Kaggle workshop

October 26, 2016

0.0.1 Kaggle workshop

Let's load all needed libraries first.

```
In [9]: library(data.table)
        library(zoo)
        library(caret)
        library(gtools)
        library(sqldf)
        library(doParallel)
        library(doRNG)
        library(VGAM)
        library(xgboost)
        library(Amelia)
```

```
Attaching package: 'zoo'

The following objects are masked from 'package:base':

    as.Date, as.Date.numeric

Loading required package: lattice
Loading required package: ggplot2
Loading required package: gsubfn
Loading required package: proto
Warning message in doTryCatch(return(expr), name, parentenv, handler):
"unable to load shared object '/Library/Frameworks/R.framework/Resources/modules//R
  dlopen(/Library/Frameworks/R.framework/Resources/modules//R_X11.so, 6): Library n
  Referenced from: /Library/Frameworks/R.framework/Resources/modules//R_X11.so
  Reason: image not found"Could not load tcltk.  Will use slower R code instead.
Loading required package: RSQLite
Loading required package: DBI
Loading required package: foreach
Loading required package: iterators
Loading required package: parallel
Loading required package: rngtools
Loading required package: pkgmaker
```

```
Loading required package: registry

Attaching package: 'pkgmaker'

The following object is masked from 'package:base':

    isNamespaceLoaded

Loading required package: stats4
Loading required package: splines

Attaching package: 'VGAM'

The following object is masked from 'package:gtools':

    logit

The following object is masked from 'package:caret':

    predictors

Loading required package: Rcpp
##
## Amelia II: Multiple Imputation
## (Version 1.7.4, built: 2015-12-05)
## Copyright (C) 2005-2016 James Honaker, Gary King and Matthew Blackwell
## Refer to http://gking.harvard.edu/amelia/ for more information
##
```

Set working folder, loading pre-defined cross-validation split in order to guarantee reproducibility. Also I'm defining how many cores I'm going to use to parallelize mean encoding feature generation. And in order to be able to run everything fast I'm using subsampling.

```
In [10]: Sys.time()
         setwd("/Users/branden/h2oDallas") # change your working directory
         load("./data_trans/cvFoldsList.rda")
         threads <- max(detectCores() - 2, 1) # Used for parallelizing mean encodi
         row_sampling <- 5000 # Feature engineering requires a lot of memory,
                              #so subsample for demonstration purposes -- set to <=(

[1] "2016-10-26 13:37:33 CDT"
```

Load some very important functions we will use for feature generation, like: * my.f2cnt() # https://github.com/owenzhang/Kaggle-AmazonChallenge2013/blob/master/__final_utils.R * my.f3cnt() # https://github.com/owenzhang/Kaggle-AmazonChallenge2013/blob/master/__final_utils.R * catNWayAvgCV() * gold_features() * gold_featuresUnCor()

```
In [11]: source("./data_trans/utils.R")
```

The following feature interaction lists come from Dmitry, one of my teammates during the compeition. I believe he got these from the output from XGBFi which will be shown in a bit.

Start with pairs of features.

```
In [12]: comb2List <- list(c("v50","v6"),c("v21","v5"),c("v10","v12"),c("v50","v78"
                           c("v115","v52"),c("v21","v24"),c("v50","v66"),c("v30","v
                           c("v129","v24"),c("v3","v50"),c("v39","v66"),c("v34","v5
                           c("v113","v12"),c("v114","v22"),c("v120","v50"),c("v50",
                           c("v12","v52"),c("v34","v91"),c("v12","v58"),c("v14","v2
                           c("v1","v45"),c("v40","v66"),c("v125","v34"),c("v2","v21
                           c("v66","v74"),c("v31","v56"),c("v114","v12"),c("v24","v
                           c("v125","v22"),c("v113","v22"),c("v125","v52"),c("v39",
                           c("v12","v42"),c("v10","v47"),c("v112","v34"),c("v21","v
                           c("v41","v49"),c("v10","v66"),c("v50","v98"),c("v10","v1
                           c("v21","v74"),c("v113","v21"),c("v12","v66"),c("v24","v
                           c("v21","v45"),c("v50","v52"),c("v131","v50"),c("v12","v
                           c("v1","v40"),c("v34","v40"),c("v24","v50"),c("v22","v56
                           c("v113","v80"),c("v122","v50"),c("v14","v38"),c("v10","
                           c("v49","v56"),c("v10","v56"),c("v50","v68"),c("v16","v3
                           c("v31","v66"),c("v106","v56"),c("v112","v14"),c("v34","
                           c("v50","v69"),c("v113","v56"),c("v12","v47"),c("v10","v
                           c("v50","v80"),c("v125","v47"),c("v113","v66"),c("v21","
                           c("v113","v50"),c("v38","v56"),c("v115","v34"),c("v14","
                           c("v14","v72"),c("v14","v50"),c("v113","v131"),c("v21","
                           c("v114","v47"),c("v125","v14"),c("v113","v24"),c("v50",
                           c("v12","v99"),c("v125","v24"),c("v58","v85"),c("v1","v5
                           c("v56","v85"),c("v21","v47"),c("v12","v71"),c("v125","v
                           c("v21","v6"),c("v50","v72"),c("v131","v34"),c("v40","v5
                           c("v21","v58"),c("v10","v21"),c("v127","v56"),c("v66","v
                           c("v34","v50"),c("v131","v27"),c("v30","v66"),c("v45","v
                           c("v100","v114"),c("v45","v66"),c("v56","v88"),c("v14","
                           c("v21","v85"),c("v112","v56"),c("v100","v80"),c("v30","
                           c("v114","v40"),c("v50","v99"),c("v44","v56"),c("v10","v
                           c("v12","v18"),c("v14","v21"),c("v113","v14"),c("v114","
                           c("v47","v56"),c("v56","v80"),c("v24","v40"),c("v100","v
                           c("v45","v50"),c("v113","v47"),c("v22","v40"),c("v113","
                           c("v1","v56"),c("v30","v91"),c("v112","v40"),c("v112","v
                           c("v24","v72"),c("v22","v52"),c("v31","v47"),c("v30","v5
                           c("v10","v62"),c("v10","v40"),c("v38","v66"),c("v56","v6
                           c("v21","v52"),c("v112","v114"),c("v31","v50"),c("v113",
                           c("v100","v66"),c("v14","v66"),c("v34","v47"),c("v38","v
                           c("v1","v14"),c("v24","v66"),c("v40","v47"),c("v24","v56
                           c("v14","v24"),c("v50","v7"),c("v100","v27"),c("v114","v
                           c("v10","v50"),c("v114","v50"),c("v40","v74"),c("v12","v
                           c("v115","v21"),c("v112","v113"),c("v24","v31"),c("v125"
                           c("v56","v99"),c("v52","v6"),c("v12","v56"),c("v100","v5
```

```
                                c("v14","v47"),c("v114","v71"),c("v113","v45"),c("v10","
                                c("v56","v68"),c("v21","v22"),c("v50","v85"),c("v40","v5
                                c("v12","v40"),c("v129","v66"),c("v19","v50"),c("v47","v
                                c("v113","v114"),c("v34","v51"),c("v50","v6"),c("v56","v
                                c("v129","v50"),c("v125","v21"),c("v50","v56"),c("v22","
                                c("v114","v58"),c("v12","v91"),c("v21","v40"),c("v24","v
                                c("v14","v80"),c("v39","v6"),c("v131","v6"),c("v12","v39
                                c("v12","v21"),c("v12","v125"),c("v12","v14"),c("v56","v
                                c("v45","v47"),c("v24","v6"),c("v113","v72"),c("v12","v5
                                c("v14","v40"),c("v100","v40"),c("v47","v50"),c("v56","v
                                c("v24","v34"),c("v115","v50"),c("v24","v62"),c("v39","v
                                c("v100","v24"),c("v52","v56"),c("v18","v21"),c("v12","v
                                c("v113","v40"),c("v30","v47"),c("v12","v5"),c("v50","v6
                                c("v14","v52"),c("v127","v98"),c("v12","v120"),c("v50","
                                c("v66","v72"),c("v112","v52"),c("v100","v50"),c("v45","
                                c("v40","v56"),c("v34","v6"),c("v125","v40"),c("v125","v
                                c("v114","v34"),c("v34","v35"),c("v127","v39"),c("v114",
                                c("v24","v47"),c("v45","v90"),c("v12","v38"),c("v50","v9
                                c("v21","v5"),c("v30","v50"),c("v112","v12"),c("v14","v3
                                c("v120","v45"),c("v38","v78"),c("v114","v125"),c("v114"
                                c("v127","v21"),c("v114","v21"),c("v22","v50"),c("v12","
                                c("v34","v66"),c("v14","v56"),c("v12","v22"),c("v40","v9
                                c("v11","v50"),c("v12","v85"),c("v29","v77"),c("v24","v5
                                c("v12","v78"),c("v28","v50"),c("v112","v47"),c("v114","
                                c("v80","v99"),c("v129","v56"),c("v127","v19"),c("v14","
                                c("v21","v34"),c("v10","v52"),c("v10","v113"),c("v10","v
                                c("v112","v50"),c("v100","v47"),c("v21","v66"),c("v1","v
                                c("v115","v12"))
```

