Supplemental Material for 'Optimizing Model Performance and Fairness Through Evolved Sample Weights'

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Contents

Chapter 1

Introduction

This is not intended as a stand-alone document, but as a companion to our manuscript.

1.1 Contributing authors

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- Emily F. Wong
- Jason H. Moore

1.2 About our supplemental material

As you may have noticed (unless you're reading a pdf version of this), our supplemental material is hosted using GitHub pages. We compiled our data analyses and supplemental documentation into this nifty web-accessible book using bookdown.

The code used for this supplemental material can be found in this GitHub repository.

Our supplemental material includes the following:

- Heart disease results (Section 2)
- Student math results (Section 3)
- Student por results (Section 4)
- CreditG results (Section 5)
- Titanic results (Section 6)

- US Crime results (Section 7)
- Compas Violent results (Section 8)
- NLSY results (Section 9)
- Compas results (Section 10)
- Speed dating results (Section 11)
- PMAD EPDS results (Section 12)
- PMAD PHQ results (Section 13)

1.3 Supplemental material setup

1.3.1 Required packages and variables

Variable set up.

```
library(ggplot2)
library(cowplot)
library(dplyr)
library(PupillometryR)

NAMES <- c('Evolved','Calculated','None')
TASKS <- c('heart_disease', 'student_math', 'student_por', 'creditg', 'titanic', 'us_cr
SHAPE <- c(21,24,22)
cb_palette <- c('#D81B60','#1E88E5','#FFC107')
TSIZE <- 19

p_theme <- theme(
  plot.title = element_text( face = "bold", size = 22, hjust=0.5),
  panel.border = element_blank(),
  panel.grid.minor = element_blank(),
  legend.title=element_text(size=18),
  legend.text=element_text(size=18),
  axis.title = element_text(size=18),
  axis.text = element_text(size=14),
  legend.position="bottom",
  panel.background = element_rect(fill = "#f1f2f5",
                                  colour = "white",
                                  linewidth = 0.5, linetype = "solid")
)

testing <- read.csv(paste('./', 'hv_test.csv', sep = "", collapse = NULL), header = TRU
testing$exp <- gsub('Evolved Weights', 'Evolved', testing$ex)
testing$exp <- gsub('Calculated Weights', 'Calculated', testing$ex)
testing$exp <- gsub('No Weights', 'None', testing$ex)
testing$exp <- factor(testing$exp, levels = NAMES)
```

1.3.2 Helper functions

Function to plot hypervolume results

```
  # function to plot hyper-volume data
  volume_plotter <- function(data, id)
  {
    ggplot(data, aes(x = exp, y = hv, color = exp, fill = exp, shape = exp)) +
    geom_flat_violin(position = position_nudge(x = .1, y = 0), scale = 'width', alpha = 0.2, widt
    geom_boxplot(color = 'black', width = .07, outlier.shape = NA, alpha = 0.0, size = 1.0, posit
    geom_point(position = position_jitter(width = 0.02, height = 0.0001), size = 1.5, alpha = 1.0
    scale_y_continuous(
      name="Volume",
    ) +
    scale_x_discrete(
      name="Strategy"
    )+
    scale_shape_manual(values=SHAPE, name="Weight\nStrategy") +
    scale_colour_manual(values = cb_palette, name="Weight\nStrategy") +
    scale_fill_manual(values = cb_palette, name="Weight\nStrategy") +
    ggtitle(TASKS[id])+
    p_theme + coord_flip()
  }
```

Function to summarize hypervolume results

```
# function to plot hyper-volume data
volume_summarize <- function(data)
  {
    data %>%
    group_by(exp) %>%
    dplyr::summarise(
      count = n(),
      na_cnt = sum(is.na(hv)),
      min = min(hv, na.rm = TRUE),
      median = median(hv, na.rm = TRUE),
      mean = mean(hv, na.rm = TRUE),
      max = max(hv, na.rm = TRUE),
      IQR = IQR(hv, na.rm = TRUE)
    )
  }
```

