# Analysis of various machine learning algorithms through both their learning phase and testing phase.

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## 1 Training Phase Analysis

### 1.1 Ranking

Average ranks obtained by applying the Friedman procedure to the accuracy reported by each of the algorithms during their training phase.

| Algorithm | Ranking |
|---|---|
| AdaBoost.NC-C | 4.3636 |
| C45-C | 3.1818 |
| Ripper-C | 3.4545 |
| SIA-C | 1.5909 |
| GFS-GCCL-C | 5.8182 |
| Chi-RW-C | 5.4545 |
| iRProp+-c | 4.1364 |

Table 1: Average Rankings of the algorithms

Friedman statistic considering reduction performance (distributed according to chi-square with 6 degrees of freedom: 29.094156.

P-value computed by Friedman Test: 5.8390905970928664E-5.

## 1.2 Post hoc comparisons

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

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

| $i$ | algorithms | $z = (R_0 - R_i)/SE$ | $p$ | Holm | Shaffer |
|---|---|---|---|---|---|
| 21 | SIA-C vs. GFS-GCCL-C | 4.589213 | 0.000004 | 0.002381 | 0.002381 |
| 20 | SIA-C vs. Chi-RW-C | 4.194442 | 0.000027 | 0.0025 | 0.003333 |
| 19 | AdaBoost.NC-C vs. SIA-C | 3.010129 | 0.002611 | 0.002632 | 0.003333 |
| 18 | C45-C vs. GFS-GCCL-C | 2.86209 | 0.004209 | 0.002778 | 0.003333 |
| 17 | SIA-C vs. iRProp+-c | 2.763397 | 0.00572 | 0.002941 | 0.003333 |
| 16 | Ripper-C vs. GFS-GCCL-C | 2.566012 | 0.010288 | 0.003125 | 0.003333 |
| 15 | C45-C vs. Chi-RW-C | 2.467319 | 0.013613 | 0.003333 | 0.003333 |
| 14 | Ripper-C vs. Chi-RW-C | 2.171241 | 0.029913 | 0.003571 | 0.003571 |
| 13 | Ripper-C vs. SIA-C | 2.023201 | 0.043052 | 0.003846 | 0.003846 |
| 12 | GFS-GCCL-C vs. iRProp+-c | 1.825816 | 0.067878 | 0.004167 | 0.004167 |
| 11 | C45-C vs. SIA-C | 1.727123 | 0.084146 | 0.004545 | 0.004545 |
| 10 | AdaBoost.NC-C vs. GFS-GCCL-C | 1.579084 | 0.114317 | 0.005 | 0.005 |
| 9 | Chi-RW-C vs. iRProp+-c | 1.431045 | 0.152417 | 0.005556 | 0.005556 |
| 8 | AdaBoost.NC-C vs. C45-C | 1.283006 | 0.19949 | 0.00625 | 0.00625 |
| 7 | AdaBoost.NC-C vs. Chi-RW-C | 1.184313 | 0.236289 | 0.007143 | 0.007143 |
| 6 | C45-C vs. iRProp+-c | 1.036274 | 0.300074 | 0.008333 | 0.008333 |
| 5 | AdaBoost.NC-C vs. Ripper-C | 0.986928 | 0.323678 | 0.01 | 0.01 |
| 4 | Ripper-C vs. iRProp+-c | 0.740196 | 0.459181 | 0.0125 | 0.0125 |
| 3 | GFS-GCCL-C vs. Chi-RW-C | 0.394771 | 0.693012 | 0.016667 | 0.016667 |
| 2 | C45-C vs. Ripper-C | 0.296078 | 0.76717 | 0.025 | 0.025 |
| 1 | AdaBoost.NC-C vs. iRProp+-c | 0.246732 | 0.805116 | 0.05 | 0.05 |

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

Holm's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.002778$.

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.002381$.