Now three-way interactions

```
In [13]: comb3List <- list(c("v12","v24","v56"),c("v113","v14","v40"),c("v113","v14
                           c("v34","v40","v66"),c("v12","v14","v50"),c("v56","v66",
                           c("v113","v14","v34"),c("v21","v47","v50"),c("v12","v47"
                           c("v38","v47","v50"),c("v129","v50","v56"),c("v24","v40"
                           c("v10","v12","v14"),c("v24","v50","v66"),c("v31","v50",
                           c("v12","v24","v47"),c("v12","v38","v50"),c("v12","v50",
                           c("v14","v21","v40"),c("v10","v21","v66"),c("v10","v40",
                           c("v21","v50","v66"),c("v113","v40","v50"),c("v114","v14
                           c("v14","v34","v50"),c("v34","v56","v66"),c("v34","v47",
                           c("v114","v40","v66"),c("v125","v34","v40"),c("v30","v40
                           c("v114","v47","v66"),c("v10","v14","v40"),c("v45","v50"
                           c("v31","v56","v66"),c("v12","v34","v66"),c("v113","v114
                           c("v12","v40","v66"),c("v34","v51","v66"),c("v10","v113"
                           c("v50","v56","v80"),c("v50","v66","v97"),c("v10","v47",
                           c("v129","v31","v50"),c("v114","v56","v66"),c("v50","v66
                           c("v113","v129","v66"),c("v10","v114","v50"),c("v28","v5
                           c("v10","v50","v56"),c("v10","v40","v50"),c("v113","v47"
```

```
c("v114","v14","v47"),c("v14","v47","v50"),c("v40","v66"
c("v10","v21","v50"),c("v50","v66","v93"),c("v14","v21",
c("v50","v56","v68"),c("v129","v56","v66"),c("v12","v14"
c("v10","v114","v12"),c("v34","v50","v66"),c("v100","v11
c("v113","v50","v72"),c("v10","v14","v56"),c("v24","v34"
c("v12","v24","v66"),c("v10","v12","v50"),c("v14","v56",
c("v21","v50","v74"),c("v129","v14","v66"),c("v113","v11
c("v30","v47","v66"),c("v30","v40","v66"),c("v47","v56",
c("v45","v56","v66"),c("v21","v24","v66"),c("v12","v14",
c("v24","v50","v72"),c("v10","v12","v21"),c("v24","v56",
c("v100","v47","v50"),c("v50","v66","v74"),c("v113","v12
c("v14","v50","v99"),c("v12","v21","v66"),c("v10","v31",
c("v14","v50","v56"),c("v40","v66","v7"),c("v30","v34","
c("v50","v66","v7"),c("v38","v50","v66"),c("v10","v113",
c("v34","v50","v56"),c("v114","v12","v40"),c("v114","v47
c("v24","v47","v56"),c("v34","v47","v66"),c("v10","v113"
c("v114","v14","v50"),c("v114","v24","v47"),c("v113","v2
c("v50","v62","v66"),c("v114","v12","v56"),c("v24","v31"
c("v31","v47","v50"),c("v34","v66","v71"),c("v129","v24"
c("v10","v114","v47"),c("v10","v56","v66"),c("v113","v14
c("v10","v21","v56"),c("v21","v40","v66"),c("v125","v50"
c("v10","v14","v21"),c("v40","v66","v72"),c("v40","v50",
c("v38","v47","v66"),c("v24","v31","v50"),c("v14","v47",
c("v129","v24","v56"),c("v21","v56","v85"),c("v129","v40
c("v31","v40","v50"),c("v10","v47","v66"),c("v113","v40"
c("v113","v47","v66"),c("v10","v12","v40"),c("v14","v40"
c("v113","v40","v56"),c("v10","v50","v52"),c("v30","v34"
c("v34","v47","v56"),c("v114","v24","v50"),c("v24","v45"
c("v21","v56","v66"),c("v40","v47","v66"),c("v10","v12",
c("v10","v12","v47"),c("v24","v30","v47"),c("v10","v12",
c("v114","v47","v56"),c("v34","v40","v50"),c("v113","v24
c("v114","v34","v47"),c("v114","v40","v50"),c("v114","v3
c("v100","v24","v47"),c("v21","v50","v56"),c("v24","v31"
c("v113","v12","v14"),c("v14","v40","v50"),c("v24","v34"
c("v14","v34","v47"),c("v10","v24","v66"),c("v114","v31"
c("v10","v12","v34"),c("v113","v24","v34"),c("v113","v40
c("v39","v50","v66"),c("v24","v47","v66"),c("v113","v14"
c("v21","v40","v50"),c("v24","v47","v50"),c("v100","v50"
c("v129","v50","v66"),c("v12","v56","v66"),c("v113","v12
c("v113","v114","v47"),c("v113","v24","v50"),c("v113","v
c("v1","v50","v56"),c("v24","v34","v66"),c("v24","v34","
c("v31","v45","v56"),c("v114","v24","v66"),c("v113","v31
c("v10","v34","v50"),c("v21","v40","v47"),c("v40","v56",
c("v113","v34","v50"),c("v113","v34","v66"),c("v113","v5
c("v50","v56","v66"),c("v40","v47","v56"),c("v31","v50",
c("v24","v31","v47"),c("v24","v38","v50"),c("v113","v24"
c("v113","v34","v47"),c("v14","v24","v50"),c("v12","v14"
c("v10","v14","v66"),c("v31","v40","v66"))
```

