StatisticsForRoboticSystemsA2

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Libraries

```
library(readxl)
#library(magrittr)
#library(tidyverse)
#library(rstatix)
#library(ggpubr )
library(PMCMRplus)
```

```
## Warning: package 'PMCMRplus' was built under R version 4.1.2
```

Import data

Firs we import our data. Three outcomes variables were measured: time, distance, and kinematic estimation error (kte). Four conditions were tested: Adaptive Waypoint with Non-linear control (AN), Adaptive Waypoint with Proportional control (AP), Fixed Waypoint with Non-linear control (FN), Fixed Waypoint with Proportional control (FP).

```
data <- read_excel("data.xlsx")
data$id <- as.factor(data$id)
data$condition <- as.factor(data$condition)
summary(data)
```

```
##        id     condition      time          distance         kte
##  1      : 4   AN:10     Min.   :21.00   Min.   :1823   Min.   :20.89
##  2      : 4   AP:10     1st Qu.:23.00   1st Qu.:2263   1st Qu.:25.28
##  3      : 4   FN:10     Median :24.00   Median :2286   Median :34.23
##  4      : 4   FP:10     Mean   :24.80   Mean   :2284   Mean   :36.45
##  5      : 4             3rd Qu.:25.25   3rd Qu.:2342   3rd Qu.:47.37
##  6      : 4             Max.   :31.00   Max.   :2421   Max.   :58.04
##  (Other):16
```

Normality tests

We carry normality tests. Shapiro Wilk's test was used due to the small sample size. The null hypothesis for this test is that the sample distribution is normal.

```
norm_time <- shapiro.test(data$time)
distance <- shapiro.test(data$distance)
kte <- shapiro.test(data$kte)

print(norm_time)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  data$time
## W = 0.81886, p-value = 1.717e-05
```

```
print(distance)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  data$distance
## W = 0.75462, p-value = 8.703e-07
```

```
print(kte)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  data$kte
## W = 0.87698, p-value = 0.0004367
```

Friedman tests

Last tests rejected null hypothesis, hence Friedman is applied instead of ANOVA. This tests was chosen to assess differences between multiple conditions, with matched samples (i.e., same robot), and continuous/interval outcome variable. The null hyphotesis is that all conditions are equal.

```
friedman_time <- friedman.test(data$time, data$condition, data$id )
friedman_distance <- friedman.test(data$distance, data$condition, data$id )
friedman_kte <- friedman.test(data$kte, data$condition, data$id )

print(friedman_time)
```

```
##
##  Friedman rank sum test
##
## data:  data$time, data$condition and data$id
## Friedman chi-squared = 22.291, df = 3, p-value = 5.675e-05
```

```
print(friedman_distance)
```

```
##
##  Friedman rank sum test
##
## data:  data$distance, data$condition and data$id
## Friedman chi-squared = 15, df = 3, p-value = 0.001817
```

```
print(friedman_kte)
```

```
##
##  Friedman rank sum test
##
## data:  data$kte, data$condition and data$id
## Friedman chi-squared = 25.56, df = 3, p-value = 1.179e-05
```

Posthoc tests

Last tests rejected null hypothesis. Posthoc test are required for pairwise comparisons between conditions. The Bonferroni correction was chosen, as it is the standard for this test in literature.

```
posthoc_time = frdAllPairsConoverTest(y=data$time, groups=data$condition, blocks=data$id, p.adjust="bonferroni")
posthoc_distance = frdAllPairsConoverTest(y=data$distance, groups=data$condition, blocks=data$id, p.adjust="bonferroni")
posthoc_kte = frdAllPairsConoverTest(y=data$kte, groups=data$condition, blocks=data$id, p.adjust="bonferroni")

print(posthoc_time)
```

```
##
##  Pairwise comparisons using Conover's all-pairs test for a two-way balanced comple
te block design
```

```
## data: y, groups and blocks
```

```
##    AN     AP     FN
## AP 0.0297 -      -
## FN 1.0000 0.0903 -
## FP 0.0035 1.0000 0.0117
```

```
##
## P value adjustment method: bonferroni
```

```
print(posthoc_distance)
```

```
##
##  Pairwise comparisons using Conover's all-pairs test for a two-way balanced comple
te block design
##
## data: y, groups and blocks
```

```
##    AN     AP     FN
## AP 0.4176 -      -
## FN 0.0774 1.0000 -
## FP 0.0059 0.4947 1.0000
```

```
##
## P value adjustment method: bonferroni
```

```
print(posthoc_kte)
```

```
##
##  Pairwise comparisons using Conover's all-pairs test for a two-way balanced comple
te block design
##
## data: y, groups and blocks
```

```
##    AN     AP     FN
## AP 1.0000 -      -
## FN 0.0977 0.0078 -
## FP 0.0187 0.0013 1.0000
```

```
##
## P value adjustment method: bonferroni
```

Import Odometry

Odometry

```
odom <- read_excel("odom.xlsx")
odom$error <- abs(odom$error)
odom$run <- as.factor(odom$run)
odom$path <- as.factor(odom$path)
summary(odom)
```

```
##       run          path        error
##  1      :  4   huge  :40   Min.   : 0.000
##  2      :  4   medium:40   1st Qu.: 1.344
##  3      :  4   small :40   Median : 4.750
##  4      :  4   square:40   Mean   : 5.675
##  5      :  4               3rd Qu.: 7.153
##  6      :  4               Max.   :18.919
##  (Other):136
```

Normality tests

We carry normality tests. Shapiro Wilk's test was used due to the small sample size. The null hypothesis for this test is that the sample distribution is normal.

```
norm_odom <- shapiro.test(odom$error)

print(norm_odom)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  odom$error
## W = 0.87099, p-value = 1.612e-10
```

Wilcoxon tests

Last tests rejected null hypothesis, hence Wilcoxon is applied instead of T test.

```
wilcox_error <- wilcox.test(odom$error, mu=5, alternative = "greater")

print(wilcox_error)
```

```
##
##  Wilcoxon signed rank test with continuity correction
##
## data:  odom$error
## V = 5676, p-value = 0.4903
## alternative hypothesis: true location is greater than 5
```