University of Waterloo

Faculty of Engineering  
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Status Update on Exploring and Predicting Violent Crime in Chicago

University of Waterloo

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1. Data Collection and Preprocessing Code

Class Variable

library**(**tidyr**)**

library**(**dplyr**)**

library**(**plyr**)**

# crime data from 2001

crime **<-** data.frame**(**crimes2001**$**X...ID,

crimes2001**$**Date,

crimes2001**$**Primary.Type,

crimes2001**$**Description,

crimes2001**$**Location.Description,

crimes2001**$**Community.Area**)**

names**(**crime**)** **<-** c**(**'id', 'date', 'type', 'description', 'location', 'community'**)**

crime **<-** crime**[!(**is.na**(**crime**$**community**)** **|** crime**$**community**==**'' **|** crime**$**community**==**'0'**)**, **]**

# dividing offense involving children into violent vs non-violent

crime**$**type **<-** ifelse**(**grepl**((**'CRIM SEX ABUSE BY FAM MEMBER'**)**, crime**$**description**)**

**|** grepl**((**'CHILD ABUSE'**)**, crime**$**description**)**

**|** grepl**((**'AGG SEX ASSLT OF CHILD FAM MBR'**)**, crime**$**description**)**

**|** grepl**((**'CHILD ABDUCTION'**)**, crime**$**description**)**

**|** grepl**((**'AGG CRIM SEX ABUSE FAM MEMBER'**)**, crime**$**description**)**

**|** grepl**((**'SEX ASSLT OF CHILD BY FAM MBR'**)**, crime**$**description**)**

**|** grepl**((**'CRIM SEX ABUSE BY FAM MEMBER'**)**, crime**$**description**)**,

gsub**(**'OFFENSE INVOLVING CHILDREN', 'VIOLENT OFFENSE INVOLVING CHILDREN', crime**$**type**)**,

gsub**(**'OFFENSE INVOLVING CHILDREN', 'NON-VIOLENT OFFENSE INVOLVING CHILDREN', crime**$**type**))**

# generating counts

commu\_crime **<-** data.frame**(**crime**$**type, crime**$**community**)**

names**(**commu\_crime**)** **<-** c**(**'type', 'community'**)**

count\_commu\_crime **<-** ddply**(**commu\_crime, .**(**commu\_crime**$**community, commu\_crime**$**type**)**, nrow**)**

names**(**count\_commu\_crime**)** **<-** c**(**"community", "type", "count"**)**

count **<-** spread**(**count\_commu\_crime, key **=** type, value **=** count**)**

count**[**is.na**(**count**)]** **<-** 0

# population

population **<-** data.frame**(**population\_chicago**$**GeogKey,

population\_chicago**$**Geog,

population\_chicago**$**`Total Population`**)**

names**(**population**)** **<-** c**(**'community', 'community name', 'population(2010)'**)**

# sum violent crimes and total crimes

names**(**sum\_crime**)** **<-** c**(**'community'**)**

sum\_crime**$**violent\_crime **<-** **NA**

sum\_crime**$**total\_crime **<-** **NA**

sum\_crime**$**violent\_crime **<-** rowSums**(**count**[**, c**(**'ASSAULT', 'BATTERY', 'CRIM SEXUAL ASSAULT',

'HOMICIDE', 'KIDNAPPING',

'VIOLENT OFFENSE INVOLVING CHILDREN',

'PUBLIC PEACE VIOLATION', 'RITUALISM',

'ROBBERY', 'SEX OFFENSE', 'WEAPONS VIOLATION'**)])**

sum\_crime**$**total\_crime **<-** rowSums**(**count**[**, **!(**colnames**(**count**)** **==** "community"**)])**

#merge sum\_crime and population

sum\_crime **<-** merge**(**x **=** sum\_crime, y **=** population, by.x **=** 'community', by.y **=** 'community', all **=** **TRUE)**

sum\_crime **<-** sum\_crime**[**, c**(**1, 4, 5, 2, 3**)]**

Average School Rating

# Creating new dataframe for school info

schooldf **<-** data.frame**(**School\_Profile\_Information**$**School\_ID,

School\_Profile\_Information**$**Short\_Name,

School\_Profile\_Information**$**Overall\_Rating,

School\_Profile\_Information**$**Rating\_Status,

School\_Locations**$**COMMAREA,

School\_Locations**$**WARD\_15**)**

community **<-** data.frame**(**census\_data\_by\_community\_area**$**communityAreaNumber,

