7: Overall predictive performance, A12 effect sizes and Scott-Knott.BA12 statistical tests to compare learning approaches for open source data

Dataset	Approach	Recall0	Recall1	G-Mean
Tomcat	Dummy	50	50	50
	WP-OOB	58.25(1.85)[b]	63.59(1.56)[b]	57.78(0.62)[b]
	AIO-OOB	61.07(1.35)[b]	63.76(1.15)[b]	59.85(0.48)[b]
	Filter-OOB	66.99(1.24)[b]	60.05(0.99)[b]	61.57(0.53)[b]
	Ensemble-OOB	63.78(0.71)[b]	43.06(0.74)[-b]	49.12(0.2)[-b]
	OP-AIO-OOB	22.09(4.78)[-b]	85.86(2.49)[b]	40.44(5.71)[-b]
	OP-Filter-OOB	27.61(1.73)[-b]	82.4(1.5)[b]	45.75(1.3)[-b]
Jgroups	Dummy	50	50	50
	WP-OOB	57.55(1.71)[b]	59.01(1.53)[b]	54.76(0.69)[b]
	AIO-OOB	64.54(1.6)[b]	52.85(1.48)[b]	54.77(0.65)[b]
	Filter-OOB	65.94(1.34)[b]	51.59(1.24)[b]	54.68(0.43)[b]
	Ensemble-OOB	84.03(0.4)[b]	18.6(0.37)[-b]	35.51(0.3)[-b]
	OP-AIO-OOB	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-OOB	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	Dummy	50	50	50
	WP-OOB	61.13(1.67)[b]	56.09(1.33)[b]	48.41(0.71)[-b]
	AIO-OOB	65.32(0.62)[b]	61.57(0.88)[b]	60.62(0.29)[b]
	Filter-OOB	69.82(0.76)[b]	59.96(1.21)[b]	62.38(0.69)[b]
	Ensemble-OOB	73.09(0.58)[b]	37.6(0.64)[-b]	49.4(0.28)[-b]
	OP-AIO-OOB	47.2(9.1)[*]	70.94(7.57)[b]	51.79(6.1)[m]
	OP-Filter-OOB	24.67(5.81)[-b]	89.93(1.22)[b]	39.82(6.35)[-b]
Camel	Dummy	50	50	50
	WP-OOB	56.04(1.25)[b]	74.62(0.97)[b]	62.45(0.58)[b]
	AIO-OOB	53.89(1.15)[b]	75.29(0.73)[b]	62.16(0.62)[b]
	Filter-OOB	55.52(0.82)[b]	74.29(0.72)[b]	62.66(0.56)[b]
	Ensemble-OOB	55.25(0.88)[b]	55.17(0.78)[b]	52.63(0.25)[b]
	OP-AIO-OOB	25.72(2.44)[-b]	82.82(3.08)[b]	43.71(1.43)[-b]
	OP-Filter-OOB	25.06(1.21)[-b]	85.75(0.85)[b]	43.87(1.03)[-b]
Brackets	Dummy	50	50	50
	WP-OOB	49.16(0.28)[-b]	89.6(0.24)[b]	64.03(0.11)[b]
	AIO-OOB	65.47(1.01)[b]	79.68(1.32)[b]	70.85(0.48)[b]
	Filter-OOB	69.15(0.84)[b]	75.44(1.31)[b]	70.91(0.4)[b]
	Ensemble-OOB	64.89(0.77)[b]	62.81(1.13)[b]	62.68(0.48)[b]
	OP-AIO-OOB	31.33(9.76)[-b]	89.04(2.47)[b]	39.3(12.45)[-b]
	OP-Filter-OOB	49.42(1.23)[-m]	90.25(1.67)[b]	66.02(0.36)[b]
Nova	Dummy	50	50	50
	WP-OOB	68.2(0.24)[b]	86.95(0.53)[b]	75.55(0.21)[b]
	AIO-OOB	70.04(0.32)[b]	88.9(0.54)[b]	78.25(0.2)[b]
	Filter-OOB	70.91(0.31)[b]	87.24(0.38)[b]	78.01(0.18)[b]
	Ensemble-OOB	75.88(0.79)[b]	57.23(1.61)[b]	65.5(0.61)[b]
	OP-AIO-OOB	59.07(12.18)[b]	92.65(2.2)[b]	71.75(13.26)[b]
	OP-Filter-OOB	71.16(1.79)[b]	76.16(3.22)[b]	72.89(1.28)[b]
Fabric8	Dummy	50	50	50
	WP-OOB	50.56(2.72)[s]	75.72(2.21)[b]	59.75(1.01)[b]
	AIO-OOB	55.91(1.01)[b]	70.76(1.46)[b]	60.92(0.48)[b]
	Filter-OOB	61.94(1.89)[b]	73.25(1.58)[b]	66.55(0.63)[b]
	Ensemble-OOB	48.84(1.22)[-b]	61.42(1.39)[b]	53.27(0.36)[b]
	OP-AIO-OOB	10.88(2.39)[-b]	96.88(1.22)[b]	27.2(5.03)[-b]
	OP-Filter-OOB	15.42(3.65)[-b]	87.62(4.89)[b]	28.3(4.48)[-b]
Neutron	Dummy	50	50	50
	WP-OOB	70.03(0.7)[b]	91.81(0.61)[b]	79.43(0.36)[b]
	AIO-OOB	73.24(0.42)[b]	91.39(0.5)[b]	81.48(0.24)[b]
	Filter-OOB	74.89(0.45)[b]	89.63(0.54)[b]	81.51(0.26)[b]
	Ensemble-OOB	78.58(1.03)[b]	59.78(3.32)[b]	68.28(1.42)[b]
	OP-AIO-OOB	70.23(0.95)[b]	81.61(2.92)[b]	74.18(1.7)[b]
	OP-Filter-OOB	76.02(3.05)[b]	71.15(8.76)[b]	71.6(3.77)[b]
Npm	Dummy	50	50	50
	WP-OOB	36.99(2.19)[-b]	75.74(1.52)[b]	45.91(0.91)[-b]
	AIO-OOB	54.8(1.61)[b]	68.69(2.03)[b]	59.34(0.61)[b]
	Filter-OOB	55.39(1.61)[b]	68.59(1.48)[b]	59.68(0.54)[b]
	Ensemble-OOB	54.22(1.01)[b]	51.89(1.05)[b]	50.42(0.29)[b]
	OP-AIO-OOB	61.08(6.38)[b]	37.31(6.76)[-b]	35.91(2.78)[-b]
	OP-Filter-OOB	17.06(0.89)[-b]	81.46(0.61)[b]	28.84(1.22)[-b]
BroadleafCommerce	Dummy	50	50	50
	WP-OOB	58.44(1.58)[b]	69.82(2.13)[b]	60.41(0.83)[b]
	AIO-OOB	67.28(1.37)[b]	72.11(1.54)[b]	69.01(0.58)[b]
	Filter-OOB	67.41(0.94)[b]	70.53(0.98)[b]	68.39(0.42)[b]
	Ensemble-OOB	61.96(0.89)[b]	56.48(1.08)[b]	57.31(0.18)[b]
	OP-AIO-OOB	42.99(1.3)[-b]	71.99(2.46)[b]	53.27(0.67)[b]
	OP-Filter-OOB	54.22(4.85)[b]	68.75(5.18)[b]	58.04(1.23)[b]
Ranking	Dummy	4	4	5
	WP-OOB	3	**1**	2
	AIO-OOB	2	**1**	**1**
	Filter-OOB	2	**1**	**1**
	Ensemble-OOB	2	4	4
	OP-AIO-OOB	5	**1**	6
	OP-Filter-OOB	5	**1**	6

Dataset	Approach	Recall0	Recall1	G-Mean
Tomcat	Dummy	50	50	50
	WP-ORB	58.41(1.72)[b]	64.49(1.21)[b]	59.78(0.83)[b]
	AIO-ORB	61.98(1.19)[b]	63.38(0.74)[b]	61.72(0.82)[b]
	Filter-ORB	61.07(0.89)[b]	63.31(0.74)[b]	61.25(0.48)[b]
	Ensemble-ORB	61.75(1.23)[b]	47.67(1.08)[-b]	50.82(0.34)[b]
	OP-AIO-ORB	46.92(5.41)[-b]	54.07(4.56)[b]	42.31(2.63)[-b]
	OP-Filter-ORB	49.5(5.02)[*]	45.05(3.66)[-b]	36.03(3.38)[-b]
Jgroups	Dummy	50	50	50
	WP-ORB	61.18(0.71)[b]	56.93(1.28)[b]	57.2(0.81)[b]
	AIO-ORB	62.77(0.94)[b]	56.67(0.96)[b]	57.92(0.66)[b]
	Filter-ORB	63.05(1.07)[b]	57.21(1.26)[b]	58.29(0.68)[b]
	Ensemble-ORB	83.72(0.33)[b]	20.1(0.42)[-b]	37.35(0.33)[-b]
	OP-AIO-ORB	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-ORB	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	Dummy	50	50	50
	WP-ORB	71.92(1.0)[b]	45.83(1.31)[-b]	51.73(0.78)[b]
	AIO-ORB	67.51(0.86)[b]	69.48(1.05)[b]	67.77(0.75)[b]
	Filter-ORB	68.57(0.84)[b]	69.93(0.83)[b]	68.61(0.58)[b]
	Ensemble-ORB	74.61(0.48)[b]	39.98(0.67)[-b]	52.4(0.54)[b]
	OP-AIO-ORB	76.29(2.16)[b]	61.45(4.22)[b]	67.5(1.79)[b]
	OP-Filter-ORB	81.69(8.13)[b]	42.21(7.74)[-b]	56.2(3.9)[b]
Camel	Dummy	50	50	50
	WP-ORB	59.59(1.18)[b]	70.11(1.15)[b]	62.92(0.98)[b]
	AIO-ORB	59.12(0.52)[b]	73.1(0.56)[b]	65.01(0.37)[b]
	Filter-ORB	58.58(0.62)[b]	72.7(0.53)[b]	64.48(0.43)[b]
	Ensemble-ORB	61.46(0.88)[b]	52.33(1.13)[b]	54.26(0.51)[b]
	OP-AIO-ORB	60.0(8.59)[b]	47.9(7.2)[-m]	51.05(2.66)[b]
	OP-Filter-ORB	52.14(10.01)[s]	46.55(11.0)[-*]	46.44(3.82)[-b]
Brackets	Dummy	50	50	50
	WP-ORB	61.31(0.74)[b]	76.66(1.43)[b]	63.31(0.49)[b]
	AIO-ORB	66.9(1.03)[b]	74.94(1.71)[b]	69.98(0.87)[b]
	Filter-ORB	66.34(0.92)[b]	75.35(1.33)[b]	69.78(0.74)[b]
	Ensemble-ORB	61.7(1.09)[b]	69.14(1.23)[b]	64.71(0.75)[b]
	OP-AIO-ORB	52.23(1.53)[b]	84.23(2.0)[b]	64.42(0.55)[b]
	OP-Filter-ORB	49.77(2.14)[-s]	85.76(4.24)[b]	63.91(1.56)[b]
Nova	Dummy	50	50	50
	WP-ORB	74.25(1.49)[b]	80.57(2.64)[b]	75.42(0.66)[b]
	AIO-ORB	74.15(0.89)[b]	81.95(1.27)[b]	77.28(0.32)[b]
	Filter-ORB	72.72(0.21)[b]	82.85(0.54)[b]	76.83(0.35)[b]
	Ensemble-ORB	76.76(0.76)[b]	68.42(1.8)[b]	71.7(0.59)[b]
	OP-AIO-ORB	53.97(38.63)[m]	67.03(25.53)[b]	37.92(27.73)[*]
	OP-Filter-ORB	69.64(3.22)[b]	79.47(7.14)[b]	72.83(2.93)[b]
Fabric8	Dummy	50	50	50
	WP-ORB	61.32(2.17)[b]	67.83(1.32)[b]	61.42(1.04)[b]
	AIO-ORB	57.39(1.44)[b]	73.78(1.42)[b]	63.7(1.03)[b]
	Filter-ORB	64.14(0.62)[b]	71.8(1.09)[b]	67.42(0.42)[b]
	Ensemble-ORB	49.61(1.24)[-s]	65.68(1.22)[b]	55.91(0.59)[b]
	OP-AIO-ORB	72.26(5.51)[b]	41.86(8.81)[-b]	50.3(5.86)[-*]
	OP-Filter-ORB	77.01(18.09)[b]	31.63(19.81)[-b]	40.84(4.19)[-b]
Neutron	Dummy	50	50	50
	WP-ORB	80.47(1.71)[b]	79.52(1.88)[b]	79.52(0.58)[b]
	AIO-ORB	75.34(0.57)[b]	87.53(0.89)[b]	80.72(0.39)[b]
	Filter-ORB	74.01(0.81)[b]	88.98(1.02)[b]	80.67(0.54)[b]
	Ensemble-ORB	77.01(1.55)[b]	72.02(3.41)[b]	74.28(1.1)[b]
	OP-AIO-ORB	70.35(18.03)[b]	66.39(7.53)[b]	66.55(12.39)[b]
	OP-Filter-ORB	74.34(9.05)[b]	70.43(21.56)[b]	70.28(6.99)[b]
Npm	Dummy	50	50	50
	WP-ORB	54.93(1.17)[b]	63.67(1.32)[b]	53.81(0.95)[b]
	AIO-ORB	50.95(1.56)[b]	76.91(1.92)[b]	60.03(1.11)[b]
	Filter-ORB	51.23(4.02)[-s]	73.26(3.94)[b]	59.15(1.94)[b]
	Ensemble-ORB	52.48(1.25)[b]	56.11(0.97)[b]	52.41(0.58)[b]
	OP-AIO-ORB	73.38(16.16)[b]	44.16(24.46)[-*]	47.99(19.35)[b]
	OP-Filter-ORB	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
BroadleafCommerce	Dummy	50	50	50
	WP-ORB	59.43(2.96)[b]	65.93(3.01)[b]	59.72(1.29)[b]
	AIO-ORB	66.78(0.85)[b]	70.12(1.02)[b]	67.85(0.58)[b]
	Filter-ORB	66.83(0.64)[b]	69.2(1.48)[b]	67.51(0.85)[b]
	Ensemble-ORB	61.57(1.2)[b]	59.13(1.46)[b]	58.94(0.45)[b]
	OP-AIO-ORB	84.29(4.22)[b]	26.63(7.15)[-b]	44.42(7.7)[-b]
	OP-Filter-ORB	76.78(5.08)[b]	35.82(4.08)[-b]	50.57(2.62)[s]
Ranking	Dummy	4	4	5
	WP-ORB	2	2	2
	AIO-ORB	2	**1**	**1**
	Filter-ORB	2	**1**	**1**
	Ensemble-ORB	2	3	3
	OP-AIO-ORB	**1**	4	5
	OP-Filter-ORB	**1**	5	6

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the Dummy approach. Scott-Knott.BA12 was run for all OOB- and ORB-based approaches together. The groups' rankings retrieved by Scott-Knott.BA12 are shown in the ranking rows, with smaller numbers indicating better rankings.

