Vehicular Data Analytics for Smart Driving

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Why?

Reckless Driving

Driving Anomaly Detection

IoT

+

Data Analytics

→

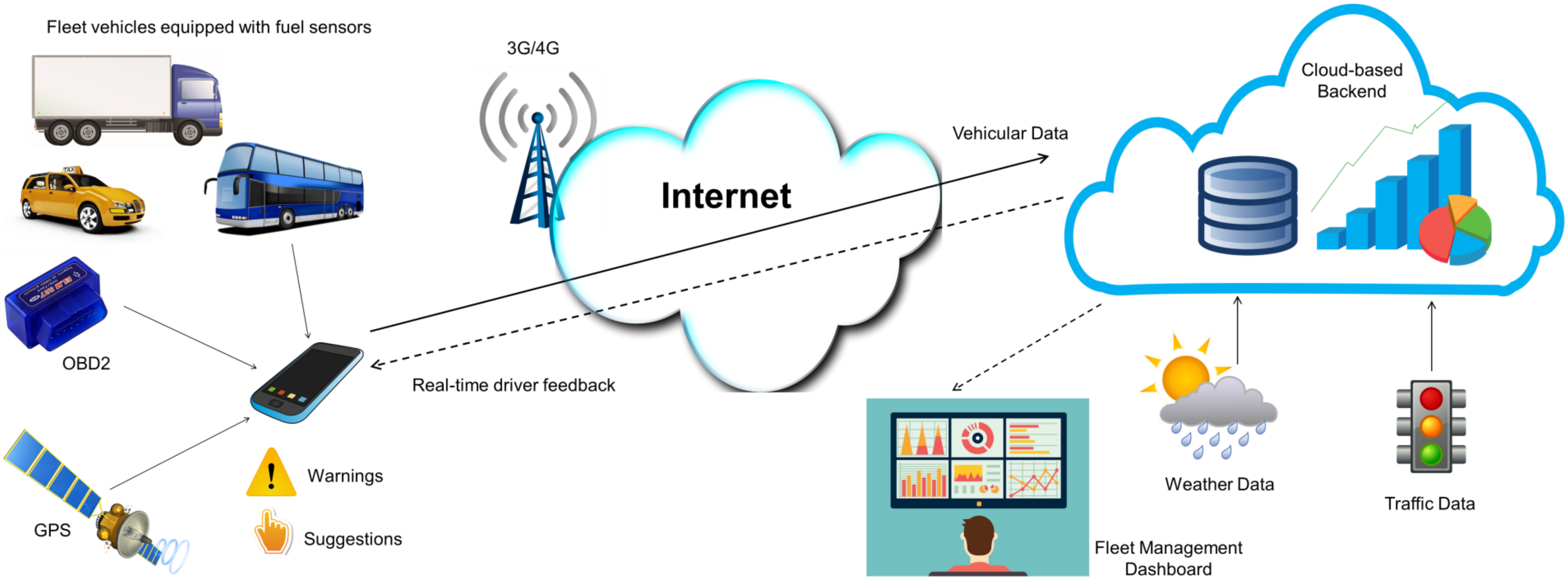
Smart Driving

Fault Detection & Prediction

Fuel Fraud

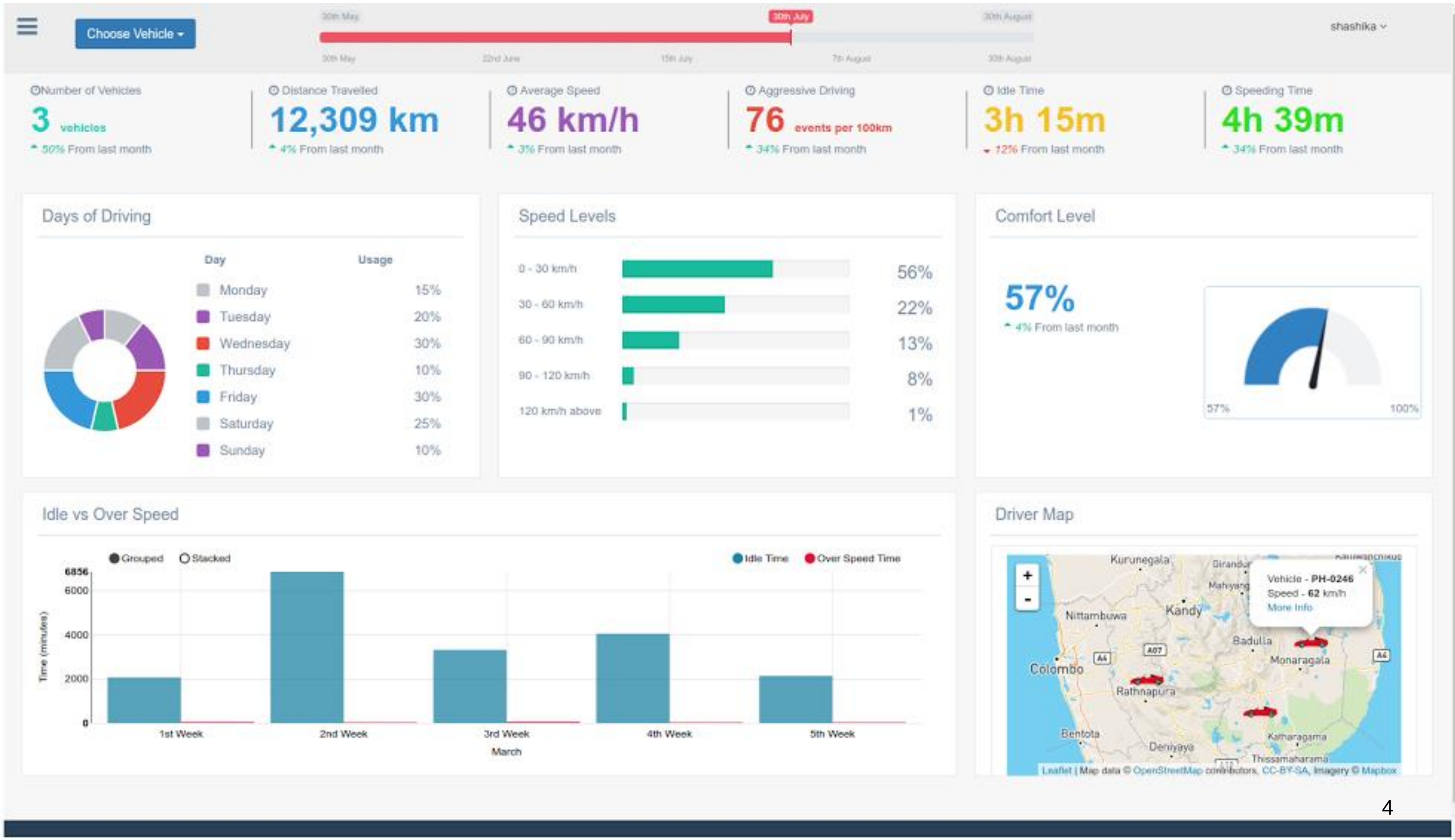
Tracking & Surveillance

Solution Architecture



- Real-time analysis
  - Driving anomaly detection
  - Fuel fraud
  - Geo fencing
  - Vehicle fault detection
- Historical analysis
  - Driver profiling
  - Driver coaching
  - Predicting sensor failure
  - Case analysis

