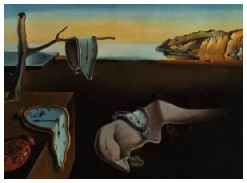


Journal of Statistical Software

MMMMMM YYYY, Volume VV, Issue II. *doi: 10.18637/jss.v000.i00*

Team 15 The Scientists: Crime Prediction Proposal

Xiangyu Jin (xjin13)
UIUC

Vinayak Bagdi (vbagdi2)
UIUC

Abstract

The project aims to predict the type of crime an arrestee may have committed based on their background information such as race, sex, age, and other attributes. The central idea is to examine whether there are any relationships between crime types and arrestee's background information and to study the crime distribution in Champaign The project employs classification models or random forests model to predict the crime type based on the information about the arrestees. The project uses data before 2018 as training data and data after 2018 as testing data to test the model's accuracy. The methods employed so far include data cleaning, feature engineering, data manipulation, data visualization, and data analysis using R. The implications of the work done so far will help to improve the understanding of crime distribution in Champaign and aid in the development of effective crime prevention and control strategies.

Keywords: R, group project.

0.1. Introduction

The project aims to examine the relationship between the type of crime and the background information of the arrestees, including race, sex, age, and other attributes. The problem being addressed is the high rate of crime in Champaign, which poses a significant threat to the safety and well-being of residents. It is essential to develop effective crime prevention and control strategies that take into account the underlying factors contributing to crime. The objective of the project is to predict the type of crime an arrestee may have committed based on their background information, which can aid in developing effective crime prevention strategies.

The motivation for pursuing this problem is to improve the understanding of crime distribution in Champaign and to identify potential factors contributing to the high rate of crime. The project can aid in the development of targeted crime prevention and control strategies that can help to reduce crime rates in the city. Additionally, the project can help law enforcement agencies to allocate resources effectively and efficiently.

0.2. Related Works

Guido Vittorio Travaini,Federico Pacchioni, Silvia Bellumore, Marta Bosia, Francesco De Micco (2022) explores the use of machine learning algorithms to predict the likelihood of criminal recidivism. The study used a dataset consisting of demographic and criminal history variables of inmates to develop a prediction model. This study is relevant to our project as it also uses machine learning algorithms to predict criminal activities based on input features. However, the focus of our project is on predicting the type of crime based on the background information of the arrestees, whereas the study by Guido Vittorio Travaini,Federico Pacchioni, Silvia Bellumore, Marta Bosia, Francesco De Micco (2022) is focused on predicting the likelihood of criminal recidivism. Both employ machine learning algorithms to predict criminal activities based on input features. However, the input features and prediction targets are different. Our project focuses on predicting the type of crime based on the background information of the arrestees, whereas the study by Guido Vittorio Travaini,Federico Pacchioni, Silvia Bellumore, Marta Bosia, Francesco De Micco (2022) focuses on predicting the likelihood of criminal recidivism based on demographic and criminal history variables of inmates.

Umair Saeed (2015) explores the use of machine learning algorithms to classify criminal activities based on the input features. The study used a dataset consisting of demographic and behavioral variables of criminals to develop a prediction model.This study is relevant to the current project as it also uses machine learning algorithms to predict criminal activities based on input features. The focus of our project is on predicting the type of crime based on the background information of the arrestees, whereas the study by Umair Saeed (2015) is focused on classifying criminal activities based on the input features. Both employ machine learning algorithms to predict criminal activities based on input features. However, the prediction targets are different. Our project focuses on predicting the type of crime based on the background information of the arrestees, whereas the study by Umair Saeed (2015) focuses on classifying criminal activities based on the input features.

