EDA

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Load Libraries & Data

```
knitr::opts_chunk$set(warning = FALSE, message = FALSE)
```

```
library(ggplot2)
library(dplyr)
```

```
# make sure you are in the EMS Stations Project directory
# alternatively, click the emsData.RData file to load it into your global environment
load("./Data/emsData.RData")
```

```
head(x)
```

```
##    REF.GRID DISPATCH.PRIORITY.NAME REF.GPS.LAT REF.GPS.LON BASE.NAME VEH.GRID
## 1   3 South              Emergency     36.3085    -78.4563 Company 9  Medic 5
## 2 2 Central              Emergency     36.3306    -78.4040 Company 9  Medic 6
## 3 2 Central              Emergency     36.3335    -78.4399 Company 9  Medic 1
## 4 2 Central              Emergency     36.3351    -78.4410 Company 9  Medic 5
## 5 2 Central          Non Emergency     36.3401    -78.4017 Company 9  Medic 6
## 6 2 Central              Emergency     36.3315    -78.3929 Company 9  Medic 1
##             VEHCGPS              DT.DISP          DT.ENROUTE           DT.ARRIVE
## 1 36.345, -78.3905 2024-01-01 06:46:00 2024-01-01 06:46:00 2024-01-01 06:52:00
## 2 36.345, -78.3905 2024-01-01 08:30:00 2024-01-01 08:30:00 2024-01-01 08:34:00
## 3 36.345, -78.3905 2024-01-01 10:22:00 2024-01-01 10:22:00 2024-01-01 10:27:00
## 4 36.345, -78.3905 2024-01-01 11:38:00 2024-01-01 11:38:00 2024-01-01 11:44:00
## 5 36.345, -78.3905 2024-01-01 12:33:00 2024-01-01 12:33:00 2024-01-01 12:37:00
## 6 36.345, -78.3905 2024-01-01 14:18:00 2024-01-01 14:18:00 2024-01-01 14:22:00
##              DT.LVREF           DT.ARVREC        DT.AVAILABLE
## 1 2024-01-01 07:07:00 2024-01-01 07:13:00 2024-01-01 07:32:00
## 2 2024-01-01 08:39:00 2024-01-01 08:46:00 2024-01-01 09:00:00
## 3 2024-01-01 10:36:00 2024-01-01 10:39:00 2024-01-01 10:54:00
## 4                 <NA>                <NA> 2024-01-01 12:08:00
## 5 2024-01-01 12:38:00 2024-01-01 12:45:00 2024-01-01 12:52:00
## 6 2024-01-01 14:38:00 2024-01-01 14:47:00 2024-01-01 15:11:00
##                REC.NAME   REC.LON  REC.LAT observedTT onSceneDur toHospitalTT
## 1 Maria Parham Hospital -78.44931 36.33089   360 secs   900 secs     360 secs
## 2 Maria Parham Hospital -78.44931 36.33089   240 secs   300 secs     420 secs
## 3 Maria Parham Hospital -78.44931 36.33089   300 secs   540 secs     180 secs
## 4                              NA       NA   360 secs    NA secs      NA secs
```

```
## 5 Maria Parham Hospital -78.44931 36.33089   240 secs    60 secs     420 secs
## 6 Maria Parham Hospital -78.44931 36.33089   240 secs   960 secs     540 secs
##   atHospitalDur arriveToClearTime Dist.So Dist.Ce Dist.NN Dist.FN eTT.GL.So
## 1     1140 secs         2400 secs    9258    8434   17426   25709       561
## 2      840 secs         1560 secs    7048    2422   12212   20495       578
## 3      900 secs         1620 secs   10969    5301   12540   20823       759
## 4       NA secs         1440 secs    8781    5068   12307   20590       734
## 5      420 secs          900 secs    8967    1516   12228   20511       770
## 6     1440 secs         2940 secs    7800    2298   13267   21550       696
##   eTT.GL.Ce eTT.GL.NN eTT.GL.FN eTT.Pe.So eTT.Pe.Ce eTT.Pe.NN eTT.Pe.FN
## 1       411       827      1198       616       440       859      1267
## 2       234       635      1007       650       251       689      1076
## 3       366       752      1124       918       384       796      1217
## 4       298       685      1056      1026       363       784      1193
## 5       191       656      1027       965       220       725      1123
## 6       245       795      1166       890       250       963      1358
##   eTT.BG.So eTT.BG.Ce eTT.BG.NN eTT.BG.FN eTT.Op.So eTT.Op.Ce eTT.Op.NN
## 1       539       406       805      1173       507       372       758
## 2       549       220       633       993       508       210       587
## 3       752       346       743      1127       699       343       728
## 4       770       306       712      1085       679       283       671
## 5       766       181       670      1036       728       187       642
## 6       722       235       815      1186       668       243       753
##   eTT.Op.FN hosp.Dist hosp.GL eTT.Pe.Hosp eTT.BG.Hosp eTT.Op.Hosp
## 1      1097      3151     309         300         271         267
## 2       933      6060     443         489         404         393
## 3      1090      1372     219         222         178         208
## 4      1032        NA      NA          NA          NA          NA
## 5       994      6076     447         557         438         414
## 6      1124      8416     557         661         553         531
```

```
colnames(x)
```

```
##  [1] "REF.GRID"              "DISPATCH.PRIORITY.NAME" "REF.GPS.LAT"
##  [4] "REF.GPS.LON"           "BASE.NAME"              "VEH.GRID"
##  [7] "VEHCGPS"               "DT.DISP"                "DT.ENROUTE"
## [10] "DT.ARRIVE"             "DT.LVREF"               "DT.ARVREC"
## [13] "DT.AVAILABLE"          "REC.NAME"               "REC.LON"
## [16] "REC.LAT"               "observedTT"             "onSceneDur"
## [19] "toHospitalTT"          "atHospitalDur"          "arriveToClearTime"
## [22] "Dist.So"               "Dist.Ce"                "Dist.NN"
## [25] "Dist.FN"               "eTT.GL.So"              "eTT.GL.Ce"
## [28] "eTT.GL.NN"             "eTT.GL.FN"              "eTT.Pe.So"
## [31] "eTT.Pe.Ce"             "eTT.Pe.NN"              "eTT.Pe.FN"
## [34] "eTT.BG.So"             "eTT.BG.Ce"              "eTT.BG.NN"
## [37] "eTT.BG.FN"             "eTT.Op.So"              "eTT.Op.Ce"
## [40] "eTT.Op.NN"             "eTT.Op.FN"              "hosp.Dist"
## [43] "hosp.GL"               "eTT.Pe.Hosp"            "eTT.BG.Hosp"
## [46] "eTT.Op.Hosp"
```