Chapter 2

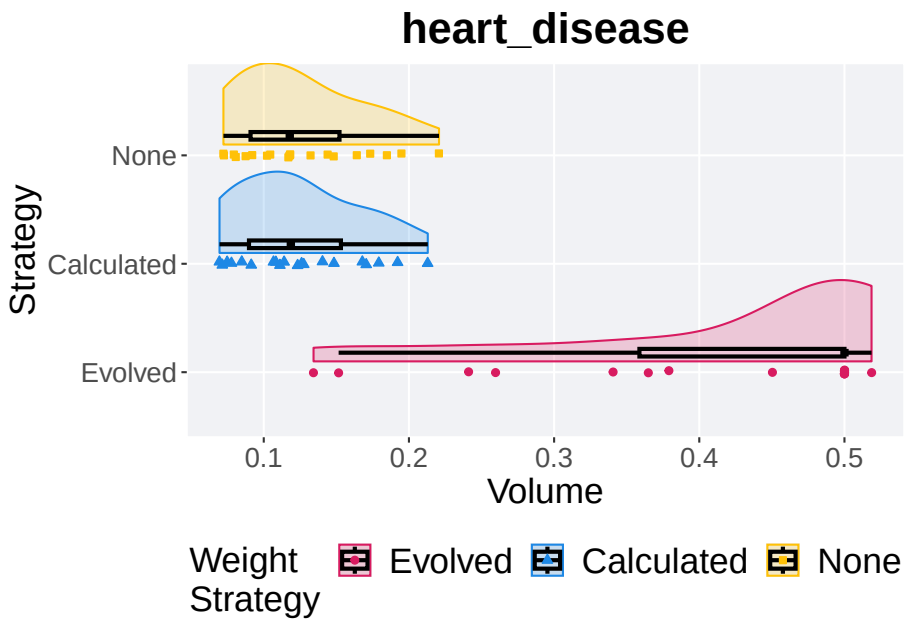
Heart Disease

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `heart_disease` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "heart_disease")
```

2.1 Hypervolume

```
volume_plotter(data,1)
```



2.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt    min median  mean   max    IQR
##   <fct>      <int>  <int>  <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.134   0.5   0.417 0.519 0.141
## 2 Calculated    20      0 0.0695  0.119 0.125 0.213 0.0633
## 3 None          20      0 0.0722  0.118 0.126 0.221 0.0613
```

2.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 34.987, df = 2, p-value = 2.528e-08
```

2.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 4.5e-07 -
## None       4.5e-07 1
##
## P value adjustment method: bonferroni
```

Chapter 3

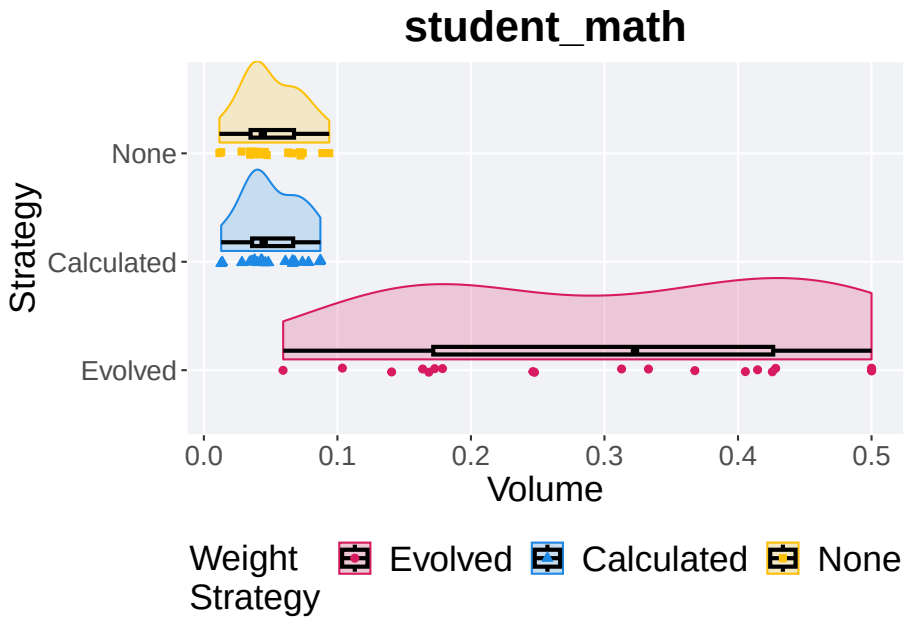
Student Math

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `student_math` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "student_math")
```

3.1 Hypervolume

```
volume_plotter(data,2)
```



3.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt    min median   mean    max    IQR
##   <fct>      <int>  <int>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 Evolved       20      0 0.0594 0.323  0.308  0.5    0.255
## 2 Calculated    20      0 0.0129 0.0448 0.0504 0.0873 0.0307
## 3 None          20      0 0.0116 0.0441 0.0503 0.0939 0.0326
```

