Data Analysis of the Paper Design and Evaluation of a Handheld-based 3D User Interface for Collaborative Object Manipulation

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Contents

1 Data analyisis

This is the analysis of the data collected in the user experiment performed for the ACM CHI Conference on Human Factors in Computing Systems

2 Design and Procedure

We aim to investigate the relationship between group sizes and the time and accuracy to complete the tasks. Furthermore, we intend to understand the influence of work distribution balance and work division in the performance of each group combination. Thus, the experiment follows a between subject design with Group size as the only independent variable, with one, two, three or four participants. Dependent variables collected were time to complete the task and accuracy of thegroup, and transformation actions (translation, rotation, scale or camera rotation), including duration and magnitude of the action performed by each individual subject. The accuracy is measured as described before in Section Collaborative 3D Manipulation Assessment.

2.1 Task

We used the obstacle crossing game with three wall configurations. The training sessions consist of the first two walls. The test session is formed by one trial for each practice wall and two trials for the tunnel.

The results reported here only use the two trials in the tunnel task for the statistical analysis.

2.2 Subjects

Sixty subjects participated voluntarily in this experiment (nine female), aged 24 years in average (SD=3.6). They were all Computer Science students with no movement restrictions on wrists and arms. Thirteen of the

individuals had never used gestural interactions with Kinect, Wiimote or mobile devices. We arranged the participants in 5 groups of one, 7 groups of two, 7 groups of three and 5 groups of four individuals.

2.3 Hypotesis

- H1. Groups with more than one member complete the tasks faster
- H2. Groups with more than one member complete the tasks with more accuracy
- H3. For the tested group size range, if groups increase in members, the time to complete tasks drops proportionally
- H4. For the tested group size range, if groups increase in members, the accuracy to complete tasks increase proportionally

3 Statistical Analysis Results

3.1 Data Summary

```
#sourceDataGroups <- read.csv("errorTimeAndVarPerTeam.csv",header = TRUE,  sep=";", dec = ",")
#sourceDataGroups <- read.csv("errorTimeAndVarPerTeamOnlyTask3and4.csv",header = TRUE,  sep="\t")
sourceDataGroups <- read.csv("errorMedianAndTimePerTeamOnlyTask3and4.csv", header = FALSE,  sep=";")
sourceDataGroups
```

```
##          V1        V2       V3        V4       V5       V6       V7
## 1   44.5060  86.01300 127.2309 162.96200 7.861463 2.260774 2.711916
## 2   56.6990  90.59442  82.5638  87.06737 9.248310 2.767702 3.181414
## 3  129.5357  87.26190 120.6714  74.45340 5.619129 4.420655 4.090105
## 4   88.6565 113.11968  91.1117  71.80547 3.876767 3.795666 3.396920
## 5  281.5956  69.36490  76.8215  56.40480 6.004525 5.324064 4.424443
## 6  225.2061  58.41970  55.2902  63.90760 5.216207 3.984116 4.767183
## 7  105.6555 139.37750  86.8132 127.17520 2.660728 5.078261 3.269525
## 8  139.6341 111.04040  61.2443  60.76750 2.895181 2.542164 4.584655
## 9         NA 109.53340 283.4138 212.14000 7.370132 5.102038 1.681474
## 10        NA  83.16500 192.7240 113.40100 6.931314 6.086377 2.685176
## 11        NA  99.48090  41.2966        NA       NA 4.205052 4.419264
## 12        NA  93.11320  38.1163        NA       NA 4.758173 4.131297
##          V8
## 1  2.509332
## 2  1.978163
## 3  2.854236
## 4  1.911809
## 5  2.344555
## 6  2.784301
## 7  1.736374
## 8  1.853528
## 9  2.504749
## 10 1.641644
## 11       NA
## 12       NA
```

```
#sourceDataTasks <- read.csv("errorAndTimePerTask.csv",header = TRUE,  sep="\t")
sourceDataTasks <- read.csv("errorMedianAndTimePerTaskOnlyTask3and4.csv",header = TRUE,  sep="\t")
sourceDataTasks
```

```
##    Members.Task Time.task.3 Time.task.4 Error.task.3 Error.task.4
## 1             1     44.5060    56.69900     7.861463     9.248310
## 2             1    129.5357    88.65650     5.619129     3.876767
## 3             1    130.7602    63.44300     6.004525     5.216207
## 4             1    281.5956   225.20610     2.660728     2.895181
## 5             1    105.6555   139.63410     7.370132     6.931314
## 6             2     86.0130    90.59442     2.260774     2.767702
## 7             2     87.2619   113.11968     4.420655     3.795666
## 8             2     69.3649    58.41970     5.324064     3.984116
## 9             2    139.3775   111.04040     5.078261     2.542164
## 10            2    109.5334    83.16500     5.102038     6.086377
## 11            2     99.4809    93.11320     4.205052     4.758173
## 12            3    127.2309    82.56380     2.711916     3.181414
## 13            3    120.6714    91.11170     4.090105     3.396920
## 14            3     76.8215    55.29020     4.424443     4.767183
## 15            3     86.8132    61.24430     3.269525     4.584655
## 16            3    283.4138   192.72400     1.681474     2.685176
## 17            3     41.2966    38.11630     4.419264     4.131297
## 18            4    162.9620    87.06737     2.509332     1.978163
## 19            4     74.4534    71.80547     2.854236     1.911809
## 20            4     56.4048    63.90760     2.344555     2.784301
## 21            4    127.1752    60.76750     1.736374     1.853528
## 22            4    212.1400   113.40100     2.504749     1.641644
```

