# SSD

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2022-09-11

## Introduction

SSD can obtain an estimator based on small-size pilot data which could be used to generate different sizes of training data and test data. Then it will calculate the corresponding classification error/ARI/AMI and draw the plot which has the same trend as the true data. People can determine the sample size according the plot we draw.

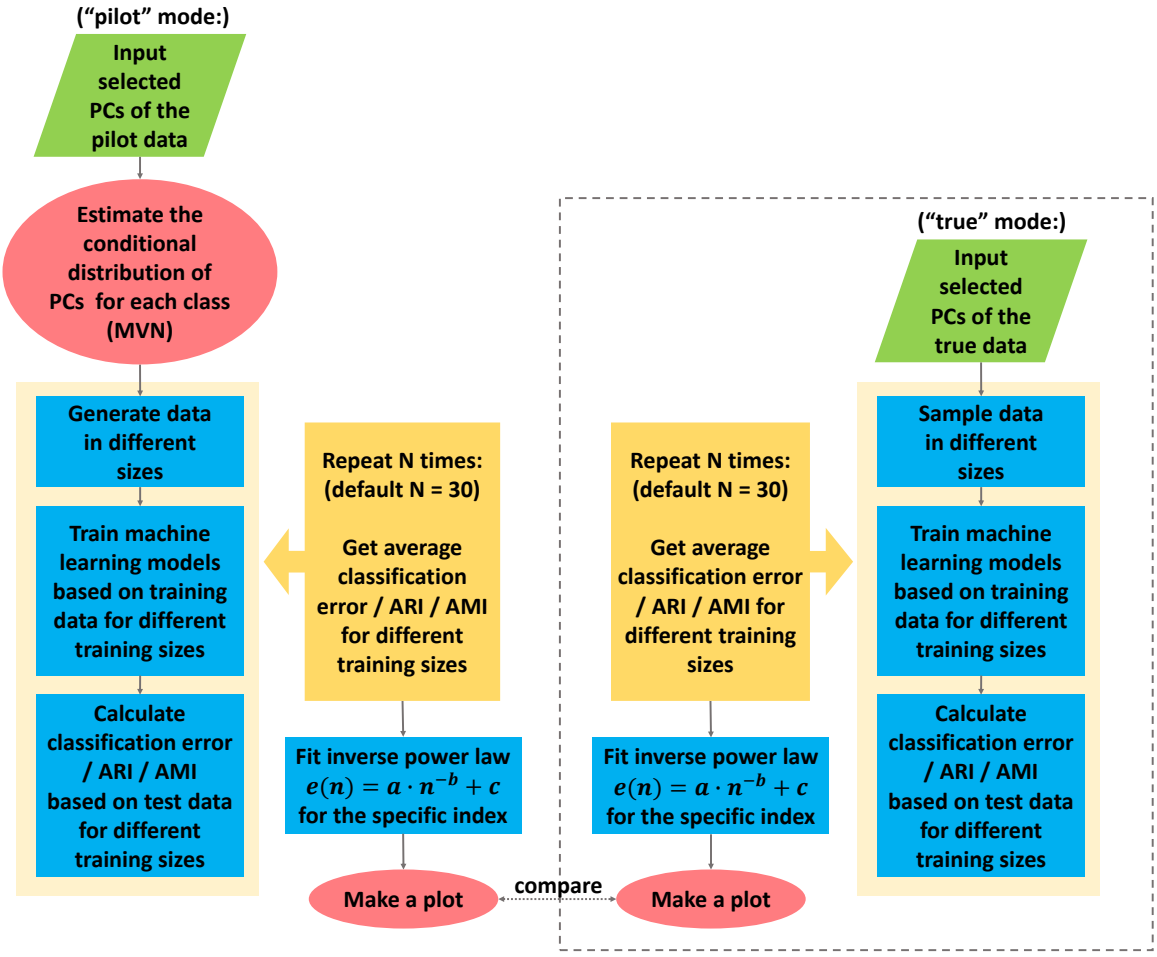



Figure 1: Workflow of the SSD package

## Preparations

Before we dive into the main task, we need to load the package and an example dataset for our task. The dataset we use is the **pbmc_68k** dataset from 10x Genomics.

We pre-processed the dataset: In this dataset, *phenoid* is the y label which has 10 classes. We sampled 15 observations from the original dataset for each class and assemble them as the pilot data. we normalize and scale the pilot data at first and then run principal component analysis (PCA) and keep 18 PCs according to *JackStrawPlot* and *ElbowPlot* mentioned in Seurat - Guided Clustering Tutorial. The *JackStrawPlot* and *ElbowPlot* are shown below:

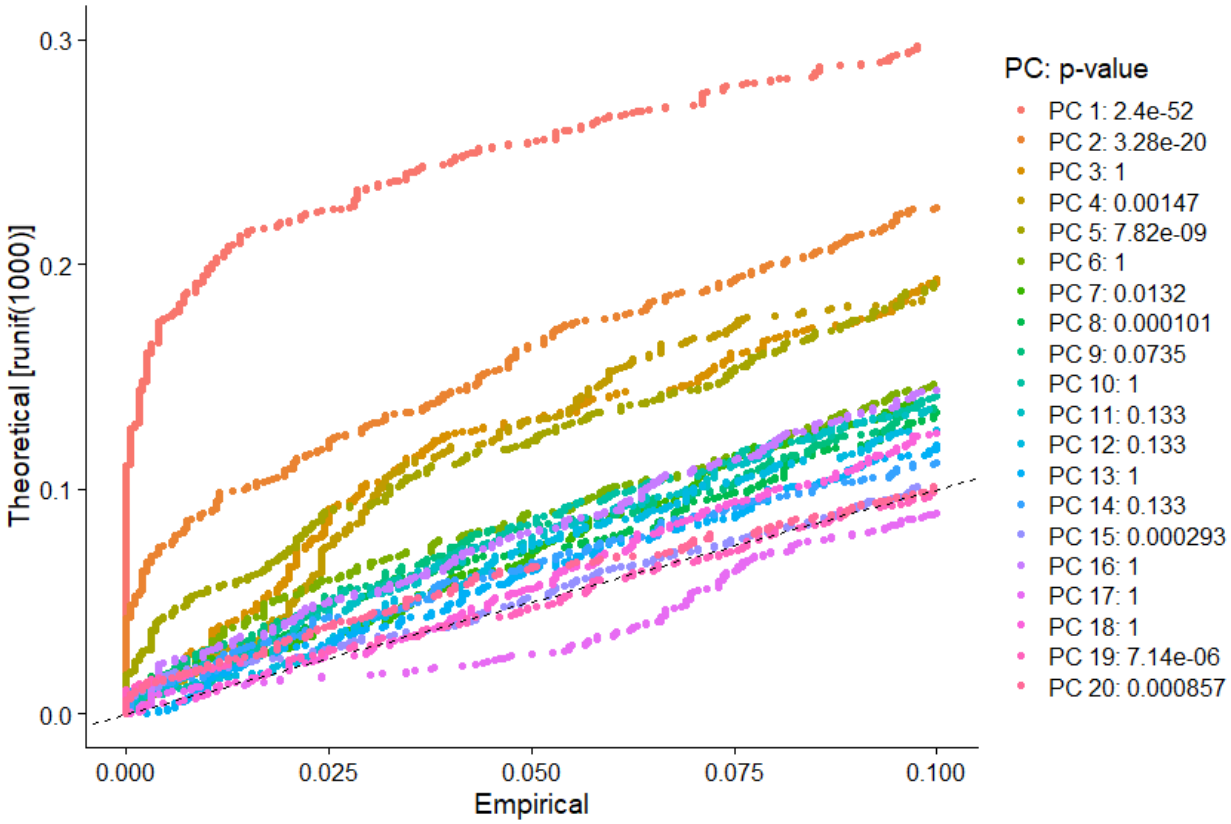



Figure 2: JackStrawPlot of the pilot data

For the whole dataset, we pre-processed it using the same stratigies and keep 23 PCs according to *JackStrawPlot* and *ElbowPlot*.

We put the pro-processed data into our package and we can load them directly.

```
library(SSD)

# load data ------------------------------------------------------------------------
pilot_data <- read.csv(system.file("extdata", "data_pbmc68k_pilot_18pc.csv",
                                   package = "SSD"),row.names=1)
print(table(pilot_data$phenoid))
#>
#>              CD14+_Monocyte                       CD19+_B
#>                          15                            15
#>             CD4+/CD25_T_Reg   CD4+/CD45RA+/CD25-_Naive_T
```