The recalls of the approaches across data sets are influenced by trade-offs between Recall0 and Recall1, resulting in several approaches obtaining the same best rank across datasets. This is because a given approach sometimes performs better in terms of Recall0 and sometimes in terms of Recall1, resulting overall in the same rank. However, given the G-Mean results, which combine Recall0 and Recall1, the trade-offs between recalls obtained by AIO and Filtering were better than those obtained by WP, Ensemble and Offline approaches.

TABLE 8: Overall predictive performance, A12 effect sizes and Scott-Knott.BA12 statistical tests to compare learning approaches for proprietary data

Dataset	Approach	Recall0	Recall1	G-Mean
C1	Dummy	50	50	50
	WP-OOB	59.25(4.79)[b]	39.37(3.88)[-b]	32.65(1.53)[-b]
	AIO-OOB-combined	51.6(3.65)[b]	48.3(2.55)[-b]	40.28(1.53)[-b]
	AIO-OOB-proprietary	31.75(8.46)[-b]	65.14(7.2)[b]	35.84(3.45)[-b]
	Filter-OOB-combined	53.56(3.43)[b]	49.18(3.1)[-s]	45.25(1.17)[-b]
	OP-AIO-OOB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-AIO-OOB-proprietary	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-OOB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	Dummy	50	50	50
	WP-OOB	16.33(0.12)[-b]	87.15(0.0)[b]	25.95(0.37)[-b]
	AIO-OOB-combined	22.23(0.53)[-b]	76.41(0.42)[b]	31.76(0.45)[-b]
	AIO-OOB-proprietary	45.82(7.4)[-b]	49.25(10.34)[m]	33.47(5.27)[-b]
	Filter-OOB-combined	45.22(1.27)[-b]	63.81(1.77)[b]	47.24(0.74)[-b]
	OP-AIO-OOB-combined	43.5(4.07)[-b]	55.23(3.49)[b]	43.6(1.86)[-b]
	OP-AIO-OOB-proprietary	98.4(2.76)[b]	1.54(1.88)[-b]	5.53(6.16)[-b]
	OP-Filter-OOB-combined	47.57(5.6)[-s]	55.6(4.04)[b]	45.06(2.91)[-b]
C3	Dummy	50	50	50
	WP-OOB	59.78(4.95)[b]	38.31(4.5)[-b]	39.57(1.1)[-b]
	AIO-OOB-combined	41.52(0.84)[-b]	69.57(1.43)[b]	44.83(0.71)[-b]
	AIO-OOB-proprietary	26.4(2.25)[-b]	66.45(3.09)[b]	36.85(1.35)[-b]
	Filter-OOB-combined	52.59(1.18)[b]	59.66(0.99)[b]	45.05(0.82)[-b]
	OP-AIO-OOB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-AIO-OOB-proprietary	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-OOB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	Dummy	50	50	50
	WP-OOB	21.56(0.74)[-b]	81.96(0.66)[b]	33.75(0.86)[-b]
	AIO-OOB-combined	37.79(1.76)[-b]	76.64(1.34)[b]	49.57(1.45)[-s]
	AIO-OOB-proprietary	66.59(6.0)[b]	55.44(8.47)[m]	56.52(3.02)[b]
	Filter-OOB-combined	61.15(3.35)[b]	54.41(2.64)[b]	46.88(2.53)[-b]
	OP-AIO-OOB-combined	50.98(1.91)[b]	61.59(1.59)[b]	52.9(0.9)[b]
	OP-AIO-OOB-proprietary	40.49(3.43)[-b]	62.7(3.37)[b]	44.31(1.36)[-b]
	OP-Filter-OOB-combined	49.25(0.0)[-b]	61.33(0.0)[b]	41.71(0.0)[-b]
C5	Dummy	50	50	50
	WP-OOB	11.93(0.67)[-b]	85.44(1.43)[b]	22.91(0.42)[-b]
	AIO-OOB-combined	34.86(1.67)[-b]	67.71(3.08)[b]	45.44(1.35)[-b]
	AIO-OOB-proprietary	22.52(1.1)[-b]	90.05(1.31)[b]	42.33(0.98)[-b]
	Filter-OOB-combined	38.55(2.54)[-b]	67.07(4.08)[b]	48.94(1.67)[-b]
	OP-AIO-OOB-combined	76.39(3.78)[b]	26.8(5.51)[-b]	43.17(5.15)[-b]
	OP-AIO-OOB-proprietary	42.76(5.1)[-b]	67.8(4.34)[b]	48.35(2.86)[-m]
	OP-Filter-OOB-combined	23.54(6.53)[-b]	82.43(6.63)[b]	41.11(4.03)[-b]
C6	Dummy	50	50	50
	WP-OOB	10.98(0.58)[-b]	87.91(0.56)[b]	23.23(1.17)[-b]
	AIO-OOB-combined	33.15(1.82)[-b]	69.53(1.63)[b]	42.06(1.29)[-b]
	AIO-OOB-proprietary	40.29(10.26)[-b]	64.4(9.58)[b]	44.79(4.18)[-b]
	Filter-OOB-combined	35.22(2.81)[-b]	69.57(2.4)[b]	42.47(1.85)[-b]
	OP-AIO-OOB-combined	48.6(1.25)[-b]	56.66(0.81)[b]	39.62(0.37)[-b]
	OP-AIO-OOB-proprietary	70.97(0.35)[b]	30.75(0.28)[-b]	33.3(0.15)[-b]
	OP-Filter-OOB-combined	54.93(1.23)[b]	48.66(0.77)[-b]	40.49(0.42)[-b]
C7	Dummy	50	50	50
	WP-OOB	22.78(0.75)[-b]	83.52(0.51)[b]	33.94(0.92)[-b]
	AIO-OOB-combined	38.25(12.04)[-b]	70.7(7.58)[b]	46.62(5.4)[-m]
	AIO-OOB-proprietary	23.12(1.65)[-b]	93.33(1.26)[b]	43.06(1.67)[-b]
	Filter-OOB-combined	44.7(2.1)[-b]	61.98(3.79)[b]	43.96(1.28)[-b]
	OP-AIO-OOB-combined	77.52(2.22)[b]	38.87(2.4)[-b]	53.38(1.97)[b]
	OP-AIO-OOB-proprietary	34.57(1.17)[-b]	69.48(2.97)[b]	43.4(0.71)[-b]
	OP-Filter-OOB-combined	26.99(0.75)[-b]	65.72(0.78)[b]	33.73(0.52)[-b]
C8	Dummy	50	50	50
	WP-OOB	13.04(0.1)[-b]	83.1(0.01)[b]	18.12(0.43)[-b]
	AIO-OOB-combined	46.57(1.22)[-b]	60.3(1.79)[b]	48.97(0.81)[-b]
	AIO-OOB-proprietary	29.57(4.44)[-b]	74.84(4.67)[b]	42.21(4.03)[-b]
	Filter-OOB-combined	46.6(1.38)[-b]	48.41(1.65)[-b]	38.35(1.15)[-b]
	OP-AIO-OOB-combined	66.69(2.8)[b]	34.9(2.52)[-b]	43.53(1.52)[-b]
	OP-AIO-OOB-proprietary	77.63(10.75)[b]	32.16(10.48)[-b]	47.17(6.24)[*]
	OP-Filter-OOB-combined	24.94(3.74)[-b]	74.12(2.55)[b]	33.53(4.49)[-b]
C9	Dummy	50	50	50
	WP-OOB	20.64(1.34)[-b]	86.52(0.42)[b]	32.19(1.44)[-b]
	AIO-OOB-combined	44.53(2.53)[-b]	69.19(3.39)[b]	48.8(1.44)[-b]
	AIO-OOB-proprietary	59.51(4.62)[b]	52.23(7.1)[s]	49.04(2.87)[-s]
	Filter-OOB-combined	52.2(2.63)[b]	58.09(2.72)[b]	47.67(1.32)[-b]
	OP-AIO-OOB-combined	59.8(7.99)[b]	41.63(6.31)[-b]	37.1(4.46)[-b]
	OP-AIO-OOB-proprietary	93.81(5.79)[b]	13.24(5.36)[-b]	28.35(3.15)[-b]
	OP-Filter-OOB-combined	52.0(0.16)[b]	46.24(0.5)[-b]	28.67(0.68)[-b]
Ranking	Dummy	2	4	**1**
	WP-OOB	5	**1**	5
	AIO-OOB-combined	4	2	2
	AIO-OOB-proprietary	4	2	3
	Filter-OOB-combined	3	3	2
	OP-AIO-OOB-combined	**1**	5	3
	OP-AIO-OOB-proprietary	**1**	5	5
	OP-Filter-OOB-combined	2	4	5

