A Logistic Regression Approach to CoIL Challenge 2000

Corey Arnouts, Adam Douglas, Jason Givens-Doyle, Michael Silva

# Abstract

A logistic regression based solution to the CoIL Challenge 2000 is described in this paper. The challenge consists of correctly identifying potential customers for an insurance product, and describing their characteristics. Models were trained on over sampled data. The model out preformed other’s attemps.

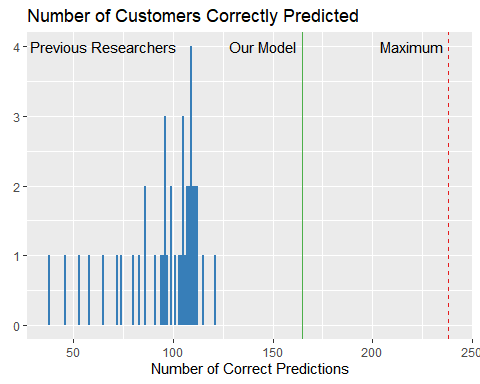
*Key words: CoIL Challenge, Logistic Regression*

# Introduction

Businesses use data science to extract insights from data. One pratical application is identifying households to include in a marketing campaign. In this paper we set out to identify potential customers for an insurance product using real world data from the Computational Intelligence and Learning (CoIL) Challenge.

# Literature Review

Fourty-three other research teams have attempted to identify potential caravan insurance customers (Putten, Ruiter, and Someren 2000). They used a variety of approaches including: Boosted Decision Tree (McKone and Stenger 2000), Classification and Regression Tree (CART) (Simmonds 2000), Classification Trees with Bagging (White and Liu 2000), C4.5 (Rickets 2000; Seewald 2000), Evolutionary Algorithm (Koudijs 2000), Fuzzy Classifier (János Abonyi 2000; Kaymak and Setnes 2000), Genetic Algorithms and Hill-climbers (Carter 2000), Inductive Learning by Logic Minimization (ILLM) (Gamberger 2000; Šmuc 2000), Instance Based Reasoning (iBARET) (Mikšovský and Klema 2000), K-Means (Vesanto and Sinkkonen 2000), KXEN (Bera and Lamy 2000), LOGIT (Doornik and Moyle 2000), Mask Perceptron with Boosting (Leckie and Ferra 2000), Midos Algorithm (Krogel 2000), N-Tuple Classifier (Jorgensen and Linneberg 2000), Naïve Bayes (Elkan 2000; Kontkanen 2000), Neural Networks(Brierley 2000; Crocoll 2000; Kim and Street 2000; Shtovba and Mashnitskiy 2000), Phase Intervals and Genetic Algorithms (Shtovba 2000), Scoring System (Lewandowski 2000), Support Vector Machines(Keerthi and Ong 2000), and XCS (Greenyer 2000).



The maximum number of potential policy owners that could be found is 238. Previous researchers identified 95 policy owners on average. The best preforming model (Elkan 2000) during the initial challenge identified 121 policy owners. A meta analysis found that simpler algorithms tended to outpreform more complicated ones (Putten, Ruiter, and Someren 2000).

# Methodology

## Experimentation and Results

## Discussion

# Conclusions

# Appendix

## Correlation Coefficients for Variables of Interest

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | CARAVAN | PPERSAUT | PBRAND | APERSAUT | LIKELY\_CUSTOMERS |
| **CARAVAN** | 1 | 0.3432 | 0.1762 | 0.3188 | 0.2507 |
| **PPERSAUT** | 0.3432 | 1 | 0.1889 | 0.8879 | 0.07748 |
| **PBRAND** | 0.1762 | 0.1889 | 1 | 0.2215 | 0.1657 |
| **APERSAUT** | 0.3188 | 0.8879 | 0.2215 | 1 | 0.06413 |
| **LIKELY\_CUSTOMERS** | 0.2507 | 0.07748 | 0.1657 | 0.06413 | 1 |

## Data Dictionary

|  |  |
| --- | --- |
| Name | Description |
| CARAVAN | Number of mobile home policy |
| PPERSAUT | Contribution car policies |
| PBRAND | Contribution fire policies |
| APERSAUT | Number of car policies |
| LIKELY\_CUSTOMERS | MOSTYPE = 12, 8, 6, 7, 1, 2, 36, 3, 37, 10, 20, 38, or 11 |

## Confusion Matrix and Statistics for our Model

Confusion Matrix and Statistics  
  
 Reference  
Prediction 0 1  
 0 2177 73  
 1 1585 165  
   
 Accuracy : 0.5855   
 95% CI : (0.5701, 0.6008)  
 No Information Rate : 0.9405   
 P-Value [Acc > NIR] : 1   
   
