Khan

rachel sabol

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ISLR has a dataset Khan. It contains gene expression data for 4 types of small round blue cell tumors. Use help(Khan) to see details. Apply random forest and boosting to the training set, and tuning the hyperparameters to improve the models. Report your main steps and final results.

Assemble the data for training and testing

```
library(ISLR)
library(randomForest)
```

```
## randomForest 4.6-14
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
Khan.train=data.frame(x=Khan$xtrain,y=as.factor(Khan$ytrain))
Khan.test=data.frame(x=Khan$xtest,y=as.factor(Khan$ytest))

dim(Khan.test);dim(Khan.train)
```

```
## [1]   20 2309
```

```
## [1]   63 2309
```

Apply random forest modeling

```
rf=randomForest(y~.,data=Khan.train,importance=TRUE)
yhat.rf=predict(rf,newdata=Khan.test)

summary(yhat.rf)
```
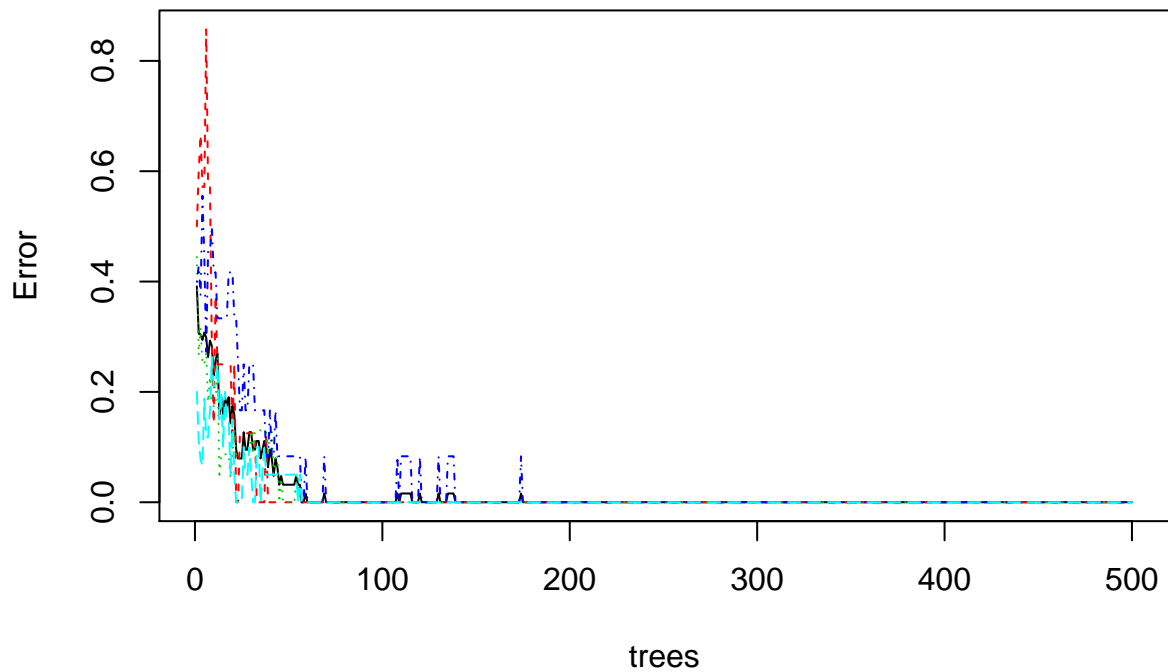
```
## 1 2 3 4
## 3 6 4 7
```

```
plot(rf)
```

rf


```r
table(yhat.rf,Khan.test$y)
```

```
##
## yhat.rf 1 2 3 4
##       1 3 0 0 0
##       2 0 6 0 0
##       3 0 0 4 0
##       4 0 0 2 5
```

Use boosting

```r
library(gbm)
```

```
## Loading required package: survival
```

```
## Loading required package: lattice
```
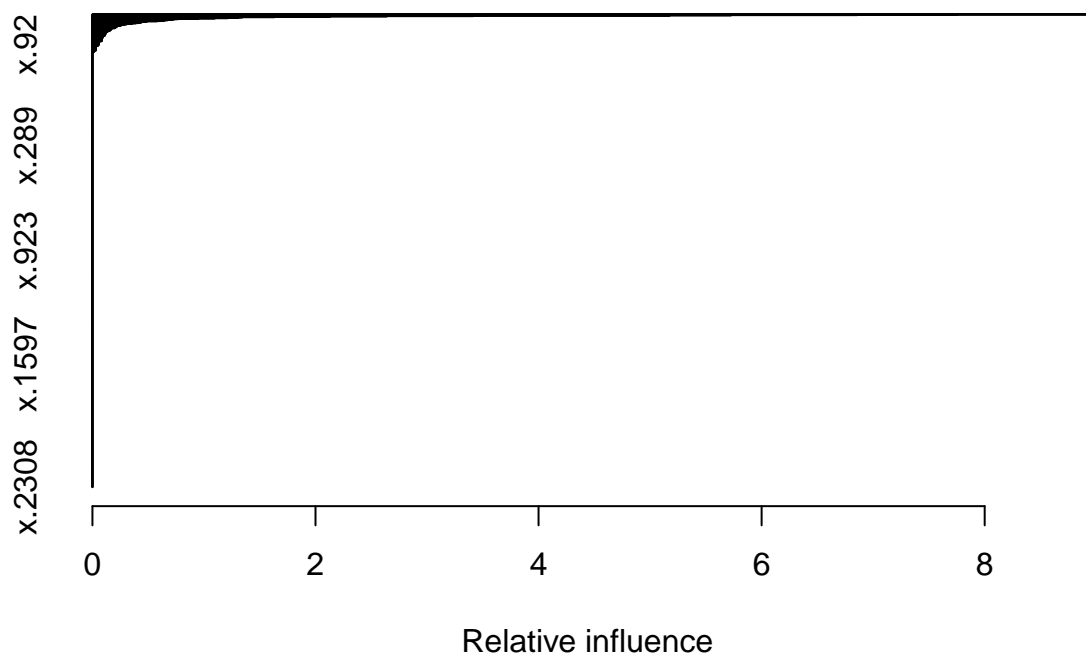
```
## Loading required package: splines
```

```
## Loading required package: parallel
```

```
## Loaded gbm 2.1.3
```

```r
boost=gbm(y~.,data=Khan.train,distribution="multinomial",n.trees=500,interaction.depth=4)
```

```r
summary(boost)
```

Relative influence

```
##            var      rel.inf
## x.1003 x.1003 8.965487e+00
## x.545   x.545 7.761705e+00
## x.1389 x.1389 7.441845e+00
## x.1954 x.1954 6.857186e+00
## x.246   x.246 5.727582e+00
## x.2050 x.2050 5.178906e+00
## x.509   x.509 3.529607e+00
## x.174   x.174 3.481545e+00
## x.1955 x.1955 3.415139e+00
## x.1319 x.1319 2.641267e+00
## x.1055 x.1055 2.134032e+00
## x.742   x.742 1.866068e+00
## x.129   x.129 1.842500e+00
## x.2046 x.2046 1.634186e+00
## x.2       x.2 1.346151e+00
## x.255   x.255 1.313407e+00
## x.1207 x.1207 1.307265e+00
## x.566   x.566 1.265909e+00
## x.1347 x.1347 1.215539e+00
## x.1708 x.1708 1.099093e+00
## x.1896 x.1896 9.548769e-01
## x.554   x.554 8.933322e-01
## x.879   x.879 8.028260e-01
## x.976   x.976 7.629960e-01
## x.910   x.910 7.337470e-01
```

```
## x.1434 x.1434 7.155159e-01
## x.1601 x.1601 6.809688e-01
## x.1645 x.1645 6.779477e-01
## x.2000 x.2000 6.746167e-01
## x.2146 x.2146 6.500255e-01
## x.187    x.187 6.427120e-01
## x.1105 x.1105 6.245638e-01
## x.67      x.67 6.099924e-01
## x.1066 x.1066 5.796555e-01
## x.123    x.123 4.927948e-01
## x.380    x.380 4.810240e-01
## x.823    x.823 4.599523e-01
## x.1299 x.1299 4.442284e-01
## x.2157 x.2157 4.430747e-01
## x.1327 x.1327 4.366085e-01
## x.169    x.169 4.232124e-01
## x.1662 x.1662 4.129935e-01
## x.1084 x.1084 4.082566e-01
## x.2159 x.2159 3.909878e-01
## x.1911 x.1911 3.598135e-01
## x.1194 x.1194 3.550103e-01
## x.585    x.585 3.413590e-01
## x.338    x.338 3.082026e-01
## x.846    x.846 3.067813e-01
## x.1914 x.1914 2.875889e-01
## x.433    x.433 2.863521e-01
## x.1862 x.1862 2.677330e-01
## x.603    x.603 2.657310e-01
## x.1477 x.1477 2.580234e-01
## x.276    x.276 2.538185e-01
## x.1924 x.1924 2.442374e-01
## x.1531 x.1531 2.386174e-01
## x.1536 x.1536 2.245914e-01
## x.1581 x.1581 2.204630e-01
## x.85      x.85 2.195196e-01
## x.801    x.801 2.162624e-01
## x.575    x.575 2.148172e-01
## x.607    x.607 2.103978e-01
## x.1738 x.1738 2.078424e-01
## x.2047 x.2047 2.077942e-01
## x.156    x.156 2.043894e-01
## x.490    x.490 2.013037e-01
## x.499    x.499 2.002816e-01
## x.2144 x.2144 1.759407e-01
## x.597    x.597 1.718638e-01
## x.1369 x.1369 1.704898e-01
## x.1422 x.1422 1.698181e-01
## x.52      x.52 1.662869e-01
## x.779    x.779 1.648669e-01
## x.1553 x.1553 1.642518e-01
## x.695    x.695 1.638166e-01
## x.365    x.365 1.612249e-01
## x.1091 x.1091 1.611093e-01
## x.1006 x.1006 1.576470e-01
```

