R Notebook

Code

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```
#Loading the data file
attach(parkinsons_updrs)
```

```
The following objects are masked from parkinsons_updrs (pos = 3):

    age, DFA, HNR, Jitter..., Jitter.Abs., Jitter.DDP, Jitter.PPQ5,
    Jitter.RAP, motor_UPDRS, NHR, PPE, RPDE, sex, Shimmer, Shimmer.APQ11,
    Shimmer.APQ3, Shimmer.APQ5, Shimmer.dB., Shimmer.DDA, subject.,
    test_time, total_UPDRS

The following objects are masked from parkinsons_updrs (pos = 7):

    age, DFA, HNR, Jitter..., Jitter.Abs., Jitter.DDP, Jitter.PPQ5,
    Jitter.RAP, motor_UPDRS, NHR, PPE, RPDE, sex, Shimmer, Shimmer.APQ11,
    Shimmer.APQ3, Shimmer.APQ5, Shimmer.dB., Shimmer.DDA, subject.,
    test_time, total_UPDRS

The following object is masked from Boston:

    age
```

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```
#1- Datas's descriptive Information
summary(parkinsons_updrs)
```

```
   subject.          age            sex           test_time        motor_UPDRS
Min.   : 1.00   Min.   :36.0   Min.   :0.0000   Min.   : -4.263   Min.   : 5.038
1st Qu.:10.00   1st Qu.:58.0   1st Qu.:0.0000   1st Qu.: 46.847   1st Qu.:15.000
Median :22.00   Median :65.0   Median :0.0000   Median : 91.523   Median :20.871
Mean   :21.49   Mean   :64.8   Mean   :0.3178   Mean   : 92.864   Mean   :21.296
3rd Qu.:33.00   3rd Qu.:72.0   3rd Qu.:1.0000   3rd Qu.:138.445   3rd Qu.:27.596
Max.   :42.00   Max.   :85.0   Max.   :1.0000   Max.   :215.490   Max.   :39.511
 total_UPDRS      Jitter...         Jitter.Abs.          Jitter.RAP
Min.   : 7.00   Min.   :0.000830   Min.   :2.250e-06   Min.   :0.000330
1st Qu.:21.37   1st Qu.:0.003580   1st Qu.:2.244e-05   1st Qu.:0.001580
Median :27.58   Median :0.004900   Median :3.453e-05   Median :0.002250
Mean   :29.02   Mean   :0.006154   Mean   :4.403e-05   Mean   :0.002987
3rd Qu.:36.40   3rd Qu.:0.006800   3rd Qu.:5.333e-05   3rd Qu.:0.003290
Max.   :54.99   Max.   :0.099990   Max.   :4.456e-04   Max.   :0.057540
 Jitter.PPQ5         Jitter.DDP          Shimmer         Shimmer.dB.
Min.   :0.000430   Min.   :0.000980   Min.   :0.00306   Min.   :0.026
1st Qu.:0.001820   1st Qu.:0.004730   1st Qu.:0.01912   1st Qu.:0.175
Median :0.002490   Median :0.006750   Median :0.02751   Median :0.253
Mean   :0.003277   Mean   :0.008962   Mean   :0.03404   Mean   :0.311
3rd Qu.:0.003460   3rd Qu.:0.009870   3rd Qu.:0.03975   3rd Qu.:0.365
Max.   :0.069560   Max.   :0.172630   Max.   :0.26863   Max.   :2.107
 Shimmer.APQ3      Shimmer.APQ5     Shimmer.APQ11      Shimmer.DDA
Min.   :0.00161   Min.   :0.00194   Min.   :0.00249   Min.   :0.00484
1st Qu.:0.00928   1st Qu.:0.01079   1st Qu.:0.01566   1st Qu.:0.02783
Median :0.01370   Median :0.01594   Median :0.02271   Median :0.04111
Mean   :0.01716   Mean   :0.02014   Mean   :0.02748   Mean   :0.05147
3rd Qu.:0.02057   3rd Qu.:0.02375   3rd Qu.:0.03272   3rd Qu.:0.06173
Max.   :0.16267   Max.   :0.16702   Max.   :0.27546   Max.   :0.48802
     NHR                HNR               RPDE             DFA
Min.   :0.000286   Min.   : 1.659   Min.   :0.1510   Min.   :0.5140
1st Qu.:0.010955   1st Qu.:19.406   1st Qu.:0.4698   1st Qu.:0.5962
Median :0.018448   Median :21.920   Median :0.5423   Median :0.6436
Mean   :0.032120   Mean   :21.680   Mean   :0.5415   Mean   :0.6532
3rd Qu.:0.031463   3rd Qu.:24.444   3rd Qu.:0.6140   3rd Qu.:0.7113
Max.   :0.748260   Max.   :37.875   Max.   :0.9661   Max.   :0.8656
     PPE
Min.   :0.02198
1st Qu.:0.15634
Median :0.20550
Mean   :0.21959
3rd Qu.:0.26449
Max.   :0.73173
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```
str(parkinsons_updrs)
```

```
'data.frame':   5875 obs. of  22 variables:
 $ subject.     : int  1 1 1 1 1 1 1 1 1 1 ...
 $ age          : int  72 72 72 72 72 72 72 72 72 72 ...
 $ sex          : int  0 0 0 0 0 0 0 0 0 0 ...
 $ test_time    : num  5.64 12.67 19.68 25.65 33.64 ...
 $ motor_UPDRS  : num  28.2 28.4 28.7 28.9 29.2 ...
 $ total_UPDRS  : num  34.4 34.9 35.4 35.8 36.4 ...
 $ Jitter...    : num  0.00662 0.003 0.00481 0.00528 0.00335 0.00353 0.00422 0.00476 0.00432
0.00496 ...
 $ Jitter.Abs.  : num  3.38e-05 1.68e-05 2.46e-05 2.66e-05 2.01e-05 ...
 $ Jitter.RAP   : num  0.00401 0.00132 0.00205 0.00191 0.00093 0.00119 0.00212 0.00226 0.0015
6 0.00258 ...
 $ Jitter.PPQ5  : num  0.00317 0.0015 0.00208 0.00264 0.0013 0.00159 0.00221 0.00259 0.00207
0.00253 ...
 $ Jitter.DDP   : num  0.01204 0.00395 0.00616 0.00573 0.00278 ...
 $ Shimmer      : num  0.0256 0.0202 0.0168 0.0231 0.017 ...
 $ Shimmer.dB.  : num  0.23 0.179 0.181 0.327 0.176 0.214 0.445 0.212 0.371 0.31 ...
 $ Shimmer.APQ3 : num  0.01438 0.00994 0.00734 0.01106 0.00679 ...
 $ Shimmer.APQ5 : num  0.01309 0.01072 0.00844 0.01265 0.00929 ...
 $ Shimmer.APQ11: num  0.0166 0.0169 0.0146 0.0196 0.0182 ...
 $ Shimmer.DDA  : num  0.0431 0.0298 0.022 0.0332 0.0204 ...
 $ NHR          : num  0.0143 0.0111 0.0202 0.0278 0.0116 ...
 $ HNR          : num  21.6 27.2 23 24.4 26.1 ...
 $ RPDE         : num  0.419 0.435 0.462 0.487 0.472 ...
 $ DFA          : num  0.548 0.565 0.544 0.578 0.561 ...
 $ PPE          : num  0.16 0.108 0.21 0.333 0.194 ...
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```
#Missing Value check
missing_values_by_column <- apply(parkinsons_updrs, 2, function(x) sum(is.na(x)))
missing_values_by_column
```

```
     subject.           age           sex     test_time   motor_UPDRS   total_UPDRS
            0             0             0             0             0             0
    Jitter...   Jitter.Abs.    Jitter.RAP   Jitter.PPQ5    Jitter.DDP       Shimmer
            0             0             0             0             0             0
  Shimmer.dB.  Shimmer.APQ3  Shimmer.APQ5 Shimmer.APQ11   Shimmer.DDA           NHR
            0             0             0             0             0             0
          HNR          RPDE           DFA           PPE
            0             0             0             0
```

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```
#2- The correlation between the different attributes or variables
cor(parkinsons_updrs)
```

