IoT and Big Data for Smart Transportation Systems

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Why?

Reckless Driving

Driving Anomaly Detection

IoT

+

Data Analytics

→

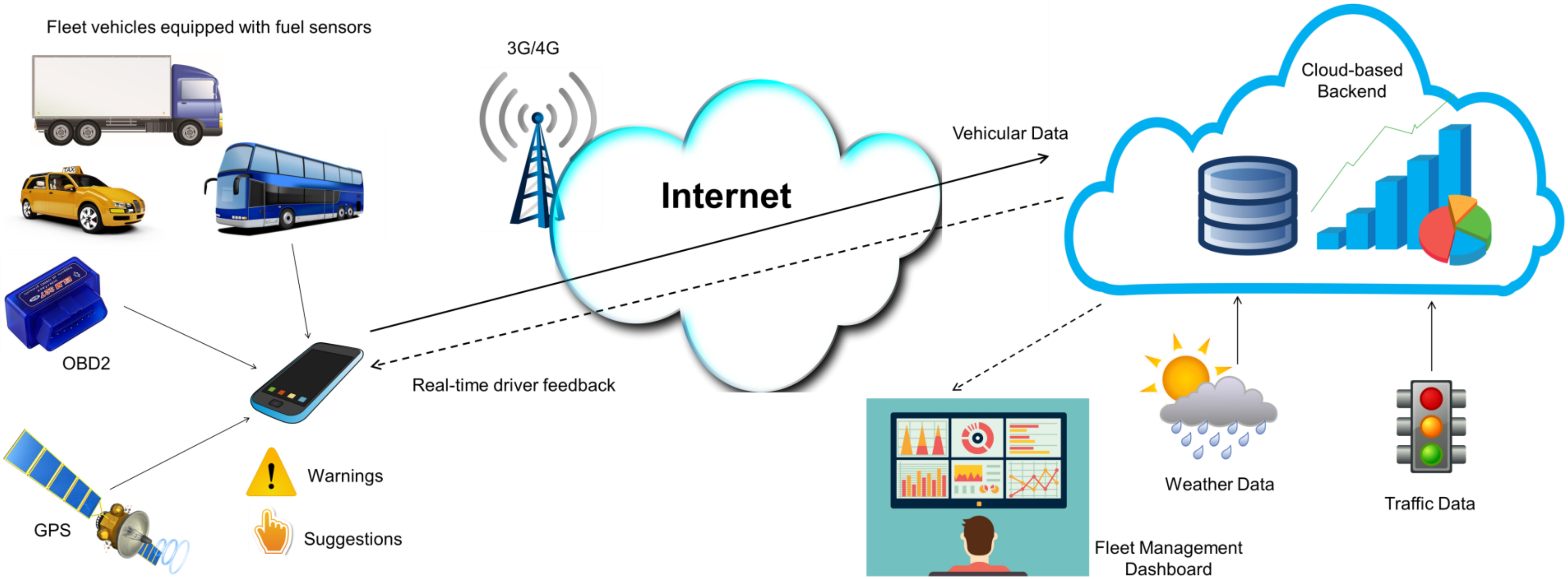
Smart Driving

Fault Detection & Prediction

Tracking & Surveillance

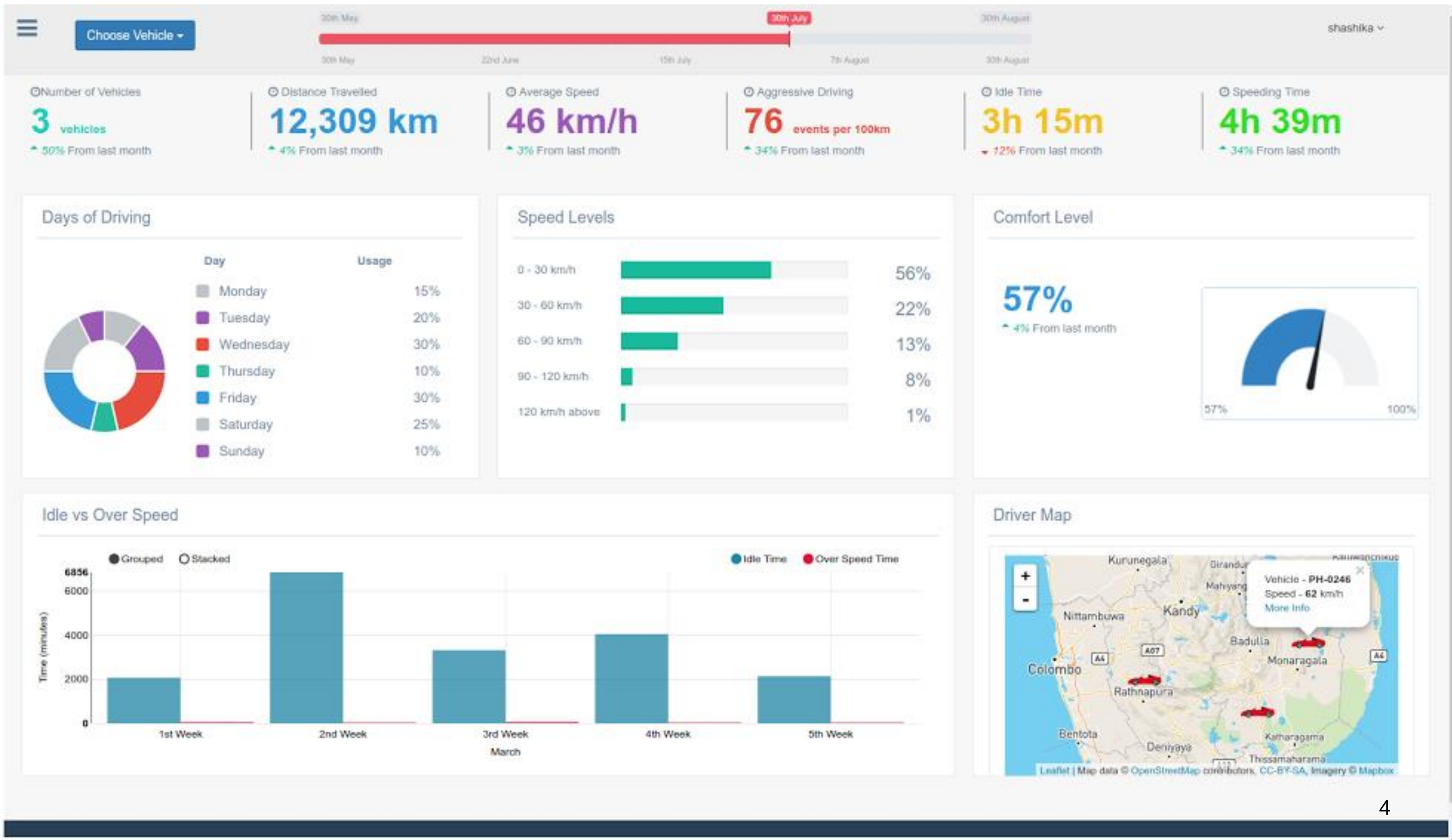
Fuel Fraud

Smart Driving – 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
Monaragala
Colombo
Rathnapura
Bentota
Deniyaya
Kataragama
Thissamaharama
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

TOYOTA's Activites towards SMART MOBILITY SOCIETY

Toyota aims to create a smart mobility society where people feel secure and happy in transport and everyday life.

COMFORT Connected with people...

The vehicle will become a trusted partner through close communication with the driver.

- The vehicle complies with the driver's verbal and nonverbal commands.
- The vehicle predicts driver's actions in order to provide services and prevent dangers.

ECOLOGY Connected with the community...

Optimizing the energy use of the entire community Achieving eco-friendly lifestyles with high quality of life.

- Actualizing a low-carbon society where homes and vehicles share energy with each other.
- Promoting local energy production/consumption.
- Creating communities that are strong enough to withstand natural disasters.

SAFETY Connected with vehicles and roads ...

Toward the realization of Toyota's ultimate goal: zero casualties from traffic accidents.