Dataset	Approach	Recall0	Recall1	G-Mean
C1	Dummy	50	50	50
	WP-ORB	64.69(5.61)[b]	30.75(3.94)[-b]	31.85(2.57)[-b]
	AIO-ORB-combined	45.4(6.03)[-b]	51.85(6.11)[b]	34.08(2.4)[-b]
	AIO-ORB-proprietary	35.64(1.4)[-b]	57.67(1.51)[b]	27.59(1.45)[-b]
	Filter-ORB-combined	69.56(8.37)[b]	37.95(8.06)[-b]	40.1(2.02)[-b]
	OP-AIO-ORB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-AIO-ORB-proprietary	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-ORB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	Dummy	50	50	50
	WP-ORB	71.46(1.01)[b]	17.49(0.83)[-b]	17.7(0.51)[-b]
	AIO-ORB-combined	35.88(3.47)[-b]	60.89(3.72)[b]	39.41(3.86)[-b]
	AIO-ORB-proprietary	38.15(6.8)[-b]	55.99(9.41)[b]	39.58(3.32)[-b]
	Filter-ORB-combined	46.15(0.69)[-b]	43.99(0.7)[-b]	29.53(0.75)[-b]
	OP-AIO-ORB-combined	82.97(2.67)[b]	25.75(4.38)[-b]	41.74(2.98)[-b]
	OP-AIO-ORB-proprietary	87.63(8.27)[b]	15.2(9.77)[-b]	30.58(12.08)[-b]
	OP-Filter-ORB-combined	89.53(3.42)[b]	23.13(6.32)[-b]	40.83(4.99)[-b]
C3	Dummy	50	50	50
	WP-ORB	58.67(1.05)[b]	49.83(0.93)[-*]	39.8(0.65)[-b]
	AIO-ORB-combined	57.37(0.69)[b]	50.82(1.05)[b]	39.31(0.47)[-b]
	AIO-ORB-proprietary	60.62(2.22)[b]	48.21(2.01)[-b]	40.49(1.24)[-b]
	Filter-ORB-combined	63.24(2.13)[b]	47.2(1.57)[-b]	41.69(0.94)[-b]
	OP-AIO-ORB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-AIO-ORB-proprietary	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
	OP-Filter-ORB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	Dummy	50	50	50
	WP-ORB	68.92(4.34)[b]	39.78(6.02)[-b]	39.52(1.0)[-b]
	AIO-ORB-combined	29.51(7.55)[-b]	78.37(5.51)[b]	40.0(4.41)[-b]
	AIO-ORB-proprietary	36.53(3.6)[-b]	77.1(1.65)[b]	46.04(2.97)[-b]
	Filter-ORB-combined	75.46(2.74)[b]	39.43(2.26)[-b]	47.36(2.04)[-b]
	OP-AIO-ORB-combined	49.04(7.88)[-s]	63.83(10.56)[b]	50.59(2.3)[s]
	OP-AIO-ORB-proprietary	36.33(0.91)[-b]	71.6(0.54)[b]	43.52(0.84)[-b]
	OP-Filter-ORB-combined	89.73(1.63)[b]	40.73(5.87)[-b]	53.77(3.53)[b]
C5	Dummy	50	50	50
	WP-ORB	95.92(0.64)[b]	5.34(1.4)[-b]	12.17(1.62)[-b]
	AIO-ORB-combined	12.04(1.74)[-b]	91.14(0.66)[b]	26.34(3.69)[-b]
	AIO-ORB-proprietary	12.84(2.2)[-b]	90.98(2.36)[b]	27.9(3.7)[-b]
	Filter-ORB-combined	21.94(3.44)[-b]	80.9(2.82)[b]	37.26(3.41)[-b]
	OP-AIO-ORB-combined	47.65(5.97)[-s]	65.06(8.41)[b]	52.84(4.12)[m]
	OP-AIO-ORB-proprietary	35.59(10.02)[-b]	74.15(9.73)[b]	47.86(4.22)[-s]
	OP-Filter-ORB-combined	44.7(4.24)[-b]	72.84(3.68)[b]	54.77(2.56)[b]
C6	Dummy	50	50	50
	WP-ORB	63.74(0.42)[b]	42.34(0.41)[-b]	31.08(0.35)[-b]
	AIO-ORB-combined	52.93(5.44)[b]	51.18(5.37)[s]	45.16(1.91)[-b]
	AIO-ORB-proprietary	52.44(5.1)[*]	55.29(2.69)[b]	42.47(3.27)[-b]
	Filter-ORB-combined	56.47(6.7)[m]	42.3(7.2)[-m]	42.15(1.66)[-b]
	OP-AIO-ORB-combined	74.96(2.93)[b]	43.37(2.3)[-b]	50.27(1.79)[s]
	OP-AIO-ORB-proprietary	76.08(8.34)[b]	27.62(7.76)[-b]	35.15(1.62)[-b]
	OP-Filter-ORB-combined	61.99(7.35)[b]	46.38(7.38)[*]	40.6(1.39)[-b]
C7	Dummy	50	50	50
	WP-ORB	48.03(5.25)[-b]	56.78(3.82)[b]	39.01(2.53)[-b]
	AIO-ORB-combined	34.47(12.93)[-b]	77.01(9.77)[b]	44.91(7.51)[-b]
	AIO-ORB-proprietary	45.97(11.53)[s]	71.25(7.13)[b]	53.99(6.85)[m]
	Filter-ORB-combined	64.89(6.69)[b]	56.2(3.68)[b]	55.47(3.0)[b]
	OP-AIO-ORB-combined	56.03(38.06)[*]	50.6(37.75)[*]	32.64(14.9)[-b]
	OP-AIO-ORB-proprietary	35.77(18.96)[-b]	61.18(21.41)[b]	35.55(7.7)[-b]
	OP-Filter-ORB-combined	100.0(0.0)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C8	Dummy	50	50	50
	WP-ORB	44.61(0.43)[-b]	43.37(0.59)[-b]	22.02(0.47)[-b]
	AIO-ORB-combined	37.94(14.26)[-b]	70.69(10.81)[b]	45.89(8.87)[-s]
	AIO-ORB-proprietary	37.06(16.4)[-b]	72.45(12.06)[b]	44.29(10.43)[-s]
	Filter-ORB-combined	55.72(6.29)[b]	44.31(4.55)[-b]	44.55(2.25)[-b]
	OP-AIO-ORB-combined	74.41(8.76)[b]	37.11(8.19)[-b]	49.87(5.01)[-s]
	OP-AIO-ORB-proprietary	89.26(3.52)[b]	24.95(5.54)[-b]	43.5(5.18)[-b]
	OP-Filter-ORB-combined	79.73(3.35)[b]	29.25(2.94)[-b]	45.84(2.09)[-b]
C9	Dummy	50	50	50
	WP-ORB	45.65(0.25)[-b]	50.03(0.09)[b]	24.88(0.36)[-b]
	AIO-ORB-combined	39.34(2.08)[-b]	63.49(1.75)[b]	35.87(1.7)[-b]
	AIO-ORB-proprietary	44.37(5.62)[-m]	61.6(4.38)[b]	38.46(3.49)[-b]
	Filter-ORB-combined	36.93(1.02)[-b]	64.24(1.19)[b]	29.96(1.05)[-b]
	OP-AIO-ORB-combined	84.62(5.2)[b]	15.86(4.1)[-b]	32.13(4.76)[-b]
	OP-AIO-ORB-proprietary	99.9(0.31)[b]	0.29(0.8)[-b]	1.82(4.42)[-b]
	OP-Filter-ORB-combined	99.96(0.0)[b]	2.71(0.0)[-b]	14.61(0.0)[-b]
Ranking	Dummy	2	4	**1**
	WP-ORB	**1**	5	5
	AIO-ORB-combined	4	2	4
	AIO-ORB-proprietary	4	2	3
	Filter-ORB-combined	2	4	3
	OP-AIO-ORB-combined	**1**	5	3
	OP-AIO-ORB-proprietary	**1**	5	5
	OP-Filter-ORB-combined	**1**	6	4

Standard deviations are shown in brackets. Symbols [*], [s], [m] and [b] represent insignificant, small, medium and large A12 effect size against the Dummy approach. Presence/absence of the sign "-" in the effect size means that the corresponding approach was worse/better than the corresponding Dummy approach. Scott-Knott.BA12 was run for all OOB- and ORB-based approaches together. The groups' rankings retrieved by Scott-Knott.BA12 are shown in the ranking rows, with smaller numbers indicating better rankings.

TABLE 9: Number of initial time steps of the initial phase, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r0	AIO-OOB_r0	Filter-OOB_r0	Ensemble-OOB_r0	OP-AIO-OOB_r0	OP-Filter-OOB_r0
Tomcat	2006	50	76.66(5.97)[b]	49.86(1.86)[*]	61.48(2.4)[b]	87.03(0.61)[b]	49.68(8.93)[-s]	50.51(4.36)[-s]
JGroups	1268	50	64.66(0.69)[b]	64.54(0.6)[b]	63.9(1.07)[b]	96.41(0.1)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	461	50	44.11(0.12)[-b]	82.6(0.65)[b]	89.71(0.87)[b]	93.25(0.28)[b]	94.09(1.18)[b]	93.59(1.02)[b]
Camel	3112	50	28.71(3.01)[-b]	55.13(1.48)[b]	56.56(1.34)[b]	84.71(0.53)[b]	38.99(1.72)[-b]	38.12(1.2)[-b]
Brackets	1569	50	15.37(0.04)[-b]	63.02(1.8)[b]	65.67(0.85)[b]	79.59(0.64)[b]	58.72(2.62)[b]	61.6(1.36)[b]
Nova	6271	50	40.64(0.34)[-b]	56.53(1.1)[b]	59.92(0.65)[b]	72.22(0.93)[b]	49.63(3.54)[-b]	66.27(4.6)[b]
Fabric8	795	50	20.81(0.24)[-b]	82.77(1.63)[b]	74.36(2.21)[b]	75.59(1.81)[b]	48.5(5.7)[-*]	72.31(3.69)[b]
Neutron	917	50	31.13(4.78)[-b]	76.39(2.09)[b]	83.57(2.48)[b]	78.45(1.24)[b]	55.59(0.31)[b]	67.5(1.98)[b]
Npm	2536	50	13.73(1.44)[-b]	44.8(4.75)[-b]	37.43(4.23)[-b]	66.7(0.68)[b]	45.28(12.29)[-*]	14.74(0.97)[-b]
BroadleafCommerce	677	50	28.24(0.2)[-b]	44.06(2.5)[-b]	52.74(3.63)[b]	81.64(0.44)[b]	38.71(7.36)[-b]	97.11(0.84)[b]
Ranking		5	6	3	2	**1**	4	2

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB_r0	Filter-ORB_r0	Ensemble-ORB_r0	OP-AIO-ORB_r0	OP-Filter-ORB_r0
Tomcat	926	50	44.26(2.49)[-b]	39.42(2.27)[-b]	42.81(2.36)[-b]	85.91(0.24)[b]	14.05(3.88)[-b]	33.08(6.91)[-b]
JGroups	1412	50	60.91(1.0)[b]	61.11(1.04)[b]	62.73(1.86)[b]	96.21(0.18)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	900	50	60.2(1.08)[b]	51.5(4.09)[b]	54.75(5.34)[b]	78.73(1.67)[b]	64.58(2.43)[b]	65.41(3.4)[b]
Camel	5111	50	51.18(2.63)[b]	48.79(1.86)[-b]	47.72(2.3)[-b]	81.14(0.78)[b]	49.09(10.16)[-b]	47.19(10.24)[-s]
Brackets	1721	50	90.26(0.58)[b]	56.53(3.0)[b]	57.46(1.31)[b]	66.97(2.0)[b]	60.73(1.59)[b]	69.53(3.63)[b]
Nova	6271	50	59.67(2.78)[b]	54.18(1.34)[b]	52.18(1.44)[b]	78.64(1.01)[b]	63.48(33.59)[m]	71.91(13.46)[b]
Fabric8	1613	50	68.33(1.0)[b]	64.01(1.22)[b]	63.02(2.22)[b]	63.35(1.33)[b]	50.32(6.14)[-s]	67.42(8.41)[b]
Neutron	3304	50	80.65(1.69)[b]	78.67(2.11)[b]	78.83(4.22)[b]	75.2(1.11)[b]	72.37(16.77)[b]	75.19(9.22)[b]
Npm	1494	50	34.45(1.91)[-b]	27.68(5.38)[-b]	35.37(9.1)[-b]	70.43(2.04)[b]	71.36(24.54)[b]	100.0(0.0)[b]
BroadleafCommerce	950	50	66.31(0.51)[b]	48.84(2.41)[-m]	49.12(2.88)[-s]	81.0(0.95)[b]	61.85(3.31)[b]	73.71(3.41)[b]
Ranking		5	3	4	4	**1**	3	2

TABLE 10: Number of initial time steps of the initial phase, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB_r1	Filter-OOB_r1	Ensemble-OOB_r1	OP-AIO-OOB_r1	OP-Filter-OOB_r1
Tomcat	2006	50	29.86(7.28)[-b]	68.53(1.27)[b]	53.51(3.0)[b]	13.92(0.61)[-b]	68.46(12.11)[b]	67.95(4.63)[b]
JGroups	1268	50	33.4(1.01)[-b]	33.2(1.08)[-b]	34.69(1.18)[-b]	3.47(0.14)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	461	50	46.42(0.12)[-b]	17.44(0.21)[-b]	23.35(0.85)[-b]	5.84(0.18)[-b]	4.25(2.27)[-b]	16.06(3.65)[-b]
Camel	3112	50	86.83(2.57)[b]	66.32(0.85)[b]	63.64(1.3)[b]	18.93(0.63)[-b]	73.69(1.78)[b]	75.82(0.71)[b]
Brackets	1569	50	90.16(0.02)[b]	72.24(4.03)[b]	72.41(1.55)[b]	30.66(0.95)[-b]	57.13(2.92)[b]	65.82(2.26)[b]
Nova	6271	50	89.01(0.2)[b]	77.39(0.59)[b]	74.26(0.65)[b]	38.58(0.76)[-b]	84.05(5.58)[b]	63.43(8.28)[b]
Fabric8	795	50	82.23(0.0)[b]	35.07(2.2)[-b]	52.17(3.01)[b]	23.28(1.07)[-b]	79.12(4.46)[b]	38.91(2.74)[-b]
Neutron	917	50	87.54(1.87)[b]	71.63(3.0)[b]	55.22(4.71)[b]	39.72(2.15)[-b]	82.38(0.61)[b]	81.75(1.46)[b]
Npm	2536	50	83.75(1.66)[b]	64.47(5.55)[b]	66.9(3.34)[b]	31.45(0.61)[-b]	54.4(13.11)[*]	82.11(1.26)[b]
BroadleafCommerce	677	50	68.1(0.27)[b]	68.31(1.68)[b]	61.71(3.15)[b]	19.0(1.74)[-b]	57.57(6.4)[b]	15.62(3.59)[-b]
Ranking		3	**1**	2	2	4	2	2

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB_r1	Filter-ORB_r1	Ensemble-ORB_r1	OP-AIO-ORB_r1	OP-Filter-ORB_r1
Tomcat	926	50	62.76(3.14)[b]	69.21(2.15)[b]	69.17(1.55)[b]	15.28(0.42)[-b]	89.31(3.92)[b]	71.27(3.18)[b]
JGroups	1412	50	33.59(1.41)[-b]	34.15(1.75)[-b]	36.92(2.56)[-b]	3.45(0.22)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	900	50	33.67(0.71)[-b]	75.53(2.76)[b]	76.83(4.92)[b]	23.52(1.65)[-b]	65.55(4.19)[b]	49.04(3.92)[-s]
Camel	5111	50	64.0(2.48)[b]	73.87(1.39)[b]	74.77(1.38)[b]	22.62(0.92)[-b]	60.05(5.27)[b]	61.62(7.17)[b]
Brackets	1721	50	12.52(0.64)[-b]	83.0(4.49)[b]	81.15(1.65)[b]	41.78(1.67)[-b]	72.56(2.48)[b]	56.79(6.54)[b]
Nova	6271	50	67.77(2.12)[b]	82.87(1.83)[b]	82.68(0.96)[b]	34.71(1.46)[-b]	48.24(29.93)[-s]	50.51(15.16)[-s]
Fabric8	1613	50	29.88(0.81)[-b]	66.59(4.18)[b]	66.66(2.39)[b]	38.18(1.22)[-b]	72.86(5.75)[b]	52.85(5.62)[b]
Neutron	3304	50	66.62(3.15)[b]	73.45(3.72)[b]	73.2(5.88)[b]	68.09(1.99)[b]	60.24(11.34)[b]	69.18(18.12)[b]
Npm	1494	50	64.79(1.01)[b]	74.2(6.94)[b]	66.41(8.14)[b]	29.39(2.14)[-b]	38.91(27.87)[-s]	0.0(0.0)[-b]
BroadleafCommerce	950	50	32.16(0.49)[-b]	66.7(5.17)[b]	65.56(6.86)[b]	22.82(1.17)[-b]	59.82(6.63)[b]	40.34(3.41)[-b]
Ranking		3	3	**1**	**1**	4	2	3

