

# Detecting pneumatic failures on temporary immersion bioreactors: An approach based on contrast patterns.

Tables of the statistical tests for all the tested classifiers, according to the ZFP measure.

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## 1 Average rankings of Friedman test

Average ranks obtained by applying the Friedman procedure

Algorithm	Ranking
MLP	2.0357
RF	3.3929
PBC4cip	3.5
3NN	7.0714
AB.M1	5.8571
BTPMiner	9.4286
C4.5	9.5357
LogReg	5.7857
NBayes	9.8214
SVM	7.0714
TreeBagger	6.4286
OCKRA	8.0714

Table 1: Average Rankings of the algorithms

Friedman statistic considering reduction performance (distributed according to chi-square with 11 degrees of freedom: 76.956044.

P-value computed by Friedman Test: 5.152034354694024E-11.

## 2 Post hoc comparisons

Results achieved on post hoc comparisons for  $\alpha = 0.05$ ,  $\alpha = 0.10$  and adjusted p-values.

### 2.1 P-values for $\alpha = 0.05$

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value  $\leq 0.000758$ .

$i$	algorithms	$z = (R_0 - R_i)/SE$	$p$	Shaffer
66	MLP vs. NBayes	5.713152	0	0.000758
65	C4.5 vs. MLP	5.503495	0	0.000909
64	BTPMiner vs. MLP	5.424874	0	0.000909
63	NBayes vs. RF	4.717282	0.000002	0.000909
62	NBayes vs. PBC4cip	4.63866	0.000004	0.000909
61	C4.5 vs. RF	4.507625	0.000007	0.000909
60	BTPMiner vs. RF	4.429003	0.000009	0.000909
59	C4.5 vs. PBC4cip	4.429003	0.000009	0.000909
58	MLP vs. OCKRA	4.429003	0.000009	0.000909
57	BTPMiner vs. PBC4cip	4.350382	0.000014	0.000909
56	3NN vs. MLP	3.695204	0.00022	0.000909
55	MLP vs. SVM	3.695204	0.00022	0.000909
54	RF vs. OCKRA	3.433133	0.000597	0.001087
53	PBC4cip vs. OCKRA	3.354511	0.000795	0.001087
52	MLP vs. TreeBagger	3.223476	0.001266	0.001087
51	LogReg vs. NBayes	2.961405	0.003062	0.001087
50	AB.M1 vs. NBayes	2.90899	0.003626	0.001087
49	AB.M1 vs. MLP	2.804162	0.005045	0.001087
48	C4.5 vs. LogReg	2.751748	0.005928	0.001087
47	LogReg vs. MLP	2.751748	0.005928	0.001087
46	3NN vs. RF	2.699333	0.006948	0.001087
45	AB.M1 vs. C4.5	2.699333	0.006948	0.001111
