Evaluating the detectionspace - statistical report

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## Introduction

This is the statistical report associated with the paper “Evaluating the detection space” by Milo Marsfeldt Skovfoged & Alexander Schiller Rasmussen. The field of study lies in researching visually impaired/blind navigation through environments, to find an ideal Range of looking ahead and Field of Detection (FOD), for the most progressive travel-route, while avoiding collisions as much as possible. This report gives an overview of what data was gathered and analysed, in regrads to different points of interrest.

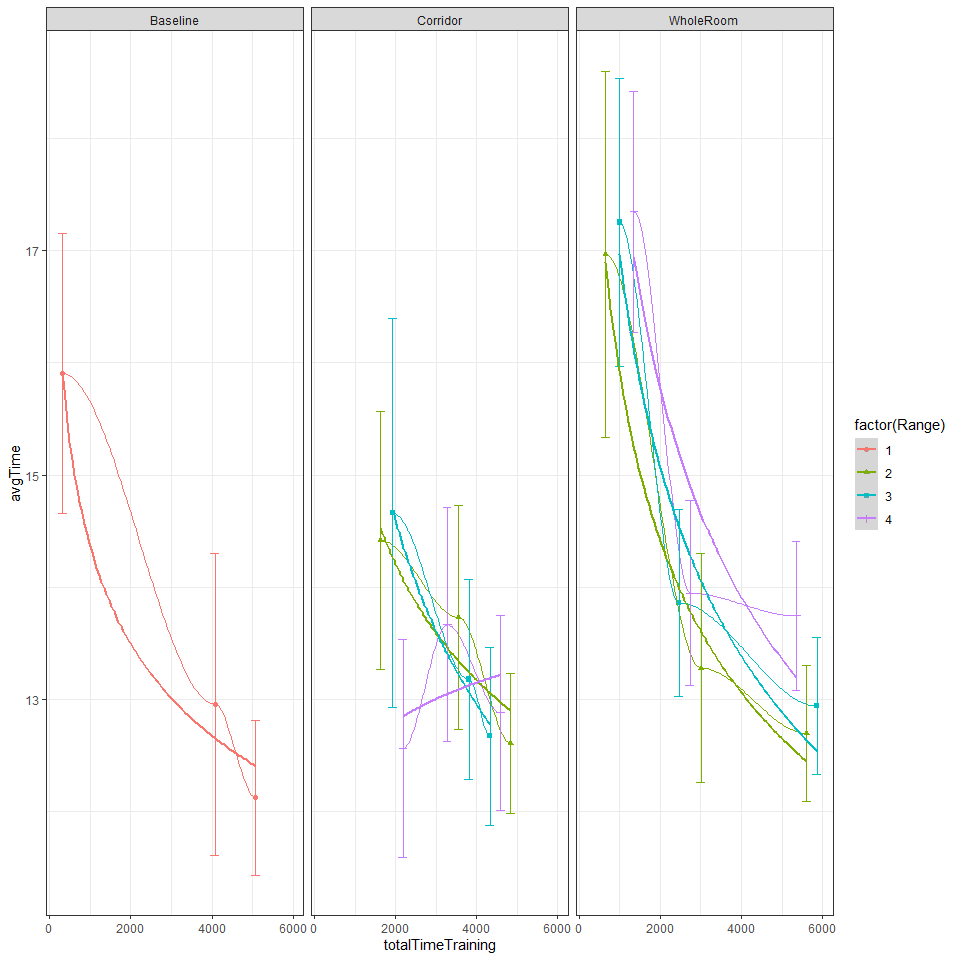
## Data information

Below, a summary of our data is presented. In total, 420 tests were completed over three days (140 per day), using three different Field Of Detections (FOD - Baseline, WholeRoom and Corridor), with exception of WholeRoom and Corridor differing between three ranges (two, three and four meters), as Baseline represents the original wite cane. Scenarios describe the amount of different parkours the system was tested on (each condition with different lengths). In addition, each test logged the speed of the participant, the amount of objects detected by the cane, the amount of collisions by the user and the completion time of the individual parkours.