TABLE 11: Number of time steps of the drop periods, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r0	AIO-OOB_r0	Filter-OOB_r0	Ensemble-OOB_r0	OP-AIO-OOB_r0	OP-Filter-OOB_r0
Tomcat	3855	50	31.23(2.14)[-b]	56.4(1.5)[b]	55.7(1.87)[b]	52.88(0.77)[b]	16.43(5.44)[-b]	24.05(2.03)[-b]
JGroups	4353	50	35.87(2.17)[-b]	44.61(2.27)[-b]	45.33(1.87)[-b]	87.01(0.74)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	3973	50	55.56(0.93)[b]	60.18(0.97)[b]	66.39(1.19)[b]	75.7(0.67)[b]	39.74(8.09)[-b]	14.66(3.63)[-b]
Camel	6009	50	35.64(2.26)[-b]	38.98(1.58)[-b]	40.43(1.45)[-b]	58.66(0.75)[b]	33.15(3.18)[-b]	34.51(1.2)[-b]
Nova	4427	50	50.2(0.15)[b]	50.37(0.32)[b]	50.08(0.42)[m]	57.99(2.9)[b]	51.22(6.41)[b]	60.05(8.38)[b]
Fabric8	3443	50	39.92(4.78)[-b]	44.8(1.56)[-b]	57.77(3.01)[b]	46.04(1.47)[-b]	7.38(2.8)[-b]	9.57(5.02)[-b]
Npm	1202	50	16.96(1.59)[-b]	61.28(3.82)[b]	65.92(2.88)[b]	43.91(1.65)[-b]	29.65(11.83)[-b]	3.59(1.47)[-b]
BroadleafCommerce	3579	50	30.83(0.89)[-b]	63.03(2.05)[b]	61.69(1.63)[b]	52.65(1.29)[b]	35.69(2.06)[-b]	48.59(7.28)[*]
Ranking		3	4	2	**1**	**1**	4	4

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB_r0	Filter-ORB_r0	Ensemble-ORB_r0	OP-AIO-ORB_r0	OP-Filter-ORB_r0
Tomcat	2265	50	36.98(2.68)[-b]	51.19(1.39)[b]	50.41(1.46)[s]	63.44(1.1)[b]	11.32(7.33)[-b]	11.85(8.18)[-b]
JGroups	2066	50	54.18(2.44)[b]	56.29(2.23)[b]	58.59(2.13)[b]	86.4(0.84)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	2319	50	80.73(1.08)[b]	67.42(1.13)[b]	69.26(1.31)[b]	78.78(0.64)[b]	75.17(2.31)[b]	85.25(10.16)[b]
Camel	1105	50	31.65(4.85)[-b]	39.12(2.46)[-b]	39.62(3.65)[-b]	49.84(2.02)[*]	62.66(14.5)[b]	69.42(15.09)[b]
Nova	4408	50	50.13(1.16)[-*]	51.79(1.58)[b]	49.12(0.5)[-b]	75.65(0.92)[b]	62.33(45.16)[m]	71.99(14.35)[b]
Fabric8	1473	50	42.44(9.12)[-b]	46.4(2.69)[-b]	56.46(1.83)[b]	44.15(2.17)[-b]	68.9(6.57)[b]	76.77(22.73)[b]
Npm	936	50	24.56(6.1)[-b]	25.46(5.22)[-b]	29.76(14.42)[-b]	51.03(1.82)[s]	63.73(30.54)[s]	100.0(0.0)[b]
BroadleafCommerce	2703	50	36.45(3.67)[-b]	61.89(2.39)[b]	63.22(1.42)[b]	60.94(1.41)[b]	84.17(4.51)[b]	73.09(4.61)[b]
Ranking		**1**	**1**	**1**	**1**	**1**	**1**	**1**

TABLE 12: Number of time steps of the drop periods, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB_r1	Filter-OOB_r1	Ensemble-OOB_r1	OP-AIO-OOB_r1	OP-Filter-OOB_r1
Tomcat	3855	50	79.18(1.59)[b]	66.49(1.43)[b]	68.96(1.55)[b]	55.09(0.89)[b]	88.44(3.35)[b]	83.28(1.76)[b]
JGroups	4353	50	66.56(1.72)[b]	62.87(1.54)[b]	61.74(1.41)[b]	12.58(0.49)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	3973	50	46.64(0.61)[-b]	61.5(1.37)[b]	58.25(1.56)[b]	29.61(0.68)[-b]	76.14(6.23)[b]	92.76(1.73)[b]
Camel	6009	50	82.26(0.96)[b]	83.98(0.81)[b]	83.43(0.82)[b]	50.67(0.66)[b]	79.0(2.42)[b]	79.26(0.95)[b]
Nova	4427	50	89.62(0.25)[b]	89.38(0.36)[b]	89.56(0.28)[b]	56.78(2.24)[b]	85.2(7.7)[b]	77.97(13.94)[b]
Fabric8	3443	50	75.01(3.84)[b]	75.04(1.69)[b]	75.48(2.09)[b]	64.82(1.62)[b]	98.38(0.9)[b]	93.65(4.43)[b]
Npm	1202	50	91.4(0.63)[b]	65.49(3.48)[b]	65.63(3.93)[b]	60.13(1.23)[b]	72.95(9.92)[b]	95.92(0.84)[b]
BroadleafCommerce	3579	50	83.84(0.72)[b]	73.57(1.44)[b]	71.92(1.27)[b]	59.12(1.27)[b]	81.22(2.79)[b]	68.43(6.13)[b]
Ranking		3	**1**	2	2	3	2	**1**

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB_r1	Filter-ORB_r1	Ensemble-ORB_r1	OP-AIO-ORB_r1	OP-Filter-ORB_r1
Tomcat	2265	50	68.09(1.91)[b]	64.83(1.63)[b]	65.49(1.56)[b]	47.3(1.24)[-b]	79.75(7.14)[b]	78.84(6.49)[b]
JGroups	2066	50	52.87(1.89)[b]	52.96(2.08)[b]	53.38(2.15)[b]	14.83(0.42)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	2319	50	23.79(1.23)[-b]	61.78(1.91)[b]	62.65(2.08)[b]	30.52(0.82)[-b]	59.67(4.55)[b]	36.54(6.56)[-b]
Camel	1105	50	79.67(2.64)[b]	80.45(1.59)[b]	78.7(1.8)[b]	64.43(1.78)[b]	53.3(5.85)[b]	48.44(13.95)[s]
Nova	4408	50	90.62(0.92)[b]	88.25(1.32)[b]	90.76(0.42)[b]	50.09(1.31)[s]	43.35(42.41)[-m]	54.78(18.64)[s]
Fabric8	1473	50	74.95(3.71)[b]	72.6(2.28)[b]	72.23(1.47)[b]	69.46(1.63)[b]	46.74(9.2)[-m]	34.42(20.9)[-b]
Npm	936	50	84.78(3.52)[b]	89.18(2.12)[b]	81.1(9.66)[b]	49.68(1.19)[-s]	47.6(34.37)[-s]	0.0(0.0)[-b]
BroadleafCommerce	2703	50	77.47(2.05)[b]	73.22(1.72)[b]	71.44(1.93)[b]	52.63(1.41)[b]	31.66(5.93)[-b]	47.8(3.95)[-b]
Ranking		**1**	**1**	**1**	**1**	**1**	**1**	**1**

TABLE 13: Number of time steps of the stable periods, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r0	AIO-OOB_r0	Filter-OOB_r0	Ensemble-OOB_r0	OP-AIO-OOB_r0	OP-Filter-OOB_r0
Tomcat	13046	50	63.41(2.5)[b]	64.18(1.87)[b]	71.17(1.47)[b]	63.42(0.91)[b]	19.51(6.07)[-b]	25.14(2.25)[-b]
JGroups	12704	50	64.27(1.94)[b]	71.36(1.86)[b]	73.2(1.63)[b]	81.77(0.41)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	4316	50	68.09(3.04)[b]	68.21(0.87)[b]	70.84(0.7)[b]	68.54(0.79)[b]	49.06(12.12)[s]	26.51(9.06)[-b]
Camel	21454	50	65.71(1.45)[b]	57.89(1.33)[b]	59.6(0.95)[b]	50.03(1.23)[s]	21.71(2.47)[-b]	20.51(1.36)[-b]
Brackets	15795	50	52.52(0.31)[b]	65.71(1.15)[b]	69.5(0.91)[b]	63.43(0.83)[b]	28.61(10.71)[-b]	48.21(1.36)[-b]
Nova	38291	50	74.79(0.3)[b]	74.53(0.39)[b]	75.12(0.39)[b]	78.54(0.75)[b]	61.52(15.06)[b]	73.25(0.91)[b]
Fabric8	8868	50	57.35(2.36)[b]	57.82(1.12)[b]	62.45(1.86)[b]	47.53(1.28)[-b]	8.86(2.35)[-b]	12.59(3.59)[-b]
Neutron	18605	50	71.95(0.73)[b]	73.08(0.43)[b]	74.46(0.43)[b]	78.59(1.09)[b]	70.95(1.0)[b]	76.44(3.18)[b]
Npm	4182	50	56.86(4.13)[b]	59.0(1.14)[b]	63.26(1.66)[b]	49.61(1.35)[-s]	79.69(1.73)[b]	22.34(1.15)[-b]
BroadleafCommerce	10754	50	69.53(2.14)[b]	70.16(1.62)[b]	70.23(1.07)[b]	63.82(0.9)[b]	45.69(1.31)[-b]	53.39(4.63)[b]
Ranking		3	2	2	**1**	2	3	3

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB_r0	Filter-ORB_r0	Ensemble-ORB_r0	OP-AIO-ORB_r0	OP-Filter-ORB_r0
Tomcat	15716	50	62.33(2.08)[b]	64.86(1.38)[b]	63.69(1.06)[b]	60.08(1.4)[b]	53.99(5.5)[b]	55.9(4.88)[b]
JGroups	14847	50	62.18(0.76)[b]	63.83(1.0)[b]	63.7(1.18)[b]	82.16(0.37)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Spring-Integration	5531	50	70.14(1.53)[b]	70.15(0.82)[b]	70.53(0.78)[b]	72.19(0.67)[b]	78.67(2.39)[b]	82.84(8.52)[b]
Camel	24359	50	62.63(1.3)[b]	62.2(0.74)[b]	61.72(0.56)[b]	57.85(1.03)[b]	62.17(9.55)[b]	52.39(11.16)[*]
Brackets	15643	50	58.12(0.78)[b]	68.04(1.09)[b]	67.31(1.02)[b]	61.12(1.1)[b]	51.29(1.6)[b]	47.6(2.14)[-b]
Nova	38310	50	79.42(1.86)[b]	79.99(1.02)[b]	78.8(0.13)[b]	76.58(0.96)[b]	51.45(39.22)[s]	69.0(2.4)[b]
Fabric8	10020	50	62.97(1.73)[b]	57.94(1.52)[b]	65.44(0.57)[b]	48.2(1.32)[-b]	76.29(6.63)[b]	78.59(19.32)[b]
Neutron	16218	50	80.44(1.88)[b]	74.66(0.65)[b]	73.03(1.07)[b]	77.38(1.86)[b]	69.93(18.31)[b]	74.16(9.09)[b]
Npm	5490	50	65.67(1.21)[b]	61.62(1.05)[b]	59.2(1.95)[b]	47.85(1.65)[-b]	75.57(13.52)[b]	100.0(0.0)[b]
BroadleafCommerce	11357	50	64.33(3.56)[b]	69.45(0.82)[b]	69.17(0.71)[b]	60.09(1.43)[b]	86.2(4.61)[b]	77.91(5.57)[b]
Ranking		4	2	2	2	3	**1**	**1**

TABLE 14: Number of time steps of the stable periods, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Opensource data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB_r1	Filter-OOB_r1	Ensemble-OOB_r1	OP-AIO-OOB_r1	OP-Filter-OOB_r1
Tomcat	13046	50	64.16(1.84)[b]	62.22(1.63)[b]	58.42(1.22)[b]	43.98(0.91)[-b]	87.77(3.7)[b]	84.37(1.98)[b]
JGroups	12704	50	58.97(1.89)[b]	51.37(1.91)[b]	49.8(1.54)[-s]	22.18(0.43)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	4316	50	65.82(2.5)[b]	66.35(1.04)[b]	65.44(1.26)[b]	48.34(0.98)[-b]	73.27(10.71)[b]	95.21(0.76)[b]
Camel	21454	50	70.71(1.21)[b]	74.15(0.87)[b]	73.27(0.84)[b]	61.68(0.99)[b]	85.22(3.59)[b]	89.01(0.92)[b]
Brackets	15795	50	89.55(0.26)[b]	80.42(1.4)[b]	75.74(1.38)[b]	66.01(1.25)[b]	92.2(2.7)[b]	92.68(1.92)[b]
Nova	38291	50	86.3(0.67)[b]	90.73(0.7)[b]	89.09(0.48)[b]	60.33(1.88)[b]	94.92(1.2)[b]	78.04(1.82)[b]
Fabric8	8868	50	75.41(1.83)[b]	72.29(1.62)[b]	74.27(1.66)[b]	63.53(1.57)[b]	97.89(1.3)[b]	89.65(5.59)[b]
Neutron	18605	50	92.02(0.63)[b]	92.36(0.51)[b]	91.32(0.57)[b]	60.77(3.51)[b]	81.57(3.07)[b]	70.63(9.17)[b]
Npm	4182	50	66.38(2.76)[b]	72.18(0.89)[b]	70.47(1.6)[b]	61.9(1.56)[b]	16.7(2.57)[-b]	76.91(0.6)[b]
BroadleafCommerce	10754	50	65.26(2.92)[b]	71.86(1.92)[b]	70.63(1.18)[b]	57.95(1.13)[b]	69.83(2.73)[b]	72.2(5.26)[b]
Ranking		3	**1**	**1**	**1**	2	**1**	**1**