Dashboard

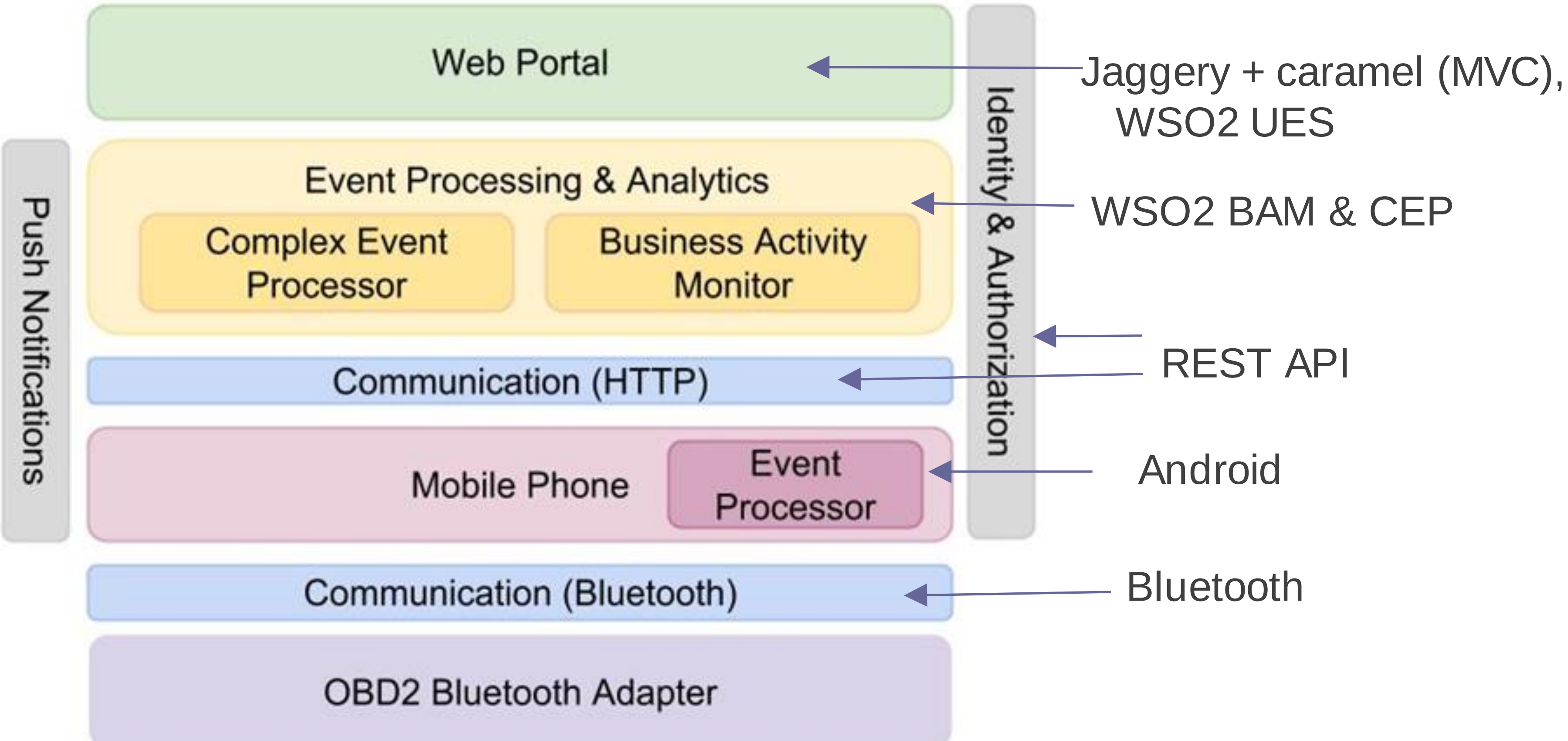


Choose Vehicle
30th July
shashika
Number of Vehicles
3 vehicles
50% From last month
Distance Travelled
12,309 km
4% From last month
Average Speed
46 km/h
3% From last month
Aggressive Driving
76 events per 100km
34% From last month
Idle Time
3h 15m
12% From last month
Speeding Time
4h 39m
34% From last month
Days of Driving
Day
Usage
Monday 15%
Tuesday 20%
Wednesday 30%
Thursday 10%
Friday 30%
Saturday 25%
Sunday 10%
Speed Levels
0 - 30 km/h 56%
30 - 60 km/h 22%
60 - 90 km/h 13%
90 - 120 km/h 8%
120 km/h above 1%
Comfort Level
57%
4% From last month
57%
100%
Idle vs Over Speed
Grouped
Stacked
Idle Time
Over Speed Time
Time (minutes)
6856
6000
4000
2000
0
1st Week
2nd Week
3rd Week
4th Week
5th Week
March
Driver Map
Vehicle - PH-0246
Speed - 62 km/h
More Info
Kurunegala
Nittambuwa
Kandy
Badulla
Colombo
Monaragala
Rathnapura
Bentota
Deniyaya
Kataragama
Thissamaharama
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

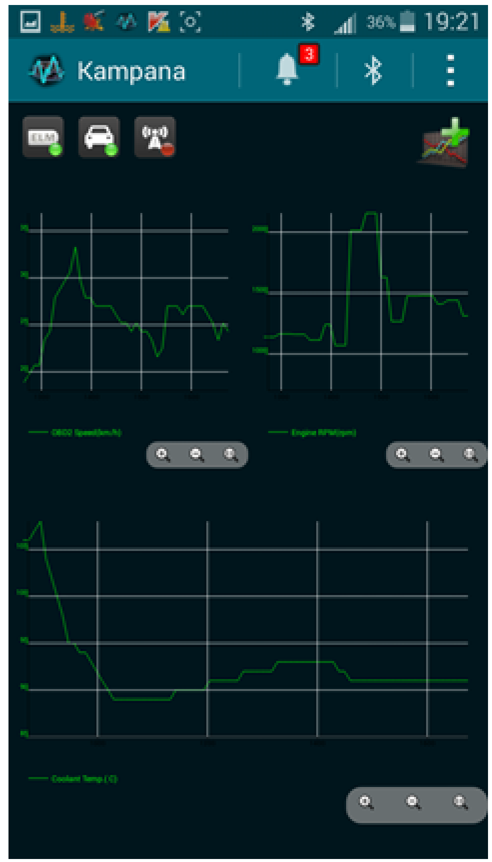
OBD2 Based Analysis

- OBD – On Board Diagnostics
  - Available in many vehicles since 1996
  - OBD2 – In most vehicles since 2005
  - Speed, RPM, Odometer, Cooleant Temperature, Padle Position, Oxygen, Mass Air Flow, etc.

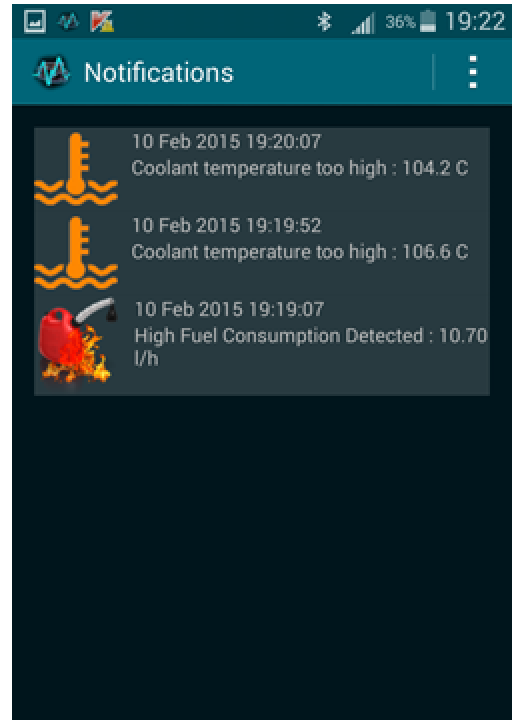
Solution Architecture



App-Level Processing – Real-Time Dashboard

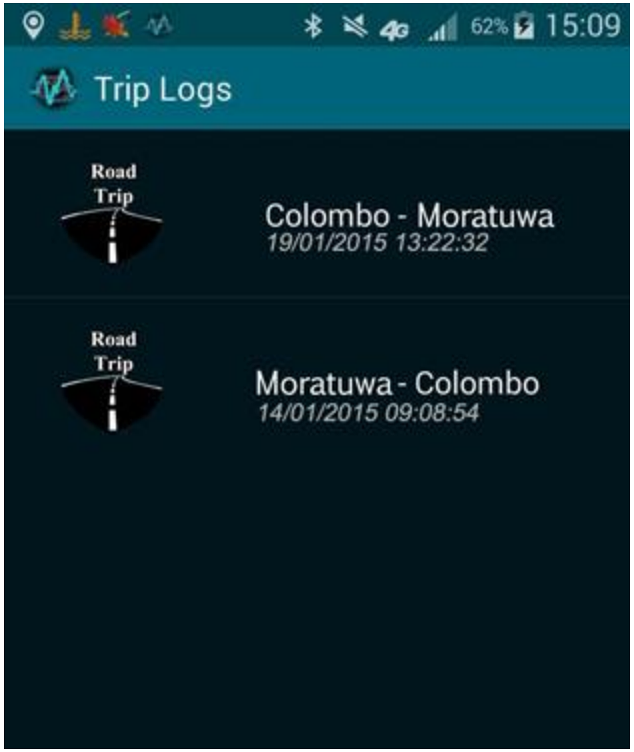


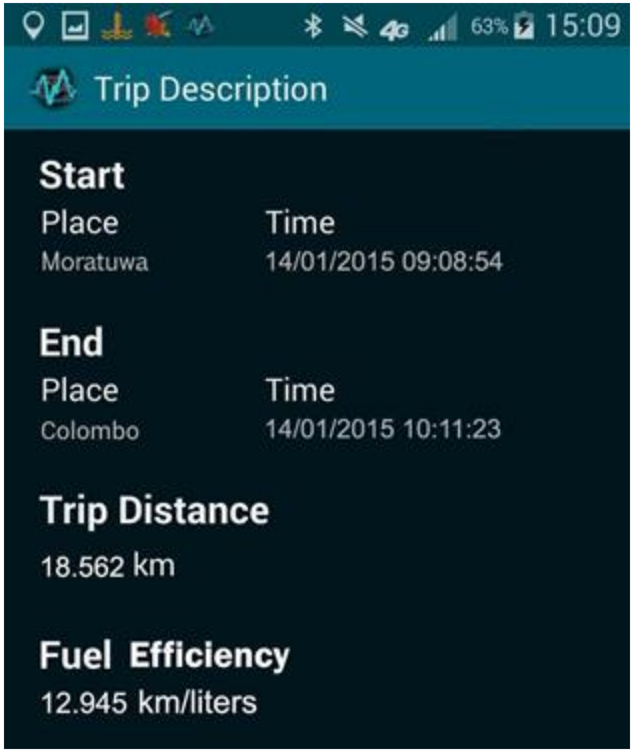
Fuel Economy & Coolant Temperature Monitoring



- Implemented using Siddhi CEP on smartphone
- Minimum impact on battery level
  - Bandwidth saving due to local processing → Reduce energy consumption

