Course Capstone Project

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Introduction

The data set that we will analyze is the opening response time (ms) of an electromechanical valve. The valve controls the flow of several fluids where the opening and closing is actuated by a solenoid. The shutoff seal is an elastomer that is attached to the end of the solenoid plunger. In this project, we will determine how the seal vintage, fluid and applied coil voltage affects the valve's opening response time.

Exploratory Data Analysis

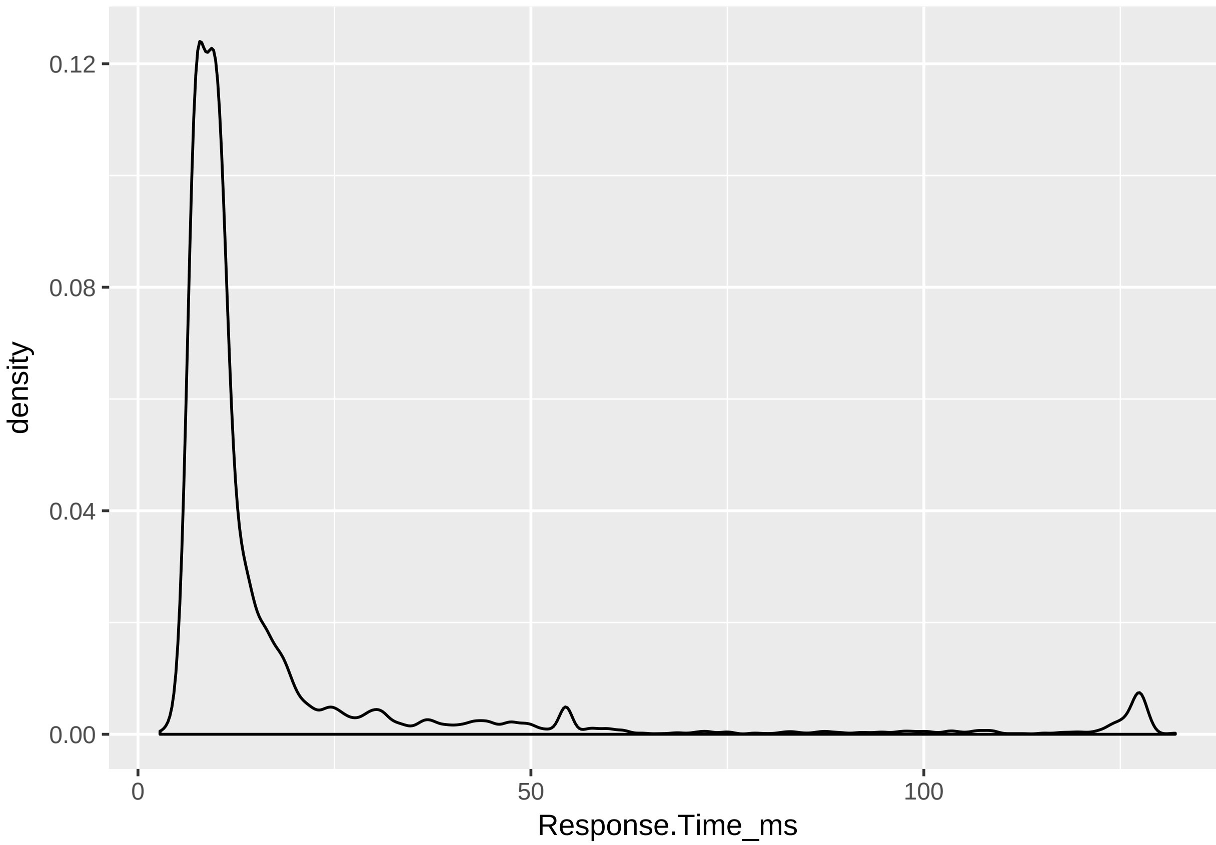
The summary of the data set is

```
##  Valve.Rev  Fluid    Time.Between.Actuations_hr Plunger.Age Coil.Age
##  New:2082   A: 845   Min.   :  0.0              New:2692    New:2722
##  Old:3118   B: 400   1st Qu.:  0.0              Old:2508    Old:2478
##             C: 378   Median : 24.0
##             D: 479   Mean   : 32.5
##             E:1059   3rd Qu.: 24.0
##             F:2039   Max.   :336.0
##  Voltage   Seal.Type Seal.Age   Response.Time_ms
##  24:1099   A:5080    New:2922   Min.   :  2.80
##  30:4101   B: 120    Old:2278   1st Qu.:  8.00
##                                 Median : 10.00
##                                 Mean   : 17.64
##                                 3rd Qu.: 14.40
##                                 Max.   :132.00
```

