ASSESSMENT OF HIT AND RUN ACCIDENTS-A MODIFICATION TOWARDS PREDICTING THE CONTRIBUTING FACTORS OF HIT AND RUN ACCIDENT

Gurdiljot Gill, College of Engineering, California State Polytechnic University - Pomona, 3801 W.Temple Ave, Pomona, 91768, 909-908-7084, gurdiljotg@cpp.edu
Xiaofei Wang, College of Life and Environment, Huangshan University, Huangshan, 245041, Anhui, China, +86-18855913096, wxf@hsu.edu.cn
Wen Cheng, College of Engineering, California State Polytechnic University-Pomona, 3801 W.Temple Ave, Pomona, 91768, 909-869-2957, wcheng@cpp.edu
Meiquan Xie, College of Engineering, California State Polytechnic University-Pomona, 3801 W.Temple Ave, Pomona, 91768, 909-282-9142, mxie@cpp.edu

ABSTRACT

Hit and Run (HR) accident is considered as a crime in most states and is an occurrence that constantly catches researchers' attention. The main objective of the study is to introduce a new approach, based on individual features of roadway, for investigating the influence of various factors leading to HR accidents such as personal characteristics, environmental settings, and roadway features. Two types of Logit regression models are employed: Binary and Multinomial. The crash data used for this study are HR accidents for a 5-year period that occurred on segments of United State Route 101 in Los Angeles area Caltrans District 7.

PROJECT DESCRIPTION/OBJECTIVE

According to the World Health Organization report in 2004, "1.2 million people were killed in traffic collisions" [1]. In addition to this, in the United States alone there were about 32,367 traffic collisions in 2011 [2]. Although there are different causes of accidents that contribute to public road safety, but among these traffic collision types an average of 12% -18% are caused by Hit and Run accidents, which are a serious offense in many countries, and seen as a heinous crime as there is no prior disposition. HR crashes greatly influence road safety and economy. In terms of road safety, previous studies [3] explained the ordeal effects that HR victims had to face, when they were left behind. In terms of financial responsibility, if the offender is not caught or prosecuted, the insurance company or the victims have to pay from their own pocket, which puts additional strain on already suffering victims. This is also most unfortunate for the offenders if they are convicted because based on the severity of the accident they are not only financially responsible for damages, but are convicted for a serious crime which affects them severely. It is important for researchers and engineers to analyze the influential causes that are leading to such accidents, and provide guidance to mitigate them. The main focus of this study is to investigate HR accident occurrence on a specific type of road located in the Los Angeles area, which is one of the busiest commuter areas that receive a high volume of traffic every day. It is approximated that there about 9,962,789 people living in the Los Angeles County [4]. Based on the high number of commuters and traffic volume, accidents like HR occurrence are more common in the metropolitan areas like Los Angeles. The study will analyze a particular type of roadway that is in the Los Angeles area more specifically the U.S route 101 which is overseen by Caltrans District 7. The geometric structure of the highway has a combination of horizontal tangent lanes and curbs throughout the section. In addition to this, the study will further discuss how the influential factors related to HR accidents are affected by the social, environmental and economic conditions in Los Angeles area within that time

span. HR accidents can be influenced by social and political factors as well, and these concepts will be discussed in terms how they contribute to HR accidents the Los Angeles area.

DATA COLLECTION

Statewide Integrated Traffic Records Systems (SWITRS) - Is a database system that contains detailed incident report for the state of California. The database system was remodeled for collision reports in 2002 and contains accident incidents for over a decade. In addition to this, starting from 2006 the raw data also contain latitude and longitude for the locations of the accidents for all types of roadway [5]. The new raw data report is divided into three different groups, and they are Collision Report, Party Report, and Victims Report. In term of this study the Collision Raw Report and the Party Raw Report were chosen and used for both Binomial and Multinomial Regression Model. The raw data reports for HR accidents were based on these standards.

- Highway: Route 101; Post mile: 0-38.1; Time Frame: From January 1, 2005 to December 31, 2010; Location : Los Angeles County

METHODOLOGY

The first process was to organize the data to be fitted for the mapping system (Arc GIS) and for the data analysis. In terms of the Arc-GIS, the collision raw data was organized by Felony and Misdemeanor HR accidents based on over the five years span from 2005 to 2010. The following data that were established in the Arc GIS were based on the Latitude and Longitude values, which were retrieved from Google Earth based on post mile locations. The coefficient factors that were considered to be used for the data analysis study were grouped in two reports. The Collision Data Report contained data variables pertaining to factors such as: Travel Mode, Damages, Collision Factor, Environment, Other Condition, Background, Location, and Time. The second set of variables were procured from the Party Data Report, which applies for both victims and offender characteristic information, such as: Gender, age range, fault, direction of travel, insurance status, cell phone use, physical condition, vehicle make, vehicle year, violation code, and so on. These are original Coefficient variables that were used for both Binomial and Multinomial Regression Model using the R-Project for Statistical Computing, which is a database program that can be used to analyze trend, cost benefits, using statistical analysis [6]. In terms of this study, R-code was utilized with the goal to form sufficient Binomial and Multinomial functions, which explain the trend and overall situation of HR accidents for the U.S. Route 101 more specifically the Los Angeles Area. There are total of 6 regression model (3 for each types of model) they are as follows.