Varun Mandalapu (2023) is a systematic review of crime prediction using machine learning techniques. The authors reviewed and analyzed 82 research papers from 2010 to 2019. The review highlights the importance of data preprocessing, feature selection, and algorithm selection in crime prediction. The authors also discuss the limitations and challenges of using machine learning in crime prediction, such as data imbalance, interpretability, and ethical concerns. This work relates to our current project as it provides insights into the state of the art in crime prediction using machine learning techniques. It highlights the importance of data preprocessing and algorithm selection, which are critical steps in our project. It also discusses the challenges and limitations of using machine learning in crime prediction, which we should be aware of when interpreting our results. Our approach will be similar to the reviewed papers in terms of using machine learning techniques for crime prediction. However, we will focus on a specific dataset from Champaign and investigate the relationship between crime types and arrestee's background information. We will also perform data preprocessing, feature engineering, and model selection based on the characteristics of our dataset.

0.3. Data

```
library(tidyverse)
```

```
-- Attaching packages --------------------------------------- tidyverse 1.3.2 --
v ggplot2 3.4.0     v purrr   1.0.1
v tibble  3.1.8     v dplyr   1.1.0
v tidyr   1.3.0     v stringr 1.5.0
v readr   2.1.3     v forcats 1.0.0
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
```

```
library(ggplot2)
library(hrbrthemes)
```

```
NOTE: Either Arial Narrow or Roboto Condensed fonts are required to use these themes.
      Please use hrbrthemes::import_roboto_condensed() to install Roboto Condensed and
      if Arial Narrow is not on your system, please see https://bit.ly/arialnarrow
```

```
# Reading online CSV file with big limit
my_data = read_csv("https://data.urbanaillinois.us/resource/afbd-8beq.csv?$limit=999999")
```

```
Warning: One or more parsing issues, call `problems()` on your data frame for details,
e.g.:
  dat <- vroom(...)
  problems(dat)
```

```
Rows: 216554 Columns: 25
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (19): arrest_code, incident_number, arrest_type_description, crime_code...
dbl   (4): year_of_arrest, month_of_arrest, disposition_code, age_at_arrest
lgl   (1): conspiracy_code
dttm  (1): date_of_arrest

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
summary(my_data)
```

```
 arrest_code        incident_number    date_of_arrest
 Length:216554      Length:216554      Min.   :1988-01-01 00:00:00.0
 Class :character   Class :character   1st Qu.:1996-07-10 00:00:00.0
 Mode  :character   Mode  :character   Median :2004-07-05 00:00:00.0
                                       Mean   :2004-08-27 15:07:28.5
                                       3rd Qu.:2012-06-21 00:00:00.0
                                       Max.   :2023-02-14 00:00:00.0
                                       NA's   :1
 year_of_arrest month_of_arrest  arrest_type_description  crime_code
 Min.   :1988   Min.   : 1.000   Length:216554          Length:216554
 1st Qu.:1996   1st Qu.: 4.000   Class :character       Class :character
 Median :2004   Median : 6.000   Mode  :character       Mode  :character
 Mean   :2004   Mean   : 6.458
```

```
3rd Qu.:2012   3rd Qu.: 9.000
Max.   :2023   Max.   :12.000
NA's   :1      NA's   :1
crime_code_description crime_category_code crime_category_description
Length:216554          Length:216554       Length:216554
Class :character       Class :character    Class :character
Mode  :character       Mode  :character    Mode  :character
```

```
conspiracy_code   statute           violation         disposition_code
Mode:logical    Length:216554      Length:216554      Min.   :86.00
TRUE:2          Class :character   Class :character   1st Qu.:87.00
NA's:216552     Mode  :character   Mode  :character   Median :87.00
                                                      Mean   :87.81
                                                      3rd Qu.:88.00
                                                      Max.   :98.00
                                                      NA's   :1
disposition_description age_at_arrest      arrestee_sex
Length:216554           Min.   :-7172.00   Length:216554
Class :character        1st Qu.:   20.00   Class :character
Mode  :character        Median :   26.00   Mode  :character
                        Mean   :   29.48
                        3rd Qu.:   36.00
                        Max.   :   99.00
                        NA's   :1
arrestee_race      arrestee_employment_description
Length:216554      Length:216554
Class :character   Class :character
Mode  :character   Mode  :character
```

```
arrestee_residency_description arrestee_home_city arrestee_home_state
Length:216554                  Length:216554      Length:216554
Class :character               Class :character   Class :character
Mode  :character               Mode  :character   Mode  :character
```

```
arrestee_home_zip  arrest_resolution  mapped_address
Length:216554      Length:216554      Length:216554
Class :character   Class :character   Class :character
Mode  :character   Mode  :character   Mode  :character
```

