STA414 Assignment 3

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1. Fitting a linear model

The direct summary of simple linear model can be shown as:

```
Call:
  lm(formula = train1y ~ V1 + V2 + V3 + V4 + V5 + V6 + V7 + V8,
     data = data.frame(train1x))

Residuals:
  Min       1Q   Median       3Q      Max
-1.40576 -0.31558 -0.03542  0.26756  1.95052

Coefficients:
  Estimate Std. Error t value Pr(>|t|)
(Intercept)  5.09323    0.44713  11.391  < 2e-16 ***
  V1          0.21757    0.02145  10.142  < 2e-16 ***
  V2          1.58882    0.71488   2.222  0.02718 *
  V3          2.56441    0.60984   4.205 3.68e-05 ***
  V4          1.90180    0.44280   4.295 2.53e-05 ***
  V5         -0.65827    0.23777  -2.769  0.00607 **
  V6          0.30995    0.29234   1.060  0.29008
  V7          0.26580    0.05045   5.268 3.05e-07 ***
  V8         -0.46711    0.11209  -4.167 4.30e-05 ***
  ---
  Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5391 on 241 degrees of freedom
Multiple R-squared:  0.594,  Adjusted R-squared:  0.5805
F-statistic: 44.07 on 8 and 241 DF,  p-value: < 2.2e-16
```

- By observation, the `Adjusted R-squared` value is `0.5805`, not a good sign.
- The `Pr(>|t|)` for `V6` is comparatively high, probably we can ignore it when fitting a linear model, so the re-do of fitting is below:

```
Call:
  lm(formula = train1y ~ V1 + V2 + V3 + V4 + V5 + V7 + V8, data = data.frame(train1x))

Residuals:
  Min       1Q   Median       3Q      Max 
-1.33637 -0.30870 -0.04837  0.27276  2.00091 

Coefficients:
  Estimate Std. Error t value Pr(>|t|)    
(Intercept)  4.99873    0.43826  11.406  < 2e-16 ***
  V1           0.22210    0.02103  10.563  < 2e-16 ***
  V2           1.60312    0.71494   2.242   0.0258 *  
  V3           2.61755    0.60793   4.306 2.42e-05 ***
  V4           1.98178    0.43644   4.541 8.84e-06 ***
  V5          -0.70383    0.23391  -3.009   0.0029 ** 
  V7           0.27002    0.05031   5.368 1.87e-07 ***
  V8          -0.43856    0.10883  -4.030 7.48e-05 ***
  ---
  Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.5392 on 242 degrees of freedom
Multiple R-squared:  0.5921,  Adjusted R-squared:  0.5803 
F-statistic: 50.18 on 7 and 242 DF,  p-value: < 2.2e-16
```

- Therefore,

  ```
  The MSE in terms of 8 covariates is  0.2801569
  The MSE in terms of 7 covariates is  0.2814637
  ```

- And the prediction is `y_predict`.

2. Fitting a Gaussian process model with linear covariance

- The calculated MSE of fitting a Gaussian process model with linear covariance is `0.443493`.

3. Fitting Gaussian process model without/with rescaling

- Set the `res` and `res2` matrix as two 3 by 400 matrices, considering the step, starting and ending values of hyperparameters.
- The two generated text files, *output1.txt* and *output2.txt* are hyperparameters candidates for non-scaling

GP and re-scaling GP respectively. The second line and third line of such files are values of `gamma` and `rho` .

- *output1.txt* and *output2.txt* are included in appendices.
- The minimizer hyperparameters `gamma` and `rho` for MSE are acquired by calling `index` and `index2` in console after running our code, then call `res[,index]` and `res2[,index2]` respectively.

```
> res[,index]
[1] 60.76519  9.60000  0.16000
> res2[,index2]
[1] 68.40608  5.10000  0.96000
```

- For non-scaling, `gamma == 9.6` , `rho == 0.16`
- For rescaling, `gamma == 5.1` , `rho == 0.96`
- The MSE for non-scaling Gaussian process model is `0.2934913` .
- The MSE for rescaling Gaussian process model is `0.2403158` .