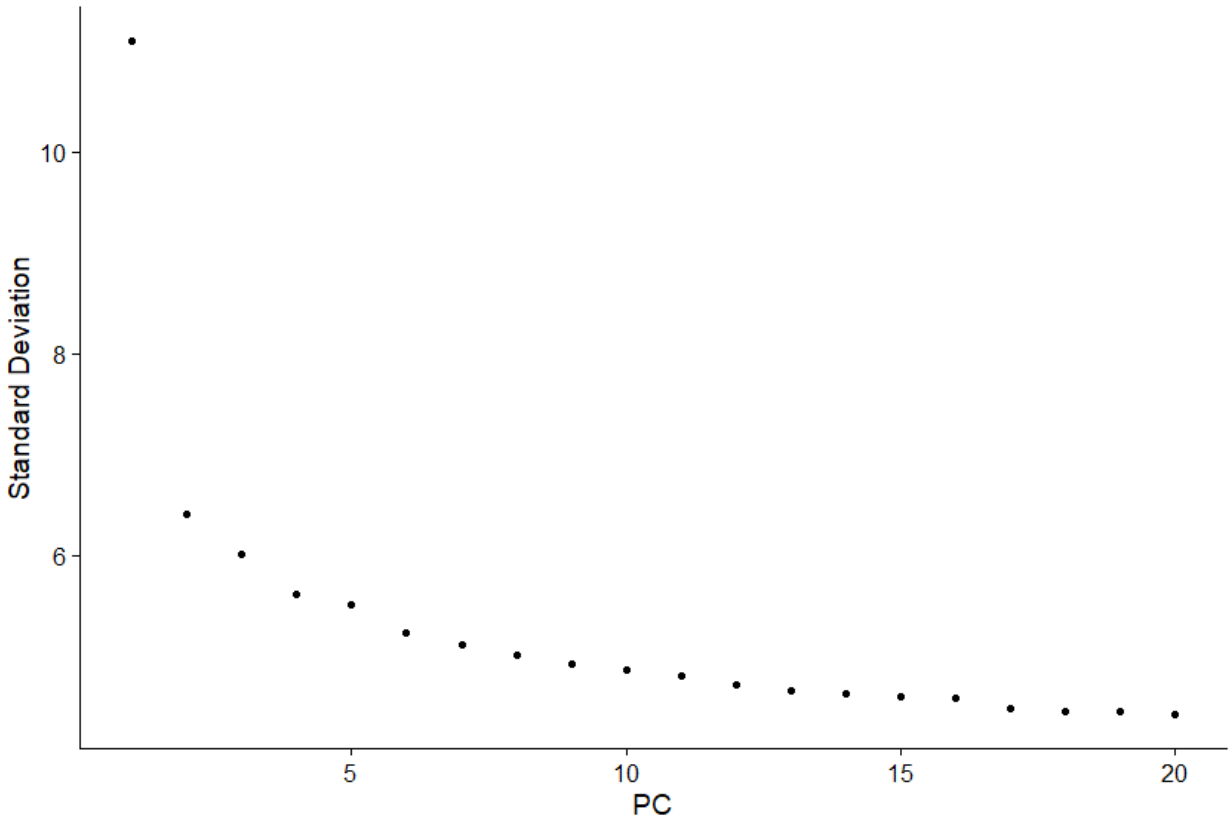



Figure 3: ElbowPlot of the pilot data

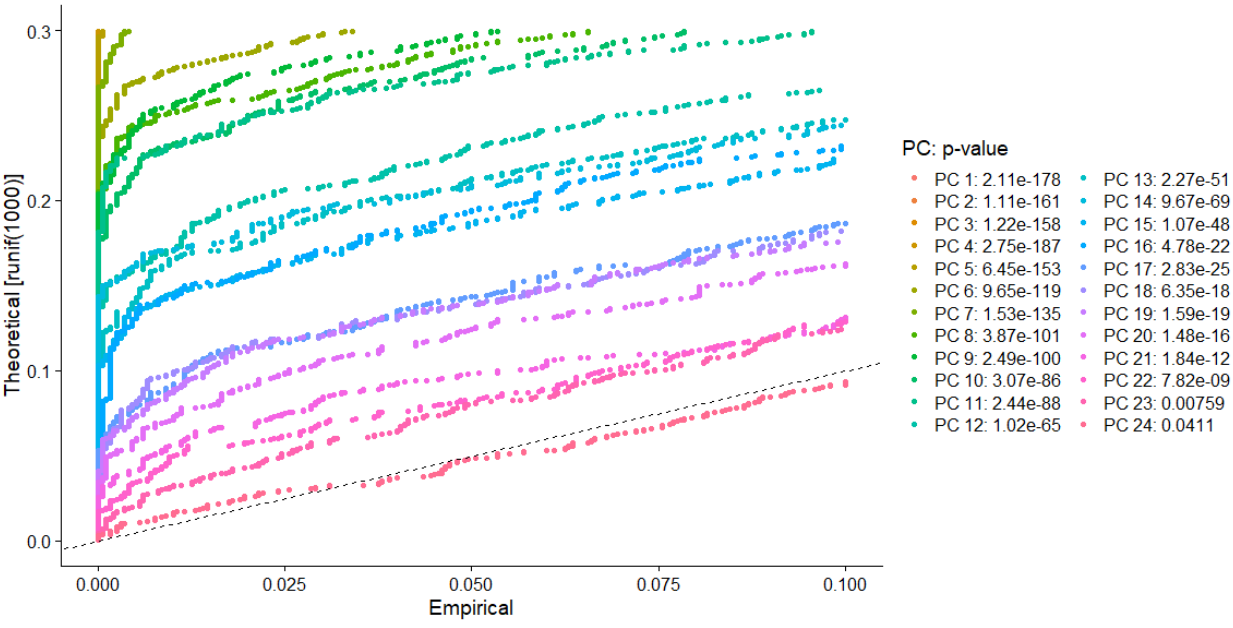



Figure 4: JackStrawPlot of the whole dataset

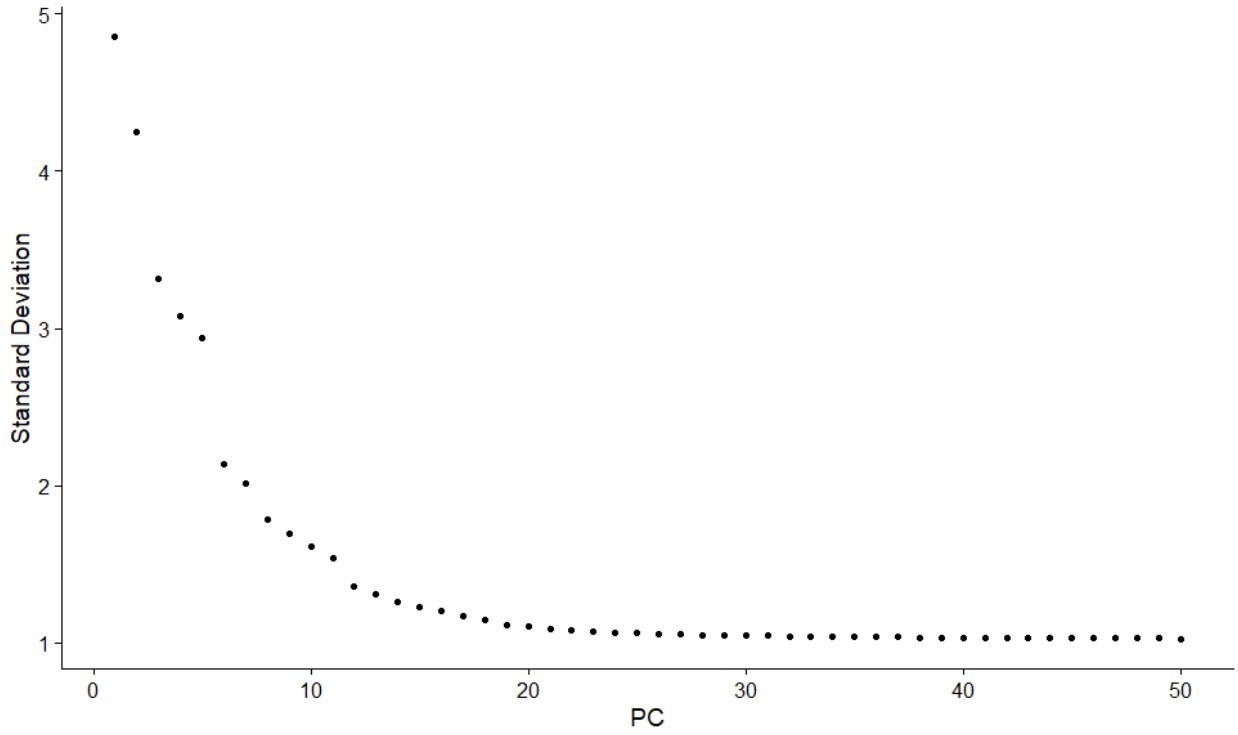



Figure 5: ElbowPlot of the whole dataset

```
#>                             15                             15
#>          CD4+/CD45RO+_Memory                CD4+_T_Helper2
#>                             15                             15
#>                       CD56+_NK CD8+/CD45RA+_Naive_Cytotoxic
#>                             15                             15
#>              CD8+_Cytotoxic_T                      Dendritic
#>                             15                             15

train_data <- read.csv(system.file("extdata", "data_pbmc68k_train_23pc.csv",
                                   package = "SSD"),row.names=1)
test_data <- read.csv(system.file("extdata", "data_pbmc68k_test_23pc.csv",
                                  package = "SSD"),row.names=1)
print(table(train_data$phenoid))
#>
#>                CD14+_Monocyte                        CD19+_B
#>                          3717                           3206
#>              CD4+/CD25_T_Reg    CD4+/CD45RA+/CD25-_Naive_T
#>                          2712                           3026
#>          CD4+/CD45RO+_Memory                CD4+_T_Helper2
#>                          5759                          11345
#>                       CD56+_NK CD8+/CD45RA+_Naive_Cytotoxic
#>                         14012                          21875
#>              CD8+_Cytotoxic_T                      Dendritic
#>                          1765                            162
print(table(test_data$phenoid))
#>
```

```
#>              CD14+_Monocyte                       CD19+_B
#>                         100                           100
#>            CD4+/CD25_T_Reg   CD4+/CD45RA+/CD25-_Naive_T
#>                         100                           100
#>       CD4+/CD45RO+_Memory              CD4+_T_Helper2
#>                         100                           100
#>                  CD56+_NK CD8+/CD45RA+_Naive_Cytotoxic
#>                         100                           100
#>          CD8+_Cytotoxic_T                     Dendritic
#>                         100                           100
```

