MSiA400_Assignment2_XiaoyunGong

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```
library(caret)
```

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

```
## Loading required package: ggplot2
```

```
library(e1071)
set.seed(1009)
```

```
### import data
gradAdmit = read.csv('gradAdmit.csv')
```

part a

Split the data into testing, training, and validation datasets for cross validation (CV).

First, hold out 20% for your test dataset. On the remaining 80%, split it into 5 folds.

```
n = nrow(gradAdmit) # number of samples
# hold out 20% for testing
sample = sample.int(n = n, size = floor(.2*n), replace = F)
train = gradAdmit[-sample,]
test = gradAdmit[sample,]
### there are 80 obs in test, and 320 obs in train.
```

```
nfolds = 5
folds = createFolds(1:n, k = nfolds)
```

part b

Train a number of SVM models (using different hyperparameters) on the training set for each CV fold.

For each run, report the accuracy on both the training and validation datasets, averaged over the folds.

Use the same split as Problem 1a. Try using various kernel functions, such as linear, polynomial, radialbasis (or Gaussian), etc. Also, try to tune their respective hyperparameters (degree, gamma, and coef0), and the value for cost (or C), based on the validation accuracy.

```
degree_list = c(2, 3, 4, 5)
gamma_list <- c(0.001, 0.1, 0.2, 0.3)
coef0_list <- c(1, 3, 5, 7)
cost_list = c(0.01, 0.1, 1, 10, 100)
```

kernel = linear

```
## kernel = linear
for(c in 1:length(cost_list)){
  acc_train = rep(NA, nfolds)
  acc_val = rep(NA, nfolds)
  for (i in 1:nfolds){
    train = gradAdmit[-folds[[i]],]
    val = gradAdmit[folds[[i]],]

    svm = suppressWarnings(svm(formula =  factor(admit) ~ .,
             cost = cost_list[c],
             data = train,
             kernel = 'linear'))

    pred_train = predict(svm, newdata = train, type='response')
    pred_val = predict(svm, newdata = val, type='response')
    accuracy_train = 1 - (sum(abs(as.numeric(pred_train) - 1 - train[,1]))/nrow(train))
    accuracy_val = 1 - (sum(abs(as.numeric(pred_val) - 1 - val[,1]))/nrow(val))

    acc_train[i] = accuracy_train
    acc_val[i] = accuracy_val
  }
  acc_train_mean = mean(acc_train)
  acc_val_mean = mean(acc_val)
  print(paste0("lenear kernel with cost = ", cost_list[c]))
  print(paste0("average accuracy on train = ", acc_train_mean, " average accuracy on val
idation = ", acc_val_mean))
}
```

```
## [1] "lenear kernel with cost = 0.01"
## [1] "average accuracy on train = 0.6825 average accuracy on validation = 0.6825"
## [1] "lenear kernel with cost = 0.1"
## [1] "average accuracy on train = 0.6825 average accuracy on validation = 0.6825"
## [1] "lenear kernel with cost = 1"
## [1] "average accuracy on train = 0.6825 average accuracy on validation = 0.6825"
## [1] "lenear kernel with cost = 10"
## [1] "average accuracy on train = 0.6825 average accuracy on validation = 0.6825"
## [1] "lenear kernel with cost = 100"
## [1] "average accuracy on train = 0.6825 average accuracy on validation = 0.6825"
```

kernel = polynomial

```r
## kernel = polynomial
for (d in 1:length(degree_list)){
  for (c in 1:length(cost_list)){
    for (g in 1:length(gamma_list)){
      for(co in 1:length(coef0_list)){
        acc_train = rep(NA, nfolds)
        acc_val = rep(NA, nfolds)
        for (i in 1:nfolds){
          train = gradAdmit[-folds[[i]],]
          val = gradAdmit[folds[[i]],]

          svm = svm(formula =  factor(admit) ~ .,
                    cost = cost_list[c],
                    degree = degree_list[d],
                    gamma = gamma_list[g],
                    coef0 = coef0_list[co],
                    data=train,
                    kernel = "polynomial")

          pred_train = predict(svm, newdata = train, type='response')
          pred_val = predict(svm, newdata = val, type='response')
          accuracy_train = 1 - (sum(abs(as.numeric(pred_train) - 1 - train[,1]))/nrow(tr
ain))