44	RF vs. SVM	2.699333	0.006948	0.001136
43	BTPMiner vs. LogReg	2.673126	0.007515	0.001163
42	3NN vs. PBC4cip	2.620712	0.008775	0.00119
41	AB.M1 vs. BTPMiner	2.620712	0.008775	0.00122
40	SVM vs. PBC4cip	2.620712	0.008775	0.00125
39	NBayes vs. TreeBagger	2.489676	0.012786	0.001282
38	C4.5 vs. TreeBagger	2.28002	0.022607	0.001316
37	RF vs. TreeBagger	2.227605	0.025907	0.001351
36	BTPMiner vs. TreeBagger	2.201398	0.027708	0.001389
35	TreeBagger vs. PBC4cip	2.148984	0.031636	0.001429
34	NBayes vs. SVM	2.017948	0.043597	0.001471
33	3NN vs. NBayes	2.017948	0.043597	0.001515
32	AB.M1 vs. RF	1.808291	0.070561	0.001563
31	C4.5 vs. SVM	1.808291	0.070561	0.001613
30	3NN vs. C4.5	1.808291	0.070561	0.001667
29	LogReg vs. RF	1.755877	0.079109	0.001724
28	AB.M1 vs. PBC4cip	1.72967	0.083689	0.001786
27	BTPMiner vs. SVM	1.72967	0.083689	0.001852
26	3NN vs. BTPMiner	1.72967	0.083689	0.001923
25	LogReg vs. PBC4cip	1.677256	0.093492	0.002
24	LogReg vs. OCKRA	1.677256	0.093492	0.002083
23	AB.M1 vs. OCKRA	1.624841	0.104196	0.002174
22	NBayes vs. OCKRA	1.284149	0.19909	0.002273
21	TreeBagger vs. OCKRA	1.205528	0.228	0.002381
20	C4.5 vs. OCKRA	1.074492	0.282602	0.0025
19	MLP vs. PBC4cip	1.074492	0.282602	0.002632
18	BTPMiner vs. OCKRA	0.995871	0.319313	0.002778
17	MLP vs. RF	0.995871	0.319313	0.002941
16	3NN vs. LogReg	0.943456	0.345448	0.003125
15	LogReg vs. SVM	0.943456	0.345448	0.003333
14	3NN vs. AB.M1	0.891042	0.372907	0.003571
13	AB.M1 vs. SVM	0.891042	0.372907	0.003846
12	SVM vs. OCKRA	0.733799	0.463071	0.004167
11	3NN vs. OCKRA	0.733799	0.463071	0.004545
10	LogReg vs. TreeBagger	0.471728	0.637121	0.005
9	3NN vs. TreeBagger	0.471728	0.637121	0.005556
8	SVM vs. TreeBagger	0.471728	0.637121	0.00625
7	AB.M1 vs. TreeBagger	0.419314	0.674987	0.007143
6	BTPMiner vs. NBayes	0.288278	0.773134	0.008333
5	C4.5 vs. NBayes	0.209657	0.833935	0.01
4	BTPMiner vs. C4.5	0.078621	0.937334	0.0125
3	RF vs. PBC4cip	0.078621	0.937334	0.016667
2	AB.M1 vs. LogReg	0.052414	0.958199	0.025
1	3NN vs. SVM	0	1	0.05