And, finally, quadruples

```
In [14]: comb4List <- list(c("v100","v40","v50","v66"),c("v34","v40","v47","v66"),c
                           c("v31","v40","v50","v66"),c("v31","v47","v56","v66"),c
                           c("v31","v47","v50","v56"),c("v24","v50","v66","v72"),c
                           c("v40","v50","v56","v66"),c("v113","v31","v50","v56"),c
                           c("v113","v12","v24","v66"),c("v24","v34","v50","v66"),c
                           c("v114","v14","v50","v66"),c("v30","v40","v47","v66"),c
                           c("v12","v47","v50","v66"),c("v129","v40","v50","v56"),c
                           c("v113","v40","v50","v66"),c("v10","v31","v56","v66"),c
                           c("v10","v40","v50","v66"),c("v113","v31","v50","v66"),c
                           c("v113","v34","v50","v66"),c("v12","v24","v47","v66"),c
                           c("v31","v47","v50","v66"),c("v114","v24","v50","v66"),c
                           c("v113","v12","v14","v66"),c("v24","v40","v50","v66"),c
                           c("v14","v24","v47","v66"),c("v21","v47","v50","v66"),c
                           c("v10","v114","v50","v66"),c("v34","v47","v50","v66"),c
                           c("v113","v50","v56","v66"),c("v12","v14","v47","v66"),c
                           c("v14","v40","v50","v66"),c("v21","v24","v47","v50"),c
                           c("v113","v21","v50","v66"),c("v30","v34","v50","v66"),c
                           c("v113","v114","v50","v66"),c("v129","v50","v56","v68")
                           c("v113","v14","v24","v66"),c("v24","v40","v47","v50"),c
                           c("v3","v40","v50","v66"),c("v14","v38","v50","v66"),c('
                           c("v114","v24","v47","v50"),c("v12","v31","v47","v66"),c
                           c("v24","v30","v34","v47"),c("v114","v40","v50","v66"),c
                           c("v24","v31","v56","v66"),c("v40","v50","v60","v66"),c
                           c("v31","v50","v56","v68"),c("v129","v24","v50","v66"),c
                           c("v113","v34","v47","v66"),c("v24","v40","v47","v66"),c
                           c("v12","v50","v56","v66"),c("v10","v113","v31","v66"),c
                           c("v113","v24","v47","v66"),c("v10","v113","v40","v66"),
                           c("v113","v24","v40","v66"),c("v47","v50","v66","v72"),c
                           c("v30","v50","v56","v66"),c("v34","v50","v56","v66"),c
                           c("v12","v24","v40","v66"),c("v113","v40","v47","v66"),c
                           c("v24","v30","v40","v47"),c("v31","v45","v56","v66"),c
                           c("v114","v24","v47","v66"),c("v21","v34","v50","v66"),c
                           c("v114","v34","v47","v50"),c("v10","v31","v47","v66"),c
                           c("v10","v100","v47","v66"),c("v10","v40","v47","v66"),c
                           c("v40","v47","v50","v66"),c("v40","v47","v56","v66"),c
                           c("v38","v50","v66","v78"),c("v113","v114","v24","v66"),
                           c("v14","v47","v50","v66"),c("v10","v113","v47","v66"),c
                           c("v12","v24","v47","v56"),c("v129","v47","v50","v66"),c
                           c("v14","v47","v56","v66"),c("v24","v34","v40","v47"))
```

Done with preliminary preparations, let's load dataset.

```
In [15]: t1 <- fread("train.csv")
         s1 <- fread("test.csv")
```

If row_sampling is above zero, run subsampling, to get smaller dataset.

```
In [16]: if (row_sampling>0){
           if (row_sampling==5000 & file.exists("./data_trans/train_sample.csv") &
               cat("reading samples from file")
               train_sample <- fread("./data_trans/train_sample.csv")
               test_sample <- fread("./data_trans/test_sample.csv")
             } else {
             cat("no sampling files exist or default row_sampling changed, creating
             set.seed(102)
             train_sample <- data.table(sample=sample(t1$ID, size = row_sampling, r
             write.csv(train_sample, "./data_trans/train_sample.csv", row.names=FAL
             set.seed(103)
             test_sample <- data.table(sample=sample(s1$ID, size = row_sampling, re
             write.csv(test_sample, "./data_trans/test_sample.csv", row.names=FALSE
           } # end row_sampling==5000 if

           t1 <- t1[ID %in% train_sample$sample]
           s1 <- s1[ID %in% test_sample$sample]
         } # end row_sampling > 0 if
```

```
reading samples from file
```

Import cvFoldsList for consistency if row_sampling is the default (5000), else create new folds

```
In [17]: if (row_sampling==5000 & file.exists("./data_trans/cvFoldsList.rda")){
             cat("loading cvFoldsList from file for consistency")
             load("./data_trans/cvFoldsList.rda")
           } else{
             cat("row_sampling changed from default(5000) or no cvFoldsList file ex
             set.seed(2016)
             cvFoldsList <- createFolds(t1$ID, k=5, list=TRUE) # Need to overwrite
             save(cvFoldsList, file="./data_trans/cvFoldsList.rda")
           }
```

```
loading cvFoldsList from file for consistency
```

```
In [18]: # Add target to test set for binding
         s1 <- s1[,target:=-1]
         # Combine into 1 data frame
         l <- list(t1, s1)
         ts1 <- data.table(do.call(smartbind,l))
         # Add pred0, dummy, and filter columns for mean encoding interaction featu
         ts1 <- cbind(pred0=mean(t1$target), dummy="A", filter=c(rep(0, nrow(t1)),
```

