Empirical assignment of congestion causes to congestion events

Master's Thesis of Benjamin Bampoh

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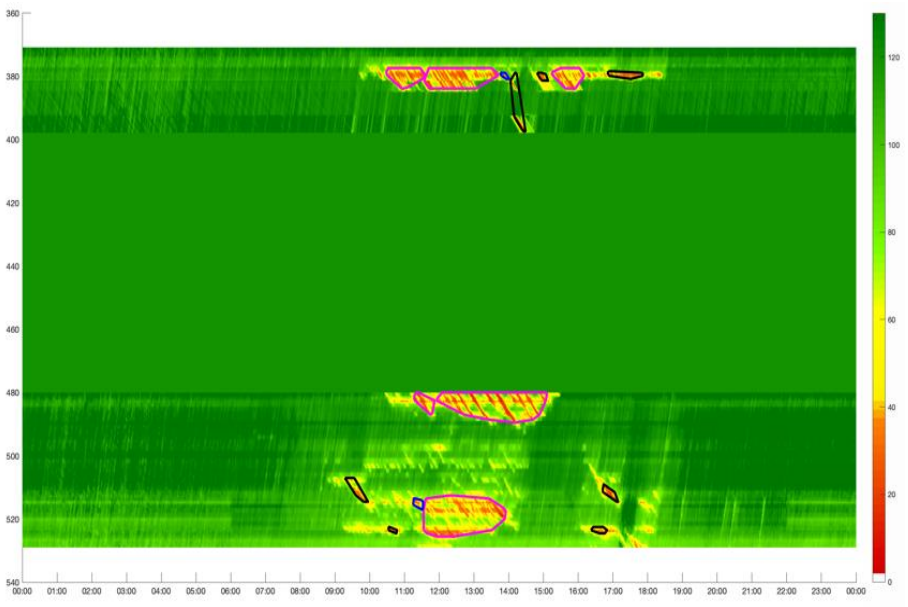

Figure 1: Typical clusters of Stop-and-Go waves; Source (Kessler, 2021)

Background and Goal

Congestion occurs when the present traffic demand on a given section of a road exceeds its functional capacity. Congestion has a cost (direct and/or indirect). In Germany, Munich often tops the list of cities with high losses of time in congestion with costs of congestion estimated as almost twice the national average (INRIX, 2018, 2021).

Various authors have proposed different classifications for congestion. Bogenberger (2010) proposed a 4-tier classification namely: Jam waves, Stop-and-Go waves, Wide jams, and Mega jams. Kessler (2021) researched these further and developed a novel strategy that could fuse both low- and high-resolution data from multiple sensor technologies in detecting these congestion types. Applied on a section of the A9 freeway in Bavaria between Munich and Nürnberg, a total of 1,835 congestion incidents were detected in 2019 with their frequencies shown in Figure 2 below. This research empirically assigns the causes of congestion to these congestion events identified by Kessler (2021).

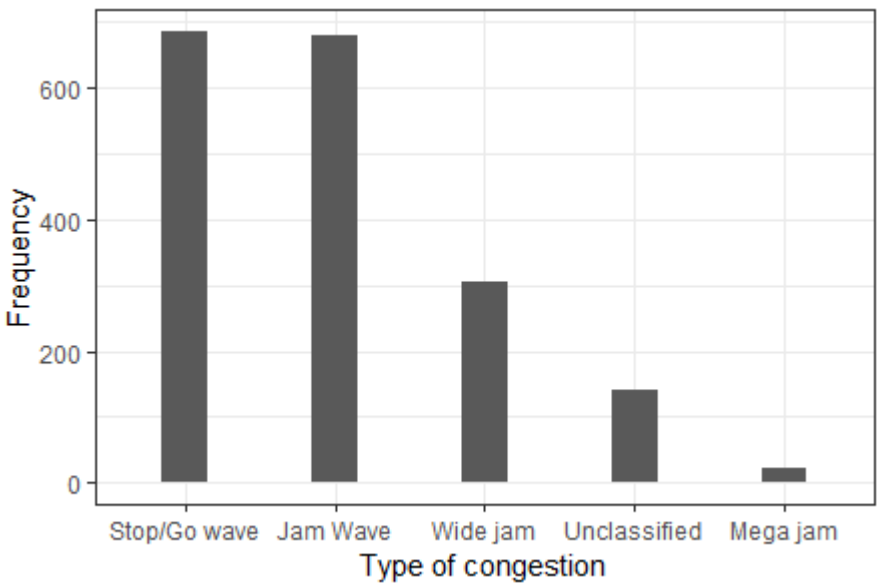

Figure 2: Frequencies of identified congestion types

Methodology

In undertaking this research, a database consisting of several variables was compiled for detailed analysis. These variables were mainly drawn from literature, and a few of them from the local environment in which the spatio-temporal dimensions of the project was set. Variables such as the spatio-temporal dimensions of the identified congestions, weather and atmospheric condition, football matchdays at major sporting event centers, public holidays in Bavaria, accident records on the relevant sections of the A9 freeway, number of intersections affected by each congestion event, etc., were researched and analyzed.

Data analysis was done in R programming language (version 4.1.2 (2021-11-01) - "Bird Hippie"). A multinomial logistic regression with neural networks model was developed and used as the prediction model. Goodness of fit parameters appraised in ascertaining the usefulness of the model were model accuracy, model sensitivity and Kappa value.

Main Findings

Odds	Key variables	Odds Ratio
Stop-and-Go waves relative to Jam waves	Atmospheric condition (wintry mix)	2.47×10^{96}
	Accident	2.49
	Congestion length	1.44
Wide jams relative to Jam waves	Accident	10.23
	Number of intersections	1.33
Mega jams relative to Jam waves	Atmospheric condition (wintry mix)	3.91×10^{98}
	Day (Wednesday)	1.00×10^{57}
	Month (May)	4.15×10^{55}
	Month (December)	2.21×10^{10}
	Accident	30.11

Table 1: Key variables that influence the odds of the congestion types

References

Bogenberger, K. (2010). *Stauklassifizierung und Untersuchung des Zusammenhangs Verkehrsstarke und Verkehrszusammenbruch* [Abschlussbericht].

INRIX. (2018). INRIX 2017 Global Traffic Scorecard. INRIX. Retrieved 03.10.2022 from https://www.missionline.it/wp-content/uploads/2018/02/INRIX_2017_Traffic_Scorecard_Final.pdf

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Kessler, L. (2021). *Strategies for Detection of Congestion Patterns Using Multiple Sensor Technologies* [PhD. Dissertation, Technische Universität München].