A Review of Big Data sources and Implementation for Traffic Safety Management

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Fatality Rates vs Infrastructure Development

Road Incident Death Rates (per 100,000 people), 2016

Source: IHME, Global Burden of Disease (GBD)
Fatality Rates

- USA in 2016, traffic fatalities, 0.73 per 100 million vehicle km traveled, 16.9 Fatalities per 100,000 Licensed Drivers,
  11.6 fatalities per 100,000 of population
  13.9 Fatalities per 100,000 Registered Vehicles

- KSA, in 2016 reported traffic fatalities 9031, population 32 Million and total registered vehicles 6,895,799,
  28 fatalities per 100,000 of population
  131 Fatalities per 100,000 Registered Vehicles
US Strategic Highway Safety Plan

- **NATIONAL GOAL**: AASHTO in 1998, a total reduction of annual highway fatalities by 5,000 to 7,000.

- In 2003, AASHTO, the Governors Highway Safety Association, The American Association of Motor Vehicle Administrators, and the U.S. Department of Transportation set as a goal the reduction of the nation’s highway fatality rate by 2008 to not more than one fatality per 100 million vehicle miles traveled (VMT).
Contributing factors for the rise in fatalities from 2013 to 2016

- Driver distraction (more frequent use of smartphones/devices)
- Inefficient enforcement of DUI and seatbelt use
- Need mitigation measures to reduce over-speeding related crashes
Strategic Highway Safety Plan
AASHTO SHSP 22 key emphasis areas

Drivers
- Young
- Unlicensed/Suspended/Revoked Drivers
- Aggressive
- Impaired
- Distracted/Fatigued
- Seat Belt Use
- Speed

Special Users
- Pedestrians
- Bicyclists

Highways
- Trees
- Run off the Road
- Horizontal Curves
- Utility Poles
- Unsignalized X
- Head-on crash
- Head-on crash on Freeways
- Work Zones

EMS
- Rural Emergency Medical Services

Management
- Data
- Integrated Safety Management Process

Mostly also reflected in States’ SHSP
In 2015 AASHTO participated in the **National Strategy on Highway Safety Toward Zero Deaths (TZD) campaign** to wipe out traffic fatalities.

**Aim:** achieve the following

- Safer road users (all)
- Safer infrastructure
- Safer vehicles
- Better emergency medical services (EMS) and EMS response
- Better *safety management*

**Efforts of AASHTO and State Departments of Transportation**

- Guide *research* and strengthen safety culture
- Aid in the cooperation of agencies of the multiple branches to address road safety via a *data-driven* course of action (includes policies and programs)
Crash Risk Visualization
Crowdsourced Data

- Fatality Analysis Reporting System (FARS)
- Crash Analysis Reporting (CAR) System
- Crash Modification Factors (CMF) Clearinghouse
- Violation Data

- Regional Integrated Transportation Information System (HERE, INRIX, and NPMRDS)
  - Microwave Vehicle Detection System (MVDS)
  - Inductive Loop Detectors
  - Automated Vehicle Identification (AVI)
  - Bluetooth Detectors
  - CCTV cameras

- Automated Traffic Signal Performance Measures
- Adaptive Traffic Signal Control Systems

- Quality Controlled Local Climatological Data (QCLCD)
- Helios® Real-time Ground Weather Intelligence

- Historical Data for Traffic Safety
- Crash Data
- Traffic Data
- Traffic Control Data

- Weather Data
- Geographic Data
- Social Media

- Roadway Characteristics Inventory (RCI)
REAL-TIME VISUALIZATION for Operators

UCF-SST

Real-Time Crash Risk

Freeway Arterial

Top 5 High-Risk Arterial Segments

1013_2
1104_3
1006_1
2004_2
1006_3

Risk Score

0 0.2 0.4 0.6 0.8

Chart Detail

Real-Time Status

Pro-Active Traffic Mgmt
Active Traffic Management (ATM) is a method of increasing capacity and smoothing traffic flow (e.g., travel time reliability) on major highways:

- Speed Harmonization,
- Queue Warning,
- Advanced Information,
- Ramp Metering,
- Hard Shoulder Running,
- Managed Lanes,
- Variable Speed Limits,
- Truck Restrictions, etc.
Traffic Management Strategies

- Remedies to low visibility
  - Visibility sensors
  - VSL: Recommend a new speed limit according to visibility
  - DMS: Notifications of adverse conditions
  - Connected Vehicles
Data and Monitoring

- **Traffic Detection Systems**
  - Loop detectors
  - Automatic Vehicle Identification (AVI) Systems
  - Microwave Vehicle Detection Systems (MVDS)
  - BlueTooth Detectors
Traffic Detection Systems

- AVI Data
  - Data collected for vehicle equipped with tags
  - Uncapped AVI Data
    - Vehicle based
    - Uncapped at speed limit
    - Partial traffic volume (equipped with tag)

- MVDS/RTMS Data
  - Usually 20-60 -seconds intervals
  - Lane and Lane Type (lanes, ramps, etc)
  - Speed
  - Volume
  - Lane Occupancy
  - Vehicle Classes
  - Spacing
Bluetooth and Private data on Arterials

- HERE
  - Third-party speed data, from probe vehicles and infrastructure detectors (black box)
  - 1 min aggregated space mean speed of a link

- Bluetooth
  - Link travel time for individual vehicles: BlueTOAD, BlueMAC
  - Travel time of BlueMAC is calculated by matching logs of the same vehicle. There are several matching methods to overcome the multiple detection.