1. Binomial Regression Model based on Collision Data
2. Binomial Regression Model based on Party: Victims Data
3. Binomial Regression Model based on Offender: Offender Data
4. Multinomial Regression Model based on Collision Data
5. Multinomial Regression Model based on Party: Victims Data
6. Multinomial Regression Model based on Offender: Offender Data

Binomial/ Binary Logit Model

The Binomial Regression model estimates the probability of success or failure of a dependent variable based on multiple independent variables. In terms of this study, the binomial regression model will look at the probability of HR (Yes vs. No) based on independent variables such as weather, vehicle, lighting condition etc. There will be three types of Binary Logit model as explained below.

1. Binomial Logit Model 1 will explore the probability of HR crash
2. Binomial Logit Model 2 will explore the probability of a person being a victim of HR crashes.
3. Binomial Logit Model 3 will explore the probability of a person being an offender of HR crashes.

Binary /Binomial Model

$$f(x) = \log e\left(\frac{\text{pr(yi)}}{1-\text{pr(yi)}}\right) = \log(\text{pr(yi)}) - \log(\text{pr(yi)} - 1) \quad (1)$$

Where, yi: accident

Regression Model

$$f(x) = \beta_o + \beta 1x\,1 + \beta 2x\,2 + \beta 3x\,3 + \cdots + \beta mxn \quad (2)$$

Where, β: Coefficient and, xi: Variables

Probability of being success*: pr (yi)*

$$pr(yi) = \frac{1}{1+e^{-f(x)}} \quad (3)$$

Multinomial Logit Model

The multinomial Logit model is more complicated than the Binomial / Binary Logit model. The main difference is multinomial Logit model is more detail in terms of predicting the probability between a base factors with category factor. The factors are in order of the following.

1. Base Factor : P1- No HR; 2. Category Factor 1: P2- Misdemeanor HR [7]; 3. Category Factor 3: P3- Felony HR [8]

Similar to Binary Logit model, there will also be three Multinomial Logit model that will look over the Misdemeanor and Felony HR crash value based on the general, victim and offender individual characteristic.

Multinomial Model

$$fj(x) = \log e\left(\frac{pr(yij)}{pr(yi1)}\right) \quad where\ j = 2,3,4 \ldots n \quad (4)$$

Regression Model

$$fj(x) = \beta_o + \beta 1x1j + \beta 2x\,2j + \beta 3x\,3j + \cdots + \beta mxnj \quad where\ j = 2,3,4..n \quad (5)$$

Probability of being success: pr (yij)

$$pr(yi1) = \frac{e^{fj(x)}}{1+\sum_j e^{fj(x)}}\ where\ j = 2,3,4 \ldots n \quad (6)$$

RESULTS

Binary Logit Model

The following equations (7-9) show the statistically significant contributing factors (at 95% confidence interval) that are important to calculate the probability of HR accident based on the post mile for LA 101. These significant factors that can be used to understand which type of drivers are more probable to be HR Victims and which types of Driver are more probable to be HR offenders based on the Driver

characteristics, Vehicle Type, Environment, Laws on Violation, etc. This will make a big contribution to HR because CHP, Insurance Companies, and future researchers who can use the binomial function to plan and organize are toward minimizing future HR accidents. Also, another reason this Binary Logit Model is useful because it can be used more accurately to figure out which location are more probable for HR accident for a major freeway. This can be used to help and understand with the addition of Arc GIS mapping, about which area need more surveillance based on these key character types.

Binomial Model 1 (7)

f(x)= -.8655582+ 0.035555 DAY_OF_WEEK -0.031036 POSTMILE -0.361104 RRS +0.236778 RL-0.119451 COLLISION_SEVERITY +0.048107 PCF_VIOL_CATEGORY -0.220501 RTOC -0.051756 RMVIW- 0.192609 RSVAF + 0.039392 CHP_VEHTYPE_AT_FAULT

Binomial Model 2 (8)

f(x)= 36.9101764 -0.0822432AGE.RANGE -0.2010597R.SVAF -0.2958252R.TOC -0.0305790POSTMILE -0.1105641COLLISION.SEVERITY+ 0.0500440R.PARTY.SOBRIETY -0.0186254VEHICLE.YEAR -0.1716509WEEKDAYS -0.2072263R1.WEATHER+ 0.2301513R.L+ 0.0540413 PCF_VIOL_CATEGORY+ 0.0389559 CHP_VEHTYPE_AT_FAULT

