The relationship between daily traffic and daily encounters: a micro-simulation study

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The relationship between daily traffic and daily encounters, a micro-simulation study

Expected number of crashes ($\lambda$) = exposure (N) $\cdot$ crash rate (p)

Where:

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$$\text{Crash rate} = \frac{\text{number of crashes}}{\text{unit of exposure}}$$

*exposure refer to the number of trials while crash rate refer to the probability of failure at each trial*
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\[
\text{Crash rate} = \frac{\text{number of crashes}}{\text{unit of exposure}}
\]

As Elvik* argues:

Crash rate is not independent of exposure, but tends to decline as exposure increases.

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The second problem in computing and using accident rates arises in the case of composite exposure (i.e., exposure consisting of two or more traffic movements that both contribute to the risk of crash).

A crash can be understood as follows: (A Binomial distribution in which)

Expected number of crashes ($\lambda$) = exposure ($N$) \cdot crash rate ($p$)

The number of repetitions $n$ is very large (exposure) $\Rightarrow n \to \infty$

The likelihood of a crash to happen ($p$) is very low $\Rightarrow p \to 0$
A crash can be understood as follows:

(A Binomial distribution in which)

Both \( n \) and \( p \) are not known, but their product is the expected number of crashes of a certain location per unit of time (i indicates the element)

\[ n \cdot p = \lambda_i \]

This is known as the Poisson process, which models discrete, non-negative events like road crashes

\[ P(y_i) = \frac{e^{-\lambda_i} \cdot \lambda_i^{y_i}}{y_i!} \]
A crash can be understood as follows:

\[ P(y_i) = \frac{e^{-\lambda_i} \cdot \lambda_i^{y_i}}{y_i!} \]

\( P(y_i) \) is the probability of the element \( i \) to have \( y_i \) accidents per unit of time

\( \lambda_i \) is the expected number of accidents per unit of time (Poisson parameter)
Nordic Traffic Safety Academy - 8th annual scientific seminar May 6th - 7th 2019 Espoo, Finland

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As $\lambda_i$ becomes larger, the distribution normalizes its shape.

Applying the Poisson distribution establishes a null probability for negative outputs.
Come back to the exposure...(in symbols)

\[ Y_i = \beta_0 \cdot AADT^{\beta_1} \cdot e^{\sum \beta_j \cdot X_j} \]

Typical SPF model form for roadway segments

If \( \beta_1 = 0 \)

- The number of accidents remains the same regardless of traffic

If \( \beta_1 = 1 \)

- The number of accidents is proportional to traffic (i.e., crash rates are constant regardless of traffic)

HSM Approach!

...
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**HSM Approach!**

**What happen to the crash rate when \( \beta_1 \) assumes different value?**

*The importance of the linear relationship*

Let see some examples...
• Considering $\beta_1 = 1$...

Element 1 is more hazardous since for the same exposure, the number of accidents is always higher. The analysis of crash rates gives the same result, since they remain constant regardless of AADT.
• Considering $\beta_1 < 1$...

In this case, when considering the evolution of accidents depending on the exposure, Element 1 is safer than Element 2, despite of presenting a higher crash rate for the examined traffic conditions.
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• Considering $\beta_1 < 1$...

Perhaps a different measure of exposure can better explain the phenomena such as simultaneous arrivals at intersections which only include scenarios which could develop into crashes or SSM

Simultaneous arrivals and a finer time resolution could be a better exposure measures, but how to count them? ...and for VRUs are still working?
• Considering $\beta_1 < 1$...

**Exposure where Element 2 is safer than Element 1**

**Exposure where Element 1 is safer than Element 2**

Perhaps a different measure of exposure can better explain the phenomena such as simultaneous arrivals at intersections which only include scenarios which could develop into crashes or SSM.

**Simultaneous arrivals and a finer time resolution could be a better exposure measures, but how to count them?**

...and for VRUs are still working?

Can we do that with **microsimulation**?
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Building intersection layout signal timing and traffic flows...

Number of unit entering the intersection

<table>
<thead>
<tr>
<th>Hours of the day</th>
<th>Bike Flow</th>
<th>Vehicle Flow</th>
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<td>23</td>
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Signal timing of the intersection...

Simulating only the conflicting flows...

Introduction | Statistical background | Why exposure? | VISSIM model | Think. behind research
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We are looking for simultaneous arrival...

All the cars in queue with all the bikes in the queue

Only the left turn related simultaneous arrival (LT)

A node analysis was used in VISSIM for tracking vehicles over time

The boundaries of the intersection was the stopping lines of each leg
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\[ T_{EntVehicle} \geq T_{EntBike} \geq T_{ExtVehicle} \]

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Analyzing vehicles and bikes approaching the node...

![Graph showing simulated and observed arrivals over hours of the day.]

- Simulated Sim. arrivals
- Observed Sim. arrivals
- Simulated
- Observed
We are looking for simultaneous arrival...

\[
\text{Sim}_\text{Arriv} = 0.0045 \times (\text{Traffic flow})
\]

\[R^2 = 0.8898\]

\[
\text{Sim}_\text{Arriv} = 0.0037 \times (\text{Traffic flow})
\]

\[R^2 = 0.5492\]
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We are looking for simultaneous arrival...

Sim Arrivals = 0.0017(Traffic flows)$^2$ - 0.1705(Traffic flows)

$R^2 = 0.9083$

Sim Arrivals = 0.0004(Traffic flows)$^2$ + 0.1186(Traffic flows)

$R^2 = 0.6669$

different trend but better goodness of fit
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We are looking for simultaneous arrival...

Sim_Arriv = 0.2228*(Traffic flow)
R² = 0.6405

Sim_Arriv = 0.218*(Traffic flow)
R² = 0.6026

Similar trend but lower goodness of fit
Conclusions of a first step...

• Microsimulation is really promising in developing models able to reproduce observed measure of exposure for road safety analysis involving VRUs;

• Simultaneous arrival can be difficult to get from observed data, microsimulation can help by reproducing the real world in a virtual environment;

• The linear regression shows that relationship between observed and simulated simultaneous arrivals and traffic flows is similar;

• A non linear regression shows in general a better gof of the model to data, This can resemble the not linear relationship between traffic flow and crashes.
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Next steps will be to...

• Consider that **microsimulation models calibrated only using observed hourly traffic produce a good prediction of simultaneous arrivals for lower values of traffic**, while for higher values there is a over/under estimation of simulated one, models need to be validated considering different traffic volumes ranges;

• Calibrate the microsimulation models based on other observed data to get more accurate output of traffic operation parameter;

• **Investigate the relationship between traffic and alternatives measure of exposures** obtained by varying traffic and analyze simulation outputs;

• Consider different measures of exposures for estimating Crashes/Conflicts for different crashes typology involving VRUs.
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For contacts 24/7...

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