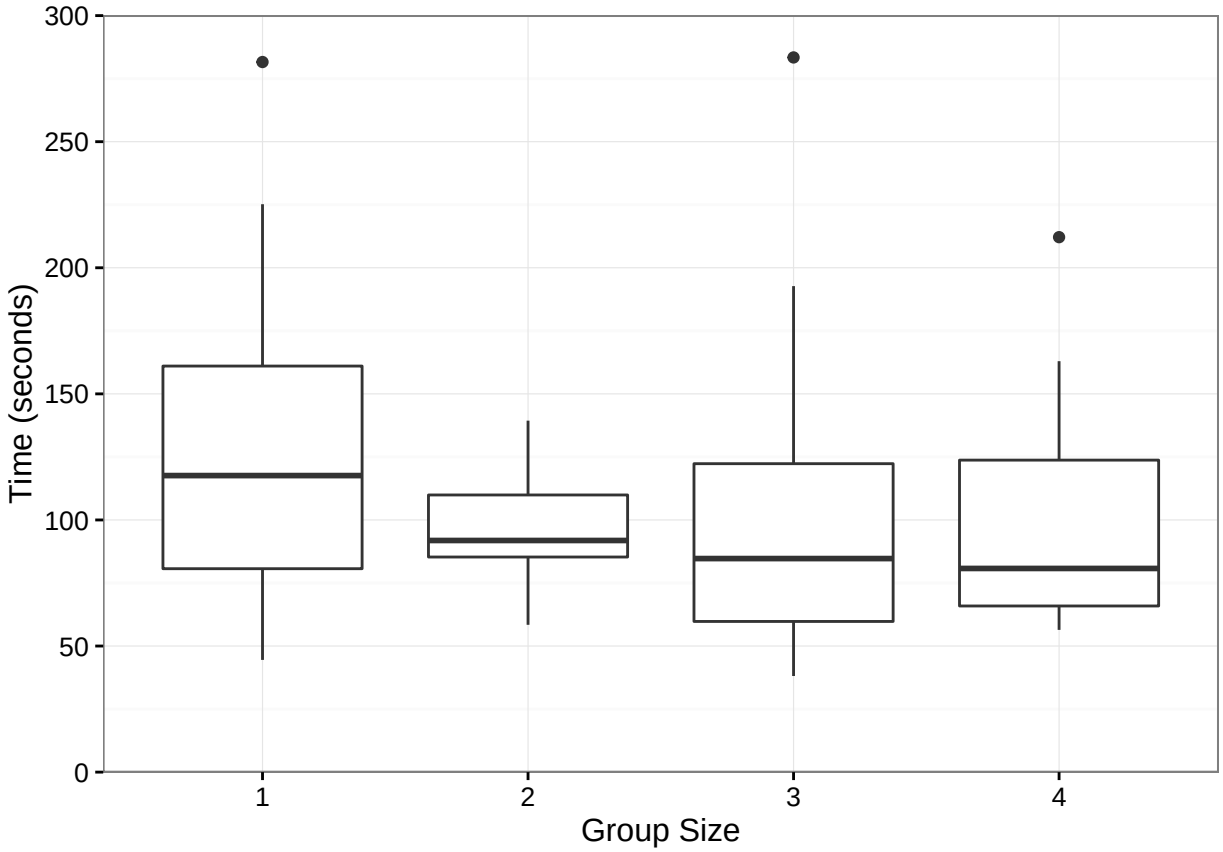
Below the data is summarized:

```
#describe(sourceDataGroups)
```