3.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 36.282, df = 2, p-value = 1.323e-08
```

3.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 3.3e-07 -
## None       3.3e-07 1
##
## P value adjustment method: bonferroni
```

Chapter 4

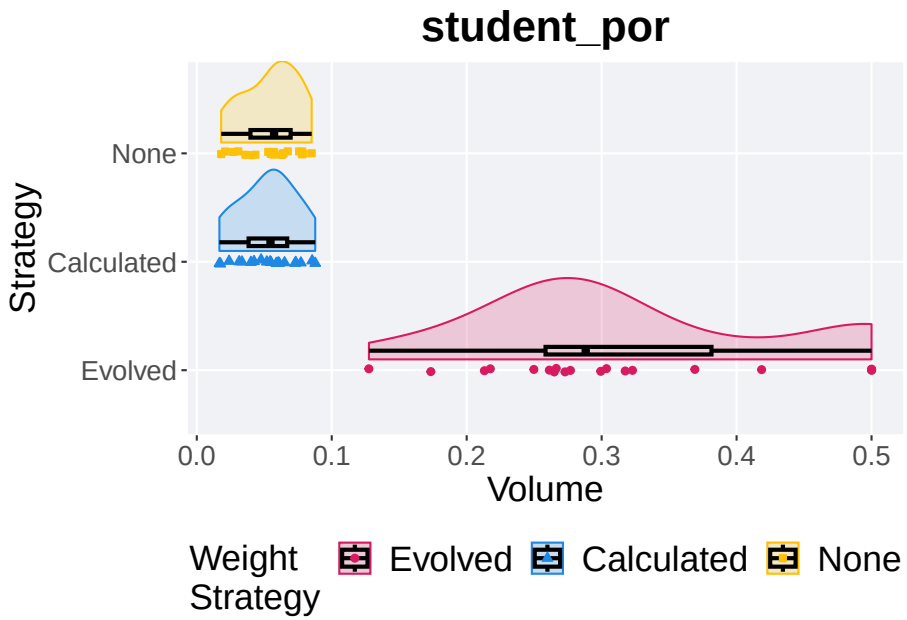
Student Por

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `student_por` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "student_por")
```

4.1 Hypervolume

```
volume_plotter(data,3)
```



4.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt    min median   mean    max    IQR
##   <fct>      <int>  <int>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 Evolved       20      0 0.128  0.288  0.318  0.5    0.123
## 2 Calculated    20      0 0.0168 0.0546 0.0528 0.0878 0.0286
## 3 None          20      0 0.0181 0.0573 0.0547 0.0851 0.0298
```

4.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 39.429, df = 2, p-value = 2.742e-09
```

4.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 1e-07   -
## None       1e-07   1
##
## P value adjustment method: bonferroni
```

Chapter 5

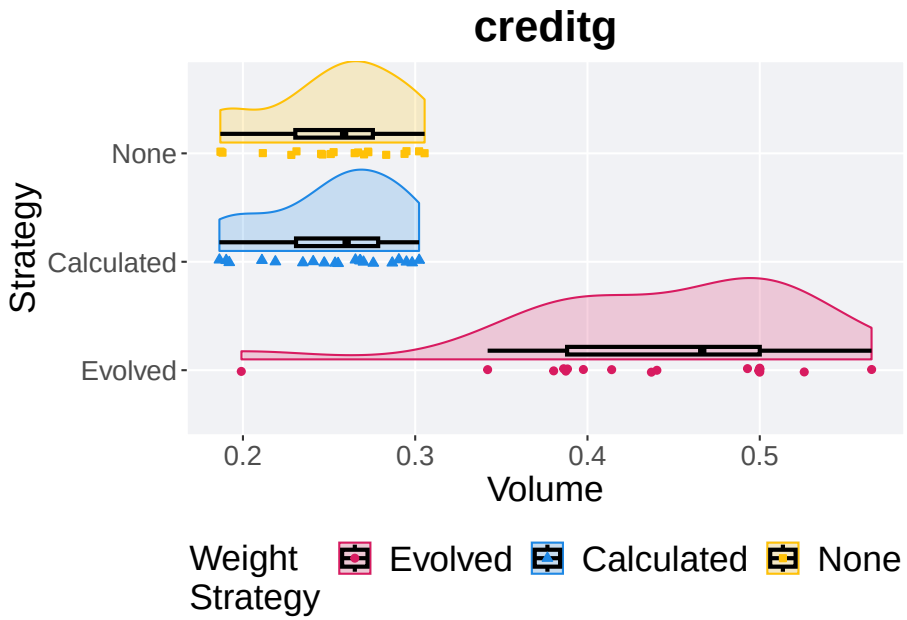
CreditG

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `creditg` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "creditg")
```

5.1 Hypervolume

