Report On Stochastic Process Discovery By Weight Estimation Experimental Results

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Abstract. Many algorithms now exist for discovering process models from event logs. These models usually describe a control flow and are intended for use by people in analysing and improving real-world organizational processes. The relative likelihood of choices made while following a process is highly relevant information which few existing algorithms make available in their automatically discovered models. This can addressed by automatically discovered stochastic process models. This report presents more detailed experimental results related to a framework for automatic discovery of stochastic process models, detailed in a companion paper.

Key words: Stochastic Petri nets, process mining, stochastic process mining, stochastic process discovery

1 Introduction

In related work [1], we have introduced a framework for stochastic process discovery, six weight estimators, and details on implementation and evaluation. This report supplies full experimental results excluded from that article for reasons of space.

The results used to generate these figures and tables are also available as XML data files at `https://github.com/adamburkegh/spd_we`. The result data is more detailed than the data presented here, e.g., including the text of error messages. The source code for the estimator implementations, test run harnesses and report generation is available at the same site.

2 Results

Table 1 provides an overview of the real-life event logs used in evaluation. All logs are publicly available at `https://data.4tu.nl/`.

Table 2 explains short identifiers for miners and miner-estimator combinations used as keys throughout this report.

Figure 1 shows truncated Earth Movers stochastic conformance with 0.8 probability mass (tEMSC 0.8) [2] by event log.