census\_data\_by\_community\_area**$**Community**)**

names**(**schooldf**)** **<-** c**(**'id', 'name', 'rating', 'status', 'community', 'ward'**)**

names**(**community**)** **<-** c**(**'number', 'name'**)**

# Converting ratings to numbers

schooldf**[**, 'rating'**]** **=** toupper**(**schooldf**[**, 'rating'**])**

schooldf**$**rating\_num **<-** **NA**

schooldf**$**rating\_num**[**schooldf**$**rating**==**'INABILITY TO RATE'**]** **<-** **-**1

schooldf**$**rating\_num**[**is.na**(**schooldf**$**rating**)]** **<-** **-**1

schooldf**$**rating\_num**[**schooldf**$**rating**==**'LEVEL 3'**]** **<-** 1

schooldf**$**rating\_num**[**schooldf**$**rating**==**'LEVEL 2'**]** **<-** 2

schooldf**$**rating\_num**[**schooldf**$**rating**==**'LEVEL 2+'**]** **<-** 3

schooldf**$**rating\_num**[**schooldf**$**rating**==**'LEVEL 1'**]** **<-** 4

schooldf**$**rating\_num**[**schooldf**$**rating**==**'LEVEL 1+'**]** **<-** 5

# Calculating average rating by community area

avg **<-** aggregate**(**schooldf**$**rating\_num, list**(**schooldf**$**community**)**, mean**)**

names**(**avg**)** **<-** c**(**'community', 'avg\_rating'**)**

# Add community number

community**[**, 'name'**]** **=** toupper**(**community**[**, 'name'**])**

community**[**, 'name'**]** **<-** gsub**(**'[^[:alnum:][:space:]]', '', community**[**, 'name'**])**

# Join two data frames

avg\_commu **<-** merge**(**x **=** community, y **=** avg, by.x **=** 'name', by.y **=** 'community', all **=** **TRUE)**

avg\_commu\_ordered **<-** avg\_commu**[**, c**(**2, 1, 3**)]**

avg\_commu\_ordered **<-** avg\_commu\_ordered**[**with**(**avg\_commu\_ordered, order**(**number**))**, **]**

Average SSL Rating

# Create data frame for ssl and community

ssl **<-** data.frame**(**Strategic\_Subject\_List**$**`SSL SCORE`,

Strategic\_Subject\_List**$**`COMMUNITY AREA`**)**

community **<-** data.frame**(**census\_data\_by\_community\_area**$**communityAreaNumber,

census\_data\_by\_community\_area**$**Community**)**

names**(**ssl**)** **<-** c**(**'score', 'community'**)**

names**(**community**)** **<-** c**(**'number', 'name'**)**

# Eliminate rows with blank community

ssl **<-** ssl**[!(**is.na**(**ssl**$**community**)** **|** ssl**$**community**==**''**)**, **]**

# Standardize community names

ssl**[**, 'community'**]** **=** toupper**(**ssl**[**, 'community'**])**

ssl**[**, 'community'**]** **<-** gsub**(**'[^[:alnum:][:space:]]', '', ssl**[**, 'community'**])**

# Calculate the average

avg **<-** aggregate**(**ssl**$**score, list**(**ssl**$**community**)**, mean**)**

names**(**avg**)** **<-** c**(**'community', 'avg\_rating'**)**

# Add community number

community**[**, 'name'**]** **=** toupper**(**community**[**, 'name'**])**

community**[**, 'name'**]** **<-** gsub**(**'[^[:alnum:][:space:]]', '', community**[**, 'name'**])**

# Join two data frames

avg\_commu **<-** merge**(**x **=** community, y **=** avg, by.x **=** 'name', by.y **=** 'community', all **=** **TRUE)**

avg\_commu\_ordered **<-** avg\_commu**[**, c**(**2, 1, 3**)]**

avg\_commu\_ordered **<-** avg\_commu\_ordered**[**with**(**avg\_commu\_ordered, order**(**number**))**, **]**

Total Park Area

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#parks by community area

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library**(**rgdal**)**

library**(**sp**)**

library**(**dplyr**)**

library**(**sf**)**

library**(**tidyverse**)**

library**(**raster**)**

#import the shape files

chicagoparks **<-** readOGR**(**'4A/MSCI 446/R/dataToPreprocess/chicagoparksshapefile', 'geo\_export\_287c1e81-adfc-4076-bbd4-7ac4b1ca62c2'**)**

chicagocommunityareas **<-** readOGR**(**'4A/MSCI 446/R/dataToPreprocess/communityareashapefile', 'geo\_export\_f2c553e7-eb62-4773-9655-8037a1bdd109', stringsAsFactors **=** **FALSE)**