 Kappa : 0.0684   
   
 Mcnemar's Test P-Value : <2e-16   
   
 Sensitivity : 0.57868   
 Specificity : 0.69328   
 Pos Pred Value : 0.96756   
 Neg Pred Value : 0.09429   
 Prevalence : 0.94050   
 Detection Rate : 0.54425   
 Detection Prevalence : 0.56250   
 Balanced Accuracy : 0.63598   
   
 'Positive' Class : 0

## R statistical programming code.

# CoIL Challenge Source Code   
library(tidyverse)   
library(caret)   
   
## Download the data sets from UCI if they are not present   
url <- "https://archive.ics.uci.edu/ml/machine-learning-databases/tic-mld/"   
files <- c("ticdata2000.txt", "ticeval2000.txt", "tictgts2000.txt")   
for (file\_name in files) {   
 file\_path <- paste0("data/", file\_name)   
 file\_url <- paste0(url, file\_name)   
 if (!file.exists(file\_path)) {   
 message(paste("Downloading", file\_name))   
 download.file(file\_url, file\_path)   
 }   
}   
   
## Read in and clean the data   
prepare\_data <- function(df){   
 names(df) <- c(   
 "MOSTYPE", "MAANTHUI", "MGEMOMV", "MGEMLEEF", "MOSHOOFD", "MGODRK",   
 "MGODPR", "MGODOV", "MGODGE", "MRELGE", "MRELSA", "MRELOV", "MFALLEEN",   
 "MFGEKIND", "MFWEKIND", "MOPLHOOG", "MOPLMIDD", "MOPLLAAG", "MBERHOOG",   
 "MBERZELF", "MBERBOER", "MBERMIDD", "MBERARBG", "MBERARBO", "MSKA",   
 "MSKB1", "MSKB2", "MSKC", "MSKD", "MHHUUR", "MHKOOP", "MAUT1", "MAUT2",   
 "MAUT0", "MZFONDS", "MZPART", "MINKM30", "MINK3045", "MINK4575",   
 "MINK7512", "MINK123M", "MINKGEM", "MKOOPKLA", "PWAPART", "PWABEDR",   
 "PWALAND", "PPERSAUT", "PBESAUT", "PMOTSCO", "PVRAAUT", "PAANHANG",   
 "PTRACTOR", "PWERKT", "PBROM", "PLEVEN", "PPERSONG", "PGEZONG",   
 "PWAOREG", "PBRAND", "PZEILPL", "PPLEZIER", "PFIETS", "PINBOED",   
 "PBYSTAND", "AWAPART", "AWABEDR", "AWALAND", "APERSAUT", "ABESAUT",   
 "AMOTSCO", "AVRAAUT", "AAANHANG", "ATRACTOR", "AWERKT", "ABROM",   
 "ALEVEN", "APERSONG", "AGEZONG", "AWAOREG", "ABRAND", "AZEILPL",   
 "APLEZIER", "AFIETS", "AINBOED", "ABYSTAND", "CARAVAN")   
   
 MOSTYPE\_labels <- c(   
 "1" = "1 High Income, expensive child",   
 "2" = "2 Very Important Provincials",   
 "3" = "3 High status seniors",   
 "4" = "4 Affluent senior apartments",   
 "5" = "5 Mixed seniors",   
 "6" = "6 Career and childcare",   
 "7" = "7 Dinki's (double income no kids)",   
 "8" = "8 Middle class families",   
 "9" = "9 Modern, complete families",   
 "10" = "10 Stable family",   
 "11" = "11 Family starters",   
 "12" = "12 Affluent young families",   
 "13" = "13 Young all american family",   
 "14" = "14 Junior cosmopolitan",   
 "15" = "15 Senior cosmopolitans",   
 "16" = "16 Students in apartments",   
 "17" = "17 Fresh masters in the city",   
 "18" = "18 Single youth",   
 "19" = "19 Suburban youth",   
 "20" = "20 Ethnically diverse",   
 "21" = "21 Young urban have-nots",   
 "22" = "22 Mixed apartment dwellers",   
 "23" = "23 Young and rising",   
 "24" = "24 Young, low educated",   
 "25" = "25 Young seniors in the city",   
 "26" = "26 Own home elderly",   
 "27" = "27 Seniors in apartments",   
 "28" = "28 Residential elderly",   
 "29" = "29 Porchless seniors: no front yard",   
 "30" = "30 Religious elderly singles",   
 "31" = "31 Low income catholics",   
 "32" = "32 Mixed seniors",   
 "33" = "33 Lower class large families",   
 "34" = "34 Large family, employed child",   
 "35" = "35 Village families",   
 "36" = "36 Couples with teens 'Married with children'",   
 "37" = "37 Mixed small town dwellers",   
 "38" = "38 Traditional families",   
 "39" = "39 Large religous families",   
 "40" = "40 Large family farms",   
 "41" = "41 Mixed rurals")   
   
