Data_analysis

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```
library(ggplot2)
```

```
results <- read.csv("Output.csv")
results[, "Strategy"] <- as.factor(results[, "Strategy"])
results[, "Placed.on.Edges"] <- as.factor(results[, "Placed.on.Edges"])
results[, "Extinguish.Ratio"] <- round(results[, "Truck.Extinguish"]/
                (results[, "Self.Extinguish"] + results[, "Truck.Extinguish"]), 4)


summary(results[, 1:5])
```

```
##                      Strategy  Number.of.Truck    Max.speed
##  Goes to the biggest fire:41   Min.   : 10.00   Min.   : 10.00
##  Goes to the closest fire:69   1st Qu.: 20.00   1st Qu.: 50.00
##  Parallel attack         :22   Median : 20.00   Median : 50.00
##                                Mean   : 35.23   Mean   : 57.12
##                                3rd Qu.: 50.00   3rd Qu.: 70.00
##                                Max.   :100.00   Max.   :100.00
##      Vision      Placed.on.Edges
##  Min.   :100.0   FALSE:86
##  1st Qu.:100.0   TRUE :46
##  Median :100.0
##  Mean   :101.1
##  3rd Qu.:100.0
##  Max.   :125.0
```

```
dim(results)
```

```
## [1] 132   8
```

```
# Simple model without interaction terms (not used in analysis)
model.1 <- lm(Extinguish.Ratio~Strategy + Number.of.Truck + Max.speed + Vision
              + Placed.on.Edges, data = results)
summary(model.1)
```

```
##
## Call:
## lm(formula = Extinguish.Ratio ~ Strategy + Number.of.Truck +
##     Max.speed + Vision + Placed.on.Edges, data = results)
```

```
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.080440 -0.010940  0.002194  0.013912  0.053468
##
## Coefficients:
##                                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)                       1.047e-01  4.154e-02   2.520   0.0130 *
## StrategyGoes to the closest fire -4.390e-03  4.759e-03  -0.922   0.3581
## StrategyParallel attack           3.599e-02  6.036e-03   5.963 2.37e-08 ***
## Number.of.Truck                   1.757e-03  8.183e-05  21.471  < 2e-16 ***
## Max.speed                         4.219e-04  9.554e-05   4.416 2.15e-05 ***
## Vision                           -9.923e-04  4.199e-04  -2.363   0.0197 *
## Placed.on.EdgesTRUE              -4.305e-02  4.631e-03  -9.298 5.95e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.02242 on 125 degrees of freedom
## Multiple R-squared:  0.8512, Adjusted R-squared:  0.844
## F-statistic: 119.1 on 6 and 125 DF,  p-value: < 2.2e-16
```

```
# Full model (used in analysis)
model.2 <- lm(Extinguish.Ratio~(Strategy + Number.of.Truck + Max.speed + Vision
              + Placed.on.Edges)^2, data = results)
summary(model.2)
```

```
##
## Call:
## lm(formula = Extinguish.Ratio ~ (Strategy + Number.of.Truck +
##     Max.speed + Vision + Placed.on.Edges)^2, data = results)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.067615 -0.006722  0.000248  0.009030  0.036641
##
## Coefficients: (3 not defined because of singularities)
##                                                          Estimate Std. Error
## (Intercept)                                             3.483e-02  8.614e-02
## StrategyGoes to the closest fire                       -2.294e-02  6.498e-02
## StrategyParallel attack                                 2.243e-02  1.491e-02
## Number.of.Truck                                         5.681e-03  3.622e-03
## Max.speed                                               1.810e-04  2.163e-04
## Vision                                                 -2.308e-04  8.953e-04
## Placed.on.EdgesTRUE                                    -3.191e-02  1.463e-02
## StrategyGoes to the closest fire:Number.of.Truck       -2.106e-04  1.813e-04
## StrategyParallel attack:Number.of.Truck                 8.607e-04  1.839e-04
## StrategyGoes to the closest fire:Max.speed             -1.816e-04  1.748e-04
## StrategyParallel attack:Max.speed                      -3.143e-04  2.177e-04
## StrategyGoes to the closest fire:Vision                 3.662e-04  6.583e-04
## StrategyParallel attack:Vision                                 NA         NA
## StrategyGoes to the closest fire:Placed.on.EdgesTRUE    7.090e-03  9.043e-03
## StrategyParallel attack:Placed.on.EdgesTRUE             7.701e-05  1.963e-02
## Number.of.Truck:Max.speed                               1.670e-05  8.333e-06
## Number.of.Truck:Vision                                 -4.622e-05  3.772e-05
```