#RUN THIS CODE FOR TOTAL PARK AREA FOR EACH COMMUNITY AREA#

totalParkAreaForCommunityAreas **<-** rep**(**0, nrow**(**chicagocommunityareas**))**

**for(**i **in** 1**:**nrow**(**chicagocommunityareas**))** **{**

totalArea **<-** 0

**for** **(**j **in** 1**:**nrow**(**chicagoparks**))** **{**

#get intersection of community area & park

intersect **<-** intersect**(**chicagocommunityareas**[**i, **]**, chicagoparks**[**j, **])**

**if** **(!**is.null**(**intersect**))** **{**

#if intersection!=null, add to totalArea for current community area

totalArea **<-** totalArea **+** area**(**intersect**)**

**}**

**}**

totalParkAreaForCommunityAreas**[**i**]** **<-** totalArea

**}**

#create the dataframe consisting of three columns: communityArea, communityAreaNumber, and totalParkArea

library**(**readxl**)**

censusdata **<-** read\_excel**(**"4A/MSCI 446/R/dataToPreprocess/Census-Data-by-Chicago-Community-Area-2017 (2).xlsx"**)**

censusdata **<-** data.frame**(**censusdata**$**Community, censusdata**$**CommunityAreaNumber**)**

names**(**censusdata**)** **<-** c**(**'Community', 'communityAreaNumber'**)**

censusdata**$**Community **<-** toupper**(**censusdata**$**Community**)**

chicagocommunityareas@data**$**community**[**75**]** **<-** 'O\'HARE' #naming difference

communityAreaNumber **<-** rep**(**0, nrow**(**chicagocommunityareas**))**

#Need to match totalParkAreaForCommunityAreas to each communityAreaNumber

**for(**i **in** 1**:**nrow**(**chicagocommunityareas**))** **{**

communityAreaNumber**[**i**]** **<-** censusdata**[**which**(**censusdata**$**Community**==**chicagocommunityareas@data**$**community**[**i**])**,2**]**

**}**

totalParkAreaDF **<-** data.frame**(**chicagocommunityareas@data**$**community, communityAreaNumber, totalParkAreaForCommunityAreas**)**

names**(**totalParkAreaDF**)** **<-** c**(**'Community', 'communityAreaNumber', 'totalParkArea'**)**

#save the totalParkArea by Community Area Number

write.csv**(**totalParkAreaDF, 'totalParkAreaByCommunityArea.csv'**)**

Number of Hospitals, Teen Mom Birth Rate, Infant Mortality Rate

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#Public Safety Data

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library**(**rgdal**)**

library**(**sp**)**

library**(**dplyr**)**

library**(**sf**)**

library**(**tidyverse**)**

library**(**raster**)**

#Code for numHospitalsPerCommunityArea#################################

hospitals **<-** readOGR**(**'4A/MSCI 446/R/dataToPreprocess/Hospitals', 'Hospitals', stringsAsFactors **=** **FALSE)**

numHospitalsPerCommunityArea **<-** as.data.frame**(**table**(**hospitals@data**$**AREA\_NUMBE**))**

names**(**numHospitalsPerCommunityArea**)** **<-** c**(**'communityAreaNum', 'numHospitals'**)**

numHospitalsPerCommunityArea**$**communityAreaNum **<-** as.numeric**(**levels**(**numHospitalsPerCommunityArea**$**communityAreaNum**))**

**for** **(**i **in** 1**:**77**)** **{**

**if** **(**sum**(**numHospitalsPerCommunityArea**$**communityAreaNum **==** i**)** **==** 0**)** **{**

newDF **<-** data.frame**(**i,0**)**

names**(**newDF**)<-**c**(**'communityAreaNum', 'numHospitals'**)**

numHospitalsPerCommunityArea **<-** rbind**(**numHospitalsPerCommunityArea, newDF**)**

