Homework2

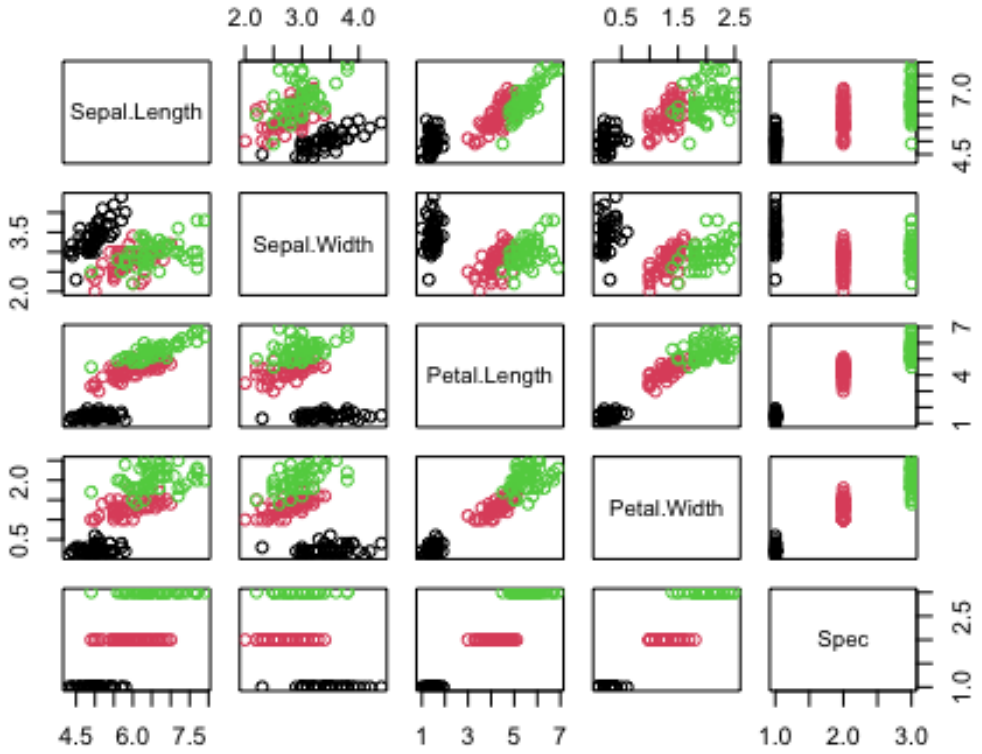
1. The iris data set (in the default R package) includes 50 observations each for three species of iris: setosa, versicolor and virginica. Each observation has four variables: sepal length, sepal width, petal length, and petal width. We want to classify observations into three species by the four variables.

```
Spec <- as.factor(c(rep("s",50),rep("e",50),rep("i",50)))
Spec <- factor(Spec, levels = c("s", "e", "i"))
# s for setosa; e for versicolor; i for virginica
iris <- cbind(iris[,1:4], Spec)
rm(Spec)
head(iris)
```

```
##   Sepal.Length Sepal.Width Petal.Length Petal.Width Spec
## 1          5.1         3.5          1.4         0.2    s
## 2          4.9         3.0          1.4         0.2    s
## 3          4.7         3.2          1.3         0.2    s
## 4          4.6         3.1          1.5         0.2    s
## 5          5.0         3.6          1.4         0.2    s
## 6          5.4         3.9          1.7         0.4    s
```

(b) Make a pairwise scatter plot of all 150 observations with differentiating color by species.

```
pairs(iris, col = iris$Spec)
```



(c) Implement linear discriminant analysis (LDA) to classify three species by petal length and petal width.

```
library(MASS)
LDA <- lda(iris$Spec~iris$Petal.Length+iris$Petal.Width)
```

(d) Estimate the probabilities for setosa/versicolor/virginica for each observation.

```
LDA.predict.prob <- predict(LDA, type="repsonse")
LDA.predict.prob$posterior
```

```
##                  s            e            i
## 1    1.000000e+00 8.750491e-12 4.742801e-26
## 2    1.000000e+00 8.750491e-12 4.742801e-26
## 3    1.000000e+00 2.640992e-12 9.514213e-27
## 4    1.000000e+00 2.899331e-11 2.364269e-25
## 5    1.000000e+00 8.750491e-12 4.742801e-26
## 6    1.000000e+00 4.815647e-09 1.094346e-21
## 7    1.000000e+00 3.403655e-11 6.472943e-25
## 8    1.000000e+00 2.899331e-11 2.364269e-25
## 9    1.000000e+00 8.750491e-12 4.742801e-26
## 10   1.000000e+00 7.453919e-12 1.732328e-26
## 11   1.000000e+00 2.899331e-11 2.364269e-25
## 12   1.000000e+00 9.606455e-11 1.178580e-24
## 13   1.000000e+00 2.249673e-12 3.475106e-27
```

```
## 14  1.000000e+00 6.184766e-14 2.805317e-29
## 15  1.000000e+00 7.970796e-13 1.908582e-27
## 16  1.000000e+00 4.386559e-10 4.403831e-23
## 17  1.000000e+00 3.995704e-11 1.772175e-24
## 18  1.000000e+00 3.403655e-11 6.472943e-25
## 19  1.000000e+00 1.238060e-09 8.018404e-23
## 20  1.000000e+00 1.127745e-10 3.226739e-24
## 21  1.000000e+00 3.182940e-10 5.875178e-24
## 22  1.000000e+00 4.386559e-10 4.403831e-23
## 23  1.000000e+00 7.260575e-14 7.680451e-29
## 24  1.000000e+00 1.873129e-08 1.493556e-20
## 25  1.000000e+00 3.494292e-09 1.459974e-22
## 26  1.000000e+00 9.606455e-11 1.178580e-24
## 27  1.000000e+00 1.453414e-09 2.195294e-22
## 28  1.000000e+00 2.899331e-11 2.364269e-25
## 29  1.000000e+00 8.750491e-12 4.742801e-26