```
                 subject.          age           sex     test_time motor_UPDRS
subject.       1.0000000000 -0.030863612  0.2868514199 -0.0008815743  0.25291853
age           -0.0308636122  1.000000000 -0.0416017291  0.0198838435  0.27366476
sex            0.2868514199 -0.041601729  1.0000000000 -0.0098049838 -0.03120501
test_time     -0.0008815743  0.019883844 -0.0098049838  1.0000000000  0.06791826
motor_UPDRS    0.2529185298  0.273664760 -0.0312050144  0.0679182641  1.00000000
total_UPDRS    0.2536427490  0.310289929 -0.0965588806  0.0752626604  0.94723131
Jitter...      0.1354475184  0.023071181  0.0514216175 -0.0228370926  0.08481576
Jitter.Abs.    0.0751561345  0.035691340 -0.1546453007 -0.0113648117  0.05090328
Jitter.RAP     0.1203393232  0.010254988  0.0767182203 -0.0288878317  0.07268353
Jitter.PPQ5    0.1364738360  0.013199367  0.0879947680 -0.0232899083  0.07629087
Jitter.DDP     0.1203500584  0.010257836  0.0767031684 -0.0288759827  0.07269792
Shimmer        0.1462017730  0.101553856  0.0587357861 -0.0338701798  0.10234870
Shimmer.dB.    0.1428639729  0.111129664  0.0564805319 -0.0309624121  0.11007600
Shimmer.APQ3   0.1129497993  0.098912301  0.0449371995 -0.0290196929  0.08426056
Shimmer.APQ5   0.1382636007  0.089982893  0.0648192972 -0.0365044263  0.09210517
Shimmer.APQ11  0.1733326282  0.135237944  0.0233598626 -0.0391096958  0.13656029
Shimmer.DDA    0.1129486657  0.098913123  0.0449375945 -0.0290168593  0.08426039
NHR            0.1687433623  0.007092699  0.1681695195 -0.0263570332  0.07496727
HNR           -0.2069286890 -0.104842069 -0.0001671123  0.0365448637 -0.15702858
RPDE           0.1473003405  0.090208319 -0.1592624409 -0.0388869742  0.12860740
DFA            0.0974642595 -0.092870159 -0.1651134712  0.0192608786 -0.11624248
PPE            0.1575592025  0.120789753 -0.0999006846 -0.0005633701  0.16243297
               total_UPDRS   Jitter... Jitter.Abs.  Jitter.RAP Jitter.PPQ5
subject.       0.25364275  0.13544752  0.07515613  0.12033932  0.13647384
age            0.31028993  0.02307118  0.03569134  0.01025499  0.01319937
sex           -0.09655888  0.05142162 -0.15464530  0.07671822  0.08799477
test_time      0.07526266 -0.02283709 -0.01136481 -0.02888783 -0.02328991
motor_UPDRS    0.94723131  0.08481576  0.05090328  0.07268353  0.07629087
total_UPDRS    1.00000000  0.07424667  0.06692673  0.06401542  0.06335178
Jitter...      0.07424667  1.00000000  0.86557722  0.98418075  0.96821443
Jitter.Abs.    0.06692673  0.86557722  1.00000000  0.84462628  0.79053765
Jitter.RAP     0.06401542  0.98418075  0.84462628  1.00000000  0.94719593
Jitter.PPQ5    0.06335178  0.96821443  0.79053765  0.94719593  1.00000000
Jitter.DDP     0.06402746  0.98418354  0.84463035  0.99999962  0.94720256
Shimmer        0.09214091  0.70979112  0.64904638  0.68172901  0.73274748
Shimmer.dB.    0.09878973  0.71670399  0.65587068  0.68555054  0.73459079
Shimmer.APQ3   0.07936272  0.66414874  0.62382984  0.65022614  0.67671149
Shimmer.APQ5   0.08346725  0.69400164  0.62140081  0.65983121  0.73402075
Shimmer.APQ11  0.12083750  0.64596519  0.58999842  0.60308168  0.66841348
Shimmer.DDA    0.07936324  0.66414746  0.62382750  0.65022465  0.67671017
NHR            0.06095164  0.82529366  0.69995990  0.79237273  0.86486425
HNR           -0.16211683 -0.67518824 -0.70641805 -0.64147280 -0.66240886
RPDE           0.15689651  0.42712754  0.54709960  0.38289088  0.38150298
DFA           -0.11347483  0.22654994  0.35226386  0.21488132  0.17535854
PPE            0.15619488  0.72184881  0.78785284  0.67065210  0.66349144
               Jitter.DDP     Shimmer Shimmer.dB. Shimmer.APQ3 Shimmer.APQ5
subject.       0.12035006  0.14620177  0.14286397   0.11294980   0.13826360
age            0.01025784  0.10155386  0.11112966   0.09891230   0.08998289
sex            0.07670317  0.05873579  0.05648053   0.04493720   0.06481930
test_time     -0.02887598 -0.03387018 -0.03096241  -0.02901969  -0.03650443
motor_UPDRS    0.07269792  0.10234870  0.11007600   0.08426056   0.09210517
total_UPDRS    0.06402746  0.09214091  0.09878973   0.07936272   0.08346725
Jitter...      0.98418354  0.70979112  0.71670399   0.66414874   0.69400164
Jitter.Abs.    0.84463035  0.64904638  0.65587068   0.62382984   0.62140081
```

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Jitter.RAP     0.99999962  0.68172901  0.68555054   0.65022614   0.65983121
Jitter.PPQ5    0.94720256  0.73274748  0.73459079   0.67671149   0.73402075
Jitter.DDP     1.00000000  0.68173376  0.68555613   0.65022816   0.65983319
Shimmer        0.68173376  1.00000000  0.99233407   0.97982804   0.98490432
Shimmer.dB.    0.68555613  0.99233407  1.00000000   0.96801480   0.97637257
Shimmer.APQ3   0.65022816  0.97982804  0.96801480   1.00000000   0.96272296
Shimmer.APQ5   0.65983319  0.98490432  0.97637257   0.96272296   1.00000000
Shimmer.APQ11  0.60309033  0.93545684  0.93633812   0.88569537   0.93893494
Shimmer.DDA    0.65022667  0.97982731  0.96801427   0.99999998   0.96272308
NHR            0.79237731  0.79515848  0.79807697   0.73273634   0.79817315
HNR           -0.64148177 -0.80141600 -0.80249646  -0.78069689  -0.79063822
RPDE           0.38288580  0.46823455  0.47240859   0.43687810   0.45088990
DFA            0.21489299  0.13253994  0.12611117   0.13073500   0.12803754
PPE            0.67066035  0.61570856  0.63516268   0.57670395   0.59367655
               Shimmer.APQ11 Shimmer.DDA          NHR            HNR        RPDE
subject.         0.17333263  0.11294867  0.168743362 -0.2069286890  0.14730034
age              0.13523794  0.09891312  0.007092699 -0.1048420689  0.09020832
sex              0.02335986  0.04493759  0.168169520 -0.0001671123 -0.15926244
test_time       -0.03910970 -0.02901686 -0.026357033  0.0365448637 -0.03888697
motor_UPDRS      0.13656029  0.08426039  0.074967270 -0.1570285788  0.12860740
total_UPDRS      0.12083750  0.07936324  0.060951644 -0.1621168287  0.15689651
Jitter...        0.64596519  0.66414746  0.825293655 -0.6751882442  0.42712754
Jitter.Abs.      0.58999842  0.62382750  0.699959896 -0.7064180505  0.54709960
Jitter.RAP       0.60308168  0.65022465  0.792372728 -0.6414728036  0.38289088
Jitter.PPQ5      0.66841348  0.67671017  0.864864252 -0.6624088579  0.38150298
Jitter.DDP       0.60309033  0.65022667  0.792377310 -0.6414817715  0.38288580
Shimmer          0.93545684  0.97982731  0.795158485 -0.8014160019  0.46823455
Shimmer.dB.      0.93633812  0.96801427  0.798076972 -0.8024964615  0.47240859
Shimmer.APQ3     0.88569537  0.99999998  0.732736344 -0.7806968895  0.43687810
Shimmer.APQ5     0.93893494  0.96272308  0.798173148 -0.7906382164  0.45088990
Shimmer.APQ11    1.00000000  0.88569414  0.711546170 -0.7779743467  0.48073856
Shimmer.DDA      0.88569414  1.00000000  0.732733983 -0.7806962950  0.43687244
NHR              0.71154617  0.73273398  1.000000000 -0.6844118571  0.41665964
HNR             -0.77797435 -0.78069630 -0.684411857  1.0000000000 -0.65905315
RPDE             0.48073856  0.43687244  0.416659644 -0.6590531523  1.00000000
DFA              0.17964765  0.13073592 -0.022087779 -0.2905194517  0.19203007
PPE              0.62341606  0.57670220  0.564654472 -0.7587222059  0.56606485
                      DFA           PPE
subject.       0.09746426  0.1575592025
age           -0.09287016  0.1207897526
sex           -0.16511347 -0.0999006846
test_time      0.01926088 -0.0005633701
motor_UPDRS   -0.11624248  0.1624329732
total_UPDRS   -0.11347483  0.1561948752
Jitter...      0.22654994  0.7218488137
Jitter.Abs.    0.35226386  0.7878528397
Jitter.RAP     0.21488132  0.6706520982
Jitter.PPQ5    0.17535854  0.6634914441
Jitter.DDP     0.21489299  0.6706603464
Shimmer        0.13253994  0.6157085590
Shimmer.dB.    0.12611117  0.6351626782
Shimmer.APQ3   0.13073500  0.5767039508
Shimmer.APQ5   0.12803754  0.5936765462
Shimmer.APQ11  0.17964765  0.6234160550
Shimmer.DDA    0.13073592  0.5767021962
NHR           -0.02208778  0.5646544721
```

```
HNR           -0.29051945 -0.7587222059
RPDE           0.19203007  0.5660648549
DFA            1.00000000  0.3946496554
PPE            0.39464966  1.0000000000
```

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```
# We can observe de 1's along the diagonal for the correlation matrix
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```
#3- Divide the data into training and testing

#a) Divide the data into training and testing sets
library(caret)
set.seed(123) # for reproducibility

# Create a vector of row indices
rows <- 1:nrow(parkinsons_updrs)


# Randomly sample 80% of the row indices for the training set
training_rows <- sample(rows, floor(0.8 * length(rows)))

# The remaining rows are for the testing set
testing_rows <- setdiff(rows, training_rows)

# Write the training and testing sets to separate files
write.table(parkinsons_updrs[training_rows, ], file = "Park_training_data.txt", row.names = F
ALSE, col.names = FALSE)
write.table(parkinsons_updrs[testing_rows, ], file = "Park_testing_data.txt", row.names = FAL
SE, col.names = FALSE)

training_data <- parkinsons_updrs[training_rows, ]
testing_data <- parkinsons_updrs[-training_rows, ]

# Remove the variable 'motor_UPDRS' (Training and Testing)
training_data_new <- subset(training_data, select = -motor_UPDRS)
testing_data_new <- subset(testing_data, select = -motor_UPDRS)

#b) Division Verification in number of Examples
cat("Number of examples in training data:", nrow(training_data_new), "\n")
```

```
Number of examples in training data: 4700
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```
cat("Number of examples in testing data:", nrow(testing_data_new), "\n")
```

```
Number of examples in testing data: 1175
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```
#4- Multiple Regression Model Generation

parkinsons_updrs_model=lm(total_UPDRS~., data=training_data_new)

# Use the model to make predictions on the testing data
predictions <- predict(parkinsons_updrs_model, newdata = testing_data_new)

#a) Significant predictors
summary(parkinsons_updrs_model)
```

```

Call:
lm(formula = total_UPDRS ~ ., data = training_data_new)

Residuals:
    Min      1Q  Median      3Q     Max 
-27.478  -6.760  -1.208   7.082  23.747 