- The data set contains both numerical and character data. City of Urbana collected the data and this data set is available on Urbana's Open Data website. The whole data set contains 216554 observations and 25 features. The data set is updated monthly with two months lag. When we load the data, we need to specify length of csv file as large as possible. Otherwise, only first 1000 observations will be loaded.
- Ref: https://data.urbanaillinois.us/Police/Urbana-Police-Arrests-Since-1988/afbd-8beq

```
# First five observations of the dataset.
head(my_data, n = 5)
```

```
# A tibble: 5 x 25
  arrest_c~1 incid~2 date_of_arrest      year_~3 month~4 arres~5 crime~6 crime~7
  <chr>      <chr>   <dttm>                <dbl>   <dbl> <chr>   <chr>   <chr>
1 A23-00466  T23-00~ 2023-02-14 00:00:00    2023       2 SUMMON~ 2460    CANCEL~
2 A23-00459  T23-00~ 2023-02-13 00:00:00    2023       2 SUMMON~ 2481    DRIVIN~
3 A23-00461  U23-02~ 2023-02-13 00:00:00    2023       2 SUMMON~ 6621    FAILUR~
4 A23-00460  T23-00~ 2023-02-13 00:00:00    2023       2 SUMMON~ 6601    SPEEDI~
5 A23-00462  U23-02~ 2023-02-13 00:00:00    2023       2 SUMMON~ 2461    OPERAT~
# ... with 17 more variables: crime_category_code <chr>,
#   crime_category_description <chr>, conspiracy_code <lgl>, statute <chr>,
#   violation <chr>, disposition_code <dbl>, disposition_description <chr>,
#   age_at_arrest <dbl>, arrestee_sex <chr>, arrestee_race <chr>,
#   arrestee_employment_description <chr>,
#   arrestee_residency_description <chr>, arrestee_home_city <chr>,
#   arrestee_home_state <chr>, arrestee_home_zip <chr>, ...
```