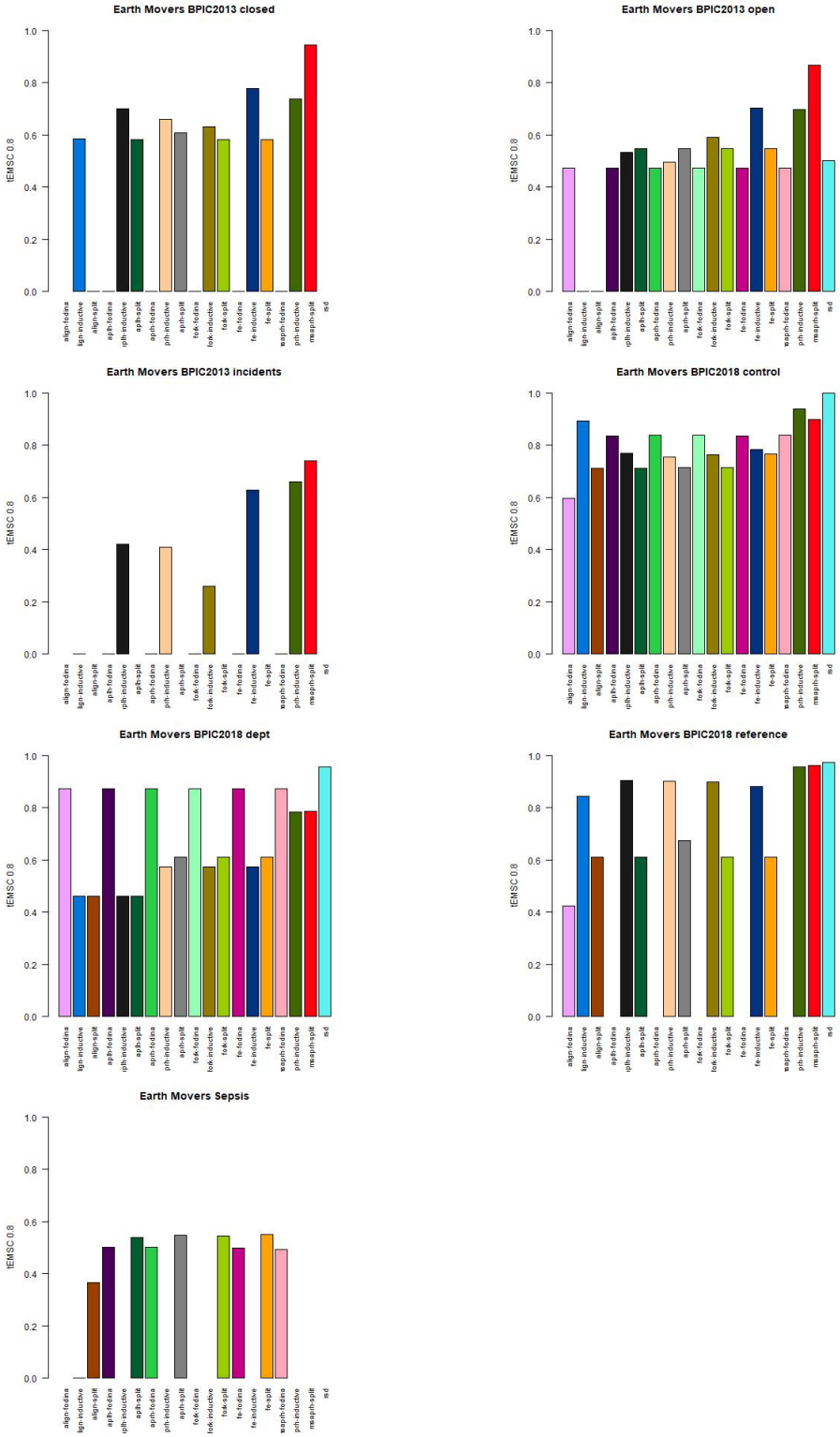

Fig. 1: Earth movers experiment results

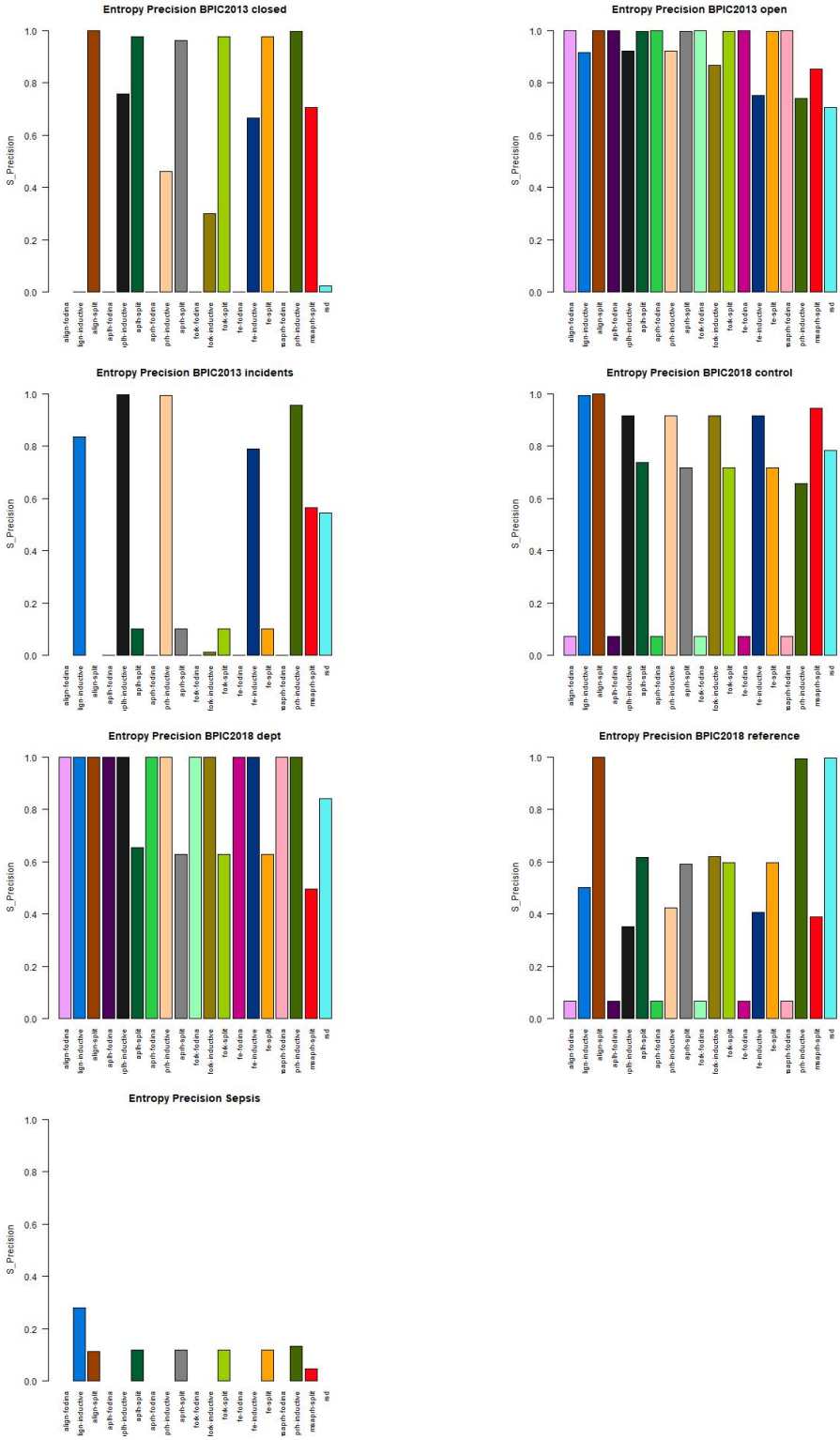

Fig. 2: Entropy precision experiment results

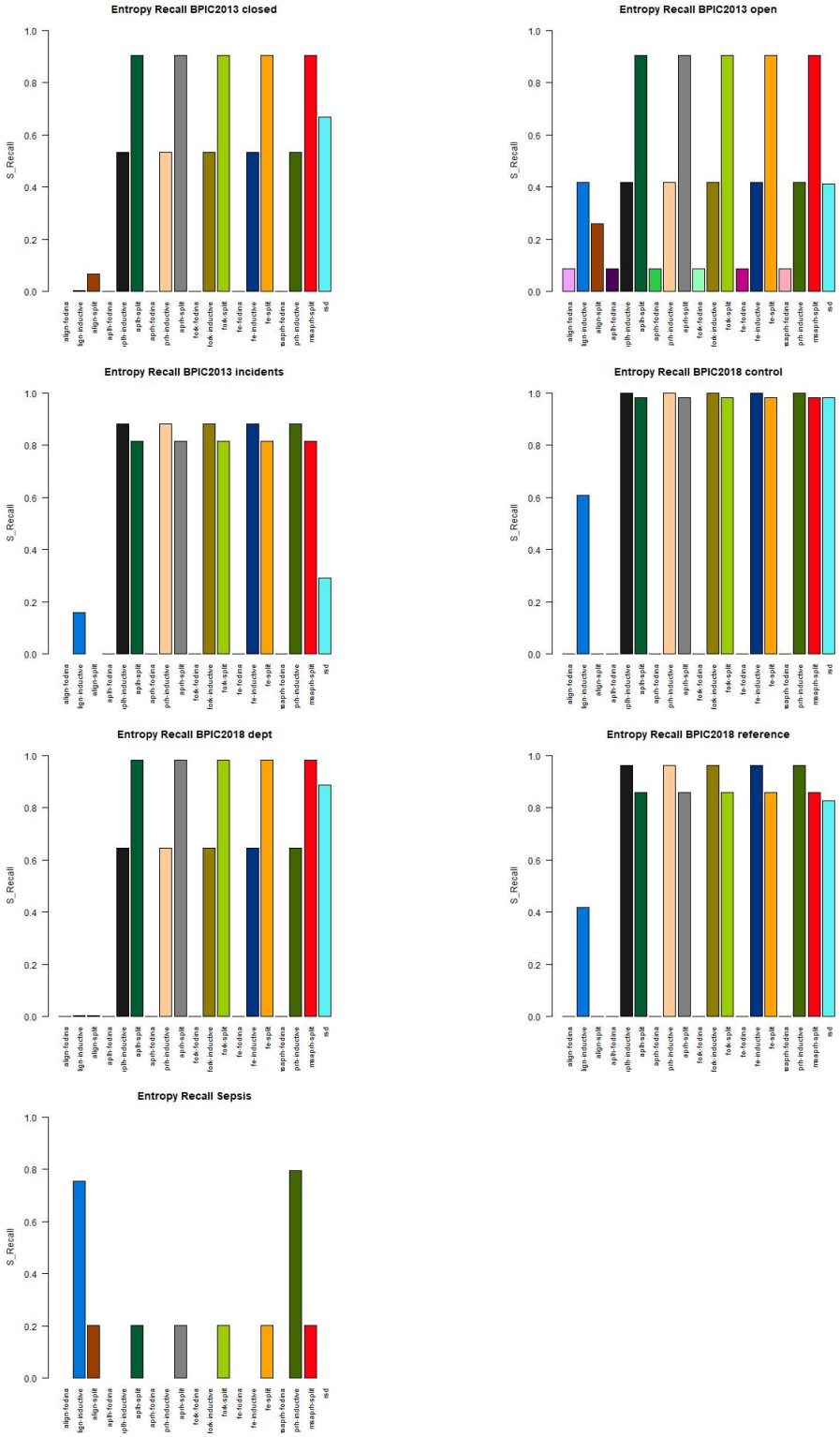

Fig. 3: Entropy recall experiment results

Event Log	Traces	Events
BPIC2013 closed	1487	6660
BPIC2013 incidents	7554	65533
BPIC2013 open	819	2531
BPIC2018 control	43808	161296
BPIC2018 dept	29297	46669
BPIC2018 reference	43802	128554
sepsis	1054	15214

Table 1: Event log overview.

Short Id	Artifact Creator Full Name	Type
align	Alignment	Estimator
aplh	Activity Pair Left-Handed	Estimator
aprh	Activity Pair Right-Handed	Estimator
msaprh	Mean-Scaled Activity Pair Right-Handed	Estimator
fork	Fork-Distributed Estimator	Estimator
fe	Frequency	Estimator
fodina	Fodina Miner	Control Flow Miner
inductive	Inductive Miner[4]	Control Flow Miner
split	Split Miner	Control Flow Miner
rsd	RSD technique [4]	Stochastic Miner