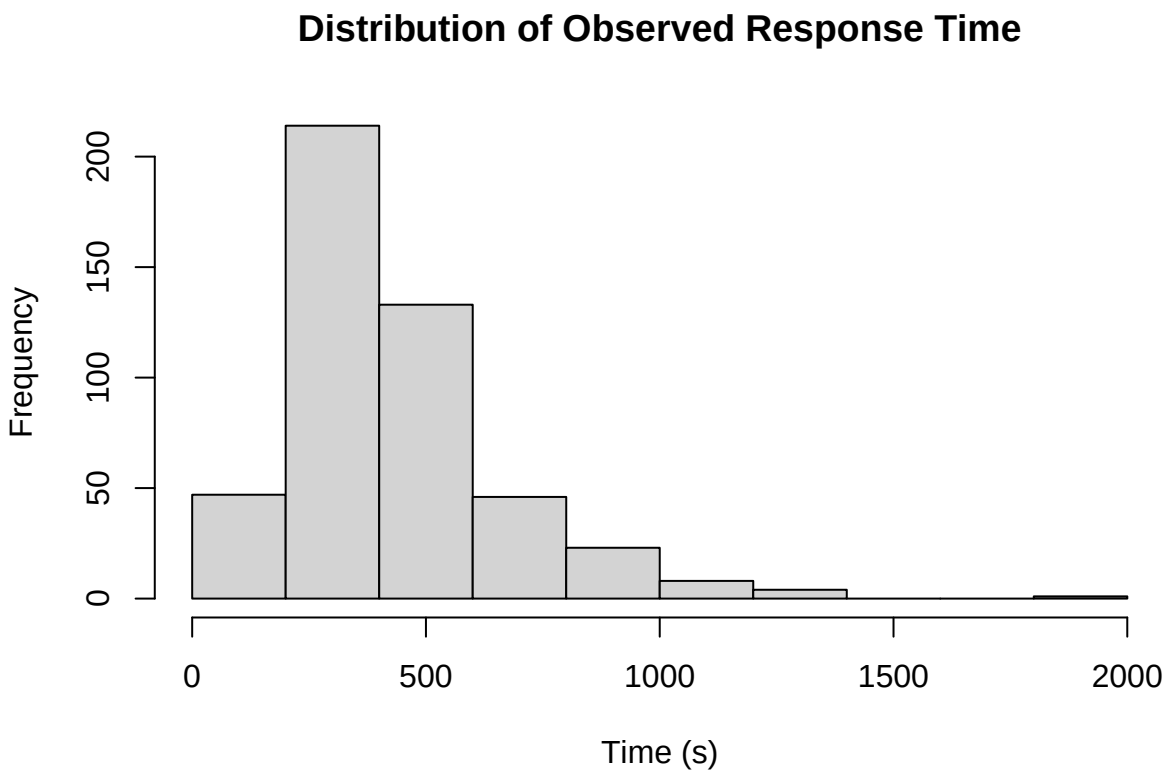
EDA

Observed Response Time

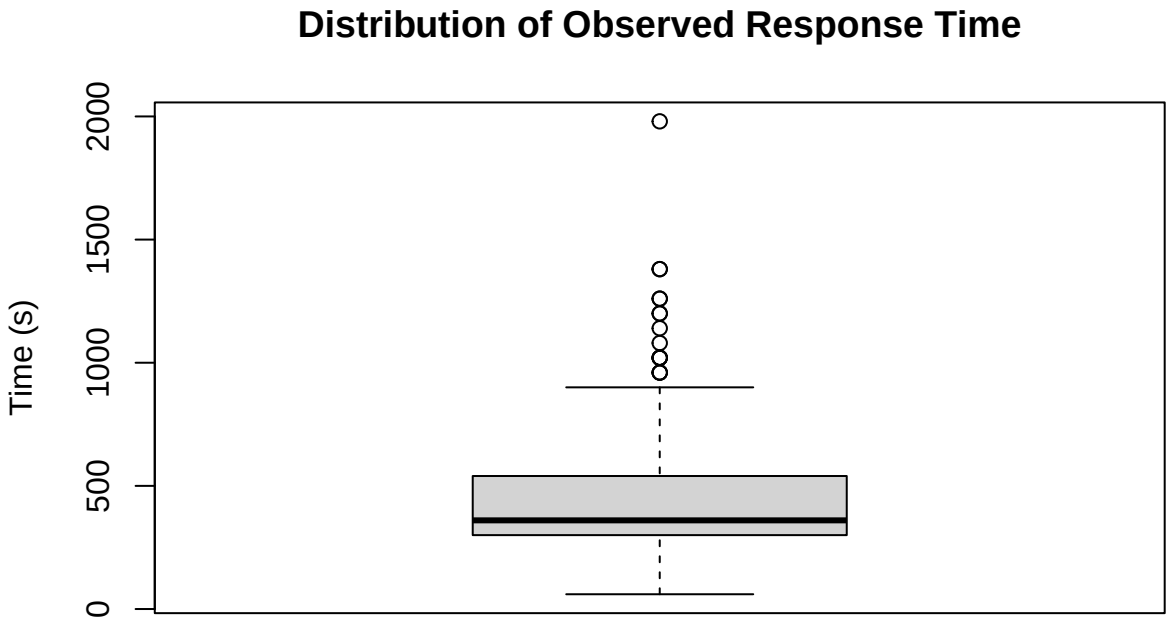
```
# observed response time distribution
x$observedTT_numeric <- as.numeric(x$observedTT)
# remove rows with NA and 0 values in the observedTT_numeric column
x <- x[!is.na(x$observedTT_numeric) & x$observedTT_numeric != 0, ]
summary(x$observedTT_numeric)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##      60     300     360     432     540    1980
```

```
# observed response time histogram
hist(x$observedTT_numeric,
     main = "Distribution of Observed Response Time",
     xlab = "Time (s)",
     ylab = "Frequency")
```




```
# observed response time boxplot
boxplot(x$observedTT_numeric,
        main = "Distribution of Observed Response Time",
        ylab = "Time (s)")
```