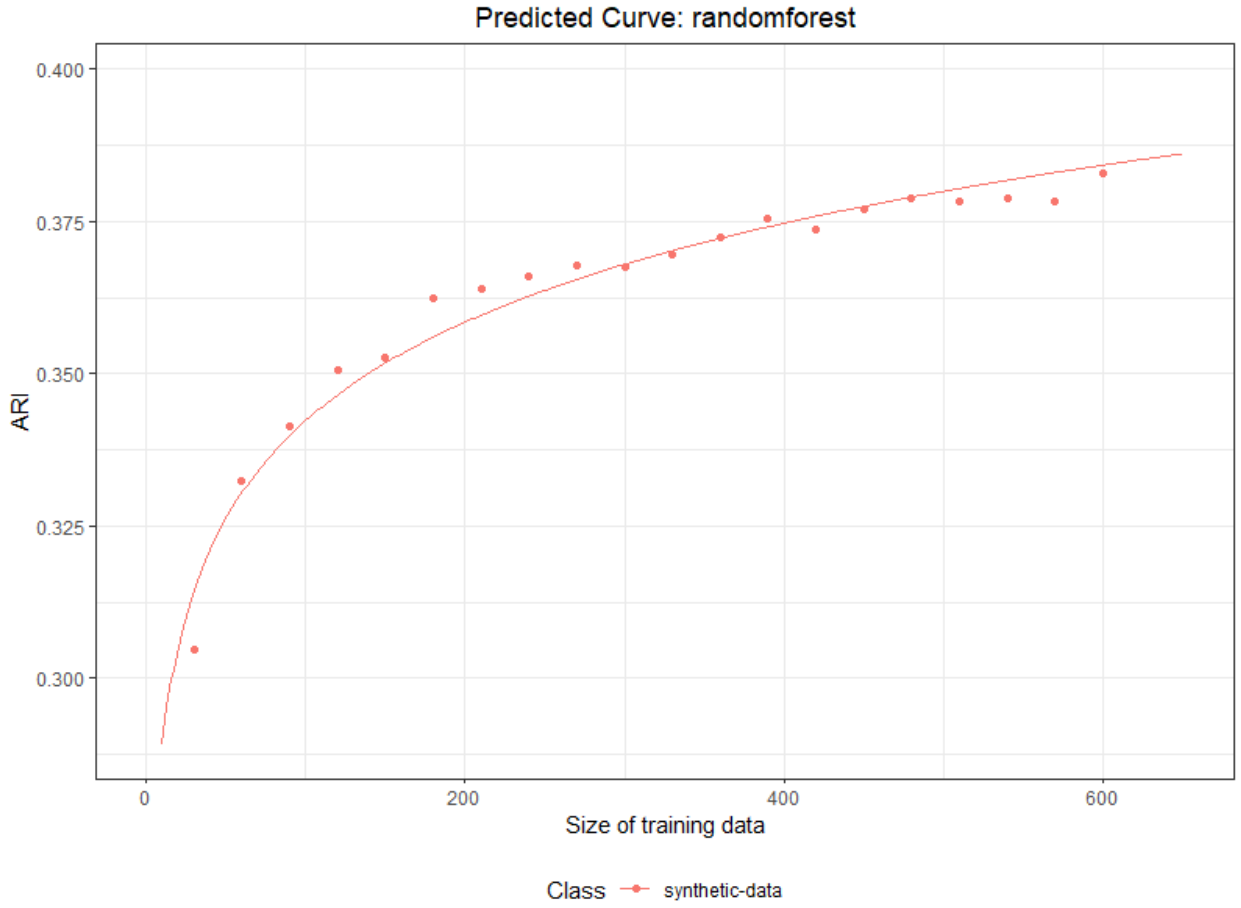
# Task

## With pilot data, draw the plot and determine sample size using the built-in model

In the default setting, we use the built-in *random forest* to train the model. The `index` we use is Adjusted Rand Index (ARI). By default, the size of training data for each class is (30, 60, 90, 120, ... , 540, 570, 600) and the size of test data for each class is 300.

```
x_pilot = pilot_data[,-length(pilot_data)]
y_pilot = pilot_data[,length(pilot_data)]

result_pilot = ssd(x_pilot, y_pilot)
```



The plot is drawn only based on the pilot data and we could use the plot to determine the sample size if we don't have large enough true. We should focus on the trends of the plots because the results produced by synthetic data are usually better than true data, but the trends are pretty similar.

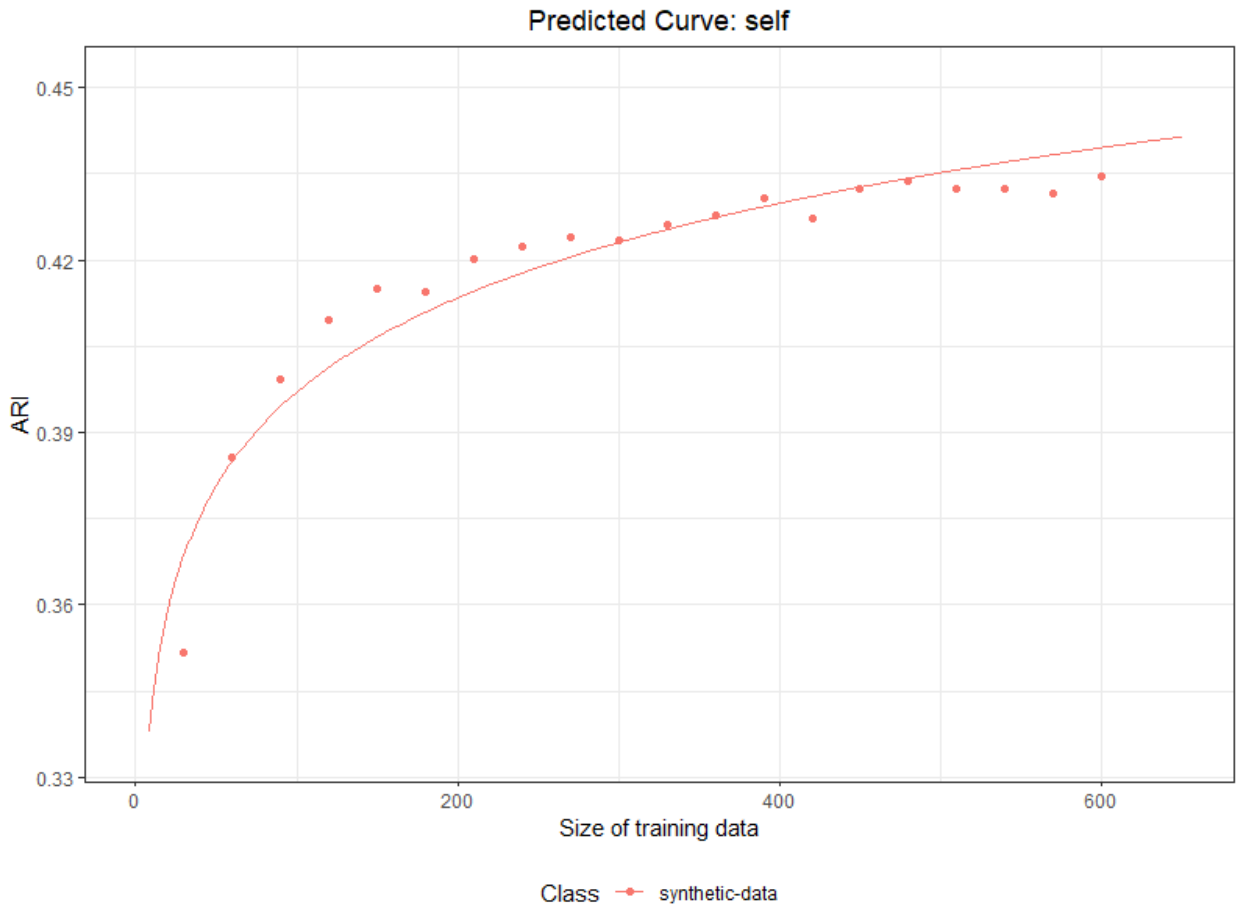
## With pilot data, draw the plot and determine sample size using the self-defined model