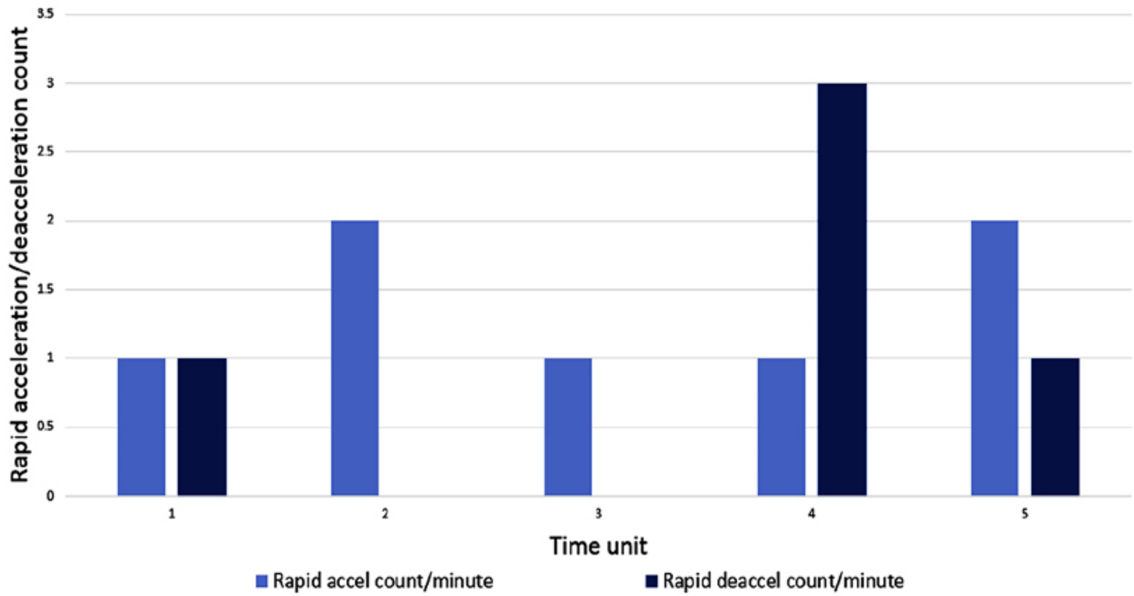
Trip Logs





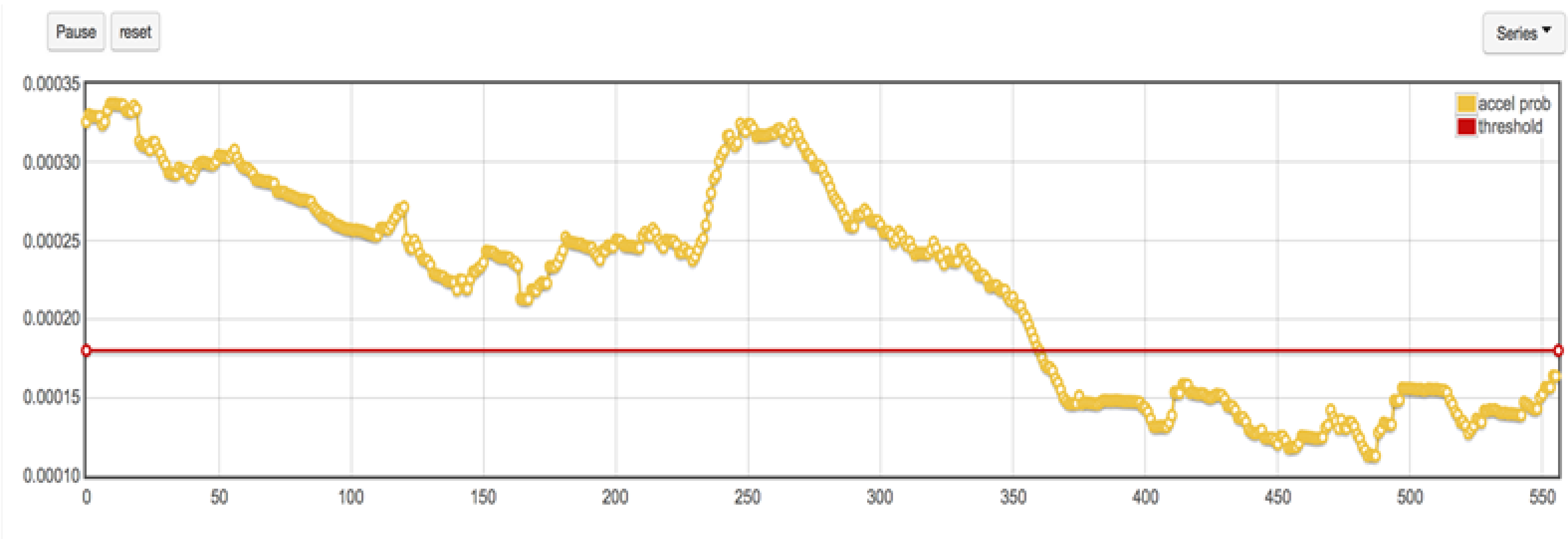
- Standard car → High-end Car

Backend Processing – Reckless Driving

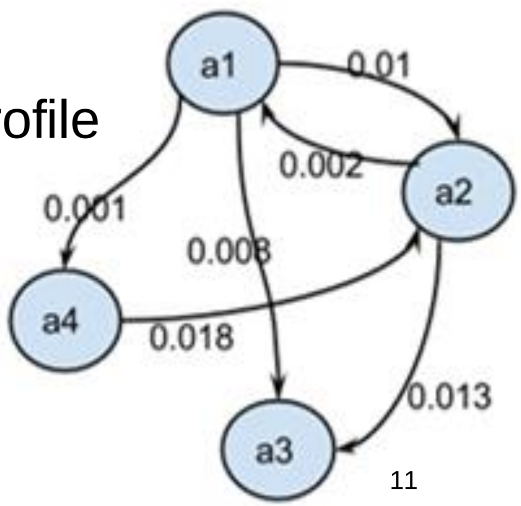


- Hard accelerations & deceleration count above a threshold
  - Per 100 Km
  - Per 1 Hour
- Count depends on average speed of vehicle in last *t* seconds
- Implemented using Siddhi CEP
- Computed values stored in RDBMS

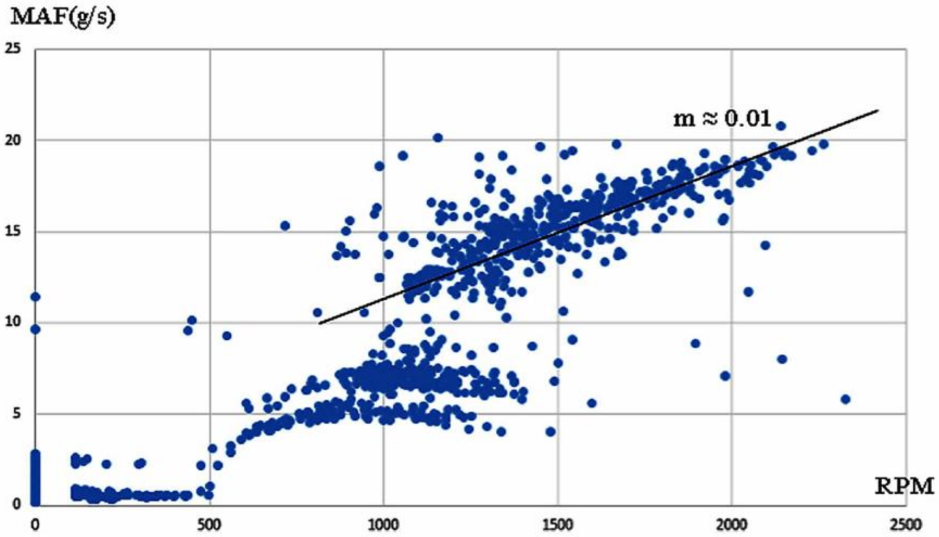
Driver Profiling

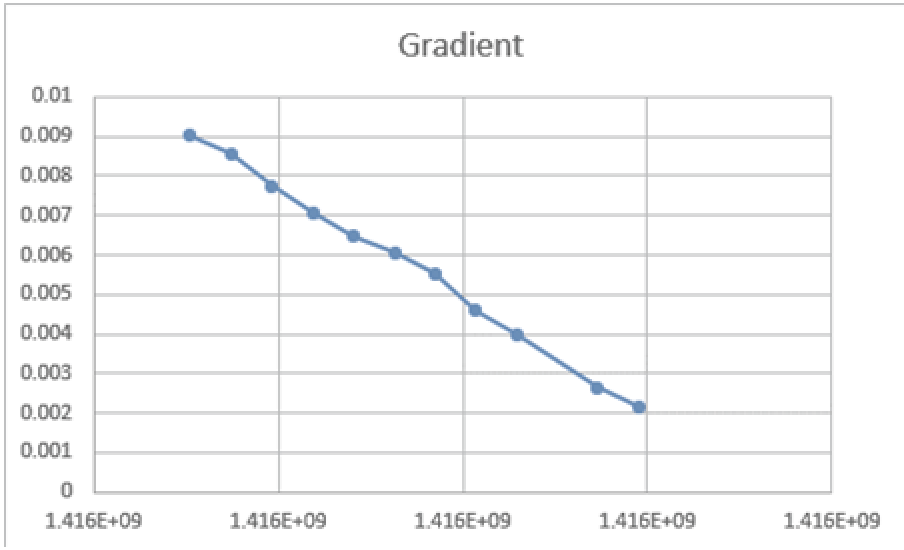


- Detection of anomalies
  - Hidden Markov Model based on acceleration profile
  - Model implemented in BAM
  - Validator implemented in CEP



