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Deep Learning of Scene-Specific Classifier for Pedestrian Detection in Dubai

by

Abduljalil Alolama

A Capstone Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Professional Studies:

Data Analytics

Department of Graduate Programs & Research

Rochester Institute of Technology

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Master of Science in Professional Studies:

Data Analytics

Graduate Capstone Approval

Student Name**: Abduljalil Alolama**

Graduate Capstone Title**: Deep Learning of Scene-Specific Classifier for Pedestrian Detection in Dubai**

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Member of committee

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Foremost, I would like to express my gratitude to Allah for allowing me to have this chance at this degree at my age and bless me with good family who always support me in my endeavors. I would also like to express my thanks to Rochester Institute of Technology for allowing me to join its society and giving me the honor to graduate from one of the best master programs in the world. Special thanks to all professors for their patience, motivation, enthusiasm, and immense knowledge. Especially, Dr. Ehsan for his guidance as a mentor, which helped me in all the time of capstone project, and Dr. Sanjay for prioritizing student's wellbeing and counsel over his vacation, which I admire greatly. Last but not the least, I would like to thank My colleagues and classmates, I am truly grateful to you.

Abstract

The performance of a generic pedestrian detector varies based on the data fed to it; when applied to a specific scene, its performance degrades dramatically, which require the detector to be fed with the specific target in mind so that it can produce the desired predictions and detect for the user the specified target. In this paper, I propose to feed the automated specialization of a scene-specific pedestrian detector, with multiple sources from pictures to even videos beginning with a generic video surveillance detector, however manually marking samples to ease the process, as the knowledge accumulated from the master program is still insufficient to produce high-end automated sample marking for the detector. The key idea is to consider a deep detector as a feature that produces a perception of the likelihood of a pedestrian being detected in the target. The system then will be fed with the manually marked samples to enhance its performance and the usage of an already existing system using the Monte Carlo sequential filter system. There has been the implementation of the pedestrian detectors in China, where it showcased the different patterns, the detector can classify and assess whether a pedestrian is present within the testing data or not. The project is truly fascinating as it shows how a machine can learn when fed with the right data and produce sensible results that lead to human renovation and up their living standards by decreasing the number of accidents related to pedestrians affecting the overall rate of accidents. “Many real-world data analysis tasks involve estimating unknown quantities from some given observations” as addressed by the authors within their report on Monte Carlo methods (Doucet A., de Freitas N., Gordon N.). In order to compute rational approximations, it is also important to follow numerical techniques. The techniques of Monte Carlo method (MCM) are powerful tools that allow us to achieve this objective (Andrieu C., Doucet A., Punskaya E.).

Keywords: *Pedestrian accidents, Monte Carlo method*, *Deep learning, Scene specific, detector*

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Chapter 1: Introduction

1.1 Background

Pedestrians accidents are the number one priority that Dubai police authority tries to minimize at all cost, since most of the accidents related to pedestrians lead to certain death, which is why the authority aspires to minimize this type of accident by all means possible to ensure the safety of Dubai citizens are treated as top priority in order to sustain life and spread happiness within the city, contributing the vision set by His Highness Sheikh Mohammad Bin Rashid Al Maktoum, ruler of emirate of Dubai and UAE prime minister. To tackle this issue, the authority set their employees into finding and researching for the best methods to reduce the number of casualties resulted from pedestrians related accidents, hence this study will try to tackle the issue and provide a solution using the Monte Carlo Method. Monte Carlo method, also known as the Monte Carlo simulation, is a mathematical technique, which is used to estimate the possible outcomes of an uncertain event. The Monte Carlo Method was invented by John von Neumann and Stanislaw Ulam during World War II to improve decision making under uncertain conditions. It was named after a well-known casino town, called Monaco, since the component of chance is core to the modelling method, similar to a game of roulette. Since its introduction, Monte Carlo method have assessed the impact of risk in numerous real-life scenarios, such as in Artificial Intelligence, stock prices, sales forecasting, project management, and pricing. (IBM, 2020). In addition, Monte Carlo method is utilized for long time predictions due to how accurate they are compared to other predication approaches, a simple example of how the method is used can be viewed when calculating the probability of rolling two dices, there are 36 possible amalgamations of dice rolls. It can be used by following certain steps and they are as follow:

- Set up the predictive model.
- Specify probability distribution of the independent variables.
- Run simulations repeatedly.

1.2 Statement of problem

The number of Pedestrians related accidents that occur within Dubai account for about 30% (Shahbandari, 2017) of the total percentage of accidents that occur within Dubai, these accidents being either by road unawareness, insurance gains, distracted drivers, weather conditions, etc. (J.L.Castro, M.Delgado, J.Medina, & M.D.Ruiz-Lozano, 2010) which can be considered as a high rate recorded for a city that aspires

to become the world happiest city, (Smart Dubai, 2018), as happiness is aligned with a sense of safety, hence this study has been created to generate a theoretical based program that minimizes pedestrian-related accidents through the usage of data analytics and its many tools. Using deep learning techniques, specifically that of a scene-specific classifier, to detect how accurate are the reasons known for the pedestrian-related accidents, and how it can be prevented using produced results from the study to minimize the number of pedestrian-related accidents. The main problem to be solved is as follow:

- How accurate are the reasons known for the occurrence of pedestrian-related accidents?
- What are the human factors that allow such accidents to occur?
- How can I utilize data analytics in reducing the number of pedestrian-related accidents?

1.3 Project goals

Pedestrian detection is a complex job with a great deal of interest in computer vision. Important progress has been made in recent years. However, the efficiency of detectors depends a lot on the data set of training. The main goal of this project is to establish a pedestrian detector that can differentiate whether the pictures and videos fed to it contain the marked objects of interest, i.e., pedestrians, and calculate how accurate are the reasons for pedestrians related accidents since insurance companies suffer from intentional accidents done by their customers to benefit from their insurance, increase the number of fatalities, disregard the safety measures set by the law enforcement entities within said city, etc.

1.4 Methodology

This paper aims to study the deep learning of scene-specific classifiers for pedestrian detectors and how accurate it is, and how applicable it is in Dubai to reduce the number of pedestrian-related accidents. In recent years, the particle filtering area has seen an upsurge in interest, and many improvements to the basic techniques have been proposed in the literature following this upsurge (Godsill S., Clapp T.). However, it is pertinent to understand that without data, there can be no foundation to base our study upon, so the first approach is to research for datasets available on the subject of pedestrian detector that can be used for this study, as the Gantt chart shows in the below section titled “Project timeline” duration of 10 days was assigned as this task requires a lot of time and focus when researching for the right dataset to work with. Next, the methods to be implemented and tested on the dataset by segmenting the dataset, profile it, apply some data mining techniques to solve the questions imposed above. Then I will be checking which pedestrian detector approach is best suited to apply in Dubai to achieve its strategy

toward becoming the happiest city on Earth (Smart Dubai, 2018). The Sequential Monte Carlo, also known as SMC, is initially based on tracking and vision applications. These techniques are now very common and have had a substantial effect on nearly all fields of signal and image processing related to Bayesian dynamic models. The below figure showcases how a Sequential Monte Carlo approach works (François Vallee, Jean-François Toubeau, Zacharie De Greve, & Jacques Lobry, 2014):

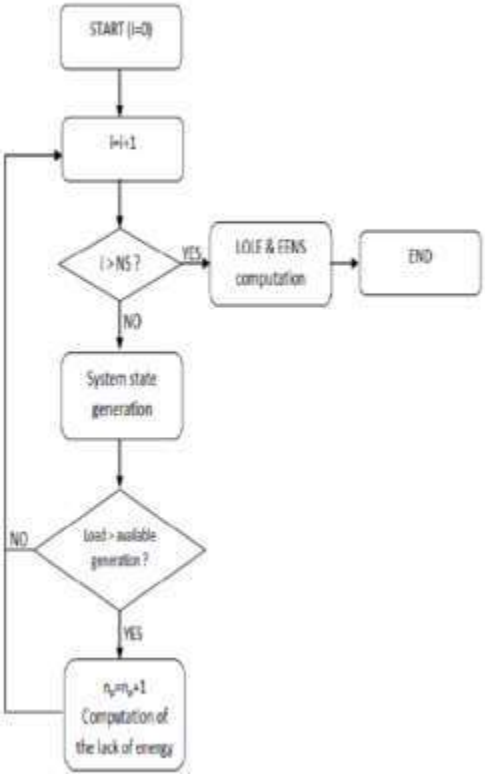

Figure 1: SMC approach implemented in sampling.

The tools that can be utilized for the study are the following, with each entailing what they will be used for:

- R studio: will handle the dataset and will host the different data analytics and data mining techniques to visualize and answer the imposed questions.
- Python: will handle the dataset in case r does not comprehend the amount of data.
- Google scholarly search engine: research the many articles, codes, reading materials, datasets, etc.
- Lecture slides from previous courses: utilize the codes and techniques taught, the writing methods, and how to describe charts and plots.

1.5 Limitations of the Study

As with any machine learning solution, finding the best model is not the only concern to deal with, there are multiple other factors that affect the progression of this study. For example, the number and the size of records in the dataset could affect the result of the model, that could lead to tune the model to overfitting. In addition, the fewer the features in the dataset it could confuse the model in predicting the wrong value in a classification problem more than the regression problem.