BASELINE GBM Getting a baseline score is one of the first things you should do.
This allows us to check if features we engineer are usefull to the model
We can also get feature importance from h2o.gbm or xgboost

```
In [19]: excludeCols <- c("ID","target","filter","dummy","pred0")
         varCols <- setdiff(colnames(ts1), excludeCols)
```

```
        # All numerics are greater than 0 so we can set NAs as 1
        ts1[is.na(ts1)] <- -1
        # Need to convert categoricals to numeric -- will encode them as numeric i
        factorCols <- colnames(ts1)[sapply(ts1, is.character)]
        for (col in factorCols){
          set(ts1, j=col, value=as.numeric(as.factor(ts1[[col]])))
        }

        varnames <- setdiff(colnames(ts1), excludeCols)
        dtrain <- xgb.DMatrix(data=data.matrix(ts1[filter==0,varnames,with=F]), la

        param <- list(objective="binary:logistic",
                      eval_metric="logloss",
                      eta = .01,
                      max_depth=7,
                      min_child_weight=1,
                      subsample=.8,
                      colsample_bytree=.4,
                      nthread=6
        )

        set.seed(201512)
        (tme <- Sys.time())
        xgbBaselineCV <- xgb.cv(data = dtrain,
                                params = param,
                                nrounds = 8000,
                                folds=cvFoldsList,
                                maximize=FALSE,
                                prediction=TRUE,
                                print.every.n = 50,
                                early.stop.round=200)
        Sys.time() - tme
        save(xgbBaselineCV, file = "./stack_models/xgbBaselineCV.rda")
        print(paste("Best result: ",min(xgbBaselineCV$dt$test.logloss.mean)))
        # subsampling 5,000 rows from train set -- best logloss -- 0.4892
        # entire train set -- best logloss -- 0.4629
```

```
[1] "2016-10-26 13:46:12 CDT"
```

```
[0]         train-logloss:0.689058+0.000351         test-logloss:0.689733+0.000231
[50]         train-logloss:0.544969+0.001871         test-logloss:0.579315+0.002522
[100]         train-logloss:0.465438+0.002351         test-logloss:0.530059+0.003168
[150]         train-logloss:0.414566+0.003111         test-logloss:0.507237+0.004212
[200]         train-logloss:0.378221+0.003462         test-logloss:0.496596+0.004713
[250]         train-logloss:0.350072+0.003154         test-logloss:0.491636+0.005407
[300]         train-logloss:0.327372+0.002453         test-logloss:0.489725+0.006184
[350]         train-logloss:0.308620+0.002720         test-logloss:0.489346+0.006856
```

```
[400]        train-logloss:0.292960+0.003091        test-logloss:0.489704+0.007689
[450]        train-logloss:0.278941+0.003025        test-logloss:0.490008+0.008363
[500]        train-logloss:0.266167+0.003272        test-logloss:0.491014+0.008837
Stopping. Best iteration: 341

Time difference of 50.34584 secs


[1] "Best result:  0.489201"
```

Create baseline model for important features and XGBFI

```
In [20]: set.seed(201512)
         (tme <- Sys.time())
         xgbBaseline <- xgb.train(data = dtrain,
                                  params = param,
                                  nrounds = which.min(xgbBaselineCV$dt$test.logloss
         Sys.time() - tme
         xgbImp <- xgb.importance(feature_names = varnames, model = xgbBaseline)
         head(xgbImp,25)

[1] "2016-10-26 13:48:29 CDT"


Time difference of 7.407129 secs
```

Feature	Gain	Cover	Frequence
v50	0.117167577	0.120305006	0.044074221
v12	0.044451488	0.056153723	0.039093834
v114	0.029929192	0.028013838	0.028868615
v66	0.028757162	0.045603756	0.011767817
v10	0.026851617	0.038425984	0.020097845
v47	0.026585171	0.036603018	0.008462250
v14	0.025658339	0.026566495	0.029926396
v22	0.023894063	0.017108043	0.031028252
v40	0.023561622	0.024795441	0.026180087
v21	0.021804640	0.024354655	0.024328970
v56	0.018571800	0.024154458	0.020053771
v34	0.018145558	0.016515899	0.023623782
v110	0.013314397	0.018523739	0.004010754
v125	0.012956662	0.009227555	0.018863767
v113	0.012553775	0.014438453	0.013266341
v9	0.010884954	0.010530343	0.012208559
v122	0.009962278	0.014996519	0.010842258
v112	0.009367368	0.009347463	0.011988188
v82	0.008978639	0.010188860	0.010533739
v79	0.008398520	0.012415824	0.006919653
v90	0.008162666	0.009714368	0.009123364
v120	0.007906788	0.006661340	0.009123364
v1	0.007846859	0.007944344	0.009960774
v45	0.007626105	0.004826787	0.008506325
v31	0.007513029	0.016695951	0.002600379

XGBFI – https://github.com/Far0n/xgbfi XGBFI is a tool for extracting feature importance and interactions from XGBoost models

This can be helpful for feature engineering

Requires Mono to run – http://www.mono-project.com/download/

```
In [21]: create_feature_map <- function(fmap_filename, features){
           for (i in 1:length(features)){
             cat(paste(c(i-1,features[i],"q"), collapse = "\t"), file=fmap_filename
           }
         }

         # Need to create a feature mapping and then dump the XGBoost model
         if(!file.exists("./data_trans/xgbBaseline_fmap.txt")){ #Create fmap if it
           create_feature_map("./data_trans/xgbBaseline_fmap.txt", varnames)
         }

         dump_result <- xgb.dump(
             model=xgbBaseline,
             fname="./data_trans/xgbBaseline_dump",
             fmap="./data_trans/xgbBaseline_fmap.txt",
```

```
            with.stats = TRUE)
        if(dump_result) {print("Dump succesfully created")}
```