## 30  1.000000e+00 9.606455e-11 1.178580e-24
## 31  1.000000e+00 9.606455e-11 1.178580e-24
## 32  1.000000e+00 4.386559e-10 4.403831e-23
## 33  1.000000e+00 7.453919e-12 1.732328e-26
## 34  1.000000e+00 8.750491e-12 4.742801e-26
## 35  1.000000e+00 2.899331e-11 2.364269e-25
## 36  1.000000e+00 7.970796e-13 1.908582e-27
## 37  1.000000e+00 2.640992e-12 9.514213e-27
## 38  1.000000e+00 2.249673e-12 3.475106e-27
## 39  1.000000e+00 2.640992e-12 9.514213e-27
## 40  1.000000e+00 2.899331e-11 2.364269e-25
## 41  1.000000e+00 1.027259e-11 1.298493e-25
## 42  1.000000e+00 1.027259e-11 1.298493e-25
## 43  1.000000e+00 2.640992e-12 9.514213e-27
## 44  1.000000e+00 2.198951e-08 4.089088e-20
## 45  9.999999e-01 5.286709e-08 2.719436e-20
## 46  1.000000e+00 3.403655e-11 6.472943e-25
## 47  1.000000e+00 9.606455e-11 1.178580e-24
## 48  1.000000e+00 8.750491e-12 4.742801e-26
## 49  1.000000e+00 2.899331e-11 2.364269e-25
## 50  1.000000e+00 8.750491e-12 4.742801e-26
## 51  6.374340e-14 9.866918e-01 1.330822e-02
## 52  1.786015e-13 9.795208e-01 2.047918e-02
## 53  1.366513e-15 9.032414e-01 9.675857e-02
## 54  1.101358e-09 9.997798e-01 2.202481e-04
## 55  5.335259e-14 9.695038e-01 3.049615e-02
## 56  2.753979e-12 9.983047e-01 1.695331e-03
## 57  3.661924e-15 8.575942e-01 1.424058e-01
## 58  2.841172e-04 9.997156e-01 2.921771e-07
## 59  8.304700e-13 9.974515e-01 2.548471e-03
## 60  9.378934e-10 9.994865e-01 5.135016e-04
## 61  2.588683e-05 9.999735e-01 6.615331e-07
## 62  6.591881e-12 9.938983e-01 6.101698e-03
## 63  6.482781e-08 9.999948e-01 5.099696e-06
```

```
## 64  6.374340e-14 9.866918e-01 1.330822e-02
## 65  1.327599e-07 9.999569e-01 4.299345e-05
## 66  2.340632e-12 9.960551e-01 3.944861e-03
## 67  1.786015e-13 9.795208e-01 2.047918e-02
## 68  1.956568e-08 9.999923e-01 7.672553e-06
## 69  1.786015e-13 9.795208e-01 2.047918e-02
## 70  5.522181e-08 9.999881e-01 1.189319e-05
## 71  2.089917e-17 2.453540e-01 7.546460e-01
## 72  1.101358e-09 9.997798e-01 2.202481e-04
## 73  1.366513e-15 9.032414e-01 9.675857e-02
## 74  9.763474e-13 9.989057e-01 1.094348e-03
## 75  3.026234e-11 9.992503e-01 7.496736e-04
## 76  2.340632e-12 9.960551e-01 3.944861e-03
## 77  1.911013e-14 9.801111e-01 1.988889e-02
## 78  1.011318e-17 3.350960e-01 6.649040e-01
## 79  1.786015e-13 9.795208e-01 2.047918e-02
## 80  2.588683e-05 9.999735e-01 6.615331e-07
## 81  1.829691e-07 9.999919e-01 7.905028e-06
## 82  2.358077e-06 9.999961e-01 1.497459e-06
## 83  1.419661e-08 9.999583e-01 4.172912e-05
## 84  1.914274e-17 5.403039e-01 4.596961e-01
## 85  1.786015e-13 9.795208e-01 2.047918e-02
## 86  4.367303e-14 9.316549e-01 6.834514e-02
## 87  1.585839e-14 9.548133e-01 4.518670e-02
## 88  9.130046e-12 9.988725e-01 1.127469e-03
## 89  3.323648e-10 9.996687e-01 3.313299e-04
## 90  1.101358e-09 9.997798e-01 2.202481e-04
## 91  3.554154e-11 9.996784e-01 3.215890e-04
## 92  2.121500e-13 9.911148e-01 8.885169e-03