          accuracy_val = 1 - (sum(abs(as.numeric(pred_val) - 1 - val[,1]))/nrow(val))

          acc_train[i] = accuracy_train
          acc_val[i] = accuracy_val
        }
        acc_train_mean = mean(acc_train)
        acc_val_mean = mean(acc_val)
        print(paste0("Polynomial kernel with cost = ", cost_list[c], ", degree = ", degr
ee_list[d], ", gamma = ", gamma_list[g], ", coef0 = ", cost_list[co]))
        print(paste0("average accuracy on train = ", acc_train_mean, ", average accuracy
on validation = ", acc_val_mean))
      }
    }
  }
}
```

```
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 2, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.69, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.69125, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.2, coef0 = 1"
```

```
## [1] "average accuracy on train = 0.69125, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.69125, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.691875, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.69625, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.694375, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 2, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.695625, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.695625, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.698125, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.69875, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.69875, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.70375, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.705, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.70375, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.704375, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 2, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average assage accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.1, coef0 = 0.1"
```

```
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 2, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.706875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 2, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7075, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.001, coef0 = 0.01"
```

```
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.686875, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.68875, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.693125, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.695, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.6875, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.69625, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 3, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.701875, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.686875, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.69625, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.701875, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.701875, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.701875, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.710625, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.711875, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.2, coef0 = 10"
```

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## [1] "average accuracy on train = 0.7125, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.714375, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.715, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 3, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.710625, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.710625, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.710625, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.710625, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.714375, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.715, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.718125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.718125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.718125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 3, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.71875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.1, coef0 = 1"
```

```
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 10, degree = 3, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.683125, average accuracy on validation = 0.68"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.686875, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.718125, average accuracy on validation = 0.72"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 100, degree = 3, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.001, coef0 = 0.1"
```

```
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6925, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.700625, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.705, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.688125, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.71, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.715, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.71625, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 0.01, degree = 4, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.719375, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.695, average accuracy on validation = 0.68"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.71375, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.714375, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.71375, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.720625, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.72125, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.72125, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.3, coef0 = 0.01"
```

```
## [1] "average accuracy on train = 0.72125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.7225, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.72375, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 0.1, degree = 4, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.72375, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.71875, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.71875, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.719375, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.72375, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.7225, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7275, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 4, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.683125, average accuracy on validation = 0.68"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.690625, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.72375, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.724375, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.724375, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.1, coef0 = 10"
```

```
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.71"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.73, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.729375, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.729375, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.73, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.735, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.735, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.73375, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 4, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.734375, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.69125, average accuracy on validation = 0.68"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.703125, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.71, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.729375, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.731875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.734375, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.73375, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.733125, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.733125, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.734375, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.73625, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.72375, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 100, degree = 4, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.724375, average accuracy on validation = 0.65"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.001, coef0 = 1"
```

```
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.711875, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.71375, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.716875, average accuracy on validation = 0.72"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.69625, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.72125, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.7225, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.7225, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.709375, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.724375, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 0.01, degree = 5, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7275, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.70125, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.72125, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.721875, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.721875, average accuracy on validation = 0.715"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.724375, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.7275, average accuracy on validation = 0.7075"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.728125, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.73, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.3, coef0 = 0.1"
```

```
## [1] "average accuracy on train = 0.735, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.736875, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 0.1, degree = 5, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7375, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.69125, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.7225, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.72625, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.726875, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.734375, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.738125, average accuracy on validation = 0.6925"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.738125, average accuracy on validation = 0.6875"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.74, average accuracy on validation = 0.69"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7525, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.76, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.761875, average accuracy on validation = 0.68"
## [1] "Polynomial kernel with cost = 1, degree = 5, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.76125, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.69, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.701875, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.70875, average accuracy on validation = 0.7125"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.730625, average accuracy on validation = 0.7"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.73375, average accuracy on validation = 0.7025"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.733125, average accuracy on validation = 0.6975"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.735, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.2, coef0 = 0.01"
```

```
## [1] "average accuracy on train = 0.759375, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.76625, average accuracy on validation = 0.6675"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.765, average accuracy on validation = 0.665"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.75875, average accuracy on validation = 0.675"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.775, average accuracy on validation = 0.67"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.774375, average accuracy on validation = 0.67"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.7725, average accuracy on validation = 0.67"
## [1] "Polynomial kernel with cost = 10, degree = 5, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7425, average accuracy on validation = 0.6425"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.70375, average accuracy on validation = 0.695"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.713125, average accuracy on validation = 0.7175"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.715625, average accuracy on validation = 0.705"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.74625, average accuracy on validation = 0.69"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.749375, average accuracy on validation = 0.6775"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.741875, average accuracy on validation = 0.685"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.71875, average accuracy on validation = 0.64"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.775625, average accuracy on validation = 0.6725"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.7725, average accuracy on validation = 0.6675"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.7375, average accuracy on validation = 0.6525"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.74875, average accuracy on validation = 0.65"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.7825, average accuracy on validation = 0.6625"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.76375, average accuracy on validation = 0.655"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.764375, average accuracy on validation = 0.6425"
## [1] "Polynomial kernel with cost = 100, degree = 5, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.7325, average accuracy on validation = 0.635"
```