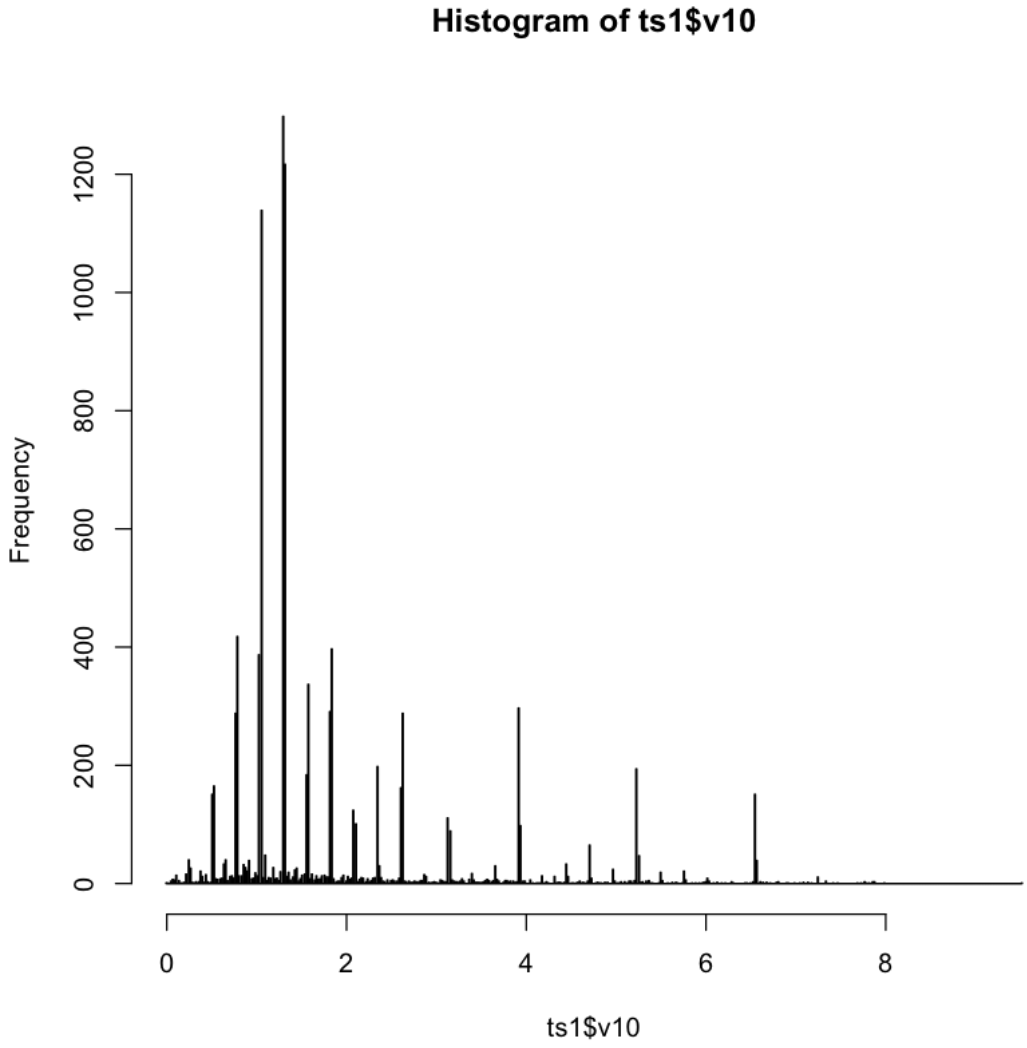
```
[1] "Dump succesfully created"
```

After this you will need to run Xgbfi from the command line (see the GitHub Readme). To save time the output is included in.

```
In [22]: # Recreate ts1 to undo feature engineering done for baseline
         ts1 <- data.table(do.call(smartbind,l))
         # Add pred0, dummy, and filter columns for mean encoding interaction featu
         ts1 <- cbind(pred0=mean(t1$target), dummy="A", filter=c(rep(0, nrow(t1)),
```

```
In [23]: # v91 and v107 are the same -- just different labels -- so remove v107
         set(ts1, j="v107", value=NULL)
```

```
In [24]: # v10 -- round v10 -- convert to categorical later
         hist(ts1$v10, breaks = 1000) # Frequency spikes at pretty even intervals,
         set(ts1, j="v10", value=round(ts1[,v10]/0.0218818357511,0)) # posted by ra
```




```
In [25]: excludeCols <- c("ID","target","filter","dummy","pred0")
         varCols <- setdiff(colnames(ts1), excludeCols)
```

Create missingness table If you look at the data you will see that rows have similar missingness patterns so we can create a feature that groups together rows with similar missingness patterns. This will better help the GBM split the data.

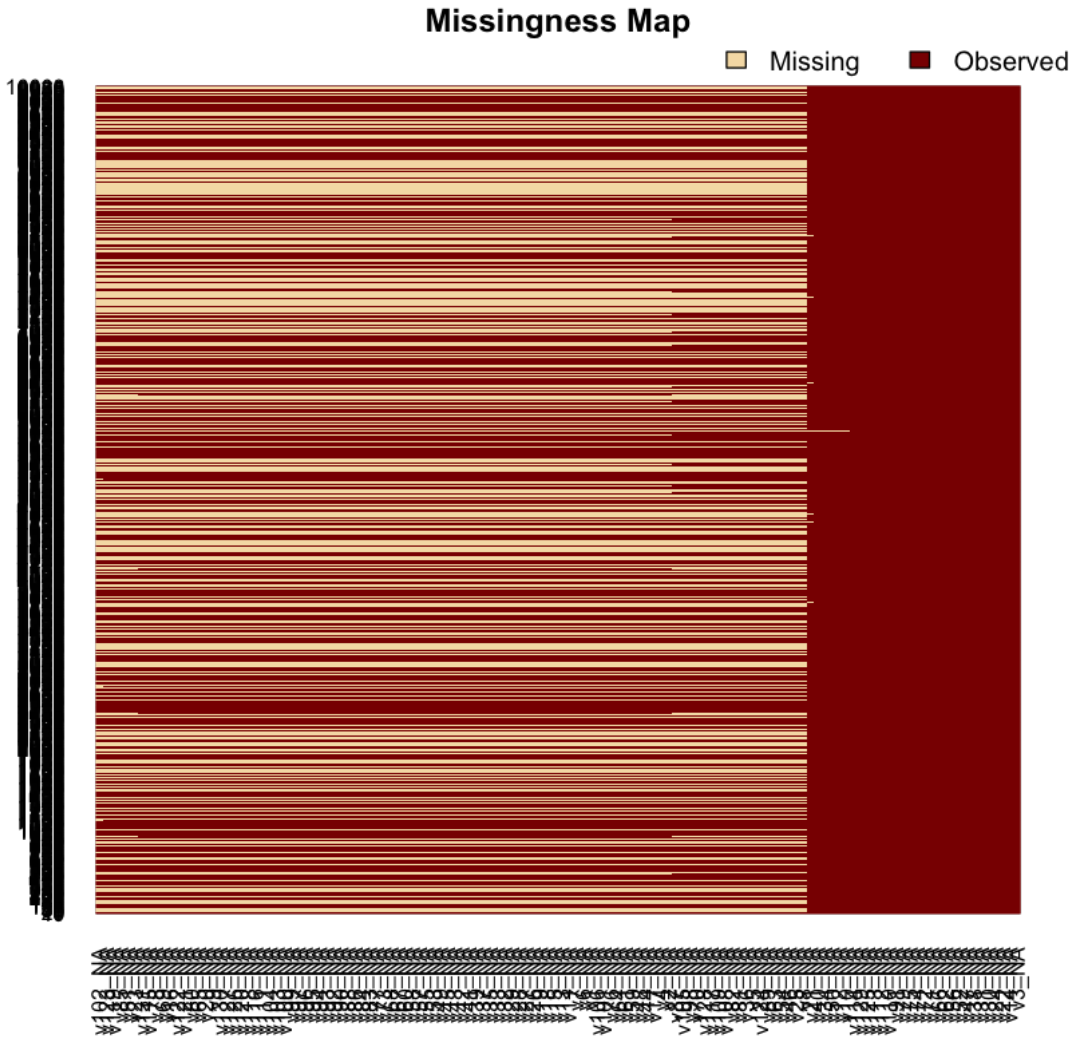
```
In [26]: charCols <- which(sapply(ts1[,-excludeCols,with=FALSE], is.character))
         ts1_miss <- copy(ts1[,-excludeCols,with=FALSE])
         for (col in charCols){
           set(ts1_miss, j=col, value=as.numeric(as.factor(ts1_miss[[col]])))
         }
         ts1_miss[!is.na(ts1_miss)] <- 0
```

```
        ts1_miss[is.na(ts1_miss)] <- 1
        colnames(ts1_miss) <- paste0(colnames(ts1_miss),"_NA")
```

```
In [ ]: #### Plot a missingness map
```

```
In [27]: ts1_miss[ts1_miss==1] <- NA #convert 1's to NAs for missingness map plot
         missmap(ts1_miss)
         ts1_miss[is.na(ts1_miss)] <- 1 #convert NAs back to 1
```

```
Warning message in if (class(obj) == "amelia") {:
"the condition has length > 1 and only the first element will be used"
```