```
volume_plotter(data,4)
```



5.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt   min median  mean   max    IQR
##   <fct>      <int>  <int> <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.199  0.467 0.443 0.565 0.112
## 2 Calculated    20      0 0.186  0.260 0.252 0.302 0.0477
## 3 None          20      0 0.187  0.259 0.253 0.305 0.0450
```

5.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 32.972, df = 2, p-value = 6.922e-08
```

5.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 1.1e-06 -
## None       1.1e-06 1
##
## P value adjustment method: bonferroni
```

Chapter 6

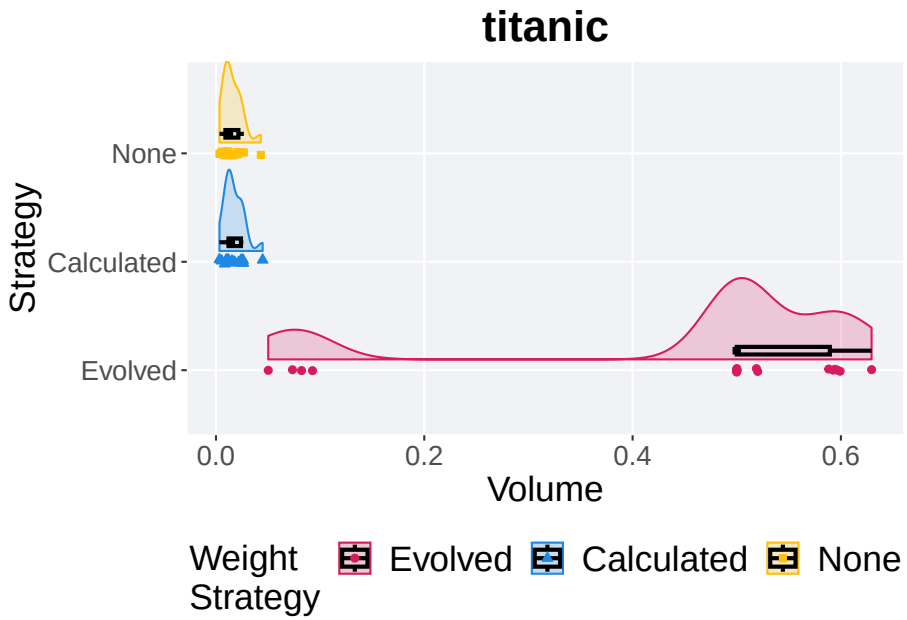
Titanic

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `titanic` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "titanic")
```

6.1 Hypervolume

```
volume_plotter(data,5)
```



6.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt     min median   mean    max    IQR
##   <fct>      <int>  <int>   <dbl>  <dbl>  <dbl>  <dbl>  <dbl>
## 1 Evolved       20      0 0.0502  0.5    0.447  0.629  0.0894
## 2 Calculated    20      0 0.00334 0.0143 0.0171 0.0448 0.0119
## 3 None          20      0 0.00340 0.0126 0.0157 0.0430 0.0125
```

6.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 39.658, df = 2, p-value = 2.445e-09
```

6.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 9e-08   -
## None       9e-08   0.74
##
## P value adjustment method: bonferroni
```