**}**

**}**

numHospitalsPerCommunityArea **<-** numHospitalsPerCommunityArea**[**order**(**numHospitalsPerCommunityArea**$**communityAreaNum**)**,**]**

var**(**numHospitalsPerCommunityArea**$**numHospitals**)**

#Code for teenMomRatePerCommunityArea#################################

teenMomsData **<-** read.csv**(**'4A/MSCI 446/R/dataToPreprocess/Public\_Health\_Statistics\_-\_Births\_to\_mothers\_aged\_15-19\_years\_old\_in\_Chicago\_\_by\_year\_\_1999-2009.csv'**)**

teenBirthRates **<-** data.frame**(**teenMomsData**$**Teen.Birth.Rate.1999,

teenMomsData**$**Teen.Birth.Rate..2000,

teenMomsData**$**Teen.Birth.Rate.2001,

teenMomsData**$**Teen.Birth.Rate.2002,

teenMomsData**$**Teen.Birth.Rate.2003,

teenMomsData**$**Teen.Birth.Rate.2004,

teenMomsData**$**Teen.Birth.Rate.2005,

teenMomsData**$**Teen.Birth.Rate.2006,

teenMomsData**$**Teen.Birth.Rate.2007,

teenMomsData**$**Teen.Birth.Rate.2008,

teenMomsData**$**Teen.Birth.Rate.2009**)**

teenBirthRates **<-** teenBirthRates**[**1**:**nrow**(**teenBirthRates**)-**1,**]**

teenBirthRatesTransposed **<-** t**(**teenBirthRates**)**

rownames**(**teenBirthRatesTransposed**)** **<-** **NULL**

colnames**(**teenBirthRatesTransposed**)** **=** seq**(**1**:**77**)**

#find the mean teenMomBirthRate for years 1999-2009. Use this as each community area's "teenMomBirthRate"

teenMomRatePerCommunityAreaVec**=**c**()**

**for(**i **in** 1**:**ncol**(**teenBirthRatesTransposed**)){**

teenMomRatePerCommunityAreaVec**[**i**]** **=** mean**(**teenBirthRatesTransposed**[**,i**]**, na.rm **=** **FALSE)**

**}**

teenMomRatePerCommunityArea **<-** data.frame**(**teenMomsData**[**1**:**nrow**(**teenMomsData**)-**1,1**]**, teenMomRatePerCommunityAreaVec**)**

names**(**teenMomRatePerCommunityArea**)** **<-** c**(**'communityAreaNum', 'teenMomRate'**)**

#Code for infantMortalityRatePerCommunityArea#################################

infantMortalityData **<-** read.csv**(**'4A/MSCI 446/R/dataToPreprocess/Public\_Health\_Statistics-\_Infant\_mortality\_in\_Chicago\_\_2005\_\_2009.csv'**)**

infantMortalityData **<-** infantMortalityData**[**1**:**nrow**(**infantMortalityData**)-**1,**]**

infantMortalityRatePerCommunityArea **<-** data.frame**(**infantMortalityData**$**ﮮCommunity.Area, infantMortalityData**$**Average.Infant.Mortality.Rate.2005...2009**)**

names**(**infantMortalityRatePerCommunityArea**)** **<-** c**(**'communityAreaNum', 'infantMortalityRate'**)**

remove**(**infantMortalityData**)**

#write all three to csv

publicHealthData **<-** data.frame**(**infantMortalityRatePerCommunityArea**$**communityAreaNum,

numHospitalsPerCommunityArea**$**numHospitals,

teenMomRatePerCommunityArea**$**teenMomRate,

infantMortalityRatePerCommunityArea**$**infantMortalityRate**)**

names**(**publicHealthData**)** **<-** c**(**'communityAreaNum',

'numHospitals',

'teenMomRate',

'infantMortalityRate'**)**

write.csv**(**publicHealthData, 'publicHealth.csv'**)**

Proportion of Different Races, and Percent of Children in Poverty

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#poverty & race by community area

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#did most of the conversion in excel, and using R to just create a csv of it.

library**(**readxl**)**

censusdata **<-** read\_excel**(**"4A/MSCI 446/R/dataToPreprocess/Census-Data-by-Chicago-Community-Area-2017 (2).xlsx"**)**

censusdata **<-** data.frame**(**censusdata**$**Community,

censusdata**$**CommunityAreaNumber,

censusdata**$**Hispanic,

censusdata**$**Black,

censusdata**$**White,

censusdata**$**Asian,

censusdata**$**Other,

censusdata**$**PercentChildrenInPoverty**)**

names**(**censusdata**)** **<-** c**(**'Community', 'communityAreaNumber', 'Hispanic', 'Black', 'White', 'Asian', 'Other', 'PercentChildrenInPoverty'**)**

write.csv**(**censusdata, 'censusdataByCommunityArea.csv'**)**

Combining all Datasets into One

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#Combining all the data

##########################################

avgSchoolRating **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/avg\_school\_rating\_by\_community.csv"**)**

avgSSLscore **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/avg\_ssl\_score\_by\_community.csv"**)**

censusData **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/censusdataByCommunityArea.csv"**)**

typesOfCrimes **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/crime\_count\_in\_community.csv"**)**

predictedVarDF **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/total\_crime\_by\_community.csv"**)**

totalParkArea **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/totalParkAreaByCommunityArea.csv"**)**

publicHealth **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/publicHealth.csv"**)**