rssmt	RSD synonym seen in some figures	Stochastic Miner

Table 2: Event log overview.

Figures 2 and 3 show Entropy Precision (S_Precision) and Recall (S_Recall) [3] results by event log.

Figure 4 shows run times for the discovery process, and reproduces a figure from [1].

Table 3 shows stochastic conformance measures and run times for each discovery run. This includes runs from a combination of control discovery algorithm and weight estimators, and those using the technique introduced by Rogge-Solti et al [4] (RSD). RSD runs show estimator durations as zero. The text FAILED reflects not being able to discover a model or conformance measure. This may be due to errors, inapplicability, or the process being halted after running beyond a duration of five hours. Actual failures of discovery were relatively rare, but there were a number of models for which conformance measures could not be calculated, such as for the sepsis log.

Artifact Creator	Miner algo	Miner t	Estimator t	Log	Entities	Edges	tEMSC 0.8	S_precision	S_recall
Alignment	fodina	47	0	BPIC2013 closed	FAILED	FAILED	FAILED	FAILED	FAILED
Activity Pair Left-Handed Estimator	fodina	47	94	BPIC2013 closed	12	14	-0	-0	-0
Activity Pair Right-Handed Estimator	fodina	47	94	BPIC2013 closed	12	14	-0	-0	-0
Fork Distributed Estimator	fodina	47	93	BPIC2013 closed	12	14	-0	-0	-0
Frequency Estimator	fodina	47	94	BPIC2013 closed	12	14	-0	-0	-0
Mean Scaled Activity Pair Estimator	fodina	47	94	BPIC2013 closed	12	14	-0	-0	-0
Alignment	inductive	172	234	BPIC2013 closed	9	10	0.5835	-0	0.0019
Activity Pair Left-Handed Estimator	inductive	172	109	BPIC2013 closed	9	10	0.6986	0.7583	0.5327
Activity Pair Right-Handed Estimator	inductive	172	93	BPIC2013 closed	9	10	0.66	0.4602	0.5327
Fork Distributed Estimator	inductive	172	94	BPIC2013 closed	9	10	0.6312	0.3005	0.5327