```
## x.1656 x.1656 1.545430e-01
## x.2083 x.2083 1.520420e-01
## x.1393 x.1393 1.455429e-01
## x.422   x.422 1.412700e-01
## x.188   x.188 1.349416e-01
## x.1916 x.1916 1.329726e-01
## x.1413 x.1413 1.307437e-01
## x.2199 x.2199 1.282190e-01
## x.1354 x.1354 1.240606e-01
## x.178   x.178 1.232073e-01
## x.17     x.17 1.208464e-01
## x.972   x.972 1.192297e-01
## x.368   x.368 1.185197e-01
## x.1548 x.1548 1.180301e-01
## x.1576 x.1576 1.176892e-01
## x.859   x.859 1.168821e-01
## x.1881 x.1881 1.156192e-01
## x.958   x.958 1.147703e-01
## x.877   x.877 1.141188e-01
## x.2007 x.2007 1.136302e-01
## x.842   x.842 1.133518e-01
## x.1543 x.1543 1.131923e-01
## x.716   x.716 1.121292e-01
## x.970   x.970 1.116458e-01
## x.1395 x.1395 1.108024e-01
## x.1634 x.1634 1.075900e-01
## x.153   x.153 1.021543e-01
## x.1283 x.1283 9.935913e-02
## x.1       x.1 9.299182e-02
## x.1188 x.1188 9.248857e-02
## x.2093 x.2093 9.184889e-02
## x.1387 x.1387 9.154788e-02
## x.1509 x.1509 9.058409e-02
## x.1011 x.1011 8.981482e-02
## x.1158 x.1158 8.979802e-02
## x.1250 x.1250 8.850392e-02
## x.849   x.849 8.845188e-02
## x.630   x.630 8.807784e-02
## x.1735 x.1735 8.696015e-02
## x.799   x.799 8.646774e-02
## x.2235 x.2235 8.616163e-02
## x.1908 x.1908 8.593364e-02
## x.325   x.325 8.536178e-02
## x.589   x.589 8.513188e-02
## x.933   x.933 8.485760e-02
## x.1572 x.1572 8.458964e-02
## x.1626 x.1626 8.433481e-02
## x.1116 x.1116 8.431518e-02
## x.1741 x.1741 8.430020e-02
## x.949   x.949 8.412469e-02
## x.951   x.951 8.184231e-02
## x.1013 x.1013 8.069373e-02
## x.1880 x.1880 7.872616e-02
## x.417   x.417 5.943320e-02
```

```
## x.1197 x.1197 5.928039e-02
## x.2211 x.2211 5.922545e-02
## x.1915 x.1915 5.771176e-02
## x.1957 x.1957 5.749277e-02
## x.555   x.555 5.684201e-02
## x.839   x.839 5.671623e-02
## x.2243 x.2243 5.668960e-02
## x.279   x.279 5.667935e-02
## x.806   x.806 5.613221e-02
## x.2019 x.2019 5.601856e-02
## x.943   x.943 5.581204e-02
## x.1415 x.1415 5.579980e-02
## x.1075 x.1075 5.566234e-02
## x.927   x.927 5.521755e-02
## x.845   x.845 5.513145e-02
## x.92     x.92 5.419580e-02
## x.494   x.494 5.319358e-02
## x.1481 x.1481 5.289953e-02
## x.1784 x.1784 5.157927e-02
## x.2031 x.2031 5.131785e-02
## x.1573 x.1573 4.699839e-02
## x.2168 x.2168 3.347471e-02
## x.1967 x.1967 3.337152e-02
## x.640   x.640 3.311987e-02
## x.1727 x.1727 3.296505e-02
## x.410   x.410 3.283200e-02
## x.1931 x.1931 3.268998e-02
## x.1223 x.1223 3.256177e-02
## x.836   x.836 3.219123e-02
## x.558   x.558 3.215841e-02
## x.307   x.307 3.193246e-02
## x.905   x.905 3.185425e-02
## x.2029 x.2029 3.148780e-02
## x.2037 x.2037 3.143722e-02
## x.562   x.562 3.131571e-02
## x.733   x.733 3.120625e-02
## x.2088 x.2088 3.098618e-02
## x.1061 x.1061 3.095570e-02
## x.1377 x.1377 3.092840e-02
## x.1950 x.1950 3.069265e-02
## x.784   x.784 3.053255e-02
## x.1617 x.1617 3.031424e-02
## x.1295 x.1295 2.996358e-02
## x.1804 x.1804 2.987868e-02
## x.2122 x.2122 1.488427e-02
## x.419   x.419 1.446278e-02
## x.2305 x.2305 1.442721e-02
## x.2129 x.2129 1.412277e-02
## x.206   x.206 1.354931e-02
## x.1285 x.1285 1.352357e-02
## x.2231 x.2231 1.336069e-02
## x.1985 x.1985 3.644463e-03
## x.1628 x.1628 3.617269e-03
## x.699   x.699 3.531671e-03
```

```