Chapter 2: Literature Review

While the popularity of walking has diminished, it remains a very widely used means of transportation. People of almost all ages, regardless of their gender, set against a backdrop of increasingly rising vehicle numbers and traffic levels. Walking almost inevitably involves crossing a highway, where the pedestrian's desire line conflicts with the higher speed and lower motor vehicle vulnerability. This can result in either delay or danger for the pedestrian when speeds and/or flows are high (Martin, 2006). Collision among moving objects in space is one of the most common risks in daily life (J.L.Castro, M.Delgado, J.Medina, & M.D.Ruiz-Lozano, 2010). Pedestrians may potentially act in a variety of ways when crossing the road. For example, by waiting for the signal to indicate that they should cross or waiting for a large enough gap in the traffic to negotiate the road safely, they could follow safety rules and procedures. Alternatively, without waiting for the signal, they might cross. They could only accept small traffic gaps and/or could walk to the center of the road and wait for a gap in the traffic there. “Learning scene-specific detectors can be considered as a domain adaptation problem. It involves two distinct types of data: xs from the source dataset and xt from the target scene, with very different distributions ps(xs) and pt(xt). The source dataset contains a large amount of labeled data while the target scene contains no or a small amount of labeled training data.” (Xingyu Zeng, Wanli Ouyang, Meng Wang, & Xiaog, 2014).

The Monte Carlo method requires the probability density functions of the data must be known or assumed, then the procedure is intermittently repeated until the result reaches a form at which its probability density function becomes near to a bell-shaped curve, because this will enable further dispensation of the results with statistical methods. (WACH) furthermore, Wach continues to elaborate that the Monte Carlo method was from the point of view of the reconstruction of road accidents. This method consists in performing repeated calculations in the same deterministic mathematical model, but by choosing the specific parameters on a pseudo-random basis within predefined uncertainties. The results of the calculation were presented as a density function of similar probability, from the point of view of its graphical representation, to a bell curve; such a form facilitates the statistical interpretation of data and uncertainties. In particular, it is possible to reduce the range of results by rejecting extreme areas of low probability. Examples were presented, centered on the questions of the calculation of speeds before impact, the location of the collision on the road and the kinematic analysis of the phase before impact of a pedestrian accident. (WACH).

Author Benjn states that “For the purposes of public safety, it is interesting to unravel important features. Often times, many features are out of the department of public safety's control -- there are few to no design variables that they can change to help them reduce crash rates.” (Guyen, 2019). Within his paper, he further indicates that using the data at hand and doing something efficient might save countless lives and money and avoid horrible accidents that can take people live. Furthermore, he insists that understanding the reasons behind such accidents and spreading awareness is the ultimate wat one can avoid getting into such accidents and urges authorities to further spread their awareness message through broadcasting systems to young drivers to be extra careful and mindful of their surroundings when driving and to not avert their attention from the road by playing with their mobile phones or chatting with their peers. The author then showcases certain exploratory data analysis using r studio and creating a map that can showcase the number of accidents from the dataset used within their report.

Another study on a different method from deep learning, the self-learning method for pedestrians which can learn by itself and detect pedestrians as the authors of the journal titled “self-learning scene-specific pedestrians detectors using a progressive latent model”. The authors further elaborate throughout this journal, a self-learning approach to addressing the problem of scene-specific pedestrian detection is proposed, with no human annotation involved. The self-learning strategy is implemented in 3 phases: object discovery, object enforcement, and label propagation. (IEEE, 2017) With the pervasive use of cctv, the demand for automatically detecting objects, such as pedestrians, has grown exponentially. Recent methods for detecting objects in images have made encouraging progress. Their efficiency in video sequences, however, is limited for the reasons listed: 1) Supervised detector learning for different scenes necessitates repeated human effort; 2) Offline-trained detectors typically degrade as the scene or camera changes; 3) The detectors do not take into account scene-specific cues such as object resolution, occlusions, and background structures. (IEEE, 2017).

Chapter 3: Project Description

This study will go through conducting Exploratory data analysis (EDA) and some visualization to understand the selected dataset for the study, find its tendencies, patterns and insights and turn them into sensible data that can progress the objective of this study. There are multiple steps to be taken to have a sensible data produced from the selected dataset, the dataset will be going through some cleaning, visualization, test some machine learning algorithms if possible, that will help to build new smart solution depending on the observation and the outcome.

3.1 Data Collection

Collecting a dataset for this particular topic was not an easy task, a lot of time was spent in researching and trying to identify the best dataset that will suit this study. Many open data sites and resources were disregarded when researching for this study as they tended to have multiple defects that would be very hard to fine tune it to suit the study. The relevant dataset consisting of images that fit the needs for this project was finally found and thankfully did not require much fine tuning as the others would have taken far more time to fine tune. Most of the images found had both the regular pedestrians that occupy the streets be it people walking along the road or bikers who are even more prone to accidents since they sometimes they must ride alongside cars on sub roads.

3.2 Dataset general information

For this study, I have found a dataset containing around 2.5 GB worth of pictures and videos that contain pedestrians and other transportation means. It showcases how close those pedestrians were to make an accident, made an accident and the reasons those accidents occurred in the first place. Through this study, I will be applying all learned codes and scripts either through R studio or Python and then will integrate the Sequential Monte Carlo approach and divide the dataset into two sets:

- Trainset: this set will contain a more significant proportion of the dataset at hand, as this will teach the model and ensure that it produces accurate results when run against the test set.

- Test set: this set will have a lesser proportion from the training set. It will be utilized to determine whether the model at hand is accurate and can be used for this study to limit accidents related to pedestrians.

The dataset retrieved from the following source (Bayturk, 2020) and (St. Paul Police station, 2016) have some of the following categories:

- Pedestrians: 1159 pictures
- Bikes: 1267 pictures
- Dataset from St. Paul Police department containing data on pedestrians and bike accidents in 2016.

This will be utilized to study deep learning for scene-specific classifiers using the Sequential Monte Carlo approach, hence producing useful scripts that can be utilized to reduce the number of pedestrians-related accidents and contribute to the UAE-Dubai vision of becoming the world happiest city and safest city on Earth.

Chapter 4: Project Analysis

4.1 Data Preprocessing

First step to understand the data will be through getting the packages in R studio called, the following are the required packages:

- Ggplot2
- Tidyverse
- Class
- Skimr
- Ggthemes
- Patchwork
- Corrplot
- Dplyr
- Rsample
- DescTools
- sjPlot
- rpart
- rpart.plot
- ranger
- lightgbm

These tools will help with the visualization of the dataset at hand and provide the reader with a better understanding of the data and what it represents.

```
#install.packages("lightgbm")
#install.packages("ggcorrplot")
library(class)
library(ggcorrplot)
library(tidyverse)
library(skimr)      # skimming data frames
library(ggthemes)
library(patchwork)  # combine separate ggplots into the same graphic
library(corrplot)
library(dplyr)
library(rsample)    # initial_split()
library(DescTools)  # PseudoR2()
library(sjPlot)     # tab_model(), print regression models as HTML table
library(caret)      # confusionMatrix()
library(mlr)        # Machine Learning in R (for SVM)
library(rpart)      # Recursive Partitioning and Regression Trees
library(rpart.plot)
library(ranger)     # Random forest
library(lightgbm)   # LightGBM (GBDT: gradient boosting decision tree)
```

Figure 2: retrieving the packages in R

The next step is to get the data columns available in the dataset.

```
[1] "Crash.Type"
[2] "Report.Made."
[3] "Date...Time"
[4] "Case.Number"
[5] "District"
[6] "Crash.Location"
[7] "Lanes.Of.Traffic"
[8] "Signal.Present."
[9] "Speed.Limit.Of.Road..MPH."
[10] "Road.Type"
[11] "Synopsis"
[12] "Ticket.Arrest."
[13] "Citation.To"
[14] "Pedestrian.Age"
[15] "Pedestrian.Gender"
[16] "Pedestrian.City.Of.Residence" [17] "Pedestrian.Zip.Code"
[18] "Biker.Age"
[19] "Biker.Gender"
[20] "Biker.City.of.Residence"
[21] "Biker.Zip.Code"
[22] "Driver.Age"
[23] "Driver.Gender"
[24] "Driver.City.Of.Residence"
[25] "Driver.Zip.Code"
[26] "Injury.to.Pedestrian."
[27] "Level.of.Injury.to.Pedestrian" [28] "Pedestrian.to.Hospital."
[29] "Injury.to.Biker."
[30] "Level.of.Injury.to.Biker"
[31] "Biker.to.Hospital."
[32] "Crash.Lat.Long.Location"
[33] "Count"
[34] "District.Council...Map"
[35] "Council.Ward"
```

Figure 3: dataset column names

4.2 Dimension reduction

Within this step, there will be a reduction in the number of columns in the dataset by removing the ones that were unnecessary, the ones that were most prominent were kept. Columns that would assist the study in extracting knowledge and are the most important insights to answer the raised questions are not

touched. Having the dataset reduced to the needed information, the next step to follow will be to cleanse the dataset and ensure there are no outliers that would deviate the accuracy of the dataset when moving to the modeling step to get answers to the imposed questions earlier on. Some general modifications were implemented in order to simplify the process of visualizing the data and be able to create more cooperative charts using the many options provided in the libraries called within R studio. Tableau was going to be used for this study, however, due to insufficient time and physical resources it was abandoned and was not carried over into this project, albeit in the future it would have been great to utilize Tableau within this study as it provides numerous chart types and can elaborate information to readers more fluently.