## testID day Scenario FOD Range   
## Min. : 1.0 Min. :1 Min. : 1.00 Baseline : 60 Min. :1.000   
## 1st Qu.:105.8 1st Qu.:1 1st Qu.: 5.75 Corridor :180 1st Qu.:2.000   
## Median :210.5 Median :2 Median :10.50 WholeRoom:180 Median :3.000   
## Mean :210.5 Mean :2 Mean :10.50 Mean :2.714   
## 3rd Qu.:315.2 3rd Qu.:3 3rd Qu.:15.25 3rd Qu.:4.000   
## Max. :420.0 Max. :3 Max. :20.00 Max. :4.000   
## avgSpeed medianSpeed maxSpeed minSpeed objectDetected   
## Min. :0.3595 Min. :0.2511 Min. :1.243 Min. :0 Min. : 0.000   
## 1st Qu.:0.5723 1st Qu.:0.5986 1st Qu.:1.835 1st Qu.:0 1st Qu.: 6.000   
## Median :0.6434 Median :0.6898 Median :2.069 Median :0 Median : 8.000   
## Mean :0.6337 Mean :0.6842 Mean :2.078 Mean :0 Mean : 9.152   
## 3rd Qu.:0.7012 3rd Qu.:0.7587 3rd Qu.:2.318 3rd Qu.:0 3rd Qu.:12.000   
## Max. :0.9803 Max. :1.2506 Max. :2.988 Max. :0 Max. :28.000   
## objectCollisions Time totalTimeTraining timeFDRtrain   
## Min. :0.000 Min. : 8.016 Min. : 18 Min. : 10.00   
## 1st Qu.:0.000 1st Qu.:12.136 1st Qu.:1737 1st Qu.: 77.75   
## Median :1.000 Median :13.625 Median :3154 Median :145.50   
## Mean :1.124 Mean :13.971 Mean :3090 Mean :147.41   
## 3rd Qu.:2.000 3rd Qu.:15.160 3rd Qu.:4522 3rd Qu.:213.25   
## Max. :6.000 Max. :25.143 Max. :5868 Max. :347.00   
## timeFDtrain timeDtrain   
## Min. : 11.0 Min. : 11.0   
## 1st Qu.: 171.5 1st Qu.: 507.5   
## Median : 360.0 Median : 997.5   
## Mean : 391.1 Mean :1004.4   
## 3rd Qu.: 604.0 3rd Qu.:1492.2   
## Max. :1031.0 Max. :2182.0

## Predicition of course completion time

The plot below shows the average time of completion of scenarios, over the course of the total time the user was training, using the system. Inspecting the x-axis, one can tell that the totalTimeTraining seems to differ between the FOD’s. The cause is the order in which the different FOD’s were tested over the three days, which ended up placing the Corridor in the middel of the dataset, leaving the Baseline and WholeRoom with more total training time on the final day.



Bacause our predicitons were that FOD Corridor would perform better than FOD WholeRoom over time, we calculated coefficients for predicting the avgTime over totalTimeTraining, by sorting the aggregated data by FOD and Range - hence the following paramters for estimations were made: **Note: FOD Corridor with a range of 4 meters gives the impression of getting worse over time, which is due to some immediate well achived run on the first day. In addition, the data contains some outliers which will need further investigation.**

###### Baseline data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 21.45979 1.86920 11.481 < 2e-16 \*\*\*  
## z -0.06329 0.01232 -5.139 3.39e-06 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.437 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 11   
## Achieved convergence tolerance: 8.356e-07

###### Corridor 2 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 31.32990 9.69222 3.232 0.00203 \*\*  
## z -0.10500 0.03899 -2.693 0.00923 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.026 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 31   
## Achieved convergence tolerance: 4.683e-08

###### Corridor 3 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 54.72364 27.45127 1.993 0.05092 .   
## z -0.17482 0.06289 -2.780 0.00733 \*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.557 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 41   
## Achieved convergence tolerance: 1.213e-07

###### Corridor 4 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 9.81972 5.16585 1.901 0.0623 .  
## z 0.03528 0.06541 0.539 0.5917   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.089 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 32   
## Achieved convergence tolerance: 5.818e-07

###### WholeRoom 2 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 37.2835 5.6165 6.638 1.18e-08 \*\*\*  
## z -0.1273 0.0204 -6.240 5.46e-08 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.441 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 19   
## Achieved convergence tolerance: 1.844e-07

###### WholeRoom 3 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 47.50384 8.32368 5.707 4.12e-07 \*\*\*  
## z -0.15325 0.02318 -6.611 1.32e-08 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.087 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 16   
## Achieved convergence tolerance: 2.502e-06