#because totalParkArea dataframe is not sorted by ascending community area number:

totalParkArea **<-** totalParkArea**[**order**(**totalParkArea**$**communityAreaNumber**)**,**]**

predTable **<-** data.frame**(**totalParkArea**$**Community,

totalParkArea**$**communityAreaNumber,

predictedVarDF**$**violent\_crime **\*** 1000 **/** **(**predictedVarDF**$**population.2010.**)**,

avgSchoolRating**$**avg\_rating,

avgSSLscore**$**avg\_rating,

totalParkArea**$**totalParkArea,

publicHealth**$**numHospitals,

publicHealth**$**teenMomRate,

publicHealth**$**infantMortalityRate,

censusData**[**,4**:**ncol**(**censusData**)])**

names**(**predTable**)** **<-** c**(**

"community",

"communityAreaNum",

"percentViolentCrimePer1000Population",

"avgSchoolRating",

"avgSSLRating",

"totalParkArea",

"numHospitals",

"teenMomRate",

"infantMortalityRate",

"hispanic",

"black",

"white",

"asian",

"other",

"percentChildrenInPov"**)**

**)**

#write to csv

write.csv**(**predTable, 'predTable.csv'**)**

1. Explanatory Data Analysis Code

# gather useful columns

explanatory **<-** data.frame**(**predTable**$**communityAreaNum,

predTable**$**percentViolentCrimePer1000Population,

predTable**$**avgSchoolRating,

predTable**$**avgSSLRating,

predTable**$**totalParkArea,

predTable**$**numHospitals,

predTable**$**teenMomRate,

predTable**$**infantMortalityRate,

100**\***predTable**$**hispanic,

100**\***predTable**$**black,

100**\***predTable**$**white,

100**\***predTable**$**asian,

100**\***predTable**$**other,

100**\***predTable**$**percentChildrenInPov**)**

names**(**explanatory**)** **<-** c**(**'community', 'number\_of\_violent\_crimes\_per\_1000\_population',

'Average\_School\_Rating', 'Normalized\_Average\_SSL', 'Total\_Park\_Area\_(m2)',

'Number\_of\_Hospitals', 'Number\_of\_Teen\_Moms\_/\_1000\_Female\_Teenagers', 'Number\_of\_Infant\_Mortality\_/\_1000\_Live\_Births',

'Percent\_of\_Hispanic\_(%)', 'Percent\_of\_Black\_(%)', 'Percent\_of\_White\_(%)',

'Percent\_of\_Asian\_(%)', 'Percent\_of\_Other\_Race\_(%)', 'Percent\_of\_Children\_in\_Poverty\_(%)'**)**

# normalize SSL (266.0711 - 304.1068)

explanatory**$**Normalized\_Average\_SSL **<-** **(**explanatory**$**Normalized\_Average\_SSL**-**min**(**explanatory**$**Normalized\_Average\_SSL**))/(**max**(**explanatory**$**Normalized\_Average\_SSL**)** **-** min**(**explanatory**$**Normalized\_Average\_SSL**))**

# num\_hospital to binary

explanatory**$**Whether\_Community\_Has\_3\_or\_More\_Hospitals **<-** **NA**

explanatory**$**Whether\_Community\_Has\_3\_or\_More\_Hospitals **<-** explanatory**$**Number\_of\_Hospitals **>=** 3

col\_names **<-** colnames**(**explanatory**)**

# scatter plot

**for(**i **in** 3**:**14**)** **{**

plot**(**explanatory**[**,i**]**, explanatory**$**number\_of\_violent\_crimes\_per\_1000\_population,

main**=**paste**(**'Violent Crime Rate V.S.', gsub**(** '\\s\*\\([^\\)]+\\)', '', gsub**(**'\_', ' ', col\_names**[**i**])))**,

xlab**=**gsub**(**'\_', ' ', col\_names**[**i**])**, ylab**=**'Number of Violent Crimes / 1000 Population', pch**=**18**)**