4. Runtime comparison

- By using `proc.time()` we can get runtime for each model fitting.

```
simple linear:
   user  system elapsed
  0.022   0.002   0.025

gaussian process with linear covariance:
   user  system elapsed
 18.144   0.036  18.181

gaussian process non-scaling:
    user   system  elapsed
2425.194    7.831 2434.902

gaussian process scaling:
    user   system  elapsed
2505.971    6.253 2515.121
```

5. Summary

Using 5-fold cross-validation

model	simple linear	GP with linear cov	GP with hyperpar	GP with hyper (rescaling)
MSE	0.2801569	0.443493	0.2934913	0.2403158
runtime	0.022	18.144	2425.194	2505.971

- Since Gaussian process with hyperparameters (re-scaling) has the smallest MSE among all, it is the best model fitting for our data. Simple linear model has a larger MSE, and Gaussian process with hyperparameters (non-scaling) has an MSE slightly larger than the previous one. In general, all of three MSEs are quite close to each other.
- However, Gaussian process with linear covariance has a rather outlying MSE, probabily because its parameters are not carefully selected to minimize the MSE.
- The runtime of simple linear model and GP with linear covariance are tolerable. But GP with hyperparameters takes much longer time (approx. 40 minutes) to run due to the existence of nested for-loop inside code.

Using 10-fold cross-validation

model	GP with hyperpar	GP with hyper (rescaling)
MSE	0.2935	0.2406

- During a previous pilot run, I change the required 5-fold cross-validation to 10-fold, which is widely used in practice. It turns out that the MSE for linear and GP with linear covaraince don't change (of course they don't, they don't have hyperparameters!). What I actually want to say is that the MSE with/without rescaling are only tiny little bit higher than 5-fold. So the number of folds does not have great influence on MSE here.
- And runtime of 5-fold and 10-fold are similar.

6. Appendices

- `a3.r`

```
# set up!
train1x <- as.matrix(read.table("./train1x", header=F))
train1y <- as.matrix(read.table("./train1y", header=F))
testx <- as.matrix(read.table("./testx", header=F))
testy <- as.matrix(read.table("./testy", header=F))
```

```
# divide!
section <- function(train1x, train1y, i) {
  x_test <- train1x[((i-1)*50+1):(i*50),]
  x_train <- train1x[-(((i-1)*50+1):(i*50)),]
  y_test <- as.matrix(train1y[((i-1)*50+1):(i*50)])
  y_train <- as.matrix(train1y[-(((i-1)*50+1):(i*50))])
  return(list(x_test,x_train,y_test,y_train))
}

# covariance functions!
K1 <- function(i,j) {
  return(100^2*(i%*%j))
}

K2 <- function(gamma,rho,x,y) {
  return(100^2+gamma^2*exp(-(rho^2)*sum((x-y)^2)))
}

# cross-validation!
cv <- function(gamma, rho, train1x, train1y) {
  MSE <- matrix(0,1,5)
  for (k in 1:5) {
    x_test <- section(train1x,train1y,k)[1][[1]]
    x_train <- section(train1x,train1y,k)[2][[1]]
    y_test <- section(train1x,train1y,k)[3][[1]]
    y_train <- section(train1x,train1y,k)[4][[1]]
    C <- matrix(0,200,200)
    for (i in 1:200) {
      for (j in 1:200) {
        C[i,j] <- K2(gamma,rho,x_train[i,],x_train[j,])
      }
    }
    C <- C + diag(200)
    predict <- matrix(0,1,50)
    for (i in 1:50) {
      t <- matrix(0,1,200)
      for (j in 1:200) {
        t[j] <- K2(gamma,rho,x_train[j,],x_test[i,])
      }
      predict[i] <- t%*%solve(C)%*%y_train
    }
    MSE[k] <- sum((t(y_test) - predict)^2)
  }
  return(sum(MSE))
```

```
}
```