Frequency Estimator	inductive	172	156	BPIC2013 closed	9	10	0.7765	0.6654	0.5327
Mean Scaled Activity Pair Estimator	inductive	172	93	BPIC2013 closed	9	10	0.7373	0.9967	0.5327
Rogge-Solti Discovery	rssmt	547	0	BPIC2013 closed	31	38	FAILED	0.0218	0.667
Alignment	split	968	141	BPIC2013 closed	17	20	-0	1	0.0657
Activity Pair Left-Handed Estimator	split	968	79	BPIC2013 closed	17	20	0.581	0.9759	0.9039
Activity Pair Right-Handed Estimator	split	968	78	BPIC2013 closed	17	20	0.6085	0.9614	0.9039
Fork Distributed Estimator	split	968	78	BPIC2013 closed	17	20	0.581	0.9759	0.9039
Frequency Estimator	split	968	94	BPIC2013 closed	17	20	0.581	0.9759	0.9039
Mean Scaled Activity Pair Estimator	split	968	78	BPIC2013 closed	17	20	0.9443	0.7049	0.9039
Alignment	fodina	47	0	BPIC2013 incidents	FAILED	FAILED	FAILED	FAILED	FAILED
Activity Pair Left-Handed Estimator	fodina	47	813	BPIC2013 incidents	10	12	-0	-0	-0
Activity Pair Right-Handed Estimator	fodina	47	812	BPIC2013 incidents	10	12	-0	-0	-0
Fork Distributed Estimator	fodina	47	813	BPIC2013 incidents	10	12	-0	-0	-0
Frequency Estimator	fodina	47	735	BPIC2013 incidents	10	12	-0	-0	-0
Mean Scaled Activity Pair Estimator	fodina	47	812	BPIC2013 incidents	10	12	-0	-0	-0
Alignment	inductive	172	1437	BPIC2013 incidents	10	12	-0	0.8356	0.1572
Activity Pair Left-Handed Estimator	inductive	172	828	BPIC2013 incidents	10	12	0.4198	0.9964	0.8817
Activity Pair Right-Handed Estimator	inductive	172	828	BPIC2013 incidents	10	12	0.4089	0.9941	0.8817
Fork Distributed Estimator	inductive	172	812	BPIC2013 incidents	10	12	0.2589	0.0107	0.8817
Frequency Estimator	inductive	172	906	BPIC2013 incidents	10	12	0.6289	0.7874	0.8817
Mean Scaled Activity Pair Estimator	inductive	172	844	BPIC2013 incidents	10	12	0.6588	0.955	0.8817
Rogge-Solti Discovery	rssmt	48097	0	BPIC2013 incidents	37	46	FAILED	0.5445	0.2902
Alignment	split	968	1062	BPIC2013 incidents	20	24	FAILED	FAILED	FAILED
Activity Pair Left-Handed Estimator	split	968	687	BPIC2013 incidents	20	24	FAILED	0.1009	0.8158
Activity Pair Right-Handed Estimator	split	968	687	BPIC2013 incidents	20	24	FAILED	0.1009	0.8158
Fork Distributed Estimator	split	968	672	BPIC2013 incidents	20	24	FAILED	0.1009	0.8158
Frequency Estimator	split	968	719	BPIC2013 incidents	20	24	FAILED	0.1009	0.8158
Mean Scaled Activity Pair Estimator	split	968	672	BPIC2013 incidents	20	24	0.7394	0.5653	0.8158
Alignment	fodina	47	47	BPIC2013 open	8	8	0.472	1	0.0865
Activity Pair Left-Handed Estimator	fodina	47	32	BPIC2013 open	8	8	0.472	1	0.0865
Activity Pair Right-Handed Estimator	fodina	47	31	BPIC2013 open	8	8	0.472	1	0.0865
Fork Distributed Estimator	fodina	47	31	BPIC2013 open	8	8	0.472	1	0.0865
Frequency Estimator	fodina	47	31	BPIC2013 open	8	8	0.472	1	0.0865
Mean Scaled Activity Pair Estimator	fodina	47	32	BPIC2013 open	8	8	0.472	1	0.0865
Alignment	inductive	172	156	BPIC2013 open	15	18	-0	0.9144	0.4166
Activity Pair Left-Handed Estimator	inductive	172	47	BPIC2013 open	15	18	0.5339	0.9211	0.4166
Activity Pair Right-Handed Estimator	inductive	172	31	BPIC2013 open	15	18	0.4961	0.9211	0.4166
Fork Distributed Estimator	inductive	172	46	BPIC2013 open	15	18	0.5901	0.8671	0.4166
Frequency Estimator	inductive	172	62	BPIC2013 open	15	18	0.702	0.7515	0.4166
Mean Scaled Activity Pair Estimator	inductive	172	48	BPIC2013 open	15	18	0.6975	0.739	0.4166
Rogge-Solti Discovery	rssmt	1046	0	BPIC2013 open	31	38	0.5014	0.7062	0.4124
Alignment	split	968	63	BPIC2013 open	15	18	-0	1	0.2581
Activity Pair Left-Handed Estimator	split	968	30	BPIC2013 open	15	18	0.5475	0.9963	0.9049
Activity Pair Right-Handed Estimator	split	968	31	BPIC2013 open	15	18	0.5475	0.9957	0.9049
Fork Distributed Estimator	split	968	31	BPIC2013 open	15	18	0.5475	0.9958	0.9049