And ploted:

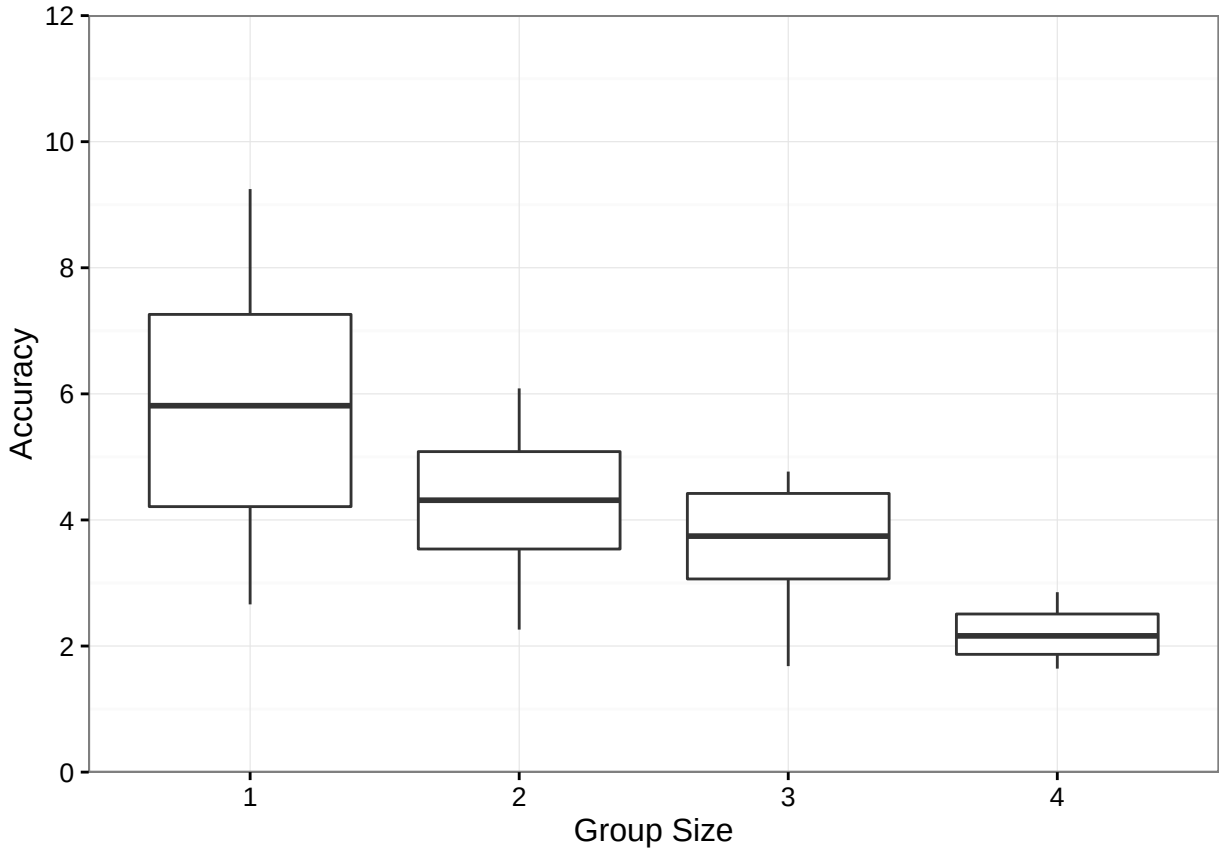
```
time <- gather(sourceDataGroups, "group", "time", 1:4)

ggplot(time, aes(x=group, y=time)) + geom_boxplot()+labs(x="Group Size", y = "Time (seconds)")+theme_bw
```

```
## Warning: Removed 6 rows containing non-finite values (stat_boxplot).
```




```
#boxplot(sourceDataGroups[5:8],xlab="Team members",ylab="Error",main="Error X Groups")
error <- gather(sourceDataGroups, "group", "error", 5:8)
ggplot(error, aes(x=group, y=error)) + geom_boxplot()+labs(x="Group Size", y = "Accuracy")+theme_bw()+ s
```

```
## Warning: Removed 4 rows containing non-finite values (stat_boxplot).
```


12
10
8
6
4
2
0
Accuracy
1
2
3
4
Group Size