Coefficients:
               Estimate Std. Error t value Pr(>|t|)    
(Intercept)    3.470e+01  3.420e+00  10.147  < 2e-16 ***
subject.       2.649e-01  1.214e-02  21.815  < 2e-16 ***
age            3.145e-01  1.618e-02  19.441  < 2e-16 ***
sex           -5.091e+00  3.514e-01 -14.490  < 2e-16 ***
test_time      1.762e-02  2.560e-03   6.883 6.66e-12 ***
Jitter...     -2.741e+02  2.321e+02  -1.181 0.237728    
Jitter.Abs.   -5.180e+04  1.043e+04  -4.966 7.07e-07 ***
Jitter.RAP    -3.157e+04  5.008e+04  -0.631 0.528387    
Jitter.PPQ5   -1.543e+02  2.110e+02  -0.732 0.464444    
Jitter.DDP     1.093e+04  1.669e+04   0.655 0.512698    
Shimmer       -2.371e+01  6.875e+01  -0.345 0.730199    
Shimmer.dB.    1.994e+00  5.310e+00   0.376 0.707245    
Shimmer.APQ3  -2.594e+04  5.005e+04  -0.518 0.604227    
Shimmer.APQ5   8.380e+01  6.201e+01   1.351 0.176644    
Shimmer.APQ11  8.355e+00  2.946e+01   0.284 0.776700    
Shimmer.DDA    8.592e+03  1.668e+04   0.515 0.606550    
NHR           -2.472e+01  6.726e+00  -3.675 0.000241 ***
HNR           -5.002e-01  7.379e-02  -6.778 1.36e-11 ***
RPDE           2.515e+00  1.956e+00   1.285 0.198696    
DFA           -3.552e+01  2.474e+00 -14.357  < 2e-16 ***
PPE            1.691e+01  3.122e+00   5.417 6.37e-08 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.31 on 4679 degrees of freedom
Multiple R-squared:  0.2539,    Adjusted R-squared:  0.2507 
F-statistic: 79.62 on 20 and 4679 DF,  p-value: < 2.2e-16
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```
summary(predictions)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  17.02   25.21   28.88   29.21   33.41   56.33 
```

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```
# from the generated summary of the full model the most significant predictors in the model a
re subject, age, sex , test_time, Jitter.Abs, NHR, HNR, DFA and PPE due to having a p-value l
ess than 0.05 according to 95% global significance and also due to having t-values far from
0.

#b) # Extraction of the RSE and R-squared values
# Calculate the residuals
residuals <- predictions - testing_data_new$total_UPDRS
residuals
```

```
           4            6            9           11           14           15
-5.850950e+00 -7.267972e+00 -1.048139e+01 -1.199183e+01 -1.295030e+01 -1.114343e+01
          22           24           28           29           33           39
-1.298773e+01 -1.748493e+01 -9.110280e+00 -7.016737e+00 -1.078024e+01 -1.367471e+01
          40           43           46           48           53           62
-1.331402e+01 -1.464697e+01 -1.543799e+01 -1.711410e+01 -9.541226e+00 -1.150416e+01
          73           74           80           85           86           91
-1.408013e+01 -1.848299e+01 -8.681579e+00 -7.478285e+00 -1.171016e+01 -1.283805e+01
          93           99          100          104          106          110
-1.297034e+01 -1.391197e+01 -6.734715e+00 -6.179135e+00 -3.732452e+00 -7.478597e+00
         111          115          118          126          133          155
-1.070107e+01 -1.358182e+01 -1.400101e+01 -5.903406e+00 -8.670158e+00  6.289306e+00
         157          158          160          168          174          175
 6.671686e+00  6.981452e+00  6.737476e+00  2.292998e+00  3.242177e-01  5.210826e+00
         176          177          184          188          189          190
 4.261181e+00  2.980151e+00  7.841258e+00  4.554901e+00  5.947664e+00  3.720704e+00
         202          205          208          210          221          225
 4.868204e+00  5.134081e+00  7.655663e+00  4.486055e+00  1.360173e+00  3.756175e+00
         226          228          233          237          245          247
 3.868861e+00  4.573308e+00  7.392348e+00  4.170399e+00 -4.730372e-01  1.176441e+00
         248          254          280          282          285          293
-1.141522e+00  5.961511e+00  6.343417e+00  5.296901e+00  2.958371e+00 -1.068316e+00
         298          308          310          312          313          320
-5.292230e+00 -1.024852e+01 -1.243707e+01 -1.225423e+01 -1.140088e+01 -3.045048e+00
         321          322          329          330          332          348
-5.397950e+00 -4.651032e+00 -1.208103e+01 -8.945275e+00 -9.065129e+00 -5.196760e+00
         349          355          356          360          367          380
-3.940883e+00 -1.090459e+01 -1.029325e+01 -1.366194e+01 -2.931524e+00 -1.013950e+01
         389          397          399          405          406          411
-1.483452e+01 -5.921409e+00 -9.483751e+00 -8.877713e+00 -1.205959e+01 -1.263952e+01
         417          424          425          430          437          446
-2.465164e-02 -1.004496e+01 -9.769617e+00 -9.137581e+00 -1.148368e+01  6.358819e+00
         452          454          455          477          488          493
 1.559293e+00  3.908019e+00  4.237095e+00  3.094971e+00  1.034992e+01  4.127629e+00
         495          499          501          509          510          512
 1.346839e+00  3.482904e+00  2.250759e+00  1.236858e+01  1.296980e+01  1.136620e+01
         516          530          538          540          545          554
 5.352300e+00  1.503114e+01  3.704592e+00  5.165107e+00  3.005419e+00  1.050379e+01
         557          565          566          571          580          585
 1.070493e+01  4.542720e+00  2.827474e+00  5.310706e+00 -1.112650e+01 -1.171977e+01
         591          593          596          597          605          611
-1.590351e+01 -1.053589e+01 -1.155315e+01 -1.048584e+01 -1.111445e+01 -1.031197e+01
         619          622          628          635          645          657
-1.284018e+01 -1.098715e+01 -1.236845e+01 -1.246837e+01 -1.137597e+01 -1.158041e+01
         662          679          681          685          687          692
-1.069487e+01 -1.124696e+01 -1.011338e+01 -1.137829e+01 -1.410587e+01 -1.205584e+01
         695          698          702          704          709          717
-1.222280e+01 -1.077093e+01 -1.088868e+01 -1.131298e+01 -9.000487e+00 -1.477017e+01
         722          725          726          728          731          734
-1.210385e+01 -8.983606e+00 -1.150645e+01 -1.071998e+01 -1.193319e+01 -8.857284e+00
         736          737          749          751          762          766
-1.381907e+01 -1.421926e+01 -1.715990e+01 -1.513085e+01 -1.304782e+01 -1.141681e+01
         770          773          784          801          802          806
-1.453692e+01 -1.658318e+01 -1.328664e+01 -1.394698e+01 -1.723296e+01 -1.737823e+01
         824          826          833          848          857          865
```

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-1.065843e+01 -1.655820e+01 -1.865845e+01 -1.424033e+01 -1.851354e+01 -1.258941e+01
          868           869           876           888           889           895
-1.229589e+01 -1.397855e+01 -1.449363e+01  7.767761e+00  5.643268e+00  6.217903e+00
          902           918           921           937           939           940
 1.031997e+01  7.127128e+00  4.883765e+00  4.578252e+00  6.304317e+00  5.325400e+00
          941           944           947           952           955           962
 3.669081e+00  6.352273e+00  6.568008e+00  7.987273e+00  1.055329e+01  7.487318e+00
          965           966           973           975           991           992
 6.565247e+00  5.685045e+00  6.652566e+00  6.632641e+00  6.327973e+00  5.645290e+00
          994           996          1011          1012          1013          1018
 6.833585e+00  6.561013e+00  1.329114e+01  1.379686e+01  1.232296e+01  4.293825e+00
         1020          1024          1033          1036          1039          1051
 5.598474e+00  5.835043e+00  7.109486e+00  1.049578e+01  1.292935e+01 -3.031523e-01
         1052          1067          1076          1090          1092          1097
-1.548624e+00 -3.156618e+00 -1.169495e+00  4.942289e+00 -4.046275e+00 -5.607906e-01
         1112          1115          1124          1125          1138          1141
 7.643254e+00  8.446577e+00 -5.139435e-01  1.375060e-01 -1.158936e+00 -2.801734e+00
         1143          1145          1150          1155          1159          1160
-3.342073e+00 -3.791306e+00  1.483592e+00 -1.744122e+00 -2.095245e-01  9.003981e-01
         1172          1174          1177          1181          1187          1197
-2.272653e+00 -6.251567e-01  2.072767e+00 -1.424836e+00  3.866698e+00 -2.870350e+00
         1200          1206          1207          1216          1218          1220
 2.718826e+00  2.862585e+00 -2.316659e-01  1.296955e+00  3.531767e+00  1.664635e+00
         1221          1228          1242          1245          1247          1253
 1.204563e+00  1.015569e+00  3.062315e+00  1.361554e+00  3.479281e+00 -5.810412e-01
         1259          1263          1269          1271          1277          1282
-9.648501e-01  3.103015e-01 -1.373153e+00  3.472496e-01  3.930389e+00 -1.899809e+00
         1285          1287          1288          1303          1305          1310
 7.571380e-01  2.975082e+00  5.073722e+00  2.503727e-01  1.951561e+00 -3.358359e-01
         1311          1320          1336          1338          1348          1361
 1.180067e-01  2.795654e-01 -1.504337e+00  3.116373e+00  4.650263e+00  5.605720e+00
         1367          1375          1377          1378          1382          1383
 6.510535e+00  2.628410e+00  2.251192e+00  2.135514e+00  2.450596e+00  1.028842e+00
         1387          1390          1396          1413          1414          1418
 2.921897e+00  7.878649e+00  4.817347e+00  4.590527e+00  6.769526e+00  8.475731e+00
         1422          1428          1434          1439          1440          1441
 5.760805e+00  2.366153e+00  3.640512e+00  5.893976e+00  3.429478e+00  3.613680e+00
         1443          1451          1454          1457          1459          1460
 4.747398e+00  3.638088e+00  6.497547e+00  6.368757e+00  8.173805e+00  5.601079e+00
         1461          1463          1473          1478          1480          1483
 9.554260e+00  8.888612e+00  4.542263e+00  5.698298e+00  7.849973e+00  6.268725e+00
         1484          1487          1491          1497          1500          1502
 7.972592e+00  9.163273e+00  9.153969e+00  6.514529e+00  1.889892e+00  4.521506e+00
         1503          1504          1508          1510          1511          1514
 1.967703e+00  2.479395e+00 -9.726436e-01 -2.583348e+00 -2.669104e+00  2.726268e+00
         1515          1519          1524          1525          1527          1528
 2.383286e+00  4.449688e+00  6.262107e-01  3.055589e+00  1.273121e+00 -8.939965e-01
         1529          1530          1535          1536          1540          1555
-7.992825e-01 -3.633375e-01 -2.298564e+00  1.390824e+00  4.879550e-01 -3.063932e+00
         1558          1560          1580          1581          1586          1590
-1.011165e+00 -1.080932e+00 -1.679122e+00 -1.545274e-01  2.364719e+00  5.226169e+00
         1592          1594          1595          1602          1603          1608
 3.298010e+00  4.459113e+00  2.887446e+00  3.282325e-01  7.541470e-01  4.001288e+00
         1617          1624          1628          1640          1642          1649
 5.274270e+00  1.583846e+00  4.799106e+00  1.633992e+00  3.442110e+00  9.074069e+00
         1669          1670          1674          1681          1683          1687
```