K-Means Cluster on missingness This will allow us to create a few distinct groups based on missingness

```
In [28]: set.seed(104)
         ts1_kmeans7 <- kmeans(ts1_miss, centers=7, iter.max=50, nstart=5)
         km_y_summ7 <- data.table(target=ts1$target, cluster=ts1_kmeans7$cluster, f
         km7 <- km_y_summ7[filter==0][,list(meanTarget=mean(target)), keyby=cluster
         km_y_summ7 <- merge(km_y_summ7, km7, by="cluster")
         ts1$km7 <- as.factor(make.names(km_y_summ7$cluster))
```

ROW SUMMARY VARIABLES These find the max, min, mean, etc. values of the numeric columns for each row. Also count the number of NAs and 0's.

```
In [29]: # Identify the numeric columns
         numCols <- names(which(sapply(ts1[,varCols,with=FALSE], is.numeric)))
         ## Add row summary variables
         ts1$rowMax <- apply(ts1[, numCols, with=FALSE], 1, max)
         ts1$rowMin <- apply(ts1[, numCols, with=FALSE], 1, min)
         ts1$rowMean <- apply(ts1[, numCols, with=FALSE], 1, mean)
         ts1$rowMed <- apply(ts1[, numCols, with=FALSE], 1, median)
         ts1$rowSD <- apply(ts1[, numCols, with=FALSE], 1, sd)
         ## Count NAs by row
         ts1$cntNA <- rowSums(is.na(ts1[, varCols, with=FALSE]))
         ts1$cntZero <- rowSums(ts1[, varCols, with=FALSE] == 0, na.rm=TRUE)
         ## Round numeric values -- This can sometimes help when a measurement is t
         for (col in numCols){
             set(ts1, j=col, value=round(ts1[[col]], 4))
         }
         #head(ts1[,(numCols) := round(.SD,4), .SDcols=numCols],25)
         ## Give blank factor levels a name -- just personal preference
         charCols <- colnames(ts1)[sapply(ts1, is.character)]
         for (col in 1:length(charCols)){
           set(ts1, i=which(is.na(ts1[[charCols[col]]])), j=charCols[col], value="N
         }
```

Convert character columns to factor

```
In [30]: ## This will be used later when we dummy code variables
         ts1 <- ts1[,(charCols):=lapply(.SD, as.factor),.SDcols=charCols]

         ## These variables have relatively few unique values compared to the other
         ## Converting these variables to factors ended up helping the model
         ts1$v10 <- as.factor(make.names(ts1$v10)) # 323 unique values
         ts1$v38 <- as.factor(make.names(ts1$v38)) # 11 unique values
         ts1$v62 <- as.factor(make.names(ts1$v62)) # 8 unique values
         ts1$v72 <- as.factor(make.names(ts1$v72)) # 13 unique values
         ts1$v129 <- as.factor(make.names(ts1$v129)) # 10 unique values
```

NAs and zero-variance features

```
In [31]: # Converting NAs to -1. Numerics are greater than 0 so -1 is out of range.
         ts1[is.na(ts1)] <- -1

         # Get rid of zero variance variables if there are any
         pp <- preProcess(ts1[filter==0, -excludeCols, with=FALSE], method="zv")
         ts1 <- predict(pp, ts1)
```

INTERACTION COUNTS AND MEAN ENCODING See: http://helios.mm.di.uoa.gr/~rouvas/ssi/sigkdd/

The idea is the encode categoricals (usual those with high cardinality) or interactions by the mean of their response. However, instead of encoding as their mean, we encode them in a Bayesian manner, using the overall average response as the prior and the mean response of each categorical value as the posterior. A weighted average of the prior and the posterior is used to encode the categorical variable (or interactions). The weight is based on the frequency of the categorical value (or the frequency of the interaction). I.e. if a category only appears a handful of times then it will be encoded as the overall mean response of the training set, if a category occurs very frequently then most the weight will be placed on the posterior average.

Numeric interactions

```
In [32]: pairs <- combn(c("v35","v21","v12","v50","v14","v40","v114","v34"), 2, sim
         cl <- makeCluster(threads)
         registerDoParallel(cl)
         set.seed(119)
         out <- foreach(i=1:length(pairs), .combine='comb', .multicombine=TRUE,
                        .init=list(list(), list()), .packages=c("data.table")) %dor
                          name <- paste0(pairs[[i]][1], "_", pairs[[i]][2], "_int2"
                          tmp <- ts1[,pairs[[i]][1], with=FALSE] / (ts1[,pairs[[i]]
                          if (var(tmp[ts1$filter==0]) != 0) # exclude columns with
                            list(tmp, name)
                        }
         stopCluster(cl)
         pairInts <- as.data.frame(out[[1]])
         colnames(pairInts) <- unlist(out[[2]])

         ts1 <- cbind(ts1, pairInts)
         rm(pairInts); x <- gc() #suppress verbose output
```

Factor 2-way interaction counts & means

```
In [33]: factCols <- colnames(ts1[,-excludeCols,with=FALSE])[sapply(ts1[,-excludeCo
         pairs <- combn(factCols, 2, simplify=FALSE)

         cl <- makeCluster(threads)
         registerDoParallel(cl)
         set.seed(120)
         out <- foreach(i=1:length(pairs), .combine='comb', .multicombine=TRUE,
                        .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                          name <- paste0(pairs[[i]][1], "_", pairs[[i]][2], "_cnt2"
```

```
                    tmp <- my.f2cnt(ts1, pairs[[i]][1], pairs[[i]][2])
                    if (var(tmp[ts1$filter==0]) != 0) # exclude columns with
                      list(tmp, name)
                  }
stopCluster(cl)
pairCnts <- as.data.frame(out[[1]])
colnames(pairCnts) <- unlist(out[[2]])

ts1 <- cbind(ts1, pairCnts)
rm(pairCnts); x <- gc() #suppress verbose output

# 2-way averages
cl <- makeCluster(threads)
registerDoParallel(cl)
set.seed(121)
out <- foreach(i=1:length(pairs), .combine='comb', .multicombine=TRUE,
               .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                 name <- paste0(paste0(pairs[[i]],collapse="_"), "_targetM
                 tmp <- catNWayAvgCV(data = ts1, pairs[[i]],
                                     y = "target",pred0 = "pred0",
                                     filter = ts1$filter==0, k = 20, f = 1
                 tmp <- logit(pmin(pmax(tmp, 1e-15), 1-1e-15))
                 list(tmp, name)
               }
stopCluster(cl)
pairMeans <- as.data.frame(out[[1]])
colnames(pairMeans) <- unlist(out[[2]])


ts1 <- cbind(ts1, pairMeans)
rm(pairMeans); x <- gc() #suppress verbose output
```