## x.80      x.80 3.481502e-03
## x.1479 x.1479 3.340780e-03
## x.430      x.430 3.060535e-03
## x.1073 x.1073 3.031431e-03
## x.1524 x.1524 3.535261e-04
## x.1998 x.1998 2.542920e-04
## x.437      x.437 1.984504e-04
## x.36        x.36 1.759779e-04
## x.378      x.378 1.514379e-04
## x.504      x.504 1.304099e-04
## x.1111 x.1111 1.240397e-04
## x.1991 x.1991 1.183479e-04
## x.1074 x.1074 1.167793e-04
## x.865      x.865 9.562305e-05
## x.2026 x.2026 8.888585e-05
## x.74        x.74 8.640715e-05
## x.1384 x.1384 7.875220e-05
## x.2077 x.2077 7.874261e-05
## x.1206 x.1206 7.820017e-05
## x.2248 x.2248 7.398902e-05
## x.1795 x.1795 7.308176e-05
## x.326      x.326 6.273644e-05
## x.762      x.762 5.977047e-05
## x.854      x.854 5.368294e-05
## x.1220 x.1220 5.352415e-05
## x.2022 x.2022 5.188550e-05
## x.1457 x.1457 4.836096e-05
## x.403      x.403 4.807225e-05
## x.1942 x.1942 4.721560e-05
## x.1883 x.1883 4.699093e-05
## x.483      x.483 4.170719e-05
## x.1196 x.1196 3.981126e-05
## x.217      x.217 3.868735e-05
## x.1328 x.1328 3.663441e-05
## x.931      x.931 3.574985e-05
## x.69        x.69 3.500418e-05
## x.1943 x.1943 3.465010e-05
## x.1759 x.1759 3.453909e-05
## x.749      x.749 3.451794e-05
## x.526      x.526 3.160558e-05
## x.848      x.848 3.116748e-05
## x.657      x.657 3.093269e-05
## x.236      x.236 3.046481e-05
## x.258      x.258 2.945144e-05
## x.1736 x.1736 2.562423e-05
## x.546      x.546 2.546232e-05
## x.1583 x.1583 2.540422e-05
## x.1436 x.1436 2.462034e-05
## x.1263 x.1263 2.447213e-05
## x.875      x.875 2.377240e-05
## x.1030 x.1030 2.366345e-05
## x.2190 x.2190 2.327376e-05
## x.2048 x.2048 2.288670e-05
## x.449      x.449 2.250828e-05
```

```
## x.405    x.405 2.201314e-05
## x.98       x.98 2.187572e-05
## x.1758 x.1758 2.157296e-05
## x.241    x.241 2.084775e-05
## x.1762 x.1762 2.075104e-05
## x.27       x.27 2.041887e-05
## x.1949 x.1949 2.034581e-05
## x.2145 x.2145 2.015292e-05
## x.746    x.746 2.004983e-05
## x.2253 x.2253 1.998456e-05
## x.1215 x.1215 1.978812e-05
## x.783    x.783 1.846626e-05
## x.81       x.81 1.830224e-05
## x.1613 x.1613 1.711553e-05
## x.3         x.3 1.691964e-05
## x.594    x.594 1.665994e-05
## x.718    x.718 1.660823e-05
## x.1975 x.1975 1.638092e-05
## x.738    x.738 1.561327e-05
## x.672    x.672 1.559557e-05
## x.113    x.113 1.529015e-05
## x.212    x.212 1.455281e-05
## x.1277 x.1277 1.451977e-05
## x.224    x.224 1.411178e-05
## x.1373 x.1373 1.407205e-05
## x.1721 x.1721 1.397528e-05
## x.590    x.590 1.357266e-05
## x.1005 x.1005 1.325683e-05
## x.796    x.796 1.297808e-05
## x.604    x.604 1.193864e-05
## x.2258 x.2258 1.191081e-05
## x.1978 x.1978 1.125245e-05
## x.1307 x.1307 1.123476e-05
## x.728    x.728 1.118015e-05
## x.1773 x.1773 1.108556e-05
## x.645    x.645 1.006983e-05
## x.116    x.116 9.841681e-06
## x.1489 x.1489 9.789662e-06
## x.2118 x.2118 9.542044e-06
## x.481    x.481 9.419392e-06
## x.639    x.639 9.300292e-06
## x.1394 x.1394 8.740197e-06
## x.872    x.872 8.655935e-06
## x.1747 x.1747 8.566862e-06
## x.1279 x.1279 8.426922e-06
## x.1856 x.1856 8.366352e-06
## x.235    x.235 8.354534e-06
## x.1067 x.1067 8.277769e-06
## x.599    x.599 8.050061e-06
## x.284    x.284 7.936258e-06
## x.1965 x.1965 7.912284e-06
## x.1750 x.1750 7.860197e-06
## x.1797 x.1797 7.814598e-06
## x.107    x.107 7.793688e-06
```

```
