Utilizing Real-time Traffic and Weather Data to Explore Crash Frequency on Urban Motorways: A Cusp Catastrophe Approach

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Introduction

- The effective treatment of crashes and the proactive transportation safety is a major concern to societies.
- Much research that utilized real-time collected traffic and weather data in freeways has been carried out recently.
- Alternative modeling techniques should also be considered.
- Non-linear relationships in crash numbers should also investigated.

Objectives

- The main objective is to propose cusp catastrophe models for modeling crash frequency.
- The dependent variable is the total crashes per segment.
- Cusp catastrophe models are applied.
- The potential existence of non-linearity in the system is examined.
- Real-time traffic and weather data from a major motorway arterials in Athens, Greece are considered.
- Cusp models are compared with traditional negative binomial models.
- The findings of the study are expected to extend previous research and add to current knowledge.

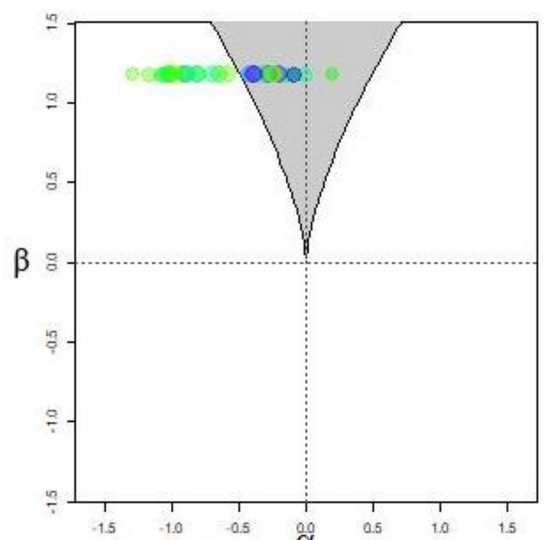
Data preparation

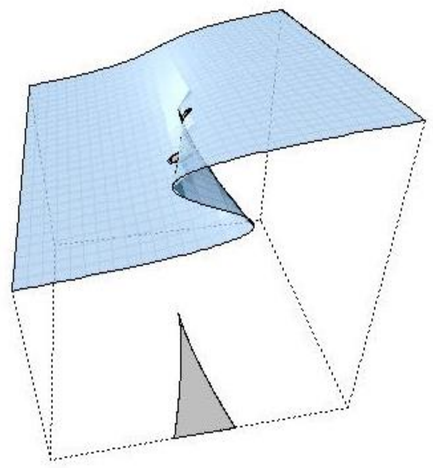
- The available dataset refers to the period 2006-2011 and come from a high demand urban motorway of Athens, Greece (Attica Tollway).
- Crash data were collected from the Greek accident database, SANTRA, which is provided by NTUA.
- Traffic data were extracted from the Traffic Management Centre (TMC) of Attica Tollway and included traffic flow, traffic occupancy, truck proportion and mean time speed every 5 minutes.
- Traffic data from the adjacent upstream loop detector were considered. Data were further aggregated to 15-min and 30-min traffic.
- Weather data were collected from the Hydrological Observatory of Athens and included: rainfall, temperature, relative humidity, solar radiation, wind direction and wind speed.
- The 10-min raw weather data were aggregated.

Methods of Analysis

- The core analysis of this study is the catastrophe theory.
- Catastrophe theory examines the qualitative changes in the behavior of systems when the control factors that influence their behavioral state face smooth and gradual changes. It assumes the existence of a dynamic system.
- It explains the sudden transition between the system states.
- Results with the cusp models will reveal potential non-linearity in the system.

Results





Asymmetry factors a	Variable	Coefficient	Std.error	p-value
ao	constant term	-1.521	0.708	0.0318 ***
a1	Q_avg_30m_upstream	0.017	0.009	0.0748**
Bifurcation factor β				
βo	constant term	1.180	0.712	0.0976 **
Dependent variable y				
wo	constant term	-2.591	0.304	< 0.001 ***
w1	Number of total crashes per km	0.563	0.077	< 0.001 ***
pseudo-R^2	0.667			
Logistic model-R^2	0.204			

**: Significant at 90% level
***: Significant at 95% level

Conclusions

- Evidence that road safety in urban freeways could be treated as nonlinear dynamic system. It may be implied that the dynamic change in urban road safety levels expressed by crash numbers is likely to be nonlinear in nature.
- Results indicate the possible existence of a catastrophic influence of medium-term changes in traffic flow on the system, as sudden changes between different states of the system take place.
- This theory could be seen as a useful tool for developing indicators of a catastrophe.
- Findings do not strongly confirm the strong presence of a dynamic system.
- Traditional models such as the negative binomial model are proved equally capable of describing the underlying phenomenon.
- Overall, one can conclude that in such cases the linearity of the safety system is preserved.

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