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB_r1	Filter-ORB_r1	Ensemble-ORB_r1	OP-AIO-ORB_r1	OP-Filter-ORB_r1
Tomcat	15716	50	64.07(1.41)[b]	62.82(0.83)[b]	62.65(0.89)[b]	49.63(1.18)[-s]	48.3(4.64)[-m]	38.64(3.47)[-b]
JGroups	14847	50	59.72(1.38)[b]	59.33(1.03)[b]	59.68(1.33)[b]	22.42(0.49)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Spring-Integration	5531	50	57.05(1.85)[b]	71.73(1.11)[b]	71.86(0.91)[b]	46.63(0.84)[-b]	61.54(5.01)[b]	43.48(9.61)[-b]
Camel	24359	50	70.95(1.2)[b]	72.6(0.93)[b]	72.0(0.57)[b]	58.01(1.27)[b]	45.11(8.54)[-b]	43.31(12.28)[-s]
Brackets	15643	50	83.71(1.53)[b]	74.05(1.74)[b]	74.72(1.49)[b]	72.15(1.31)[b]	85.52(2.18)[b]	88.95(4.3)[b]
Nova	38310	50	81.5(3.3)[b]	81.08(1.46)[b]	81.96(0.69)[b]	76.05(2.24)[b]	72.83(24.19)[b]	87.05(7.02)[b]
Fabric8	10020	50	72.89(1.25)[b]	75.11(1.35)[b]	72.57(1.16)[b]	69.55(1.36)[b]	36.16(10.58)[-b]	27.81(22.51)[-b]
Neutron	16218	50	82.15(1.91)[b]	90.39(0.75)[b]	92.2(0.74)[b]	72.82(3.94)[b]	67.64(7.47)[b]	70.68(22.39)[b]
Npm	5490	50	59.76(1.78)[b]	75.55(1.43)[b]	73.79(2.62)[b]	64.48(1.41)[b]	45.0(23.09)[s]	0.0(0.0)[-b]
BroadleafCommerce	11357	50	66.01(3.91)[b]	69.67(1.07)[b]	68.97(1.56)[b]	63.72(1.74)[b]	22.65(7.75)[-b]	32.59(4.78)[-b]
Ranking		4	2	**1**	**1**	3	4	5

TABLE 15: Number of initial time steps of the initial phase, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	#Time Steps	Dummy	WP-OOB_r0	AIO-OOB combined_r0	AIO-OOB proprietary_r0	Filter-OOB combined_r0	OP-AIO-OOB combined_r0	OP-AIO-OOB proprietary_r0	OP-Filter-OOB combined_r0
C1	284	50	8.88(3.47)[-b]	73.04(4.3)[b]	8.22(2.68)[-b]	70.29(4.65)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C2	581	50	15.39(0.12)[-b]	21.93(0.52)[-b]	45.97(7.61)[-b]	45.29(1.3)[-b]	44.24(4.15)[-b]	98.34(2.85)[b]	48.42(5.71)[s]
C3	82	50	96.32(0.0)[b]	81.86(0.0)[b]	33.22(0.0)[-b]	96.9(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C4	24	50	91.82(0.91)[b]	81.24(0.45)[b]	90.17(10.07)[b]	100.0(0.0)[b]	81.0(0.37)[b]	92.34(2.85)[b]	100.0(0.0)[b]
C5	8	50	87.37(0.0)[b]	100.0(0.0)[b]	59.16(9.56)[b]	92.0(6.19)[b]	100.0(0.0)[b]	100.0(0.0)[b]	68.66(0.0)[b]
C6	20	50	91.76(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C7	29	50	100.0(0.0)[b]	82.15(4.53)[b]	64.66(4.4)[b]	100.0(0.0)[b]	79.19(0.64)[b]	94.6(5.13)[b]	100.0(0.0)[b]
C8	39	50	100.0(0.0)[b]	100.0(0.0)[b]	86.75(6.83)[b]	100.0(0.0)[b]	99.15(1.02)[b]	87.98(3.62)[b]	100.0(0.0)[b]
C9	62	50	86.42(2.18)[b]	99.8(0.12)[b]	97.87(2.06)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
Ranking		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB combined_r0	AIO-ORB proprietary_r0	Filter-ORB combined_r0	OP-AIO-ORB combined_r0	OP-AIO-ORB proprietary_r0	OP-Filter-ORB combined_r0
C1	671	50	80.46(3.18)[b]	57.56(4.17)[b]	48.18(1.51)[-b]	83.32(2.87)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C2	582	50	72.19(0.99)[b]	35.51(3.57)[-b]	38.38(7.0)[-b]	46.17(0.7)[-b]	82.54(2.74)[b]	87.6(8.27)[b]	89.23(3.54)[b]
C3	396	50	58.74(1.01)[b]	57.67(0.67)[b]	60.56(2.2)[b]	63.26(1.94)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C4	93	50	99.8(0.03)[b]	52.43(3.65)[s]	64.64(2.18)[b]	99.77(0.7)[b]	65.36(5.61)[b]	68.91(0.74)[b]	97.48(0.37)[b]
C5	297	50	96.65(0.51)[b]	9.29(1.88)[-b]	10.18(2.27)[-b]	20.07(3.33)[-b]	46.86(5.94)[-m]	35.64(10.12)[-b]	44.37(4.11)[-b]
C6	210	50	99.74(0.0)[b]	66.1(1.25)[b]	79.56(5.66)[b]	69.83(0.59)[b]	84.04(2.45)[b]	95.09(0.43)[b]	91.91(0.63)[b]
C7	62	50	98.68(0.2)[b]	62.36(7.41)[b]	61.35(3.72)[b]	96.15(0.99)[b]	57.67(29.59)[*]	73.09(22.51)[b]	100.0(0.0)[b]
C8	232	50	99.31(0.09)[b]	49.48(13.63)[-s]	54.53(9.78)[m]	79.1(5.3)[b]	65.88(7.72)[b]	78.09(1.74)[b]	79.09(3.19)[b]
C9	198	50	99.52(0.0)[b]	87.47(1.51)[b]	91.55(1.11)[b]	88.18(0.04)[b]	99.9(0.03)[b]	99.84(0.6)[b]	100.0(0.0)[b]
Ranking		4	**1**	3	2	**1**	**1**	**1**	**1**

TABLE 16: Number of initial time steps of the initial phase, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB combined_r1	AIO-OOB proprietary_r1	Filter-OOB combined_r1	OP-AIO-OOB combined_r1	OP-AIO-OOB proprietary_r1	OP-Filter-OOB combined_r1
C1	284	50	77.86(1.91)[b]	23.38(3.7)[-b]	78.88(1.3)[b]	31.5(5.25)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	581	50	86.87(0.0)[b]	75.92(0.43)[b]	48.36(10.42)[s]	63.19(1.79)[b]	55.04(3.5)[b]	1.59(1.93)[-b]	55.4(4.09)[b]
C3	82	50	4.2(0.0)[-b]	21.43(0.0)[-b]	70.61(0.0)[b]	4.2(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	24	50	4.07(0.0)[-b]	13.33(2.96)[-b]	10.57(5.23)[-b]	0.0(0.0)[-b]	14.63(0.0)[-b]	6.82(0.0)[-b]	0.0(0.0)[-b]
C5	8	50	8.25(0.0)[-b]	0.77(1.19)[-b]	40.69(7.15)[-b]	6.49(2.79)[-b]	2.47(2.87)[-b]	0.95(2.16)[-b]	42.5(0.0)[-b]
C6	20	50	2.02(0.0)[-b]	0.65(0.0)[-b]	0.65(0.0)[-b]	0.5(0.28)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C7	29	50	0.4(0.0)[-b]	33.96(3.36)[-b]	61.03(9.37)[b]	0.0(0.0)[-b]	32.62(7.1)[-b]	17.21(10.02)[-b]	0.0(0.0)[-b]
C8	39	50	0.23(0.0)[-b]	1.98(1.69)[-b]	29.03(13.19)[-b]	0.2(0.08)[-b]	7.09(4.37)[-b]	24.31(9.13)[-b]	0.0(0.0)[-b]
C9	62	50	6.84(1.14)[-b]	7.08(4.15)[-b]	13.61(1.72)[-b]	0.19(0.0)[-b]	8.91(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
Ranking		**1**	3	3	2	3	3	3	3

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB combined_r1	AIO-ORB proprietary_r1	Filter-ORB combined_r1	OP-AIO-ORB combined_r1	OP-AIO-ORB proprietary_r1	OP-Filter-ORB combined_r1
C1	671	50	14.15(2.64)[-b]	36.95(3.74)[-b]	41.14(1.7)[-b]	23.79(4.41)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	582	50	16.46(0.81)[-b]	60.29(3.77)[b]	55.39(9.46)[b]	42.99(0.69)[-b]	26.15(4.43)[-b]	15.15(9.76)[-b]	23.4(6.47)[-b]
C3	396	50	49.01(0.88)[-b]	49.76(1.01)[-*]	47.38(1.9)[-b]	46.45(1.4)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	93	50	1.79(0.15)[-b]	49.26(5.9)[s]	48.15(0.53)[-b]	8.05(3.1)[-b]	45.95(7.39)[-s]	41.94(0.96)[-b]	11.08(0.96)[-b]
C5	297	50	3.93(0.87)[-b]	92.74(0.54)[b]	92.54(2.47)[b]	81.8(2.73)[b]	65.37(9.0)[b]	74.68(9.81)[b]	73.72(3.75)[b]
C6	210	50	0.67(0.0)[-b]	26.33(2.51)[-b]	21.52(3.79)[-b]	19.53(1.79)[-b]	20.69(2.99)[-b]	3.02(0.64)[-b]	8.7(0.74)[-b]
C7	62	50	0.61(0.15)[-b]	42.65(13.22)[-m]	39.4(5.5)[-b]	7.28(1.36)[-b]	52.9(34.22)[*]	31.78(27.81)[-b]	0.0(0.0)[-b]
C8	232	50	0.35(0.06)[-b]	64.09(9.64)[b]	61.67(8.08)[b]	21.64(4.81)[-b]	46.37(5.66)[-b]	43.14(3.28)[-b]	29.06(3.05)[-b]
C9	198	50	0.21(0.0)[-b]	19.27(2.23)[-b]	20.31(1.71)[-b]	15.84(0.0)[-b]	5.31(0.08)[-b]	0.33(1.25)[-b]	0.87(0.0)[-b]
Ranking		**1**	4	**1**	**1**	2	2	3	4

TABLE 17: Number of time steps of the drop periods, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	Time Steps	Dummy	WP-OOB_r0	AIO-OOB combined_r0	AIO-OOB proprietary_r0	Filter-OOB combined_r0	OP-AIO-OOB combined_r0	OP-AIO-OOB proprietary_r0	OP-Filter-OOB combined_r0
C1	452	50	84.77(6.19)[b]	26.11(2.22)[-b]	42.66(13.83)[-s]	32.12(2.29)[-b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C3	210	50	50.1(7.97)[-s]	27.54(1.59)[-b]	29.44(3.41)[-b]	34.69(1.83)[-b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C4	249	50	11.97(0.65)[-b]	30.74(2.16)[-b]	63.51(6.07)[b]	51.73(4.37)[*]	47.24(2.17)[-b]	32.49(3.42)[-b]	39.19(0.0)[-b]
C6	466	50	5.15(0.64)[-b]	26.33(2.09)[-b]	34.66(11.62)[-b]	28.3(3.19)[-b]	45.26(1.32)[-b]	69.05(0.41)[b]	52.66(1.28)[b]
C7	255	50	7.14(0.65)[-b]	23.99(9.19)[-b]	10.95(1.03)[-b]	21.37(1.38)[-b]	83.72(2.23)[b]	16.52(0.61)[-b]	13.71(0.14)[-b]
C8	287	50	0.63(0.17)[-b]	29.88(1.99)[-b]	14.91(4.91)[-b]	23.19(2.19)[-b]	40.46(5.0)[-b]	78.4(12.78)[b]	8.73(5.57)[-b]
C9	541	50	11.22(1.27)[-b]	34.4(3.19)[-b]	53.35(5.06)[b]	42.36(3.28)[-b]	51.07(9.71)[s]	92.54(7.04)[b]	41.65(0.21)[-b]
Ranking		**1**	3	3	2	2	**1**	**1**	**1**