Chapter 7

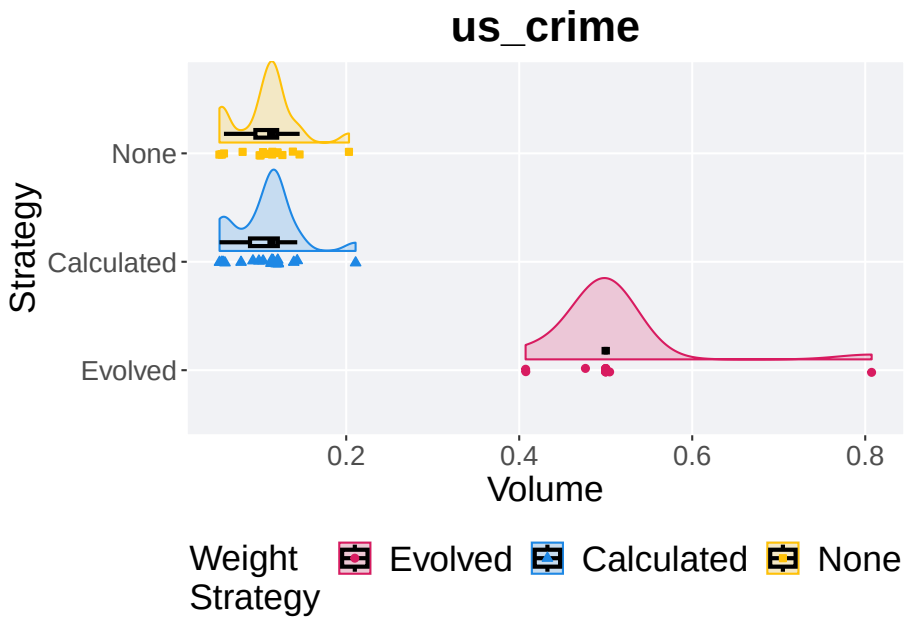
US Crime

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `us_crime` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "us_crime")
```

7.1 Hypervolume

```
volume_plotter(data,6)
```



7.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt    min median  mean   max    IQR
##   <fct>      <int>  <int>  <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.407   0.5   0.505 0.807 0
## 2 Calculated    20      0 0.0536  0.114 0.108 0.211 0.0322
## 3 None          20      0 0.0534  0.113 0.107 0.203 0.0252
```

7.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 39.978, df = 2, p-value = 2.084e-09
```

7.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 4.4e-08 -
## None       4.4e-08 1
##
## P value adjustment method: bonferroni
```

Chapter 8

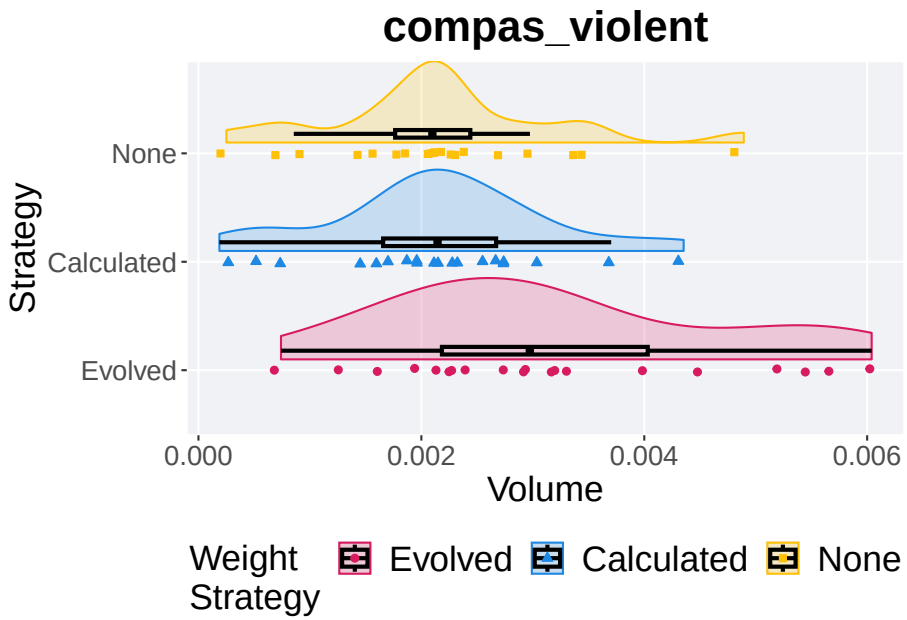
Compas Violent

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `compas_violent` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "compas_violent")
```

8.1 Hypervolume

```
volume_plotter(data,7)
```



8.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt      min  median    mean     max      IQR
##   <fct>      <int>  <int>    <dbl>   <dbl>   <dbl>   <dbl>    <dbl>
## 1 Evolved       20      0 0.000741 0.00297 0.00319 0.00604 0.00185
## 2 Calculated    20      0 0.000188 0.00215 0.00215 0.00435 0.00101
## 3 None          20      0 0.000251 0.00210 0.00217 0.00489 0.000675
```

8.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 6.7764, df = 2, p-value = 0.03377
```

8.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 0.034   -
## None       0.039   1.000
##
## P value adjustment method: bonferroni
```