4.3 Cleaning the Dataset

Next is cleansing the dataset, which is per what have been taught throughout the program to be a core step before being able to decipher or have some sense from the data that exist within the dataset chosen for this study. In this step, the dataset will undergo some modifications and some data will be removed such as noisy data, missing values, duplicate data, outliers, etc. as any source found through the complex network called the “internet”, the dataset comes with unwanted bugs, that could mess with the statistical results and the accuracy of Monte Carlo method and it should be removed or filled using any of the known statistical methods. In the earlier step, the dataset columns were reduced, and some modification took place resulting in the having featured columns remain, which took a considerable amount of time to generate a clean dataset with only the desirable data.

4.4 Data Visualization

This section will contain some visualization of the cleansed dataset in order to learn the patterns the data show, gain knowledge on how the columns correlate to each other, and insights that will assist the study into figuring out answers to the imposed questions. Furthermore, the dataset will compare the number of accidents related to pedestrians and bikers since they both are the most prone to get injured severely when contacting cars driving recklessly or at high speed and not complying to the stated laws and regulations within the area. The first thing to understand is the most frequent type of accident that occurs within the dataset retrieved St. Paul Police and get an idea how many times it occurs.

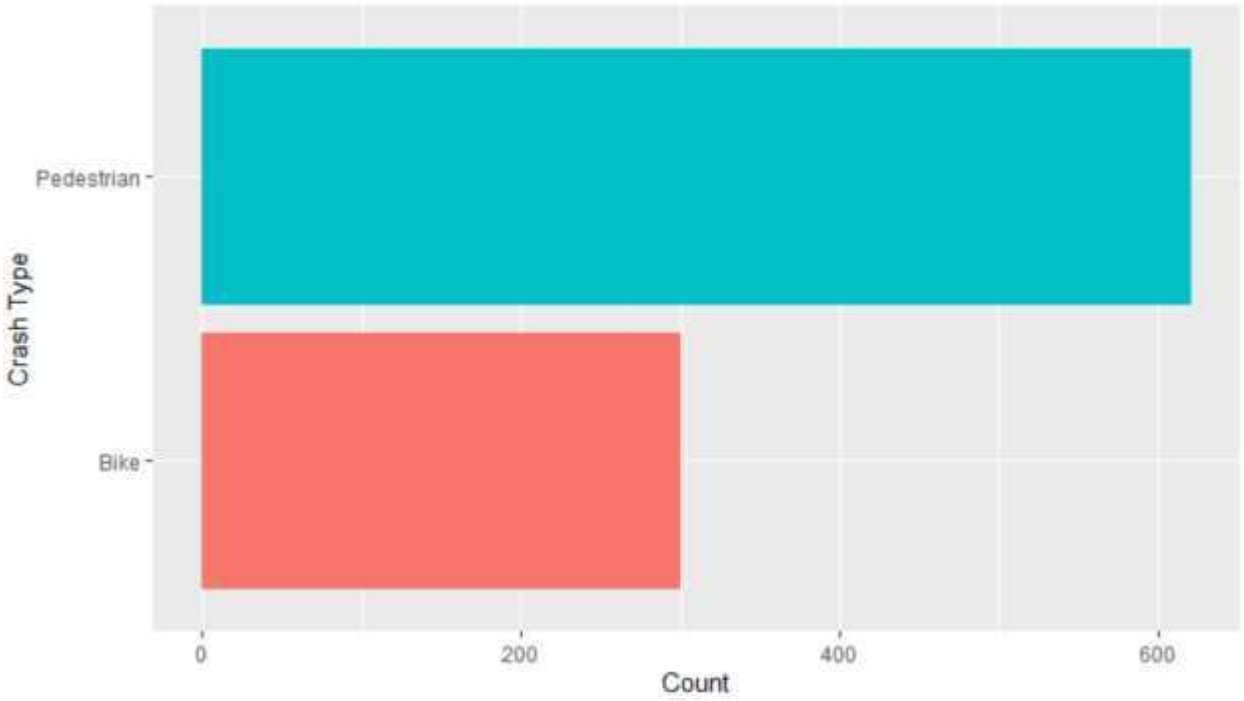

Figure 4: the predominant type of accidents that occur within the dataset

It can be observed that the two most frequent kind of accidents are pedestrians and bike riders. Furthermore, the number of accidents related to pedestrians are double of that of the bike riders, which only proves that pedestrians are far more in danger than bike riders. Moreover, this gives us insight at how much pedestrians are suffering from road accidents due to car owners not complying to the enforced laws and regulations. This creates the question of how much did the police investigate those accidents and how much did they catch on their patrols? To get an answer, the data need to showcase the different districts available within the dataset, and they are as follow:

- central district
- eastern district
- metro transit pd
- state patrol
- transit
- western district

The following figure showcases the number of accidents the police responded to in each district respectively:

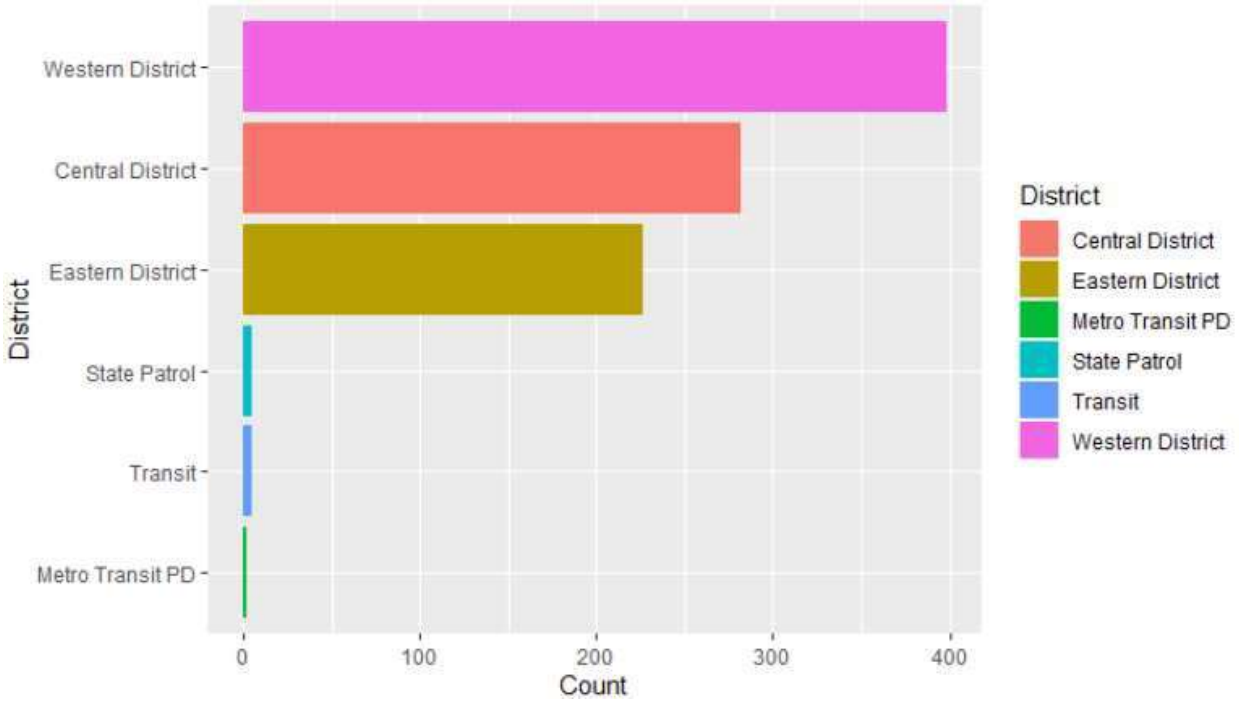

Figure 5: response from each police district for the occurring accidents

It can be surmised that the western district is the most responsive of the 6 districts, whereas the metro transit pd are the least responsive of them all. This means that the western district has the highest rate of accidents occur within their district. Which begs the question, how much of these accidents relate to pedestrians and how much relate to bike riders?

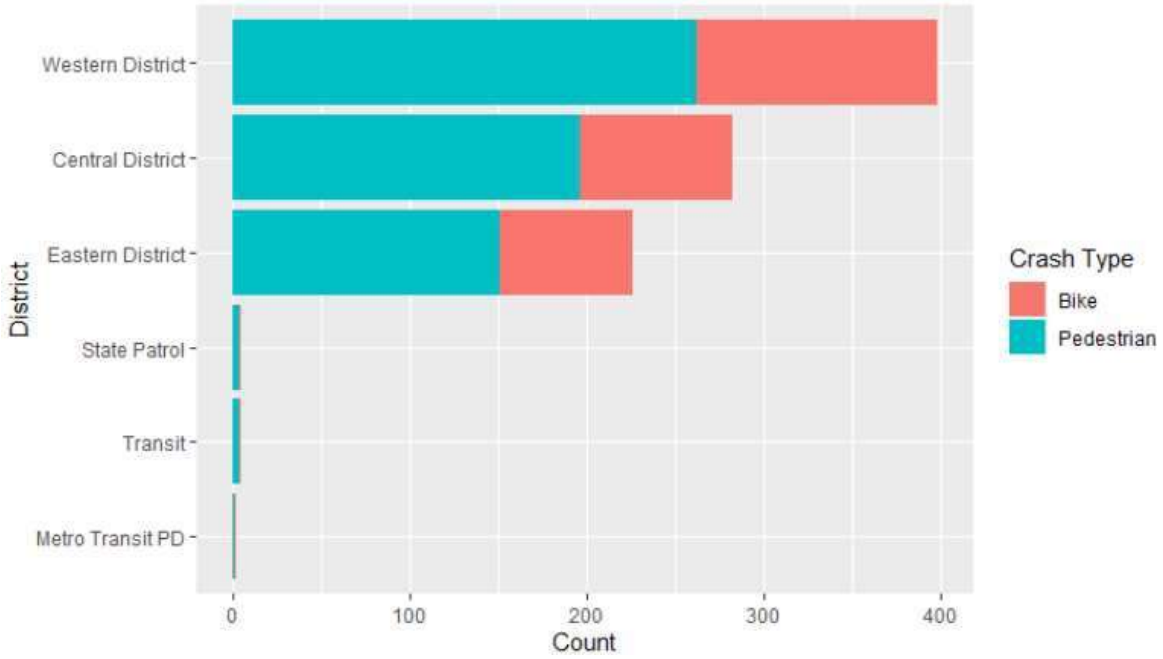

Figure 6: response from each police district for the occurring accidents relating to pedestrians and bike riders

The figure above showcases the number of accidents each district responds to, which clearly shows pedestrians have more accidents investigated than bike riders. In addition, western district takes the lead into catching those accidents and arrive at the location of the occurring accidents. On one hand, the number of accidents relating to pedestrians are high and quite frequent, on the other hand number of accidents relating to bike riders are far less than pedestrians, regardless this is quite a sad situation where pedestrians and bikers are being lost to people not adhering the laws and regulations that are set by the police authorities within each district. However, is these number of accidents are constant around the year or have different behavior based on the month or season? The figure below showcases the number of accidents relating to both pedestrians and bike riders around the year.