```
 7.801736e+00  6.457146e+00 -2.000910e+00  9.214258e+00  5.492384e+00  9.727202e+00
         1688          1695          1704          1718          1719          1728
 7.151151e+00  3.664744e+00  5.799610e+00  1.014445e+01  9.531790e+00  6.132460e-01
         1729          1731          1732          1745          1764          1765
 1.502467e+00  5.628196e+00  6.677050e+00  3.382959e+00  2.514531e-01  4.648718e-01
         1769          1772          1784          1786          1800          1817
 4.905888e-01  4.233201e+00  2.925829e+00  9.380108e-01 -8.994792e+00 -7.627628e+00
         1819          1824          1825          1826          1845          1861
 8.696264e-01  6.056468e-01  2.483615e+00  1.110412e+00  4.117189e+00  5.590285e+00
         1871          1872          1879          1890          1891          1897
 4.760814e-01 -6.062571e-01  9.315888e+00  1.093652e+00  3.018085e-01 -1.177371e+00
         1903          1910          1915          1917          1918          1919
 8.244195e+00  2.376805e+00  2.474765e+00 -1.841928e+00  2.165460e-02 -7.202496e-01
         1922          1929          1937          1939          1940          1946
-4.944315e+00  4.508604e+00  2.348675e+00  2.411100e-01 -4.402029e-01 -5.648929e+00
         1952          1953          1958          1968          1978          1983
 7.450772e+00  6.256618e+00  2.075956e+00 -2.875056e+00  3.184423e+00  2.776487e+00
         1985          1986          1991          1998          2000          2007
 1.389767e+00  2.950244e+00 -4.458690e+00  9.949727e+00  9.217535e+00  9.842696e+00
         2014          2015          2020          2023          2030          2039
 7.422307e+00  1.213443e+01  1.031588e+01  8.742092e+00  9.074352e+00  1.458822e+01
         2040          2043          2048          2050          2061          2090
 1.097547e+01  7.563353e+00  8.356157e+00  8.483823e+00  7.345245e+00  1.428097e+01
         2092          2094          2097          2102          2103          2110
 8.126075e+00  9.986381e+00  9.832403e+00  6.272572e+00  7.595558e+00  5.362587e+00
         2114          2116          2123          2126          2134          2149
 1.018900e+01  7.923188e+00  1.002325e+01  7.363818e+00  5.744308e+00  8.249024e+00
         2152          2156          2159          2162          2171          2183
 9.140153e+00  7.340820e+00  1.067147e+01  1.181857e+01  1.058530e+01  1.315806e+01
         2184          2188          2190          2193          2197          2205
 1.145541e+01  1.134872e+01  9.017065e+00  8.168972e+00  8.655013e+00  1.007060e+01
         2209          2212          2215          2221          2230          2235
 9.430038e+00  1.178022e+01  1.031932e+01  8.636573e+00  1.031183e+01  1.198656e+01
         2236          2237          2241          2243          2252          2253
 1.020884e+01  1.099037e+01  8.998170e+00  1.049300e+01  1.307893e+01  1.157287e+01
         2254          2264          2267          2270          2271          2282
 1.335902e+01  1.050699e+01  8.677989e+00  8.527400e+00  7.458765e+00 -1.170548e+01
         2289          2293          2297          2303          2307          2309
-9.651211e+00 -3.360234e+00 -8.333764e-01 -7.124470e+00 -1.463081e+01 -1.405402e+01
         2310          2316          2322          2326          2327          2332
-1.553960e+01 -5.067475e+00 -2.802865e+00 -8.436893e+00 -9.913465e+00 -1.462616e+01
         2334          2346          2351          2364          2370          2372
-1.141547e+01 -3.562224e+00 -1.158614e+01 -6.026876e+00 -3.098870e+00 -4.647759e+00
         2374          2377          2380          2382          2384          2386
-7.674412e+00 -1.142166e+01 -1.410789e+01 -1.465086e+01 -8.956495e+00 -4.328970e+00
         2388          2391          2393          2397          2400          2404
-3.936381e+00 -6.296379e-01 -1.202869e-01 -5.251851e+00 -8.945230e+00 -1.561971e+01
         2409          2410          2414          2415          2430          2440
-7.544872e+00 -5.672049e+00 -8.112926e-01  8.121194e-01  1.924064e+01  1.991496e+01
         2442          2445          2452          2458          2459          2462
 2.054317e+01  2.175737e+01  2.231184e+01  2.222969e+01  1.954923e+01  2.609968e+01
         2472          2478          2497          2500          2501          2515
 2.004914e+01  2.448828e+01  2.322255e+01  2.092601e+01  1.881512e+01  2.220024e+01
         2516          2524          2526          2534          2541          2543
 1.942616e+01  2.094844e+01  1.974961e+01  1.888351e+01  2.268463e+01 -7.566856e-01
         2548          2551          2557          2561          2566          2568
```

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-1.196874e+00  3.470228e-02  2.798895e-01  3.094404e+00 -1.228531e-02  3.234099e-01
         2569          2595          2598          2609          2611          2613
-1.953593e+00 -9.800621e-01 -1.876986e+00 -2.039406e+00 -1.388924e-01 -4.688419e-02
         2621          2622          2625          2632          2637          2638
-1.122039e+00  1.488695e+00  1.536481e+00 -8.694557e-01 -2.675465e+00 -2.773589e-01
         2642          2644          2648          2672          2679          2680
 1.207929e+00  4.484710e-01  2.478063e+00  7.295340e+00  6.971569e+00  7.724285e+00
         2681          2689          2694          2695          2696          2701
 8.320565e+00  1.079081e+01  4.938942e+00  2.933212e+00  2.770136e+00  6.953030e+00
         2702          2703          2704          2709          2713          2720
 7.416941e+00  1.133231e+01  1.050288e+01  1.066834e+01  1.231129e+01  5.551111e+00
         2725          2733          2736          2754          2766          2769
 8.728501e+00  1.306405e+01  1.104534e+01  1.153770e+01  8.759479e+00  8.802076e+00
         2770          2772          2782          2783          2790          2793
 9.967458e+00  1.377293e+01  1.219113e+01  1.195701e+01  9.667518e+00  1.078946e+01
         2796          2814          2815          2825          2828          2844
 1.385807e+01 -3.757531e+00 -5.483660e+00 -9.491868e+00 -9.178050e+00 -9.615160e+00
         2848          2857          2863          2872          2874          2877
-1.026890e+01 -2.253843e+00 -7.216520e+00 -7.205824e+00 -5.795584e+00 -2.820642e+00
         2883          2891          2904          2909          2912          2915
-9.061690e+00 -4.648731e+00 -8.208249e+00 -6.707784e+00 -3.590909e+00 -1.889002e+00
         2916          2919          2920          2929          2932          2943
-1.264410e+00 -2.427294e+00  1.330876e+00  8.081866e+00  7.932211e+00  1.020485e+01
         2947          2956          2969          2983          2990          2993
 6.823878e+00  1.216186e+01  6.920228e+00  6.978307e+00  9.646469e+00  1.208992e+01
         3003          3005          3015          3018          3020          3021
 5.694825e+00  7.715033e+00  1.346563e+01  1.085663e+01  8.151243e+00  8.507793e+00
         3025          3031          3036          3037          3044          3047
 9.152034e+00  1.152915e+01  1.177571e+01  1.020319e+01  8.226142e-01 -3.164845e-01
         3052          3058          3062          3070          3088          3089
-4.059770e+00 -4.721815e+00 -1.414906e+00 -1.964353e+00  5.921522e-01  2.796820e-01
         3096          3097          3098          3102          3105          3114
-5.968163e+00 -5.131726e+00 -7.156018e+00 -7.202315e+00 -5.332805e+00 -3.834887e-01
         3117          3120          3122          3123          3125          3131
-3.688430e+00 -3.650950e+00 -6.070459e+00 -5.205808e+00 -5.236104e+00 -2.364152e+00
         3143          3145          3153          3161          3162          3169
-4.945620e+00 -4.581739e+00 -3.876126e+00 -1.594714e+00  8.004301e-01 -5.800631e+00
         3178          3181          3184          3186          3197          3199
-1.810546e+00  1.156254e+01  8.584609e+00  1.068912e+01  9.517086e+00  1.115643e+01
         3206          3217          3218          3225          3231          3232
 1.156749e+01  9.844805e+00  1.141622e+01  1.149137e+01  1.367779e+01  1.027895e+01
         3233          3234          3251          3254          3269          3273
 1.072203e+01  1.083187e+01  1.074746e+01  9.610845e+00  9.857780e+00  1.035782e+01
         3276          3278          3284          3286          3291          3292
 1.006829e+01  9.057748e+00  1.315337e+01  1.309759e+01  1.013360e+01  1.074342e+01
         3296          3313          3319          3326          3329          3330
 7.856390e+00  8.284300e+00  9.660959e+00  1.040442e+01  9.810731e+00  1.018617e+01
         3342          3345          3346          3351          3355          3357
-1.131264e+01 -9.959475e+00 -9.866629e+00 -9.890160e+00 -1.297253e+01 -1.404039e+01
         3363          3376          3381          3382          3383          3386
-9.532829e+00 -1.359159e+01 -1.515640e+01 -1.289811e+01 -6.737915e+00 -1.051500e+01
         3387          3390          3392          3408          3409          3410
-9.892746e+00 -1.131513e+01 -1.232810e+01 -8.285928e+00 -9.090151e+00 -9.559931e+00
         3418          3422          3433          3439          3441          3448
-8.128369e+00 -1.116938e+01 -7.666399e+00 -1.118111e+01 -1.127318e+01 -1.398869e+01
         3450          3454          3459          3460          3471          3473
```

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-1.231178e+01 -1.518135e+01 -6.887098e+00 -9.843093e+00 -1.144958e+01 -1.289928e+01
         3474          3478          3479          3486          3497          3511
-1.275511e+01 -1.422298e+01 -5.957303e+00 -7.756944e+00  9.830304e-01 -8.161538e+00
         3518          3522          3528          3542          3557          3558
 2.917208e+00 -4.108211e+00 -3.952469e+00  2.776535e+00 -2.214405e+00 -1.565349e+00
         3561          3564          3568          3573          3574          3577
 2.397224e+00  4.235331e+00 -7.319721e+00 -6.057239e+00 -8.618228e+00 -8.004384e+00
         3578          3580          3582          3590          3592          3604
-6.995049e+00 -2.807078e+00 -4.117990e+00 -5.318086e+00 -5.829545e+00 -1.691753e+00
         3608          3611          3623          3633          3634          3639
 3.154236e+00  6.673555e+00  5.281645e+00  6.212051e+00  7.647293e+00  7.297566e+00
         3643          3648          3667          3671          3676          3679
 5.834934e+00 -2.809326e-01  8.047332e+00  4.986401e+00  8.370050e+00  5.431434e+00
         3686          3689          3694          3695          3697          3700
 4.237720e+00  4.636480e+00  3.597813e+00  7.363414e+00  8.405975e+00  7.924180e+00
         3704          3711          3719          3722          3729          3731
 1.044317e+01  4.609159e+00  7.898513e+00  7.190971e+00  6.011456e+00  7.625737e+00
         3733          3734          3738          3739          3748          3754
 4.597374e+00  6.301127e+00 -1.165001e+01 -1.235064e+01 -7.286945e+00 -4.044750e-01
         3757          3758          3760          3761          3766          3767
 4.025574e+00  1.846853e+00  6.061176e+00 -1.055786e+01 -9.240695e+00 -1.104473e+01
         3773          3776          3777          3778          3780          3793
-4.080305e+00 -3.856345e+00 -2.263416e+00  1.249383e+00  2.060508e+00 -7.907332e+00
         3796          3803          3817          3818          3819          3826
-6.423409e+00  3.561076e+00 -7.223733e+00 -6.698435e+00 -3.709735e+00  3.696065e+00
         3828          3837          3841          3844          3849          3850
-9.017436e+00 -7.804765e+00 -5.470130e-01  1.313715e+00  6.166294e+00 -1.029903e+01
         3864          3865          3868          3869          3877          3884
-2.135296e+00 -2.560731e+00  5.573033e+00  8.389008e+00  5.444971e+00  8.040303e+00
         3885          3887          3888          3892          3904          3905
 9.503697e+00  8.827390e+00  6.614732e+00  5.385449e+00  2.087923e+00  2.157591e+00
         3914          3923          3924          3925          3927          3928
 7.680844e+00  4.356114e+00  4.508745e+00  4.059356e+00  2.059827e+00  1.721856e+00
         3931          3935          3940          3944          3945          3950
 2.150357e+00  5.082151e+00  9.226192e+00  6.381367e+00  8.013186e+00  4.771338e+00
         3953          3957          3961          3969          3973          3979
 3.776655e+00  8.649664e-01  2.877079e+00  8.913134e+00  7.463028e+00  3.288271e+00
         3981          3985          3986          3993          3994          3998
 5.191108e+00  2.150118e+00  4.342244e+00  8.409339e+00  6.557602e+00  9.510526e+00
         4006          4008          4010          4020          4025          4028
 7.094617e+00  5.138363e+00  5.310781e+00  6.668146e+00  8.976660e+00  8.368502e+00
         4031          4038          4039          4041          4049          4064
 6.199132e+00  4.594630e+00  4.353128e+00 -2.034991e+01 -1.161182e+01  1.443172e+01
         4077          4097          4099          4102          4110          4118
-6.696048e+00 -3.331388e+00 -6.692667e+00 -4.652185e+00 -1.313256e+01 -6.773587e+00
         4122          4123          4127          4146          4148          4150
-2.922873e+00 -3.535797e+00 -1.850434e+01 -1.978695e+01 -2.009422e+01 -1.531124e+01
         4153          4161          4165          4170          4178          4181
-1.279074e+01 -6.104882e+00 -4.795431e+00  7.956913e-01  1.298848e+00  9.429419e+00
         4188          4191          4192          4193          4194          4201
 5.488099e+00 -1.181531e+00  3.452003e+00  7.297484e-02 -3.151491e+00  6.943400e+00
         4202          4207          4211          4215          4221          4227
 5.354307e+00  1.563266e+01  3.105993e+00  1.384614e+00  2.409660e+00  8.771844e+00
         4229          4231          4232          4234          4241          4245
 1.876885e+01  3.606851e+00  3.447385e+00  4.713330e-01  1.395865e+00  4.669354e+00
         4248          4250          4264          4267          4270          4273
```