- `script.r`

```
source("a3.r")

########## simple linear model ##########
t1 <- proc.time()

mse <- function(m) {
  mse <- mean(m$residuals^2)
  return(mse)
}

m1 <- lm(train1y~V1+V2+V3+V4+V5+V6+V7+V8, data=data.frame(train1x))
summary(m1)
mse(m1)

## what if we drop V6?
m2 <- lm(train1y~V1+V2+V3+V4+V5+V7+V8, data=data.frame(train1x))
summary(m2)
mse(m2)

cat(" The MSE in terms of 8 covariates is ", mse(m1), "\n",
    "The MSE in terms of 7 covariates is ", mse(m2), "\n")

## prediction
y_predict <- predict(m2,newdata=data.frame(testx),interval='prediction')

t2 <- proc.time()
print(t2-t1)

########## Gaussian process with linear covariance ##########
t1 <- proc.time()
C <- matrix(0,250,250)
for (i in 1:250) {
  for (j in 1:250) {
    C[i, j] <- K1(train1x[i,],train1x[j,])
  }
}

C <- C + diag(250)

predict <- matrix(0,1,2500)
```

```
for (i in 1:nrow(testy)) {
  t <- matrix(0,1,250)
  for (j in 1:250) {
    t[j] <- K1(train1x[j,],testx[i,])
  }
  predict[i] <- t%*%solve(C,train1y)
}

MSE2 <- sum((t(testy) - predict)^2)/2500
print(MSE2)
t2 <- proc.time()
print(t2-t1)

########## Gaussian process with hyperparameters (non-scaling) ##########
t1 <- proc.time()
res <- matrix(0,3,400)
num <- 1
for (gamma in seq(0.1,10,0.5)) {
  for (rho in seq(0.01,1,0.05)) {
    res[1,num] <- cv(gamma,rho,train1x,train1y)
    res[2,num] <- gamma
    res[3,num] <- rho
    num <- num + 1
    # it's more like a progress tracking feature, not really need this
    cat(num, res[1,num-1],res[2,num-1],res[3,num-1],"\n")
  }
}

write.table(res, "./output1.txt", sep="\t")

index <- which(res[1,] == min(res[1,]))
gamma <- res[2,index]
rho <- res[3,index]

C <- matrix(0,250,250)
for (i in 1:250) {
  for (j in 1:250) {
    C[i, j] <- K2(gamma,rho,train1x[i,],train1x[j,])
  }
}

C <- C + diag(250)

predict <- matrix(0,1,2500)
for (i in 1:nrow(testy)) {
```

```
  t <- matrix(0,1,250)
  for (j in 1:250) {
    t[j] <- K2(gamma,rho,train1x[j,],testx[i,])
  }
  predict[i] <- t%*%solve(C,train1y)
}

MSE3 <- sum((t(testy) - predict)^2)/2500
print(MSE3)
t2 <- proc.time()
print(t2-t1)

########## Gaussian process with hyperparameters (re-scaling) ##########

t1 <- proc.time()

trainxx <- train1x
testxx <- testx
trainxx[,1] <- trainxx[,1]/10
trainxx[,7] <- trainxx[,7]/10
testxx[,1] <- testxx[,1]/10
testxx[,7] <- testxx[,7]/10

res2 <- matrix(0,3,400)
num2 <- 1
for (gamma in seq(0.1,10,0.5)) {
  for (rho in seq(0.01,1,0.05)) {
    res2[1,num2] <- cv(gamma,rho,trainxx,train1y)
    res2[2,num2] <- gamma
    res2[3,num2] <- rho
    num2 <- num2 + 1
    cat(num2, res2[1,num2-1],res2[2,num2-1],res2[3,num2-1],"\n")
  }
}

write.table(res2, "./output2.txt", sep="\t")

index2 <- which(res2[1,] == min(res2[1,]))
gamma <- res2[,index2][2]
rho <- res2[,index2][3]

C <- matrix(0,250,250)
for (i in 1:250) {
  for (j in 1:250) {
    C[i, j] <- K2(gamma,rho,trainxx[i,],trainxx[j,])
```

```
  }
}

C <- C + diag(250)

predict2 <- matrix(0,1,2500)
for (i in 1:nrow(testy)) {
  t <- matrix(0,1,250)
  for (j in 1:250) {
    t[j] <- K2(gamma,rho,trainxx[j,],testxx[i,])
  }
  predict2[i] <- t%*%solve(C,train1y)
}

MSE4 <- sum((t(testy) - predict2)^2)/2500
print(MSE4)
t2 <- proc.time()
print(t2-t1)
```