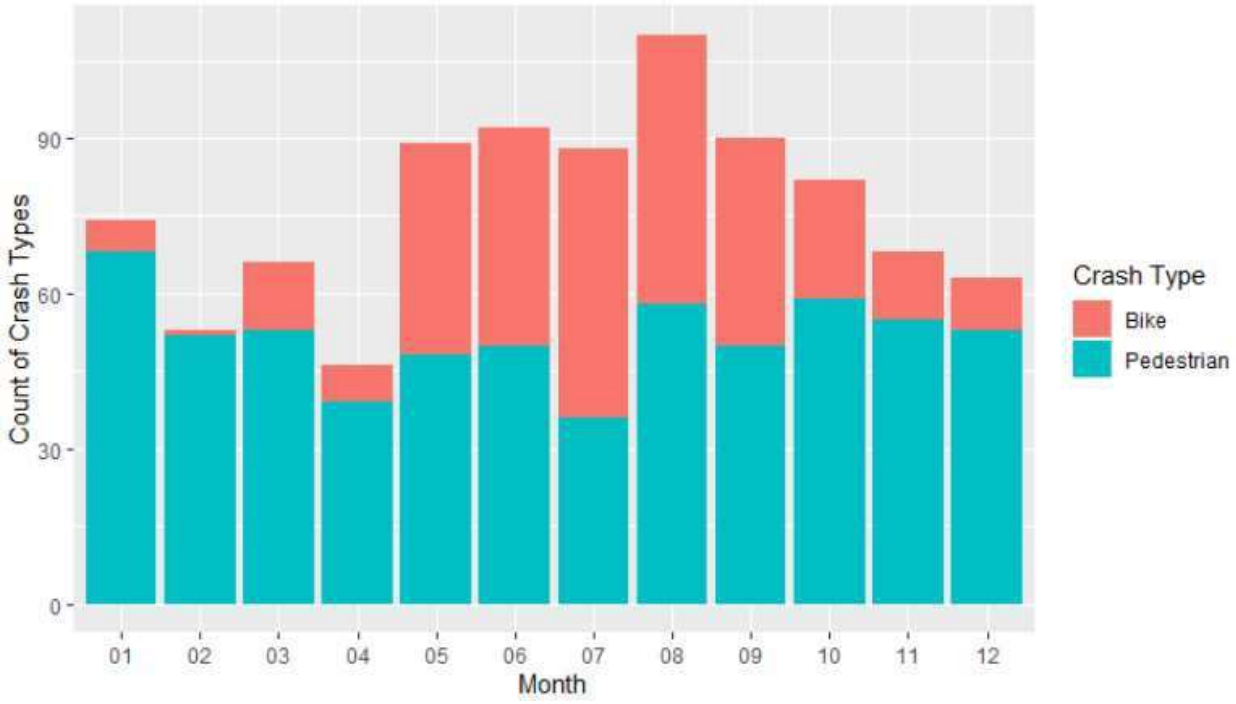

Figure 7: accidents relating to pedestrians and bike riders along the year

The figure shows the number of accidents rising in Summer more than the other seasons, it can occur due to the heat from the Sun and heat waves, or even due to road rage due to heat pressure, etc. also there is an increase in accidents in the Winter season, which can indicate that the roads might be slippery due to ice forming on the roads and crossovers, black ice which is considered the most dangerous type of ice out there, etc. hence people are not being quite careful of the roads and slipping or drivers not being

mindful of the icy roads that could affect their vehicle movements and lead to instant crash into innocent pedestrians and bike riders.

Now that I got the monthly rate of accidents relating to pedestrians and bike riders, let us find out the number of accidents that occur hourly throughout the day and at what time accidents peak through the day:

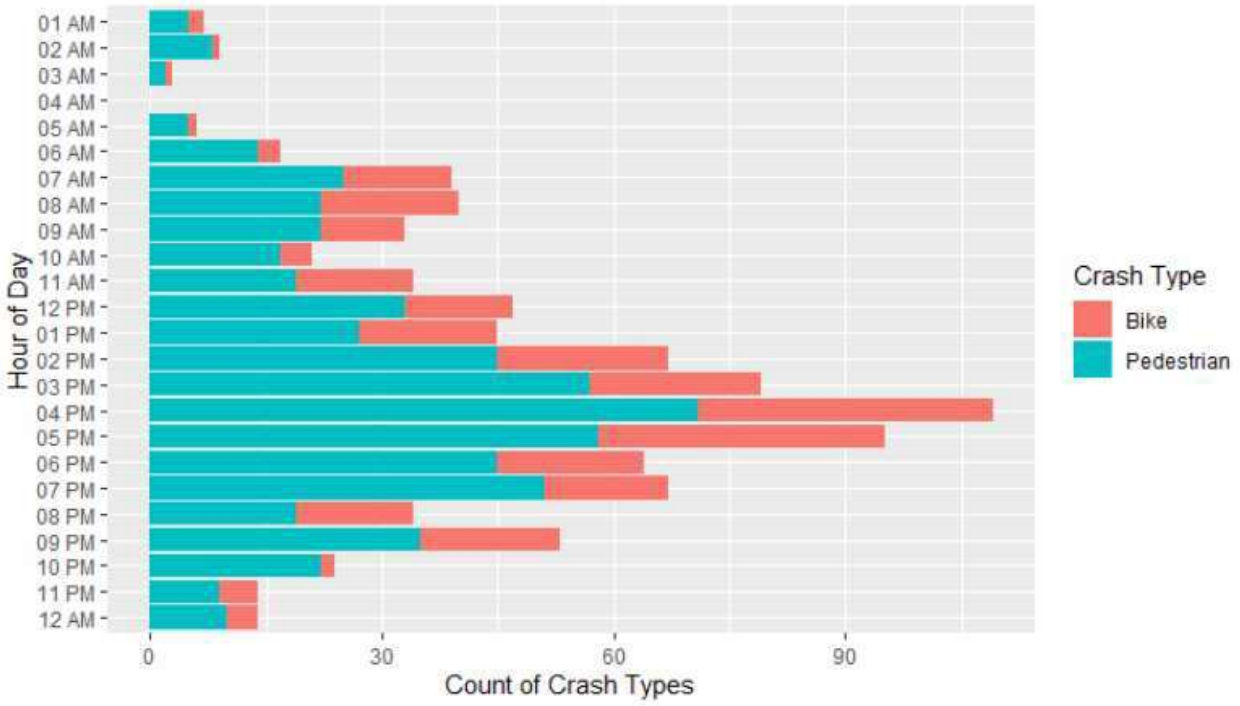

Figure 8: accidents occurrence per hour

The figure indicates that accidents peak between 2 pm and 7 pm, hence allowing us to understand that it is beneficial to install more security toward those time periods and understand the reason behind accidents peaking at that duration.