Add 3-way interaction counts & means

```
In [34]: triplets <- combn(c("v3","v10","v22","v24","v30","v38",
                            "v47","v52", "v56", "v62","v66","v72",
                            "v74","v75","v79", "v91","v110","v112","v113","v125","
cl <- makeCluster(threads)
registerDoParallel(cl)
set.seed(122)
out <- foreach(i=1:length(triplets), .combine='comb', .multicombine=TRUE,
               .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                 name <- paste0(triplets[[i]][1], "_", triplets[[i]][2],"_
                 tmp <- my.f3cnt(ts1, triplets[[i]][1], triplets[[i]][2],
                 if (var(tmp[ts1$filter==0]) != 0)  # exclude columns with
                   list(tmp, name)
                 }
stopCluster(cl)
```

```
tripCnts <- as.data.frame(out[[1]])
colnames(tripCnts) <- unlist(out[[2]])

ts1 <- cbind(ts1, tripCnts)
rm(tripCnts); x <- gc() #suppress verbose output

# add v22 to comb2List
comb2List_v22 <- lapply(comb2List, function(x) c(x,"v22"))
triplets <- c(triplets, comb2List_v22)
# sort vectors and remove duplicates
triplets <- unique(lapply(triplets, function(x) sort(x)))

# triplets <- combn(factCols, 3, simplify=FALSE)
cl <- makeCluster(threads)
registerDoParallel(cl)
set.seed(123)
out <- foreach(i=1:length(triplets), .combine='comb', .multicombine=TRUE,
               .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                 name <- paste0(paste0(triplets[[i]],collapse="_"), "_targ
                 tmp <- catNWayAvgCV(data = ts1, triplets[[i]], y = "targe
                 tmp <- logit(pmin(pmax(tmp, 1e-15), 1-1e-15))
                 list(tmp, name)
               }
stopCluster(cl)
tripMeans <- as.data.frame(out[[1]])
colnames(tripMeans) <- unlist(out[[2]])

ts1 <- cbind(ts1, tripMeans)
rm(tripMeans); x <- gc() #suppress verbose output
```

Add 4-way interaction means

```
In [35]: quads <- lapply(comb3List, function(x) c(x,"v22"))
         cl <- makeCluster(threads)
         registerDoParallel(cl)
         set.seed(127)
         out <- foreach(i=1:length(quads), .combine='comb', .multicombine=TRUE,
                        .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                          name <- paste0(paste0(quads[[i]],collapse="_"), "_targetM
                          tmp <- catNWayAvgCV(data = ts1, quads[[i]],
                                              y = "target",pred0 = "pred0",filter =
                                              k = 20, f = 10, r_k = 0.04, cv=cvFold
                          tmp <- logit(pmin(pmax(tmp, 1e-15), 1-1e-15))
                          list(tmp, name)
                        }
         stopCluster(cl)
         quadMeans <- as.data.frame(out[[1]])
         colnames(quadMeans) <- unlist(out[[2]])
```

```
ts1 <- cbind(ts1, quadMeans)
rm(quadMeans); x <- gc() #suppress verbose output
```

Add 5-way interaction means

```
In [36]: quints <- lapply(comb4List, function(x) c(x,"v22"))
cl <- makeCluster(threads)
registerDoParallel(cl)
set.seed(131)
out <- foreach(i=1:length(quints), .combine='comb', .multicombine=TRUE,
                .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                  name <- paste0(paste0(quints[[i]],collapse="_"), "_target
                  tmp <- catNWayAvgCV(data = ts1, quints[[i]], y = "target'
                  tmp <- logit(pmin(pmax(tmp, 1e-15), 1-1e-15))
                  list(tmp, name)
                }
stopCluster(cl)
quintMeans <- as.data.frame(out[[1]])
colnames(quintMeans) <- unlist(out[[2]])

ts1 <- cbind(ts1, quintMeans)
rm(quintMeans); x <- gc() #suppress verbose output
```

Add 7-way interaction means

```
In [37]: septups <- combn(c("v22","v10","v24","v47","v52",
                           "v56", "v66","v72", "v74", "v79","v110",
                           "v113","v125","v129"), 7, simplify=FALSE)
cl <- makeCluster(threads)
registerDoParallel(cl)
set.seed(135)
out <- foreach(i=1:length(septups), .combine='comb', .multicombine=TRUE,
                .init=list(list(), list()), .packages=c("sqldf", "data.tabl
                  name <- paste0(paste0(septups[[i]],collapse="_"), "_targe
                  tmp <- catNWayAvgCV(data = ts1, septups[[i]], y = "target
                                      pred0 = "pred0",filter = ts1$filter==
                                      k = 20, f = 10, r_k = 0.04, cv=cvFold
                  tmp <- logit(pmin(pmax(tmp, 1e-15), 1-1e-15))
                  list(tmp, name)
                }
stopCluster(cl)
septupsMeans <- as.data.frame(out[[1]])
colnames(septupsMeans) <- unlist(out[[2]])

ts1 <- cbind(ts1, septupsMeans)
rm(septupsMeans); x <- gc() #suppress verbose output
```

PAIRWISE CORRELATIONS (GOLDEN FEATURES) – code & idea from Tian Zhou - teammate in Homesite competition

The idea of this next section is to identify highly correlated variables and then create a new feature for each pair which is the difference between them. This results in new features which is basically an indiator of when two columns differ.