###### WholeRoom 4 meters data

##   
## Formula: Time ~ b \* totalTimeTraining^z  
##   
## Parameters:  
## Estimate Std. Error t value Pr(>|t|)   
## b 54.86090 11.77431 4.659 1.90e-05 \*\*\*  
## z -0.16613 0.02775 -5.986 1.44e-07 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 1.968 on 58 degrees of freedom  
##   
## Number of iterations to convergence: 27   
## Achieved convergence tolerance: 7.364e-06

Feeding these estimation standars into the same formula used to gather the coefficients: and pairing them with an interval of , we were able ot create curves predicting each FOD with their respective Range’s improvement over time. Plotting these new predictions onto the data, we see that FOD WholeRoom “recieves” a penalty as the Range increases, indicating, looking further ahead means slower completion time. Another aspect is that FOD Corridor seems to be at best with a Range of three meters, and also outperform FOD WholeRoom over training time

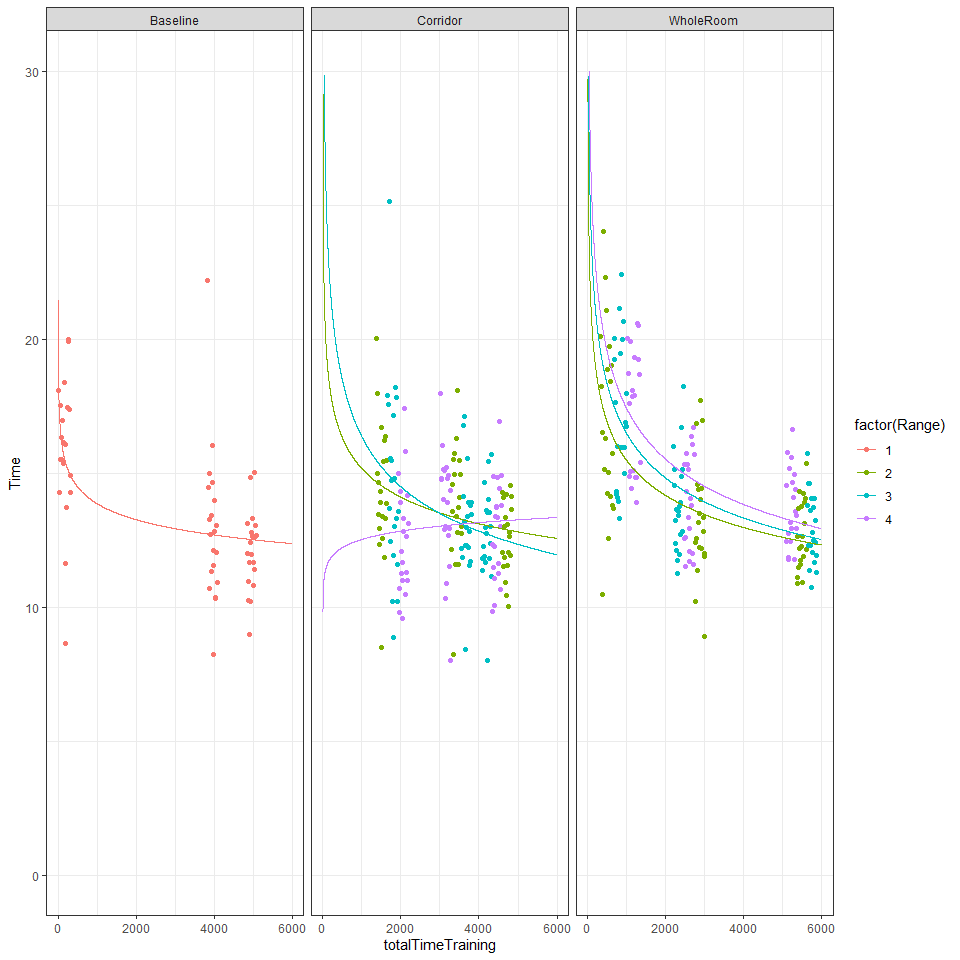
## Warning: Removed 1 row(s) containing missing values (geom\_path).