Sensor Failure Prediction





- Mass Air Flow (MAF) sensor value has a linear relationship with engine RPM
- When sensor fails, gradient between MAF & RPM reduces with time
- Rate of change of gradient can predict date of failure

Fuel Consumption Prediction

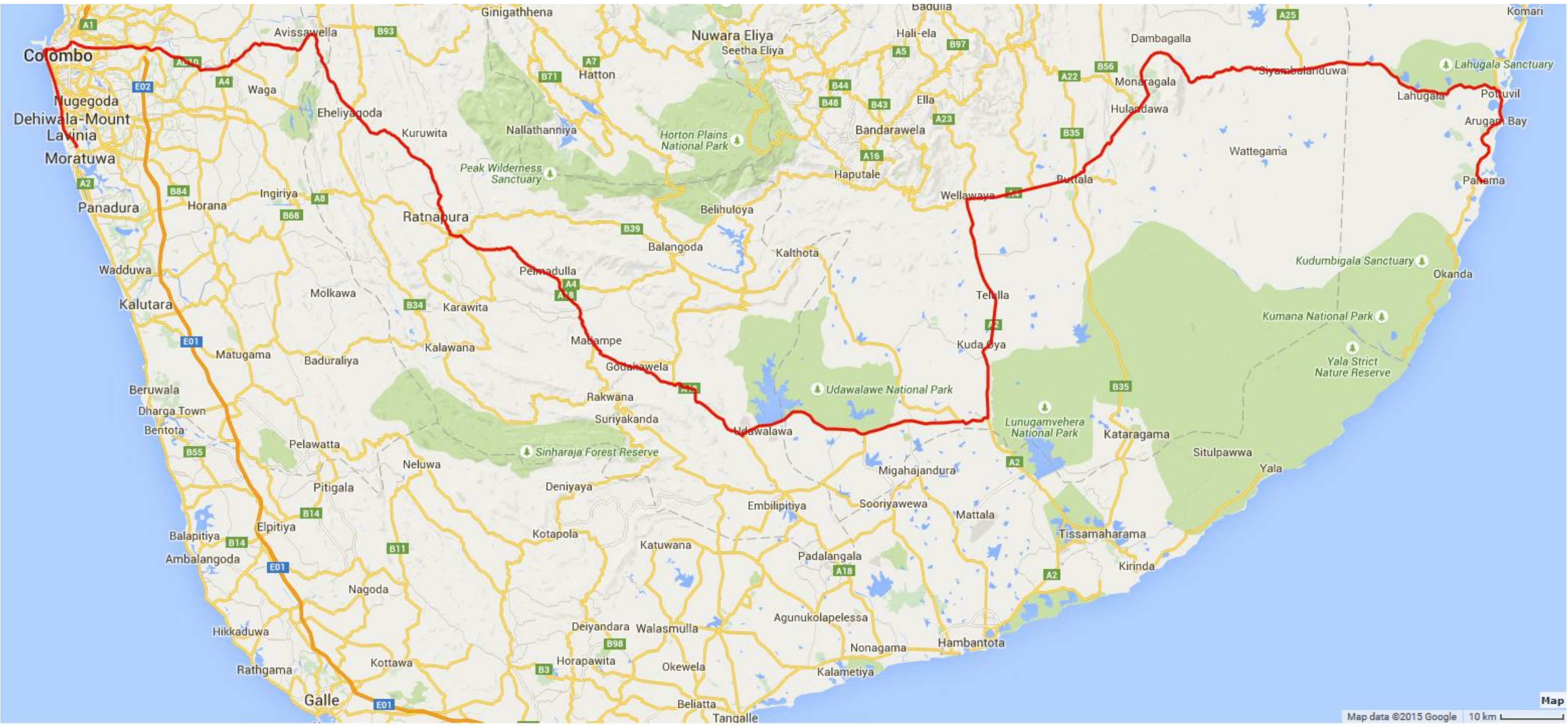
- Long-distance bus fitted with a GPS unit & high-precision fuel sensor
- Could you
  - explain variability in fuel consumption
  - predict fuel consumption of a journey
  - give tips to improve fuel consumption

?

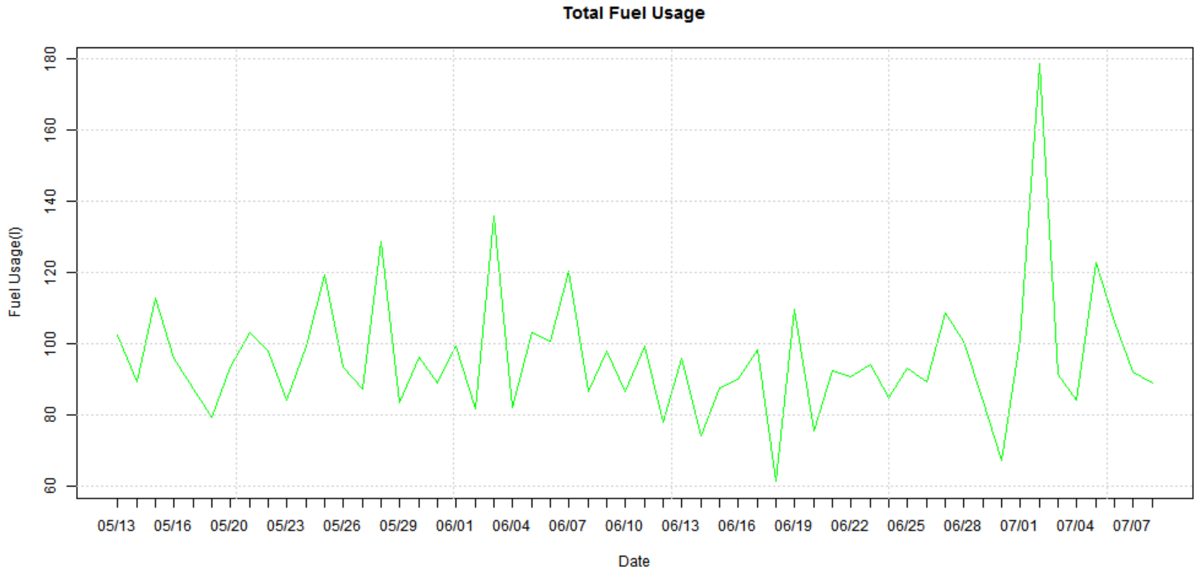
Dataset

- From 13 May 2015 – 31 August 2015
- Parameters
  - Timestamp (date and time)
  - Longitude (Min: 5.918611°N, Max: 9.835556° N)
  - Latitude (Min: 79.516667° E, Max: 81.879167° E)
  - Bearing (0° to 360°)
  - Elevation (Min: 0m, Max: 2,524m)
  - Distance traveled (km) – between two samples
  - Speed (kmh-1)
  - Acceleration (kmh-2)
  - Ignition status (1 – Ignition On or 0 – Ignition Off)
  - Current battery voltage (Min: 0v, Max: 29v)
  - Fuel level (Min: 0L, Max: 218L)
  - Fuel consumption (L)