## 93  4.284598e-09 9.999372e-01 6.278079e-05
## 94  2.841172e-04 9.997156e-01 2.921771e-07
## 95  1.002945e-10 9.995016e-01 4.984077e-04
## 96  3.902518e-10 9.998579e-01 1.420973e-04
## 97  1.002945e-10 9.995016e-01 4.984077e-04
## 98  3.026234e-11 9.992503e-01 7.496736e-04
## 99  2.650643e-03 9.973491e-01 3.003175e-07
## 100 3.323648e-10 9.996687e-01 3.313299e-04
## 101 1.333439e-33 3.691586e-07 9.999996e-01
## 102 1.594682e-20 2.648789e-02 9.735121e-01
## 103 2.306037e-28 8.417602e-05 9.999158e-01
## 104 7.173713e-23 1.223294e-02 9.877671e-01
## 105 8.423300e-29 3.609543e-05 9.999639e-01
## 106 3.014854e-33 4.824430e-06 9.999952e-01
## 107 9.584559e-15 7.952927e-01 2.047073e-01
## 108 9.487395e-28 7.092369e-04 9.992908e-01
## 109 2.906670e-24 5.441433e-03 9.945586e-01
## 110 2.674922e-34 2.453671e-07 9.999998e-01
## 111 1.190999e-21 7.694803e-03 9.923052e-01
## 112 6.513577e-22 1.187746e-02 9.881225e-01
## 113 1.423520e-25 4.311461e-04 9.995689e-01
```

```
## 114 5.914126e-21 1.153218e-02 9.884678e-01
## 115 3.459205e-26 5.115817e-05 9.999488e-01
## 116 1.899796e-26 7.929816e-05 9.999207e-01
## 117 3.554135e-22 1.829176e-02 9.817082e-01
## 118 4.431381e-35 9.138970e-07 9.999991e-01
## 119 1.306618e-37 1.150669e-07 9.999999e-01
## 120 3.932322e-16 8.612009e-01 1.387991e-01
## 121 3.076709e-29 1.547762e-05 9.999845e-01
## 122 2.931117e-20 1.724998e-02 9.827500e-01
## 123 8.254074e-33 1.125124e-05 9.999887e-01
## 124 4.568302e-18 1.776987e-01 8.223013e-01
## 125 5.729861e-27 1.905178e-04 9.998095e-01
## 126 1.173256e-25 2.411244e-03 9.975888e-01
## 127 2.089917e-17 2.453540e-01 7.546460e-01
## 128 4.568302e-18 1.776987e-01 8.223013e-01
## 129 2.856041e-26 2.866095e-04 9.997134e-01
## 130 5.100220e-22 6.310740e-02 9.368926e-01
## 131 1.727880e-27 4.576572e-04 9.995423e-01
## 132 1.022452e-30 3.831586e-05 9.999617e-01
## 133 2.093083e-27 8.170070e-05 9.999183e-01
## 134 1.109147e-16 8.048408e-01 1.951592e-01
## 135 8.757887e-19 6.524299e-01 3.475701e-01
## 136 4.982458e-32 3.020805e-06 9.999970e-01
## 137 1.123791e-29 6.636679e-06 9.999934e-01
## 138 3.554135e-22 1.829176e-02 9.817082e-01
## 139 2.089917e-17 2.453540e-01 7.546460e-01
## 140 7.094654e-25 6.485249e-04 9.993515e-01
## 141 1.123791e-29 6.636679e-06 9.999934e-01
## 142 4.720494e-25 1.794787e-04 9.998205e-01
## 143 1.594682e-20 2.648789e-02 9.735121e-01
## 144 1.238130e-30 6.837769e-06 9.999932e-01
## 145 1.651805e-31 1.257195e-06 9.999987e-01
## 146 9.470034e-26 1.193005e-04 9.998807e-01
## 147 7.844603e-20 3.932591e-02 9.606741e-01
## 148 2.395363e-22 5.127703e-03 9.948723e-01
## 149 3.811153e-27 5.270817e-05 9.999473e-01
## 150 2.040797e-19 8.714849e-02 9.128515e-01
```

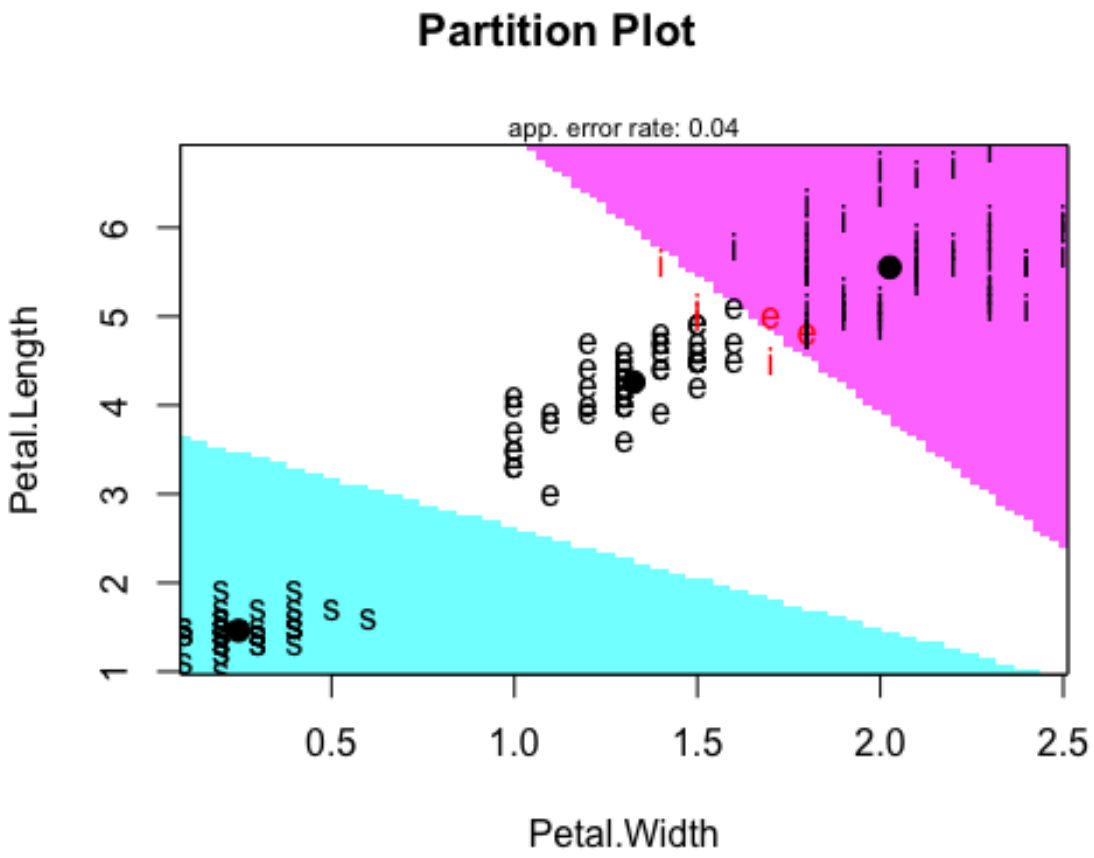
(e) Use Bayes classifier to estimate species for each observation. Namely, assign the most likely species for each observation, and make a contingency table for actual vs predicted.