If you want to use the model defined by yourself. Then you need to write a "predict_model" function including your model. The function should take *train_data_x* and *train_data_y* as the first two inputs to train the model and then take *test_data_x* as the third input and return the predicted result of *test_data_x*. Then you could set `model` to *self* and set `func` to *predict_model*, and run the model using your self-defined function.

```
library(e1071)

predict_model <- function(train_data_x, train_data_y, test_data_x){
    train_data = data.frame(train_data_x, as.factor(train_data_y))
    names(train_data)[length(train_data)] = "class"
    fit_svm<-svm(class~.,data=train_data,probability=TRUE)
    pred <- predict(fit_svm, test_data_x)
    return(pred)
}
```

```
result_pilot_self = ssd(x_pilot, y_pilot, model="self", func=predict_model)
```



You could use the following code to check the function you defined. The result has to be the predicted value of *test_data_x*.

```
num_class=10
n_train=60
n_test=100

for(i in 1:num_class){
  class_i_ids = which(train_data$phenoid == names(table(train_data$phenoid))[i])

  train_test_i_ids = sample(class_i_ids, (n_train+n_test))
  train_i_data = train_data[train_test_i_ids[1:n_train],]
  test_i_data = train_data[train_test_i_ids[(n_train+1):(n_train+n_test)],]

  if(i == 1){
    train_data_sample = train_i_data
    test_data_sample = test_i_data
  }else{
    train_data_sample = rbind(train_data_sample, train_i_data)
    test_data_sample = rbind(test_data_sample, test_i_data)
  }
}

train_data_x = train_data_sample[,-length(train_data_sample)]
train_data_y = train_data_sample$phenoid
test_data_x = test_data_sample[,-length(test_data_sample)]

result = predict_model(train_data_x, train_data_y, test_data_x)
```

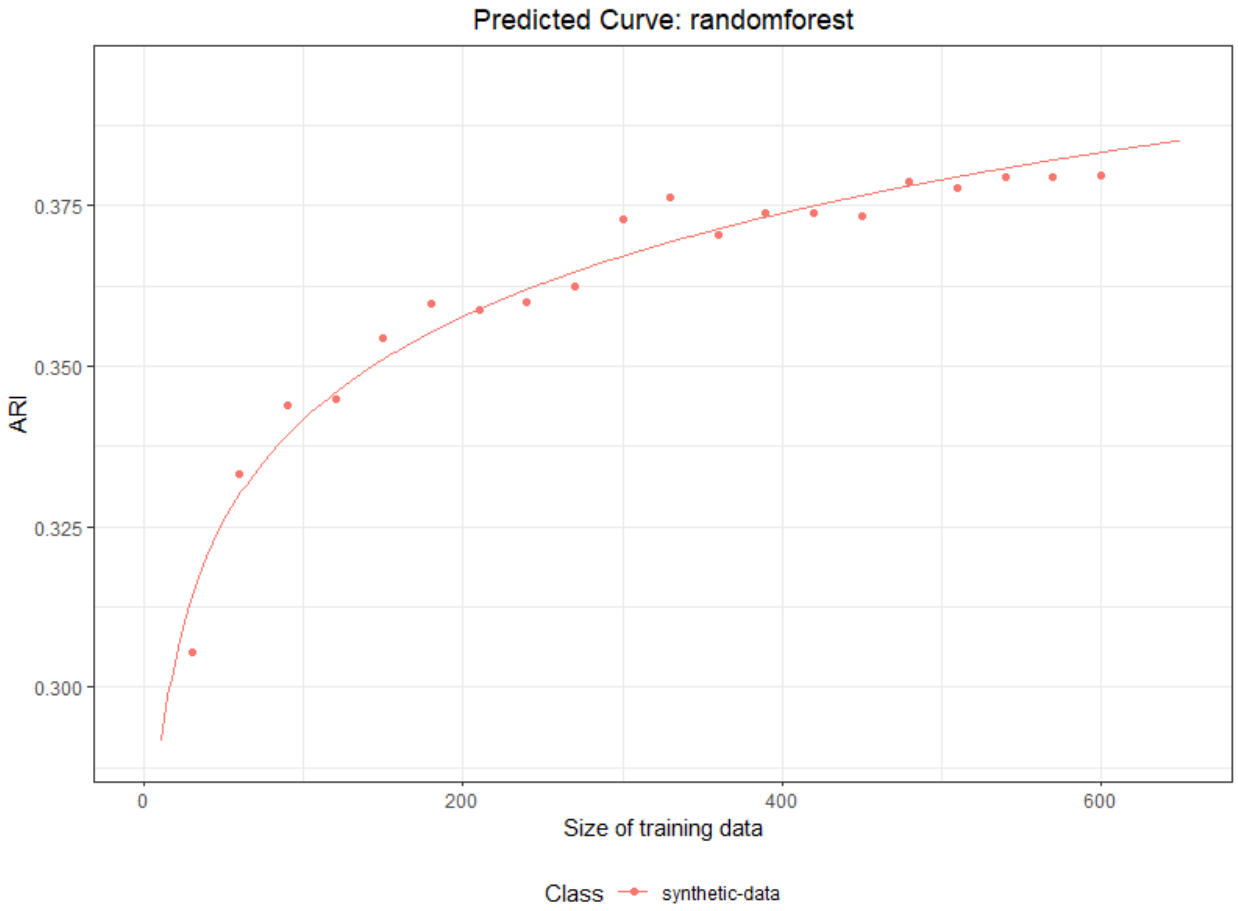
## With pilot data and large true data, draw the plot and compare the result