**}**

plot**(**explanatory**[**,15**]**, explanatory**$**number\_of\_violent\_crimes\_per\_1000\_population,

main**=**paste**(**'Violent Crime Rate V.S. ', gsub**(** '\\s\*\\([^\\)]+\\)', '', gsub**(**'\_', ' ', col\_names**[**15**])))**,

xaxt**=**'n', xlim**=**c**(-**1,2**)**, xlab**=**gsub**(**'\_', ' ', col\_names**[**15**])**, ylab**=**'Number of Violent Crimes / 1000 Population', pch**=**18**)**

axis**(**1, at**=**0**:**1, labels**=**c**(**'FALSE', 'TRUE'**))**

# histograms

hist**(**explanatory**$**number\_of\_violent\_crimes\_per\_1000\_population,

col**=**'grey',

main**=**'Number of Violent Crimes / 1000 Population (Histogram)',

xlab**=**'Number of Violent Crimes / 1000 Population', ylab**=**'Number of Communities'**)**

**for(**i **in** 3**:**14**)** **{**

hist**(**explanatory**[**,i**]**,

col**=**'grey',

main**=**paste**(**gsub**(** '\\s\*\\([^\\)]+\\)', '', gsub**(**'\_', ' ', col\_names**[**i**]))**, '(Histogram)'**)**,

xlab**=**gsub**(**'\_', ' ', col\_names**[**i**])**, ylab**=**'Number of Communities'**)**

**}**

# box plots

boxplot**(**explanatory**$**number\_of\_violent\_crimes\_per\_1000\_population, data**=**explanatory,

col**=**'grey',

main**=**"Number of Violent Crimes / 1000 Population (Box Plot)",

xlab**=**"Number of Violent Crimes / 1000 Population"**)**

**for(**i **in** 3**:**14**)** **{**

boxplot**(**explanatory**[**,i**]**, data**=**explanatory,

col**=**'grey',

main**=**paste**(**gsub**(** '\\s\*\\([^\\)]+\\)', '', gsub**(**'\_', ' ', col\_names**[**i**]))**, '(Box Plot)'**)**,

xlab**=**gsub**(**'\_', ' ', col\_names**[**i**]))**

**}**

1. Numeric Regression Code

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#Numeric Regression

##########################################

library**(**caret**)**

library**(**dplyr**)**

#Import data: includes explanatory variables AND class variable but also other columns (e.g. community area name)

data **<-** read.csv**(**"4A/MSCI 446/R/explanatoryvariables/predTable.csv"**)**

#remove extraneous columns (e.g. community area name)

dataForPred **<-** dplyr**::**select**(**data, **-**X, **-**community, **-**communityAreaNum**)**

dataForPred **<-** dataForPred**[**,1**:**13**]**

dataForPred**$**numHospitals **<-** ifelse**(**dataForPred**$**numHospitals **>=** 3, 1, 0**)**

colnames**(**dataForPred**)[**5**]** **<-** "has3OrMoreHospitals"

#Use 10-fold cross-validation for getting alpha/lambda values for glmnet

tControlObj **<-** caret**::**trainControl**(**

method **=** "cv", number **=** 10,

verboseIter **=** **TRUE**,

summaryFunction **=** defaultSummary

**)**

k **<-** 77

#leave-1-out cross validation for performance metrics (RMSE, Rsquared, MAE)

splitPlan **<-** kWayCrossValidation**(**nrow**(**dataForPred**)**, k, **NULL**, **NULL)**

#initialization of the dataframe that will store the performance metrics

metricsDF **<-** as.data.frame**(**matrix**(**nrow **=** 3, ncol **=** 4**))**

names**(**metricsDF**)** **<-** c**(**"Model", "RMSE", "Rsquared", "MAE"**)**

OLS Linear Regression

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#train using linear regression#

modelLM **<-** train**(**

x **=** dataForPred**[**,2**:**13**]**,

y **=** dataForPred**[**,1**]**,

method **=** "lm",

trControl **=** tControlObj

**)**

#Predicted vs Actual Plot

plot**(**modelLM**$**finalModel**$**fitted.values, dataForPred**[**,1**]**, main**=**'Predicted vs Actual for Simple Linear Regression', xlab**=**'Predicted', ylab**=**'Actual'**)**

#Residual Plot

plot**(**modelLM**$**finalModel**$**fitted.values, modelLM**$**finalModel**$**residuals, main**=**'Residual Plot for Simple Linear Regression', xlab**=**'Predicted', ylab**=**'Residuals'**)**

abline**(**h **=** 0, col **=** "darkgrey", lty **=** 2**)**

#Residual Histogram Plot

hist**(**modelLM**$**finalModel**$**residuals,

col**=**'grey',

main**=**'Residual Histogram for Simple Linear Regression',

xlab**=**'Residual', ylab**=**'Frequency'**)**

#Leave-1-out Cross Validation to get OLS Performance Metrics

lmPredValues **<-** data.frame**(**"predicted" **=** rep**(**0, nrow**(**dataForPred**)))**