0.4. Exploratory Data Analysis (EDA)

```
my_data %>%
  select(where(is.numeric)) %>%
  summary()
```

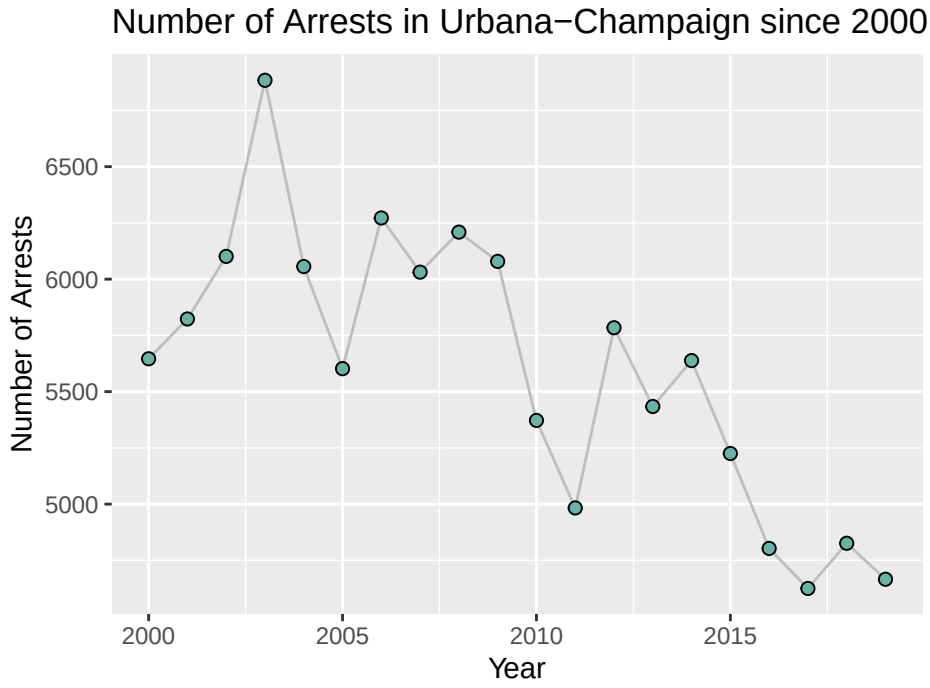
```
 year_of_arrest month_of_arrest  disposition_code age_at_arrest
 Min.   :1988   Min.   : 1.000   Min.   :86.00    Min.   :-7172.00
 1st Qu.:1996   1st Qu.: 4.000   1st Qu.:87.00    1st Qu.:   20.00
 Median :2004   Median : 6.000   Median :87.00    Median :   26.00
 Mean   :2004   Mean   : 6.458   Mean   :87.81    Mean   :   29.48
 3rd Qu.:2012   3rd Qu.: 9.000   3rd Qu.:88.00    3rd Qu.:   36.00
 Max.   :2023   Max.   :12.000   Max.   :98.00    Max.   :   99.00
 NA's   :1      NA's   :1        NA's   :1        NA's   :1
```

Data Cleaning and Feature Engineering

```
my_data = my_data %>%
  filter(year_of_arrest >= 2000) %>%
  filter(age_at_arrest > 0) %>%
  select(incident_number, year_of_arrest, month_of_arrest, crime_category_description, age
  filter(arrestee_sex == "MALE" | arrestee_sex == "FEMALE") %>%
  drop_na()
```

plots

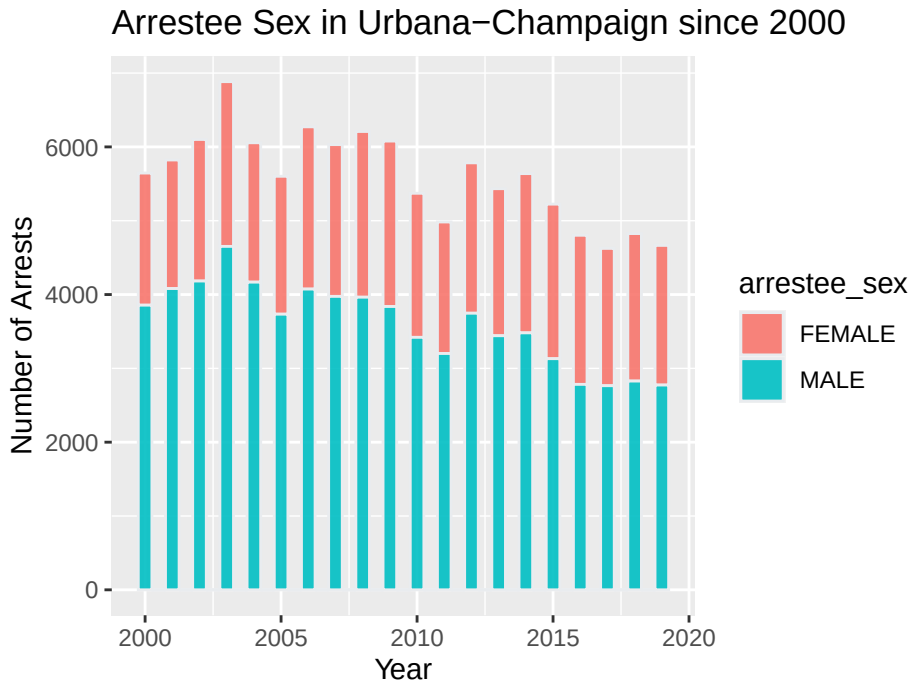
```
# number of cases versus time (year)
my_data %>%
  count(year_of_arrest) %>%
  ggplot(aes(x = year_of_arrest, y = n)) +
  geom_line( color="grey") +
  geom_point(shape=21, color="black", fill="#69b3a2", size=2) +
  ggtitle("Number of Arrests in Urbana-Champaign since 2000") +
  labs(x = "Year", y = "Number of Arrests")
```



Based on this graph, we can see that 2003 has the highest number of arrests from 2000 to 2023. Moreover, there is a decreasing trend on number of arrests through out years.