Next cell can be skipped for sake of time saving

In [38]:
```
numCols <- colnames(ts1[,-excludeCols,with=FALSE])[sapply(ts1[,-excludeCol
featCor <- cor(ts1[,numCols,with=FALSE])
hc <- findCorrelation(featCor, cutoff=0.997 ,names=TRUE)  # find highly co
hc <- sort(hc)
write.csv(hc, "./data_trans/hc.csv", row.names=F)
save(featCor, file="./data_trans/featCor_v31.rda")

featCorDF <- abs(featCor[!rownames(featCor) %in% hc, !colnames(featCor) %i
featCorDF[upper.tri(featCorDF, diag=TRUE)] <- NA
featCorDF <- melt(featCorDF, varnames = c('V1','V2'), na.rm=TRUE)
featCorDF <- featCorDF[order(featCorDF$value, decreasing=TRUE),]


goldFeats <- 300
feat_gold <- gold_features(featCorDF, goldFeats)
write.csv(as.character(featCorDF$V2[1:goldFeats]), file = "./data_trans/go

# Do not parallelize -- too much memory for some reason
cl <- makeCluster(1)
registerDoParallel(cl)
set.seed(136)
out <- foreach(i=1:length(feat_gold), .combine='comb', .multicombine=TRUE,
               .init=list(list(), list()), .packages=c("data.table")) %dor
                 name <- paste0(feat_gold[[i]][[1]],"_",feat_gold[[i]][[2]
                 tmp <- ts1[,as.character(feat_gold[[i]][[1]]), with=FALSE
                 list(tmp, name)
               }
stopCluster(cl)
goldMeans <- as.data.frame(out[[1]])
colnames(goldMeans) <- unlist(out[[2]])
write.csv(goldMeans, "./data_trans/goldMeans.csv")
```

In [39]:
```
## Since featCor takes awhile to calculate, we'll import a previously run
goldMeans <- fread("./data_trans/goldMeans.csv")
ts1 <- cbind(ts1, goldMeans)
rm(goldMeans)
x <- gc() #suppress verbose output

goldFeats <- 100
feat_gold <- gold_featuresUnCor(featCorDF, goldFeats)
```

```
# Do not parallelize -- too much memory for some reason
cl <- makeCluster(1)
registerDoParallel(cl)
set.seed(136)
out <- foreach(i=1:length(feat_gold), .combine='comb', .multicombine=TRUE,
               .init=list(list(), list()), .packages=c("data.table")) %do
                 name <- paste0(feat_gold[[i]][[1]],"_",feat_gold[[i]][[2]
                 tmp <- ts1[,as.character(feat_gold[[i]][[1]]), with=FALSE
                 list(tmp, name)
               }
stopCluster(cl)
goldAdds <- as.data.frame(out[[1]])
colnames(goldAdds) <- unlist(out[[2]])
write.csv(goldAdds, "./data_trans/goldAdds.csv")

## Since featCor takes awhile to calculate, we'll import a previously run
goldAdds <- fread("./data_trans/goldAdds.csv")
ts1 <- cbind(ts1, goldAdds)
rm(goldAdds)
x <- gc() #suppress verbose output

hc <- fread("./data_trans/hc.csv")
goldFeatNames <- fread("./data_trans/goldFeatNames.csv")
if (length(c(hc$x,goldFeatNames$x)>0))
  ts1 <- ts1[,-c(hc$x,goldFeatNames$x),with=FALSE]
#####################################################
```

HELPER COLUMNS The idea is to identify columns for each class that will help differentiate that class from the other classes These columns are then added together to create a new feature that will hopefully improve the model Only numeric columns can be used (can convert categoricals to dummy or mean encodings) Numeric columns need to be centered and scaled before choosing features.

In [40]:
```
# Scale variables so a few don't overpower the helper columns
pp <- preProcess(ts1[filter==0,-excludeCols,with=FALSE], method=c("zv","ce
ts1 <- predict(pp, ts1)

# summ <- as.data.frame(ts1[ts1$filter==0, colnames(ts1) %in% c("target",n
#                           summarise_each(funs(mean)))
cols <- c("target",numCols)
summ <- ts1[filter==0, colnames(ts1) %in% cols, with=FALSE][,lapply(.SD, m

# Find means and sd's for columns
mn1 <- sapply(summ[,2:ncol(summ),with=F], mean)
sd1 <- sapply(summ[,2:ncol(summ),with=F], sd)
# Find upper and lower thresholds
hi <- mn1+2*sd1
lo <- mn1-2*sd1
```

```
helpCols <- list()
for (i in 0:1){
  tmpHi <- (summ[summ$target==i,2:ncol(summ),with=F] - mn1)/sd1
  hiNames <- colnames(tmpHi[,order(tmpHi),with=F][,1:30,with=F])
  loNames <- colnames(tmpHi[,order(tmpHi,decreasing = TRUE), with=F][,1:30

  helpCols[[i+1]] <- c(hiNames, loNames)

}
names(helpCols) <- paste0("X", seq_along(helpCols)-1)

for (i in 0:1){
  ts1[[ncol(ts1)+1]] <- rowSums(ts1[,helpCols[[i+1]], with=FALSE])
  colnames(ts1)[ncol(ts1)] <- paste0("X", i, "_helper")}
```

Create summary variables for high-dimensional factors

In [41]:
```
factorCols <- colnames(ts1)[sapply(ts1, is.factor)]
highCardFacts <- colnames(ts1[,factorCols,with=FALSE])[sapply(ts1[,factorC

for(ii in highCardFacts) {
  print(ii)
  x <- data.frame(x1=ts1[, ii,with=FALSE])
  x[,ii] <- as.numeric(x[,ii])
  ts1[, paste(ii, "_num", sep="")] <- x
}


for(ii in highCardFacts) {
  print(ii)
  x <- data.table(x1=ts1[, ii,with=FALSE])
  colnames(x) <- "x1"
  x$x1 <- as.numeric(x$x1)
  sum1 <- x[, list(cnt=.N), by=x1]
  tmp <- merge(x, sum1, by="x1", all.x=T)
  ts1[, paste(ii, "_cnt", sep="")] <- tmp$cnt
}

# Replace high cardinality factors with target mean
for(ii in highCardFacts) {
  name <- paste0(ii, "_targetMean")
  ts1[,name] <- catNWayAvgCV(data = ts1, c(ii, "dummy"), y = "target",prec
}

# Remove high cardinality factors now that we've encoded them
ts1 <- ts1[,!colnames(ts1) %in% highCardFacts,with=FALSE]
```

```
[1] "v10"
```

```
[1] "v22"
[1] "v56"
[1] "v113"
[1] "v125"
[1] "v10"
[1] "v22"
[1] "v56"
[1] "v113"
[1] "v125"
```

```
Warning message in alloc.col(x):
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```

Create dummy variables for low-dimensional factors

In [42]:
```
factorCols <- colnames(ts1[,-excludeCols,with=FALSE])[sapply(ts1[,-exclude
ts1_dum <- as.data.table(model.matrix(~ ., data=ts1[,factorCols,with=FALSE
# remove factor cols
ts1 <- ts1[,-factorCols, with=F]
ts1 <- cbind(ts1, ts1_dum)
```

Write CSV file

```
In [43]: ts1 <- ts1[order(ts1$filter, ts1$ID),]
         write.csv(ts1, "./data_trans/ts2Trans_v31.csv", row.names=FALSE)

In [44]: # Even with row sampling running the final model can take a bit of time
         # Load in a prerun model on the subsampled dataset
         load("./stack_models/xgb46cv.rda")

In [45]: min(xgb46cv$dt$test.logloss.mean)
```

0.463343

```
In [46]: # Model run on the entire training set -- takes a few hours to train
         # Load in a prerun model on the entire train set
         load("./stack_models/xgb46cv_fulldata.rda")

In [47]: min(xgb46cv$evaluation_log$test_logloss_mean) #different format because th
```

0.430885