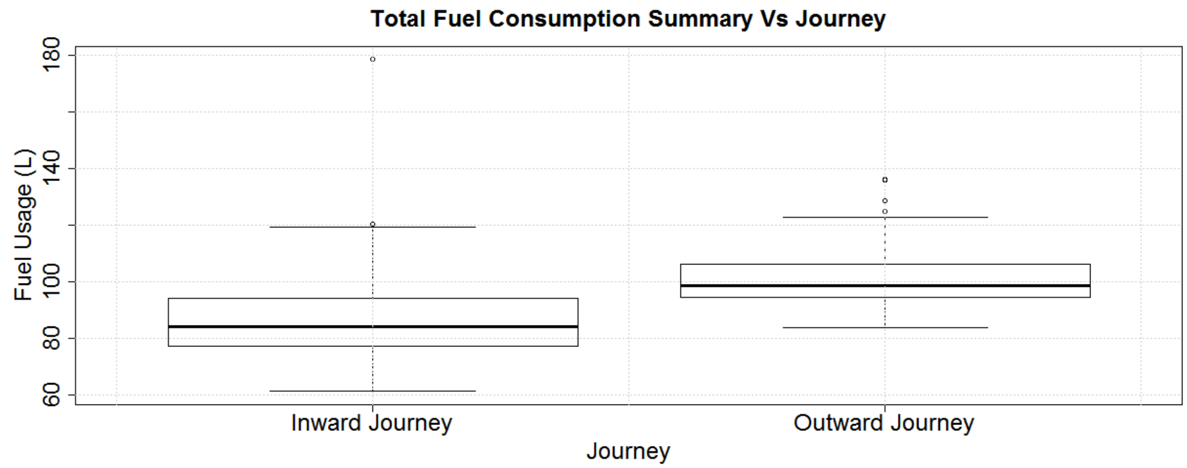
Bus Route


Colombo
Nugegoda
Dehiwala-Mount Lavinia
Moratuwa
Panadura
Horana
Ingiriya
Wadduwa
Kalutara
Molkawa
Matugama
Baduraliya
Beruwala
Dharga Town
Bentota
Pelawatta
Pitigala
Elpitiya
Balapitiya
Ambalangoda
Hikkaduwa
Rathgama
Galle
Nagoda
Kottawa
Avissawella
Waga
Eheliyagoda
Kuruwita
Ratnapura
Ginigathhena
Hatton
Nallathanniya
Peak Wilderness Sanctuary
Nuwara Eliya
Seetha Eliya
Horton Plains National Park
Belihuloya
Balangoda
Pelmadulla
Karawita
Kalawana
Madampe
Godakawela
Rakwana
Suriyakanda
Sinharaja Forest Reserve
Neluwa
Deniyaya
Kotapola
Katuwana
Deiyandara
Walasmulla
Horapawita
Okewela
Beliatta
Tangalle
Badulla
Hali-ela
Ella
Bandarawela
Haputale
Kalthota
Udawalawe National Park
Udawalawa
Embilipitiya
Migahajandura
Sooriyawewa
Padalangala
Agunukolapelessa
Nonagama
Kalametiya
Hambantota
Mattala
Tissamaharama
Kirinda
Kataragama
Lunugamvehera National Park
Wellawaya
Telulla
Kuda Oya
Buttala
Dambagalla
Monaragala
Hulandawa
Wattegama
Siyambalanduwa
Lahugala
Lahugala Sanctuary
Pottuvil
Arugam Bay
Panama
Komari
Kudumbigala Sanctuary
Okanda
Kumana National Park
Yala Strict Nature Reserve
Situlpawwa
Yala
Map
Map data ©2015 Google
10 km

Fuel Usage

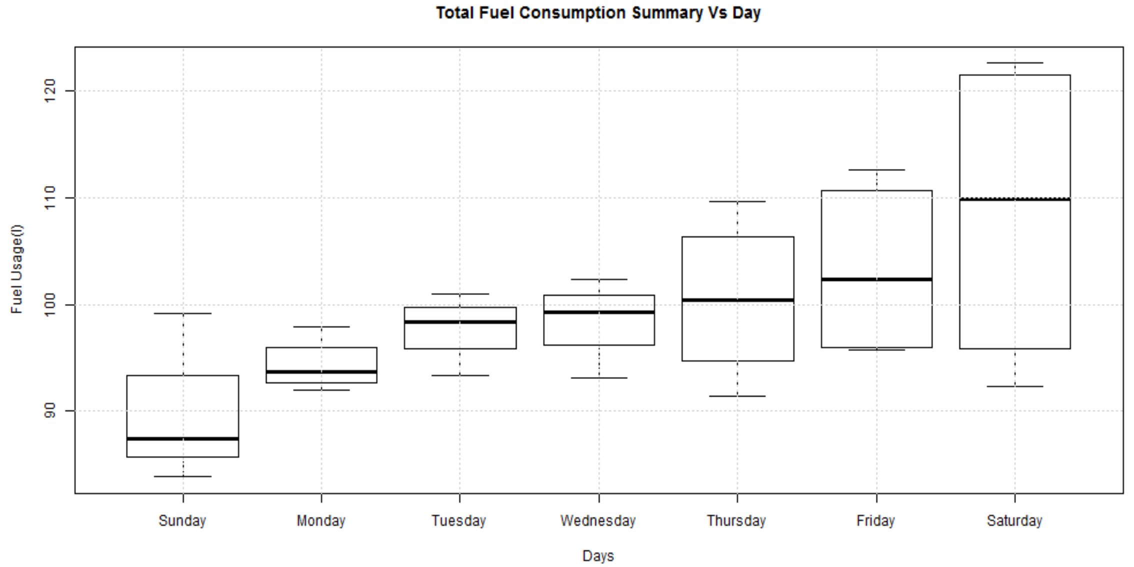


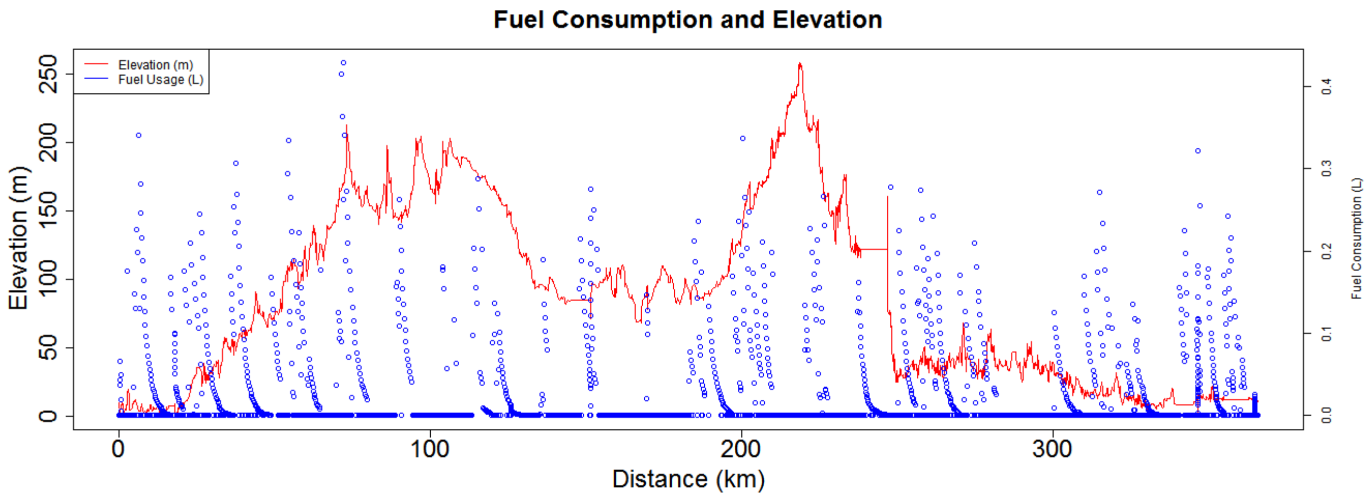
Total Fuel Usage
Fuel Usage(l)
180
160
140
120
100
80
60
05/13
05/16
05/20
05/23
05/26
05/29
06/01
06/04
06/07
06/10
06/13
06/16
06/19
06/22
06/25
06/28
07/01
07/04
07/07
Date



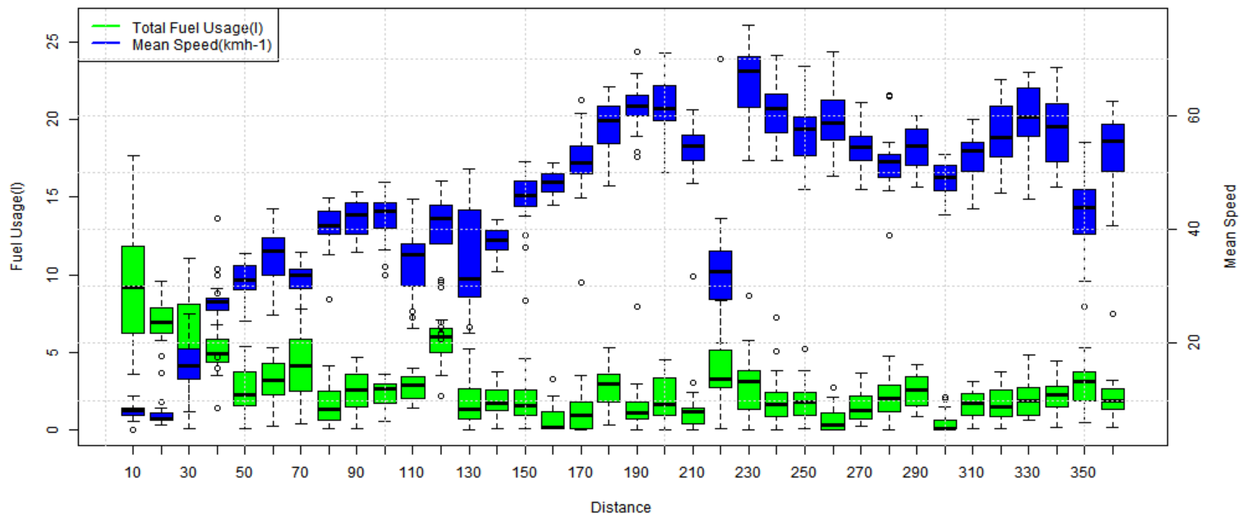
Total Fuel Consumption Summary Vs Journey
Fuel Usage (L)
180
140
100
80
60
Inward Journey
Outward Journey
Journey