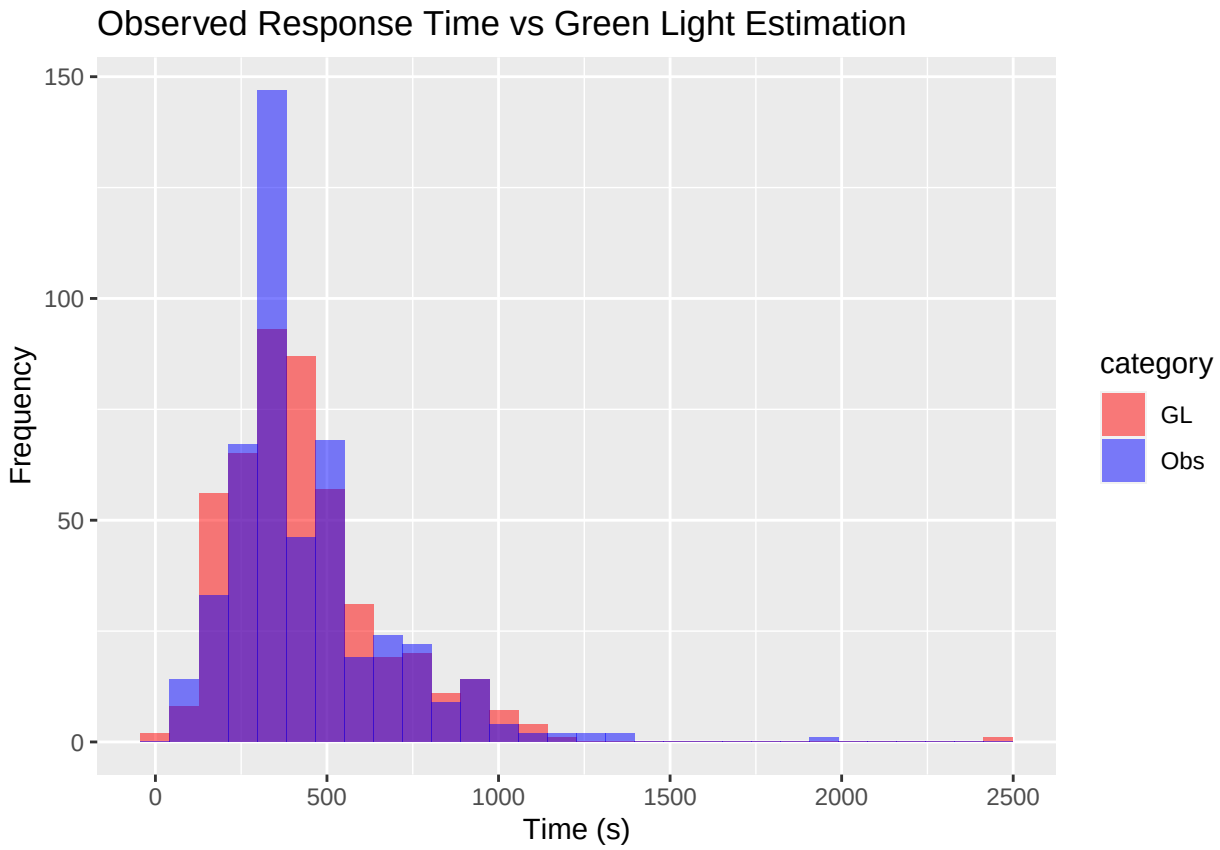
Comparison with Estimated Response Time

Visualization

```r
# for each record, extract Google map API estimation based on observed base and destination
x$eTT.GL <- ifelse(x$BASE.NAME == "Company 1", x$eTT.GL.So, x$eTT.GL.Ce)
x$eTT.Pe <- ifelse(x$BASE.NAME == "Company 1", x$eTT.Pe.So, x$eTT.Pe.Ce)
x$eTT.BG <- ifelse(x$BASE.NAME == "Company 1", x$eTT.BG.So, x$eTT.BG.Ce)
x$eTT.Op <- ifelse(x$BASE.NAME == "Company 1", x$eTT.Op.So, x$eTT.Op.Ce)
```