## x.1303 x.1303 7.771212e-06
## x.1724 x.1724 7.737621e-06
## x.819   x.819 7.707403e-06
## x.1661 x.1661 7.483647e-06
## x.1406 x.1406 7.417455e-06
## x.426   x.426 7.411161e-06
## x.2032 x.2032 7.387831e-06
## x.163   x.163 7.239132e-06
## x.1004 x.1004 6.989945e-06
## x.820   x.820 6.848812e-06
## x.1629 x.1629 6.839558e-06
## x.714   x.714 6.577794e-06
## x.979   x.979 6.273784e-06
## x.70    x.70 6.043892e-06
## x.64    x.64 5.777488e-06
## x.415   x.415 5.607810e-06
## x.1324 x.1324 5.403456e-06
## x.384   x.384 5.208032e-06
## x.1538 x.1538 5.079087e-06
## x.696   x.696 4.977226e-06
## x.1022 x.1022 4.837766e-06
## x.462   x.462 4.817490e-06
## x.1903 x.1903 4.708412e-06
## x.791   x.791 4.394209e-06
## x.347   x.347 4.390809e-06
## x.260   x.260 4.373006e-06
## x.142   x.142 4.357400e-06
## x.1966 x.1966 4.349854e-06
## x.734   x.734 3.748848e-06
## x.230   x.230 3.746546e-06
## x.606   x.606 3.481279e-06
## x.477   x.477 3.407461e-06
## x.1756 x.1756 3.399461e-06
## x.765   x.765 3.293110e-06
## x.1678 x.1678 3.230701e-06
## x.824   x.824 3.171293e-06
## x.2101 x.2101 3.050465e-06
## x.1348 x.1348 2.866120e-06
## x.383   x.383 2.837666e-06
## x.1048 x.1048 2.815708e-06
## x.1033 x.1033 2.776345e-06
## x.400   x.400 2.769306e-06
## x.487   x.487 2.736461e-06
## x.1554 x.1554 2.658813e-06
## x.1700 x.1700 2.592164e-06
## x.29    x.29 2.573325e-06
## x.99    x.99 2.555621e-06
## x.215   x.215 2.541365e-06
## x.1396 x.1396 2.537413e-06
## x.2109 x.2109 2.344366e-06
## x.328   x.328 2.326072e-06
## x.1225 x.1225 2.302891e-06
## x.1730 x.1730 2.286877e-06
## x.1580 x.1580 2.250846e-06
```

```
## x.1236 x.1236 2.247530e-06
## x.139    x.139 2.095035e-06
## x.1057 x.1057 1.995331e-06
## x.1772 x.1772 1.871024e-06
## x.238    x.238 1.753495e-06
## x.2068 x.2068 1.679369e-06
## x.1487 x.1487 1.654856e-06
## x.91      x.91 1.508813e-06
## x.1312 x.1312 1.488767e-06
## x.980    x.980 1.367571e-06
## x.31      x.31 1.337444e-06
## x.152    x.152 1.041405e-06
## x.1565 x.1565 9.941868e-07
## x.719    x.719 9.924732e-07
## x.424    x.424 9.917064e-07
## x.1473 x.1473 9.535489e-07
## x.1228 x.1228 9.318939e-07
## x.643    x.643 7.796164e-07
## x.315    x.315 7.067780e-07
## x.1496 x.1496 6.927065e-07
## x.1751 x.1751 5.893499e-07
## x.2023 x.2023 5.764264e-07
## x.1291 x.1291 5.608208e-07
## x.1934 x.1934 5.207029e-07
## x.673    x.673 5.039980e-07
## x.1092 x.1092 5.014311e-07
## x.1600 x.1600 4.869130e-07
## x.1775 x.1775 4.811664e-07
## x.2151 x.2151 4.680115e-07
## x.407    x.407 4.649813e-07
## x.1462 x.1462 4.462149e-07
## x.1930 x.1930 4.212216e-07
## x.564    x.564 4.058638e-07
## x.465    x.465 3.898952e-07
## x.2062 x.2062 3.747961e-07
## x.582    x.582 3.683051e-07
## x.1515 x.1515 3.432024e-07
## x.629    x.629 2.931156e-07
## x.312    x.312 2.883786e-07
## x.1454 x.1454 2.419534e-07
## x.1020 x.1020 2.353554e-07
## x.446    x.446 2.235009e-07
## x.431    x.431 2.144439e-07
## x.1221 x.1221 1.782162e-07
## x.420    x.420 1.503823e-07
## x.1049 x.1049 1.405216e-07
## x.1076 x.1076 1.324975e-07
## x.670    x.670 1.319842e-07
## x.1351 x.1351 1.058001e-07
## x.805    x.805 9.847358e-08
## x.1177 x.1177 8.621734e-08
## x.1740 x.1740 8.455049e-08
## x.946    x.946 7.259694e-08
## x.706    x.706 6.919982e-08
```

```
## x.281    x.281 6.664676e-08
## x.204    x.204 3.931753e-08
## x.1936 x.1936 3.080581e-08
## x.265    x.265 1.692854e-08
## x.399    x.399 1.580709e-08
## x.4        x.4 0.000000e+00
## x.5        x.5 0.000000e+00
## x.6        x.6 0.000000e+00
## x.7        x.7 0.000000e+00
## x.8        x.8 0.000000e+00
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## x.624    x.624 0.000000e+00
## x.625    x.625 0.000000e+00
## x.626    x.626 0.000000e+00
## x.627    x.627 0.000000e+00
## x.628    x.628 0.000000e+00
## x.631    x.631 0.000000e+00
## x.632    x.632 0.000000e+00
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## x.638    x.638 0.000000e+00
