Development of Zonal Level Prediction Models for Crimes Reduction and Traffic Safety Improvement

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Background

Crime Statistics

Traffic related fatalities accounts for 48% of death among young adult aged 15 to 44 (WHO, 2015).

Image Sources:
https://www.thestar.com/news/gta/2011/02/14/3_injured_as_medical_episode_leads_to_collision.html
http://www.who.int/mediacentre/factsheets/fs358/en/
DDACTS


- DDACTS Goal: Reduce social harm and increase the quality of life by decreasing the incidence of crimes, collisions and traffic violations simultaneously in a region through high visibility enforcement.
Conventional DDACTS relies on Kernel Density Estimation (KDE) to determine hotspots.
Study Goal and Objectives

Goal:

- Develop macro-level crime and collision prediction models to support place based law enforcement.

Objectives:

- To develop prediction models for Violent crimes and Fatal-Injury collisions using negative binomial regression.

- Demonstrate how these models could be used to identify Violent crimes and Fatal-Injury collisions location for enforcement.
Study Area and Data

- City of Regina (Capital city in Saskatchewan)
- Populations: 247,200 in 2016

(a) Yearly Crime Occurrences (2009-2013)  
(b) Yearly Collision Occurrences (2009-2013)
Collision and Crime Hotspots in Regina

DDACTS
Five Violent Crimes and Collision Hotspots (24 Hours)

Legend
Collision Hotspot
- High
- Very High

Crime Hotspot
- High
- Very High

Police ATOMS

Date: 01/13/2015
Coordinate System: UTM 13 North

Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community
Analysis Method

- **Negative Binomial Model**

\[ y_j \sim NB \left[ t_j \exp(\sum_k \beta_k x_{jk}), \alpha \right] \]

- **Violent crime**: Sum of five crimes (*Arson, Assault, Murder, Robbery, Sexual Assault*).

- **Collision severity**: *Fatal-Injury (FI)*.

\[
\text{Violent Crime} \propto f(\text{Sociodemographic, Landuse Variables})
\]

\[
\text{FI Collision} \propto f(\text{Exposure, Sociodemographic, Landuse Variables})
\]

- A total of 54 input variables were explored

- All information aggregated into Traffic Analysis Zone (TAZ)

- **Empirical Bayes (EB) Method**

\[ E[K_j] = w[\mu_j] + (1 - w)y_j \]

\(x_{jk}, y_j\) are the predictor and the response variables traffic zone \(j\). \(\alpha\) represents the global dispersion. \(w_{ij}\) is the geographic weight. \(E[K_j]\) is the Empirical Bayes predicted value. \(\mu_j\) is Negative Binomial model predicted value. \(w\) is the Empirical Bayes (EB) weight.
## Result of Analysis

### Estimated Model Parameters

| Variable                          | Estimate | Pr>|Z| |
|-----------------------------------|----------|-----|
| **Violent Crimes**                |          |     |
| Intercept                         | -0.1890  | 0.1950 |
| Ln(COMMERCIAL_AREA)               | 0.5740   | <0.001 |
| POPULATION_DENSITY                | 0.0002   | 0.0022 |
| POPULATION_25TO44                 | 0.0085   | <0.001 |
| POPULATION_45TO64                 | -0.0076  | <0.001 |
| POPULATION_18TO24                 | 0.0048   | 0.1385 |
| RETAIL_SPACE                      | 0.1120   | 0.0799 |
| Dispersion (α)                    | 0.9921   |     |
| **Fatal-Injury Collisions**       |          |     |
| Intercept                         | -3.7300  | < 0.001 |
| Ln(VKT)                           | 0.5150   | < 0.001 |
| SEGMENT_80KMHR                    | -0.0004  | 0.0157 |
| SEGMENT_70KMHR                    | 0.0002   | 0.0840 |
| FOUR_LEG_INTERSECTIONS            | 0.0304   | < 0.001 |
| INTERSECTION_DENSITY              | 0.6710   | 0.0017 |
| THREE_LEG_INTERSECTIONS           | -0.0140  | 0.0317 |
| Ln(COLLECTOR_LENGTH)              | -2.6000  | 0.0039 |
| URBAN_HOLDING_RESIDENTAL_AREA_PROP| -2.7200  | < 0.001 |
| Dispersion (α)                    | 0.4641   |     |
DDACTS Zones
Conclusions

- Regression analysis is a useful tool to identify DDACTS zones for law enforcement.

- Application of a regression analysis facilitates understanding of the factors that influences violent crimes and fatal-Injury collisions.
Recommendations

- Analysis of DDACTS can combine with a GIS technique to display crimes and collision hotzones. This will provide better understanding of the areas for law enforcement to reduce crimes and collision occurrences simultaneously.

- Future researches may consider the influence of weather conditions on the occurrence of violent crimes and fatal-injury collisions at zonal level
The findings, opinions, and suggestions given in this presentation do not necessarily reflect the official perspectives of any of the agencies listed here.