Chapter 9

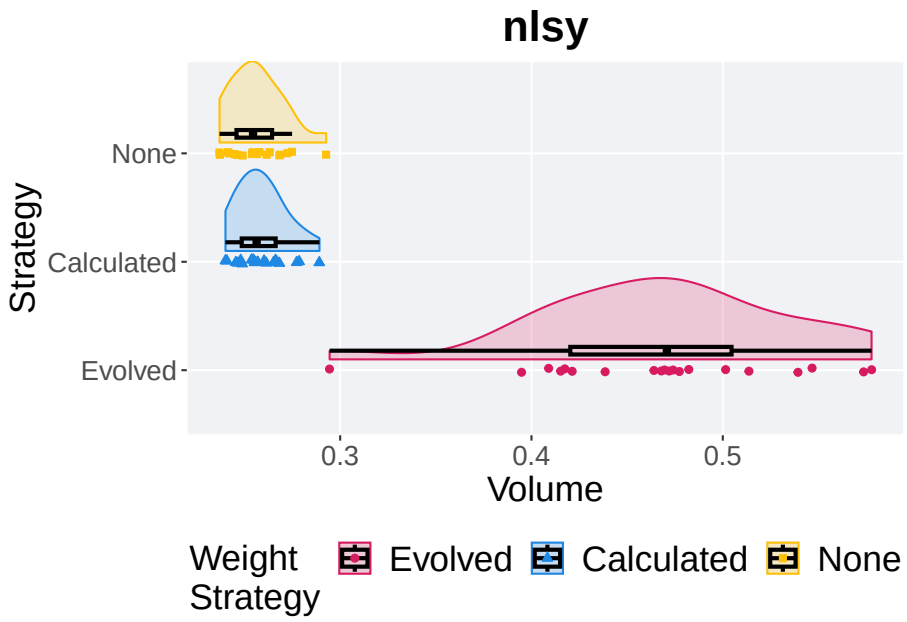
NLSY

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `nlsy` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "nlsy")
```

9.1 Hypervolume

```
volume_plotter(data,8)
```



9.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt   min median  mean   max    IQR
##   <fct>      <int>  <int> <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.294  0.471 0.468 0.578 0.0843
## 2 Calculated    20      0 0.240  0.256 0.259 0.289 0.0177
## 3 None          20      0 0.237  0.254 0.256 0.293 0.0186
```

9.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 39.518, df = 2, p-value = 2.623e-09
```

9.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 2.2e-11 -
## None       2.2e-11 0.82
##
## P value adjustment method: bonferroni
```

Chapter 10

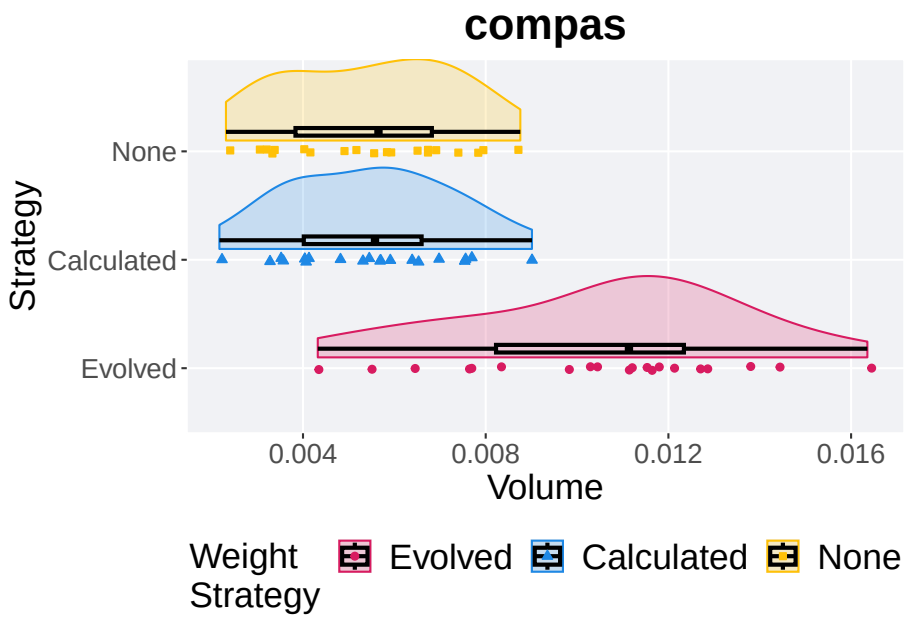
Compas

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `compas` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "compas")
```

10.1 Hypervolume

```
volume_plotter(data,9)
```



10.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt     min  median    mean     max     IQR
##   <fct>      <int>  <int>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl>
## 1 Evolved       20      0 0.00432 0.0111  0.0105  0.0164  0.00411
## 2 Calculated    20      0 0.00217 0.00558 0.00546 0.00901 0.00258
## 3 None          20      0 0.00231 0.00565 0.00548 0.00876 0.00299
```