```
## Number.of.Truck:Placed.on.EdgesTRUE                  -6.344e-04  1.782e-04
## Max.speed:Vision                                             NA         NA
## Max.speed:Placed.on.EdgesTRUE                         1.050e-04  1.871e-04
## Vision:Placed.on.EdgesTRUE                                   NA         NA
##                                                     t value Pr(>|t|)
## (Intercept)                                           0.404 0.686715
## StrategyGoes to the closest fire                     -0.353 0.724738
## StrategyParallel attack                               1.504 0.135336
## Number.of.Truck                                       1.568 0.119575
## Max.speed                                             0.837 0.404446
## Vision                                               -0.258 0.797008
## Placed.on.EdgesTRUE                                  -2.181 0.031201 *
## StrategyGoes to the closest fire:Number.of.Truck     -1.162 0.247631
## StrategyParallel attack:Number.of.Truck               4.679 7.98e-06 ***
## StrategyGoes to the closest fire:Max.speed           -1.039 0.301051
## StrategyParallel attack:Max.speed                    -1.443 0.151689
## StrategyGoes to the closest fire:Vision               0.556 0.579122
## StrategyParallel attack:Vision                           NA       NA
## StrategyGoes to the closest fire:Placed.on.EdgesTRUE  0.784 0.434641
## StrategyParallel attack:Placed.on.EdgesTRUE           0.004 0.996876
## Number.of.Truck:Max.speed                             2.004 0.047473 *
## Number.of.Truck:Vision                               -1.225 0.222933
## Number.of.Truck:Placed.on.EdgesTRUE                  -3.559 0.000544 ***
## Max.speed:Vision                                         NA       NA
## Max.speed:Placed.on.EdgesTRUE                         0.561 0.575713
## Vision:Placed.on.EdgesTRUE                               NA       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01697 on 114 degrees of freedom
## Multiple R-squared:  0.9223, Adjusted R-squared:  0.9107
## F-statistic: 79.57 on 17 and 114 DF,  p-value: < 2.2e-16
```

```
# Apply step function to eliminate variables in full model
step(model.2)
```

```
## Start:  AIC=-1059.52
## Extinguish.Ratio ~ (Strategy + Number.of.Truck + Max.speed +
##     Vision + Placed.on.Edges)^2
##
##
## Step:  AIC=-1059.52
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Strategy:Max.speed +
##     Strategy:Vision + Strategy:Placed.on.Edges + Number.of.Truck:Max.speed +
##     Number.of.Truck:Vision + Number.of.Truck:Placed.on.Edges +
##     Max.speed:Vision + Max.speed:Placed.on.Edges
##
##
## Step:  AIC=-1059.52
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Strategy:Max.speed +
##     Strategy:Vision + Strategy:Placed.on.Edges + Number.of.Truck:Max.speed +
##     Number.of.Truck:Vision + Number.of.Truck:Placed.on.Edges +
```

