



XV Jornada Nacional de Asefma
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Exploring the impact of road surface conditions on truck fleet fuel consumption using Big Data

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Background



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- ▶ Experiments (e.g. Sandberg et al 2011) and modelling (e.g. Chatti and Zaabar 2012) suggest that road surface characteristics (evenness and texture) can influence fuel consumption by up to 5%
- ▶ But maybe only 2% or 3% for UK highways
- ▶ So road maintenance could save fuel consumption, costs and emissions for the whole vehicle fleet (unlike new vehicle technologies)
- ▶ But these experiments and models are soon out of date
- ▶ And the findings are difficult to validate for real vehicle fleets, at network level and for real driving conditions where measurements are confounded by so many variables.

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Big Data



Data from sensors installed on modern trucks inform fleet managers (SAE J1939)



Highways Agency Pavement Management System database containing highway condition information for road managers

A model for:

- Routing of vehicles;
- Help in the design and maintenance of pavements;
- Improve Life Cycle Assessment and Life Cycle Cost Analysis of road pavements
- Live network, truck and fuel consumption information

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England Case Study

During 1 week in October 2016:

- ~ 300 km of motorway
- Constant speed (+/- 2.5 km/h)
- 1,110 articulated trucks (Euro 6 with 6 axles)
- 14,281 records
- 1 minute or 1 mile
- Fuel used in 0.001 l

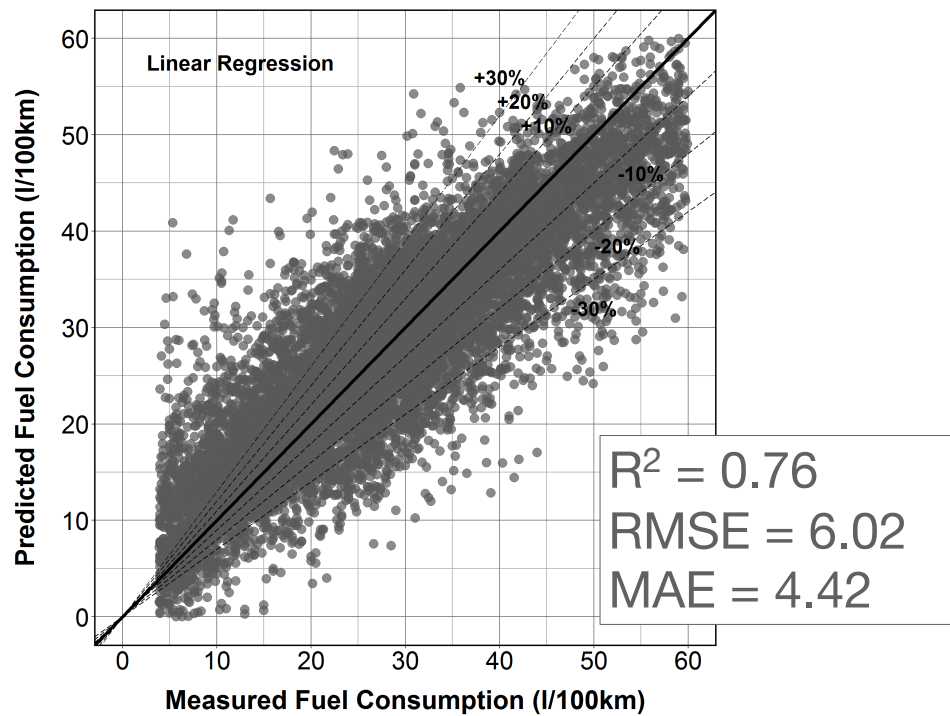


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Included Variables

- Gross Vehicle Weight
- Vehicle constant speed (+/- 2.5 km/h)
- Acceleration
- Torque Start
- Torque End
- Revolutions
- Gear
- Cruise control
- Road gradient
- Radius of curvature
- Unevenness LPV03 m
- Unevenness LPV10 m
- Unevenness LPV30 m
- Macrottexture (SMTD)