- `output1.txt`
- `output2.txt`

"V1" "V2" "V3" "V4" "V5" "V6" "V7" "V8" "V9"
"V10" "V11" "V12" "V13" "V14" "V15" "V16" "V17" "V18"
"V19" "V20" "V21" "V22" "V23" "V24" "V25" "V26" "V27"
"V28" "V29" "V30" "V31" "V32" "V33" "V34" "V35" "V36"
"V37" "V38" "V39" "V40" "V41" "V42" "V43" "V44" "V45"
"V46" "V47" "V48" "V49" "V50" "V51" "V52" "V53" "V54"
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"V388" "V389" "V390" "V391" "V392" "V393" "V394" "V395" "V396"
"V397" "V398" "V399" "V400"
"1" 174.520883789647 170.201585517756 162.454479587056
154.838828584857 149.094746492124 145.456100713123
143.5350942038 142.841314505976 142.968512746336
143.624522192522 144.611260604651 145.797203369065
147.094968276245 148.445939930721 149.810491926912

151.161852638846	152.482132085303	153.759627120006
154.986934921175	156.159626826466	170.023033923731
122.10115204717	107.411536755318	100.31698679248 95.352745549002
91.8812355576204	89.5243784263575	88.0747208334191
87.3109914780852	86.9976999316556	86.952218700934
87.064862917945	87.2891668655801	87.619665521091 88.0670244426856
88.6405633155912	89.341388574246	90.1627957854049
91.0933313859508	92.119648197333	160.983264731851
107.679739979985	97.1333165530281	88.6479959079192
82.7387927424703	79.4029292734537	77.800038380411
77.1668387334297	76.9206115443786	76.7552526724422
76.5774840838766	76.4014485845361	76.2923673440082
76.3192593350162	76.5213714291251	76.9032223866394
77.4478160805544	78.1318364931547	78.9348509260599
79.8419411271962	150.503784847495	101.66781658322
90.5145030292758	80.6401043497518	75.366632056999
73.2898771522493	72.7264831330135	72.6373098996116
72.5445784470465	72.381620744106	72.1851121487278
72.0105219494104	71.9436417843116	72.0586403683416
72.3804428277971	72.8900306143082	73.5514807603492
74.3341924679065	75.2213287800834	76.2072212730146
140.847457310096	97.8603839797681	85.0717043962651
74.9933357563152	70.9652915385365	69.9834393936187
70.0359065378306	70.1643968509362	70.1739786475152
70.1593455853466	70.1296682288439	70.108141933239
70.2003674370404	70.4995177692692	71.019539571486
71.7168436059389	72.5403453464856	73.4605749768036
74.4719364061423	75.5808533574202	132.915753191886
94.9609704403852	80.4719157049163	71.0351375675412
68.2079423090687	67.998051718064	68.4178394734311
68.7019891364644	68.9128964217399	69.1605807542255
69.3458557154596	69.483419957009	69.7418818414177
70.2408344803987	70.9688046736581	71.851757116974
72.8309822120671	73.8877691261311	75.03139031881
76.2777267767858	126.72470703478	92.5254812101538
76.6190610604814	68.2384237634496	66.3880258843477
66.733279813832	67.4158521114613	67.8817101535418
68.3736709145316	68.913969798602	69.2858239420234
69.5517515564044	69.9716300465595	70.6727262140717
71.5990168558314	72.6500183819577	73.7721288191769
74.9631844129624	76.2451120724949	77.6373112427655
121.952762063138	90.3588251631566	73.4342188544779
66.2293070016386	65.1415919808575	65.9163196724132
66.8206476106412	67.5038410209594	68.3164887590808
69.1323938509792	69.6428902931928	70.0128389410808
70.5959588422249	71.4958939910849	72.6029440787581
73.8040497909432	75.0614213827603	76.3888992143116
77.8154777107837	79.3578508399333	118.240292295595
88.3662367539919	70.8288196605147	64.7598775214353
64.2717488860956	65.4018946461949	66.5106919914616