```
##     Max.speed:Placed.on.Edges
##
##                                  Df Sum of Sq      RSS     AIC
## - Strategy:Placed.on.Edges        2 0.0001885 0.033013 -1062.8
## - Strategy:Vision                 1 0.0000891 0.032913 -1061.2
## - Max.speed:Placed.on.Edges       1 0.0000907 0.032915 -1061.2
## - Strategy:Max.speed              2 0.0007092 0.033533 -1060.7
## - Number.of.Truck:Vision          1 0.0004324 0.033257 -1059.8
## <none>                                        0.032824 -1059.5
## - Number.of.Truck:Max.speed       1 0.0011560 0.033980 -1057.0
## - Number.of.Truck:Placed.on.Edges 1 0.0036475 0.036472 -1047.6
## - Strategy:Number.of.Truck        2 0.0095832 0.042407 -1029.7
##
## Step:  AIC=-1062.76
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Strategy:Max.speed +
##     Strategy:Vision + Number.of.Truck:Max.speed + Number.of.Truck:Vision +
##     Number.of.Truck:Placed.on.Edges + Max.speed:Placed.on.Edges
##
##                                  Df Sum of Sq      RSS     AIC
## - Strategy:Vision                 1 0.0000463 0.033059 -1064.6
## - Max.speed:Placed.on.Edges       1 0.0000501 0.033063 -1064.6
## - Strategy:Max.speed              2 0.0007472 0.033760 -1063.8
## - Number.of.Truck:Vision          1 0.0004228 0.033435 -1063.1
## <none>                                        0.033013 -1062.8
## - Number.of.Truck:Max.speed       1 0.0011488 0.034161 -1060.2
## - Number.of.Truck:Placed.on.Edges 1 0.0035539 0.036567 -1051.3
## - Strategy:Number.of.Truck        2 0.0102255 0.043238 -1031.2
##
## Step:  AIC=-1064.58
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Strategy:Max.speed +
##     Number.of.Truck:Max.speed + Number.of.Truck:Vision + Number.of.Truck:Placed.on.Edges +
##     Max.speed:Placed.on.Edges
##
##                                  Df Sum of Sq      RSS     AIC
## - Max.speed:Placed.on.Edges       1 0.0000434 0.033102 -1066.4
## - Strategy:Max.speed              2 0.0007022 0.033761 -1065.8
## - Number.of.Truck:Vision          1 0.0004083 0.033467 -1065.0
## <none>                                        0.033059 -1064.6
## - Number.of.Truck:Max.speed       1 0.0011081 0.034167 -1062.2
## - Number.of.Truck:Placed.on.Edges 1 0.0035657 0.036625 -1053.1
## - Strategy:Number.of.Truck        2 0.0102300 0.043289 -1033.0
##
## Step:  AIC=-1066.41
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Strategy:Max.speed +
##     Number.of.Truck:Max.speed + Number.of.Truck:Vision + Number.of.Truck:Placed.on.Edges
##
##                                  Df Sum of Sq      RSS     AIC
## - Strategy:Max.speed              2 0.0007197 0.033822 -1067.6
## - Number.of.Truck:Vision          1 0.0003856 0.033488 -1066.9
## <none>                                        0.033102 -1066.4
## - Number.of.Truck:Max.speed       1 0.0010717 0.034174 -1064.2
```

```
## - Number.of.Truck:Placed.on.Edges  1 0.0039586 0.037061 -1053.5
## - Strategy:Number.of.Truck         2 0.0102565 0.043359 -1034.8
##
## Step:  AIC=-1067.57
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Number.of.Truck:Max.speed +
##     Number.of.Truck:Vision + Number.of.Truck:Placed.on.Edges
##
##                                   Df Sum of Sq      RSS     AIC
## - Number.of.Truck:Vision           1 0.0003728 0.034195 -1068.1
## <none>                                         0.033822 -1067.6
## - Number.of.Truck:Max.speed        1 0.0010819 0.034904 -1065.4
## - Number.of.Truck:Placed.on.Edges  1 0.0041282 0.037950 -1054.4
## - Strategy:Number.of.Truck         2 0.0110342 0.044856 -1034.3
##
## Step:  AIC=-1068.12
## Extinguish.Ratio ~ Strategy + Number.of.Truck + Max.speed + Vision +
##     Placed.on.Edges + Strategy:Number.of.Truck + Number.of.Truck:Max.speed +
##     Number.of.Truck:Placed.on.Edges
##
##                                   Df Sum of Sq      RSS     AIC
## <none>                                         0.034195 -1068.1
## - Number.of.Truck:Max.speed        1 0.0007528 0.034948 -1067.2
## - Vision                           1 0.0025635 0.036758 -1060.6
## - Number.of.Truck:Placed.on.Edges  1 0.0040841 0.038279 -1055.2
## - Strategy:Number.of.Truck         2 0.0111660 0.045361 -1034.8