```
LDA.predict <- predict(LDA, data.frame(iris$Petal.Length,iris$Petal.Width))
table(LDA.predict$class, iris$Spec)
```

```
##
##      s  e  i
##   s 50  0  0
##   e  0 48  4
##   i  0  2 46
```

(f) Use the partimat function in klaR package to visualize the boundary of the LDA in (c). The sample code is:

```
library(klaR) # for partimat
partimat(Spec~Petal.Length+Petal.Width, data = iris, method="lda")
```



(g) Implement (c)-(f) again but with 4 predictors: sepal length, sepal width, petal length and petal width.

```
LDA2 <- lda(iris$Spec~iris$Petal.Length+iris$Petal.Width+iris$Sepal.Length+ir
is$Sepal.Width)

LDA2.predict.prob  <- predict(LDA2, type="repsonse")
LDA2.predict.prob$posterior

##                 s            e            i
## 1   1.000000e+00 3.896358e-22 2.611168e-42
## 2   1.000000e+00 7.217970e-18 5.042143e-37
## 3   1.000000e+00 1.463849e-19 4.675932e-39
## 4   1.000000e+00 1.268536e-16 3.566610e-35
## 5   1.000000e+00 1.637387e-22 1.082605e-42
## 6   1.000000e+00 3.883282e-21 4.566540e-40
## 7   1.000000e+00 1.113469e-18 2.302608e-37
## 8   1.000000e+00 3.877586e-20 1.074496e-39
## 9   1.000000e+00 1.902813e-15 9.482936e-34
```

```
## 10  1.000000e+00 1.111803e-18 2.724060e-38
## 11  1.000000e+00 1.185277e-23 3.237084e-44
## 12  1.000000e+00 1.621649e-18 1.833201e-37
## 13  1.000000e+00 1.459225e-18 3.262506e-38
## 14  1.000000e+00 1.117219e-19 1.316642e-39
## 15  1.000000e+00 5.487399e-30 1.531265e-52
## 16  1.000000e+00 1.261505e-27 2.268705e-48
## 17  1.000000e+00 6.754338e-25 3.868271e-45
## 18  1.000000e+00 4.223741e-21 1.224313e-40
## 19  1.000000e+00 1.774911e-22 2.552153e-42
## 20  1.000000e+00 2.593237e-22 5.792079e-42
## 21  1.000000e+00 1.274639e-19 4.357774e-39
## 22  1.000000e+00 1.465999e-20 1.987241e-39
## 23  1.000000e+00 6.569280e-25 7.769177e-46
## 24  1.000000e+00 8.912348e-15 9.178624e-32
## 25  1.000000e+00 1.070702e-15 1.167516e-33
## 26  1.000000e+00 2.497339e-16 5.710269e-35
## 27  1.000000e+00 3.967732e-17 4.378624e-35
## 28  1.000000e+00 1.548165e-21 1.595360e-41
## 29  1.000000e+00 9.271847e-22 6.297955e-42
## 30  1.000000e+00 9.665144e-17 2.977974e-35
## 31  1.000000e+00 2.299936e-16 7.182666e-35
## 32  1.000000e+00 1.975404e-19 2.788334e-38
## 33  1.000000e+00 7.100041e-27 2.216408e-48
## 34  1.000000e+00 1.610295e-28 2.743783e-50
## 35  1.000000e+00 1.205219e-17 1.277245e-36
## 36  1.000000e+00 1.597186e-21 9.033772e-42
## 37  1.000000e+00 1.939869e-24 1.662808e-45
## 38  1.000000e+00 3.310234e-23 7.004971e-44
## 39  1.000000e+00 4.190242e-17 6.991441e-36
## 40  1.000000e+00 1.769359e-20 3.541694e-40
## 41  1.000000e+00 1.063014e-21 2.003866e-41
## 42  1.000000e+00 2.174217e-11 1.213781e-28
## 43  1.000000e+00 1.540753e-18 1.305719e-37
## 44  1.000000e+00 8.940589e-16 1.315511e-32
## 45  1.000000e+00 1.616206e-17 3.205992e-35
## 46  1.000000e+00 1.714743e-16 7.172435e-35
## 47  1.000000e+00 2.083089e-22 2.289783e-42
## 48  1.000000e+00 2.793482e-18 2.629539e-37
## 49  1.000000e+00 2.597560e-23 9.820820e-44
## 50  1.000000e+00 2.322258e-20 4.241757e-40
## 51  1.969732e-18 9.998894e-01 1.105878e-04
## 52  1.242878e-19 9.992575e-01 7.425297e-04
## 53  2.088263e-22 9.958069e-01 4.193053e-03
## 54  2.198898e-22 9.996423e-01 3.576502e-04
## 55  4.213678e-23 9.955903e-01 4.409655e-03
## 56  8.127287e-23 9.985020e-01 1.497982e-03
## 57  3.549900e-22 9.858346e-01 1.416542e-02
## 58  5.007065e-14 9.999999e-01 1.119811e-07
## 59  5.683334e-20 9.998781e-01 1.218649e-04
```