```
 8.801702e+00  1.490608e+01  2.498728e+00  4.605145e+00  1.021001e+01  1.284106e+01
         4277          4283          4285          4287          4288          4289
 2.795764e+00 -3.653937e-04  2.603763e+00  3.810257e+00  3.758529e+00  5.818279e+00
         4296          4304          4305          4308          4309          4323
-3.846061e-01  9.376719e+00  1.043718e+01  8.436762e+00  6.528771e+00  1.112283e+01
         4330          4334          4337          4344          4350          4351
-9.614314e-01  4.138826e+00  7.075246e+00  6.607043e+00  5.432785e+00  4.676128e+00
         4352          4358          4363          4365          4369          4378
 8.448956e+00  9.026329e+00  7.496168e+00  9.838964e-01  7.558611e+00  1.044949e+01
         4379          4391          4394          4400          4401          4402
 1.056295e+01  1.505129e+01  1.166765e+01  5.149405e+00  4.397934e+00  3.961647e+00
         4411          4430          4433          4435          4436          4438
 2.245626e+00  1.816009e+00  2.528094e+00  3.876882e+00  4.675037e+00  3.948292e+00
         4441          4443          4453          4457          4463          4465
 5.128380e+00  4.432469e+00  6.378027e+00  1.756606e+00  5.654756e+00  5.001691e+00
         4466          4467          4468          4474          4475          4476
 4.860467e+00  2.641182e+00  4.200015e+00  3.972874e+00  5.721284e+00  4.421983e+00
         4483          4493          4498          4503          4506          4510
 7.206745e+00  6.888381e+00  6.160693e+00  2.999111e+00  3.396364e+00  4.876612e+00
         4517          4519          4521          4525          4532          4538
 3.185745e+00  3.074749e+00  6.690077e+00  4.810674e+00 -2.588961e+00 -2.498975e+00
         4539          4545          4549          4554          4555          4556
-5.500877e-01  4.544681e-01  2.044754e+00 -2.553430e+00 -1.512356e+00 -8.884963e-01
         4558          4561          4568          4574          4575          4579
-5.856848e+00 -5.857806e+00 -2.777121e+00  3.943852e-01 -1.630430e+00 -1.575232e+00
         4586          4594          4597          4598          4605          4606
-6.503547e+00 -2.363259e+00 -3.994691e+00 -1.977019e+00 -3.726508e+00 -2.321579e+00
         4607          4614          4615          4616          4623          4632
-3.515110e+00 -5.100844e+00 -5.353811e+00 -4.047486e+00 -1.756165e+00  1.419616e+00
         4633          4637          4639          4659          4661          4664
 1.461763e+00 -3.825325e+00 -4.585449e+00  2.543488e-01 -7.364466e-01 -4.645944e+00
         4669          4679          4696          4698          4703          4708
-1.523013e+00  1.078774e+00 -2.175317e+01 -2.098713e+01 -1.989679e+01 -1.478629e+01
         4717          4728          4737          4742          4743          4748
-1.632832e+01 -2.204425e+01 -1.913259e+01 -1.780313e+01 -1.662167e+01 -2.035536e+01
         4752          4755          4758          4769          4771          4782
-2.113079e+01 -2.043528e+01 -2.023119e+01 -1.517708e+01 -1.846192e+01 -2.196675e+01
         4785          4801          4805          4810          4813          4815
-2.154656e+01 -1.683261e+01 -2.123223e+01 -1.977272e+01 -1.997353e+01 -1.973768e+01
         4824          4831          4833          4838          4842          4843
-1.701353e+01 -1.812967e+01 -1.945516e+01 -1.925559e+01 -2.090638e+01 -1.921477e+01
         4851          4857          4867          4869          4874          4884
-1.734273e+01 -1.334031e+01 -2.970076e+00 -8.529268e+00 -1.086803e+01 -5.353411e+00
         4895          4899          4904          4908          4912          4916
-6.177914e+00 -8.344663e+00 -8.509048e-01 -2.488835e+00  1.625091e+00  8.658137e-01
         4917          4922          4926          4933          4935          4940
 3.925724e+00  3.026517e+00  1.408491e+00  1.326292e+00  7.107766e-01 -1.853908e+00
         4945          4950          4961          4964          4965          4973
-7.801122e-01 -1.240458e+00 -1.250857e+00  2.927810e+00  4.676541e+00  2.643859e+00
         4977          4981          4984          4986          4989          4991
 3.265124e+00  1.340254e+00 -4.206825e-02  4.172263e+00 -5.626435e+00 -8.328042e+00
         4993          4994          4995          4999          5017          5021
-1.069522e+01 -1.009091e+01 -1.249695e+01 -1.404351e+01 -1.293102e+01 -1.468696e+01
         5022          5025          5029          5032
```

```
-1.464053e+01 -1.694424e+01 -1.996704e+01 -1.849319e+01
 [ reached getOption("max.print") -- omitted 175 entries ]
```

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```
# Calculate the RMSE
rmse <- sqrt(mean(residuals^2))
rmse
```

```
[1] 9.098539
```

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```
# Calculate the RSE
rse <- rmse / sqrt(nrow(testing_data_new))
rse
```

```
[1] 0.2654317
```

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```
#R-Squared
R2 <- summary(parkinsons_updrs_model)$r.squared
R2
```

```
[1] 0.2539257
```

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```
# with a RSE of 0.2654, I can conclude that the regression model is explaining some of the va
riability in the response variable total_UPDRS, but there is still some unexplained variabili
ty, so having a value close to 0 means that the model fits well the data.

# Regarding the R-squared, it normally depends on the application and we may be able to impro
ve maybe by removing variables that are not really significant for the response variable but
as it stand the model performs well but can perform better.
```

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```
#5- Use a interaction term, Here I will using the variables with higher correlation between t
hem and find the significance through trial.

library(caret)
highly_correlated_variables <- findCorrelation(cor(parkinsons_updrs), cutoff = 0.7, names=TRU
E)
highly_correlated_variables
```

```
 [1] "Shimmer.dB."   "Shimmer"       "Shimmer.APQ5"  "Shimmer.APQ3"  "Shimmer.DDA"
 [6] "Jitter..."     "HNR"           "Shimmer.APQ11" "Jitter.PPQ5"   "Jitter.DDP"
[11] "Jitter.RAP"    "Jitter.Abs."   "total_UPDRS"
```

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```
#a) Model Formula
parkinsons_updrs_model_with_interaction=lm(total_UPDRS~.+(Shimmer.dB.*Jitter.Abs.), data=trai
ning_data_new)

# Use the model to make predictions on the testing data
predictions1 <- predict(parkinsons_updrs_model_with_interaction, newdata = testing_data_new)

# Significant predictors
summary(parkinsons_updrs_model_with_interaction)
```

```

Call:
lm(formula = total_UPDRS ~ . + (Shimmer.dB. * Jitter.Abs.), data = training_data_new)

Residuals:
    Min      1Q  Median      3Q     Max 
-27.163  -6.732  -1.137   7.148  24.080 

Coefficients:
                         Estimate Std. Error t value Pr(>|t|)    
(Intercept)             3.720e+01  3.463e+00  10.740  < 2e-16 ***
subject.                2.617e-01  1.214e-02  21.547  < 2e-16 ***
age                     3.183e-01  1.617e-02  19.682  < 2e-16 ***
sex                    -5.182e+00  3.514e-01 -14.749  < 2e-16 ***
test_time               1.745e-02  2.555e-03   6.830 9.58e-12 ***
Jitter...              -2.331e+02  2.319e+02  -1.005   0.3149    
Jitter.Abs.            -8.666e+04  1.323e+04  -6.552 6.29e-11 ***
Jitter.RAP             -2.859e+04  4.999e+04  -0.572   0.5674    
Jitter.PPQ5            -4.983e+02  2.254e+02  -2.210   0.0271 *  
Jitter.DDP              9.959e+03  1.666e+04   0.598   0.5501    
Shimmer                -4.660e+01  6.884e+01  -0.677   0.4985    
Shimmer.dB.             2.647e+00  5.302e+00   0.499   0.6177    
Shimmer.APQ3           -3.004e+04  4.996e+04  -0.601   0.5477    
Shimmer.APQ5            7.840e+01  6.191e+01   1.266   0.2055    
Shimmer.APQ11           8.404e+00  2.940e+01   0.286   0.7750    
Shimmer.DDA             9.948e+03  1.665e+04   0.597   0.5503    
NHR                    -3.693e+01  7.298e+00  -5.061 4.32e-07 ***
HNR                    -5.949e-01  7.692e-02  -7.734 1.27e-14 ***
RPDE                    3.203e+00  1.959e+00   1.635   0.1022    
DFA                    -3.482e+01  2.475e+00 -14.069  < 2e-16 ***
PPE                     2.169e+01  3.311e+00   6.552 6.30e-11 ***
Jitter.Abs.:Shimmer.dB.  6.701e+04  1.568e+04   4.273 1.96e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.293 on 4678 degrees of freedom
Multiple R-squared:  0.2568,    Adjusted R-squared:  0.2535 
F-statistic: 76.98 on 21 and 4678 DF,  p-value: < 2.2e-16
```

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```
summary(predictions1)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  16.46   25.12   28.94   29.22   33.55   49.10 
```

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```
# Extraction of the RSE and R-squared values
# Calculate the residuals
residuals1 <- predictions1 - testing_data_new$total_UPDRS
residuals1
```