## Warning: Removed 31 row(s) containing missing values (geom\_path).

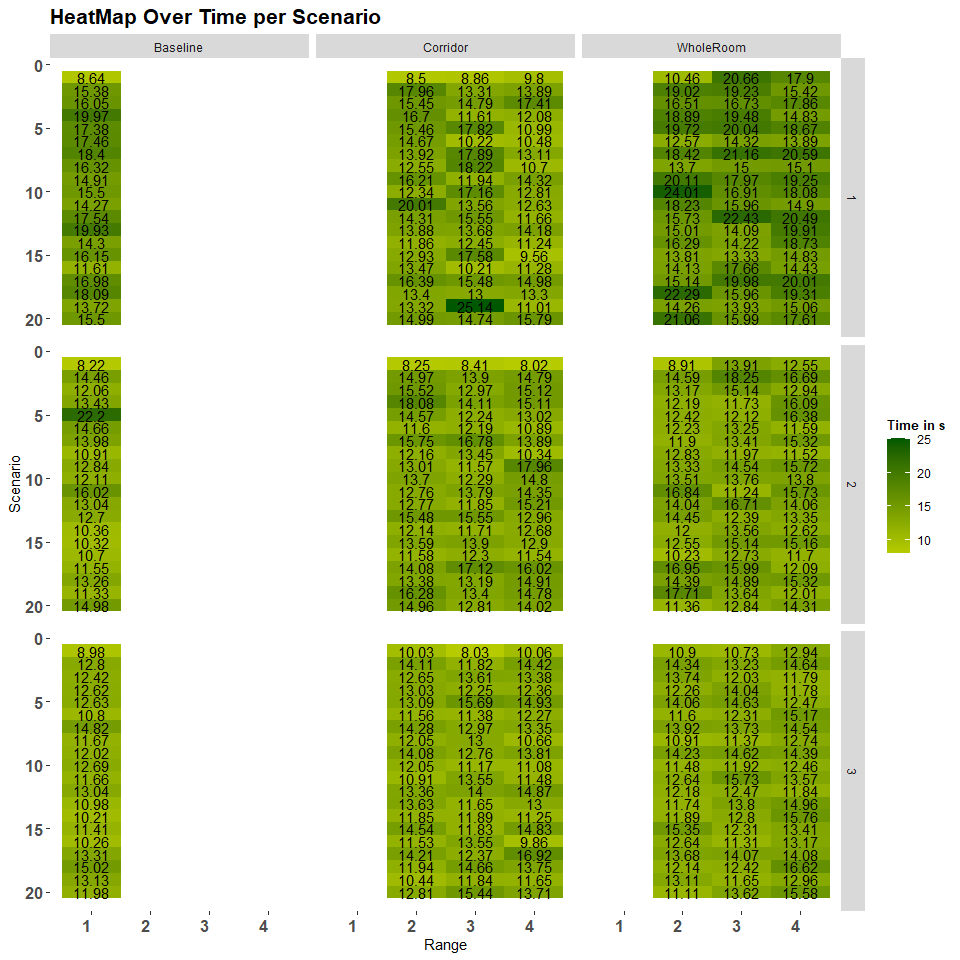
## Warning: Removed 5 row(s) containing missing values (geom\_path).