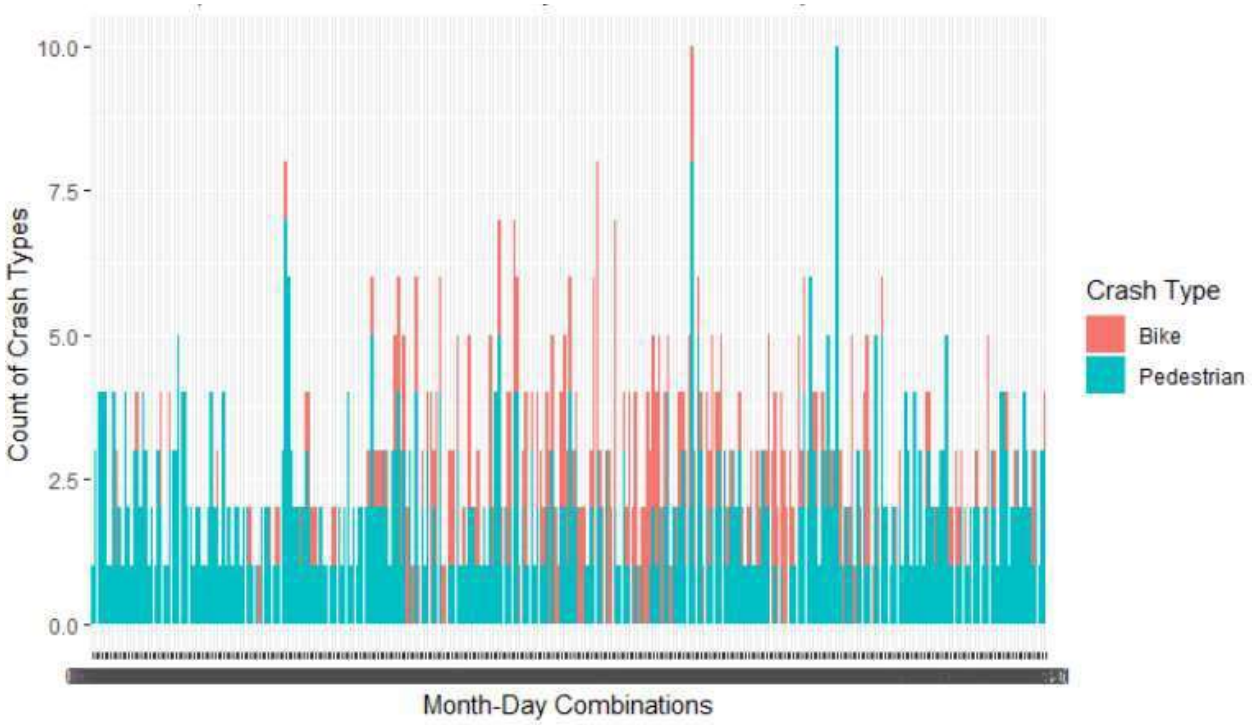

Figure 9: accidents occurrence per day and month combined.

This figure does not lead to anything conclusive as to the reason why accidents occur during those times of the day and month, hence they will be abandoned and move to the next step which is does age mean anything in these sad accidents? The figure below presents the relationship between age and pedestrian and bike riders related accidents.

Figure 10: age relationship with accidents related to both pedestrians and bike riders

It seems that the younger the driver is, the more accidents they tend to make, which does make sense logically speaking since with age comes experience and patience, and recklessness goes down. The chart also indicates that more accidents occur around the age of 25. It would seem that it is better to spread awareness toward that age category and ensure they understand the risk of driving recklessly and not paying attention toward road danger and pedestrians' safety. Now that I understood the age category at which accidents tend to occur mostly for pedestrians and bike riders, let's find the gender of those accident creators and understand how it corelates with accidents?

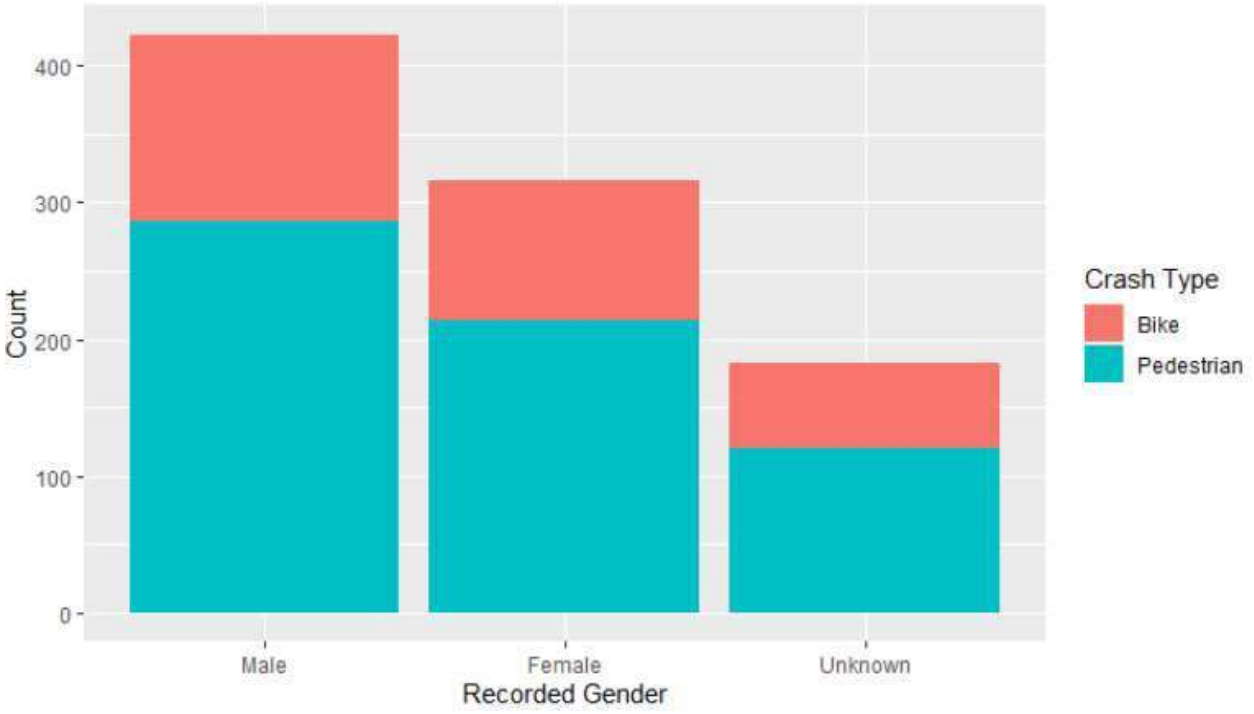

Figure 11: gender relationship with accidents related to both pedestrians and bike riders

Surprisingly, it can be seen that males are often more involved in crashes than their counterparts. Nevertheless, I would argue that there is a latent variable, which might reside in the limitation within the dataset that could unintentionally lead us to the proposed hypothesis that males are more vulnerable than females. This could be due to males being the main gender who drives more in there, since the dataset at hand does not carry information regarding the miles driven by each gender, I cannot take this into consideration due to lack of data, a simple google search proved that there are more male miles driven than female though. Onto the next exploration, how does a light signal affect the rate of accidents relating to pedestrians and bike riders?

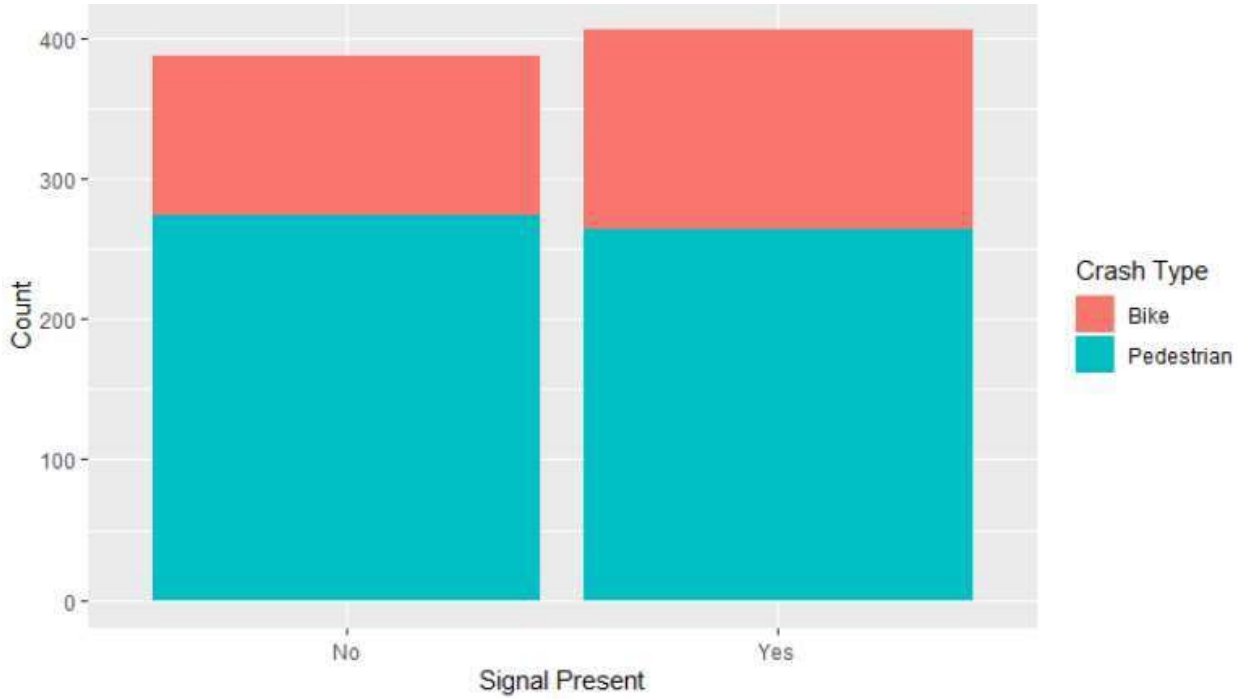

Figure 12: light signal existence relationship with accidents related to both pedestrians and bike riders

In the figure above, it can be assumed that light signals existence can hardly mean any difference when comparing the number of accidents occurring with or without light signals. This indeed pose a problem, as it implies that whether the signal is there or not, accidents occur almost similarly, hence people are not adhering to the enforced laws, which needs to be regulated and reformed even further.

Finally let us look at the type of injuries occurring for both Pedestrians and Bike riders: the figure below showcases the level of injury caused by pedestrian accidents, it is clear that most accidents result in minor injuries, then possible injury and the least being unknown, hence the number of fatalities are considerably low, however this does not mean that having the pedestrians get injured is any good, in order to have a more effective and accident free city, it is crucial that youngsters learn the dangers of driving recklessly which could lead to injuring the bystanders and even lead to fatalities.