```
          4           6           9          11          14          15
 -5.00688185  -6.57850662 -10.25998275 -12.12469953 -12.61479642 -10.83829549
         22          24          28          29          33          39
-12.88867542 -17.16314403  -9.01747583  -6.47887773 -10.41068654 -13.45268101
         40          43          46          48          53          62
-12.66935534 -14.24505379 -14.82990957 -16.87239510  -9.29782206 -11.27498533
         73          74          80          85          86          91
-13.52610711 -18.51788452  -8.75268110  -7.31364936 -11.34531660 -12.73117407
         93          99         100         104         106         110
-12.54314512 -13.09660545  -6.26179538  -5.51348538  -3.33456241  -7.87748191
        111         115         118         126         133         155
-10.02077643 -13.16115311 -14.06886858  -5.30632185  -8.16778583   6.05146945
        157         158         160         168         174         175
  6.58752417   7.05785006   7.19119709   2.24492028   0.21136879   5.59963380
        176         177         184         188         189         190
  4.30032914   2.79709419   7.95152782   4.39182322   5.96460911   3.14445060
        202         205         208         210         221         225
  4.57208345   5.35812693   7.94206359   4.21465514   0.98366918   3.70758986
        226         228         233         237         245         247
  3.47390294   4.16343325   7.32857753   3.95056947  -0.17627641   1.00759557
        248         254         280         282         285         293
 -1.23450367   6.15726047   6.37227339   5.70243207   2.54735811  -1.38070669
        298         308         310         312         313         320
 -5.25586798 -10.23483122 -12.30991748 -12.36873409 -11.18621069  -2.75447044
        321         322         329         330         332         348
 -5.26491945  -4.46904562 -11.94007354  -8.77194682  -8.82622287  -5.14694648
        349         355         356         360         367         380
 -3.82025660 -10.96785631 -10.34083309 -13.42559697  -3.19477210 -10.12485410
        389         397         399         405         406         411
-14.73730382  -5.69419453  -9.49360807  -8.43604019 -11.74842612 -12.35918171
        417         424         425         430         437         446
  0.53997713  -9.92975700  -9.28979873  -8.83409927 -11.37608007   6.21636345
        452         454         455         477         488         493
  1.09349437   3.97901855   4.12503557   3.34468558  10.46219327   4.24566489
        495         499         501         509         510         512
  1.26017880   3.70194561   2.24592869  12.59972589  13.45826558  11.74307471
        516         530         538         540         545         554
  5.46259716  15.51328135   3.62332542   5.47433331   2.76538666  10.74348060
        557         565         566         571         580         585
 10.78107858   4.79142430   2.61381318   5.80427377 -10.89459822 -11.24904211
        591         593         596         597         605         611
-16.08796025 -10.76702983 -11.29368712  -9.99931901 -11.11209672 -10.61133555
        619         622         628         635         645         657
-12.72155198 -11.02119353 -12.24340925 -12.25512386 -11.50661749 -11.62877418
        662         679         681         685         687         692
-11.18717984 -10.85357778  -9.90119553 -11.26010210 -14.01175548 -11.71047492
        695         698         702         704         709         717
-11.91380776 -10.71867162 -10.86269039 -11.19148508  -8.70715149 -14.71766804
        722         725         726         728         731         734
-11.73842650  -8.65141104 -11.50844683 -10.68556877 -12.30389686  -8.88430854
        736         737         749         751         762         766
-13.62730486 -14.40012947 -17.60075551 -15.67131812 -12.84695977 -11.19635902
        770         773         784         801         802         806
-14.53673002 -16.88029183 -13.59047709 -14.30131107 -17.64504337 -17.37239423
        824         826         833         848         857         865
```

```
-12.13686948 -16.39543367 -18.62471227 -14.30557496 -18.53063411 -12.87740213
         868          869          876          888          889          895
-12.13920036 -14.01950476 -14.41699995   6.34551811   5.65205235   6.45968204
         902          918          921          937          939          940
 10.33254349   7.19315503   4.27408019   4.40062279   6.39402638   4.93499896
         941          944          947          952          955          962
  3.75488256   6.37811490   6.23213029   7.69620375  10.52996239   7.49373226
         965          966          973          975          991          992
  6.52264199   5.43062069   6.73086773   6.70681918   6.17514134   5.83095045
         994          996         1011         1012         1013         1018
  6.96485131   5.92760250  13.34586459  13.53077252  10.94251238   4.14520391
        1020         1024         1033         1036         1039         1051
  5.26348514   5.49993147   6.82895056  10.08968051  12.92084393   0.35654291
        1052         1067         1076         1090         1092         1097
 -1.39146355  -3.34359483  -0.79928343   3.61120132  -3.78688681  -0.71685643
        1112         1115         1124         1125         1138         1141
  4.71018308   9.73287237  -0.44291439   0.51923022  -0.73479840  -2.49228012
        1143         1145         1150         1155         1159         1160
 -3.23984876  -3.72632676   1.41578085  -1.43184767   0.04238359   1.52359971
        1172         1174         1177         1181         1187         1197
 -1.88718189  -0.34563482   1.53950959  -0.99761243   2.83803060  -2.55929134
        1200         1206         1207         1216         1218         1220
  2.31839232   3.83939589  -0.69669987   0.50091627   3.84614343   1.44164936
        1221         1228         1242         1245         1247         1253
  0.83797858   0.16543512   2.58154342   1.31827231   5.33134453  -0.71469836
        1259         1263         1269         1271         1277         1282
 -1.98754704   0.19439529  -1.40950788  -0.14599162   2.56655933  -3.02995999
        1285         1287         1288         1303         1305         1310
  2.18222138   1.15955680   4.35605825   0.03084141   2.38284604  -0.45927677
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        1387         1390         1396         1413         1414         1418
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        1422         1428         1434         1439         1440         1441
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        1443         1451         1454         1457         1459         1460
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        1461         1463         1473         1478         1480         1483
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        1529         1530         1535         1536         1540         1555
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        1669         1670         1674         1681         1683         1687
```

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       1729         1731         1732         1745         1764         1765
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 0.32463004   4.14046849   2.87860207   0.74773658  -8.95416072  -7.13941300
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       1985         1986         1991         1998         2000         2007
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       2014         2015         2020         2023         2030         2039
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       2289         2293         2297         2303         2307         2309
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       2310         2316         2322         2326         2327         2332
-15.45557615  -5.05176021  -2.68968336  -8.22376920  -9.98763913 -15.02786683
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       2516         2524         2526         2534         2541         2543
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       2548         2551         2557         2561         2566         2568
```

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       4586        4594         4597         4598         4605         4606
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       4633        4637         4639         4659         4661         4664
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       4669        4679         4696         4698         4703         4708
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       4717        4728         4737         4742         4743         4748
-16.26377300 -21.86055730 -18.96195641 -17.47233222 -16.48433036 -19.90656677
       4752        4755         4758         4769         4771         4782
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       4785        4801         4805         4810         4813         4815
-21.40666548 -16.52022595 -19.74503429 -19.31948625 -19.34759953 -19.77604032
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-16.53699830 -17.87167667 -19.39239186 -18.98891162 -20.92286323 -19.04757067
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       4917        4922         4926         4933         4935         4940
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       4945        4950         4961         4964         4965         4973
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       4977        4981         4984         4986         4989         4991
  1.57524088   0.29143707   0.30861125   4.05309231  -7.30446723  -8.05781203
       4993        4994         4995         4999         5017         5021
-10.83839726 -10.23358716 -12.80752071 -14.15711148 -12.97854451 -14.72333336
       5022        5025         5029         5032
```

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-15.17492153 -17.03217952 -20.64529397 -18.72353012
 [ reached getOption("max.print") -- omitted 175 entries ]
```

Hide

```
# Calculate the RMSE
rmse1 <- sqrt(mean(residuals1^2))
rmse1
```

```
[1] 9.087112
```

Hide

```
# Calculate the RSE
rse1 <- rmse1 / sqrt(nrow(testing_data_new))
rse1
```

```
[1] 0.2650983
```

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```
#R-Squared
R2_1 <- summary(parkinsons_updrs_model_with_interaction)$r.squared
R2_1
```

```
[1] 0.2568266
```

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```
#b) regarding the RSE there was a slightly decrease but not too significant but the same happ
ened to the R_squared.
```

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```
#6-

#a) Model Formula
parkinsons_updrs_model_with_non_linear_transformation=lm(total_UPDRS~.+I(Shimmer.dB.^2), data
=training_data_new)

# Use the model to make predictions on the testing data
predictions2 <- predict(parkinsons_updrs_model_with_non_linear_transformation, newdata = test
ing_data_new)

# Significant predictors
summary(parkinsons_updrs_model_with_non_linear_transformation)
```

```
Call:
lm(formula = total_UPDRS ~ . + I(Shimmer.dB.^2), data = training_data_new)

Residuals:
    Min      1Q  Median      3Q     Max
-27.704  -6.744  -1.235   7.150  23.895

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       3.597e+01  3.494e+00  10.294  < 2e-16 ***
subject.          2.644e-01  1.214e-02  21.770  < 2e-16 ***
age               3.191e-01  1.638e-02  19.479  < 2e-16 ***
sex              -5.114e+00  3.515e-01 -14.547  < 2e-16 ***
test_time         1.765e-02  2.559e-03   6.896 6.05e-12 ***
Jitter...        -2.977e+02  2.325e+02  -1.281   0.2004
Jitter.Abs.      -5.097e+04  1.044e+04  -4.883 1.08e-06 ***
Jitter.RAP       -3.148e+04  5.007e+04  -0.629   0.5295
Jitter.PPQ5      -2.166e+02  2.139e+02  -1.013   0.3112
Jitter.DDP        1.093e+04  1.669e+04   0.655   0.5127
Shimmer          -5.393e+01  7.085e+01  -0.761   0.4466
Shimmer.dB.       8.398e-01  5.349e+00   0.157   0.8753
Shimmer.APQ3     -2.684e+04  5.004e+04  -0.536   0.5917
Shimmer.APQ5      7.956e+01  6.205e+01   1.282   0.1998
Shimmer.APQ11     1.257e+01  2.955e+01   0.425   0.6705
Shimmer.DDA       8.895e+03  1.668e+04   0.533   0.5938
NHR              -2.932e+01  7.217e+00  -4.063 4.92e-05 ***
HNR              -5.407e-01  7.728e-02  -6.996 3.00e-12 ***
RPDE              2.574e+00  1.956e+00   1.316   0.1883
DFA              -3.553e+01  2.473e+00 -14.367  < 2e-16 ***
PPE               1.787e+01  3.168e+00   5.639 1.81e-08 ***
I(Shimmer.dB.^2)  3.183e+00  1.810e+00   1.759   0.0787 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.308 on 4678 degrees of freedom
Multiple R-squared:  0.2544,    Adjusted R-squared:  0.2511
F-statistic: 76.01 on 21 and 4678 DF,  p-value: < 2.2e-16
```

Hide