## Warning: Removed 20 row(s) containing missing values (geom\_path).

## Warning: Removed 37 row(s) containing missing values (geom\_path).

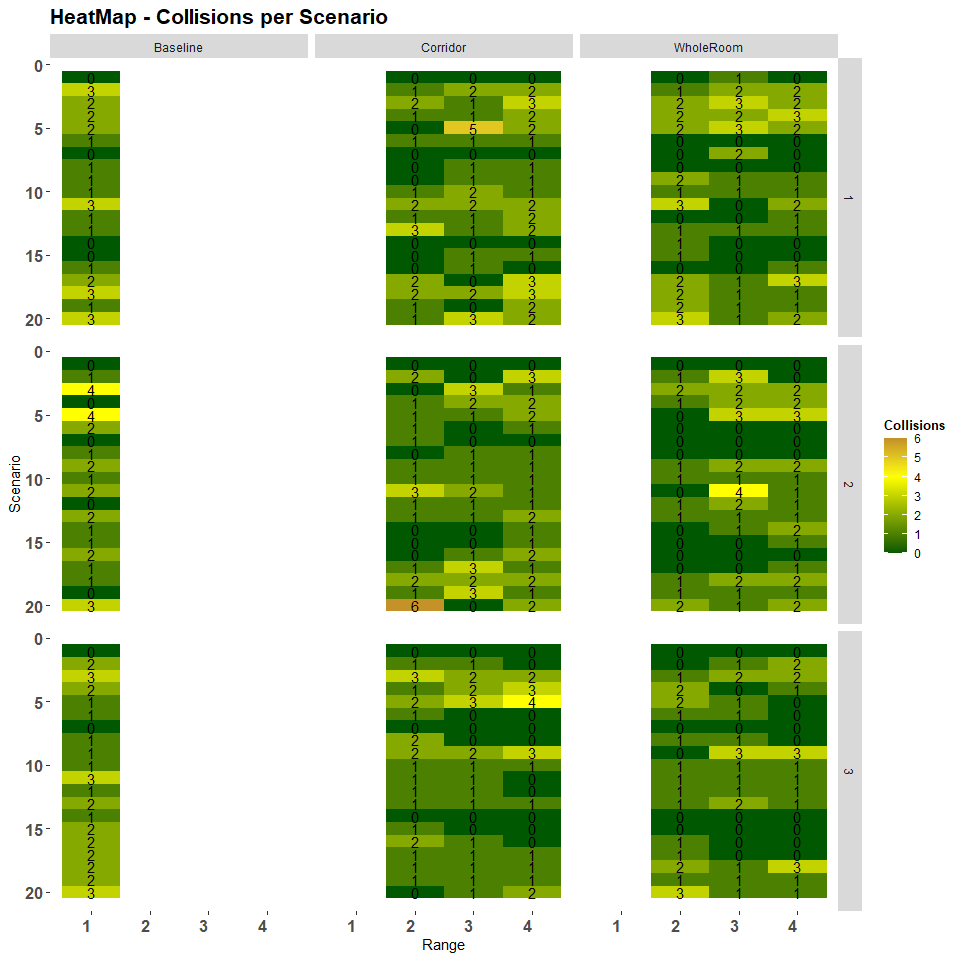


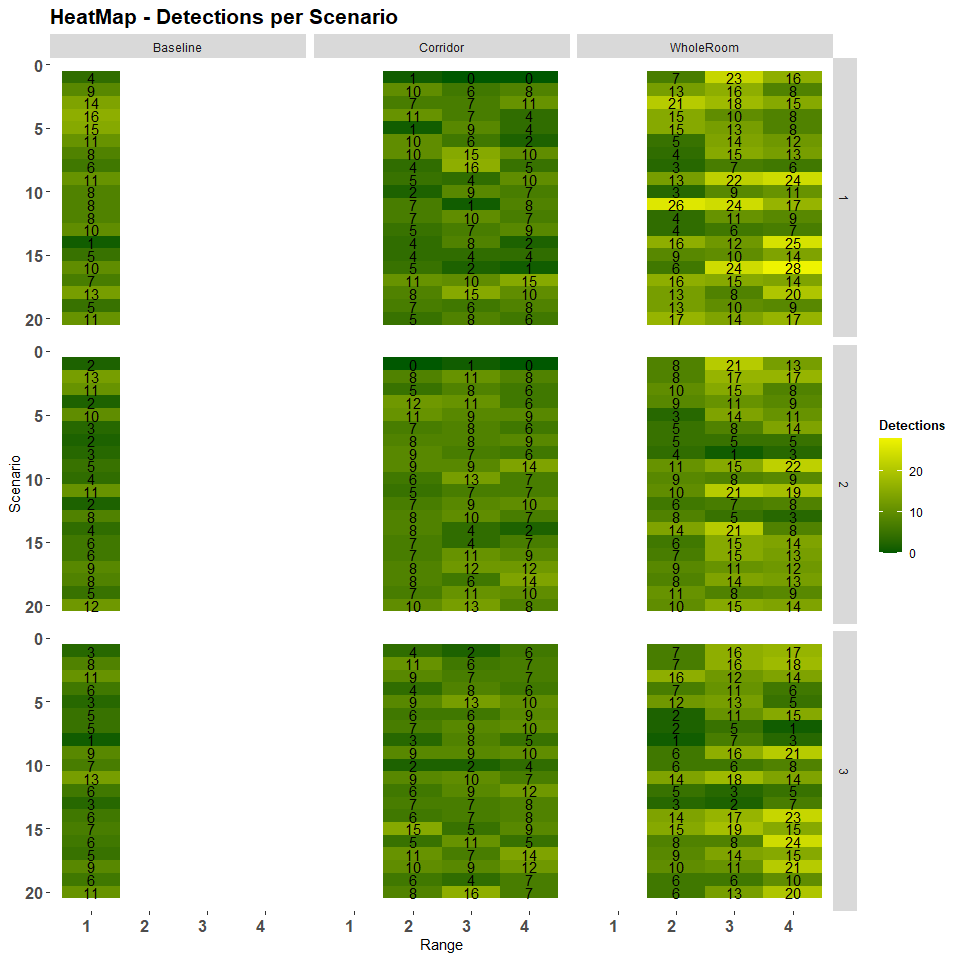
To further inspect the time used for completing each scenario, the following heatmap shows average completion time per scenario for the different FOD’s with different ranges. Here the outliers stand out, in terms of scenario 19 in FOD Corridor day one and scenario five in DOF Baseline day two. Noteworthy is also day one of FOD WholeRoom, which is slower, compared to the other FOD’s.