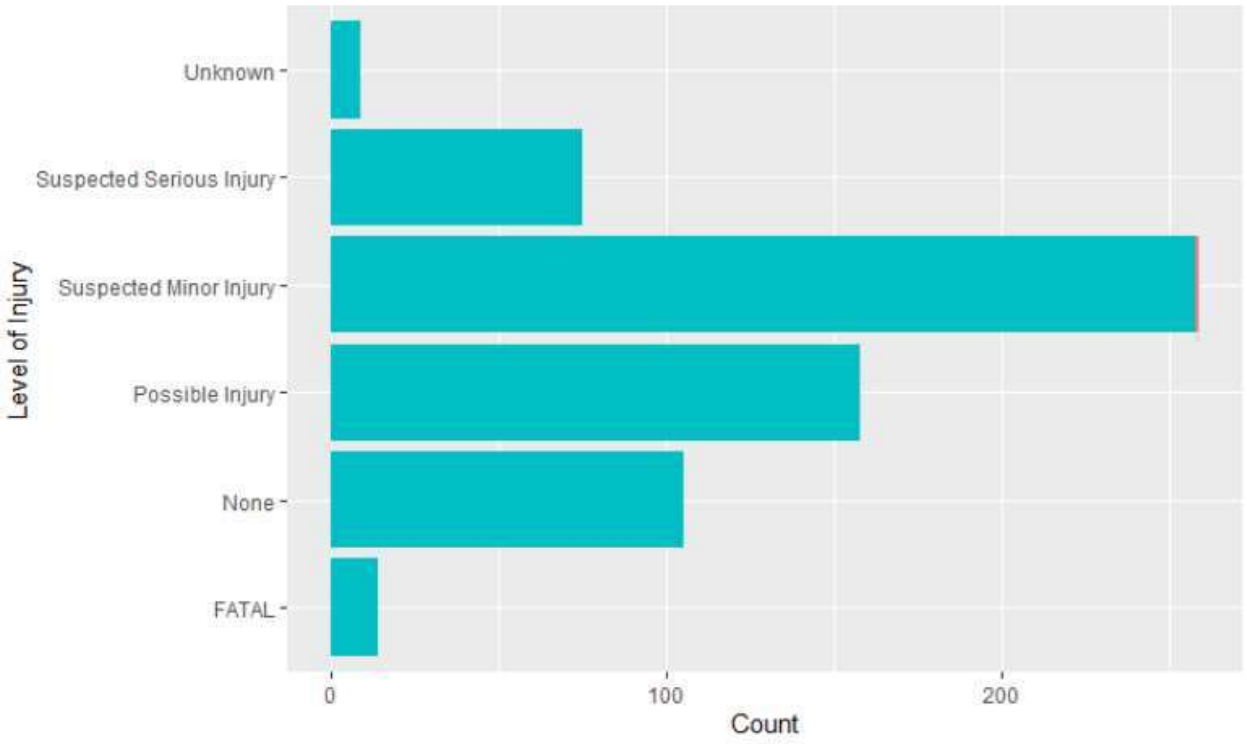

Figure 13: type of injury with accidents related to pedestrians

Next will be the type of injuries for bike riders: it is luckily better for bikers whereas their rate of being injured is higher than that of pedestrians.

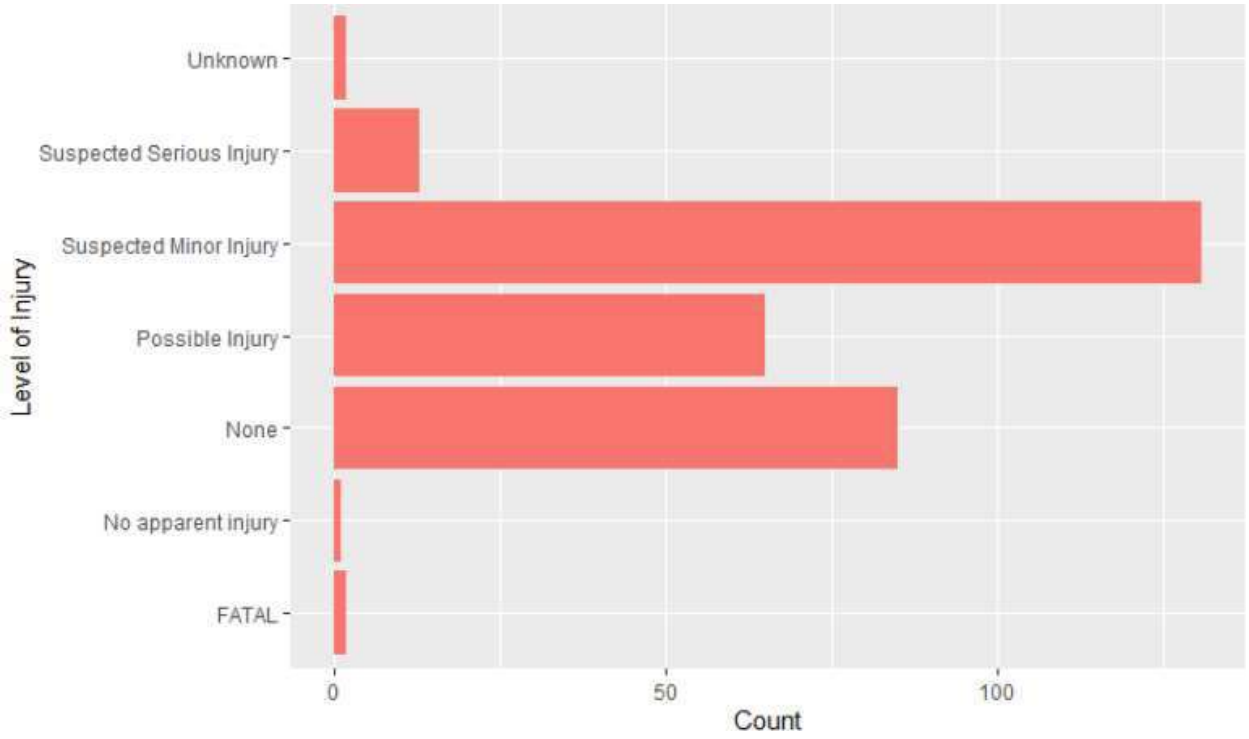

Figure 14: type of injury with accidents related to bike riders

4.5 Results

For starters, it is apparent throughout the exploratory data analysis that pedestrians are more prone to get in an accident than bikers. The yearly bar chart indicates that accidents occur mainly in summer and winter season but occur less frequently in spring and fall. Furthermore, the hour bar chart presented for the study the knowledge of having accidents occur between 2 pm and 7 pm, which provides us with a hint on how to solve these accidents through spreading monitoring devices and deputies to resolve the accidents and ensure the pedestrians and bikers are safe and sound. In addition, younger male drivers are the ones that initiate accidents more than female drivers, and finally signals have zero effect on the rate of accidents as shown earlier throughout the EDA steps.

4.6 Data Modeling

Earlier through the study, the dataset has been cleansed, missing values were dealt with, columns with unnecessary data have been removed, and there are no outliers or duplicate that could have been found after the cleansing. Therefore, the dataset is ready for the next step, which is modeling. In this step, I will be running the cleansed dataset into a modeling sequence going with both Deep learning and Monte Carlo method to check whether the detector can accurately detect pedestrians and reduce the number of pedestrians and bikers related accidents. But first, the dataset needs to be split into two sets before initiating any steps into the selected model.

4.6.1 Data Split

Before running the Monte Carlo method on the dataset, the dataset will be split into two sets, the training set with 80% and the testing set with 20%. The size of the data set for training have been increased due to the dataset being small and limited, and the test set was set to take the remaining portion of the dataset.

4.6.2 Modeling

Deep learning and scene specific detectors are quite hard to implement if the idea in itself is not understood well, so in order to prepare myself for this, a lot of research have been done to understand this part and perform it well as mentioned in the literature review earlier on by the authors of paper on

deep learning of scene specific detectors (Xingyu Zeng, Wanli Ouyang, Meng Wang, & Xiaog, 2014), using the following formula will help immensely through applying the method onto the training set and then comparing it to the testing set to check how accurate the results are.

$$\mathbf{h}_1 = \sigma(\mathbf{W}_1^{\mathrm{T}}\mathbf{f} + \mathbf{b}_1),$$
$$\mathbf{h}_2 = \sigma(\mathbf{W}_2^{\mathrm{T}}\mathbf{h}_1 + \mathbf{b}_2),$$
$$\tilde{\mathbf{c}} = softmax(\mathbf{W}_4^{\mathrm{T}}\mathbf{h}_2 + \mathbf{b}_4),$$
$$\tilde{y} = \sigma(\mathbf{w}_3^{\mathrm{T}}\mathbf{h}_2 + \mathbf{w}_5^{\mathrm{T}}\tilde{\mathbf{c}} + b_5),$$
$$\tilde{\mathbf{h}}_1 = \sigma(\tilde{\mathbf{W}}_2^{\mathrm{T}}\mathbf{h}_2 + \tilde{\mathbf{b}}_2),$$
$$\tilde{\mathbf{f}} = \sigma(\tilde{\mathbf{W}}_1^{\mathrm{T}}\mathbf{h}_i + \tilde{\mathbf{b}}_1),$$

Figure 15: formula used for the training set for the deep learning.

This formula will help the deep learning modeling as it will improve the detection rate of the scene specific by 10% as stated by the author of the paper (Xingyu Zeng, Wanli Ouyang, Meng Wang, & Xiaog, 2014). The following figure showcases how the formula will be utilized within the study and how it works.