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

| $i$ | algorithms | $z = (R_0 - R_i)/SE$ | $p$ | Holm | Shaffer |
|---|---|---|---|---|---|
| 21 | SIA-C vs. GFS-GCCL-C | 4.589213 | 0.000004 | 0.004762 | 0.004762 |
| 20 | SIA-C vs. Chi-RW-C | 4.194442 | 0.000027 | 0.005 | 0.006667 |
| 19 | AdaBoost.NC-C vs. SIA-C | 3.010129 | 0.002611 | 0.005263 | 0.006667 |
| 18 | C45-C vs. GFS-GCCL-C | 2.86209 | 0.004209 | 0.005556 | 0.006667 |
| 17 | SIA-C vs. iRProp+-c | 2.763397 | 0.00572 | 0.005882 | 0.006667 |
| 16 | Ripper-C vs. GFS-GCCL-C | 2.566012 | 0.010288 | 0.00625 | 0.006667 |
| 15 | C45-C vs. Chi-RW-C | 2.467319 | 0.013613 | 0.006667 | 0.006667 |
| 14 | Ripper-C vs. Chi-RW-C | 2.171241 | 0.029913 | 0.007143 | 0.007143 |
| 13 | Ripper-C vs. SIA-C | 2.023201 | 0.043052 | 0.007692 | 0.007692 |
| 12 | GFS-GCCL-C vs. iRProp+-c | 1.825816 | 0.067878 | 0.008333 | 0.008333 |
| 11 | C45-C vs. SIA-C | 1.727123 | 0.084146 | 0.009091 | 0.009091 |
| 10 | AdaBoost.NC-C vs. GFS-GCCL-C | 1.579084 | 0.114317 | 0.01 | 0.01 |
| 9 | Chi-RW-C vs. iRProp+-c | 1.431045 | 0.152417 | 0.011111 | 0.011111 |
| 8 | AdaBoost.NC-C vs. C45-C | 1.283006 | 0.19949 | 0.0125 | 0.0125 |
| 7 | AdaBoost.NC-C vs. Chi-RW-C | 1.184313 | 0.236289 | 0.014286 | 0.014286 |
| 6 | C45-C vs. iRProp+-c | 1.036274 | 0.300074 | 0.016667 | 0.016667 |
| 5 | AdaBoost.NC-C vs. Ripper-C | 0.986928 | 0.323678 | 0.02 | 0.02 |
| 4 | Ripper-C vs. iRProp+-c | 0.740196 | 0.459181 | 0.025 | 0.025 |
| 3 | GFS-GCCL-C vs. Chi-RW-C | 0.394771 | 0.693012 | 0.033333 | 0.033333 |
| 2 | C45-C vs. Ripper-C | 0.296078 | 0.76717 | 0.05 | 0.05 |
| 1 | AdaBoost.NC-C vs. iRProp+-c | 0.246732 | 0.805116 | 0.1 | 0.1 |

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

Holm's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.00625$.

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.004762$.

### 1.2.3 Adjusted p-values

| i | hypothesis | unadjusted $p$ | $p_{Holm}$ | $p_{Shaf}$ |
|---|---|---|---|---|
| 1 | SIA-C vs .GFS-GCCL-C | 0.000004 | 0.000093 | 0.000093 |
| 2 | SIA-C vs .Chi-RW-C | 0.000027 | 0.000547 | 0.00041 |
| 3 | AdaBoost.NC-C vs .SIA-C | 0.002611 | 0.049616 | 0.039171 |
| 4 | C45-C vs .GFS-GCCL-C | 0.004209 | 0.075754 | 0.063129 |
| 5 | SIA-C vs .iRProp+-c | 0.00572 | 0.097245 | 0.085805 |
| 6 | Ripper-C vs .GFS-GCCL-C | 0.010288 | 0.164601 | 0.154313 |
| 7 | C45-C vs .Chi-RW-C | 0.013613 | 0.204194 | 0.204194 |
| 8 | Ripper-C vs .Chi-RW-C | 0.029913 | 0.418782 | 0.329043 |
| 9 | Ripper-C vs .SIA-C | 0.043052 | 0.559681 | 0.473576 |
| 10 | GFS-GCCL-C vs .iRProp+-c | 0.067878 | 0.814536 | 0.746658 |
| 11 | C45-C vs .SIA-C | 0.084146 | 0.925601 | 0.925601 |
| 12 | AdaBoost.NC-C vs .GFS-GCCL-C | 0.114317 | 1.143168 | 1.143168 |
| 13 | Chi-RW-C vs .iRProp+-c | 0.152417 | 1.371756 | 1.371756 |
| 14 | AdaBoost.NC-C vs .C45-C | 0.19949 | 1.59592 | 1.39643 |
| 15 | AdaBoost.NC-C vs .Chi-RW-C | 0.236289 | 1.654024 | 1.654024 |
| 16 | C45-C vs .iRProp+-c | 0.300074 | 1.800446 | 1.800446 |
| 17 | AdaBoost.NC-C vs .Ripper-C | 0.323678 | 1.800446 | 1.800446 |
| 18 | Ripper-C vs .iRProp+-c | 0.459181 | 1.836725 | 1.836725 |
| 19 | GFS-GCCL-C vs .Chi-RW-C | 0.693012 | 2.079036 | 2.079036 |
| 20 | C45-C vs .Ripper-C | 0.76717 | 2.079036 | 2.079036 |
| 21 | AdaBoost.NC-C vs .iRProp+-c | 0.805116 | 2.079036 | 2.079036 |

Table 4: Adjusted $p$-values

# 2 Testing Phase Analysis

## 2.1 Ranking

Average ranks obtained by applying the Friedman procedure to the accuracy reported by each of the algorithms during their testing phase.

| Algorithm | Ranking |
|---|---|
| AdaBoost.NC-C | 4.8182 |
| C45-C | 2.6818 |
| Ripper-C | 4.6364 |
| SIA-C | 3.5909 |
| GFS-GCCL-C | 4.3182 |
| Chi-RW-C | 5.4545 |
| iRProp+-c | 2.5 |

Table 5: Average Rankings of the algorithms

Friedman statistic considering reduction performance (distributed according to chi-square with 6 degrees of freedom: 17.551948.