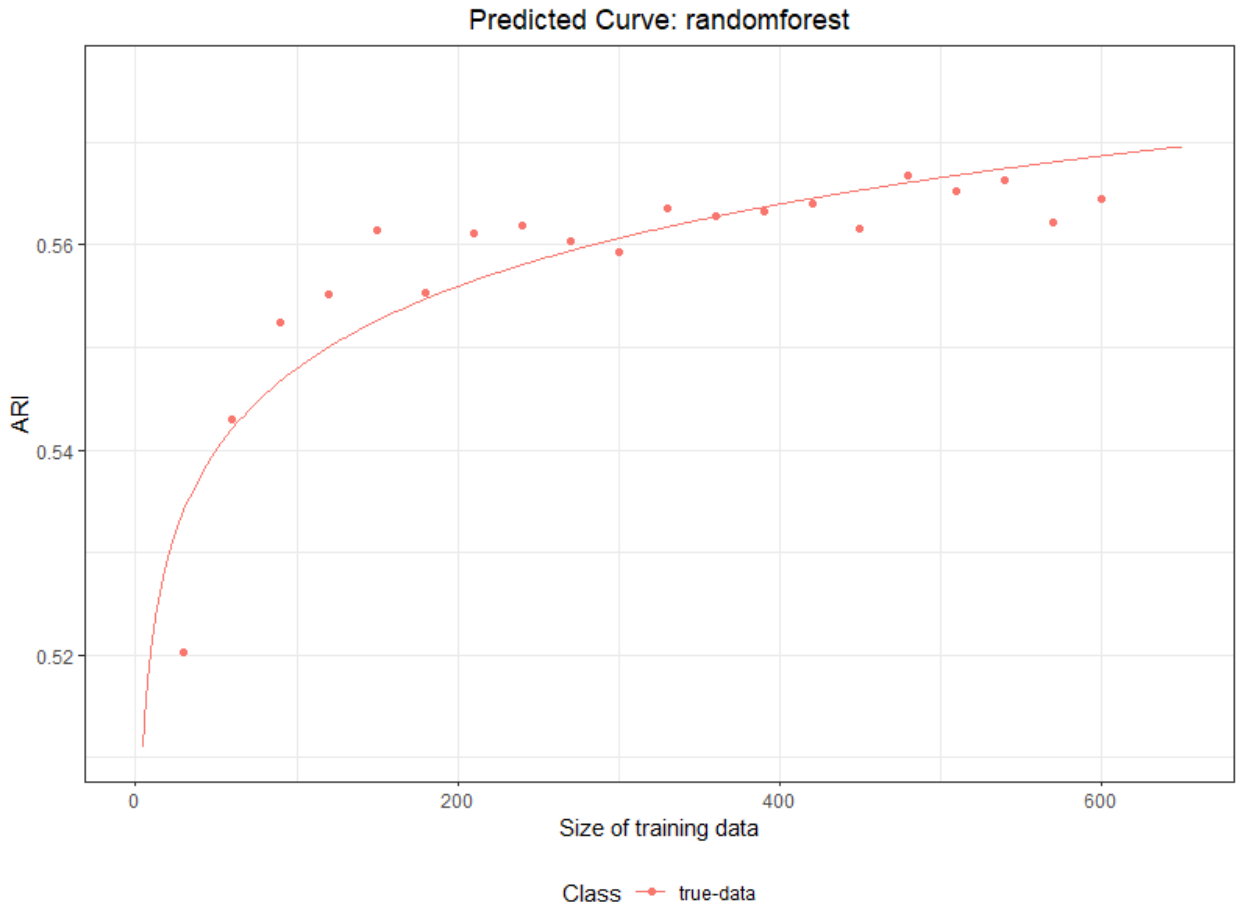
If we have large enough true data and try to compare the plot drawn based on pilot data and the plot drawn based on true data, we could change `mode` to *true* and compare the results.

```
# prepare large true data
x_true_train = train_data[,-length(train_data)]
y_true_train = train_data[,length(train_data)]

table(train_data$phenoid)
x_true_test = test_data[,-length(test_data)]
y_true_test = test_data[,length(test_data)]
table(test_data$phenoid)

# run the model using the previous pilot data, index using 'ARI'
result_pilot_11 = ssd(x_pilot, y_pilot,model = "randomforest",index = "ARI",
                      n_train_list=seq(from=30, to=600,by=30), n_test=100)
# run the model using the true data, index using 'ARI'
result_true_11 = ssd(x=x_true_train, y=y_true_train, model = "randomforest", index="ARI",
                     n_train_list=seq(from=30, to=600,by=30),mode="true",
                     test_x=x_true_test, test_y=y_true_test, n_test=100)
```

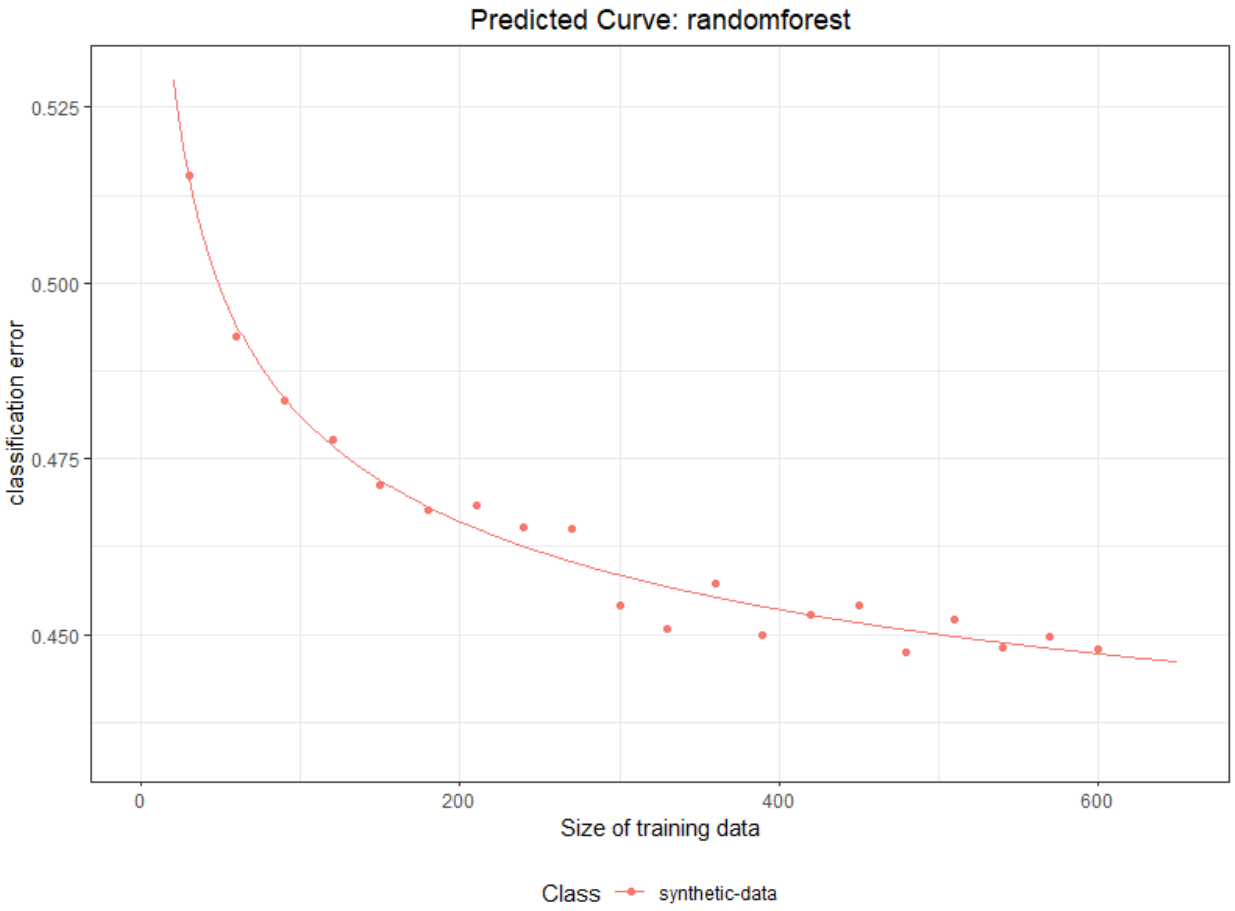

Predicted Curve: randomforest
ARI
0.375
0.350
0.325
0.300
0
200
400
600
Size of training data
Class
synthetic-data