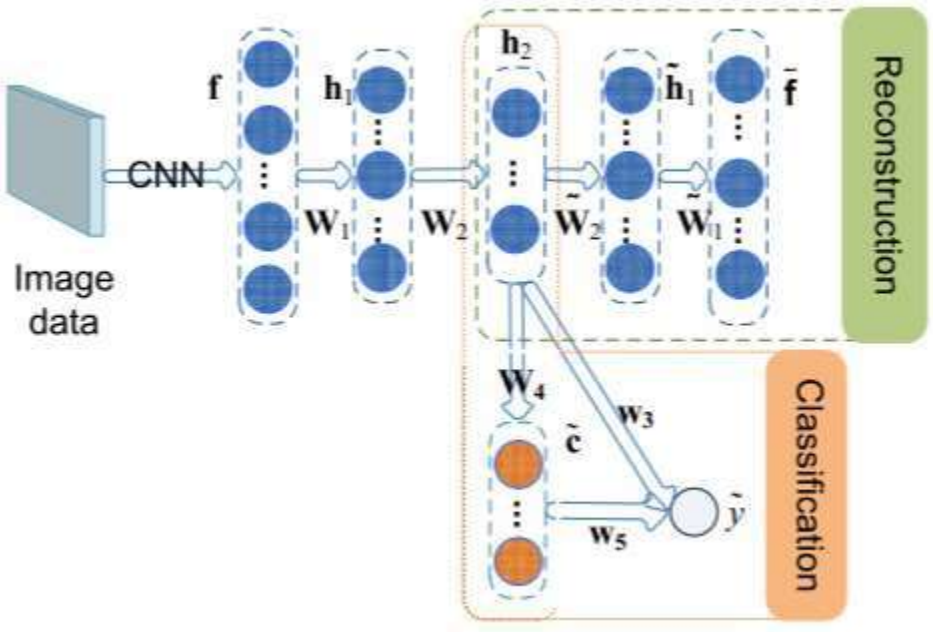

Figure 16: explanation of the formula used for the training set for the deep learning

$$\mathbf{A}''_{IN_i} = \begin{bmatrix} \cos\psi''_i & -\sin\psi''_i \\ \sin\psi''_i & \cos\psi''_i \end{bmatrix}, i = 1,2$$

Figure 17: Monte Carlo method formula used for the training set for the deep learning

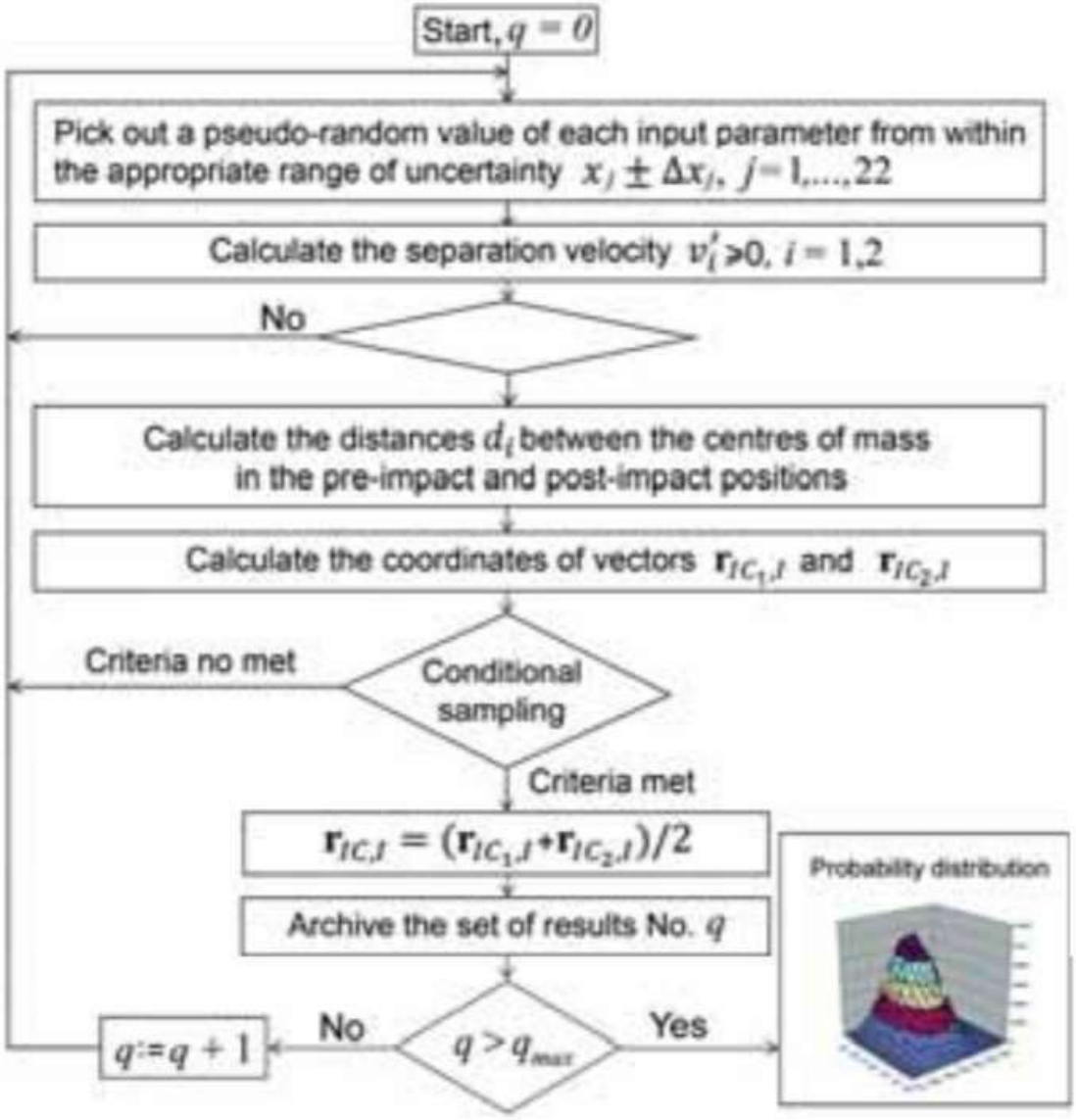

Figure 18: explanation on what does Monte Carlo formula do (WACH)

Through the combination of the deep learning model and Monte Carlo method, we can have a model that is both accurate and beneficial when implemented by the Road authorities in Dubai which will impact the number of accidents related to pedestrians and bikers. As the deep learning method will catch the

pedestrians when they walk alongside roads, and Monte Carlo method will be used to determine the angle at which the cars are coming from and understand how accidents can be avoided, therefore, reducing the number of accidents related to both pedestrians and bikers. The training set i.e., the 80% of the dataset, is run through the model, so that the model can learn and understand the shape of pedestrians, their actions within the images, differentiate between inanimate objects and pedestrians, check the number of pedestrians in each picture, etc. then the deep learning scene specific detectors is run to check its performance against the testing set, which showed small percentage of error mainly when pedestrians are blocked by an object in the images. The figures below showcase how the system detects pedestrians by marking them in rectangular boxes. To measure how accurate the model is, first we need to check if the model is producing good results in marking pedestrians in the images set for the training set. The next step is to run the model against the test set chosen earlier, which contains a number of images that contains pedestrians walking across roads and other side walk areas that are specifically designed for pedestrians crossing, however the test set also contains pedestrians who are partially blocked by objects as well. The images below showcase the model accuracy on how much it can detect pedestrians from other objects:

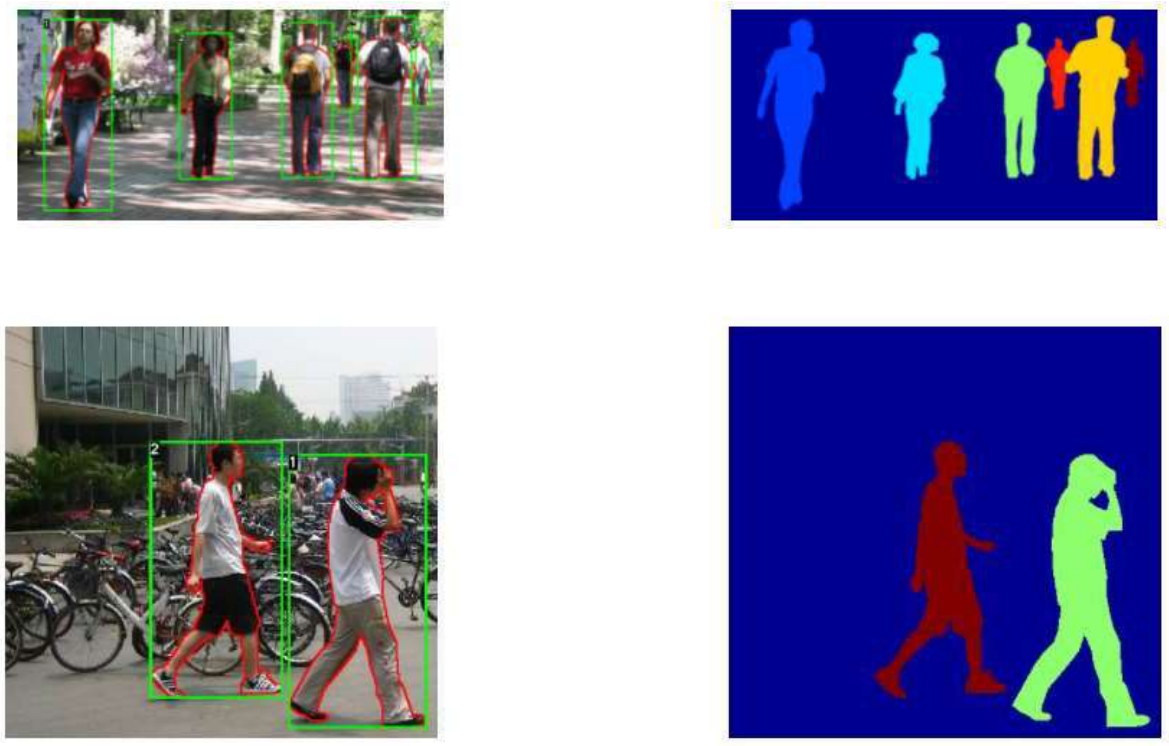

Figure 19: detecting pedestrians.