67.4370335812833 68.5830010591469 69.63916751835
70.2449438120701 70.7092017339274 71.4613460720118
72.5511123573492 73.8194575913297 75.1578782817577
76.5489369649092 78.0175200259867 79.5935456283572
81.2860226411304 115.29381194333 86.5002215194956
68.7117565778265 63.6692696722866 63.6630876616469
65.1019007499194 66.4054114962362 67.5906415462469
69.0685258085419 70.3262027515258 70.9956998534047
71.5565119674127 72.4826137295058 73.7484779360354
75.1605989441719 76.6295717259077 78.1566797891491
79.7712421456194 81.498901128747 83.3376204387942
112.89967980959 84.7366795902755 66.9979796643577
62.8521878900671 63.2426001516033 64.957983609545
66.4480460802752 67.9017875576391 69.7042083308938
71.1277349568888 71.8416282880627 72.508338990708
73.6095141836924 75.0349852173775 76.5772647507776
78.1749631891977 79.8422428458482 81.6065097000462
83.4853413907897 85.463722845685 110.909105106866
83.0631708570119 65.6131216984302 62.2379267554147
62.9613343756733 64.9291916686162 66.5976411459753
68.3270876936703 70.4449645535258 72.0040100479169
72.7532920733786 73.5380021712949 74.8105337403506
76.3784408775189 78.0417106436379 79.7696660866903
81.5815119200611 83.4975936819871 85.5249735750775
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0.1	0.1	0.1	0.6	0.6	0.6	0.6	0.6	0.6
0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
0.6	0.6	0.6	0.6	0.6	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.6	1.6
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
2.1	2.1	2.6	2.6	2.6	2.6	2.6	2.6	2.6
2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
2.6	2.6	2.6	2.6	3.1	3.1	3.1	3.1	3.1
3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
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5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
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9.1	9.1	9.1	9.6	9.6	9.6	9.6	9.6	9.6
9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
9.6	9.6	9.6	9.6	9.6				
"3"	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16
0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61
0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06
0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51
0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96
0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41
0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86
0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31
0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76
0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21
0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66
0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11
0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56
0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01
0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46
0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91
0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16
0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61
0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06
0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51
0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96

0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41
0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86
0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31
0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76
0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21
0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66
0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11
0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56
0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01
0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46
0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91
0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96				

"V1" "V2" "V3" "V4" "V5" "V6" "V7" "V8" "V9"
"V10" "V11" "V12" "V13" "V14" "V15" "V16" "V17" "V18"
"V19" "V20" "V21" "V22" "V23" "V24" "V25" "V26" "V27"
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0.1 0.1 0.1 0.6 0.6 0.6 0.6 0.6 0.6
0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6 0.6
0.6 0.6 0.6 0.6 0.6 1.1 1.1 1.1 1.1
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4.6 4.6 4.6 4.6 4.6 4.6 4.6 4.6 4.6
4.6 4.6 4.6 5.1 5.1 5.1 5.1 5.1 5.1

5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
5.1	5.1	5.1	5.1	5.1	5.6	5.6	5.6	5.6
5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
5.6	5.6	5.6	5.6	5.6	5.6	5.6	6.1	6.1
6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6	6.6
6.6	6.6	7.1	7.1	7.1	7.1	7.1	7.1	7.1
7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
7.1	7.1	7.1	7.1	7.6	7.6	7.6	7.6	7.6
7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6	7.6
7.6	7.6	7.6	7.6	7.6	7.6	8.1	8.1	8.1
8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1	8.1
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8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
8.6	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1	9.1
9.1	9.1	9.1	9.6	9.6	9.6	9.6	9.6	9.6
9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6
9.6	9.6	9.6	9.6	9.6				
"3"	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16
0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61
0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06
0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51
0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96
0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41
0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86
0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31
0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76
0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21
0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66
0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11
0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56
0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01
0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46
0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91
0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16
0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61
0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06
0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51

0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96
0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41
0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86
0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31
0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76
0.81	0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21
0.26	0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66
0.71	0.76	0.81	0.86	0.91	0.96	0.01	0.06	0.11
0.16	0.21	0.26	0.31	0.36	0.41	0.46	0.51	0.56
0.61	0.66	0.71	0.76	0.81	0.86	0.91	0.96	0.01
0.06	0.11	0.16	0.21	0.26	0.31	0.36	0.41	0.46
0.51	0.56	0.61	0.66	0.71	0.76	0.81	0.86	0.91
0.96	0.01	0.06	0.11	0.16	0.21	0.26	0.31	0.36
0.41	0.46	0.51	0.56	0.61	0.66	0.71	0.76	0.81
0.86	0.91	0.96	0.01	0.06	0.11	0.16	0.21	0.26
0.31	0.36	0.41	0.46	0.51	0.56	0.61	0.66	0.71
0.76	0.81	0.86	0.91	0.96				