P-value computed by Friedman Test: 0.007455103063423896.

## 2.2 Post hoc comparisons

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

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

| $i$ | algorithms | $z = (R_0 - R_i)/SE$ | $p$ | Holm | Shaffer |
|---|---|---|---|---|---|
| 21 | Chi-RW-C vs. iRProp+-c | 3.207515 | 0.001339 | 0.002381 | 0.002381 |
| 20 | C45-C vs. Chi-RW-C | 3.010129 | 0.002611 | 0.0025 | 0.003333 |
| 19 | AdaBoost.NC-C vs. iRProp+-c | 2.516665 | 0.011847 | 0.002632 | 0.003333 |
| 18 | AdaBoost.NC-C vs. C45-C | 2.31928 | 0.02038 | 0.002778 | 0.003333 |
| 17 | Ripper-C vs. iRProp+-c | 2.31928 | 0.02038 | 0.002941 | 0.003333 |
| 16 | C45-C vs. Ripper-C | 2.121894 | 0.033847 | 0.003125 | 0.003333 |
| 15 | SIA-C vs. Chi-RW-C | 2.023201 | 0.043052 | 0.003333 | 0.003333 |
| 14 | GFS-GCCL-C vs. iRProp+-c | 1.973855 | 0.048398 | 0.003571 | 0.003571 |
| 13 | C45-C vs. GFS-GCCL-C | 1.77647 | 0.075656 | 0.003846 | 0.003846 |
| 12 | AdaBoost.NC-C vs. SIA-C | 1.332352 | 0.182744 | 0.004167 | 0.004167 |
| 11 | GFS-GCCL-C vs. Chi-RW-C | 1.233659 | 0.21733 | 0.004545 | 0.004545 |
| 10 | SIA-C vs. iRProp+-c | 1.184313 | 0.236289 | 0.005 | 0.005 |
| 9 | Ripper-C vs. SIA-C | 1.134967 | 0.256389 | 0.005556 | 0.005556 |
| 8 | C45-C vs. SIA-C | 0.986928 | 0.323678 | 0.00625 | 0.00625 |
| 7 | Ripper-C vs. Chi-RW-C | 0.888235 | 0.374414 | 0.007143 | 0.007143 |
| 6 | SIA-C vs. GFS-GCCL-C | 0.789542 | 0.429795 | 0.008333 | 0.008333 |
| 5 | AdaBoost.NC-C vs. Chi-RW-C | 0.690849 | 0.48966 | 0.01 | 0.01 |
| 4 | AdaBoost.NC-C vs. GFS-GCCL-C | 0.54281 | 0.587261 | 0.0125 | 0.0125 |
| 3 | Ripper-C vs. GFS-GCCL-C | 0.345425 | 0.729775 | 0.016667 | 0.016667 |
| 2 | AdaBoost.NC-C vs. Ripper-C | 0.197386 | 0.843526 | 0.025 | 0.025 |
| 1 | C45-C vs. iRProp+-c | 0.197386 | 0.843526 | 0.05 | 0.05 |

Table 6: P-values Table for $\alpha = 0.05$

Holm's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.0025$.

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.002381$.