##
## Call:
## lm(formula = Extinguish.Ratio ~ Strategy + Number.of.Truck +
##     Max.speed + Vision + Placed.on.Edges + Strategy:Number.of.Truck +
##     Number.of.Truck:Max.speed + Number.of.Truck:Placed.on.Edges,
##     data = results)
##
## Coefficients:
##                                         (Intercept)
##                                           0.1078605
##                  StrategyGoes to the closest fire
##                                           0.0055651
##                           StrategyParallel attack
##                                           0.0044241
##                                      Number.of.Truck
##                                           0.0013178
##                                           Max.speed
##                                           0.0001809
##                                              Vision
##                                          -0.0009592
##                                 Placed.on.EdgesTRUE
##                                          -0.0220087
## StrategyGoes to the closest fire:Number.of.Truck
##                                          -0.0002224
##          StrategyParallel attack:Number.of.Truck
##                                           0.0008933
##                         Number.of.Truck:Max.speed
```

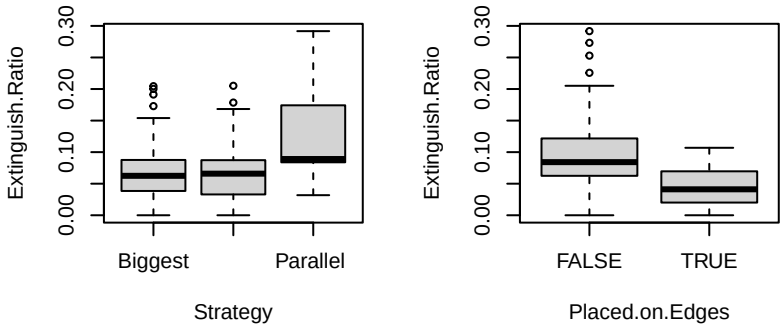
```
##                                       0.0000114
##              Number.of.Truck:Placed.on.EdgesTRUE
##                                      -0.0005998
```

```
# Final model for analysis
model.3 <- lm(Extinguish.Ratio ~ Strategy + Number.of.Truck +
    Max.speed + Vision + Placed.on.Edges + Strategy:Number.of.Truck +
    Number.of.Truck:Max.speed + Number.of.Truck:Placed.on.Edges,
    data = results)