 MGEMLEEF\_labels <- c(   
 "1" = "20-30 years",   
 "2" = "30-40 years",   
 "3" = "40-50 years",   
 "4" = "50-60 years",   
 "5" = "60-70 years",   
 "6" = "70-80 years")   
   
 MOSHOOFD\_labels <- c(   
 "1" = "Successful hedonists",   
 "2" = "Driven Growers",   
 "3" = "Average Family",   
 "4" = "Career Loners",   
 "5" = "Living well",   
 "6" = "Cruising Seniors",   
 "7" = "Retired and Religeous",   
 "8" = "Family with grown ups",   
 "9" = "Conservative families",   
 "10" = "Farmers")   
   
 MGODRK\_labels <- c(   
 "0" = "0%",   
 "1" = "1 - 10%",   
 "2" = "11 - 23%",   
 "3" = "24 - 36%",   
 "4" = "37 - 49%",   
 "5" = "50 - 62%",   
 "6" = "63 - 75%",   
 "7" = "76 - 88%",   
 "8" = "89 - 99%",   
 "9" = "100%")   
   
 PWAPART\_labels <- c(   
 "0" = "f 0",   
 "1" = "f 1 - 49",   
 "2" = "f 50 - 99",   
 "3" = "f 100 - 199",   
 "4" = "f 200 - 499",   
 "5" = "f 500 - 999",   
 "6" = "f 1000 - 4999",   
 "7" = "f 5000 - 9999",   
 "8" = "f 10,000 - 19,999",   
 "9" = "f 20,000 - ?")   
   
 set\_to\_1 <- c(12, 8, 6, 7, 1, 2, 36, 3, 37, 10, 20, 38, 11)   
   
 df %>%   
 mutate(LIKELY\_CUSTOMERS = ifelse(MOSTYPE %in% set\_to\_1, 1, 0)) %>%   
 mutate(LIKELY\_CUSTOMERS = as.factor(LIKELY\_CUSTOMERS)) %>%   
 mutate(MOSTYPE = as.factor(MOSTYPE),   
 MGEMLEEF = as.factor(MGEMLEEF),   
 MOSHOOFD = as.factor(MOSHOOFD),   
 MGODRK = as.factor(MGODRK),   
 PWAPART = as.factor(PWAPART),   
 CARAVAN = as.factor(CARAVAN)) %>%   
 mutate(MOSTYPE = recode(MOSTYPE, !!!MOSTYPE\_labels),   
 MGEMLEEF = recode(MGEMLEEF, !!!MGEMLEEF\_labels),   
 MOSHOOFD = recode(MOSHOOFD, !!!MOSHOOFD\_labels),   
 MGODRK = recode(MGODRK, !!!MGODRK\_labels),   
 PWAPART = recode(PWAPART, !!!PWAPART\_labels))   
}   
   
eval <- read.delim("data/ticeval2000.txt", header = FALSE)   
temp <- read.delim("data/tictgts2000.txt", header = FALSE)   
eval$CARAVAN <- temp$V1   
eval <- prepare\_data(eval)   
df <- prepare\_data(read.delim("data/ticdata2000.txt", header = FALSE))   
   
## Create the train and test sets   
set.seed(42)   
train\_index <- createDataPartition(df$CARAVAN, p = .7, list = FALSE)   
train <- df[train\_index,]   
test <- df[-train\_index,]   
   
## Correct the data imbalance through over sampling   
up\_train <- upSample(x = select(train, -CARAVAN),   
 y = train$CARAVAN,   
 yname = "CARAVAN")   
   
## Looking for important variables   
# set.seed(42)   
# library(randomForest)   
# rf\_fit <- randomForest(CARAVAN ~ ., up\_train)   
# varImpPlot(rf\_fit)   
   
## Find likely customer types   
MOSTYPE\_crosstab <- up\_train %>%   
 select(CARAVAN, MOSTYPE) %>%   
 table() %>%   
 data.frame()   
   
MOSTYPE\_crosstab <- MOSTYPE\_crosstab %>%   
 group\_by(MOSTYPE) %>%   
 summarise(total = sum(Freq)) %>%   
 merge(MOSTYPE\_crosstab) %>%   
 mutate(share = Freq / total) %>%   
 filter(CARAVAN == 1, share > 0.5) %>%   
 arrange(desc(share)) %>%   
 select(MOSTYPE, share)   
   