**for(**i **in** 1**:**k**)** **{**

split **<-** splitPlan**[[**i**]]**

model **<-** lm**(**percentViolentCrimePer1000Population **~** ., data **=** dataForPred**[**split**$**train,**])**

lmPredValues**$**predicted**[**split**$**app**]** **<-** predict**(**model, newdata **=** dataForPred**[**split**$**app,**])**

**}**

metricsDF**[**1,**]** **<-** c**(**"Linear Regression CV", postResample**(**lmPredValues**$**predicted, dataForPred**[**,1**]))**

metricsDF**[**4,**]** **<-** c**(**"Linear Regression", postResample**(**predict**(**modelLM, dataForPred**[**2**:**13**])**, dataForPred**[**,1**]))**

Elastic Net Regression

##########################################

#train using glmnet#

modelGLMNET **<-** train**(**

x **=** dataForPred**[**,2**:**13**]**,

y **=** dataForPred**[**,1**]**,

method **=** "glmnet",

metric **=** "RMSE",

tuneGrid **=** expand.grid**(**alpha **=** 0**:**10**/**10**)**, #lambda = seq(0.0001, 1, length = 20)

trControl **=** tControlObj

**)**

#obtain the predicted values

predictionGLMNET **<-** predict**(**modelGLMNET, dataForPred**[**, 2**:**13**])**

#plots RMSE over different alpha and lambda values.

plot**(**modelGLMNET, main**=**'Alpha and Lambda Values for GLMNET'**)**

#Predicted vs Actual Plot

plot**(**predictionGLMNET, dataForPred**[**,1**]**, main**=**'Predicted vs Actual for GLMNET Regression', xlab**=**'Predicted', ylab**=**'Actual'**)**

#Residual Plot

plot**(**predictionGLMNET, **(**dataForPred**[**,1**]-**predictionGLMNET**)**, main**=**'Residual Plot for GLMNET Regression', xlab**=**'Predicted', ylab**=**'Residuals'**)**

abline**(**h **=** 0, col **=** "darkgrey", lty **=** 2**)**

#Histogram Plot

hist**((**dataForPred**[**,1**]-**predictionGLMNET**)**,

col**=**'grey',

main**=**'Residual Histogram for GLMNET Linear Regression',

xlab**=**'Residual', ylab**=**'Frequency'**)**

#Leave-1-Out Cross Validation to get performance metrics

glmnetPredValues **<-** data.frame**(**"predicted" **=** rep**(**0, nrow**(**dataForPred**)))**

**for(**i **in** 1**:**k**)** **{**

split **<-** splitPlan**[[**i**]]**

model **<-** glmnet**(**as.matrix**(**dataForPred**[**split**$**train,2**:**13**])**, dataForPred**[**split**$**train,1**]**, alpha **=** modelGLMNET**$**bestTune**$**alpha, lambda **=** modelGLMNET**$**bestTune**$**lambda**)**

glmnetPredValues**$**predicted**[**split**$**app**]** **<-** predict**(**model, s **=** modelGLMNET**$**bestTune**$**lambda, newx **=** as.matrix**(**dataForPred**[**split**$**app,2**:**13**]))**

**}**

metricsDF**[**2,**]** **<-** c**(**"Elastic Net CV", postResample**(**glmnetPredValues**$**predicted, dataForPred**[**,1**]))**

metricsDF**[**5,**]** **<-** c**(**"Elastic Net", postResample**(**predictionGLMNET, dataForPred**[**,1**]))**

GAM Regression

##########################################

#GAM model#

#since caret can only do standard GAM model of y = s(x1) + s(x2) + etc. we will not be using caret

library**(**mgcv**)**

library**(**vtreat**)**

#GAM formula, based off scatter plots of each explanatory variable vs class variable from EDA

GAMformula **<-** percentViolentCrimePer1000Population **~**

avgSchoolRating **+**

avgSSLRating **+**

s**(**totalParkArea**)** **+**

has3OrMoreHospitals **+**

s**(**teenMomRate**)** **+**

s**(**infantMortalityRate**)** **+**

s**(**hispanic**)** **+**

black **+**

s**(**white**)** **+**

s**(**asian**)** **+**

other **+**

s**(**percentChildrenInPov**)**

#Leave-1-Out Cross Validation To get Performance Metrics

gamPredValues **<-** data.frame**(**"predicted" **=** rep**(**0, nrow**(**dataForPred**)))**