summary(model.3)
```

```
##
## Call:
## lm(formula = Extinguish.Ratio ~ Strategy + Number.of.Truck +
##     Max.speed + Vision + Placed.on.Edges + Strategy:Number.of.Truck +
##     Number.of.Truck:Max.speed + Number.of.Truck:Placed.on.Edges,
##     data = results)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.070392 -0.007692  0.000980  0.009792  0.035840
##
## Coefficients:
##                                                  Estimate Std. Error t value
## (Intercept)                                     1.079e-01  3.222e-02   3.347
## StrategyGoes to the closest fire                5.565e-03  6.233e-03   0.893
## StrategyParallel attack                         4.424e-03  7.548e-03   0.586
## Number.of.Truck                                 1.318e-03  3.756e-04   3.508
## Max.speed                                       1.809e-04  1.711e-04   1.057
## Vision                                         -9.592e-04  3.185e-04  -3.012
## Placed.on.EdgesTRUE                            -2.201e-02  6.333e-03  -3.475
## StrategyGoes to the closest fire:Number.of.Truck -2.224e-04  1.634e-04  -1.361
## StrategyParallel attack:Number.of.Truck          8.933e-04  1.784e-04   5.008
## Number.of.Truck:Max.speed                        1.140e-05  6.983e-06   1.632
## Number.of.Truck:Placed.on.EdgesTRUE             -5.998e-04  1.578e-04  -3.802
##                                                 Pr(>|t|)
## (Intercept)                                     0.001088 **
## StrategyGoes to the closest fire                0.373719
## StrategyParallel attack                         0.558862
## Number.of.Truck                                 0.000634 ***
## Max.speed                                       0.292455
## Vision                                          0.003163 **
## Placed.on.EdgesTRUE                             0.000710 ***
## StrategyGoes to the closest fire:Number.of.Truck 0.176064
## StrategyParallel attack:Number.of.Truck         1.89e-06 ***
## Number.of.Truck:Max.speed                       0.105259
## Number.of.Truck:Placed.on.EdgesTRUE             0.000227 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.01681 on 121 degrees of freedom
## Multiple R-squared:  0.919,  Adjusted R-squared:  0.9123
## F-statistic: 137.3 on 10 and 121 DF,  p-value: < 2.2e-16
```

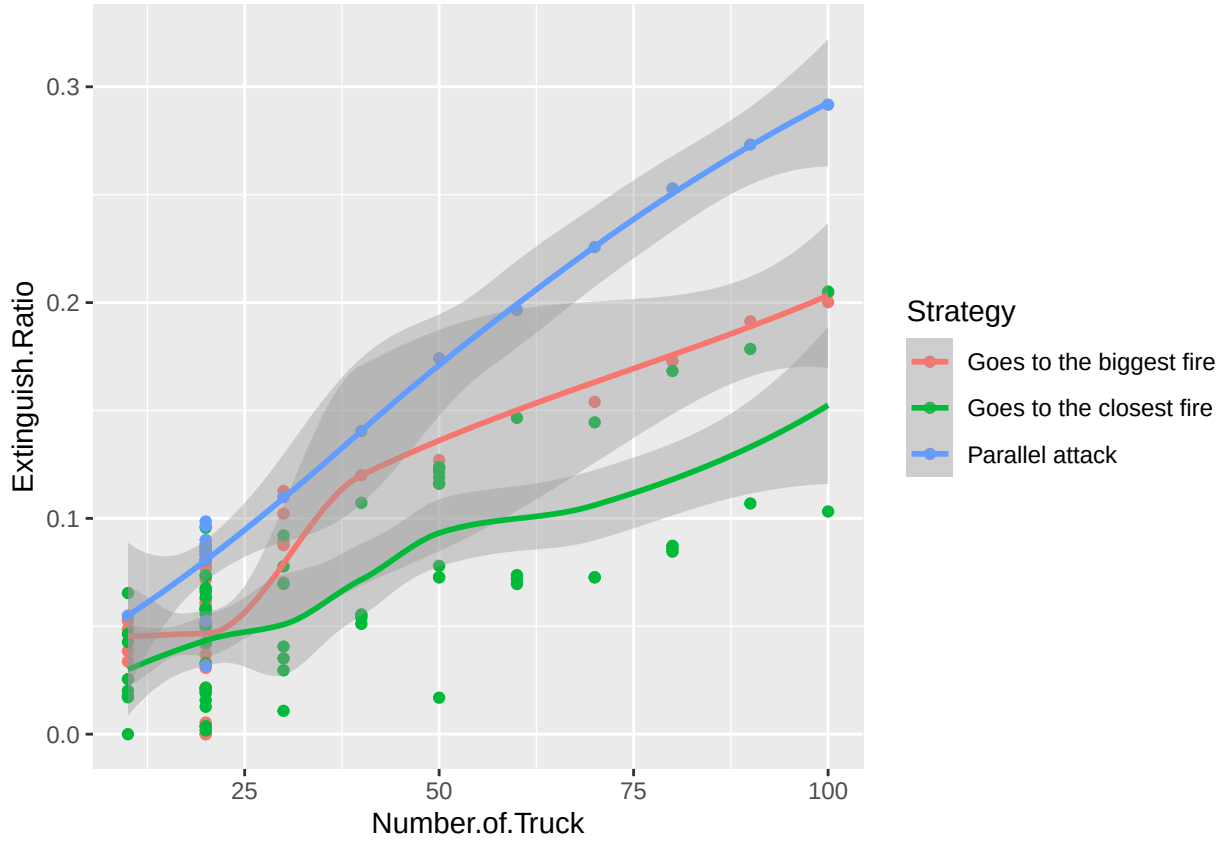
```
# Overview for some variables
par(mfrow = c(2, 3))
plot(Extinguish.Ratio~Strategy, data = results,  names = c("Biggest", "Closest", "Parallel "))
plot(Extinguish.Ratio~Placed.on.Edges, data = results)
```



The following plots are for significant variables in the final model:

```
ggplot(data = results, aes(Number.of.Truck, Extinguish.Ratio, col = Strategy)) +
  geom_point() +
  geom_smooth()
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```

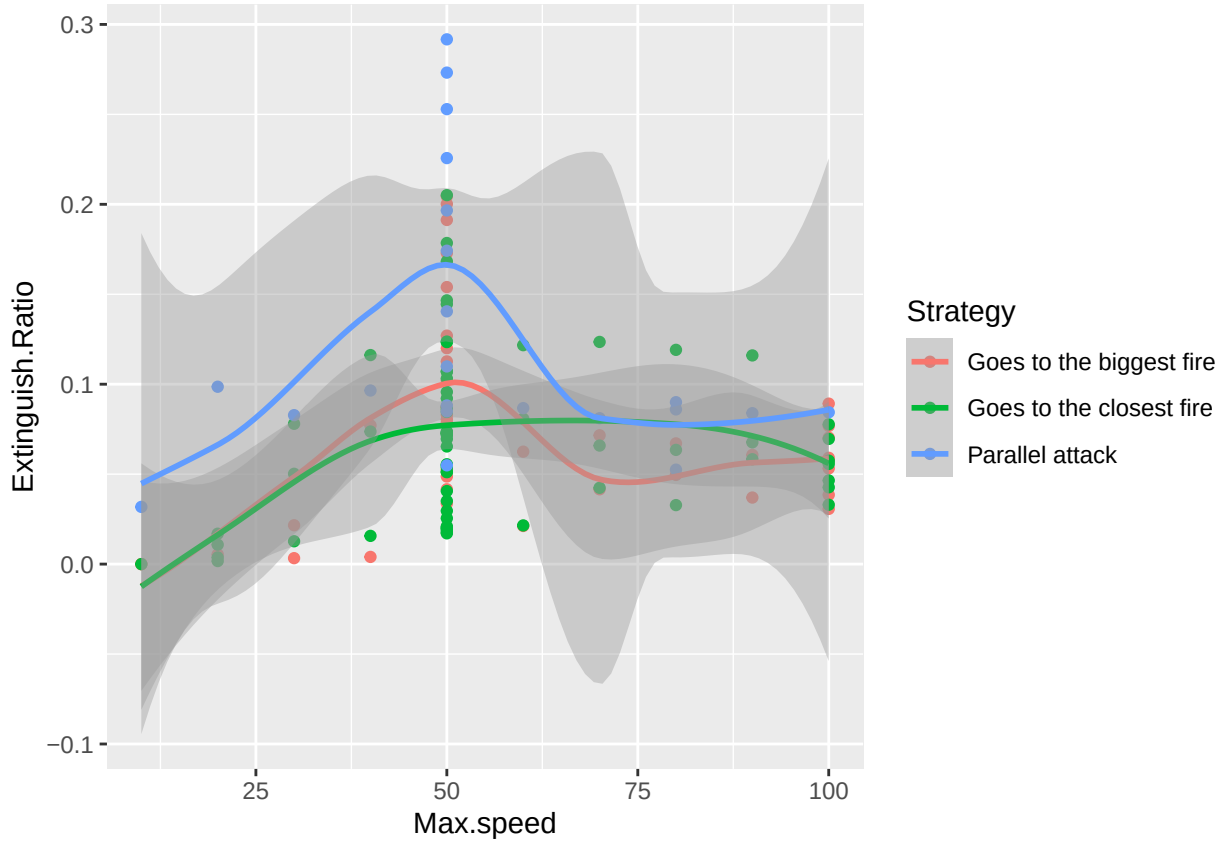



```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.2 --
## v tibble  3.1.8      v dplyr   1.0.10
## v tidyr   1.2.1      v stringr 1.4.1
## v readr   2.1.3      v forcats 0.5.2
## v purrr   0.3.5
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

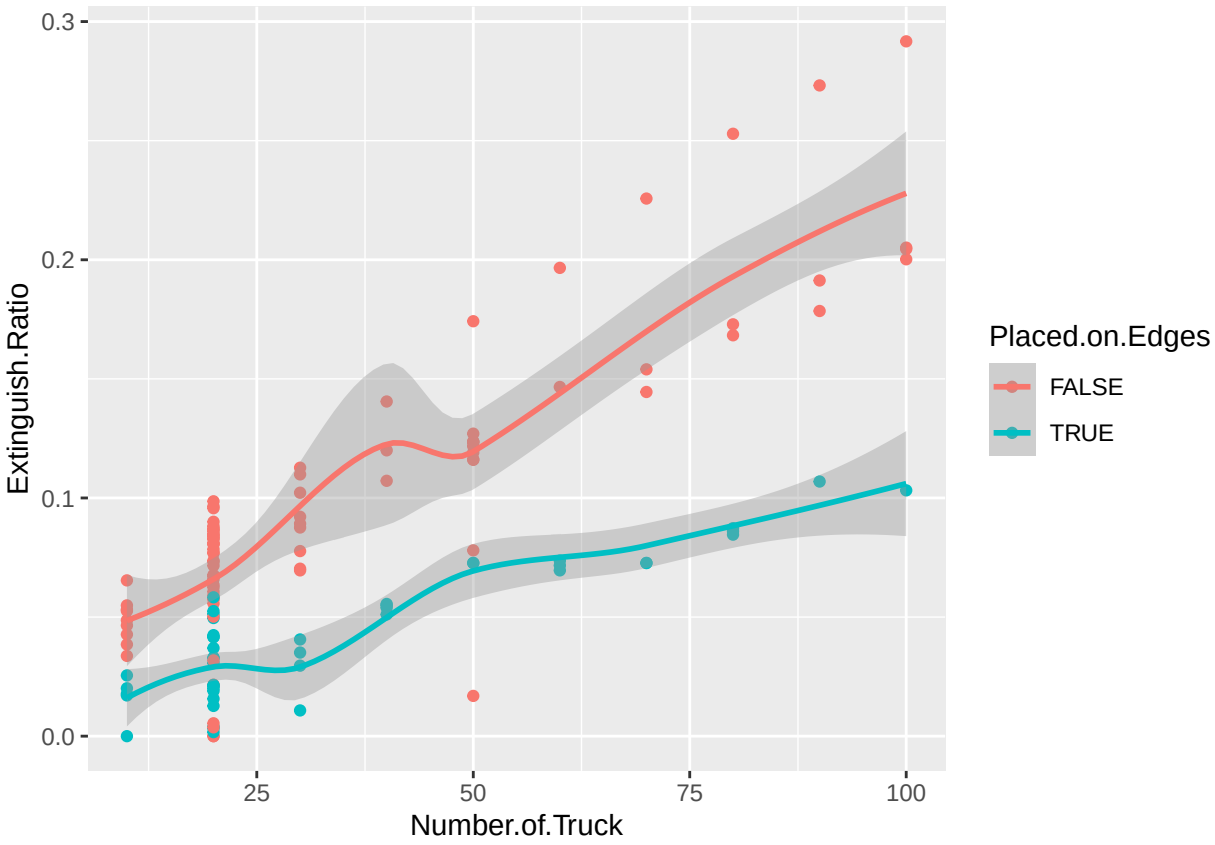
```
ggplot(data = results, aes(Max.speed, Extinguish.Ratio, col = Strategy)) +
  geom_point(aes(col = Strategy)) +
  geom_smooth()
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```




```
ggplot(data = results, aes(Number.of.Truck, Extinguish.Ratio, col = Placed.on.Edges)) +
  geom_point(aes(col = Placed.on.Edges)) +
  geom_smooth()
```

```
## `geom_smooth()` using method = 'loess' and formula 'y ~ x'
```


0.3
0.2
0.1
0.0
Extinguish.Ratio
25
50
75
100
Number.of.Truck
Placed.on.Edges
FALSE
TRUE