MOSTYPE\_crosstab   
   
## Model Building & Evaluation   
   
score\_model <- function(model, data, threshold = 0.5, predictions = FALSE){   
## Provides model scoring data   
#   
# INPUTS   
#   
# model = logit model object   
# data = data frame to make predictions for   
# threshold (optional) = the cutpoint to assign a 1 or 0 response   
# predictions (optional) = 1 or 0 you want to use for the predicitions   
#   
# RETURNS (list)   
#   
# cm = Confusion Matrix output from caret   
# correct = the number of correct CARAVAN = 1 predictions   
# accuracy = the accuracy of the CARAVAN = 1 predictions   
   
 # Generate the predicted outcome   
 if(!predictions){   
 glm\_predictions <- suppressWarnings(predict.glm(model, data, "response"))   
 predictions <- ifelse(glm\_predictions >= threshold, 1, 0)   
 }   
 data$yhat <- predictions   
   
 # Generate a confusion matrix   
 cm <- confusionMatrix(factor(predictions), factor(data$CARAVAN))   
   
 # Get the number of correct CARAVAN = 1 Predictions   
 correct <- data %>%   
 filter(yhat == 1,   
 yhat == CARAVAN) %>%   
 nrow(.)   
   
 # Get the accuracy of the model's CARAVAN = 1 Predictions   
 accuracy <- correct / nrow(data[data$CARAVAN == 1,])   
   
 # Return the data as a list   
 return(list("cm" = cm, "correct" = correct, "accuracy" = accuracy))   
}   
   
robust\_results <- function(model\_formula, n\_tries = 250){   
## Trains and evaluates the model multiple times   
#   
# INPUTS   
#   
# model\_formula = The formula for the logit model   
# n\_tries (optional) = The number of runs (250 default)   
#   
# RETURNS (data.frame)   
#   
# seed = randome number seed   
# correct = the number of correct CARAVAN = 1 predictions   
# accuracy = the accuracy of the CARAVAN = 1 predictions   
   
 # Convert the formula from a string   
 model\_formula <- as.formula(model\_formula)   
 # Begin the loop   
 for(seed in 1:n\_tries){   
 set.seed(seed)   
 # Because some models fail we need to use a try except   
 success = tryCatch({   
 # Split the data   
 train\_index <- createDataPartition(df$CARAVAN, p = .7, list = FALSE)   
 train <- df[train\_index,]   
 test\_df <- df[-train\_index,]   
 # Correct the data imbalance through over sampling   
 training\_df <- upSample(x = select(train, -CARAVAN),   
 y = train$CARAVAN,   
 yname = "CARAVAN")   
 # Build the model   
 model <- glm(model\_formula,   
 family = binomial(link = "logit"),   
 training\_df)   
 # See how it preforms   
 results <- score\_model(model, test\_df)   
 # Store the results   
 temp <- data.frame("seed" = seed,   
 "correct" = results$correct,   
 "accuracy" = results$accuracy)   
 if(exists("the\_results")){   
 the\_results <- bind\_rows(the\_results, temp)   
 } else {   
 the\_results <- temp   
 }   
 }, error = function(e) {   
 # Something bad happened   
 return(FALSE)   
 })   
 }   
 # Return the data.frame of results   
 return(the\_results)   
}   
   
### Model 1 - Top 5 Important Variables from Random Forest   
model1 <- glm(CARAVAN ~ MOSTYPE + PPERSAUT + MOSHOOFD + PBRAND + APERSAUT,   
 family = binomial(link = "logit"),   
 up\_train)   
model1\_results <- score\_model(model1, test)   
model1\_results$accuracy   
# TODO: Uncomment these lines   
#model1\_robust\_results <- robust\_results("CARAVAN ~ MOSTYPE + PPERSAUT + MOSHOOFD + PBRAND + APERSAUT")   
#summary(model1\_robust\_results$accuracy)   
   
### Model 2 - Likely Customers and Car Policies Contribution Level   
model2 <- glm(CARAVAN ~ LIKELY\_CUSTOMERS + PPERSAUT,   
 family = binomial(link = "logit"),   
 up\_train)   
model2\_results <- score\_model(model2, test)   
model2\_results$accuracy   
model2\_robust\_results <- robust\_results("CARAVAN ~ LIKELY\_CUSTOMERS + PPERSAUT")   
summary(model2\_robust\_results$accuracy)   
   
## Final Model Accuracy   
final\_model <- score\_model(model2, eval)   
final\_model$correct   
final\_model$accuracy

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