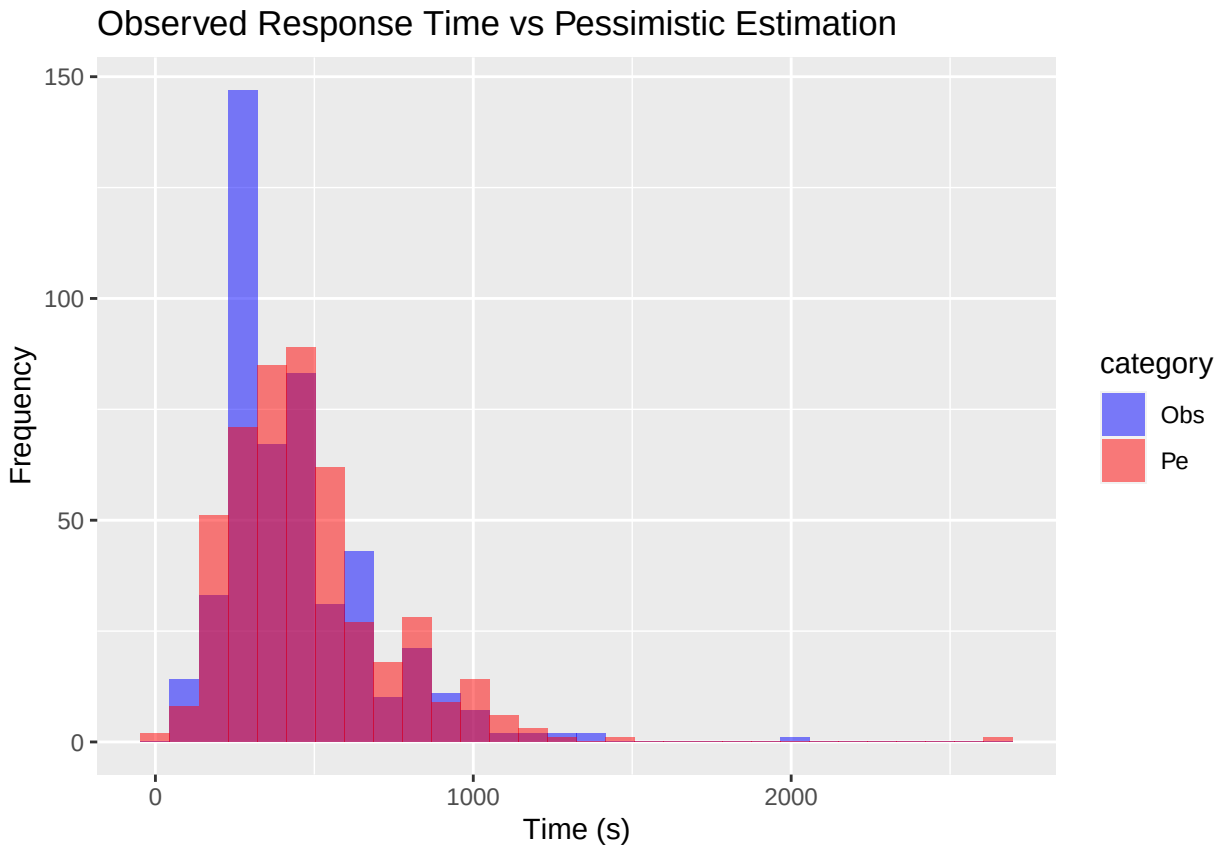
```r
# compare observed with green light
df1 <- data.frame(category = rep(c("Obs", "GL"), each = length(x$observedTT_numeric)),
                  value = c(x$observedTT_numeric, x$eTT.GL))

ggplot(df1, aes(x = value, fill = category)) +
  geom_histogram(position = "identity", alpha = 0.5) +
  labs(title = "Observed Response Time vs Green Light Estimation",
       x = "Time (s)",
       y = "Frequency") +
  scale_fill_manual(values = c("Obs" = "blue", "GL" = "red"))
```