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## x.664    x.664 0.000000e+00
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## x.665    x.665 0.000000e+00
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## x.667    x.667 0.000000e+00
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## x.669    x.669 0.000000e+00
## x.671    x.671 0.000000e+00
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## x.698    x.698 0.000000e+00
## x.700    x.700 0.000000e+00
## x.701    x.701 0.000000e+00
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## x.707    x.707 0.000000e+00
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## x.711    x.711 0.000000e+00
## x.712    x.712 0.000000e+00
## x.713    x.713 0.000000e+00
## x.715    x.715 0.000000e+00
## x.717    x.717 0.000000e+00
## x.720    x.720 0.000000e+00
## x.721    x.721 0.000000e+00
## x.722    x.722 0.000000e+00
## x.723    x.723 0.000000e+00
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## x.725    x.725 0.000000e+00
## x.726    x.726 0.000000e+00
## x.727    x.727 0.000000e+00
## x.729    x.729 0.000000e+00
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## x.731    x.731 0.000000e+00
## x.732    x.732 0.000000e+00
## x.735    x.735 0.000000e+00
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## x.737    x.737 0.000000e+00
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## x.740    x.740 0.000000e+00
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## x.747    x.747 0.000000e+00
## x.748    x.748 0.000000e+00
## x.750    x.750 0.000000e+00
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## x.778    x.778 0.000000e+00
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## x.781    x.781 0.000000e+00
## x.782    x.782 0.000000e+00
## x.785    x.785 0.000000e+00
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## x.788    x.788 0.000000e+00
## x.789    x.789 0.000000e+00
## x.790    x.790 0.000000e+00
## x.792    x.792 0.000000e+00
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## x.797    x.797 0.000000e+00
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## x.798    x.798 0.000000e+00
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## x.818    x.818 0.000000e+00
## x.821    x.821 0.000000e+00
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## x.847    x.847 0.000000e+00
## x.850    x.850 0.000000e+00
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## x.867    x.867 0.000000e+00
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## x.870    x.870 0.000000e+00
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## x.930    x.930 0.000000e+00
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## x.932    x.932 0.000000e+00
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## x.950    x.950 0.000000e+00
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## x.977    x.977 0.000000e+00
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## x.989    x.989 0.000000e+00
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## x.991    x.991 0.000000e+00
## x.992    x.992 0.000000e+00
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## x.994    x.994 0.000000e+00
## x.995    x.995 0.000000e+00
## x.996    x.996 0.000000e+00
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## x.997    x.997 0.000000e+00
## x.998    x.998 0.000000e+00
## x.999    x.999 0.000000e+00
## x.1000 x.1000 0.000000e+00
## x.1001 x.1001 0.000000e+00
## x.1002 x.1002 0.000000e+00
## x.1007 x.1007 0.000000e+00
## x.1008 x.1008 0.000000e+00
## x.1009 x.1009 0.000000e+00
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## x.1014 x.1014 0.000000e+00