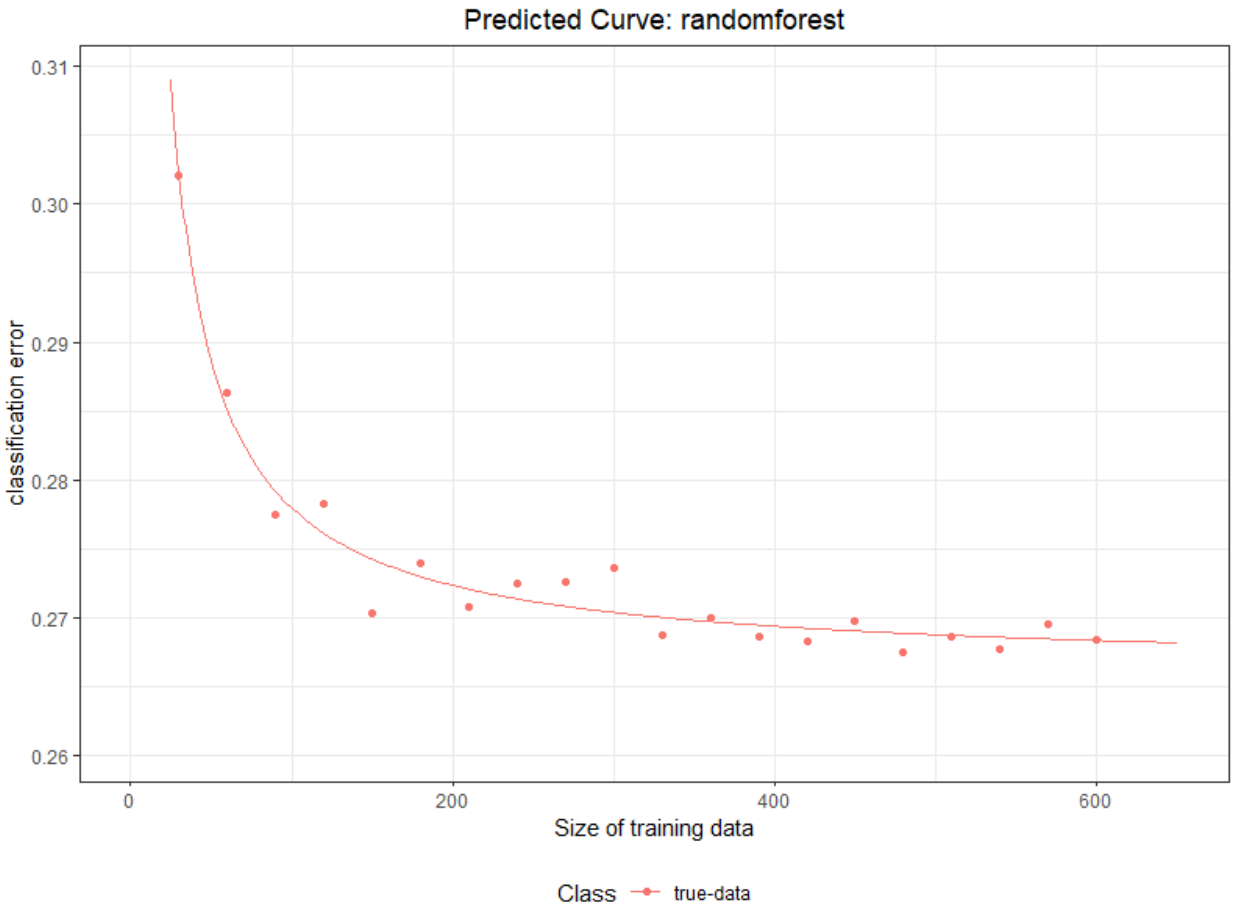



From the results above,even though the values of ARI are different, we can see that the two plots have almost the same trend, which could help us determine the sample size.

We could also try when `index` is *classification error* or *AMI* for this dataset.

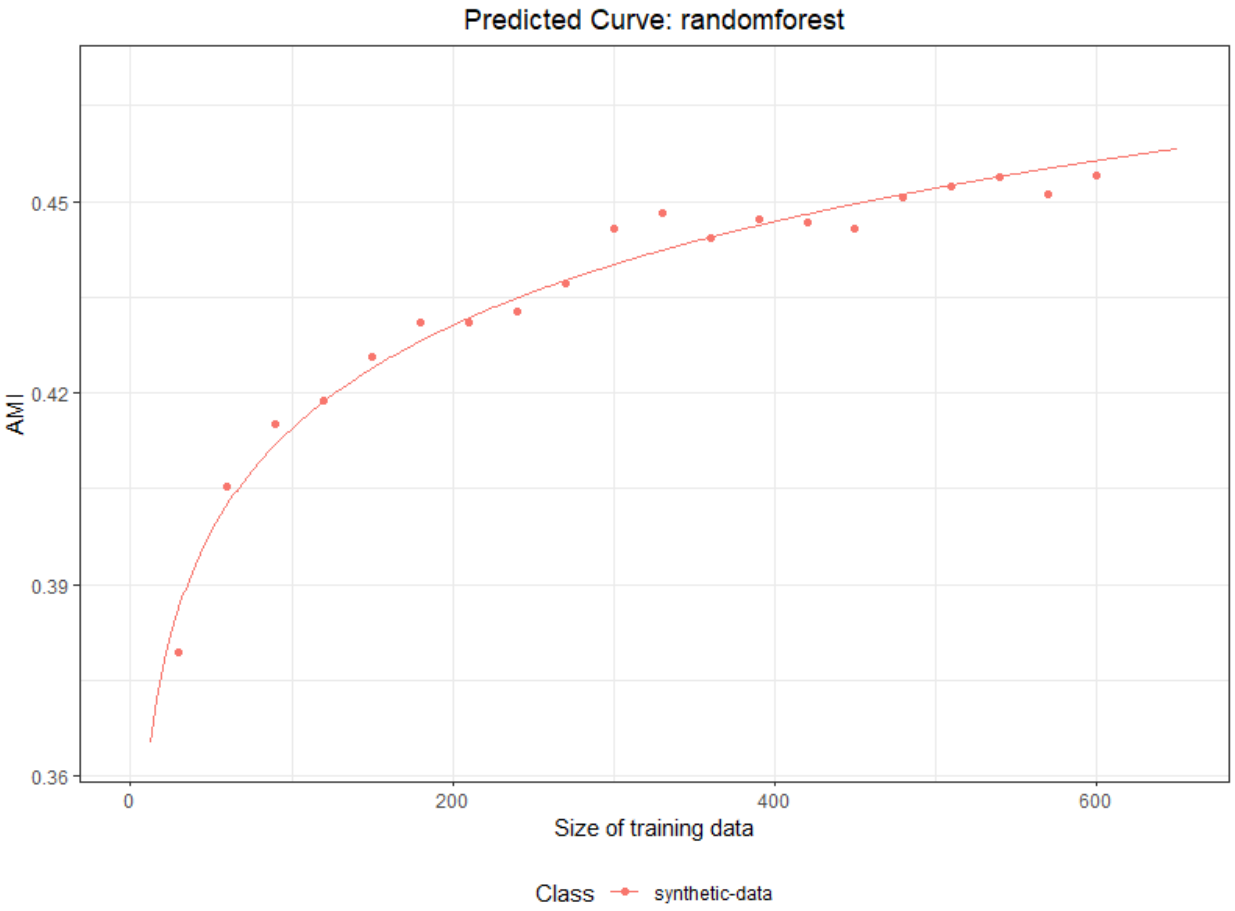
```
# run the model using the previous pilot data, index using 'classification error'
result_pilot_12 = ssd(x_pilot, y_pilot,model="randomforest",index="classification error",
                      n_train_list=seq(from=30, to=600,by=30), n_test=100)
# run the model using the true data, index using 'classification error'
result_true_12 = ssd(x=x_true_train, y=y_true_train, model = "randomforest",
                  index="classification error", n_train_list=seq(from=30, to=600,by=30),
                  mode="true", test_x=x_true_test, test_y=y_true_test, n_test=100)
```