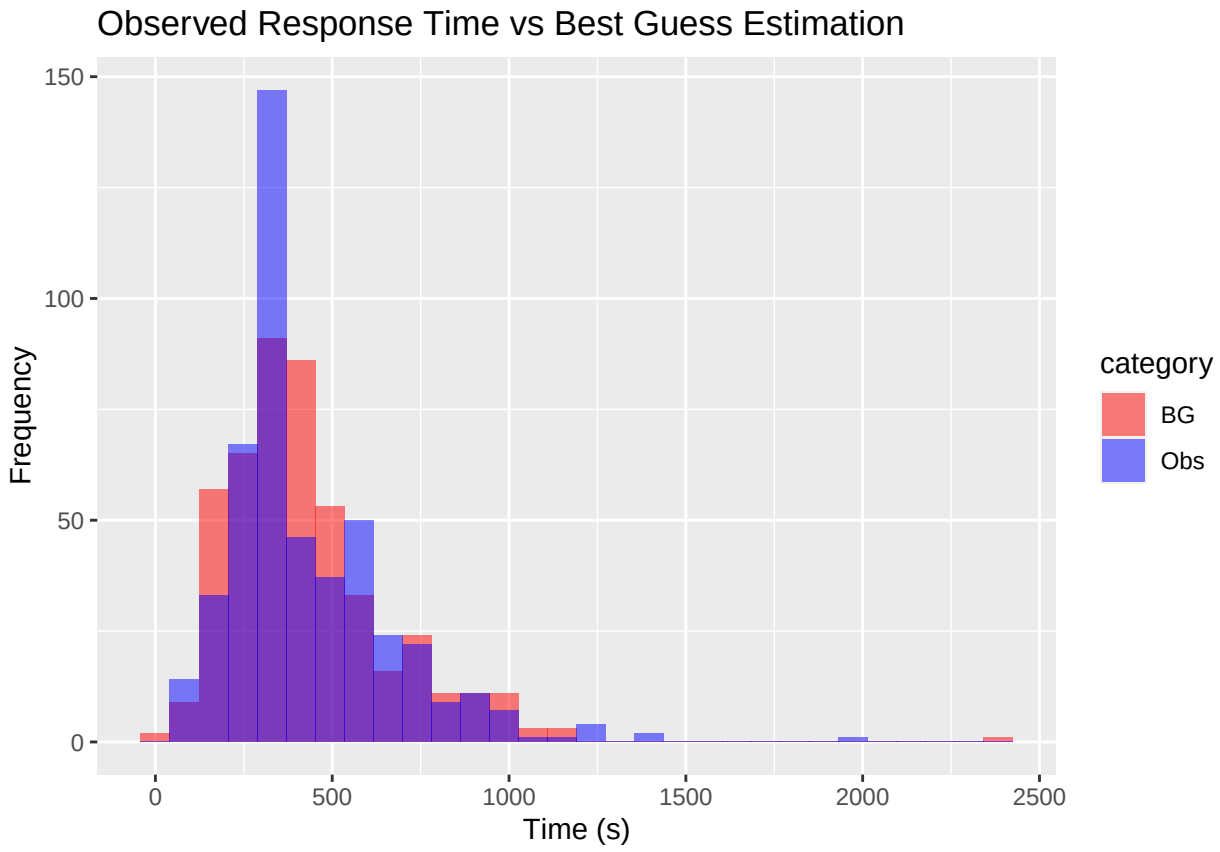

```
# compare observed with pessimistic
df2 <- data.frame(category = rep(c("Obs", "Pe"), each = length(x$observedTT_numeric)),
                  value = c(x$observedTT_numeric, x$eTT.Pe))

ggplot(df2, aes(x = value, fill = category)) +
  geom_histogram(position = "identity", alpha = 0.5) +
  labs(title = "Observed Response Time vs Pessimistic Estimation",
       x = "Time (s)",
       y = "Frequency") +
  scale_fill_manual(values = c("Obs" = "blue", "Pe" = "red"))
```