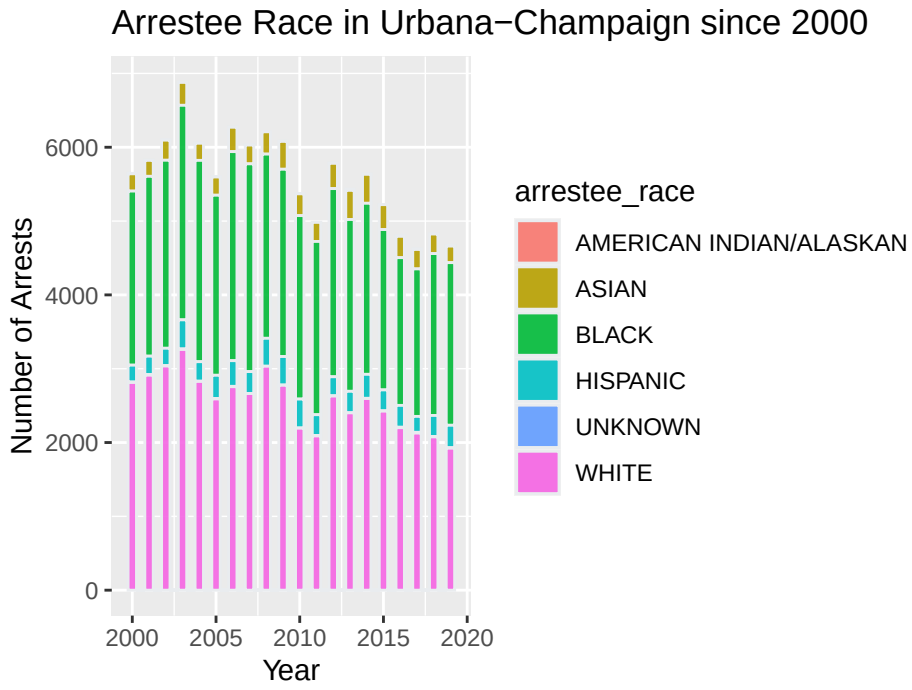
```
# Graph to see in each year arrestees sex proportion
my_data %>%
  ggplot(aes(x = year_of_arrest, fill = arrestee_sex)) +
```

```
  geom_histogram(binwidth = 0.5, color="#e9ecef", alpha=0.9) +
  ggtitle("Arrestee Sex in Urbana-Champaign since 2000") +
  labs(x = "Year", y = "Number of Arrests")
```



Based on this graph, we can see that Male contributes over 50% of arrests each year, which means that MALE is more likely to got arrested compared with FEMALE.

```
# Graph to see in each year arrestee race proportion
my_data %>%
  ggplot(aes(x = year_of_arrest, fill = arrestee_race)) +
  geom_histogram(binwidth = 0.5, color="#e9ecef", alpha=0.9) +
  ggtitle("Arrestee Race in Urbana-Champaign since 2000") +
  labs(x = "Year", y = "Number of Arrests")
```



Based on this graph, we can see there BALCK and WHITE contribute over 80% arrests. We can roughly see that WHITE contributes a little more than BLACK.