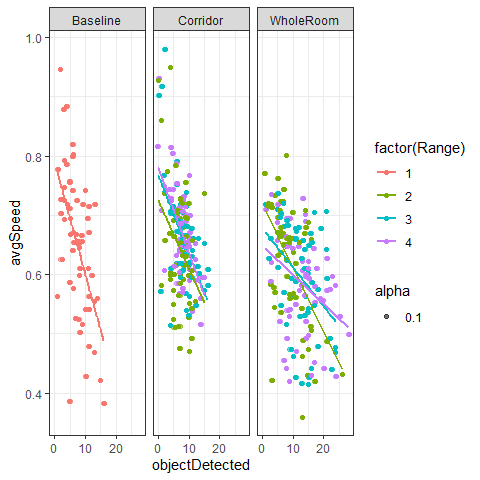
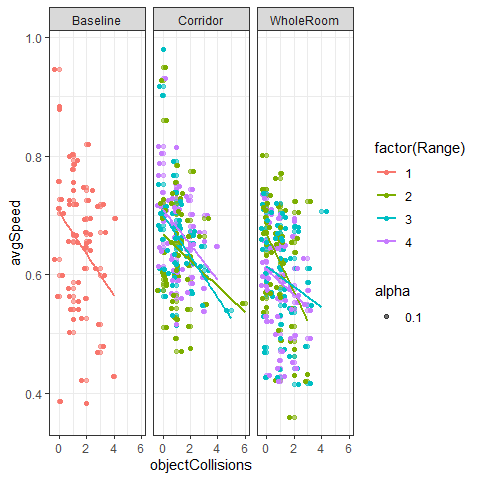
## Collisions and Detections

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| FOD w. Range | Total avg. Det. | Total avg. Coll. | avg. Det. Day 1 | avg. Det. Day 2 | avg. Det. Day 3 | avg. Coll. Day 1 | avg. Coll. Day 2 | avg. Coll. Day 3 |
| Baseline | 7.26 | 1.47 | 9 |  |  | 1.4 |  |  |
| Corridor R2 | 7.01 | 1.05 |  |  |  |  |  |  |
| Corridor R3 | 7.95 | 1.1 |  |  |  |  |  |  |
| Corridor R4 | 7.52 | 1.25 |  |  |  |  |  |  |
| WholeRoom R2 | 9 | 0.93 |  |  |  |  |  |  |
| WholeRoom R3 | 12.53 | 1.03 |  |  |  |  |  |  |
| WholeRoom R4 | 12.78 | 1.03 |  |  |  |  |  |  |

The heatmap below shows the amount of object collisions for each scenario, between differnt FOD’s and Ranges. Noteworthy that using DOF WholeRoom, the participant managed to achieve collisions on scenario one, day one, which is supposed to be a clear walkingpath with objects spread out to the sides, making it difficult to collide with an object. A potential outlier also seems to be located in DOF Corridor day two scenario 20, however, further investigation would need to be conducted. 

Another heatmap shows the amount of object detections for each scenario, between differnt FOD’s and Ranges. Again, scenario one is very noteworthy for the few detections using FOD Baseline and Corridor, where the walking path is clear, compared to FOD Wholeroom, which conducts alot of information. 