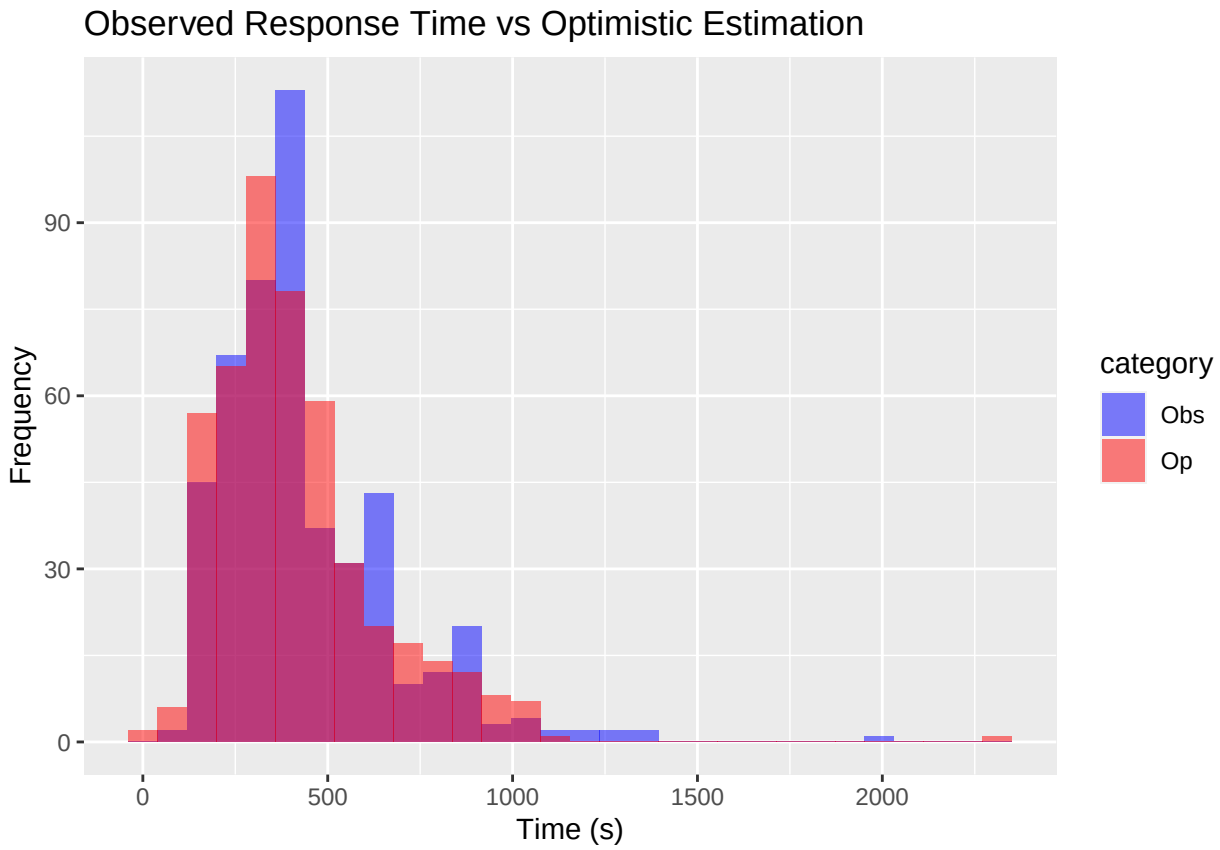

```
# compare observed with best guess
df3 <- data.frame(category = rep(c("Obs", "BG"), each = length(x$observedTT_numeric)),
                  value = c(x$observedTT_numeric, x$eTT.BG))

ggplot(df3, aes(x = value, fill = category)) +
  geom_histogram(position = "identity", alpha = 0.5) +
  labs(title = "Observed Response Time vs Best Guess Estimation",
       x = "Time (s)",
       y = "Frequency") +
  scale_fill_manual(values = c("Obs" = "blue", "BG" = "red"))
```



