

StatisticsForRoboticSystemsA2

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12/11/2022

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 complete 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 complete 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 complete 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
```