**for(**i **in** 1**:**k**)** **{**

split **<-** splitPlan**[[**i**]]**

model **<-** gam**(**GAMformula, data **=** dataForPred**[**split**$**train,**]**, family **=** gaussian**)**

gamPredValues**$**predicted**[**split**$**app**]** **<-** predict**(**model, newdata **=** dataForPred**[**split**$**app,**])**

**}**

metricsDF**[**3,**]** **<-** c**(**"GAM cv", postResample**(**gamPredValues**$**predicted, dataForPred**[**,1**]))**

#Building the final model

gamModel **<-** gam**(**GAMformula, data **=** dataForPred, family **=** gaussian**)**

finalPredictions **<-** predict**(**gamModel, dataForPred**[**, 2**:**13**])**

metricsDF**[**6,**]** **<-** c**(**"GAM", postResample**(**finalPredictions, dataForPred**[**,1**]))**

#Predicted vs Actual Plot

plot**(**finalPredictions, dataForPred**[**,1**]**, main**=**'Predicted vs Actual for GAM Regression', xlab**=**'Predicted', ylab**=**'Actual'**)**

#Residual Plot

plot**(**finalPredictions, **(**dataForPred**[**,1**]-**finalPredictions**)**, main**=**'Residual Plot for GAM Regression', xlab**=**'Predicted', ylab**=**'Residuals'**)**

abline**(**h **=** 0, col **=** "darkgrey", lty **=** 2**)**

#Residual Histogram

hist**((**dataForPred**[**,1**]-**finalPredictions**)**,

col**=**'grey',

main**=**'Residual Histogram for GAM Regression',

xlab**=**'Residual', ylab**=**'Frequency'**)**

postResample**(**predict**(**gamModel, dataForPred**[**, 2**:**13**])**, dataForPred**[**,1**])**

1. Clustering Code

# Clustering

# Normalize explanatory variables

normalized **<-** explanatory

**for** **(**col **in** 1**:**ncol**(**normalized**))** **{**

normalized**[**,col**]** **<-** **(**normalized**[**,col**]-**min**(**normalized**[**,col**]))/(**max**(**normalized**[**,col**])** **-** min**(**normalized**[**,col**]))**

**}**

# Clustering Euclidean Distance

euclidean **<-** matrix**(**, nrow **=** 25, ncol **=** 2**)**

**for(**round **in** 1**:**2**)** **{**

**for(**n **in** 1**:**25**)** **{**

cl **<-** kmeans**(**normalized**[**, 3**:**14**]**, n**)**

euclidean**[**n, round**]** **<-** cl**$**tot.withinss

**}**

**}**

# plot the euclidean distance vs number of centers

plot**(**euclidean**[**,2**]**, type**=**'o', col**=**1, pch**=**18, lty**=**1,

main**=**'Total Within-Cluster Sum of Squares v.s. Number of Centers',

xlab**=**'Number of Centers', ylab**=**'Total Within-Cluster Sum of Squares'**)**

# plot trials with different sets of starting points

plot**(**euclidean**[**,1**]**, type**=**'o', col**=**4, pch**=**18, lty**=**2,

main**=**'Results Generated by Different Randomly Chosen Start Point',

xlab**=**'Number of Centers', ylab**=**'Total Within-Cluster Sum of Squares'**)**

lines**(**euclidean**[**,2**]**, type**=**"o", pch**=**18, lty**=**1, col**=**1**)**

legend**(**18, 50, c**(**"First Trial","Second Trial"**)**, cex**=**0.8,

col**=**c**(**1,4**)**, pch**=**18**:**18, lty**=**1**:**2**)**

# perform k-means again with 50 sets of starting points and take average

**for(**n **in** 1**:**25**)** **{**

cl **<-** kmeans**(**normalized**[**, 3**:**14**]**, n, nstart**=**50**)**

euclidean**[**n, round**]** **<-** cl**$**tot.withinss

**}**

plot**(**euclidean**[**,2**]**, type**=**'o', col**=**1, pch**=**18, lty**=**1,

main**=**'Sum of Squares v.s. Number of Centers',

xlab**=**'Number of Centers', ylab**=**'Total Within-Cluster Sum of Squares'**)**

# Clustering plots with 3 centres, with 50 sets of randomly chosen starting points

cl **<-** kmeans**(**normalized**[**, 3**:**14**]**, 3, nstart**=**50**)**

plot**(**normalized**[**, 3**:**14**]**, col **=** cl**$**cluster, pch**=**20**)**

points**(**cl**$**centers, col **=** cl**$**cluster, pch **=** 8, cex **=** 2**)**

1. Association Rule Mining Code