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## x.1019 x.1019 0.000000e+00
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## x.1023 x.1023 0.000000e+00
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## x.1068 x.1068 0.000000e+00
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## x.1080 x.1080 0.000000e+00
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## x.1189 x.1189 0.000000e+00
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## x.1195 x.1195 0.000000e+00
## x.1198 x.1198 0.000000e+00
## x.1199 x.1199 0.000000e+00
## x.1200 x.1200 0.000000e+00
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## x.1798 x.1798 0.000000e+00
## x.1799 x.1799 0.000000e+00
## x.1800 x.1800 0.000000e+00
## x.1801 x.1801 0.000000e+00
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## x.1841 x.1841 0.000000e+00
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## x.1842 x.1842 0.000000e+00
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## x.1898 x.1898 0.000000e+00
## x.1899 x.1899 0.000000e+00
## x.1900 x.1900 0.000000e+00
## x.1901 x.1901 0.000000e+00
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## x.1902 x.1902 0.000000e+00
## x.1904 x.1904 0.000000e+00
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## x.1906 x.1906 0.000000e+00
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## x.1909 x.1909 0.000000e+00
## x.1910 x.1910 0.000000e+00
## x.1912 x.1912 0.000000e+00
## x.1913 x.1913 0.000000e+00
## x.1917 x.1917 0.000000e+00
## x.1918 x.1918 0.000000e+00
## x.1919 x.1919 0.000000e+00
## x.1920 x.1920 0.000000e+00
## x.1921 x.1921 0.000000e+00
## x.1922 x.1922 0.000000e+00
## x.1923 x.1923 0.000000e+00
## x.1925 x.1925 0.000000e+00
## x.1926 x.1926 0.000000e+00
## x.1927 x.1927 0.000000e+00
## x.1928 x.1928 0.000000e+00
## x.1929 x.1929 0.000000e+00
## x.1932 x.1932 0.000000e+00
## x.1933 x.1933 0.000000e+00
## x.1935 x.1935 0.000000e+00
## x.1937 x.1937 0.000000e+00
## x.1938 x.1938 0.000000e+00
## x.1939 x.1939 0.000000e+00
## x.1940 x.1940 0.000000e+00
## x.1941 x.1941 0.000000e+00
## x.1944 x.1944 0.000000e+00
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## x.1946 x.1946 0.000000e+00
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## x.1951 x.1951 0.000000e+00
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## x.1956 x.1956 0.000000e+00
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## x.1962 x.1962 0.000000e+00
## x.1963 x.1963 0.000000e+00
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## x.1968 x.1968 0.000000e+00
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## x.1970 x.1970 0.000000e+00
## x.1971 x.1971 0.000000e+00
## x.1972 x.1972 0.000000e+00
## x.1973 x.1973 0.000000e+00
## x.1974 x.1974 0.000000e+00
## x.1976 x.1976 0.000000e+00
## x.1977 x.1977 0.000000e+00
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## x.1979 x.1979 0.000000e+00
## x.1980 x.1980 0.000000e+00
## x.1981 x.1981 0.000000e+00
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## x.1983 x.1983 0.000000e+00
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## x.1993 x.1993 0.000000e+00
## x.1994 x.1994 0.000000e+00
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## x.1997 x.1997 0.000000e+00
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## x.2011 x.2011 0.000000e+00
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## x.2013 x.2013 0.000000e+00
## x.2014 x.2014 0.000000e+00
## x.2015 x.2015 0.000000e+00
## x.2016 x.2016 0.000000e+00
## x.2017 x.2017 0.000000e+00
## x.2018 x.2018 0.000000e+00
## x.2020 x.2020 0.000000e+00
## x.2021 x.2021 0.000000e+00
## x.2024 x.2024 0.000000e+00
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## x.2027 x.2027 0.000000e+00