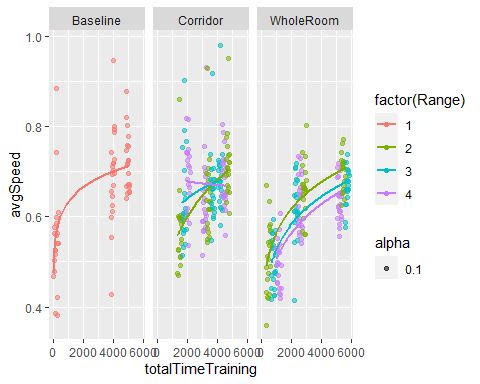
Collisions and detections also have an impact on the speed the participant moves through scenarios with. Below two graphs show that the impact of collisions as well as detections both grow while speed decreases.

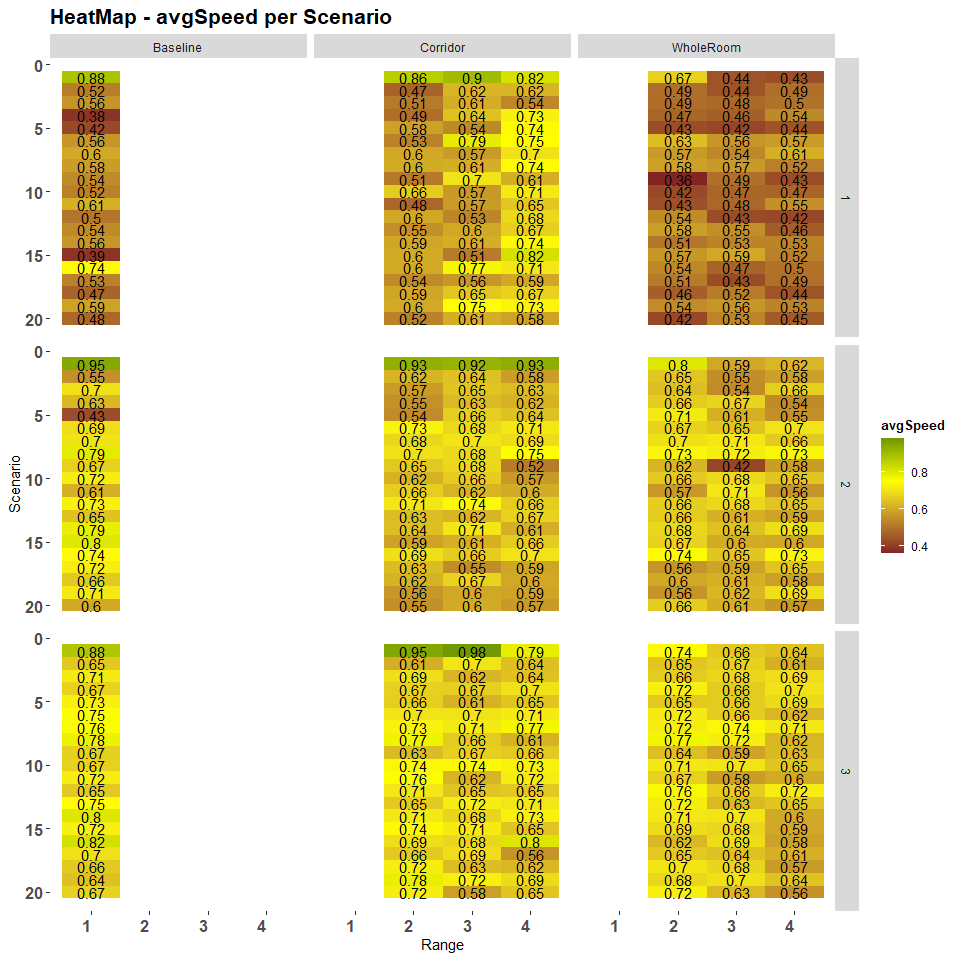


## Speed

Noteworthy, compared to the time it takes to complete a scenario over training time (as presented earlier), DOF Corridor with a Range of three meters becomes the fastest of the FOD Corridor Ranges on day three. However, looking at the average speed (as shown in the plot below), the corridor with a Range of two meters has a faster walking speed. This yields that a faster walking speed does not necessary mean a faster completion time.

ggplot(daggByScen,aes(x=totalTimeTraining,y=avgSpeed,color=factor(Range)))+  
 geom\_point(aes(alpha=.1))+   
 stat\_smooth(method = 'nls', formula = 'y~a\*x^b', method.args = list(start= c(a = 1,b=1)),se=FALSE)+  
 facet\_grid(cols=vars(FOD))





## Analysis reflection

##Analysis conclusion