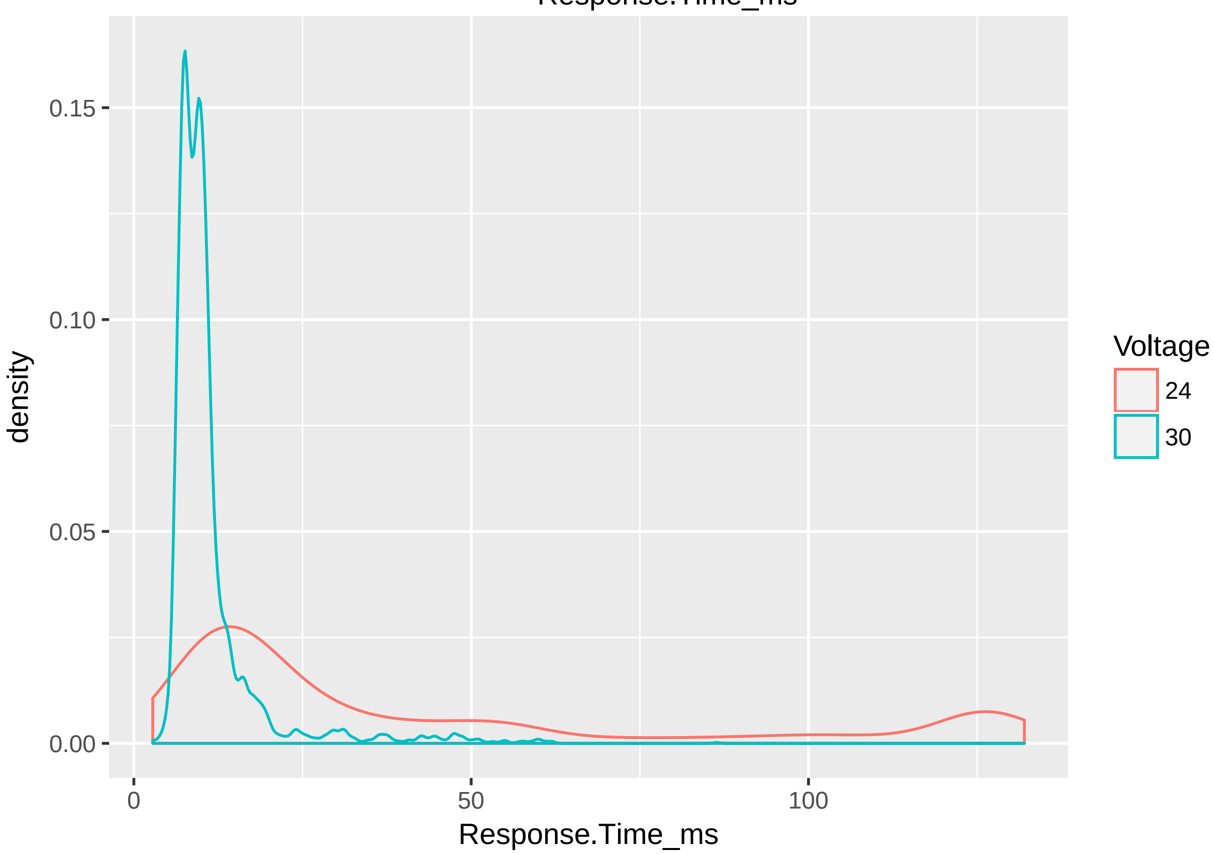
where *Valve.Rev* indicates the revision of the valve design, *Fluid* indicates the different fluids as masked factors, *Time.Between.Actuations_hr* indicates the time between valve actuations in hours, **.Age* indicates the age of the indicated component, *voltage* is the applied DC solenoid coil voltage, *Seal.Type* indicates the types of seal materials as masked factors, and *Response.Time_ms* is the time to open the valve in ms.

Plots

In the interest of report length, we show the following two density plots that illustrate the distribution of response time, overall and grouped by voltage, respectively. Additionally, box plots of response time versus the other variables would show how response time varies due to the other variables in the data set. Here, we see that the distribution of response time is right-skewed, therefore we will apply a log transformation before fitting a Bayesian regression model.



0.12
0.08
0.04
0.00
density
0
50
100
Response.Time_ms



0.15
0.10
0.05
0.00
density
0
50
100
Response.Time_ms
Voltage
24
30

Modeling

Here we will fit a Bayesian linear regression model from which we will see which predictors affect response time.

Finally, we will compute the probability that the response time is less than 100 ms given Voltage from our MCMC results.

```
## Compiling model graph
##    Resolving undeclared variables
##    Allocating nodes
## Graph information:
##    Observed stochastic nodes: 5200
##    Unobserved stochastic nodes: 10
##    Total graph size: 46987
##
## Initializing model
```

Using normal likelihood, with normal priors on the coefficients and inverse gamma prior for the variance, with tbd burn-in iterations, and tbd total iterations for the tbd chains, we get the following autocorrelation diagnostics

```
##             b[1]        b[2]        b[3]         b[4]      b[5]      b[6]
## Lag 0  1.0000000  1.00000000  1.00000000  1.000000000 1.0000000 1.0000000
## Lag 1  0.9931417  0.93260815  0.85806202  0.364637465 0.9932466 0.9634930
## Lag 5  0.9668374  0.70556927  0.50521392  0.118094329 0.9675641 0.8281543
## Lag 10 0.9355544  0.48875044  0.28988831  0.083146933 0.9379320 0.6818202
## Lag 50 0.7437230 -0.01120522 -0.02663393 -0.003050276 0.7662672 0.1466120
##             b[7]      b[8]      b[9]        sig2
## Lag 0  1.0000000 1.0000000 1.0000000 1.000000000
## Lag 1  0.9607584 0.9895931 0.9917703 0.001871715
## Lag 5  0.8256631 0.9497351 0.9653997 0.001988414
## Lag 10 0.6913494 0.9052649 0.9404616 0.002447130
## Lag 50 0.2677057 0.7048609 0.8041863 0.004066591
```

Here, we see that we haven't totally converged for parameters