## x.2028 x.2028 0.000000e+00
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## x.2038 x.2038 0.000000e+00
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## x.2040 x.2040 0.000000e+00
## x.2041 x.2041 0.000000e+00
## x.2042 x.2042 0.000000e+00
## x.2043 x.2043 0.000000e+00
## x.2044 x.2044 0.000000e+00
## x.2045 x.2045 0.000000e+00
```

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## x.2049 x.2049 0.000000e+00
## x.2051 x.2051 0.000000e+00
## x.2052 x.2052 0.000000e+00
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## x.2061 x.2061 0.000000e+00
## x.2063 x.2063 0.000000e+00
## x.2064 x.2064 0.000000e+00
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## x.2066 x.2066 0.000000e+00
## x.2067 x.2067 0.000000e+00
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## x.2070 x.2070 0.000000e+00
## x.2071 x.2071 0.000000e+00
## x.2072 x.2072 0.000000e+00
## x.2073 x.2073 0.000000e+00
## x.2074 x.2074 0.000000e+00
## x.2075 x.2075 0.000000e+00
## x.2076 x.2076 0.000000e+00
## x.2078 x.2078 0.000000e+00
## x.2079 x.2079 0.000000e+00
## x.2080 x.2080 0.000000e+00
## x.2081 x.2081 0.000000e+00
## x.2082 x.2082 0.000000e+00
## x.2084 x.2084 0.000000e+00
## x.2085 x.2085 0.000000e+00
## x.2086 x.2086 0.000000e+00
## x.2087 x.2087 0.000000e+00
## x.2089 x.2089 0.000000e+00
## x.2090 x.2090 0.000000e+00
## x.2091 x.2091 0.000000e+00
## x.2092 x.2092 0.000000e+00
## x.2094 x.2094 0.000000e+00
## x.2095 x.2095 0.000000e+00
## x.2096 x.2096 0.000000e+00
## x.2097 x.2097 0.000000e+00
## x.2098 x.2098 0.000000e+00
## x.2099 x.2099 0.000000e+00
## x.2100 x.2100 0.000000e+00
## x.2102 x.2102 0.000000e+00
## x.2103 x.2103 0.000000e+00
## x.2104 x.2104 0.000000e+00
## x.2105 x.2105 0.000000e+00
## x.2106 x.2106 0.000000e+00
## x.2107 x.2107 0.000000e+00
## x.2108 x.2108 0.000000e+00
## x.2110 x.2110 0.000000e+00
## x.2111 x.2111 0.000000e+00
```

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## x.2112 x.2112 0.000000e+00
## x.2113 x.2113 0.000000e+00
## x.2114 x.2114 0.000000e+00
## x.2115 x.2115 0.000000e+00
## x.2116 x.2116 0.000000e+00
## x.2117 x.2117 0.000000e+00
## x.2119 x.2119 0.000000e+00
## x.2120 x.2120 0.000000e+00
## x.2121 x.2121 0.000000e+00
## x.2123 x.2123 0.000000e+00
## x.2124 x.2124 0.000000e+00
## x.2125 x.2125 0.000000e+00
## x.2126 x.2126 0.000000e+00
## x.2127 x.2127 0.000000e+00
## x.2128 x.2128 0.000000e+00
## x.2130 x.2130 0.000000e+00
## x.2131 x.2131 0.000000e+00
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## x.2156 x.2156 0.000000e+00
## x.2158 x.2158 0.000000e+00
## x.2160 x.2160 0.000000e+00
## x.2161 x.2161 0.000000e+00
## x.2162 x.2162 0.000000e+00
## x.2163 x.2163 0.000000e+00
## x.2164 x.2164 0.000000e+00
## x.2165 x.2165 0.000000e+00
## x.2166 x.2166 0.000000e+00
## x.2167 x.2167 0.000000e+00
## x.2169 x.2169 0.000000e+00
## x.2170 x.2170 0.000000e+00
## x.2171 x.2171 0.000000e+00
## x.2172 x.2172 0.000000e+00
## x.2173 x.2173 0.000000e+00
## x.2174 x.2174 0.000000e+00
## x.2175 x.2175 0.000000e+00
```

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## x.2176 x.2176 0.000000e+00
## x.2177 x.2177 0.000000e+00
## x.2178 x.2178 0.000000e+00
## x.2179 x.2179 0.000000e+00
## x.2180 x.2180 0.000000e+00
## x.2181 x.2181 0.000000e+00
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## x.2183 x.2183 0.000000e+00
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## x.2197 x.2197 0.000000e+00
