

# Project 3 - Main Script (Baseline Model - GBM)

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## Group 8

This is the report for our baseline model. In this `main.Rmd`, we use Boosted Decision Stumps to predict neighborhood pixels in order to enhance the resolution of blurry and low-resolution images.

**Note: please use Mac OS system** to reproduce this file on your computer successfully.

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```
# load required packages
if(!require("EBImage")){
  source("https://bioconductor.org/biocLite.R")
  biocLite("EBImage")
}
if(!require("gbm")){
  install.packages("gbm")
}
if(!require("plyr")){
  install.packages("plyr")
}
if(!require("doMC")){
  install.packages("doMC")
}
library("EBImage")
library("gbm")
library("plyr")
library("doMC")
```

## Step 0: specify directories.

Set the working directory to the image folder. Specify the training and the testing set. For data without an independent test/validation set, you need to create your own testing data by random subsampling. In order to obtain reproducible results, `set.seed()` whenever randomization is used.

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```
# set work directory
set.seed(2018)
setwd("../doc")
```

Provide directories for training images. Low-resolution (LR) image set and High-resolution (HR) image set will be in different subfolders.

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```
train_dir <- "../data/train_set/" # This will be modified for different data sets.
train_LR_dir <- paste(train_dir, "LR/", sep="")
train_HR_dir <- paste(train_dir, "HR/", sep="")
```

## Step 1: set up controls for evaluation experiments.

In this chunk, we have a set of controls for the evaluation experiments.

- (T/F) cross-validation on the training set
- (number) K, the number of CV folds
- (T/F) process features for training set
- (T/F) run evaluation on an independent test set
- (T/F) process features for test set

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```
run.cv=TRUE # run cross-validation on the training set
K <- 5 # number of CV folds
run.feature.train=TRUE # process features for training set
run.test=TRUE # run evaluation on an independent test set
run.feature.test=TRUE # process features for test set
```

Using cross-validation or independent test set evaluation, we compare the performance of models with different specifications. In this file, we use GBM with depth one and compare between different values of shrinkage and number of trees. In the following chunk, we list, in a vector, setups corresponding to models that we will compare - three shrinkage values and three numbers of trees values. Therefore, we will compare  $3 \times 3 = 9$  models in the cross validation part.

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```
# shrinkage
shrinkage_values <- c(0.001, 0.01, 0.1)
# number of trees
ntrees_values <- c(100,200,300)
# nine model labels
model_labels <- c()
for (shrink in shrinkage_values){
  model_labels <- c(model_labels,
                    paste("gbm with shrinkage rate=", shrink,
                          "number of trees=", ntrees_values))
}
```

## Step 2: construct features and responses

`feature.R` should be the wrapper for all your feature engineering functions and options. The function `feature( )` should have options that correspond to different scenarios for your project and produces an R object that contains features and responses that are required by all the models you are going to evaluate later.

- `feature.R`
  - Input: a path for low-resolution images.
  - Input: a path for high-resolution images.
  - Output: an RData file that contains extracted features and corresponding responses

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```
source("../lib/feature.R")

tm_feature_train <- NA
if(run.feature.train){
  tm_feature_train <- system.time(dat_train <- feature(train_LR_dir, train_HR_dir))
  feat_train <- dat_train$feature
  label_train <- dat_train$label
}

save(dat_train, file="../output/feature_train.RData")
save(tm_feature_train, file="../output/tm_feature_train.RData")
```

## Step 3: Train a classification model with training images

Call the train model and test model from library.

`train.R` and `test.R` should be wrappers for all your model training steps and your classification/prediction steps.

- `train.R`
  - Input: a path that points to the training set features and responses.
  - Output: an RData file that contains trained classifiers in the forms of R objects: models/settings/links to external trained configurations.
- `test.R`
  - Input: a path that points to the test set features.
  - Input: an R object that contains a trained classifier.
  - Output: an R object of response predictions on the test set. If there are multiple classifiers under evaluation, there should be multiple sets of label predictions.