Frequency Estimator	split	968	32	BPIC2013 open	15	18	0.5475	0.9958	0.9049
Mean Scaled Activity Pair Estimator	split	968	32	BPIC2013 open	15	18	0.8662	0.8521	0.9049
Alignment	fodina	47	3656	BPIC2018 control	36	46	0.5951	0.0727	0
Activity Pair Left-Handed Estimator	fodina	47	3546	BPIC2018 control	36	46	0.836	0.0727	0
Activity Pair Right-Handed Estimator	fodina	47	3531	BPIC2018 control	36	46	0.8361	0.0727	0
Fork Distributed Estimator	fodina	47	3515	BPIC2018 control	36	46	0.8362	0.0727	0
Frequency Estimator	fodina	47	3515	BPIC2018 control	36	46	0.836	0.0727	0
Mean Scaled Activity Pair Estimator	fodina	47	3515	BPIC2018 control	36	46	0.8363	0.0727	0
Alignment	inductive	172	3906	BPIC2018 control	23	28	0.8926	0.9928	0.6085
Activity Pair Left-Handed Estimator	inductive	172	3640	BPIC2018 control	23	28	0.7692	0.9165	0.9995
Activity Pair Right-Handed Estimator	inductive	172	3468	BPIC2018 control	23	28	0.7534	0.9165	0.9995
Fork Distributed Estimator	inductive	172	3531	BPIC2018 control	23	28	0.7624	0.9152	0.9995
Frequency Estimator	inductive	172	3703	BPIC2018 control	23	28	0.7826	0.9145	0.9995
Mean Scaled Activity Pair Estimator	inductive	172	3562	BPIC2018 control	23	28	0.9375	0.6568	0.9995
Rogge-Solti Discovery	rssmt	5014	0	BPIC2018 control	34	40	0.9991	0.7837	0.9824
Alignment	split	968	3562	BPIC2018 control	23	28	0.7111	1	0.0016
Activity Pair Left-Handed Estimator	split	968	3531	BPIC2018 control	23	28	0.7111	0.7372	0.9824
Activity Pair Right-Handed Estimator	split	968	3530	BPIC2018 control	23	28	0.7152	0.7153	0.9824
Fork Distributed Estimator	split	968	3609	BPIC2018 control	23	28	0.7152	0.7153	0.9824
Frequency Estimator	split	968	3515	BPIC2018 control	23	28	0.7647	0.7153	0.9824
Mean Scaled Activity Pair Estimator	split	968	3499	BPIC2018 control	23	28	0.8973	0.9428	0.9824
Alignment	fodina	47	1860	BPIC2018 dept	40	56	0.8707	1	0
Activity Pair Left-Handed Estimator	fodina	47	1562	BPIC2018 dept	40	56	0.8707	1	0
Activity Pair Right-Handed Estimator	fodina	47	1593	BPIC2018 dept	40	56	0.8707	1	0
Fork Distributed Estimator	fodina	47	1671	BPIC2018 dept	40	56	0.8707	1	0
Frequency Estimator	fodina	47	1578	BPIC2018 dept	40	56	0.8707	1	0
Mean Scaled Activity Pair Estimator	fodina	47	1578	BPIC2018 dept	40	56	0.8707	1	0
Alignment	inductive	172	2312	BPIC2018 dept	17	20	0.4604	1	0.0023
Activity Pair Left-Handed Estimator	inductive	172	1921	BPIC2018 dept	17	20	0.4604	1	0.645
Activity Pair Right-Handed Estimator	inductive	172	1906	BPIC2018 dept	17	20	0.5715	1	0.645
Fork Distributed Estimator	inductive	172	1922	BPIC2018 dept	17	20	0.5715	1	0.645
Frequency Estimator	inductive	172	2015	BPIC2018 dept	17	20	0.5715	1	0.645
Mean Scaled Activity Pair Estimator	inductive	172	1906	BPIC2018 dept	17	20	0.784	1	0.645
Rogge-Solti Discovery	rssmt	12200	0	BPIC2018 dept	44	54	0.9562	0.84	0.8861
Alignment	split	968	1875	BPIC2018 dept	32	42	0.4604	1	0.0023
Activity Pair Left-Handed Estimator	split	968	1781	BPIC2018 dept	32	42	0.4604	0.6539	0.9801
Activity Pair Right-Handed Estimator	split	968	1610	BPIC2018 dept	32	42	0.6104	0.627	0.9801
Fork Distributed Estimator	split	968	1609	BPIC2018 dept	32	42	0.6104	0.627	0.9801
Frequency Estimator	split	968	1734	BPIC2018 dept	32	42	0.6104	0.627	0.9801
Mean Scaled Activity Pair Estimator	split	968	1624	BPIC2018 dept	32	42	0.7845	0.4949	0.9801
Alignment	fodina	47	3624	BPIC2018 reference	35	46	0.4223	0.065	0
Activity Pair Left-Handed Estimator	fodina	47	3093	BPIC2018 reference	35	46	FAILED	0.065	0
Activity Pair Right-Handed Estimator	fodina	47	3125	BPIC2018 reference	35	46	FAILED	0.065	0
Fork Distributed Estimator	fodina	47	2984	BPIC2018 reference	35	46	FAILED	0.065	0
Frequency Estimator	fodina	47	3109	BPIC2018 reference	35	46	FAILED	0.065	0