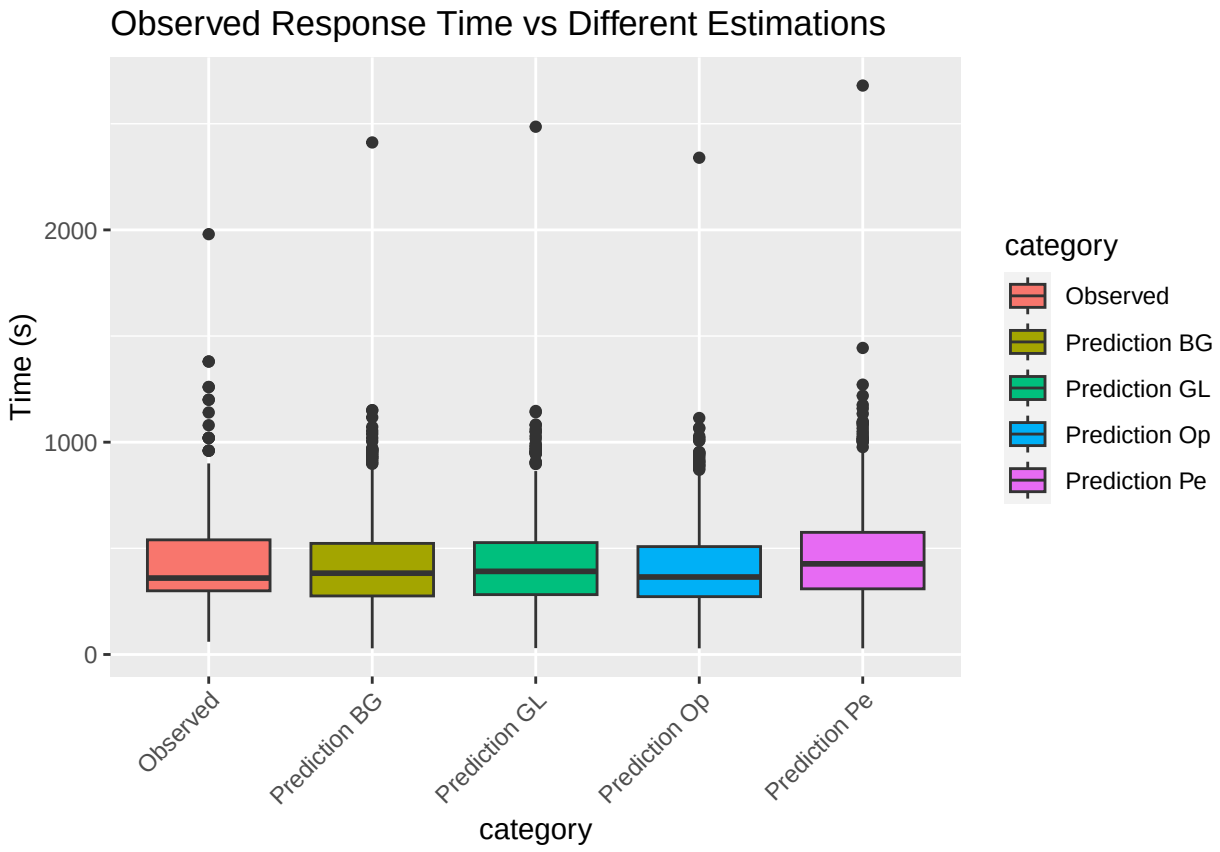

```
# compare observed with optimistic
df4 <- data.frame(category = rep(c("Obs", "Op"), each = length(x$observedTT_numeric)),
                  value = c(x$observedTT_numeric, x$eTT.Op))

ggplot(df4, aes(x = value, fill = category)) +
  geom_histogram(position = "identity", alpha = 0.5) +
  labs(title = "Observed Response Time vs Optimistic Estimation",
       x = "Time (s)",
       y = "Frequency") +
  scale_fill_manual(values = c("Obs" = "blue", "Op" = "red"))
```




```r
# boxplot to compare five response time distributions
observed_df <- data.frame(category = "Observed", value = x$observedTT_numeric)
pred1_df <- data.frame(category = "Prediction GL", value = x$eTT.GL)
pred2_df <- data.frame(category = "Prediction Pe", value = x$eTT.Pe)
pred3_df <- data.frame(category = "Prediction BG", value = x$eTT.BG)
pred4_df <- data.frame(category = "Prediction Op", value = x$eTT.Op)
combined_df <- bind_rows(observed_df, pred1_df, pred2_df, pred3_df, pred4_df)

ggplot(combined_df, aes(x = category, y = value, fill = category)) +
  geom_boxplot() +
  labs(title = "Observed Response Time vs Different Estimations",
       y = "Time (s)") +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



RMSE