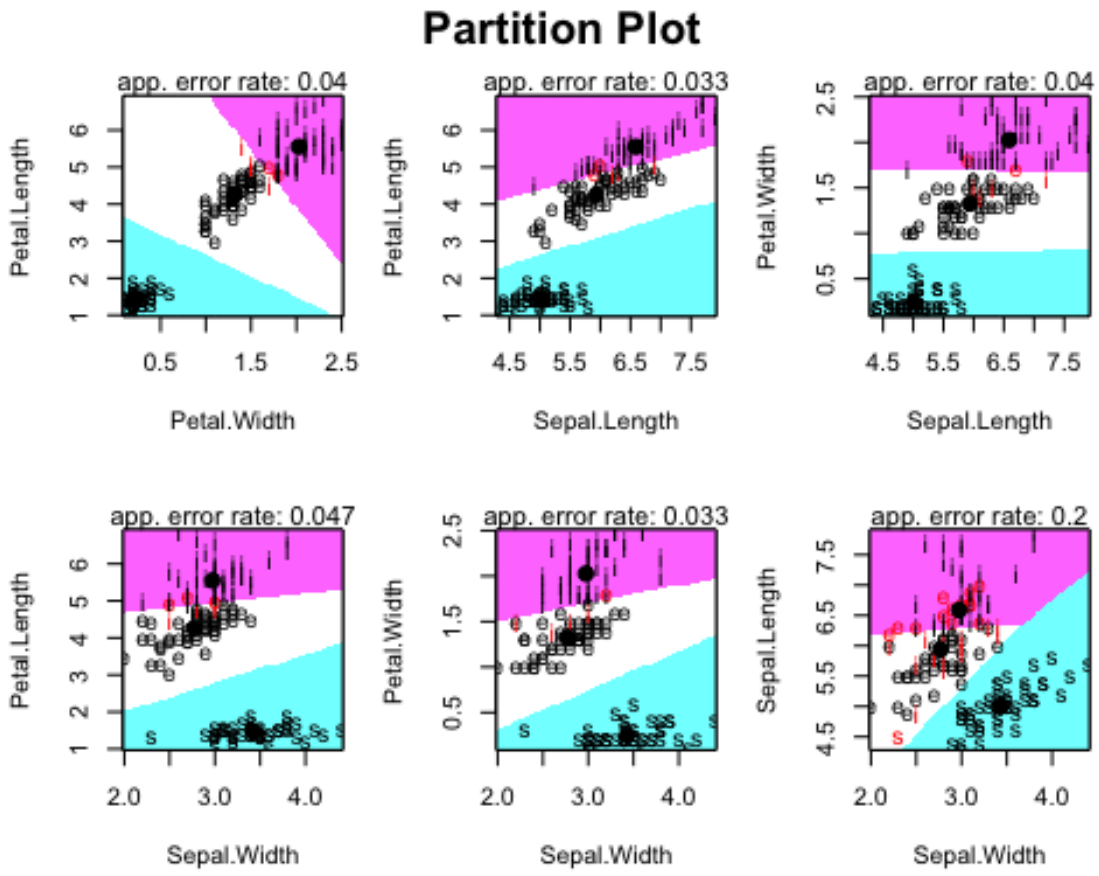
```
## 60  1.241039e-20 9.995027e-01 4.973085e-04
## 61  1.956628e-18 9.999986e-01 1.420841e-06
## 62  5.968900e-20 9.992294e-01 7.705716e-04
## 63  2.716128e-18 9.999988e-01 1.220169e-06
## 64  1.184445e-23 9.943267e-01 5.673286e-03
## 65  5.574931e-14 9.999984e-01 1.649215e-06
## 66  2.369511e-17 9.999573e-01 4.268212e-05
## 67  8.429328e-24 9.806471e-01 1.935289e-02
## 68  2.505072e-16 9.999991e-01 9.151716e-07
## 69  1.670352e-27 9.595735e-01 4.042653e-02
## 70  1.341503e-17 9.999967e-01 3.296105e-06
## 71  7.408118e-28 2.532282e-01 7.467718e-01
## 72  9.399292e-17 9.999907e-01 9.345291e-06
## 73  7.674672e-29 8.155328e-01 1.844672e-01
## 74  2.683018e-22 9.995723e-01 4.277469e-04
## 75  7.813875e-18 9.999758e-01 2.421458e-05
## 76  2.073207e-18 9.999171e-01 8.290530e-05
## 77  6.357538e-23 9.982541e-01 1.745936e-03
## 78  5.639473e-27 6.892131e-01 3.107869e-01
## 79  3.773528e-23 9.925169e-01 7.483138e-03
## 80  9.555338e-12 1.000000e+00 1.910624e-08
## 81  1.022109e-17 9.999970e-01 3.007748e-06
## 82  9.648075e-16 9.999997e-01 3.266704e-07
## 83  1.616405e-16 9.999962e-01 3.778441e-06
## 84  4.241952e-32 1.433919e-01 8.566081e-01
## 85  1.724514e-24 9.635576e-01 3.644242e-02
## 86  1.344746e-20 9.940401e-01 5.959931e-03
## 87  3.304868e-21 9.982223e-01 1.777672e-03
## 88  2.034571e-23 9.994557e-01 5.443096e-04
## 89  5.806986e-18 9.999486e-01 5.137101e-05
## 90  5.981190e-21 9.998183e-01 1.816870e-04
## 91  5.878614e-23 9.993856e-01 6.144200e-04
## 92  5.399006e-22 9.980934e-01 1.906591e-03
## 93  3.559507e-18 9.999887e-01 1.128570e-05
## 94  2.104146e-14 9.999999e-01 1.135016e-07
## 95  4.700877e-21 9.996980e-01 3.020226e-04
## 96  1.584328e-17 9.999817e-01 1.826327e-05
## 97  2.802293e-19 9.998892e-01 1.108315e-04
## 98  1.626918e-18 9.999536e-01 4.640488e-05
## 99  7.638378e-11 1.000000e+00 1.867332e-08
## 100 4.679301e-19 9.999269e-01 7.305863e-05
## 101 7.503075e-52 7.127303e-09 1.000000e+00
## 102 5.213802e-38 1.078251e-03 9.989217e-01
## 103 1.231264e-42 2.592826e-05 9.999741e-01
## 104 1.537499e-38 1.068139e-03 9.989319e-01
## 105 6.242501e-46 1.812963e-06 9.999982e-01
## 106 4.209281e-49 6.656263e-07 9.999993e-01
## 107 3.797837e-33 4.862025e-02 9.513797e-01
## 108 1.352176e-42 1.395463e-04 9.998605e-01
## 109 1.323390e-42 2.235313e-04 9.997765e-01
```

```
## 110 3.453358e-46 1.727277e-07 9.999998e-01
## 111 5.452660e-32 1.305353e-02 9.869465e-01
## 112 1.182560e-37 1.673875e-03 9.983261e-01
## 113 5.204321e-39 2.006352e-04 9.997994e-01
## 114 1.269953e-40 1.948672e-04 9.998051e-01
## 115 1.685361e-45 1.000455e-06 9.999990e-01
## 116 5.141640e-40 2.605493e-05 9.999739e-01
## 117 1.909820e-35 6.083553e-03 9.939164e-01
## 118 1.207799e-44 1.503799e-06 9.999985e-01
## 119 3.181265e-59 1.317279e-09 1.000000e+00
## 120 1.598511e-33 2.207990e-01 7.792010e-01
## 121 1.119461e-42 