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB combined_r0	AIO-ORB proprietary_r0	Filter-ORB combined_r0	OP-AIO-ORB combined_r0	OP-AIO-ORB proprietary_r0	OP-Filter-ORB combined_r0
C1	238	50	28.63(13.15)[-b]	18.76(9.38)[-b]	9.59(1.98)[-b]	39.79(21.63)[-m]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C6	64	50	15.33(0.84)[-b]	43.57(15.27)[-s]	17.24(14.47)[-b]	35.03(13.43)[-b]	70.55(11.14)[b]	48.53(18.28)[s]	27.19(15.64)[-b]
C7	85	50	11.98(7.33)[-b]	15.04(14.72)[-b]	38.83(18.82)[*]	52.99(13.53)[b]	65.2(35.14)[*]	24.48(10.46)[-b]	100.0(0.0)[b]
C8	80	50	5.22(0.63)[-b]	28.9(21.24)[-b]	26.31(21.4)[-b]	46.81(14.55)[-b]	73.35(15.25)[b]	94.11(6.34)[b]	64.39(8.61)[b]
C9	23	50	6.55(0.76)[-b]	19.86(7.08)[-b]	7.77(3.32)[-b]	4.68(0.68)[-b]	70.41(10.03)[b]	99.92(0.22)[b]	100.0(0.0)[b]
Ranking		2	6	4	5	3	**1**	**1**	**1**

TABLE 18: Number of time steps of the drop periods, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB combined_r1	AIO-OOB proprietary_r1	Filter-OOB combined_r1	OP-AIO-OOB combined_r1	OP-AIO-OOB proprietary_r1	OP-Filter-OOB combined_r1
C1	452	50	14.17(5.18)[-b]	75.04(1.66)[b]	55.83(12.28)[b]	71.1(2.06)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C3	210	50	38.31(7.4)[-b]	84.22(2.58)[b]	53.73(4.45)[b]	79.31(1.67)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	249	50	92.64(0.8)[b]	86.92(1.29)[b]	60.85(9.01)[b]	67.4(3.03)[b]	71.16(2.01)[b]	71.82(3.15)[b]	74.73(0.0)[b]
C6	466	50	93.91(0.63)[b]	76.17(1.87)[b]	69.32(10.57)[b]	76.44(2.69)[b]	61.56(0.87)[b]	33.49(0.32)[-b]	52.8(0.83)[b]
C7	255	50	95.62(0.4)[b]	78.93(6.05)[b]	96.88(0.44)[b]	79.55(2.64)[b]	30.7(3.52)[-b]	81.1(2.69)[b]	74.01(1.18)[b]
C8	287	50	96.02(0.01)[b]	67.92(2.38)[b]	84.97(4.07)[b]	71.01(1.43)[b]	50.75(3.4)[*]	29.82(14.73)[-b]	88.28(3.54)[b]
C9	541	50	96.6(0.32)[b]	79.08(3.72)[b]	56.0(7.53)[b]	69.08(3.31)[b]	48.92(7.65)[-s]	16.19(6.51)[-b]	56.0(0.61)[b]
Ranking		4	**1**	**1**	3	2	5	5	4

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB combined_r1	AIO-ORB proprietary_r1	Filter-ORB combined_r1	OP-AIO-ORB combined_r1	OP-AIO-ORB proprietary_r1	OP-Filter-ORB combined_r1
C1	238	50	66.05(9.28)[b]	81.33(10.05)[b]	89.84(1.73)[b]	66.29(16.21)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C6	64	50	82.03(0.92)[b]	64.93(12.54)[b]	84.23(6.62)[b]	62.55(14.31)[b]	54.05(6.53)[b]	51.0(15.78)[-s]	76.68(14.92)[b]
C7	85	50	86.32(6.53)[b]	87.8(9.7)[b]	74.54(11.65)[b]	69.47(7.09)[b]	42.91(36.14)[*]	77.92(14.99)[b]	0.0(0.0)[-b]
C8	80	50	79.23(0.73)[b]	72.81(17.24)[b]	76.26(17.36)[b]	58.39(10.8)[b]	33.68(12.15)[-b]	12.23(7.25)[-b]	33.15(4.47)[-b]
C9	23	50	85.4(0.1)[b]	83.72(3.25)[b]	88.1(4.28)[b]	91.63(1.04)[b]	28.74(8.68)[-b]	0.16(0.38)[-b]	3.23(0.0)[-b]
Ranking		4	2	2	**1**	3	5	5	5

TABLE 19: Number of time steps of the stable periods, and average Recall0, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	#Time Steps	Dummy	WP-OOB_r0	AIO-OOB combined_r0	AIO-OOB proprietary_r0	Filter-OOB combined_r0	OP-AIO-OOB combined_r0	OP-AIO-OOB proprietary_r0	OP-Filter-OOB combined_r0
C1	294	50	68.67(6.6)[b]	70.1(8.12)[b]	37.69(12.32)[-b]	70.35(7.36)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C2	20	50	43.79(0.31)[-b]	30.97(1.95)[-b]	41.47(3.28)[-b]	43.23(0.92)[-b]	21.96(2.01)[-b]	99.98(0.05)[b]	22.88(2.55)[-b]
C3	125	50	52.06(3.31)[m]	38.54(0.51)[-b]	16.82(2.45)[-b]	53.6(0.98)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C4	68	50	31.88(1.5)[-b]	48.23(1.18)[-b]	69.56(7.66)[b]	81.94(1.26)[b]	54.09(1.83)[b]	51.46(4.05)[*]	68.18(0.0)[b]
C5	315	50	10.01(0.68)[-b]	33.2(1.71)[-b]	21.59(1.02)[-b]	37.2(2.6)[-b]	75.79(3.88)[b]	41.3(5.23)[-b]	22.39(6.7)[-b]
C6	69	50	26.94(0.59)[-b]	59.83(0.9)[b]	60.97(6.52)[b]	63.14(1.68)[b]	56.29(1.15)[b]	75.51(0.09)[b]	57.25(1.23)[b]
C7	262	50	29.44(1.12)[-b]	47.27(16.27)[-s]	30.36(2.47)[-b]	61.28(3.15)[b]	71.3(2.59)[b]	45.49(1.51)[-b]	31.83(1.42)[-b]
C8	472	50	13.41(0.09)[-b]	52.31(1.41)[b]	33.75(5.39)[-b]	56.43(1.92)[b]	79.96(2.43)[b]	76.31(10.7)[b]	28.6(3.5)[-b]
C9	91	50	31.84(2.71)[-b]	67.15(1.64)[b]	70.01(7.7)[b]	78.09(1.55)[b]	84.37(3.2)[b]	97.16(2.58)[b]	80.82(0.0)[b]
Ranking		2	4	2	3	**1**	**1**	**1**	**1**

Dataset	#Time Steps	Dummy	WP-ORB_r0	AIO-ORB combined_r0	AIO-ORB proprietary_r0	Filter-ORB combined_r0	OP-AIO-ORB combined_r0	OP-AIO-ORB proprietary_r0	OP-Filter-ORB combined_r0
C1	121	50	48.22(13.97)[-m]	30.34(12.18)[-b]	17.33(2.88)[-b]	51.83(15.36)[-*]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C2	19	50	49.13(2.37)[-m]	47.11(1.46)[-b]	31.07(7.39)[-b]	45.37(0.7)[-b]	96.24(2.41)[b]	88.57(12.86)[b]	98.83(0.49)[b]
C3	21	50	57.23(2.36)[b]	51.87(1.99)[b]	61.63(3.36)[b]	62.94(6.05)[b]	100.0(0.0)[b]	100.0(0.0)[b]	100.0(0.0)[b]
C4	248	50	57.35(5.96)[b]	20.91(9.31)[-b]	26.0(4.32)[-b]	66.35(3.78)[b]	42.92(9.0)[-b]	24.12(1.07)[-b]	86.82(2.22)[b]
C5	26	50	87.66(3.65)[b]	43.52(1.95)[-b]	43.15(2.6)[-b]	43.25(6.74)[-b]	56.71(16.81)[s]	35.02(10.21)[-b]	48.57(17.23)[-m]
C6	281	50	47.86(0.68)[-b]	45.21(8.02)[-b]	40.18(6.55)[-b]	51.36(10.57)[m]	69.18(4.7)[b]	68.15(12.22)[b]	47.56(10.78)[-b]
C7	399	50	47.84(5.89)[-m]	34.28(14.53)[-b]	45.1(11.62)[-*]	62.56(6.54)[b]	53.82(40.33)[*]	32.37(20.88)[-b]	100.0(0.0)[b]
C8	486	50	24.99(0.64)[-b]	33.92(17.42)[-b]	30.49(21.0)[-b]	46.02(8.36)[-m]	78.66(10.29)[b]	93.79(4.3)[b]	82.56(4.77)[b]
C9	473	50	25.0(0.33)[-b]	20.13(2.46)[-b]	26.41(7.98)[-b]	17.05(1.48)[-b]	78.91(7.13)[b]	99.92(0.2)[b]	99.94(0.0)[b]
Ranking		2	2	3	3	2	**1**	**1**	**1**

TABLE 20: Number of time steps of the stable periods, and average Recall1, A12 effect sizes and Scott-Knott.BA12 to compare learning approaches on this initial phase for OOB and ORB for Proprietary data

Dataset	#Time Steps	Dummy	WP-OOB_r1	AIO-OOB combined_r1	AIO-OOB proprietary_r1	Filter-OOB combined_r1	OP-AIO-OOB combined_r1	OP-AIO-OOB proprietary_r1	OP-Filter-OOB combined_r1
C1	294	50	40.94(5.53)[-b]	31.25(5.18)[-b]	66.19(9.31)[b]	32.55(4.31)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	20	50	95.41(0.0)[b]	90.63(0.34)[b]	75.08(8.04)[b]	81.76(1.55)[b]	60.95(3.34)[b]	0.18(0.24)[-b]	61.4(3.04)[b]
C3	125	50	60.68(2.77)[b]	76.54(0.57)[b]	85.09(4.0)[b]	63.03(0.57)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	68	50	70.33(0.48)[b]	61.33(2.18)[b]	51.46(10.89)[-s]	26.06(3.45)[-b]	43.13(0.67)[-b]	49.03(5.56)[-s]	33.88(0.0)[-b]
C5	315	50	87.4(1.47)[b]	69.41(3.14)[b]	91.31(1.18)[b]	68.6(4.17)[b]	27.42(5.61)[-b]	69.5(4.43)[b]	83.45(6.8)[b]
C6	69	50	72.3(0.29)[b]	44.65(0.54)[-b]	49.66(6.76)[*]	43.24(2.6)[-b]	39.98(0.67)[-b]	21.17(0.19)[-b]	34.78(0.67)[-b]
C7	262	50	80.94(0.76)[b]	66.75(10.32)[b]	93.45(1.45)[b]	51.74(5.52)[s]	47.51(1.64)[-b]	63.96(3.6)[b]	64.92(0.49)[b]
C8	472	50	82.1(0.01)[b]	60.49(2.11)[b]	72.47(5.79)[b]	38.65(2.13)[-b]	27.55(2.61)[-b]	34.23(9.42)[-b]	71.64(2.57)[b]
C9	91	50	80.9(0.96)[b]	52.67(3.64)[b]	56.11(12.84)[m]	32.22(2.12)[-b]	20.54(2.67)[-b]	4.74(2.18)[-b]	19.72(0.54)[-b]
Ranking		3	**1**	2	**1**	3	5	5	4

Dataset	#Time Steps	Dummy	WP-ORB_r1	AIO-ORB combined_r1	AIO-ORB proprietary_r1	Filter-ORB combined_r1	OP-AIO-ORB combined_r1	OP-AIO-ORB proprietary_r1	OP-Filter-ORB combined_r1
C1	121	50	53.31(10.56)[m]	76.43(12.42)[b]	86.06(2.21)[b]	60.7(13.86)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C2	19	50	49.07(1.59)[-b]	79.24(2.8)[b]	74.37(8.71)[b]	74.63(1.04)[b]	13.63(2.74)[-b]	16.78(11.42)[-b]	14.6(2.42)[-b]
C3	21	50	65.32(2.08)[b]	70.67(2.53)[b]	63.99(4.56)[b]	61.4(5.67)[b]	0.0(0.0)[-b]	0.0(0.0)[-b]	0.0(0.0)[-b]
C4	248	50	54.03(8.28)[m]	89.28(6.21)[b]	87.96(2.23)[b]	51.19(2.72)[s]	70.53(12.32)[b]	82.72(0.47)[b]	51.85(7.74)[s]
C5	26	50	21.41(7.72)[-b]	72.84(2.94)[b]	73.21(3.27)[b]	70.62(5.21)[b]	61.45(8.44)[b]	68.01(10.35)[b]	62.72(9.68)[b]
C6	281	50	64.44(0.61)[b]	66.63(8.06)[b]	73.93(4.33)[b]	54.71(11.81)[-s]	57.88(3.96)[b]	40.69(11.55)[-b]	67.63(11.18)[b]
C7	399	50	59.21(4.05)[b]	80.05(10.58)[b]	75.5(7.1)[b]	60.97(3.76)[b]	51.88(38.94)[*]	62.18(22.32)[b]	0.0(0.0)[-b]
C8	486	50	58.0(0.87)[b]	73.5(12.77)[b]	76.96(15.2)[b]	52.81(5.95)[s]	33.26(9.93)[-b]	18.36(6.82)[-b]	28.7(3.47)[-b]
C9	473	50	69.17(0.12)[b]	81.02(1.72)[b]	77.59(6.14)[b]	83.16(1.7)[b]	19.65(5.55)[-b]	0.29(0.68)[-b]	3.45(0.0)[-b]
Ranking		4	3	**1**	**1**	2	5	5	5

2 Plots of Predictive Performance Through Time

This section shows plots of the G-Means through time for all approaches investigated in the study.