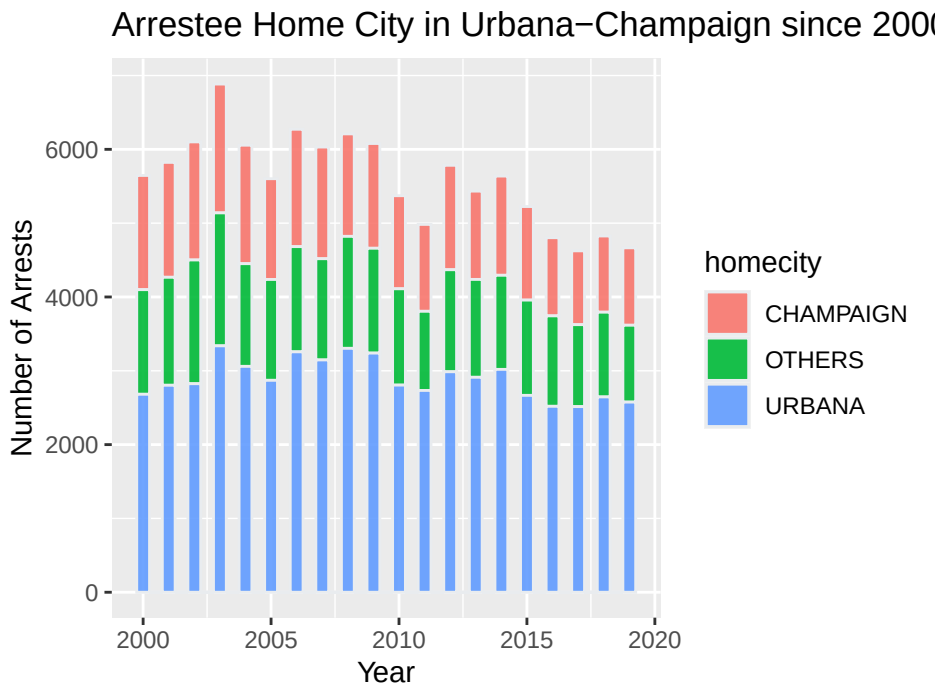
```
# Check CHAMPAIGN spelling
unique(str_extract_all(my_data$arrestee_home_city, pattern = "\\bCHAMPA\\w*", simplify = T
```

```
      [,1]
 [1,] ""
 [2,] "CHAMPAIGN"
 [3,] "CHAMPAING"
 [4,] "CHAMPAGIN"
 [5,] "CHAMPAAIGN"
 [6,] "CHAMPAIGNN"
 [7,] "CHAMPAIGH"
 [8,] "CHAMPAIG"
 [9,] "CHAMPAGN"
[10,] "CHAMPAIGGN"
```

```
## Check URBANA spelling
unique(str_extract_all(my_data$arrestee_home_city, pattern = "\\bURBA\\w*", simplify = TRU
```