10.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 26.298, df = 2, p-value = 1.947e-06
```

10.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 1.4e-06 -
## None       3.6e-06 1
##
## P value adjustment method: bonferroni
```

Chapter 11

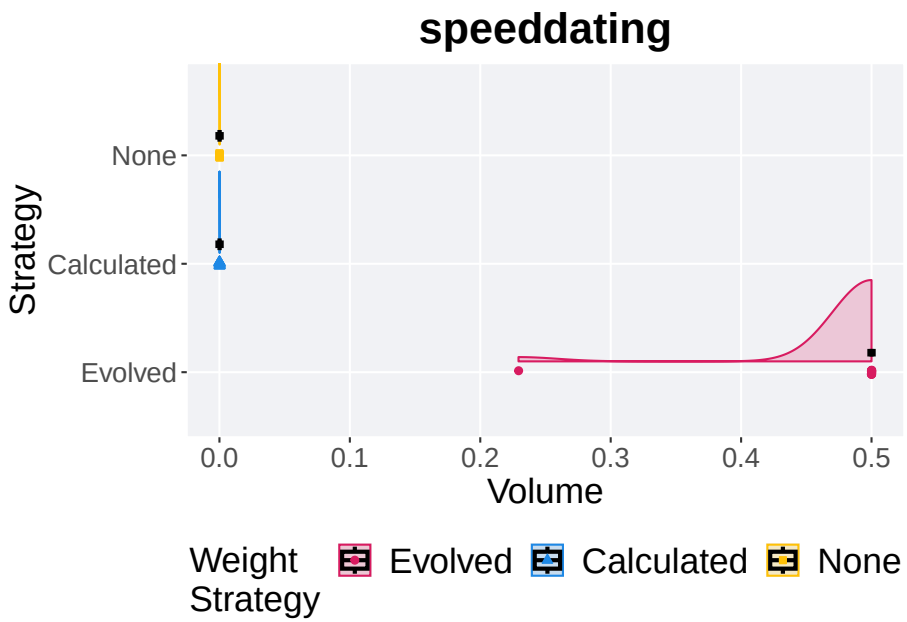
Speeddating

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `speeddating` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "speeddating")
```

11.1 Hypervolume

```
volume_plotter(data,10)
```



11.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt       min   median     mean      max      IQR
##   <fct>      <int>  <int>     <dbl>    <dbl>    <dbl>    <dbl>    <dbl>
## 1 Evolved       20      0 0.229     0.5      0.486    0.5      0
## 2 Calculated    20      0 0.0000388 0.000102 0.000114 0.000239 0.000121
## 3 None          20      0 0.0000297 0.000109 0.000124 0.000255 0.000122
```

11.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 40.672, df = 2, p-value = 1.473e-09
```

11.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 1.7e-08 -
## None       1.7e-08 1
##
## P value adjustment method: bonferroni
```

Chapter 12

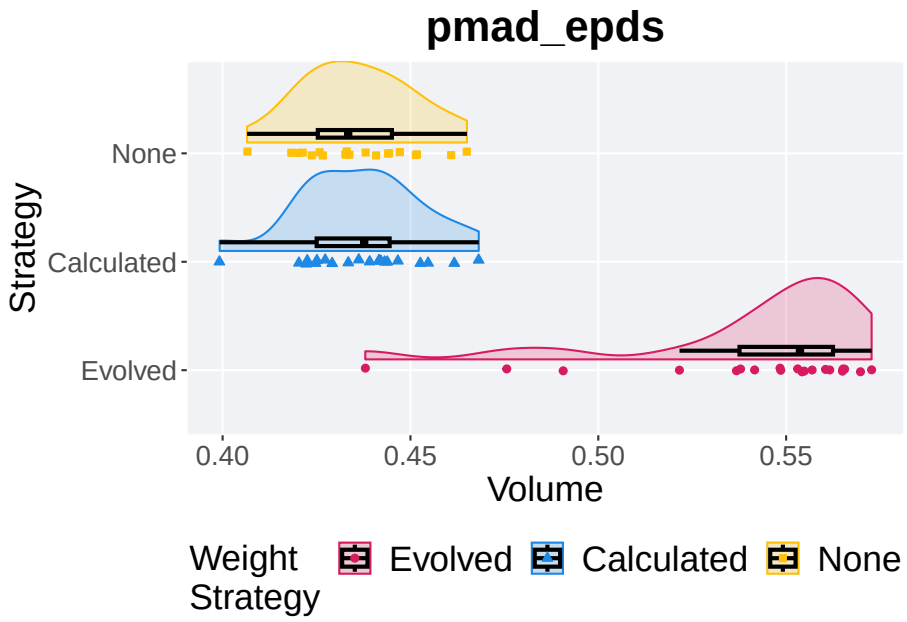
PMAD EPDS

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `pmad_epds` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "pmad_epds")
```

12.1 Hypervolume