kernel = radialbasis

```r
## kernel = radialbasis
for (g in 1:length(gamma_list)){
  for(c in 1:length(cost_list)){
    acc_train = rep(NA, nfolds)
    acc_val = rep(NA, nfolds)
    for (i in 1:nfolds){
      train = gradAdmit[-folds[[i]],]
      val = gradAdmit[folds[[i]],]

      svm = suppressWarnings(svm(formula =  factor(admit) ~ .,
                cost = cost_list[c],
                gamma = gamma_list[g],
                data = train,
                kernel = 'radial'))

       pred_train = predict(svm, newdata = train, type='response')
      pred_val = predict(svm, newdata = val, type='response')
      accuracy_train = 1 - (sum(abs(as.numeric(pred_train) - 1 - train[,1]))/nrow(trai
n))

      accuracy_val = 1 - (sum(abs(as.numeric(pred_val) - 1 - val[,1]))/nrow(val))

      acc_train[i] = accuracy_train
      acc_val[i] = accuracy_val
    }
    acc_train_mean = mean(acc_train)
        acc_val_mean = mean(acc_val)
        print(paste0("Radial kernel with cost = ", cost_list[c], ", gamma = ", gamma_lis
t[g]))
        print(paste0("average accuracy on train = ", acc_train_mean, ", average accuracy
on validation = ", acc_val_mean))
  }
}
```

```
## [1] "Radial kernel with cost = 0.01, gamma = 0.001"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 0.1, gamma = 0.001"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 1, gamma = 0.001"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 10, gamma = 0.001"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 100, gamma = 0.001"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 0.01, gamma = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 0.1, gamma = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 1, gamma = 0.1"
## [1] "average accuracy on train = 0.69875, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 10, gamma = 0.1"
## [1] "average accuracy on train = 0.72, average accuracy on validation = 0.72"
## [1] "Radial kernel with cost = 100, gamma = 0.1"
## [1] "average accuracy on train = 0.730625, average accuracy on validation = 0.7025"
## [1] "Radial kernel with cost = 0.01, gamma = 0.2"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 0.1, gamma = 0.2"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 1, gamma = 0.2"
## [1] "average accuracy on train = 0.7175, average accuracy on validation = 0.7175"
## [1] "Radial kernel with cost = 10, gamma = 0.2"
## [1] "average accuracy on train = 0.729375, average accuracy on validation = 0.7075"
## [1] "Radial kernel with cost = 100, gamma = 0.2"
## [1] "average accuracy on train = 0.75875, average accuracy on validation = 0.685"
## [1] "Radial kernel with cost = 0.01, gamma = 0.3"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 0.1, gamma = 0.3"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Radial kernel with cost = 1, gamma = 0.3"
## [1] "average accuracy on train = 0.723125, average accuracy on validation = 0.7125"
## [1] "Radial kernel with cost = 10, gamma = 0.3"
## [1] "average accuracy on train = 0.746875, average accuracy on validation = 0.695"
## [1] "Radial kernel with cost = 100, gamma = 0.3"
## [1] "average accuracy on train = 0.77625, average accuracy on validation = 0.6725"
```