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

| $i$ | algorithms | $z = (R_0 - R_i)/SE$ | $p$ | Holm | Shaffer |
|---|---|---|---|---|---|
| 21 | Chi-RW-C vs. iRProp+-c | 3.207515 | 0.001339 | 0.004762 | 0.004762 |
| 20 | C45-C vs. Chi-RW-C | 3.010129 | 0.002611 | 0.005 | 0.006667 |
| 19 | AdaBoost.NC-C vs. iRProp+-c | 2.516665 | 0.011847 | 0.005263 | 0.006667 |
| 18 | AdaBoost.NC-C vs. C45-C | 2.31928 | 0.02038 | 0.005556 | 0.006667 |
| 17 | Ripper-C vs. iRProp+-c | 2.31928 | 0.02038 | 0.005882 | 0.006667 |
| 16 | C45-C vs. Ripper-C | 2.121894 | 0.033847 | 0.00625 | 0.006667 |
| 15 | SIA-C vs. Chi-RW-C | 2.023201 | 0.043052 | 0.006667 | 0.006667 |
| 14 | GFS-GCCL-C vs. iRProp+-c | 1.973855 | 0.048398 | 0.007143 | 0.007143 |
| 13 | C45-C vs. GFS-GCCL-C | 1.77647 | 0.075656 | 0.007692 | 0.007692 |
| 12 | AdaBoost.NC-C vs. SIA-C | 1.332352 | 0.182744 | 0.008333 | 0.008333 |
| 11 | GFS-GCCL-C vs. Chi-RW-C | 1.233659 | 0.21733 | 0.009091 | 0.009091 |
| 10 | SIA-C vs. iRProp+-c | 1.184313 | 0.236289 | 0.01 | 0.01 |
| 9 | Ripper-C vs. SIA-C | 1.134967 | 0.256389 | 0.011111 | 0.011111 |
| 8 | C45-C vs. SIA-C | 0.986928 | 0.323678 | 0.0125 | 0.0125 |
| 7 | Ripper-C vs. Chi-RW-C | 0.888235 | 0.374414 | 0.014286 | 0.014286 |
| 6 | SIA-C vs. GFS-GCCL-C | 0.789542 | 0.429795 | 0.016667 | 0.016667 |
| 5 | AdaBoost.NC-C vs. Chi-RW-C | 0.690849 | 0.48966 | 0.02 | 0.02 |
| 4 | AdaBoost.NC-C vs. GFS-GCCL-C | 0.54281 | 0.587261 | 0.025 | 0.025 |
| 3 | Ripper-C vs. GFS-GCCL-C | 0.345425 | 0.729775 | 0.033333 | 0.033333 |
| 2 | AdaBoost.NC-C vs. Ripper-C | 0.197386 | 0.843526 | 0.05 | 0.05 |
| 1 | C45-C vs. iRProp+-c | 0.197386 | 0.843526 | 0.1 | 0.1 |

Table 7: P-values Table for $\alpha = 0.10$

Holm's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.005263$.

Shaffer's procedure rejects those hypotheses that have an unadjusted p-value $\leq 0.004762$.

### 2.2.3 Adjusted p-values

| i | hypothesis | unadjusted $p$ | $p_{Holm}$ | $p_{Shaf}$ |
|---|---|---|---|---|
| 1 | Chi-RW-C vs .iRProp+-c | 0.001339 | 0.028116 | 0.028116 |
| 2 | C45-C vs .Chi-RW-C | 0.002611 | 0.052227 | 0.039171 |
| 3 | AdaBoost.NC-C vs .iRProp+-c | 0.011847 | 0.225096 | 0.177707 |
| 4 | AdaBoost.NC-C vs .C45-C | 0.02038 | 0.366838 | 0.305698 |
| 5 | Ripper-C vs .iRProp+-c | 0.02038 | 0.366838 | 0.305698 |
| 6 | C45-C vs .Ripper-C | 0.033847 | 0.541546 | 0.507699 |
| 7 | SIA-C vs .Chi-RW-C | 0.043052 | 0.645786 | 0.645786 |
| 8 | GFS-GCCL-C vs .iRProp+-c | 0.048398 | 0.677575 | 0.645786 |
| 9 | C45-C vs .GFS-GCCL-C | 0.075656 | 0.983522 | 0.832211 |
| 10 | AdaBoost.NC-C vs .SIA-C | 0.182744 | 2.192934 | 2.010189 |
| 11 | GFS-GCCL-C vs .Chi-RW-C | 0.21733 | 2.390628 | 2.390628 |
| 12 | SIA-C vs .iRProp+-c | 0.236289 | 2.390628 | 2.390628 |
| 13 | Ripper-C vs .SIA-C | 0.256389 | 2.390628 | 2.390628 |
| 14 | C45-C vs .SIA-C | 0.323678 | 2.589425 | 2.390628 |
| 15 | Ripper-C vs .Chi-RW-C | 0.374414 | 2.620901 | 2.620901 |
| 16 | SIA-C vs .GFS-GCCL-C | 0.429795 | 2.620901 | 2.620901 |
| 17 | AdaBoost.NC-C vs .Chi-RW-C | 0.48966 | 2.620901 | 2.620901 |
| 18 | AdaBoost.NC-C vs .GFS-GCCL-C | 0.587261 | 2.620901 | 2.620901 |
| 19 | Ripper-C vs .GFS-GCCL-C | 0.729775 | 2.620901 | 2.620901 |
| 20 | AdaBoost.NC-C vs .Ripper-C | 0.843526 | 2.620901 | 2.620901 |
| 21 | C45-C vs .iRProp+-c | 0.843526 | 2.620901 | 2.620901 |

Table 8: Adjusted $p$-values