Table 2: P-values Table for  $\alpha = 0.05$

## 2.2 P-values for $\alpha = 0.10$

$i$	algorithms	$z = (R_0 - R_i)/SE$	$p$	Shaffer
66	MLP vs. NBayes	5.713152	0	0.001515
65	C4.5 vs. MLP	5.503495	0	0.001818
64	BTPMiner vs. MLP	5.424874	0	0.001818
63	NBayes vs. RF	4.717282	0.000002	0.001818
62	NBayes vs. PBC4cip	4.63866	0.000004	0.001818
61	C4.5 vs. RF	4.507625	0.000007	0.001818
60	BTPMiner vs. RF	4.429003	0.000009	0.001818
59	C4.5 vs. PBC4cip	4.429003	0.000009	0.001818
58	MLP vs. OCKRA	4.429003	0.000009	0.001818
57	BTPMiner vs. PBC4cip	4.350382	0.000014	0.001818
56	3NN vs. MLP	3.695204	0.00022	0.001818
55	MLP vs. SVM	3.695204	0.00022	0.001818
54	RF vs. OCKRA	3.433133	0.000597	0.002174
53	PBC4cip vs. OCKRA	3.354511	0.000795	0.002174
52	MLP vs. TreeBagger	3.223476	0.001266	0.002174
51	LogReg vs. NBayes	2.961405	0.003062	0.002174
50	AB.M1 vs. NBayes	2.90899	0.003626	0.002174
49	AB.M1 vs. MLP	2.804162	0.005045	0.002174
48	C4.5 vs. LogReg	2.751748	0.005928	0.002174
47	LogReg vs. MLP	2.751748	0.005928	0.002174
46	3NN vs. RF	2.699333	0.006948	0.002174
45	AB.M1 vs. C4.5	2.699333	0.006948	0.002222
44	RF vs. SVM	2.699333	0.006948	0.002273
43	BTPMiner vs. LogReg	2.673126	0.007515	0.002326
42	3NN vs. PBC4cip	2.620712	0.008775	0.002381
41	AB.M1 vs. BTPMiner	2.620712	0.008775	0.002439
40	SVM vs. PBC4cip	2.620712	0.008775	0.0025
39	NBayes vs. TreeBagger	2.489676	0.012786	0.002564
38	C4.5 vs. TreeBagger	2.28002	0.022607	0.002632
37	RF vs. TreeBagger	2.227605	0.025907	0.002703
36	BTPMiner vs. TreeBagger	2.201398	0.027708	0.002778
35	TreeBagger vs. PBC4cip	2.148984	0.031636	0.002857
34	NBayes vs. SVM	2.017948	0.043597	0.002941
33	3NN vs. NBayes	2.017948	0.043597	0.00303
32	AB.M1 vs. RF	1.808291	0.070561	0.003125
31	C4.5 vs. SVM	1.808291	0.070561	0.003226
30	3NN vs. C4.5	1.808291	0.070561	0.003333
29	LogReg vs. RF	1.755877	0.079109	0.003448
28	AB.M1 vs. PBC4cip	1.72967	0.083689	0.003571
27	BTPMiner vs. SVM	1.72967	0.083689	0.003704
26	3NN vs. BTPMiner	1.72967	0.083689	0.003846
25	LogReg vs. PBC4cip	1.677256	0.093492	0.004
24	LogReg vs. OCKRA	1.677256	0.093492	0.004167
23	AB.M1 vs. OCKRA	1.624841	0.104196	0.004348
22	NBayes vs. OCKRA	1.284149	0.19909	0.004545
21	TreeBagger vs. OCKRA	1.205528	0.228	0.004762
20	C4.5 vs. OCKRA	1.074492	0.282602	0.005
19	MLP vs. PBC4cip	1.074492	0.282602	0.005263
18	BTPMiner vs. OCKRA	0.995871	0.319313	0.005556
17	MLP vs. RF	0.995871	0.319313	0.005882
16	3NN vs. LogReg	0.943456	0.345448	0.00625
15	LogReg vs. SVM	0.943456	0.345448	0.006667
14	3NN vs. AB.M1	0.891042	0.372907	0.007143
13	AB.M1 vs. SVM	0.891042	0.372907	0.007692
12	SVM vs. OCKRA	0.733799	0.463071	0.008333
11	3NN vs. OCKRA	0.733799	0.463071	0.009091
10	LogReg vs. TreeBagger	0.471728	0.637121	0.01
9	3NN vs. TreeBagger	0.471728	0.637121	0.011111
8	SVM vs. TreeBagger	0.471728	0.637121	0.0125
7	AB.M1 vs. TreeBagger	0.419314	0.674987	0.014286
6	BTPMiner vs. NBayes	0.288278	0.773134	0.016667
5	C4.5 vs. NBayes	0.209657	0.833935	0.02
4	BTPMiner vs. C4.5	0.078621	0.937334	0.025
3	RF vs. PBC4cip	0.078621	0.937334	0.033333
2	AB.M1 vs. LogReg	0.052414	0.958199	0.05
1	3NN vs. SVM	0	1	0.1

Table 3: P-values Table for  $\alpha = 0.10$

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value  $\leq 0.001515$ .