Mean Scaled Activity Pair Estimator	fodina	47	3202	BPIC2018 reference	35	46	FAILED	0.065	0
Alignment	inductive	172	3828	BPIC2018 reference	23	28	0.8447	0.5002	0.4162
Activity Pair Left-Handed Estimator	inductive	172	3625	BPIC2018 reference	23	28	0.9036	0.3517	0.9618
Activity Pair Right-Handed Estimator	inductive	172	3265	BPIC2018 reference	23	28	0.9013	0.422	0.9618
Fork Distributed Estimator	inductive	172	3296	BPIC2018 reference	23	28	0.8986	0.6195	0.9618
Frequency Estimator	inductive	172	3874	BPIC2018 reference	23	28	0.8795	0.4049	0.9618
Mean Scaled Activity Pair Estimator	inductive	172	3280	BPIC2018 reference	23	28	0.9545	0.994	0.9618
Rogge-Solti Discovery	rssmt	9576	0	BPIC2018 reference	35	42	0.9739	0.9963	0.8258
Alignment	split	968	3515	BPIC2018 reference	26	32	0.6108	1	0.0008
Activity Pair Left-Handed Estimator	split	968	3124	BPIC2018 reference	26	32	0.6108	0.6159	0.8566
Activity Pair Right-Handed Estimator	split	968	3108	BPIC2018 reference	26	32	0.673	0.5901	0.8566
Fork Distributed Estimator	split	968	3187	BPIC2018 reference	26	32	0.6108	0.5967	0.8566
Frequency Estimator	split	968	3125	BPIC2018 reference	26	32	0.6108	0.5967	0.8566
Mean Scaled Activity Pair Estimator	split	968	3218	BPIC2018 reference	26	32	0.9604	0.3892	0.8566
Alignment	fodina	47	641	Sepsis	64	82	0	FAILED	FAILED
Activity Pair Left-Handed Estimator	fodina	47	110	Sepsis	64	82	0.5002	FAILED	FAILED
Activity Pair Right-Handed Estimator	fodina	47	109	Sepsis	64	82	0.4998	FAILED	FAILED
Fork Distributed Estimator	fodina	47	110	Sepsis	64	82	FAILED	FAILED	FAILED
Frequency Estimator	fodina	47	126	Sepsis	64	82	0.4974	FAILED	FAILED
Mean Scaled Activity Pair Estimator	fodina	47	109	Sepsis	64	82	0.4921	FAILED	FAILED
Alignment	inductive	172	1421	Sepsis	47	62	0	0.2779	0.7542
Activity Pair Left-Handed Estimator	inductive	172	141	Sepsis	47	62	FAILED	FAILED	FAILED
Activity Pair Right-Handed Estimator	inductive	172	125	Sepsis	47	62	FAILED	FAILED	FAILED
Fork Distributed Estimator	inductive	172	125	Sepsis	47	62	FAILED	FAILED	FAILED
Frequency Estimator	inductive	172	172	Sepsis	47	62	FAILED	FAILED	FAILED
Mean Scaled Activity Pair Estimator	inductive	172	125	Sepsis	47	62	RUNNING	0.1325	0.7939
Rogge-Solti Discovery	rssmt	0	0	Sepsis	FAILED	FAILED	FAILED	FAILED	FAILED
Alignment	split	968	1765	Sepsis	52	66	0.3645	0.1134	0.2024
Activity Pair Left-Handed Estimator	split	968	94	Sepsis	52	66	0.5392	0.1167	0.2024
Activity Pair Right-Handed Estimator	split	968	93	Sepsis	52	66	0.5467	0.1191	0.2024
Fork Distributed Estimator	split	968	125	Sepsis	52	66	0.543	0.1177	0.2024
Frequency Estimator	split	968	94	Sepsis	52	66	0.5499	0.1177	0.2024
Mean Scaled Activity Pair Estimator	split	968	109	Sepsis	52	66	FAILED	0.0472	0.2024