6.451865e-06 9.999935e-01
## 122 3.038170e-37 8.272676e-04 9.991727e-01
## 123 6.032879e-50 9.509838e-07 9.999990e-01
## 124 1.951261e-31 9.711942e-02 9.028806e-01
## 125 1.956408e-39 8.836845e-05 9.999116e-01
## 126 1.109337e-36 2.679310e-03 9.973207e-01
## 127 7.841997e-30 1.883675e-01 8.116325e-01
## 128 7.964690e-30 1.342431e-01 8.657569e-01
## 129 6.190641e-44 1.303681e-05 9.999870e-01
## 130 1.406448e-32 1.036823e-01 8.963177e-01
## 131 4.108129e-42 1.442338e-04 9.998558e-01
## 132 1.555697e-36 5.198047e-04 9.994802e-01
## 133 1.320330e-45 3.014091e-06 9.999970e-01
## 134 1.283891e-28 7.293881e-01 2.706119e-01
## 135 1.926560e-35 6.602253e-02 9.339775e-01
## 136 1.271083e-45 2.152818e-06 9.999978e-01
## 137 3.038963e-44 8.881859e-07 9.999991e-01
## 138 4.605973e-35 6.165648e-03 9.938344e-01
## 139 4.538634e-29 1.925262e-01 8.074738e-01
## 140 2.140232e-36 8.290895e-04 9.991709e-01
## 141 6.570902e-45 1.180810e-06 9.999988e-01
## 142 6.202588e-36 4.276398e-04 9.995724e-01
## 143 5.213802e-38 1.078251e-03 9.989217e-01
## 144 1.073945e-45 1.028519e-06 9.999990e-01
## 145 4.048249e-46 2.524984e-07 9.999997e-01
## 146 4.970070e-39 7.473361e-05 9.999253e-01
## 147 4.616611e-36 5.898784e-03 9.941012e-01
## 148 5.548962e-35 3.145874e-03 9.968541e-01
## 149 1.613687e-40 1.257468e-05 9.999874e-01
## 150 2.858012e-33 1.754229e-02 9.824577e-01
```

```
LDA2.predict <- predict(LDA2, data.frame(iris$Petal.Length,iris$Petal.Width))
table(LDA2.predict$class, iris$Spec)
```

```
##
##      s  e  i
##   s 50  0  0
##   e  0 48  1
##   i  0  2 49
```

```
partimat(Spec~Petal.Length+Petal.Width+Sepal.Length+Sepal.Width, data = iris,
method="lda")
```



(h) Implement quadratic discriminant analysis (QDA) in the same way as (c)-(f).

```
QDA <- qda(iris$Spec~iris$Petal.Length+iris$Petal.Width)

QDA.predict.prob <- predict(QDA, type="repsonse")
QDA.predict.prob$posterior
```

```
##                   s            e            i
## 1    1.000000e+00 1.045735e-09 3.290438e-18
## 2    1.000000e+00 1.045735e-09 3.290438e-18
## 3    1.000000e+00 5.552684e-10 1.504252e-18
## 4    1.000000e+00 2.538252e-09 1.007099e-17
## 5    1.000000e+00 1.045735e-09 3.290438e-18
## 6    9.999996e-01 3.973496e-07 7.766431e-15
## 7    1.000000e+00 2.939159e-09 2.009028e-17
## 8    1.000000e+00 2.538252e-09 1.007099e-17
## 9    1.000000e+00 1.045735e-09 3.290438e-18
## 10   1.000000e+00 1.246490e-09 4.683643e-18
## 11   1.000000e+00 2.538252e-09 1.007099e-17
## 12   1.000000e+00 7.940394e-09 4.312971e-17
## 13   1.000000e+00 5.231361e-10 1.278331e-18
```

```
## 14   1.000000e+00 1.772382e-10 1.950452e-19
## 15   1.000000e+00 3.799954e-10 9.622175e-19
## 16   1.000000e+00 2.925560e-08 6.214630e-16
## 17   1.000000e+00 5.943225e-09 1.906125e-16
## 18   1.000000e+00 2.939159e-09 2.009028e-17
## 19   9.999999e-01 9.511765e-08 9.198838e-16
## 20   1.000000e+00 7.267329e-09 5.136683e-17
## 21   1.000000e+00 3.201427e-08 2.584439e-16
## 22   1.000000e+00 2.925560e-08 6.214630e-16
## 23   1.000000e+00 3.809886e-10 1.078538e-18
## 24   9.999977e-01 2.333877e-06 1.555361e-13
## 25   9.999989e-01 1.114112e-06 2.542157e-14
## 26   1.000000e+00 7.940394e-09 4.312971e-17