Binomial Model 3 (9)

f(x)= 0.047808+ 0.133162 R.PARTY.SOBRIETY-0.330203INSURANCE.STATUS+ 0.224104CELL.PHONE.IN.USE-0.108071COLLISION.SEVERITY -0.085295RMVIW-0.176145RTOC -0.223886RSVAF -0.051007OTHER.FACTORS1+ 0.023189VEH.MOVE.PRIOR.COL-0.042195RACE-0.031664POSTMILE -0.253516R.RS+0.193714RL+0.041028CHP_VEHTYPE_AT_FAULT

For brevity purpose, we can take Equation 7 as an example to further understand the relationship between various contributing factors and probability of occurrence of HR crash. In Equation 7, it is known that DAY_OF_WEEK, RL, PCF_VIOL_CATEGORY, and CHP_VEHTYPE_AT_FAULT have a positive relationship with the probability of HR crashes, while POSTMILE, RRS, RTOC, RMVIW, and RSVAF have a negative relationship.

Multinomial Model

Unlike Previous studies there has been no work done to formulate Multinomial HR accident. Thanks to R council and SWITRS database which provide the type of HR that are Misdemeanor HR (2) and Felony Hit-and (3) -Run or a multinomial function has been formulated to predict the probability. The following three equations (10-12) show the contributing factors for Felony and Misdemeanor HR accidents.

Multinomial Model 1: A- Misdemeanor, B-Felony **(**10**)**

f(x)= 0.5049972MISDEMEANOR- 0.03011011 DAY_OF_WEEK MISDEMEANOR -0.0122105POSTMILE MISDEMEANOR +0.1885831RLocation MISDEMEANOR -0.3062734 RRS MISDEMEANOR +0.22967488 RL MISDEMEANOR -0.3871530 COLLISION_SEVERITY MISDEMEANOR -0.1753151R.PCF MISDEMEANOR -0.2675681 RTOC MISDEMEANOR -0.0509437 RMVIW MISDEMEANOR - 0.1706200 RSVAF MISDEMEANOR -0.1034657R.Control MISDEMEANOR

f(x)= -5.9025087FELONY+ 0.0429926DAY_OF_WEEK FELONY -0.0397605POSTMILE FELONY -0.4900575RRS FELONY + 0.2270488RL FELONY + 0.8307704COLLISION_SEVERITY FELONY -

0.1283162 RTOC FELONY -0.0943450 RMVIW FELONY+ 0.4417167RPA -0.2132339RSVAF FELONY

Multinomial Model 2: A- Misdemeanor, B-Felony **(**11**)**

f(x)= -0.5524547MISDEMEANOR -0.0044132 PARTY_AGEMISDEMEANOR - 0.0592275 R_Party_SOBRIETY MISDEMEANOR+ 0.0340400DAY_OF_WEEK MISDEMEANOR -0.0245466 POSTMILE MISDEMEANOR -0.2286615 R1.weather MISDEMEANOR + 0.2316543 R.L MISDEMEANOR -0.3593003 COLLISION_SEVERITY MISDEMEANOR -0.2519562 R.TOC MISDEMEANOR -0.0425758 R.MVIW MISDEMEANOR -0.2093188 R.SVAF MISDEMEANOR + 0.0585217 PCF_VIOL_CATEGORY MISDEMEANOR + 0.0377022 CHP_VEHTYPE_AT_FAULT MISDEMEANOR

f(x)= -5.0738647FELONY -0.0619737 POSTMILE FELONY -0.3290892 R1.weather FELONY + 0.2790704 FELONY + 0.8598192COLLISION_SEVERITY FELONY -0.2194167 R.TOC FELONY - 0.0871206 R.MVIW FELONY -0.1620443 R.SVAF FELONY + 0.0750255 PCF_VIOL_CATEGORY FELONY + 0.0413495 CHP_VEHTYPE_AT_FAULT FELONY

Multinomial Model 3: A- Misdemeanor, B-Felony **(**12)

f(x)= -0.34318746MISDEMEANOR -0.00465372PARTY_AGEMISDEMEANOR + 0.13460840 R_Party_SOBRIETY MISDEMEANOR -0.28298485 Insurance_Status MISDEMEANOR+ 0.22336586 CELL.PHONE.IN.USE MISDEMEANOR -0.03956054 OTHER.FACTORS1 MISDEMEANOR + 0.02136705 VEH_MOVE_PRIOR_COLL MISDEMEANOR -0.04663975 Race MISDEMEANOR + 0.19800689 R.L MISDEMEANOR -0.33574228 COLLISION_SEVERITY MISDEMEANOR -0.20578215 R.TOC MISDEMEANOR -0.06651821 R.MVIW MISDEMEANOR - 0.22142744 R.SVAF MISDEMEANOR + 0.03957721 CHP_VEHTYPE_AT_FAULT MISDEMEANOR