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```
source("../lib/train.R")
source("../lib/test.R")
```

## Model selection with cross-validation

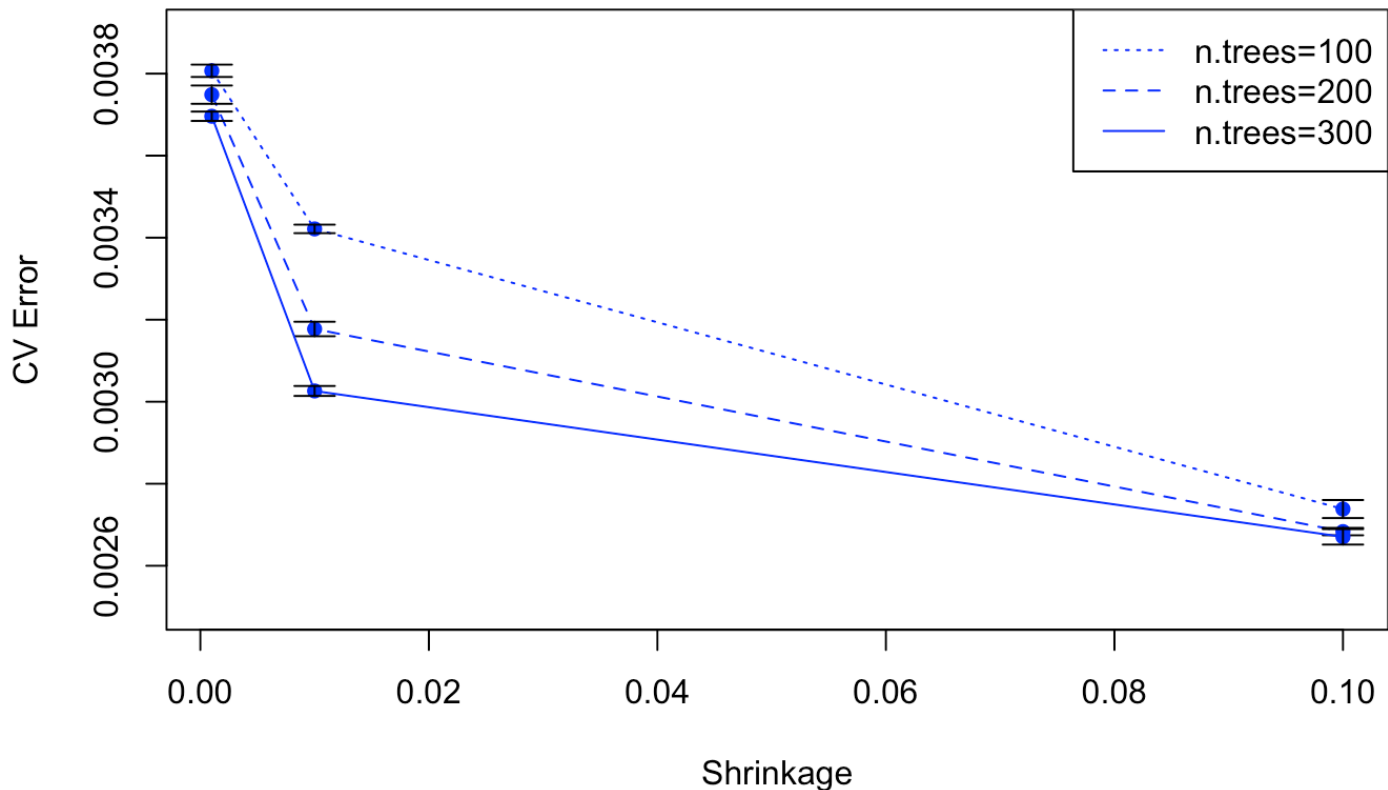
- Do model selection by choosing among different values of training model parameters, that is, the shrinkage and number of trees for GBM in this file.

Visualize cross-validation results.

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```
if(run.cv){
  load("../output/err_cv.RData")
  plot(shrinkage_values, err_cv[c(1,5,9),1], xlab="Shrinkage", ylab="CV Error",
       main="Cross Validation Error", type="n", ylim=c(0.0025, 0.0039))
  for (i in c(2,1,0)) {
    points(shrinkage_values, err_cv[((1:3)*3-i),1], col="blue", pch=16)
    lines(shrinkage_values, err_cv[((1:3)*3-i),1], col="blue", lty=i+1)
    arrows(shrinkage_values, err_cv[((1:3)*3-i),1]-err_cv[((1:3)*3-i),2], shrinkage_v
alues,
          err_cv[((1:3)*3-i),1]+err_cv[((1:3)*3-i),2], length=0.1, angle=90, code=3)
  }
  legend("topright", legend=c("n.trees=100", "n.trees=200", "n.trees=300"),
        lty=c(3,2,1), col="blue")
}
```

### Cross Validation Error



- Choose the “best” parameter value according to one standard error rule

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```
#model_best=model_values[1]
# if(run.cv){
#   best_ind <- which.min(err_cv[,1])
# }
# according to one standard error rule
best_ind <- 8
best_ntrees_ind <- (best_ind-1)%length(shrinkage_values)+1
best_shrink_ind <- (best_ind-best_ntrees_ind)%length(shrinkage_values)+1
par_best <- list(shrink=shrinkage_values[best_shrink_ind],
                n.trees=ntrees_values[best_ntrees_ind])
print(par_best)
```

```
$shrink
[1] 0.1

$n.trees
[1] 200
```

- Train the model with the entire training set using the selected model (model parameter) via cross-validation.

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```
set.seed(2018)
tm_train=NA
tm_train <- system.time(fit_train <- train(feet_train, label_train, par_best))
save(fit_train, file="../output/fit_train.RData")
save(tm_train, file="../output/tm_train.RData")
```

## Step 4: Super-resolution for test images

Feed the final training model with the completely holdout testing data.

- `superResolution.R`
  - Input: a path that points to the folder of low-resolution test images.
  - Input: a path that points to the folder (empty) of high-resolution test images.
  - Input: an R object that contains tuned predictors.
  - Output: construct high-resolution versions for each low-resolution test image.

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```
source("../lib/superResolution.R")
test_dir <- "../data/test_set/" # This will be modified for different data sets.
test_LR_dir <- paste(test_dir, "LR/", sep="")
test_HR_dir <- paste(test_dir, "HR/", sep="")

tm_test=NA
if(run.test){
  load(file="../output/fit_train.RData")
  tm_test <- system.time(superResolution(test_LR_dir, test_HR_dir, fit_train))
}
save(tm_test, file="../output/tm_test.RData")
```

## Summarize Running Time

Prediction performance matters, so does the running times for constructing features and for training the model, especially when the computation resource is limited.

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```
load("../output/tm_feature_train.RData")
cat("Time for constructing training features=", tm_feature_train[3], "s \n")
```

```
Time for constructing training features= 204.918 s
```

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```
load("../output/tm_train.RData")
cat("Time for training model=", tm_train[3], "s \n")
```

```
Time for training model= 1612.68 s
```

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```
load("../output/tm_test.RData")
cat("Time for super-resolution=", tm_test[3], "s \n")
```