## x.2198 x.2198 0.000000e+00
## x.2200 x.2200 0.000000e+00
## x.2201 x.2201 0.000000e+00
## x.2202 x.2202 0.000000e+00
## x.2203 x.2203 0.000000e+00
## x.2204 x.2204 0.000000e+00
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## x.2206 x.2206 0.000000e+00
## x.2207 x.2207 0.000000e+00
## x.2208 x.2208 0.000000e+00
## x.2209 x.2209 0.000000e+00
## x.2210 x.2210 0.000000e+00
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## x.2216 x.2216 0.000000e+00
## x.2217 x.2217 0.000000e+00
## x.2218 x.2218 0.000000e+00
## x.2219 x.2219 0.000000e+00
## x.2220 x.2220 0.000000e+00
## x.2221 x.2221 0.000000e+00
## x.2222 x.2222 0.000000e+00
## x.2223 x.2223 0.000000e+00
## x.2224 x.2224 0.000000e+00
## x.2225 x.2225 0.000000e+00
## x.2226 x.2226 0.000000e+00
## x.2227 x.2227 0.000000e+00
## x.2228 x.2228 0.000000e+00
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## x.2230 x.2230 0.000000e+00
## x.2232 x.2232 0.000000e+00
## x.2233 x.2233 0.000000e+00
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## x.2234 x.2234 0.000000e+00
## x.2236 x.2236 0.000000e+00
## x.2237 x.2237 0.000000e+00
## x.2238 x.2238 0.000000e+00
## x.2239 x.2239 0.000000e+00
## x.2240 x.2240 0.000000e+00
## x.2241 x.2241 0.000000e+00
## x.2242 x.2242 0.000000e+00
## x.2244 x.2244 0.000000e+00
## x.2245 x.2245 0.000000e+00
## x.2246 x.2246 0.000000e+00
## x.2247 x.2247 0.000000e+00
## x.2249 x.2249 0.000000e+00
## x.2250 x.2250 0.000000e+00
## x.2251 x.2251 0.000000e+00
## x.2252 x.2252 0.000000e+00
## x.2254 x.2254 0.000000e+00
## x.2255 x.2255 0.000000e+00
## x.2256 x.2256 0.000000e+00
## x.2257 x.2257 0.000000e+00
## x.2259 x.2259 0.000000e+00
## x.2260 x.2260 0.000000e+00
## x.2261 x.2261 0.000000e+00
## x.2262 x.2262 0.000000e+00
## x.2263 x.2263 0.000000e+00
## x.2264 x.2264 0.000000e+00
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## x.2266 x.2266 0.000000e+00
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## x.2269 x.2269 0.000000e+00
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## x.2271 x.2271 0.000000e+00
## x.2272 x.2272 0.000000e+00
## x.2273 x.2273 0.000000e+00
## x.2274 x.2274 0.000000e+00
## x.2275 x.2275 0.000000e+00
## x.2276 x.2276 0.000000e+00
## x.2277 x.2277 0.000000e+00
## x.2278 x.2278 0.000000e+00
## x.2279 x.2279 0.000000e+00
## x.2280 x.2280 0.000000e+00
## x.2281 x.2281 0.000000e+00
## x.2282 x.2282 0.000000e+00
## x.2283 x.2283 0.000000e+00
## x.2284 x.2284 0.000000e+00
## x.2285 x.2285 0.000000e+00
## x.2286 x.2286 0.000000e+00
## x.2287 x.2287 0.000000e+00
## x.2288 x.2288 0.000000e+00
## x.2289 x.2289 0.000000e+00
## x.2290 x.2290 0.000000e+00
## x.2291 x.2291 0.000000e+00
## x.2292 x.2292 0.000000e+00
```
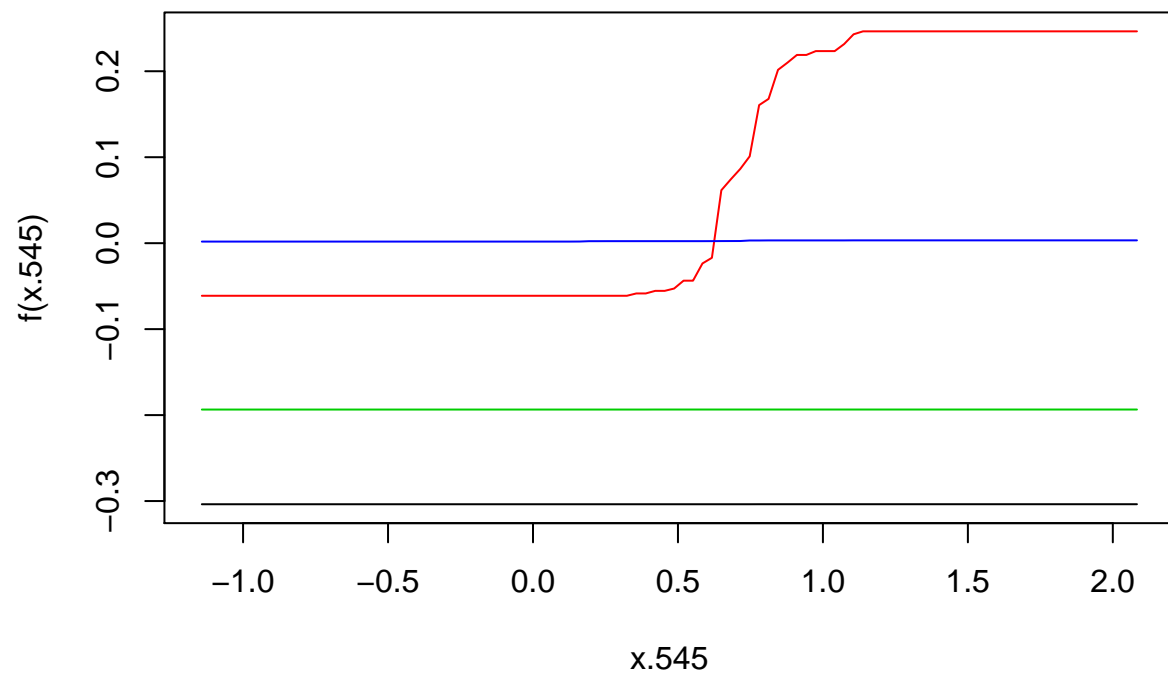
```
## x.2293 x.2293 0.000000e+00
## x.2294 x.2294 0.000000e+00
## x.2295 x.2295 0.000000e+00
## x.2296 x.2296 0.000000e+00
## x.2297 x.2297 0.000000e+00
## x.2298 x.2298 0.000000e+00
## x.2299 x.2299 0.000000e+00
## x.2300 x.2300 0.000000e+00
## x.2301 x.2301 0.000000e+00
## x.2302 x.2302 0.000000e+00
## x.2303 x.2303 0.000000e+00
## x.2304 x.2304 0.000000e+00
## x.2306 x.2306 0.000000e+00
## x.2307 x.2307 0.000000e+00
## x.2308 x.2308 0.000000e+00
```

```r
yhat.boost=predict(boost,newdata=Khan.test,n.trees=500)
table(yhat.rf,Khan.test$y)
```
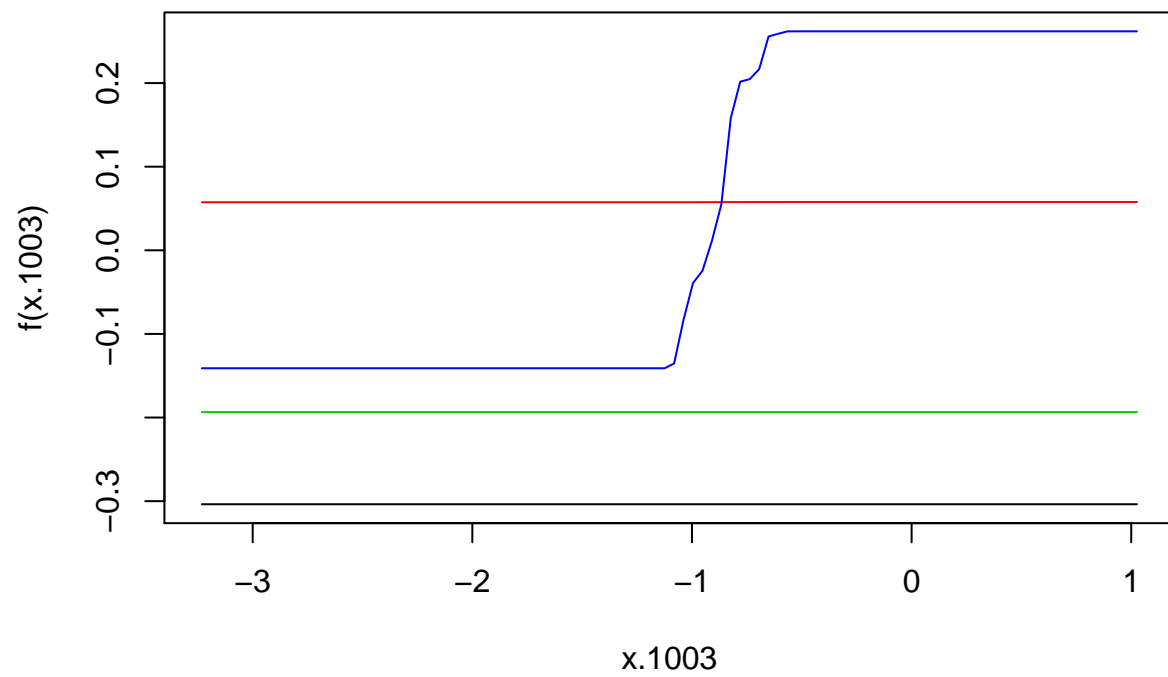
```
## 
## yhat.rf 1 2 3 4
##       1 3 0 0 0
##       2 0 6 0 0
##       3 0 0 4 0
##       4 0 0 2 5
```

Random forest with and without boosting have each made one prediction incorrectly.
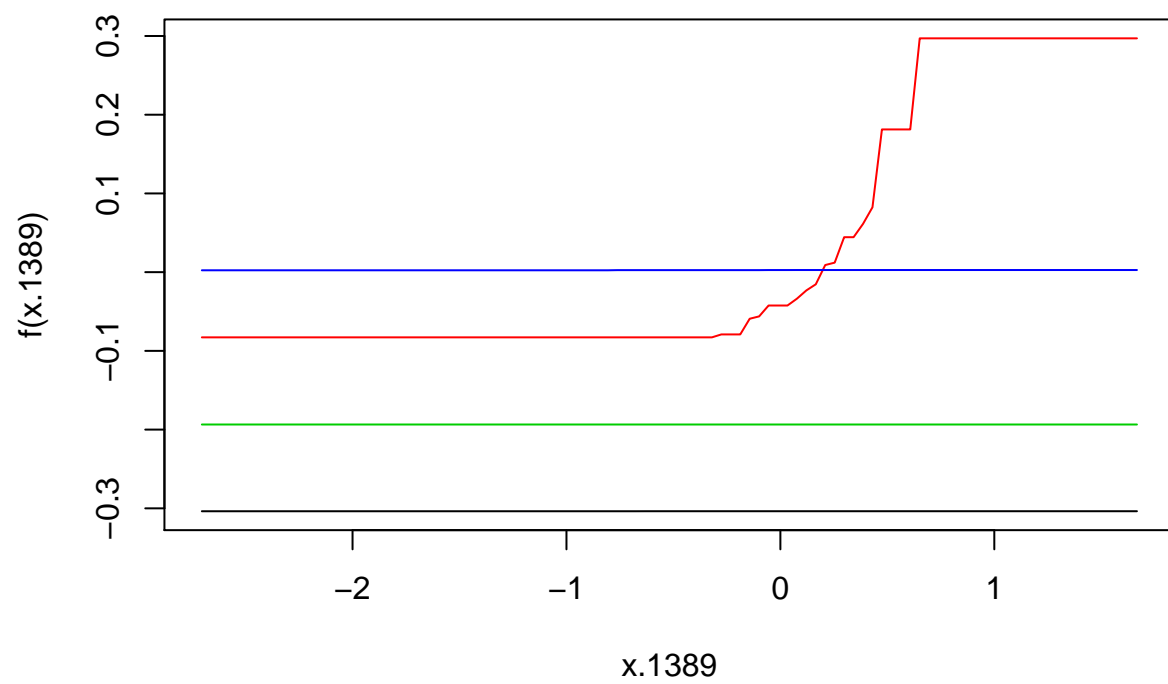
```r
plot(boost, i="x.545",main="boost")
```

```
plot(boost, i="x.1003",main="boost")
```

```
plot(boost, i="x.1389",main="boost")
```

```r
plot(boost, i="x.1954",main="boost")
```

50