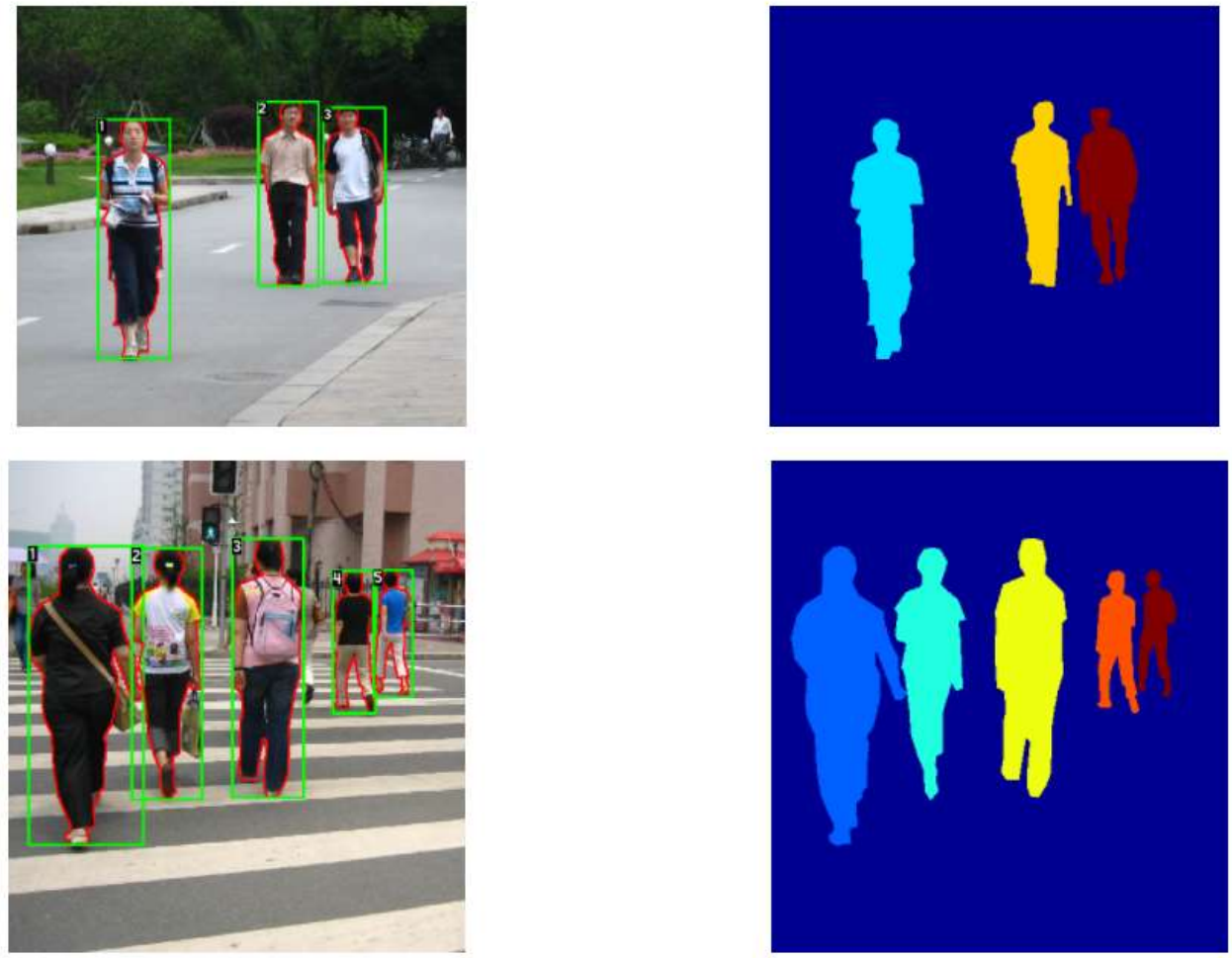

Figure 20: pedestrians walking on the street and marked by the system.

However, there were some images where pedestrians were not visible enough that the system could not detect them as the image below portraits the system unable to detect the pedestrian when they are blocked.

Figure 21: some pedestrians are blocked while walking on the street and the system unable to mark them.

The figures shown above indicate that the system is quite accurate at getting the pedestrians marked and is able to differentiate pedestrians from inanimate objects, however it cannot detect pedestrians when they walk side by side and being hidden behind or blocked by other pedestrians as the system can detect pedestrians that are quite clear in the images available in both the training set and testing set.

Chapter 5: Conclusion

5.1 Conclusion

In conclusion, accidents are extremely hard to control, as the reasons for an accident to occur can vary based on the location, weather, people, gender, age, etc. hence it is in Dubai's best interest to ensure that youngsters are knowledgeable on the dangers of the roads before getting their licenses and through spreading awareness messages and videos we can limit the amount of accidents that can occur, and be able to contribute to H.H. Sheikh Mohammad Bin Rashid Al Maktoum, ruler of emirate of Dubai and UAE prime minister vision for Dubai to become the safest and happiest city on earth. Through the EDA and modeling done on the dataset for this study, we can understand how to mitigate accidents related to pedestrians and bikers through deep learning detection for pedestrians and Monte Carlo method for drivers in their cars, resulting in a more sophisticated system for road authorities to ensure pedestrians safety and reduce the number of accidents resulting in the contribution for the Dubai Vision set by the prime minister. Throughout the study, I understood the reasons behind pedestrians and bikers related accidents, the factors that affect and lead to these kinds of accidents, the age, gender, and injury level caused by these accidents, etc. I truly believe that data analytics is key to our future and without it, the data available in the world are lost and utterly wasted.

5.2 Recommendations

Connecting the study with Police department and Health authorities will maximize the benefits from this study, as it will decrease the number of accidents related to pedestrians and also allow health authorities to reach accident prone areas much easier and be able to perform their ultimate job, which is to save humans lives. Establishing the benefits gained from this study will surely have great impacts on pedestrians when they perform their daily routines, going across the streets feeling safer and believing that the authorities are doing their outmost to ensure their safety is always kept intact at all times.

5.3 Future Work

The study in itself is quite beneficial for both UAE and other countries around the world, it would be great if there are ready datasets that can be utilized for this study, as it was quite the issue finding a dataset for this study. Furthermore, should there be more time to investigate the dataset more it would be great. Big data would be great for this kind of study, it could benefit us with valuable solutions to accidents related

to pedestrians in UAE, as per the saying of the late Sheikh Zayed (peace upon him) “Humans are the true treasure of any nation, we need to invest in them so that they can uplift their nation, and all shall prosper”. Furthermore, it would be great if the study utilized the variety of plots and charts generated from the Tableau software, as it provides great tools to enhance the data and showcase the data in a more presentable fashion.

Bibliography

Anaud Doucet, Nando Freitas, & Niel Gordon. (n.d.). *An introduction to sequential monte carlo methods.* opaque this.

François Vallee, Jean-François Toubeau, Zacharie De Greve, & Jacques Lobry. (2014). Consideration of Extreme Wind Geographical Correlation Scenarios in Reliability Assessment Studies Using Sequential Monte Carlo Simulations. *Research Gate*.

Guyen, B. (2019). *Pedestrian-bike-data.* github.

IBM. (2020, 08 24). *Monte Carlo Simulation*. Retrieved from www.ibm.com: https://www.ibm.com/cloud/learn/monte-carlo-simulation

IEEE. (2017). Self-learning Scene-specific Pedestrian Detectors using a Progressive Latent Model.

J.L.Castro, M.Delgado, J.Medina, & M.D.Ruiz-Lozano. (2010, 07 07). *Why Walkers Get Hit: Common Causes of Pedestrian Accidents*. Retrieved from https://braunslaw.com/: https://braunslaw.com/library/7-common-reasons-pedestrian-accidents-occur/

Martin, A. (2006). *FACTORS INFLUENCING PEDESTRIAN SAFETY: A LITERATURE REVIEW.* London: TRL limited.

Shahbandari, S. (2017, 03 12). *Pedestrians account for 30% of road deaths in Dubai*. Retrieved from https://gulfnews.com/: https://gulfnews.com/uae/transport/pedestrians-account-for-30-of-road-deaths-in-dubai-1.1992799

Smart Dubai. (2018). *Smart Dubai — towards becoming the happiest city on Earth.* Dubai: Smart Dubai.

St. Paul Police station. (2016). Retrieved from www.stpaul.gov: https://www.stpaul.gov/user/login?destination=/departments/police/pedestrian-and-bike-crash-data-city-st-paul

WACH, W. (n.d.). *MONTE CARLO METHOD IN ANALYSIS OF ROAD ACCIDENTS VERSUS INTERPRETATION OF CALCULATION RESULTS.* Institute of Forensic Research.

Xingyu Zeng, Wanli Ouyang, Meng Wang, & Xiaog. (2014). *Deep Learning of Scene-Specific Classifier.* Switzerland: Springer International Publishing Switzerland.