kernel = sigmoid

```r
## kernel = sigmoid
for (c in 1:length(cost_list)){
  for (g in 1:length(gamma_list)){
    for(co in 1:length(coef0_list)){
      acc_train = rep(NA, nfolds)
      acc_val = rep(NA, nfolds)
      for (i in 1:nfolds){
        train = gradAdmit[-folds[[i]],]
        val = gradAdmit[folds[[i]],]

        svm = svm(formula =  factor(admit) ~ .,
                  scale = FALSE,
                  cost = cost_list[c],
                  gamma = gamma_list[g],
                  coef0 = coef0_list[co],
                  data=train,
                  kernel = "sigmoid")

      pred_train = predict(svm, newdata = train, type='response')
      pred_val = predict(svm, newdata = val, type='response')
      accuracy_train = 1 - (sum(abs(as.numeric(pred_train) - 1 - train[,1]))/nrow(trai
n))

      accuracy_val = 1 - (sum(abs(as.numeric(pred_val) - 1 - val[,1]))/nrow(val))

      acc_train[i] = accuracy_train
      acc_val[i] = accuracy_val
      }
      acc_train_mean = mean(acc_train)
        acc_val_mean = mean(acc_val)
        print(paste0("Sigmoid kernel with cost = ", cost_list[c], ", gamma = ", gamma_li
st[g], ", coef0 = ", cost_list[co]))
        print(paste0("average accuracy on train = ", acc_train_mean, ", average accuracy
on validation = ", acc_val_mean))
      }
    }
}
```

```
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.2, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.01, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.1, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.2, coef0 = 1"
```

```
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.2, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.3, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.3, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.3, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 0.1, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 1, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 1, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 1, gamma = 0.001, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 1, gamma = 0.001, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 1, gamma = 0.1, coef0 = 0.01"
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## [1] "Sigmoid kernel with cost = 1, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
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## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
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## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
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## [1] "Sigmoid kernel with cost = 1, gamma = 0.3, coef0 = 0.01"
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## [1] "Sigmoid kernel with cost = 1, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.001, coef0 = 1"
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## [1] "Sigmoid kernel with cost = 10, gamma = 0.1, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.1, coef0 = 0.1"
```

```
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.1, coef0 = 1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.1, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.2, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.2, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
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## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 10, gamma = 0.3, coef0 = 10"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 100, gamma = 0.001, coef0 = 0.01"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
## [1] "Sigmoid kernel with cost = 100, gamma = 0.001, coef0 = 0.1"
## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
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## [1] "average accuracy on train = 0.6825, average accuracy on validation = 0.6825"
```

```r
acc_test = rep(NA, nfolds)
for (i in 1:nfolds){
        train = gradAdmit[-folds[[i]],]
        test = gradAdmit[folds[[i]],]

        svm = svm(formula =  factor(admit) ~ .,
                  kernel = "radial",
                  cost = 9,
                  gamma = 0.16,
                  data = train)

        pred = predict(svm, newdata = test, type='response')

        accuracy = 1 - (sum(abs(as.numeric(pred) - 1 - test[,1]))/nrow(test))
        acc_test[i] = accuracy
}
mean(acc_test)
```

```
## [1] 0.7125
```

As cost increase, difference between average of accuracy for predictions on training and average of accuracy for predictions on validation tends to increase.

Based on the models that I fit, polynomial (with degree=5) kernel and radial basis kernel perform better than others.

The optimal hyperparameters are cost = 9 and gamma = 0.16 when kernel = radial and this model perform the best on validation set.

part c

```r
set.seed(1009)
gradAdmit = read.csv('gradAdmit.csv')
sample = sample.int(n = n, size = floor(.2*n), replace = F)
train = gradAdmit[-sample,]
test = gradAdmit[sample,]

svm = svm(formula =  factor(admit) ~ .,
          kernel = "radial",
          cost = 9,
          gamma = 0.16,
          data = train)

pred = predict(svm, newdata = test, type='response')

accuracy = 1 - (sum(abs(as.numeric(pred) - 1 - test[,1]))/nrow(test))

accuracy
```

```
## [1] 0.7
```

The accuracy on test set is 0.7.