Multiple Linear Regression

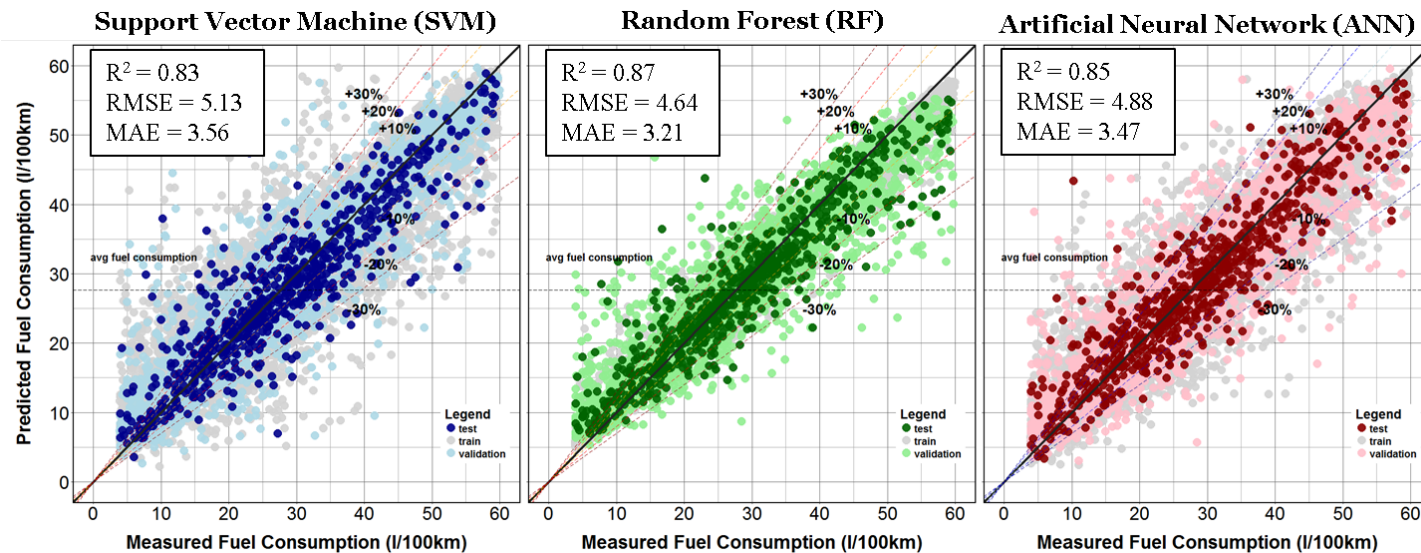


Can we improve this using machine learning?

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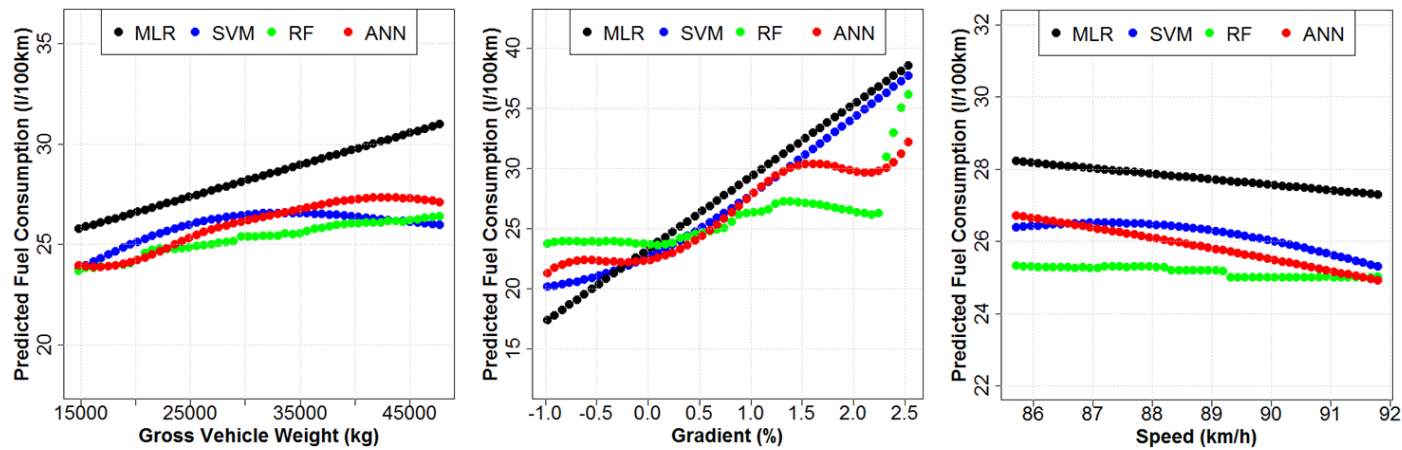
Machine Learning

72% records for training, 23% records for validation, 5% records for test
10-fold cross-validation: R^2 , RMSE, and MAE calculated on test sets (average of 10).



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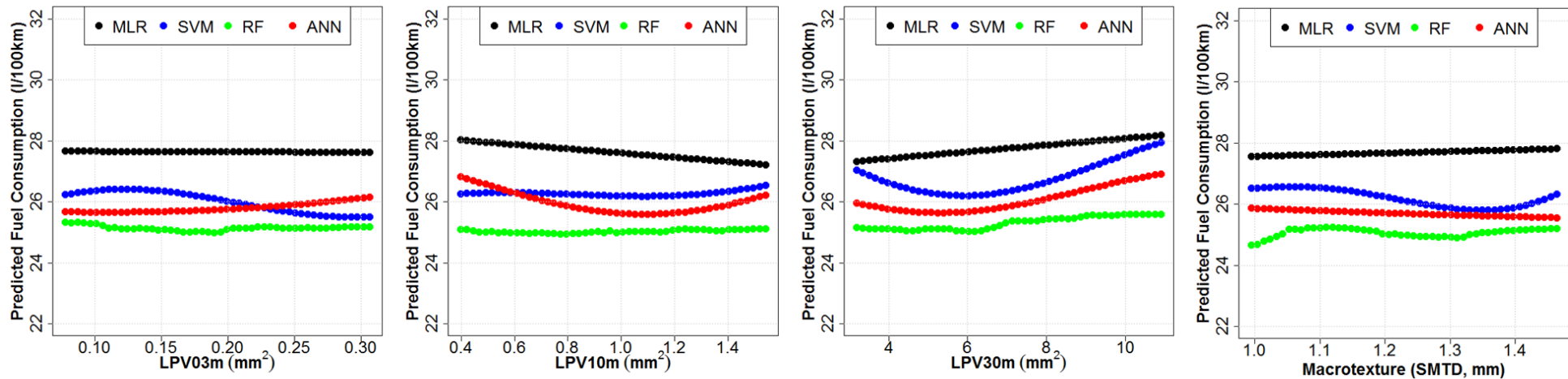
Parametric Analysis