## 2.3 Adjusted p-values

i	hypothesis	unadjusted $p$	$p_{Shaf}$
1	MLP vs .NBayes	0	0.000001
2	C4.5 vs .MLP	0	0.000002
3	BTPMiner vs .MLP	0	0.000003
4	NBayes vs .RF	0.000002	0.000131
5	NBayes vs .PBC4cip	0.000004	0.000193
6	C4.5 vs .RF	0.000007	0.000361
7	BTPMiner vs .RF	0.000009	0.000521
8	C4.5 vs .PBC4cip	0.000009	0.000521
9	MLP vs .OCKRA	0.000009	0.000521
10	BTPMiner vs .PBC4cip	0.000014	0.000747
11	3NN vs .MLP	0.00022	0.012084
12	MLP vs .SVM	0.00022	0.012084
13	RF vs .OCKRA	0.000597	0.027446
14	PBC4cip vs .OCKRA	0.000795	0.036572
15	MLP vs .TreeBagger	0.001266	0.058257
16	LogReg vs .NBayes	0.003062	0.14087
17	AB.M1 vs .NBayes	0.003626	0.166795
18	AB.M1 vs .MLP	0.005045	0.232059
19	C4.5 vs .LogReg	0.005928	0.27268
20	LogReg vs .MLP	0.005928	0.27268
21	3NN vs .RF	0.006948	0.319601
22	AB.M1 vs .C4.5	0.006948	0.319601
23	RF vs .SVM	0.006948	0.319601
24	BTPMiner vs .LogReg	0.007515	0.319601
25	3NN vs .PBC4cip	0.008775	0.342211
26	AB.M1 vs .BTPMiner	0.008775	0.342211
27	SVM vs .PBC4cip	0.008775	0.342211
28	NBayes vs .TreeBagger	0.012786	0.498652
29	C4.5 vs .TreeBagger	0.022607	0.836442
30	RF vs .TreeBagger	0.025907	0.958553
31	BTPMiner vs .TreeBagger	0.027708	0.997483
32	TreeBagger vs .PBC4cip	0.031636	1.075613
33	NBayes vs .SVM	0.043597	1.482286
34	3NN vs .NBayes	0.043597	1.482286
35	AB.M1 vs .RF	0.070561	2.187396
36	C4.5 vs .SVM	0.070561	2.187396
37	3NN vs .C4.5	0.070561	2.187396
38	LogReg vs .RF	0.079109	2.294172
39	AB.M1 vs .PBC4cip	0.083689	2.343299
40	BTPMiner vs .SVM	0.083689	2.343299
41	3NN vs .BTPMiner	0.083689	2.343299
42	LogReg vs .PBC4cip	0.093492	2.343299
43	LogReg vs .OCKRA	0.093492	2.343299
44	AB.M1 vs .OCKRA	0.104196	2.396516
45	NBayes vs .OCKRA	0.19909	4.379977
46	TreeBagger vs .OCKRA	0.228	4.787994
47	C4.5 vs .OCKRA	0.282602	5.652045
48	MLP vs .PBC4cip	0.282602	5.652045
49	BTPMiner vs .OCKRA	0.319313	5.747634
50	MLP vs .RF	0.319313	5.747634
51	3NN vs .LogReg	0.345448	5.747634
52	LogReg vs .SVM	0.345448	5.747634
53	3NN vs .AB.M1	0.372907	5.747634
54	AB.M1 vs .SVM	0.372907	5.747634
55	SVM vs .OCKRA	0.463071	5.747634
56	3NN vs .OCKRA	0.463071	5.747634
57	LogReg vs .TreeBagger	0.637121	6.371208
58	3NN vs .TreeBagger	0.637121	6.371208
59	SVM vs .TreeBagger	0.637121	6.371208
60	AB.M1 vs .TreeBagger	0.674987	6.371208
61	BTPMiner vs .NBayes	0.773134	6.371208
62	C4.5 vs .NBayes	0.833935	6.371208
63	BTPMiner vs .C4.5	0.937334	6.371208
64	RF vs .PBC4cip	0.937334	6.371208
65	AB.M1 vs .LogReg	0.958199	6.371208
66	3NN vs .SVM	1	6.371208

Table 4: Adjusted  $p$ -values