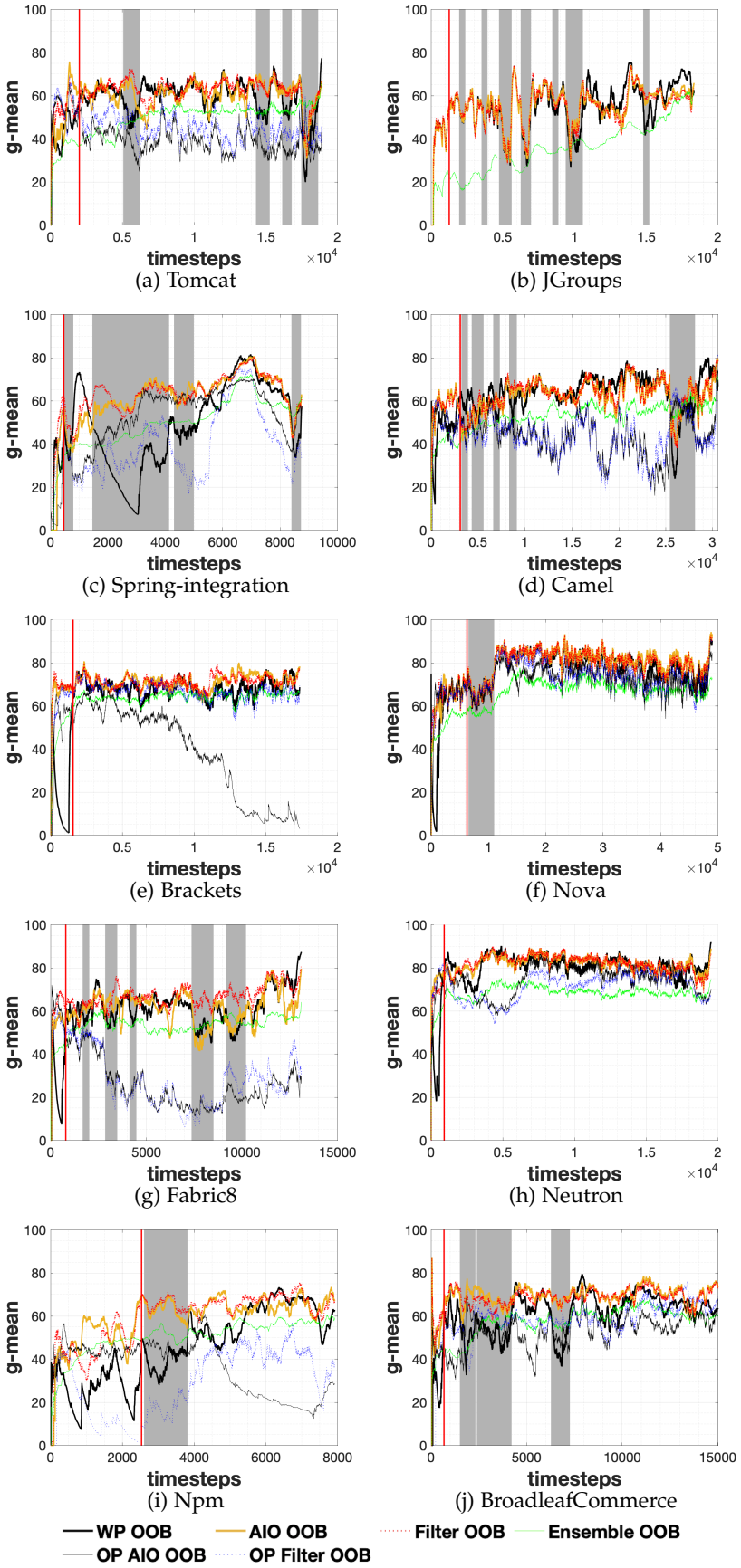


Fig. 1: G-Mean for all datasets through time using OOB. The vertical red bar indicates the last time step of the initial phase of the project. The periods highlighted in grey background are the sudden drop periods.

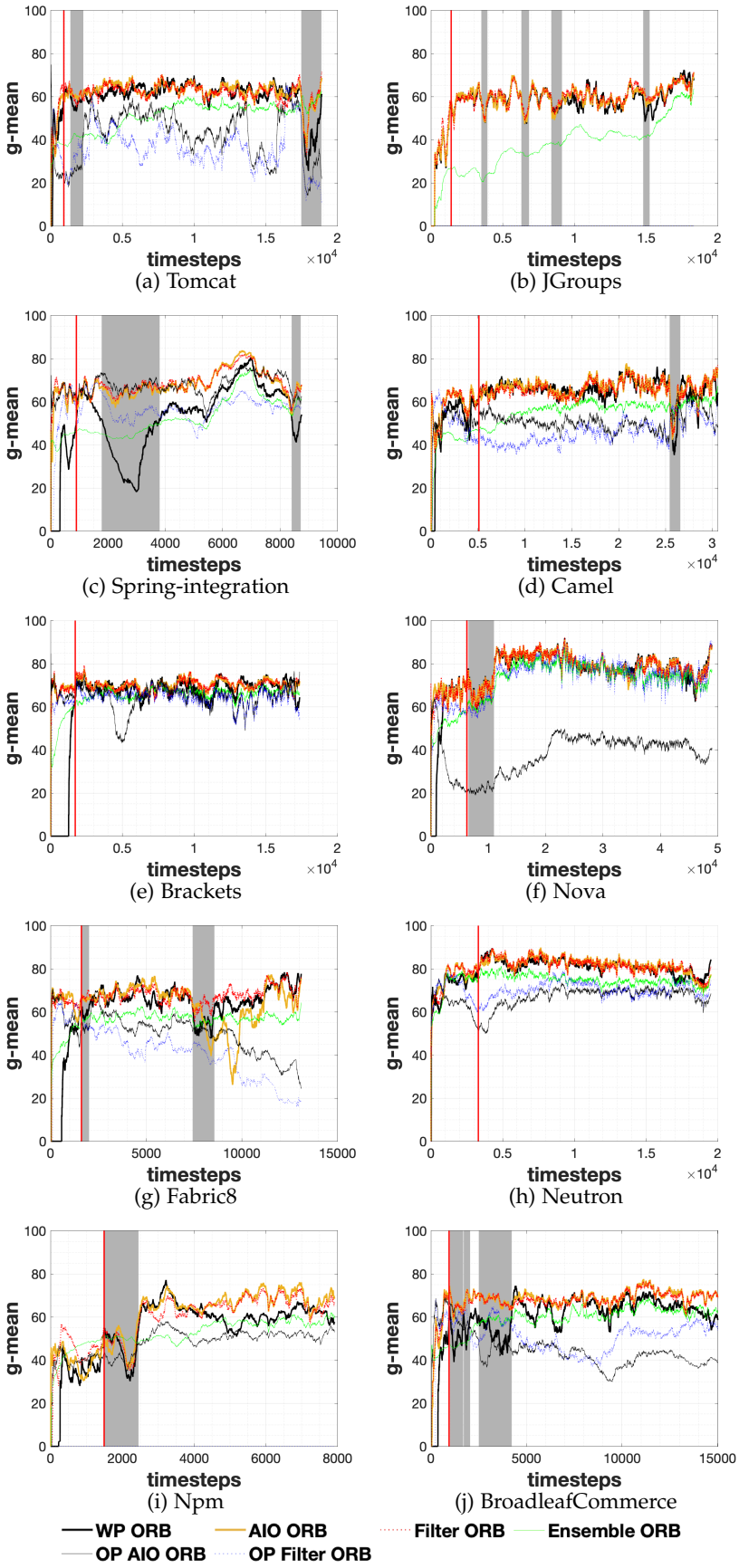


Fig. 2: G-Mean for all datasets through time using ORB. The vertical red bar indicates the last time step of the initial phase of the project. The periods highlighted in grey background are the sudden drop periods.

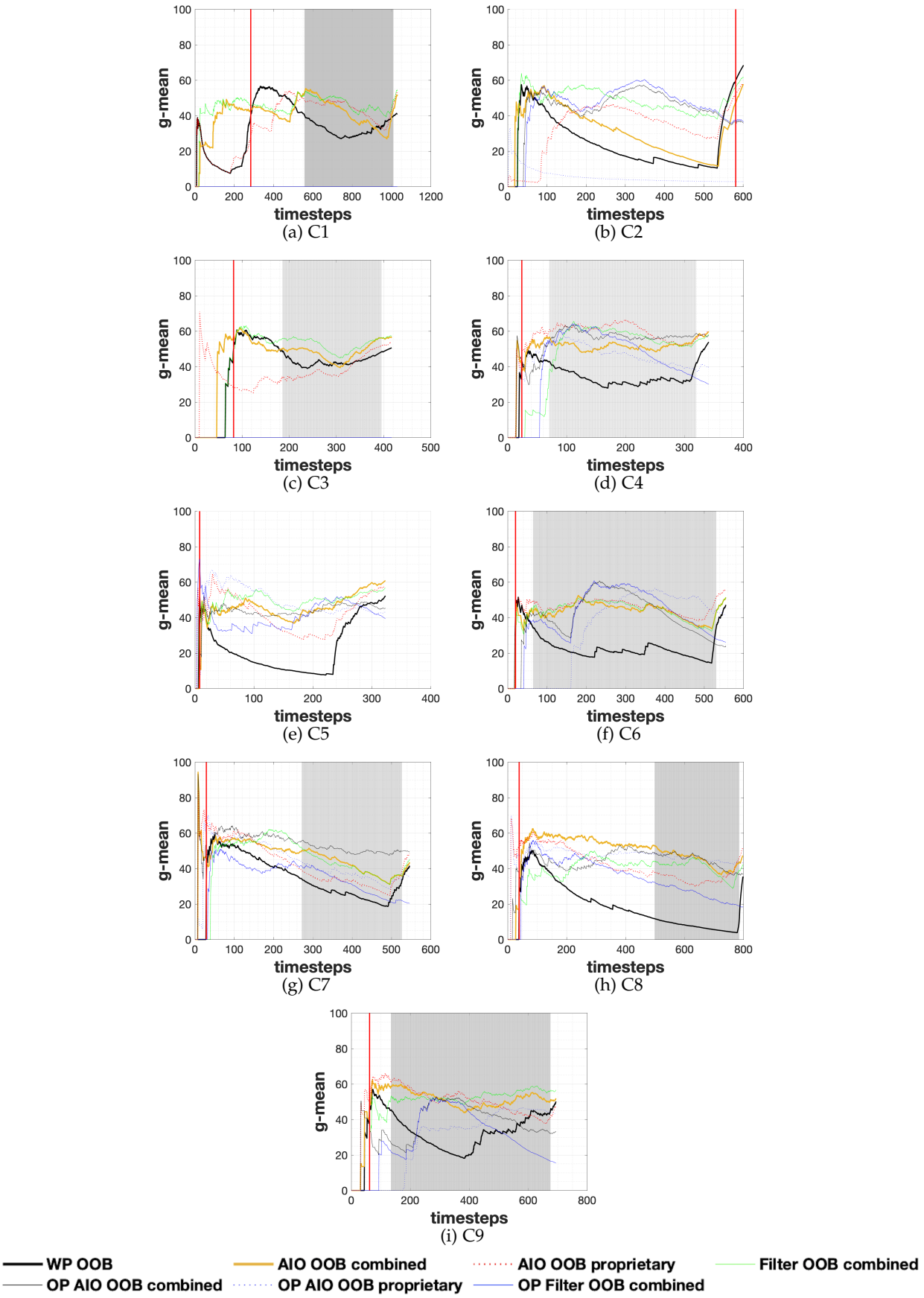


Fig. 3: G-Mean for all datasets through time using OOB. The vertical red bar indicates the last time step of the initial phase of the project. The periods highlighted in grey background are the sudden drop periods.

