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Network analysis methods for smart inspection in the transport domain

Bruin, G.J. de

Citation

Bruin, G. J. de. (2023, November 16). *Network analysis methods for smart inspection in the transport domain*. SIKS Dissertation Series. Retrieved from <https://hdl.handle.net/1887/3656981>

Version: Publisher's Version

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Note: To cite this publication please use the final published version (if applicable).

Network Analysis Methods
for Smart Inspection
in the Transport Domain

Gerrit Jan de Bruin



Human Environment and Transport
Inspectorate
*Ministry of Infrastructure
and Water Management*



Universiteit
Leiden

The work in this book was funded by the Ministry of Infrastructure and Water Management through Leiden University. The author used facilities at the Leiden Centre of Data Science, the Leiden Institute of Advanced Computer Science, and the Innovation and Data Lab of the Human Environment and Transport Inspectorate (part of the Ministry of Infrastructure and Water Management).



SIKS Dissertation Series No. 2023-21

The research reported in this thesis has been carried out under the auspices of SIKS, the Dutch Research School for Information and Knowledge Systems.

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Typesetting & Figures: \LaTeX , Gephi, diagrams.net, Matplotlib, and Seaborn.

All software used is open-source.

Open access: <https://scholarlypublications.universiteitleiden.nl/>

Cover design: Wolters Vormgeving

Printed by: Gildeprint, Enschede, the Netherlands, <https://www.gildeprint.nl/>

ISBN: 978-94-6419-967-3

Network Analysis Methods for Smart Inspection in the Transport Domain

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op donderdag 16 november 2023
klokke 13.45 uur

door

Gerrit Jan de Bruin
geboren te Amersfoort
in 1993

Promotor:

Prof.dr. H.J. van den Herik

Copromotores:

Dr. F.W. Takes

Dr. C.J. Veenman

Promotiecommissie:

Prof.dr. H.C.M. Kleijn

Prof.dr. T.H.W. Bäck

Dr. W.A. Kusters

Prof.dr. J.N. Kok (Universiteit Twente)

Prof.dr. N.V. Litvak (Universiteit Twente)

Preface

This thesis is part of an extensive collaboration between the Dutch Ministry of Infrastructure and Water Management (I&W) and Leiden University. My first personal encounter with I&W was during my master's study in Analytical Chemistry. I was determined to work on a subject with societal relevance, leading me to Jasper van Vliet, who worked at the Inspectie Leefomgeving en Transport (ILT), part of I&W. The aim of my master thesis was to conduct efficient compliance monitoring of cargo ship's fuel by using the information from chemical sensors. The thesis made it to a letter to the parliament [88, 89]. Afterward, Jasper invited me to participate in a new Ph.D. project of the Ministry. In this project, the ambition is to arrive at intelligence-led vehicle inspection by risk assessments. Two research directions were launched to explore the risk assessment of vehicles: (1) the application of machine learning techniques and (2) the application of network science techniques.

During my Ph.D. research, many developments occurred related to the topics of the thesis. I would like to mention two specific events that have had an impact on my research. The first one is the introduction of the General Data Protection Regulation (GDPR) in 2018. This law requires the use of transparent models that allow for an explanation of the results achieved. The new law led to increased awareness of the importance of fair data and fair models. The second event is the upset of the Dutch childcare benefits ("De Toeslagenaffaire"). In 2019 it became painfully clear how things can go wrong when authorities are (1) relying on biased data and (2) using models that are not validated fairly. I will address the two points (biases and non-validated models) in my thesis, although I work with non-personal data. They are in particular relevant for the proposed procedure to implement a smart inspection of cargo ships in Chapter 6.

Working both at Leiden University and at the ILT allowed me to interact with the wonderful world of academia and to stay in close contact with a governmental organization that makes a big impact by ensuring safe transportation and reducing the environmental pollution in the Netherlands. This enriching combination has helped me to create this thesis, for which I am grateful.

Gerrit Jan de Bruin, Utrecht, March 8th, 2023

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List of Abbreviations

AA	Adamic-Adar	24, 29, 30, 32
Aminer	Arnetminer	35
ANPR	Automatic Number-Plate Recognition	13, 68, 73, 82
AP	Average Precision	57, 60, 61
AUC	Area Under the Receiver Operating Characteristic Curve	33, 36, 38, 45, 57, 76, 103–105, 108–110, 113
CN	Common Neighbors	24, 29, 30, 32, 56
DBLP	Digital Bibliography & Library Project	xix, 30, 31, 34, 37, 39, 43, 44
FOC	“Flag Of Convenience”	98
GC	Giant Component	xx, 6, 9, 10, 57, 71, 72, 80, 81, 83, 84, 87–89, 91, 106, 107
GDPR	General Data Protection Regulation	vii
GPS	Global Positioning System	66
HPLP	High-Performance Link Prediction	55
I&W	Infrastructure and Water Management	vii, 13, 82
ILT	Inspectie Leefomgeving en Transport (English: Human Environment and Transport Inspectorate)	vii, viii, 1, 2, 5
IMO	International Maritime Organization	98
JC	Jaccard Coefficient	24, 30, 32
KONECT	KOblenz NEtwork CollecTion	35
MoU	Memorandum of Understanding	94, 98, 113
NIR	New Inspection Regime	94–96
NL	the Netherlands	85
NN	Number of Neighbors	56
NSI	Netherlands Shipping Inspectorate	2
PA	Preferential Attachment	24, 30, 32
PF	PropFlow	56
PSC	Port State Control	94

RDW	Rijksdienst voor het Wegverkeer (English: Netherlands Vehicle Authority)	85
ROC	Receiver Operating Characteristic	xv, xx, 33, 76, 77
SCAFF	Splitting Criterion Area under the curve for Fairness	103, 106
SNAP	Stanford Network Analysis Project	35
SP	Shortest Paths	56
WiFi	Wireless Fidelity	66
WTF	Weighted Temporal Features	32
XGBoost	eXtreme Gradient Boosting	36, 38, 39, 56, 59

List of Definitions

1	Data-driven assessment for inspection	2
2	Smart inspection	3
3	Model validation	3
4	Model testing	3
5	Fair model	4
6	Interpretable model	5
7	Network	6
8	Assortativity	7
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