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Parametric Analysis

Perrotta et al (2017) DOI: 10.1109/BigData.2017.8258382



For articulated trucks at constant high-speed on highways in good condition:

LPV03m / LPV10m / Macrottexture: No significant effect?

LPV30m: Possible Increased Fuel Consumption?

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Ongoing before-and-after maintenance studies



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HDM4 Calibration

Perrotta et al (2019) DOI: 10.1016/j.trd.2018.11.001

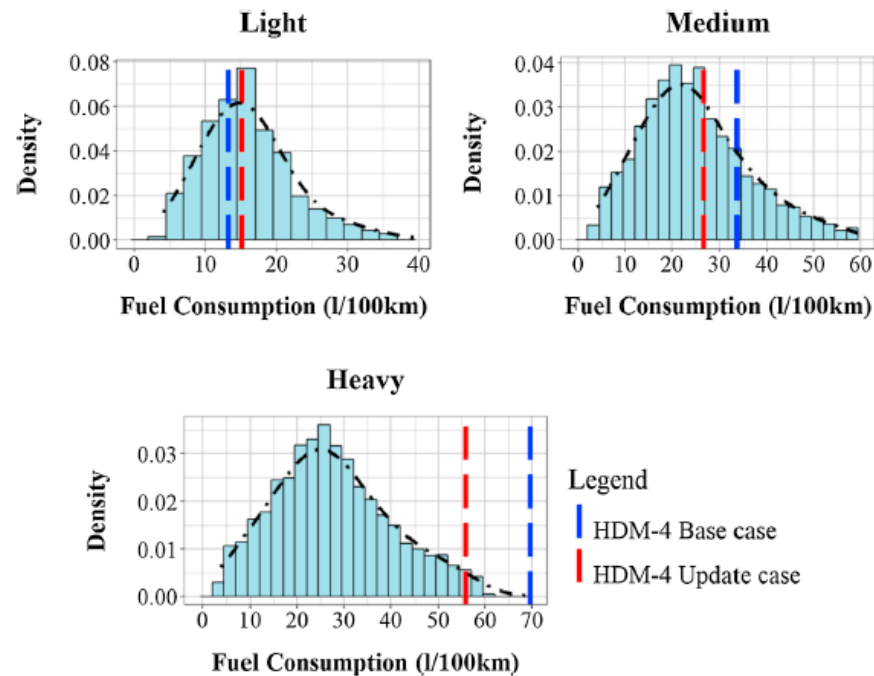


Fig. 1. Comparison of HDM-4 estimates ('Base case' and 'Update Case') with measured fuel consumption distributions for light, medium and heavy trucks.

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Roundabout Collision Risk

Kamla et al (2019) DOI: 10.1016/j.aap.2018.04.31



Fig. 1. Grade-separated roundabout (J28 on M1 motorway, UK) with accident (left) and truck HBI (right) positions.

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Roundabout Collision Risk

Kamla et al (2019) DOI: 10.1016/j.aap.2018.04.31

Table 7

Effect of an Increase in Geometric and Traffic Variables on Total Accidents, Truck Accidents, and HBIs using Random-Parameters Models.

Roundabout category	Variable	Total accident numbers	Truck accident numbers	HBI numbers
Whole roundabouts	ln(AADT)	↑↑	↑↑	↑↑
	Percentage of average annual daily truck traffic	86% ↑↑	↑↑	↑↑
	Un-signalised roundabouts compared to partially signalised roundabouts	↓↓	↓↓	51% ↓↓
	Signalised roundabouts compared to partially signalised roundabouts	–	76% ↓↓	48% ↓↓
	Two-lane roundabouts compared to three-lane roundabouts	–	66% ↓	–
	ICD	↑	↑	–
	Three-arm roundabouts compared to six-arm roundabouts	–	↓↓ ↓	48% ↓↓
	Circulatory roadway width	–	↓ ↓	↓↓
	Entry width	–	–	↑

Conclusions

- ▶ Case study shows the feasibility of using Big Data to:
 - ▶ Monitor the impact of road condition on vehicle fuel consumption
 - ▶ For real vehicles and driving conditions at highway network level
 - ▶ Continuously
- ▶ Many other potential uses for this Big Data approach, including:
 - ▶ Calibration of pavement-vehicle interaction models
 - ▶ Life Cycle Assessment use phase / Life Cycle Cost Analysis of road maintenance
 - ▶ Collision risk



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Gracias por su atención!!

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