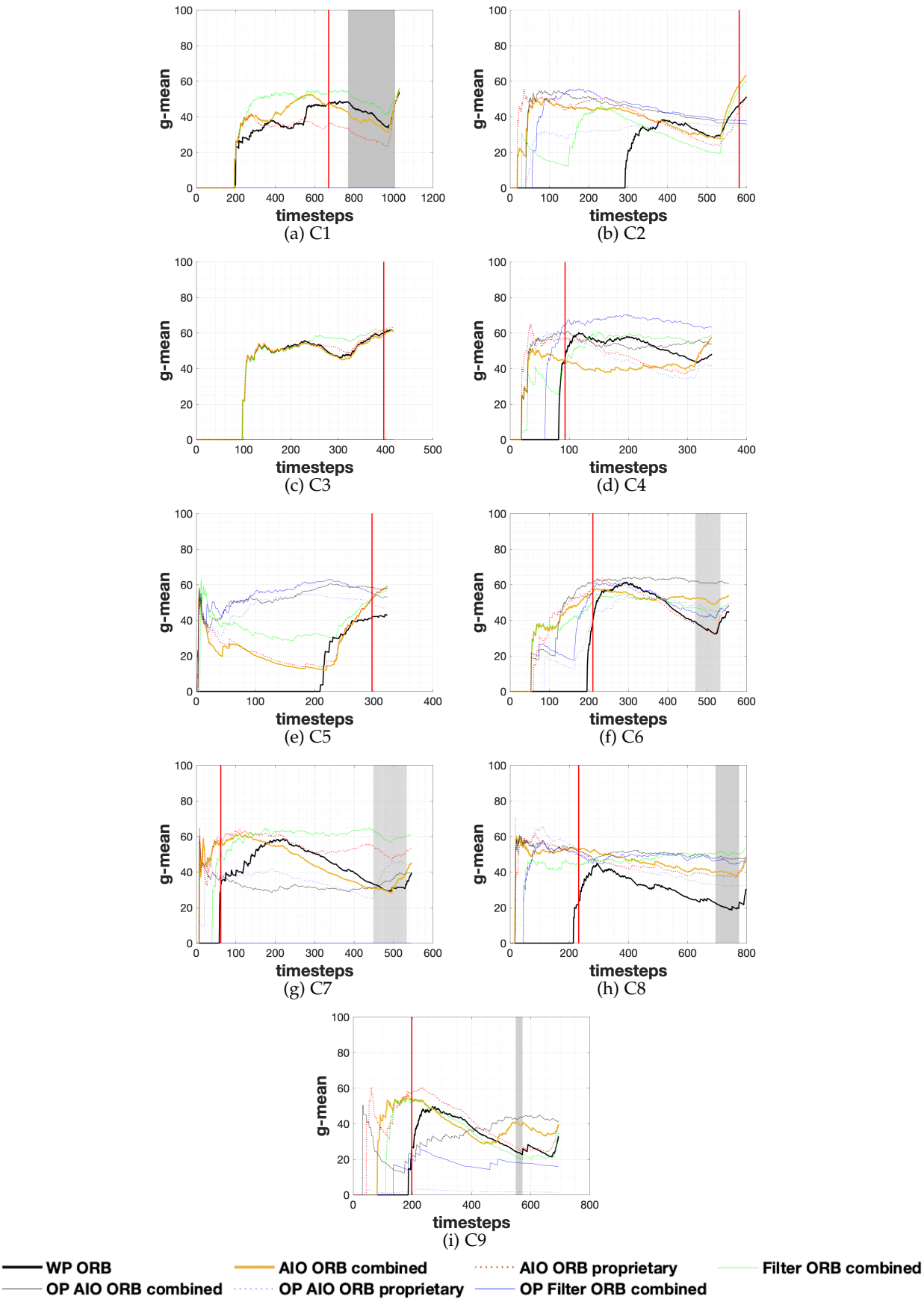
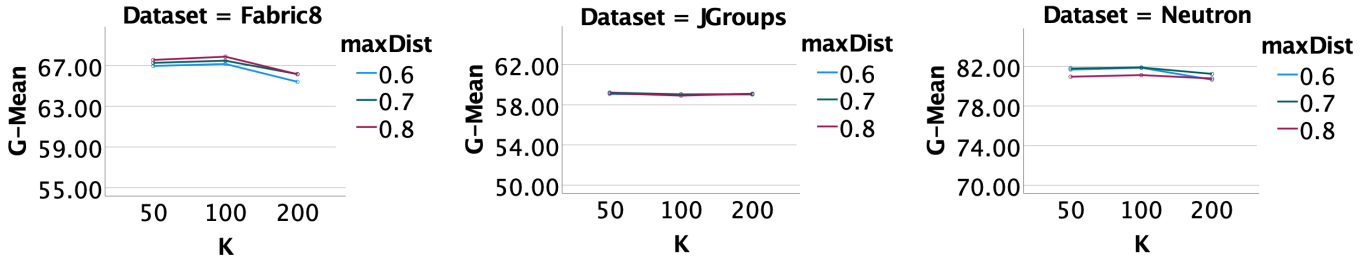


Fig. 4: G-Mean for all datasets through time using ORB. The vertical red bar indicates the last time step of the initial phase of the project. The periods highlighted in grey background are the sudden drop periods.

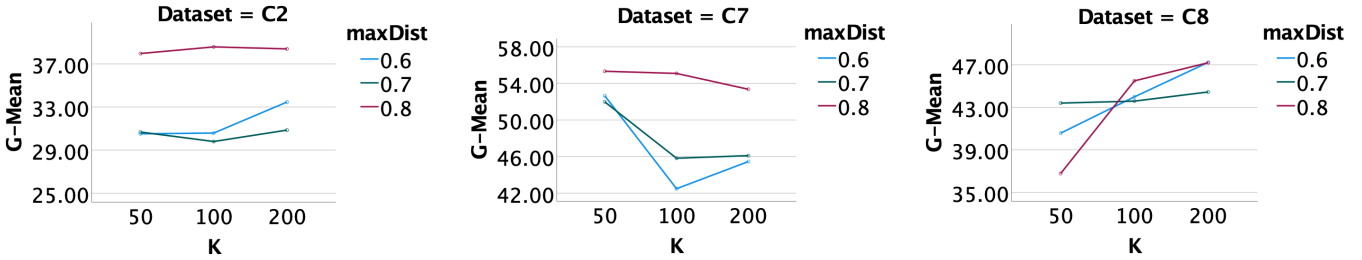
3 Hyperparameter Sensitivity Analysis

This section shows the tables and plots of results corresponding to the analysis of sensitivity to hyperparameters when using Filtering-ORB.



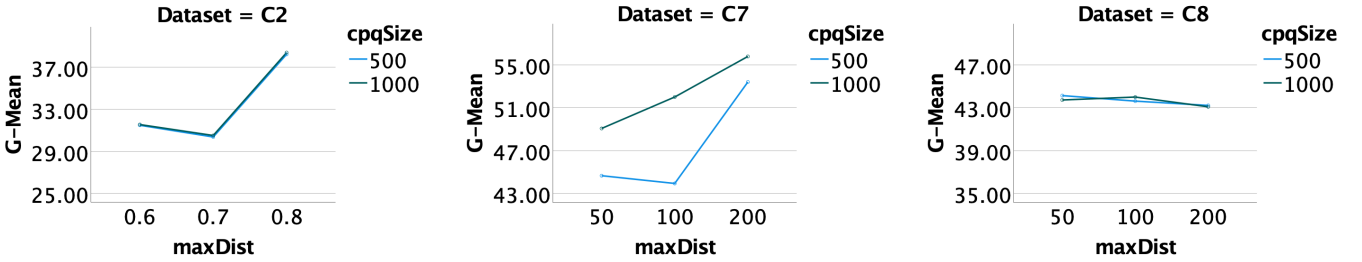
(a) Effect of $K * maxDist$ with Fabric8 (b) Effect of $K * maxDist$ with JGroups (c) Effect of $K * maxDist$ with Neutron

Fig. 5: Plots of Marginal Means for Filtering-ORB's Factors K, $maxDist$ and $dataset$ (Open source data)



(a) Effect of $K * maxDist$ with C2 (b) Effect of $K * maxDist$ with C7 (c) Effect of $K * maxDist$ with C8

Fig. 6: Plots of Marginal Means for Filtering-ORB's Factors K, $maxDist$ and $dataset$ (Proprietary data)



(a) Effect of $maxDist * cpqSize$ with C2 (b) Effect of $maxDist * cpqSize$ with C7 (c) Effect of $maxDist * cpqSize$ with C8

Fig. 7: Plots of Marginal Means for Filtering-ORB's Factors $cpqSize$, $maxDist$ and $dataset$ (Proprietary data)

TABLE 21: ANOVA and Effect Size Results for Filtering-ORB (Opensource Data)

Within Subject Test for Filtering-ORB (Opensource Data)					
K	554.041	1.847	300.027	1139.471	0.929
K * Dataset	417.928	4	104.482	429.767	0.908
maxDist * Dataset	212.243	4	53.061	245.435	0.849
windowSize*K	175.995	3.447	51.062	179.843	0.674
windowSize	89.059	2	44.529	151.658	0.635
maxDist	50.859	2	25.43	117.626	0.575
windowSize * K * Dataset	100.475	8	12.559	51.336	0.541
windowSize * Dataset	56.363	4	14.091	47.99	0.525
K * maxDist * Dataset	39.91	8	4.989	22.385	0.34
K * maxDist	23.317	4	5.829	26.156	0.231
windowSize * maxDist	23.299	4	5.825	23.286	0.211
windowSize * maxDist * Dataset	17.442	8	2.18	8.716	0.167
windowSize * K * maxDist	31.295	8	3.912	15.318	0.15
cpqSize * Dataset	2.593	2	1.296	5.246	0.108
K * cpqSize * Dataset	3.871	4	0.968	3.102	0.067
windowSize * K * maxDist * Dataset	12.364	16	0.773	3.026	0.065
maxDist * cpqSize	1.977	2	0.989	3.697	0.041
windowSize * K * cpqSize	2.5	3.543	0.706	2.872	0.032
windowSize * maxDist * cpqSize * Dataset	2.82	8	0.352	1.428	0.032
K * maxDist * cpqSize * Dataset	2.598	8	0.325	1.328	0.03
windowSize * K * maxDist * cpqSize * Dataset	3.545	16	0.222	0.886	0.02
windowSize * cpqSize * Dataset	0.806	4	0.202	0.763	0.017
windowSize * K * maxDist * cpqSize	2.651	6.754	0.392	1.325	0.015
K * cpqSize	0.748	2	0.374	1.199	0.014
maxDist * cpqSize * Dataset	0.518	4	0.129	0.484	0.011
windowSize * K * cpqSize * Dataset	0.524	8	0.066	0.301	0.007
windowSize * maxDist * cpqSize	0.574	4	0.143	0.581	0.007
windowSize * cpqSize	0.194	2	0.097	0.367	0.004
cpqSize	0.064	1	0.064	0.257	0.003
K * maxDist * cpqSize	0.285	4	0.071	0.291	0.003
Between Subject Test with ORB					
Dataset	412679.309	2	206339.654	918130.525	1

TABLE 22: ANOVA Analysis of Hyperparameters for Filtering-ORB (Proprietary Data)

Within Subject Test with ORB					
Factor/Int.	SS	DF	MS	F	η_p^2
maxDist	23566.525	1.747	13493.132	1355.966	0.938
maxDist*dataset	16407.829	4	4101.957	472.035	0.913
K*dataset	20278.404	4	5069.601	428.2	0.905
cpqSize*dataset	6741.644	2	3370.822	390.947	0.897
cpqSize	3519.707	1	3519.707	408.214	0.819
K*maxDist	6321.242	4	1580.31	170.739	0.655
K*maxDist*dataset	4267.894	8	533.487	57.639	0.562
maxDist*cpqSize*dataset	1409.002	4	352.25	40.993	0.477
maxDist*cpqSize	946.645	2	473.322	55.083	0.38
K	1285.156	2	642.578	54.275	0.376
K*cpqSize*dataset	203.465	4	50.866	4.622	0.093
K*maxDist*cpqSize	250.999	4	62.75	7.113	0.073
Between Subject Test with ORB					
dataset	229263.263	2	114631.632	9383.673	0.995

4 ALGORITHMS

This section lists the pseudocode of the online CP Ensemble approach and the pseudocode of the systematic procedure for identifying periods of sudden drop in predictive performance.

Algorithm 1 Sudden Drop Detection Approach

Input: d_thr = Detecta threshold, $gmeans$ = G-mean for each time step t

$drop\_periods = \{\}$
$peaks$ = $detecta\_onset(d\_thr, gmeans)$ // time steps with peaks
for time step $t = 1$ to $gmeans.length()$ **do**
  if $t \in peaks$ **then**
    $latest\_peak = t$
  end if
  $window\_avg = average(gmeans[latest\_peak : t])$
  $drop\_thr$ = $window\_avg - (0.20 * window\_avg)$
  if $gmeans[t] < drop\_thr$ **then**
    $peak\_left$ = $latest\_peak$
    $peak\_right$ = Get next peak after timestamp t from $peaks$
    $drop\_periods.add([peak.left, peak.right])$
  end if
end for
Return $drop\_periods$

Algorithm 2 Ensemble approach

Inputs: S = stream of incoming changes from n projects, b = index identifying the test project, w = waiting period

initialise ensemble model M consisting of n models $\{m_1, m_2, ..., m_n\}$
for each incoming change $x_p^t \in S$ **do** // x_p^t is a change arriving from project p at timestamp t
  if $p = b$ **then**
    $\hat{Y}$-$List \leftarrow$ get probability $\hat{y}_i$ of change x_p^t being defect-inducing from each model in M
    $MeanY$ = mean of values in $\hat{Y}$-$List$
    if $MeanY < 0.5$ **then**
      $\hat{y} = 0$
    else
      $\hat{y} = 1$
    end if
  end if
  store x_p^t in a queue WFL-Q_p for project p // WFL -Q_p is the queue of incoming changes of project p waiting to be used for trained
  for each model m_p in M **do**
    for each change q^i in WFL-Q_p **do**
      if a defect was linked to q^i at a timestamp $\leq$ t **then**
        create defect-inducing $training\_example$ for q^i
        train(m_p, $training\_example$)
        remove q^i from WFL-Q_p
      else
        create a clean $training\_example$ for q^i
        train(m_p, $training\_example$)
        remove q^i from WFL-Q
        store $training\_example$ in CL_p-H // CL_p-H is a hash of clean training examples for project p
      end if
    end for
  end for
  if a defect was linked to a $training\_example$ in CL_p-H before time t **then**
    Swap the label of $training\_example$ to defect-inducing
    train(m_p, $training\_example$)
    remove h from CL_p-H
  end if
end for