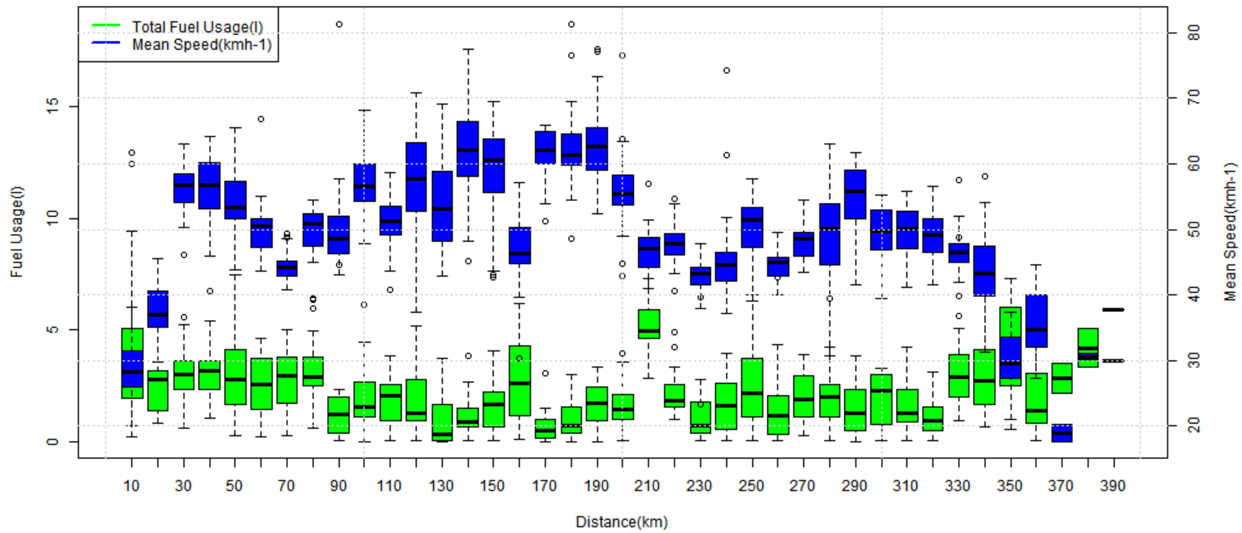
Factors Contributing to Fuel Usage



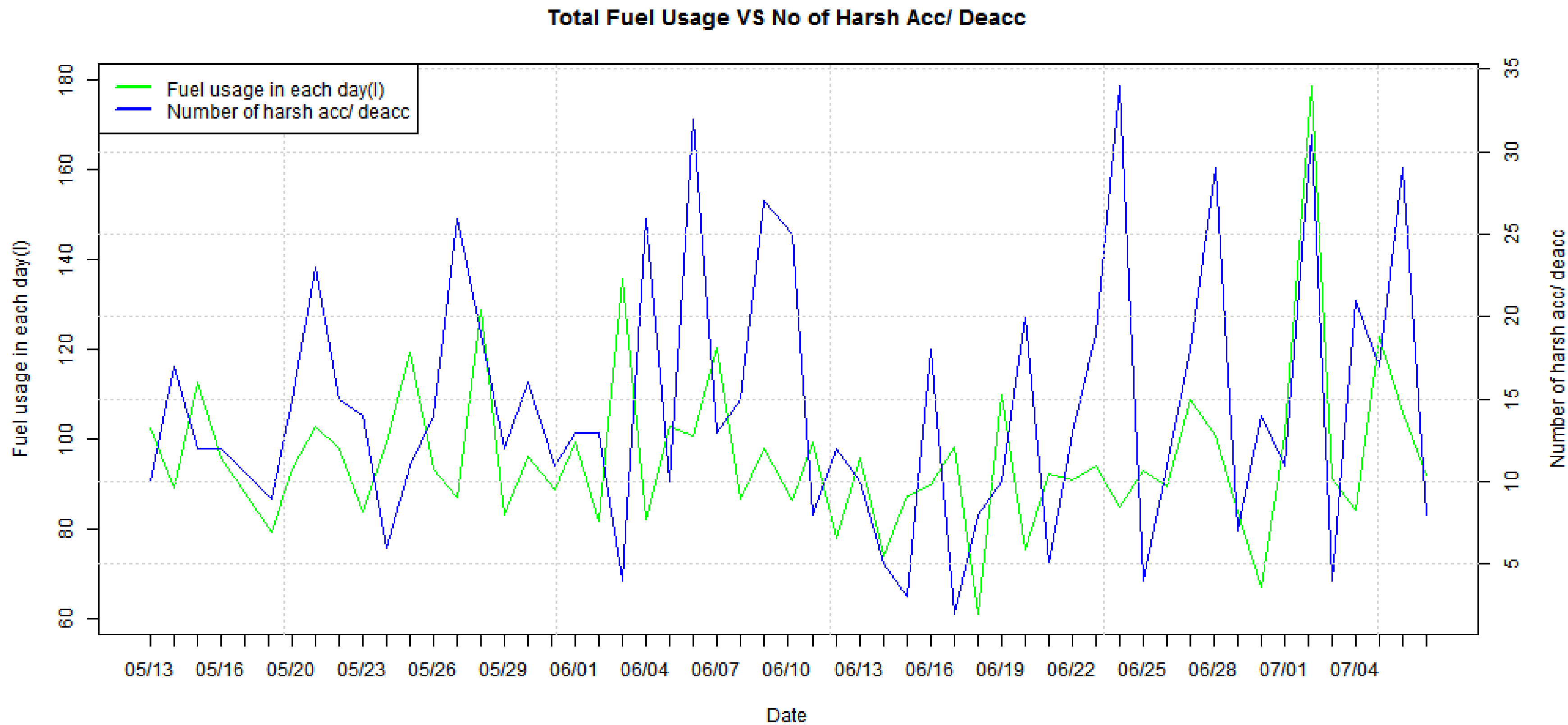


Factors Contributing to Fuel Usage (Cont.)