## 27   9.999999e-01 9.497162e-08 1.857272e-15
## 28   1.000000e+00 2.538252e-09 1.007099e-17
## 29   1.000000e+00 1.045735e-09 3.290438e-18
## 30   1.000000e+00 7.940394e-09 4.312971e-17
## 31   1.000000e+00 7.940394e-09 4.312971e-17
## 32   1.000000e+00 2.925560e-08 6.214630e-16
## 33   1.000000e+00 1.246490e-09 4.683643e-18
## 34   1.000000e+00 1.045735e-09 3.290438e-18
## 35   1.000000e+00 2.538252e-09 1.007099e-17
## 36   1.000000e+00 3.799954e-10 9.622175e-19
## 37   1.000000e+00 5.552684e-10 1.504252e-18
## 38   1.000000e+00 5.231361e-10 1.278331e-18
## 39   1.000000e+00 5.552684e-10 1.504252e-18
## 40   1.000000e+00 2.538252e-09 1.007099e-17
## 41   1.000000e+00 1.532024e-09 1.099449e-17
## 42   1.000000e+00 1.532024e-09 1.099449e-17
## 43   1.000000e+00 5.552684e-10 1.504252e-18
## 44   9.999956e-01 4.439362e-06 2.531984e-12
## 45   9.999851e-01 1.489043e-05 3.720181e-13
## 46   1.000000e+00 2.939159e-09 2.009028e-17
## 47   1.000000e+00 7.940394e-09 4.312971e-17
## 48   1.000000e+00 1.045735e-09 3.290438e-18
## 49   1.000000e+00 2.538252e-09 1.007099e-17
## 50   1.000000e+00 1.045735e-09 3.290438e-18
## 51   5.451288e-81 9.633620e-01 3.663800e-02
## 52   1.470998e-75 9.625927e-01 3.740734e-02
## 53   6.963672e-92 8.757640e-01 1.242360e-01
## 54   5.999566e-53 9.981320e-01 1.868011e-03
## 55   1.812939e-79 9.546669e-01 4.533312e-02
## 56   9.536170e-71 9.893093e-01 1.069072e-02
## 57   3.583226e-86 8.503161e-01 1.496839e-01
## 58   7.312464e-27 9.999703e-01 2.972039e-05
## 59   1.219091e-74 9.807425e-01 1.925753e-02
## 60   5.322536e-52 9.919687e-01 8.031319e-03
## 61   4.651940e-32 9.999513e-01 4.873605e-05
## 62   1.678923e-64 9.663003e-01 3.369973e-02
## 63   5.596231e-47 9.992934e-01 7.066001e-04
```

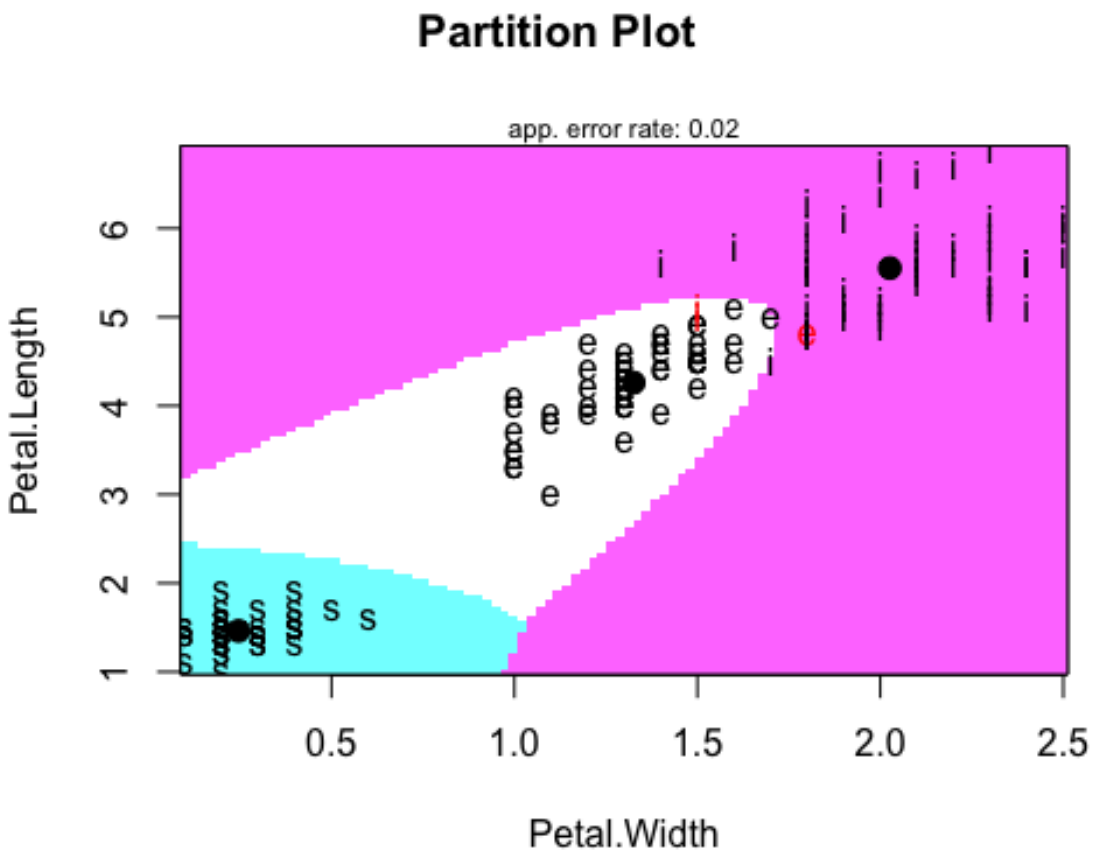
```
## 64   5.451288e-81 9.633620e-01 3.663800e-02
## 65   1.072682e-40 9.979836e-01 2.016383e-03
## 66   2.757682e-69 9.886356e-01 1.136444e-02
## 67   1.470998e-75 9.625927e-01 3.740734e-02
## 68   2.710560e-50 9.984576e-01 1.542433e-03
## 69   1.470998e-75 9.625927e-01 3.740734e-02
## 70   1.314029e-45 9.996488e-01 3.512044e-04
## 71   9.103843e-97 1.602015e-01 8.397985e-01
## 72   5.999566e-53 9.981320e-01 1.868011e-03
## 73   6.963672e-92 8.757640e-01 1.242360e-01
## 74   1.822906e-76 9.375954e-01 6.240462e-02
## 75   2.696284e-63 9.958295e-01 4.170540e-03
## 76   2.757682e-69 9.886356e-01 1.136444e-02
## 77   4.042419e-85 9.373884e-01 6.261160e-02
## 78  6.144545e-102 5.089681e-01 4.910319e-01
## 79   1.470998e-75 9.625927e-01 3.740734e-02
## 80   4.651940e-32 9.999513e-01 4.873605e-05
## 81   1.662573e-42 9.997689e-01 2.310785e-04
## 82   1.072528e-37 9.998890e-01 1.110178e-04
## 83   1.370194e-47 9.994077e-01 5.922697e-04
## 84  1.713609e-103 6.406860e-01 3.593140e-01
## 85   1.470998e-75 9.625927e-01 3.740734e-02
## 86   3.142167e-78 8.609685e-01 1.390315e-01
## 87   1.722533e-83 9.407384e-01 5.926161e-02
## 88   5.762532e-67 9.935849e-01 6.415056e-03
## 89   2.750199e-56 9.977503e-01 2.249714e-03
## 90   5.999566e-53 9.981320e-01 1.868011e-03
## 91   8.524436e-65 9.939192e-01 6.080760e-03
## 92   5.628744e-77 9.770306e-01 2.296936e-02
## 93   8.247737e-51 9.991987e-01 