```
rmse1 <- sqrt(mean((observed_df$value - pred1_df$value)^2))
rmse2 <- sqrt(mean((observed_df$value - pred2_df$value)^2))
rmse3 <- sqrt(mean((observed_df$value - pred3_df$value)^2))
rmse4 <- sqrt(mean((observed_df$value - pred4_df$value)^2))

print(rmse1)
```

```
## [1] 189.8238
```

```
print(rmse2)
```

```
## [1] 212.1679
```

```
print(rmse3)
```

```
## [1] 188.9788
```

```
print(rmse4)
```

```
## [1] 183.6995
```

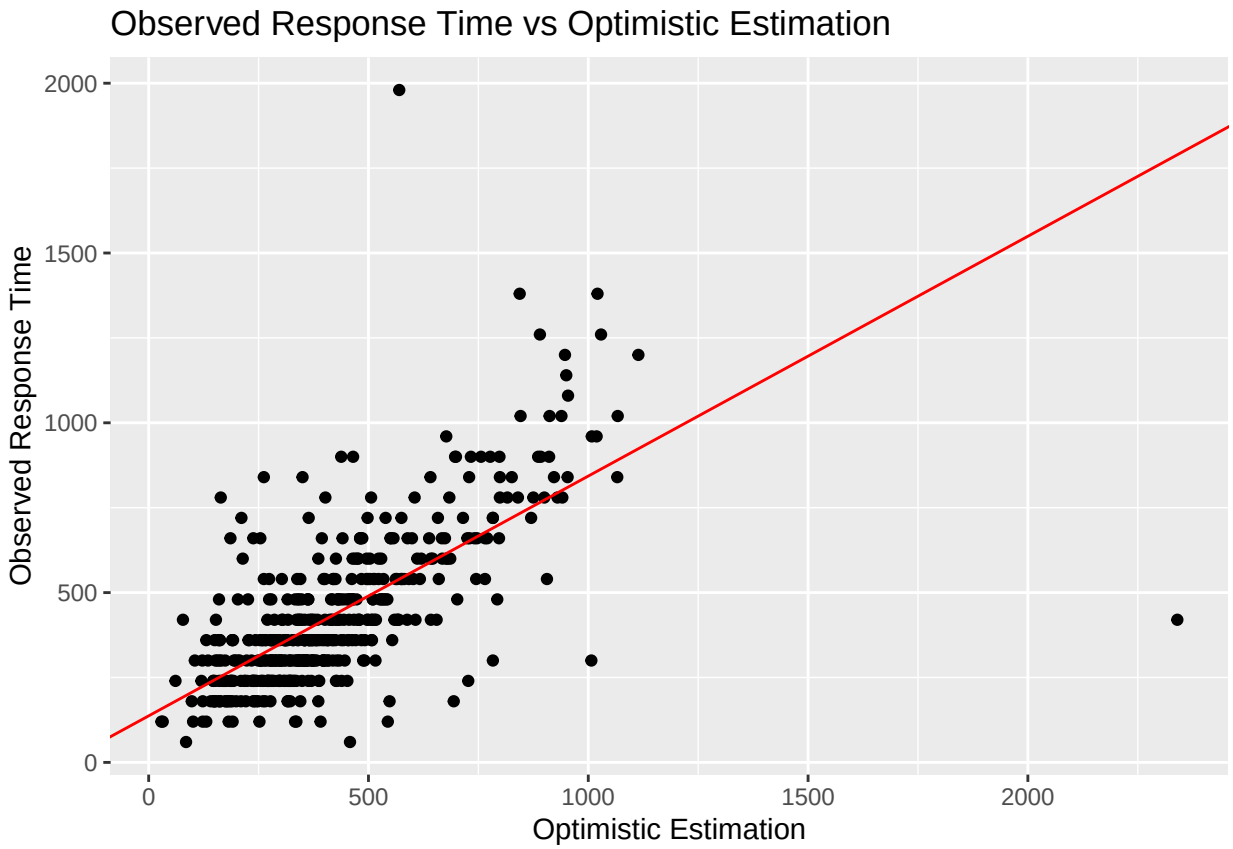
The optimistic Google Map API has the best estimation among the four, based on the RMSE criteria.

Linear Regression (Obs vs Op)

```r
# perform the linear regression
lm_model <- lm(observed_df$value ~ pred4_df$value)
summary(lm_model)
```

```
##
## Call:
## lm(formula = observed_df$value ~ pred4_df$value)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1369.36   -86.97   -20.68    56.54  1440.51
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)    136.99639   16.41909   8.344 7.92e-16 ***
## pred4_df$value   0.70614    0.03454  20.443  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 170.9 on 474 degrees of freedom
## Multiple R-squared:  0.4686, Adjusted R-squared:  0.4674
## F-statistic: 417.9 on 1 and 474 DF,  p-value: < 2.2e-16
```

```r
# scatter plot
ggplot(data = NULL, aes(x = pred4_df$value, y = observed_df$value)) +
  geom_point() +
  geom_abline(intercept = coef(lm_model)[1],
              slope = coef(lm_model)[2],
              color = "red") +
  labs(title = "Observed Response Time vs Optimistic Estimation",
       x = "Optimistic Estimation",
       y = "Observed Response Time")
```


Observed Response Time vs Optimistic Estimation
Observed Response Time
Optimistic Estimation
0
500
1000
1500
2000