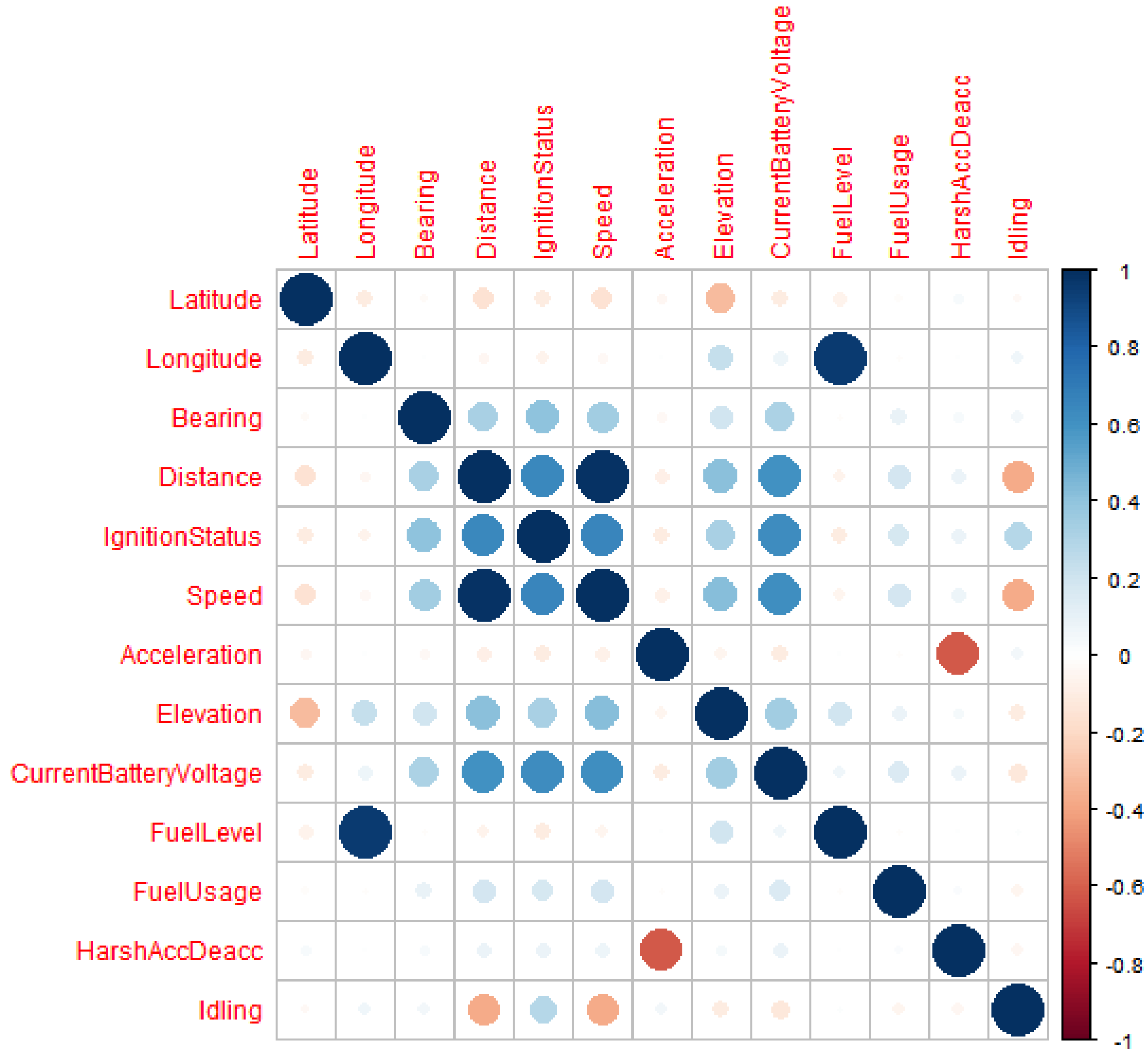




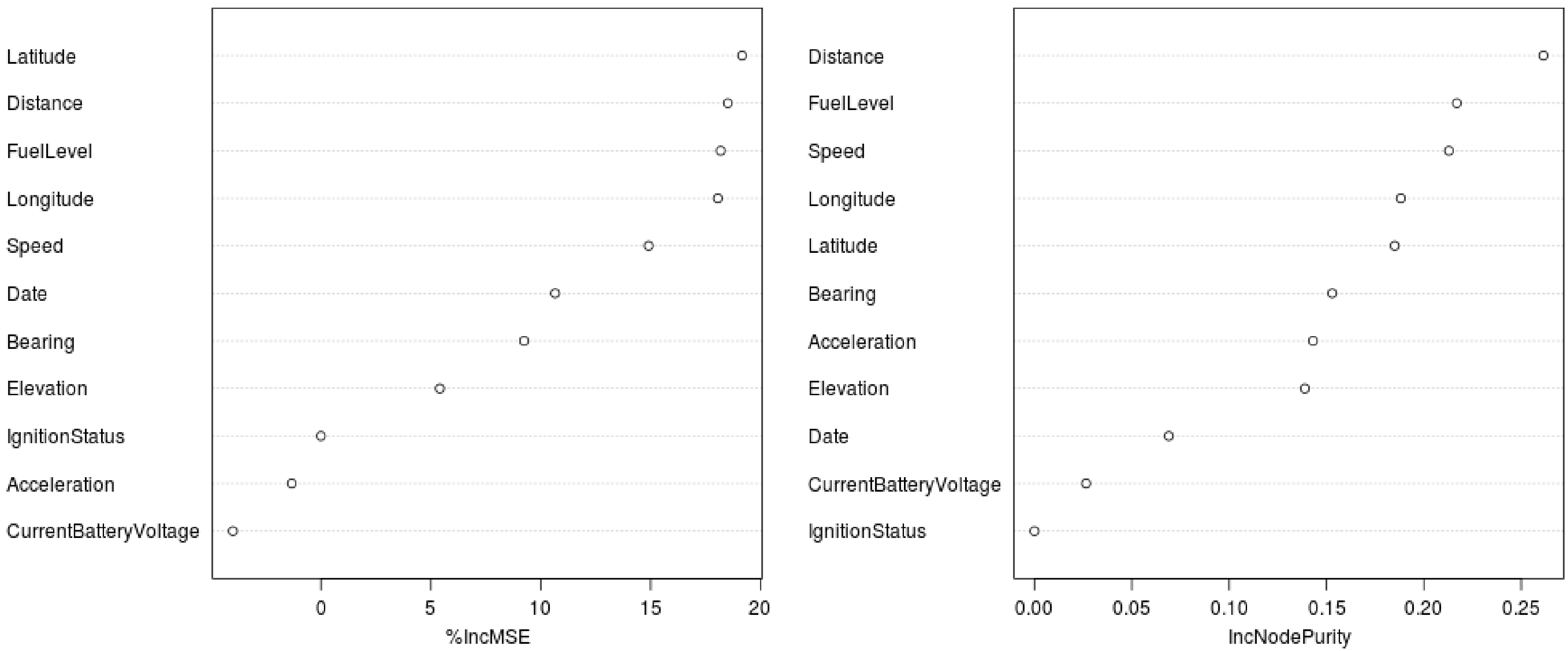
Factors Contributing to Fuel Usage (Cont.)



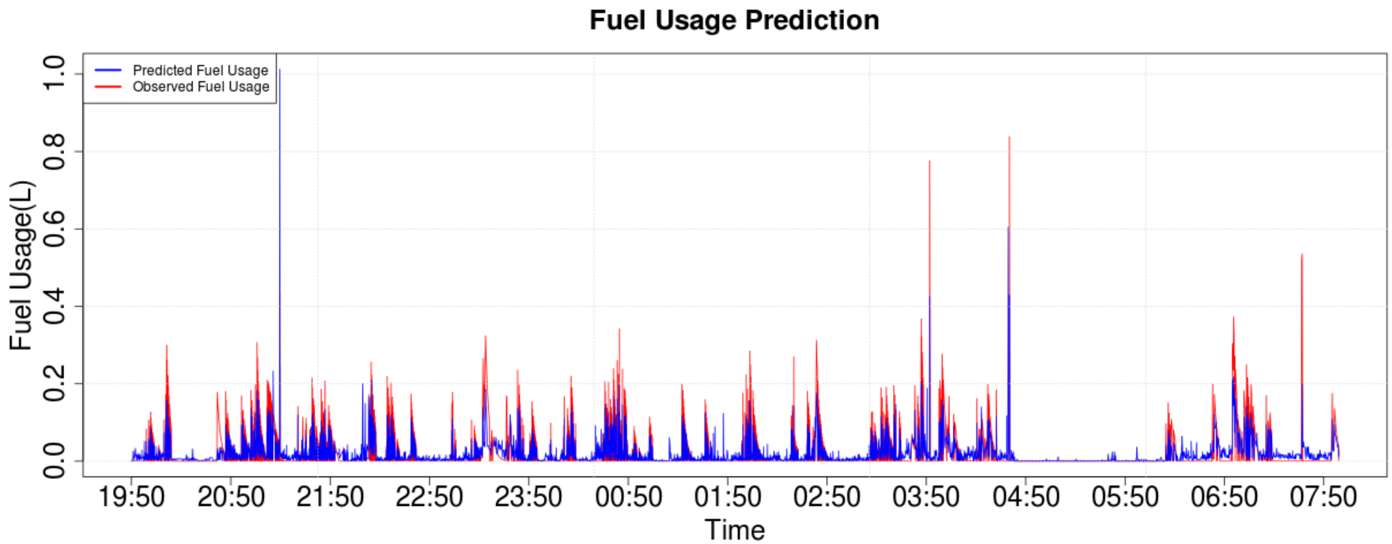
Factors Contributing to Fuel Usage (Cont.)