```
summary(predictions2)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  16.74   25.15   28.95   29.22   33.46   57.45
```

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```
# Extraction of the RSE and R-squared values
# Calculate the residuals
residuals2 <- predictions2 - testing_data_new$total_UPDRS
residuals2
```

```
           4            6            9           11           14           15
 -5.728026359 -7.119208638 -10.736030229 -11.985816299 -12.890953855 -11.125126841
          22           24           28           29           33           39
-13.115273629 -17.496572521  -8.988977059  -6.772142838 -10.715394278 -13.554327003
          40           43           46           48           53           62
-13.133487943 -14.638193001 -15.325619913 -17.145275178  -9.328779506 -11.395486269
          73           74           80           85           86           91
-14.075787743 -18.570347427  -8.770142854  -7.574427439 -11.631648798 -12.928206726
          93           99          100          104          106          110
-12.880739839 -13.734399757  -6.517450671  -5.989849593  -3.626934043  -7.633616970
         111          115          118          126          133          155
-10.486176647 -13.393651530 -13.937932284  -5.593643962  -8.379592427   6.106144294
         157          158          160          168          174          175
  6.395676362   6.976324122   6.676335252   2.055390654  -0.060026314   5.154284392
         176          177          184          188          189          190
  4.112633172   2.782267247   7.699583818   4.596561042   5.804261903   3.550659641
         202          205          208          210          221          225
  4.675596256   5.182193639   7.585775827   4.293294097   1.116990734   3.510107200
         226          228          233          237          245          247
  3.694829352   4.224540470   7.253208987   4.018938151  -0.562452635   1.171279730
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         321          322          329          330          332          348
 -5.295651248  -4.488323599 -11.840085726  -9.053416135  -9.050024932  -5.138164173
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         389          397          399          405          406          411
-14.835589292  -5.804260509  -9.429667203  -8.722724753 -11.789590383 -12.540658787
         417          424          425          430          437          446
  0.220325060  -9.964980299  -9.374341213  -8.908986504 -11.180733887   6.055336722
         452          454          455          477          488          493
  1.073411195   3.696650431   4.085187835   3.051969594  10.277948513   3.980061330
         495          499          501          509          510          512
  1.162791294   3.346838595   2.193252796  12.329738598  13.038693743  11.372266996
         516          530          538          540          545          554
  5.237467574  15.085690013   3.419214698   5.116973785   2.738517370  10.435724953
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         591          593          596          597          605          611
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-12.866814070 -11.183963170 -12.319270682 -12.504999367 -11.526611021 -11.737602228
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         824          826          833          848          857          865
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          902           918           921           937           939           940
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          941           944           947           952           955           962
  3.862468149   6.237118416   6.577281724   7.881457487  10.784949726   7.700336750
          965           966           973           975           991           992
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  7.049898168   6.278394781  13.268502104  13.850883250  11.942566497   4.362284541
         1020          1024          1033          1036          1039          1051
  5.506374060   5.725271234   6.958544130  10.391337964  12.985618347  -0.249316615
         1052          1067          1076          1090          1092          1097
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         1112          1115          1124          1125          1138          1141
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         1311          1320          1336          1338          1348          1361
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         1387          1390          1396          1413          1414          1418
  3.170159012   7.933672941   4.673474656   4.641756854   6.791214739   8.728187415
         1422          1428          1434          1439          1440          1441
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  4.987946755   3.496516191   6.376887915   6.503899132   8.311394815   5.663471438
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        1769          1772          1784          1786          1800          1817
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        1819          1824          1825          1826          1845          1861
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        2114          2116          2123          2126          2134          2149
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        2152          2156          2159          2162          2171          2183
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        2184          2188          2190          2193          2197          2205
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        2209          2212          2215          2221          2230          2235
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        2236          2237          2241          2243          2252          2253
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        2254          2264          2267          2270          2271          2282
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        3025          3031          3036          3037          3044          3047
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        3052          3058          3062          3070          3088          3089
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         3518          3522          3528          3542          3557          3558
  3.257304270  -4.305926691  -4.065489129   2.700994748  -2.234198614  -1.510962438
         3561          3564          3568          3573          3574          3577
  2.256042391   4.034531661  -7.324527290  -6.271586090  -8.879881283  -8.312684330
         3578          3580          3582          3590          3592          3604
 -7.254337475  -3.112286002  -4.670025557  -5.254602464  -6.036452763  -1.646461362
         3608          3611          3623          3633          3634          3639
  2.905885941   6.150469894   5.305995817   5.767551646   7.265290525   7.041498849
         3643          3648          3667          3671          3676          3679
  5.904130557  -0.560738269   8.140006603   4.898460424   7.929713820   5.396973498
         3686          3689          3694          3695          3697          3700
  4.139517845   4.690765037   3.553822397   7.005506046   8.483945646   7.917699126
         3704          3711          3719          3722          3729          3731
 10.642423251   4.676086874   8.065534255   7.214432902   6.119972117   7.637743955
         3733          3734          3738          3739          3748          3754
  4.516320287   6.200308873 -11.585003842 -12.243792149  -7.530844080  -0.551789062
         3757          3758          3760          3761          3766          3767
  4.054914557   1.867210288   6.278804321 -10.302184258  -8.883849869 -11.125598068
         3773          3776          3777          3778          3780          3793
 -3.847887086  -3.818027982  -2.244245204   1.335690321   2.184138780  -7.656029617
         3796          3803          3817          3818          3819          3826
 -6.355622309   3.709290666  -7.103202316  -6.616453361  -3.541759743   3.900688616
         3828          3837          3841          3844          3849          3850
 -8.889451385  -7.682175913  -0.667000074   1.519326699   6.408310994 -10.375716812
         3864          3865          3868          3869          3877          3884
 -2.023896622  -2.449397034   5.766707921   8.522005841   5.279801117   7.918927685
         3885          3887          3888          3892          3904          3905
  9.643555235   8.583307096   6.412872848   5.146071884   1.753948973   1.882813378
         3914          3923          3924          3925          3927          3928
  7.570831522   4.073983071   4.655668521   3.886093218   2.109783774   1.892445144
         3931          3935          3940          3944          3945          3950
  1.962692205   5.236095694   9.167480048   6.354229286   7.713802411   5.151491260
         3953          3957          3961          3969          3973          3979
  3.546660416   0.591450328   2.731092752   9.119568320   7.592489175   2.953291102
         3981          3985          3986          3993          3994          3998
  5.170797680   1.930317850   4.264910613   8.539698995   6.424206260   9.400268715
         4006          4008          4010          4020          4025          4028
  7.040111421   4.974479717   5.363775623   6.895380045   8.874691517   8.465824013
         4031          4038          4039          4041          4049          4064
  6.137819779   4.541612788   4.667663181 -20.286122987 -11.382665483  15.556543729
         4077          4097          4099          4102          4110          4118
 -6.469544307  -3.152323072  -6.583552463  -4.703772172 -12.903906166  -6.428164588
         4122          4123          4127          4146          4148          4150
 -2.693207099  -3.544010544 -18.315642995 -19.712882426 -20.066869714 -15.344095122
         4153          4161          4165          4170          4178          4181
-12.540808611  -5.881781301  -4.885233291   0.827341537   1.025594120   9.457835003
         4188          4191          4192          4193          4194          4201
  5.480501365  -0.984869038   3.496678620   0.307749362  -1.388010876   6.931131712
         4202          4207          4211          4215          4221          4227
  5.401775583  15.489738637   3.133065772   1.390516811   2.404503780   8.769970042
         4229          4231          4232          4234          4241          4245
 19.271761935   3.477541821   3.388936072   0.545466751   1.286824065   4.544043999
         4248          4250          4264          4267          4270          4273
```

```
 8.930507587  14.818991367   2.552958422   4.517335275  10.280799666  12.908253421
        4277          4283          4285          4287          4288          4289
 2.668517222  -0.066815224   2.673707150   3.811832135   3.750398233   5.775904349
        4296          4304          4305          4308          4309          4323
-0.438978810   8.970219805  10.398563026   8.165383017   6.104794329  11.079541007
        4330          4334          4337          4344          4350          4351
-1.030301073   3.888567522   6.950062716   6.494932343   5.448535177   4.562674043
        4352          4358          4363          4365          4369          4378
 8.215462707   8.946000651   7.629172008   0.969932441   7.533177953  10.493644074
        4379          4391          4394          4400          4401          4402
10.624718710  15.091088225  11.740735525   5.185106890   4.425845110   3.815777830
        4411          4430          4433          4435          4436          4438
 2.091017058   1.788777319   2.341510603   3.699072983   4.678835322   5.558776088
        4441          4443          4453          4457          4463          4465
 5.278080112   4.332962205   6.359548655   1.665518343   5.598028294   4.940010774
        4466          4467          4468          4474          4475          4476
 4.770508893   2.671443940   4.154976145   3.908954022   5.446994196   4.338934751
        4483          4493          4498          4503          4506          4510
 7.111783577   6.894942952   6.266116958   2.725267238   3.381959084   4.773761125
        4517          4519          4521          4525          4532          4538
 3.224522290   3.077281715   6.646235399   4.670043152  -2.452633135  -2.526049463
        4539          4545          4549          4554          4555          4556
-0.542102688   0.664425601   2.363602280  -2.357430518  -1.190836239  -0.717280459
        4558          4561          4568          4574          4575          4579
-5.702962319  -5.514580956  -2.511020252   0.720256521  -1.314109648  -1.213446072
        4586          4594          4597          4598          4605          4606
-6.258937435  -2.060418308  -3.897293690  -1.598269517  -3.463114450  -2.101058523
        4607          4614          4615          4616          4623          4632
-3.297879715  -4.812950349  -5.056756916  -3.860537933  -1.325894728   1.892412211
        4633          4637          4639          4659          4661          4664
 1.393051360  -3.528943308  -4.866692992   0.520018329  -0.359051993  -4.437946839
        4669          4679          4696          4698          4703          4708
-1.321970800   1.270476388 -21.772656375 -20.890717910 -20.007638944 -14.590621467
        4717          4728          4737          4742          4743          4748
-16.480017165 -21.952795100 -19.284516031 -17.759562337 -16.511671527 -20.327260427
        4752          4755          4758          4769          4771          4782
-21.306002079 -20.304102308 -20.359272886 -15.030459384 -18.675110799 -22.146731942
        4785          4801          4805          4810          4813          4815
-21.783054665 -16.891227703 -21.315091564 -19.626804197 -19.807960732 -19.962739769
        4824          4831          4833          4838          4842          4843
-16.913398678 -18.223539251 -19.361478304 -19.130904734 -21.096344670 -19.393262393
        4851          4857          4867          4869          4874          4884
-17.398239194 -13.444004781  -2.607652013  -5.788565163  -8.660288167  -4.309353658
        4895          4899          4904          4908          4912          4916
 -4.980450277  -7.853466644  -2.288489925  -3.620878464   1.283443984   1.230664982
        4917          4922          4926          4933          4935          4940
  4.237955241   3.156035835   1.209527742   0.643819322   2.114884513  -0.040758189
        4945          4950          4961          4964          4965          4973
 -0.671462081  -2.202452312  -0.707183088   2.648663348   4.770283077   3.788684776
        4977          4981          4984          4986          4989          4991
  3.156181263   1.226612569   0.083986641   4.218691019  -5.944251847  -8.185272970
        4993          4994          4995          4999          5017          5021
-10.754695829 -10.122786433 -12.783219543 -14.160206916 -12.942747386 -14.827056227
        5022          5025          5029          5032
```

```
-14.884257015 -16.905645852 -20.358635532 -18.426676471
 [ reached getOption("max.print") -- omitted 175 entries ]
```