8.013309e-04
## 94   7.312464e-27 9.999703e-01 2.972039e-05
## 95   9.778666e-60 9.970594e-01 2.940571e-03
## 96   1.394992e-57 9.981242e-01 1.875794e-03
## 97   9.778666e-60 9.970594e-01 2.940571e-03
## 98   2.696284e-63 9.958295e-01 4.170540e-03
## 99   1.177088e-21 9.998437e-01 1.562650e-04
## 100  2.750199e-56 9.977503e-01 2.249714e-03
## 101 6.588080e-187 7.488342e-08 9.999999e-01
## 102 1.247242e-113 3.690876e-02 9.630912e-01
## 103 8.186778e-162 1.154219e-03 9.988458e-01
## 104 2.270318e-134 5.883893e-02 9.411611e-01
## 105 7.216439e-161 1.719882e-04 9.998280e-01
## 106 7.682537e-204 6.681733e-05 9.999332e-01
## 107  2.907523e-81 4.690325e-01 5.309675e-01
## 108 5.987457e-175 3.148741e-04 9.996851e-01
## 109 3.173008e-145 2.037162e-02 9.796284e-01
## 110 2.624256e-192 1.298890e-07 9.999999e-01
## 111 6.892310e-118 3.729757e-03 9.962702e-01
## 112 6.871266e-123 4.133589e-02 9.586641e-01
## 113 5.245151e-141 9.649728e-04 9.990350e-01
```

```
## 114 1.480417e-113 2.552093e-03 9.974479e-01
## 115 9.990458e-139 1.825536e-09 1.000000e+00
## 116 1.381755e-141 8.328070e-07 9.999992e-01
## 117 3.629604e-129 8.744611e-02 9.125539e-01
## 118 3.352583e-214 2.626995e-05 9.999737e-01
## 119 1.195090e-231 5.068242e-06 9.999949e-01
## 120  2.886228e-96 8.059249e-01 1.940751e-01
## 121 1.336365e-160 9.401833e-06 9.999906e-01
## 122 2.272036e-109 1.608121e-03 9.983919e-01
## 123 4.959482e-207 2.312167e-05 9.999769e-01
## 124 5.652914e-101 1.811555e-01 8.188445e-01
## 125 4.056269e-151 1.243668e-03 9.987563e-01
## 126 1.129009e-156 4.954561e-03 9.950454e-01
## 127  9.103843e-97 1.602015e-01 8.397985e-01
## 128 5.652914e-101 1.811555e-01 8.188445e-01
## 129 5.455933e-146 1.141404e-03 9.988586e-01
## 130 1.206140e-139 9.819896e-03 9.901801e-01
## 131 9.798837e-166 2.574428e-03 9.974256e-01
## 132 1.797579e-187 2.979344e-04 9.997021e-01
## 133 1.274645e-150 1.057495e-04 9.998943e-01
## 134 8.668049e-101 6.926195e-01 3.073805e-01
## 135 4.505534e-124 8.509817e-03 9.914902e-01
## 136 5.987487e-182 2.849798e-05 9.999715e-01
## 137 5.202464e-161 1.886771e-07 9.999998e-01
## 138 3.629604e-129 8.744611e-02 9.125539e-01
## 139  9.103843e-97 1.602015e-01 8.397985e-01
## 140 3.603939e-136 7.514768e-04 9.992485e-01
## 141 5.202464e-161 1.886771e-07 9.999998e-01
## 142 5.920644e-133 1.513772e-07 9.999998e-01
## 143 1.247242e-113 3.690876e-02 9.630912e-01
## 144 5.538038e-171 1.929283e-05 9.999807e-01
## 145 1.389003e-171 8.763490e-09 1.000000e+00
## 146 3.383319e-137 3.699543e-07 9.999996e-01
## 147 3.222976e-109 3.095077e-02 9.690492e-01
## 148 2.293032e-122 5.020228e-03 9.949798e-01
## 149 4.033050e-146 1.726828e-06 9.999983e-01
## 150 8.291947e-110 1.886656e-01 8.113344e-01
```

```
QDA.predict <- predict(QDA, data.frame(iris$Petal.Length,iris$Petal.Width))
table(QDA.predict$class, iris$Spec)
```

```
##
##      s  e  i
##   s 50  0  0
##   e  0 49  2
##   i  0  1 48
```

```
partimat(Spec~Petal.Length+Petal.Width, data = iris, method="qda")
```




```
library(class)
t <- cbind(iris$Petal.Length,iris$Petal.Width)
KNN <- knn(t, t, iris$Spec, k=10)
table(KNN, iris$Spec)

##
## KNN  s  e  i
##   s 50  0  0
##   e  0 47  3
##   i  0  3 47
```