- Aggregated link space mean speed is calculated by individual link travel time
Sources of Big Data in transportation
- Web traffic, network comments
- ITS facilities (traffic sensors)
- Weather Detection Systems
  - Weather sensors (e.g. temperature, precipitation, visibility, fog, etc.)
- Roadway geometric database
- Crash database
- GIS database
- Socio-demographic database

Data type
- Structured data
  - Traffic detection data
  - Road geometric data
  - Crash data
  - Socio-demographic data
- Unstructured data
  - Video images
  - Social media text
  - Text documents

*Data source from Twitter
*Data source from Facebook

*Automatic Vehicle Identification (AVI) System (above)
*Microwave Vehicle Detection System (MVDS) (right)
Examples of Big Data for ATM

Data sources for IATM
- CFX
- RITIS
- Orange County
- Seminole County
- FTE
- SunGuide
- MVDS (1 min)
- AVI using toll tags
- DMS logs (1 sec)
- Toll transactions
- Trying to collect
- BlueTOAD (5 min)
- Only for SR 417
- BlueMAC (Raw data)
- Iteris (Matched data)
- InSync (Adaptive Signal Data)
- BlueTOAD (Matched data)
- Signal Performance Metrics System

Data sources for IATM
- HERE
- INRIX
- FTE
- District 5
- CFX
- SunGuide
- Twitter
- Google Map

Since Dec. 2013 (1 min)
- Only University Blvd of 2013
- Detector data (1 min) (All freeways under FTE)
- Detector data (30 sec) (All freeways under FDOT)
- Detector data (1 min) (All expressways under CFX)
- MVDS (30 sec) (All freeways)
- Travel time for the public
- DMS message logs
- No BlueTOAD
- No Signal Operation Log
- No expressway data
- Travel times (5-minute interval)
- Event logs
- Incidents
- Twitter

Since March, 2017
- BlueMAC (first detection data)
- BlueTOAD (5 min)

Since April, 2017
- BlueMAC (Raw data)
- InSync (Adaptive Signal Data)
- BlueTOAD (Matched data)
- Signal Performance Metrics System

Only University Blvd of 2013
- District 5
- MVDS (30 sec)
- ALL freeways under FTE
- ALL freeways under FDOT
- ALL freeways under CFX
- Detector data (1 min)
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Safety Planning
Big Data from Multiple Sources

- State DOT, regional MPO, US Census Bureau, etc.

Layer 4: Crash data (FDOT/MPO)

Layer 3: Roadway data (FDOT)

Layer 2: Socio-demographic data (US Census Bureau)

Layer 1: TAZ data (MPO)
Residence and Crash Location

- Crash occurrences are influenced not only by the characteristics of crash locations but also by the residential characteristics of at-fault drivers.

Residence
(ZIP based data: US Census Bureau)

Crash Location
(Geocoded data: FDOT)
Macro- and Micro-level Screening

Macro-level screening + Micro-level screening
GIS Analysis of Severe Crashes

- Severe crash count: highest in metropolitan areas
- Severe crash rates: higher in rural areas whereas lower in urban areas
Two-Level Screening in Traffic Safety Analysis

- Micro- and macro-level screening

Macro-screening + Micro-screening = Integration
Drowsiness related traffic fatality analysis

- Microscopic (i.e., individual crash level) and Macroscopic (i.e., county level) statistical modeling
- Screening: Kernel density estimation (left) and EB-based PSI screening (right)
Future Potential of Big Data in Pro-active Traffic Management

- Access to new data
- Development of the data management and programming capabilities needed to work with large-scale data sets
- Creative approaches to summarize, describe and analyze the information contained in the data
- New applications of the data
Recommendations

- Improve Accident Databases (at least fatal crashes).
- Benefit from the wealth of Safety Research from around the world while tailoring it to the specific country
- Incorporating Safety at the Planning Level
- Integrated 5E approach
Overall Safety Strategy

Engineering

Education

Enforcement

Emergency Response

Evaluation

Traffic Safety

5 E’s
Recommendations

- Evaluation of Current Traffic Safety Practices at different countries
- Interaction Between Traffic Engineers and Traffic Police to achieve the common goal
- **National Goal**: Reduce Traffic Fatalities and Serious Injuries, e.g. by 50%
Thank You

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September 2019