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```
# Calculate the RMSE
rmse2 <- sqrt(mean(residuals2^2))
rmse2
```

```
[1] 9.092107
```

Hide

```
# Calculate the RSE
rse2 <- rmse2 / sqrt(nrow(testing_data_new))
rse2
```

```
[1] 0.265244
```

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```
#R-Squared
R2_2 <- summary(parkinsons_updrs_model_with_non_linear_transformation)$r.squared
R2_2
```

```
[1] 0.2544187
```

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```
#b) regarding the RSE and R_squared, it seems there has been slightly increase in RSE and a d
ecrease in R_squared from the non linear transformation term.
```

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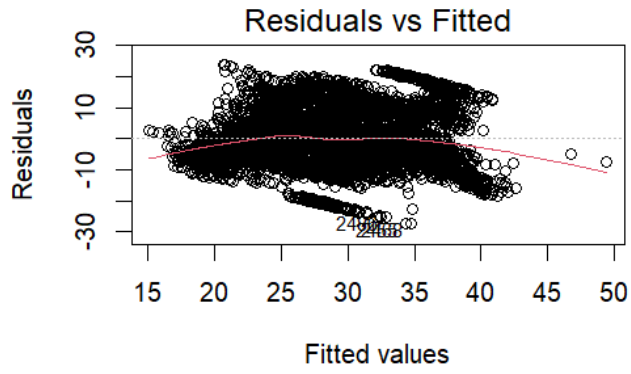
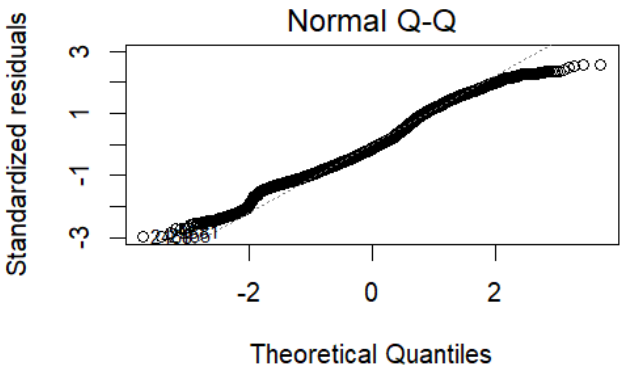
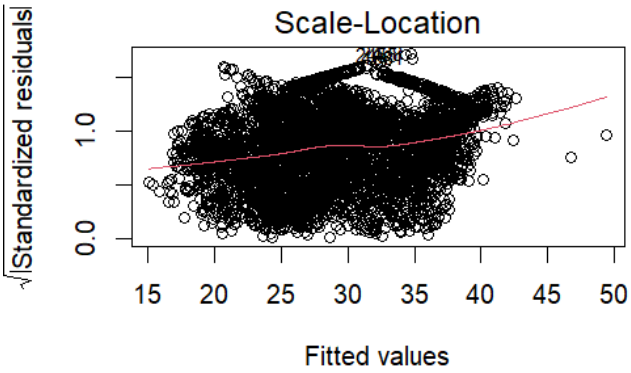
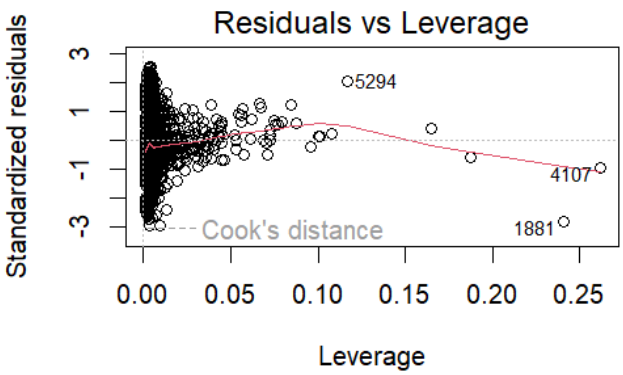
```
#7- Diagnostic plots

par(mfrow=c(2,2))
plot(parkinsons_updrs_model)
```



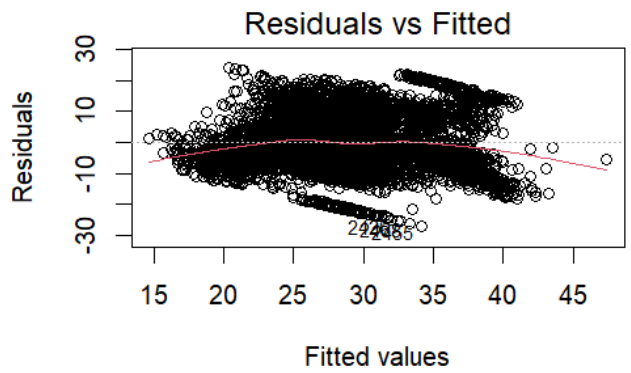


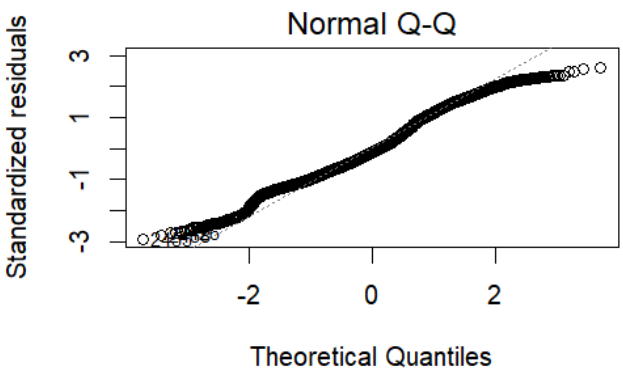


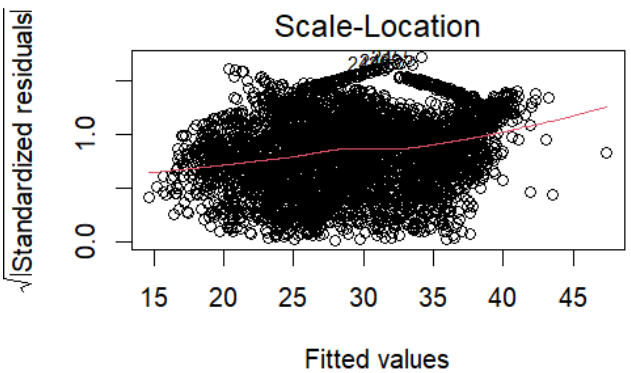


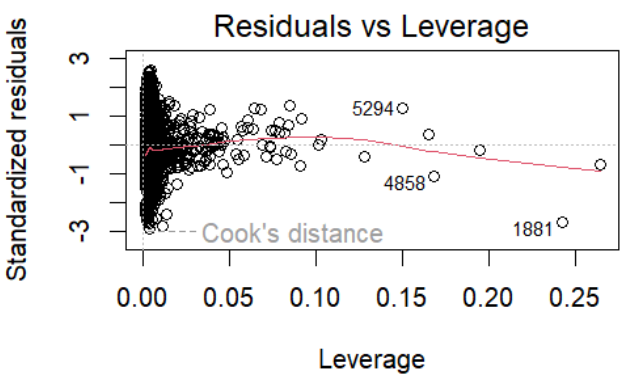
Hide

```
par(mfrow=c(2,2))
plot(parkinsons_updrs_model_with_interaction)
```









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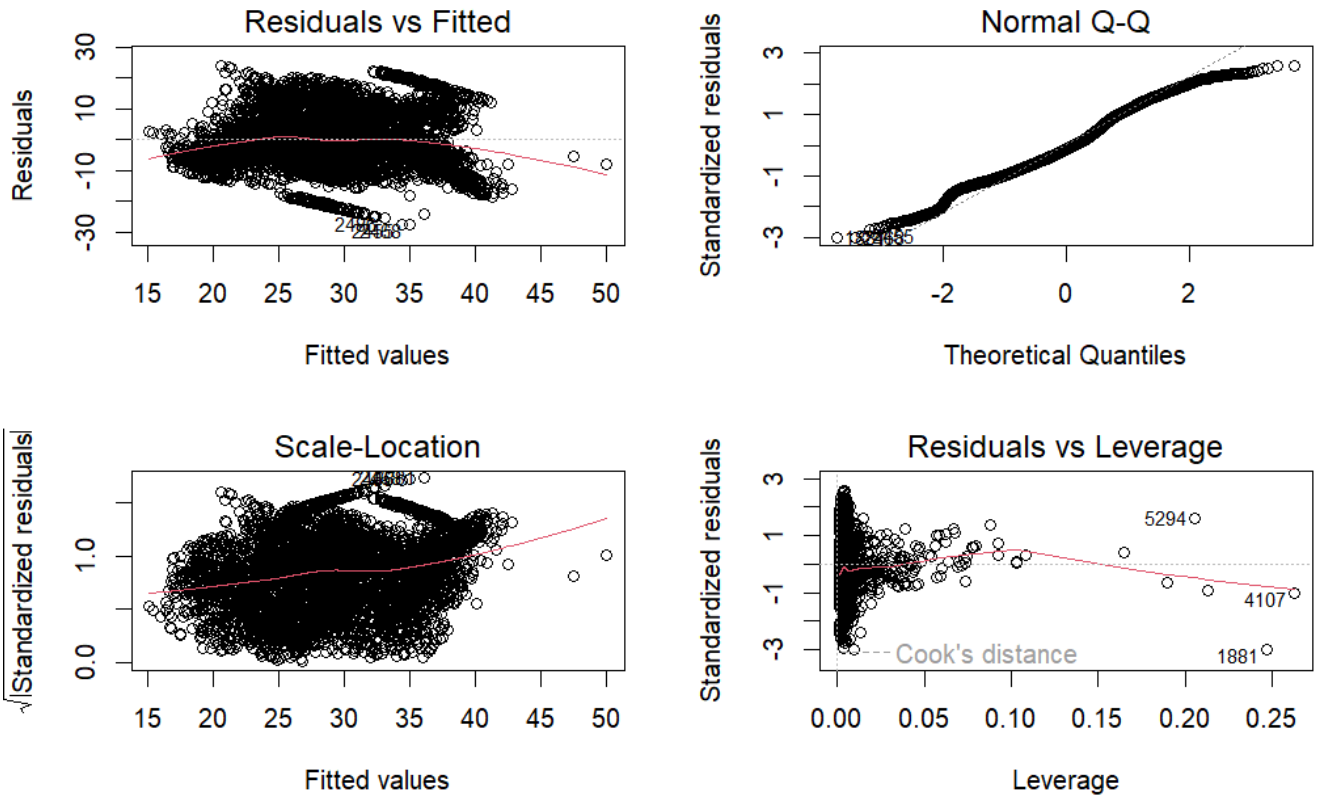
```
par(mfrow=c(2,2))
plot(parkinsons_updrs_model_with_non_linear_transformation)
```



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```
# From the generated graphs, it looks like that the models are appropriate but different tech
niques can be applied to produce better models and better plots.
```