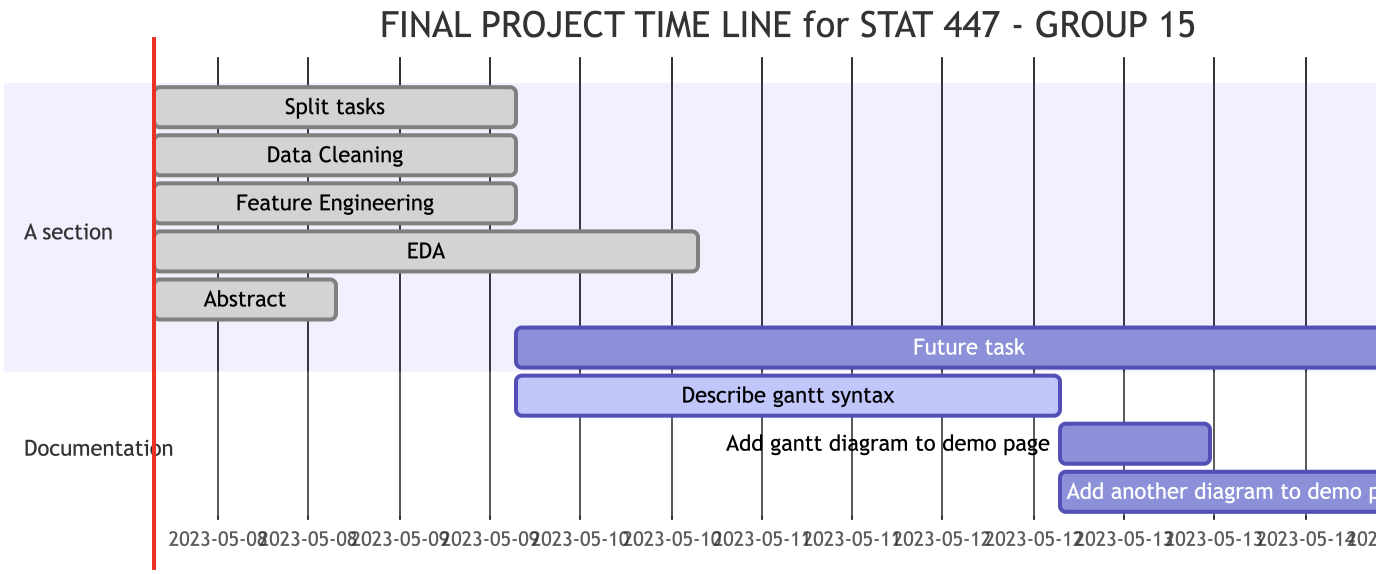
```
     [,1]
[1,] "URBANA"
[2,] ""
[3,] "URBAAN"
[4,] "URBANDALE"
[5,] "URBANQA"
[6,] "URBANAI"
```

```
[7,] "URBAN"

## Replace wrong spelling
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "\\bCHA
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "URBAAN
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "URBANQ
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "URBANA
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "URBAN"
my_data$arrestee_home_city = str_replace_all(my_data$arrestee_home_city, pattern = "URBANA

# mutate a column specify Champaign or Urbana or other home cities.
my_data %>%
  mutate(homecity = ifelse((arrestee_home_city == "CHAMPAIGN" | arrestee_home_city == "URB
## Graph to show proportions of arrestee home city in each year
  ggplot(aes(x = year_of_arrest, fill = homecity)) +
  geom_histogram(binwidth = 0.5, color="#e9ecef", alpha=0.9) +
  ggtitle("Arrestee Home City in Urbana-Champaign since 2000") +
  labs(x = "Year", y = "Number of Arrests")
```



Based on this graph, we can see that most arrestees are from URBANA. Arrestess from CHAMPAIGN and Other home cities roughtly contribute the same to the total number of arrests in each year.

0.5. Time Line



1. Contribution

Xiangyu Jin is responsible for Explanatory Data Analysis: 50%

Vinayak Bagdi is responsible for Abstract, Introduction and Related Works: 50%

References

Guido Vittorio Travaini,Federico Pacchioni, Silvia Bellumore, Marta Bosia, Francesco De Micco (2022). *Machine Learning and Criminal Justice: A Systematic Review of Advanced Methodology for Recidivism Risk Prediction.*

Umair Saeed (2015). *Application of Machine learning Algorithms in Crime Classification and Classification Rule Mining.* Umair Saeed,Muhammad Sarim, Amna Usmani, Aniqa Mukhtar.

Varun Mandalapu Lavanya Elluri PV (2023). *Crime Prediction Using Machine Learning and Deep Learning: A Systematic Review and Future Directions.*

Affiliation:

Xiangyu Jin (xjin13)
Department of Statistics
E-mail: xjin13@illinois.edu

Vinayak Bagdi (vbagdi2)
Department of Statistics
E-mail: vbagdi2@illinois.edu

Journal of Statistical Software
published by the Foundation for Open Access Statistics
MMMMMM YYYY, Volume VV, Issue II
doi:10.18637/jss.v000.i00

http://www.jstatsoft.org/
http://www.foastat.org/
Submitted: yyyy-mm-dd
Accepted: yyyy-mm-dd