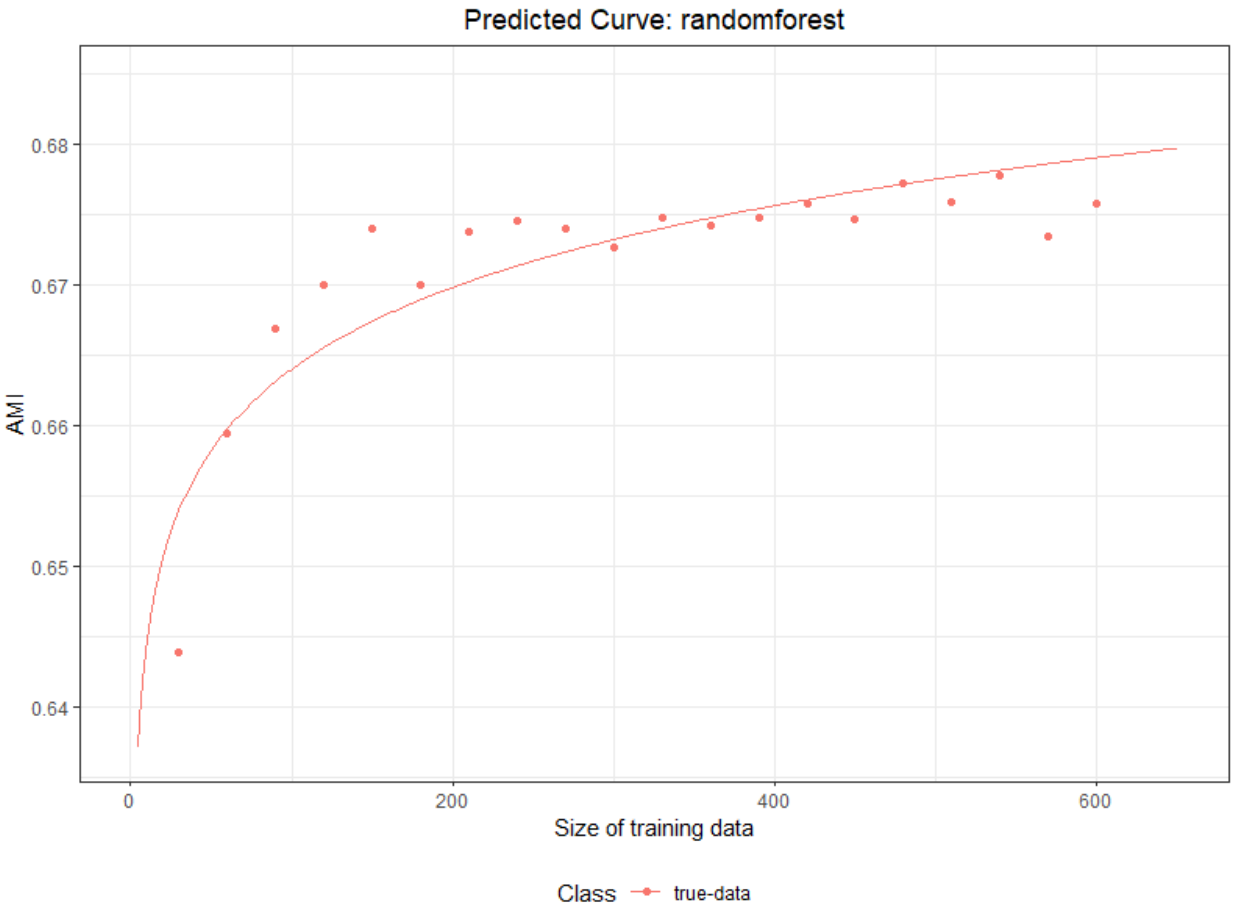

Predicted Curve: randomforest
0.525
0.500
0.475
0.450
classification error
0
200
400
600
Size of training data
Class
synthetic-data




```
# prepare large true data
x_true = data[,-length(data)]
y_true = data[,length(data)]

# run the model using the previous pilot data, index using 'AMI'
result_pilot_13 = ssd(x_pilot, y_pilot,model = "randomforest",index = "AMI",
                      n_train_list=seq(from=30, to=600,by=30), n_test=100)
# run the model using the true data, index using 'AMI'
result_true_13 = ssd(x=x_true_train, y=y_true_train, model = "randomforest", index="AMI",
                     n_train_list=seq(from=30, to=600,by=30),mode="true",
                     test_x=x_true_test,test_y=y_true_test, n_test=100)
```


Predicted Curve: randomforest
AMI
0.45
0.42
0.39
0.36
0
200
400
600
Size of training data
Class
synthetic-data


Predicted Curve: randomforest
AMI
0.68
0.67
0.66
0.65
0.64
0
200
400
600
Size of training data
Class
true-data