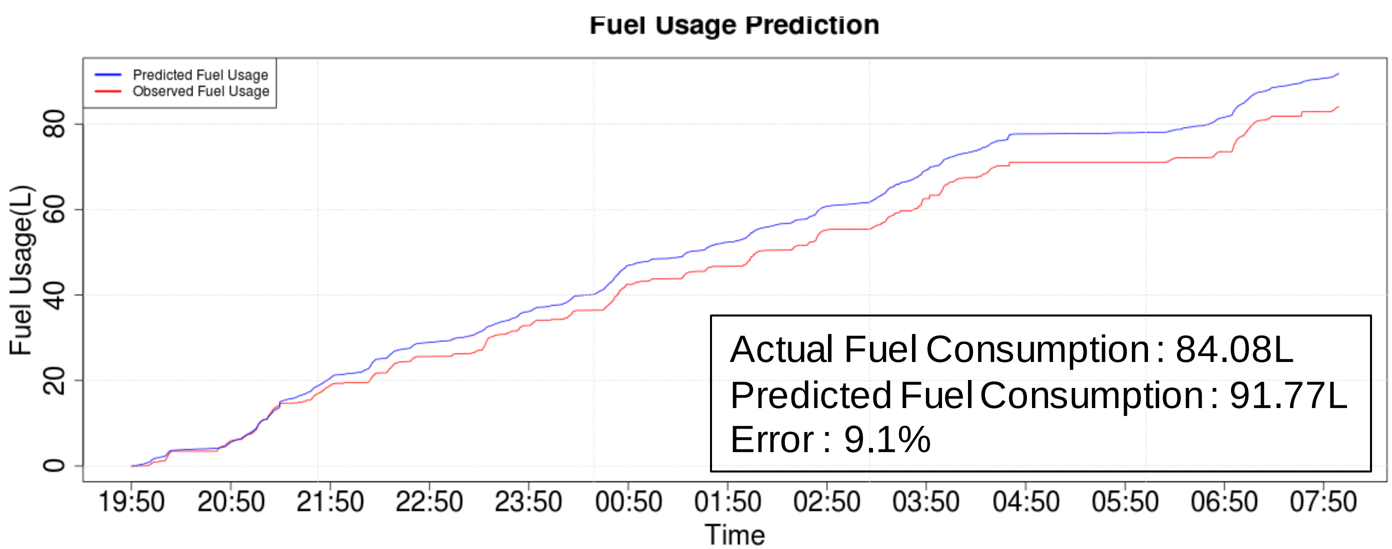


Variable Importance

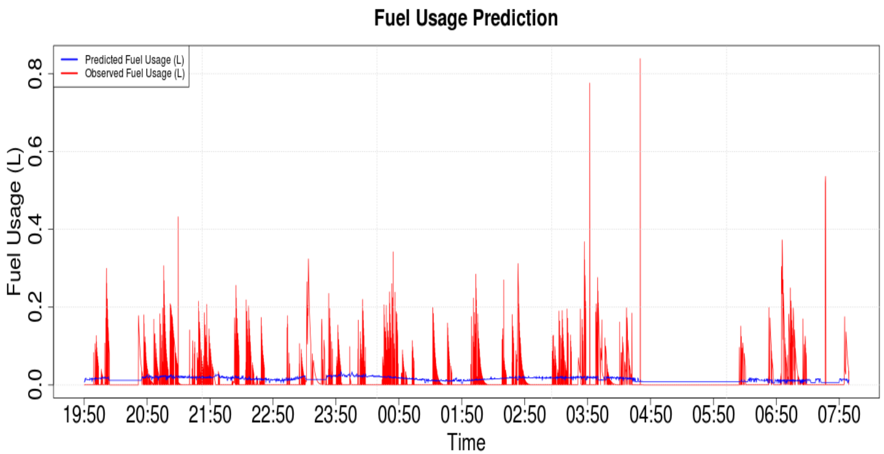


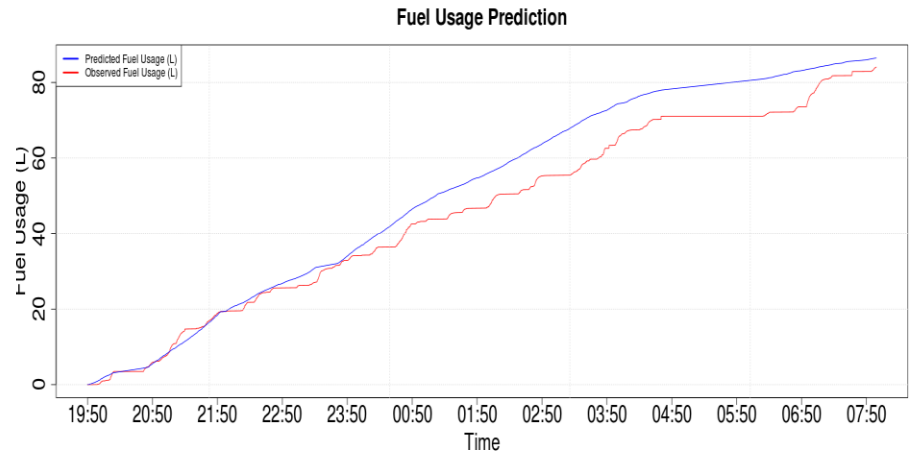
Predicting Fuel Consumption – Random Forrest

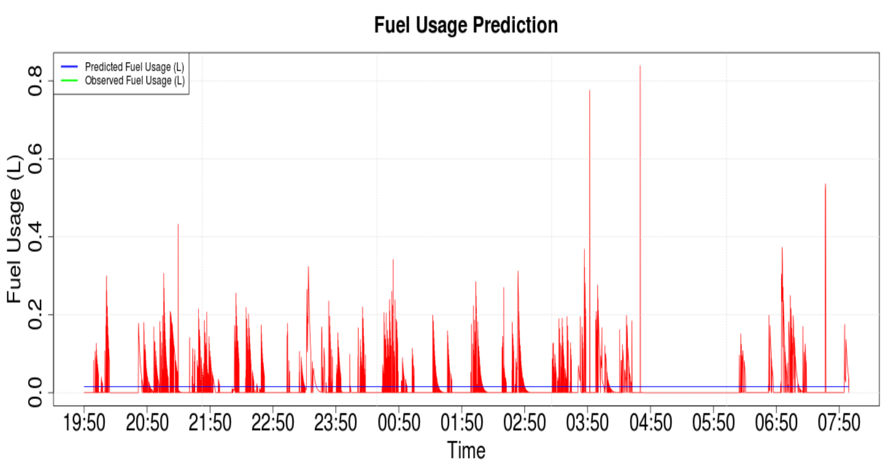


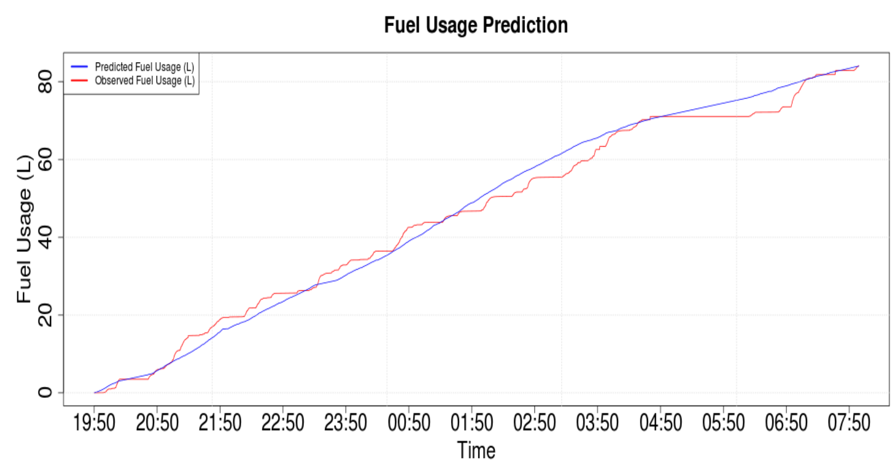


Predicting Fuel Consumption – Gradient Boosting & Neural Network









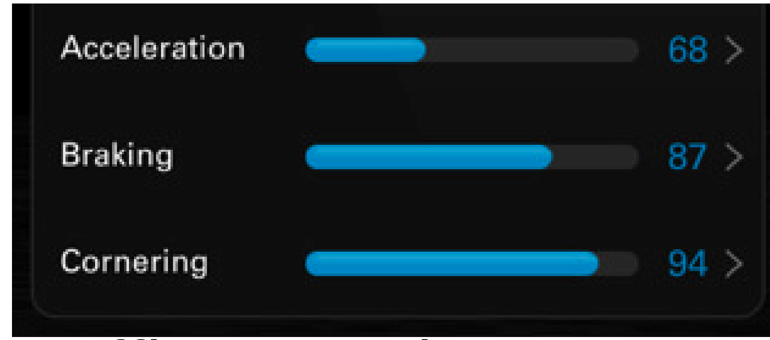
Predicting Fuel Consumption (Cont.)

Model	Nash-Sutcliffe Efficiency
RF	0.26189
GB	-0.00240
ANN	-0.01304

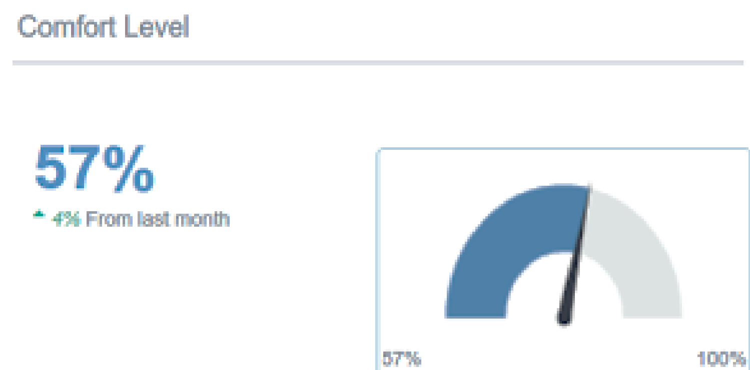
Error Statistics	RF	GB	ANN
BIAS	0.00477	0.00045	0.00274
MAE	0.02296	0.02585	0.02756
RMSE	0.04046	0.04715	0.04740

On Going Work

- Dashboard design
- Driver profiling
  - Beyond acceleration profile
  - Correlating with location, time, traffic, & weather
  - Usage-Based Insurance (UBI)



- Quantifying passenger comfort
- Case analysis
  - Traffic, weather
- Driver feedback
  - Real-time & long-term
- Process re-engineering



Research Challenges

- Lack of annotated data
  - Events, GIS, weather
- Optimum sampling frequency – 4Vs of big data
  - GPS 10 Hz, practically < 0.2 Hz
  - OBD2 ~10 Hz per PID
- Enhancing accuracy of detected events
- Correlating with location, time, traffic, & weather
  - Lack of (real-time) data
- Relating numbers to physical events such that drivers could understand

Publications

- M. Amarasinghe, S. Muramudalige, S. Kottegoda, A. L. Arachchi, and H. M. N. Dilum Bandara, “Cloud-Based Driver Monitoring and Vehicle Diagnostic with OBD2 Telematics,” Intl. J. of Handheld Computing Research (IJHCR), to appear.
- S. Wickramanayake and H.M.N.D. Bandara, “Poster: Enhancing Fuel Economy of Fleet Vehicles Through Real-Time Driver Monitoring and Feedback,” in Proc. 1st Asian Students Symposium on Emerging Technologies (ASSET 2016), June 2016.
- S. Muramudalige and H.M.N.D. Bandara, “Demo: Cloud-Based Vehicular Data Analytics Platform,” in Proc. 1st Asian Students Symposium on Emerging Technologies (ASSET 2016), June 2016.
- S. Wickramanayake and H.M.N.D. Bandara, “Fuel Consumption Prediction of Fleet Vehicles Using Machine Leaning: A Comparative Study,” In Proc. 2nd Moratuwa Engineering Research Conference (MERCon 2016), Apr. 2016.
- M. Amarasinghe, S. Kottegoda, A. L. Arachchi, S. Muramudalige, H.M.N.D. Bandara, and A. Azeez, “Cloud-Based Driver Monitoring and Vehicle Diagnostic with OBD2 Telematics,” In Proc. Intl. Conf. on Advances in ICT for Emerging Regions (ICTer), Aug. 2015.

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  - Mr. Nishal Samarasekera (Dept. of TLM)
- Data
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  - Many other drivers who help us collected data

Q&A

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