Table 3: Evaluation results. Times (t) are in milliseconds.

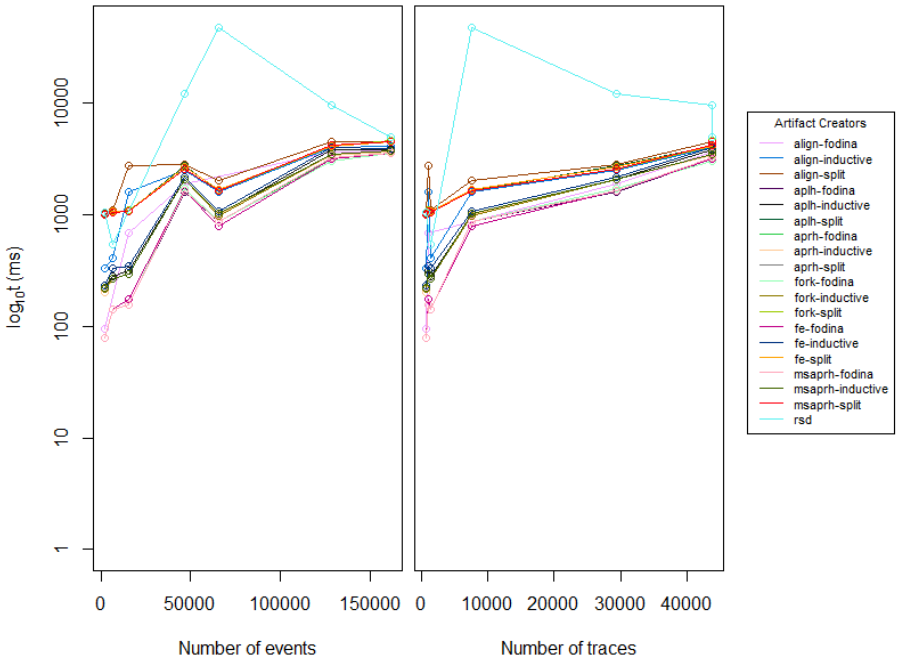

Fig. 4: Run times for control flow discovery and weight estimation by event and trace count. 12 hour time out for RSD [4] on sepsis log is excluded.

References

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