```
volume_plotter(data,11)
```



12.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt   min median  mean   max    IQR
##   <fct>      <int>  <int> <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.438  0.554 0.541 0.573 0.0249
## 2 Calculated    20      0 0.399  0.438 0.437 0.468 0.0194
## 3 None          20      0 0.407  0.433 0.436 0.465 0.0197
```

12.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 35.731, df = 2, p-value = 1.742e-08
```

12.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 3.0e-09 -
## None       2.1e-09 1
##
## P value adjustment method: bonferroni
```

Chapter 13

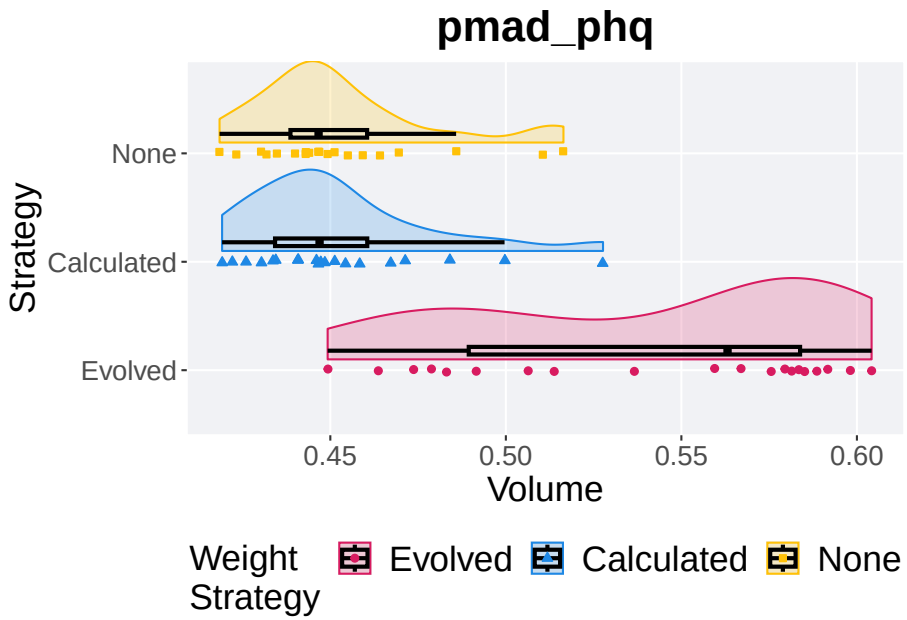
PMAD PHQ

Here we report the **hypervolume** achived by evaluating the performance of each solution wihtin the Pareto front on the test set of the `pmad_phq` dataset.

```
# heart-disease data
data <- filter(testing, dataset == "pmad_phq")
```

13.1 Hypervolume

```
volume_plotter(data,13)
```



13.1.1 Summary stats

```
volume_summarize(data)
```

```
## # A tibble: 3 x 8
##   exp        count na_cnt   min median  mean   max    IQR
##   <fct>      <int>  <int> <dbl>  <dbl> <dbl> <dbl>  <dbl>
## 1 Evolved       20      0 0.449  0.563 0.541 0.604 0.0944
## 2 Calculated    20      0 0.419  0.447 0.452 0.528 0.0263
## 3 None          20      0 0.418  0.447 0.453 0.516 0.0218
```

13.1.2 Kruskal-Wallis test

Detected differences between weight strategies.

```
kruskal.test(hv ~ exp, data = data)
```

```
##
##  Kruskal-Wallis rank sum test
##
## data:  hv by exp
## Kruskal-Wallis chi-squared = 29.615, df = 2, p-value = 3.708e-07
```

13.1.3 Pairwise wlcoxon test

```
pairwise.wilcox.test(x = data$hv, g = data$exp, p.adjust.method = "bonferroni",
                     paired = FALSE, conf.int = FALSE, alternative = 'l')
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  data$hv and data$exp
##
##            Evolved Calculated
## Calculated 2.5e-07 -
## None       3.2e-07 1
##
## P value adjustment method: bonferroni
```