f(x)= -3.05813666 FELONY -0.43062731 Gender FELONY + 0.10613600 R_Party_SOBRIETY FELONY -0.48014561 Insurance_status FELONY -0.09422189 OTHER.FACTORS1 FELONY + 0.02962157 VEH_MOVE_PRIOR_COLL FELONY -0.48545266 R1.weather FELONY + 0.21616937 R.L FELONY + 0.78433205 COLLISION_SEVERITY FELONY -0.16157654 R.MVIW FELONY - 0.21637286 R.SVAF FELONY + 0.04042537 CHP_VEHTYPE_AT_FAULT FELONY

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the Binomial and Multinomial function it can be deduced that PCF Factors 3: Unsafe Speed is one of the leading causes for majority of the HR accidents for the U.S route 101. In previous studies, DUI violations were observed as a leading cause of HR accidents, but for this study other violations also proved to be as contributing factors toward HR accidents, such as PCF Violation 3: Unsafe Speed, PCF Violation 7: Unsafe Lane Change, PCF Violation 8: Improper Turning, and PCF Violation 1: Driving Under the Influence. Another important contributing factor which proved to be significant was the Vehicle type at fault. The leading type of vehicle which was involved in for most of the crash are shown: Passenger Car, Station Wagon=1552 Cases; Sports Utility Vehicle=382 Cases; Pick-up or Panel Truck=347 Cases; Minivan=121 Cases; Motorcycle=40 Cases. This plays a key factor, because majority of the HR offender place their trust on speeding vehicles to escape the scene on a freeway. Another reason is unlike arterial or local highways, it takes longer for the local authorities to reach the accident sites on time, by then the offender is long gone. The geometric design of the freeway also exhibited some influence over HR crashes. In most cases, based on the map representation and data

analysis, the majority of the HR accidents occurred at near the merging traffic for on and off ramp. But in the case of unsafe speed, the occurrence of crash was not dependent on whether the U.S route had curved or tangent horizontal alignment. In general, for day of the week, Saturday was observed to have the highest number of HR crashes. Majority of the Misdemeanor accident occurred on Friday while for Felony majority of accident occurred on Sunday. This high occurrence of HR during weekend is in line with the findings of another study [9]. In this study, having vehicle insurance increased the probability of HR because in most cases the drivers may believe that if they are caught their insurance rate will increase, and this might be a leading motivation to flee the scene. In addition to this majority of the Hit-and-Run offenders were in the on their late 20s to early 30s. Based on the results observed in this study, one of recommendation for mitigation of HR accidents is better surveillance, more specifically in the on and off ramp for the merging traffics. Also, awareness drives would help educate the public about the influential factors and consequences of such accidents. Overall, further exploration in this field is desired and the authors recommend to use this process in another type of roadway for comparison of the contributing factors, as well as trying this process for similar types of roadway to check if there are any emerging patterns. Understanding the influential factors contributing to HR accident can help researchers, law authority, and highway landscape policy maker to take better measure toward preventing HR accidents.

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REFERENCES

1. Peden, M., et al., (2004). World Report on Traffic Injury Prevention. World Health Organization, Geneva.
2. National Highway Traffic Safety Administration (2011). “FARS Encyclopedia.” NHSTA , <http://www-fars.nhtsa.dot.gov/Main/index.aspx> (May 3, 2012)
3. MacLeod, K. E., Griswold, J. B., Arnold, L. S., Ragland, D. R., (2011). “Factors associated with hit –and-run pedestrian fatalities and driver identification.” J. Accident Analysis and Prevention., 45, 366-372
4. United State Census Bureau (2013). “State and County Quick Facts” Census Bureau, <http://quickfacts.census.gov/qfd/states/06000.html >(December . 1, 2013)
5. CHPs Statewide Integrated Traffic Records Systems (SWITRS) (2012). “SWITRS Reports.” The California Highway Patrol, < http://iswitrs.chp.ca.gov/Reports/jsp/userLogin.jsp > (May. 5, 2012)
6. The R-Project for Statistical Computing (2012). “What is R?” R , < http://www.r-project.org/index.html> (May 12, 2012)
7. Shouse California Law Group (2013). “Misdemeanor Hit and Run in California Vehicle Code 2002 VC”, <http://www.shouselaw.com/mishr.html> (Dec. 1, 2013).
8. Shouse California Law Group (2013). “Felony Hit and Run Involving Death or Injury California Vehicle Code 20001 VC”, < http://www.shouselaw.com/felonyhr.html> (Dec. 1, 2013).
9. Tay, R., Barua, U., and Kattan, Lina. (2008b). “Factors contributing to hit-and –run in fatal crashes.” J. Accident Analysis and Prevention. 41(2), 227-233.