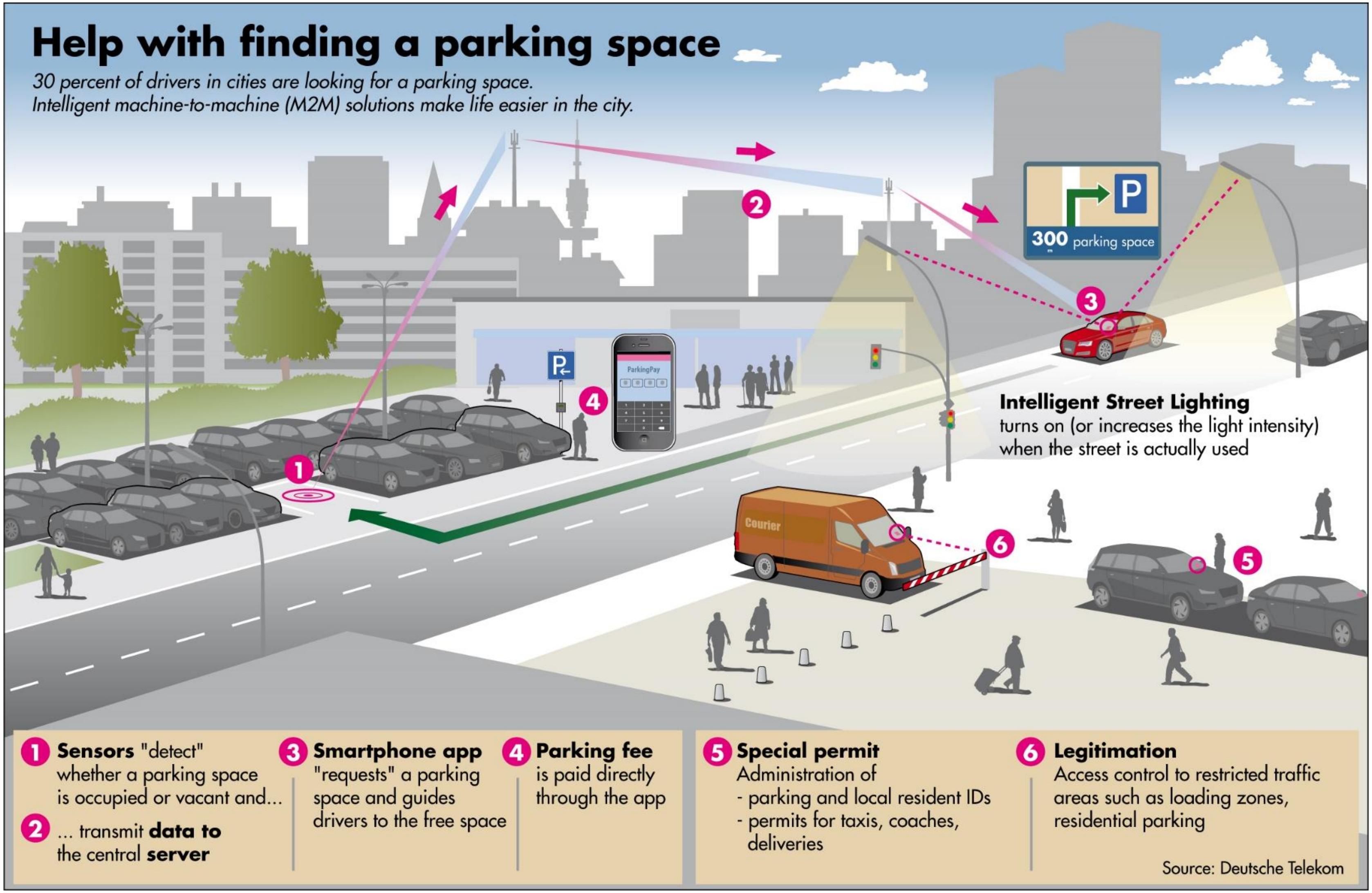
- Vehicles exchange their locations and speeds at all times.
- Vehicles receive useful information from roadside infrastructure.

CONVENIENCE Connected with society...

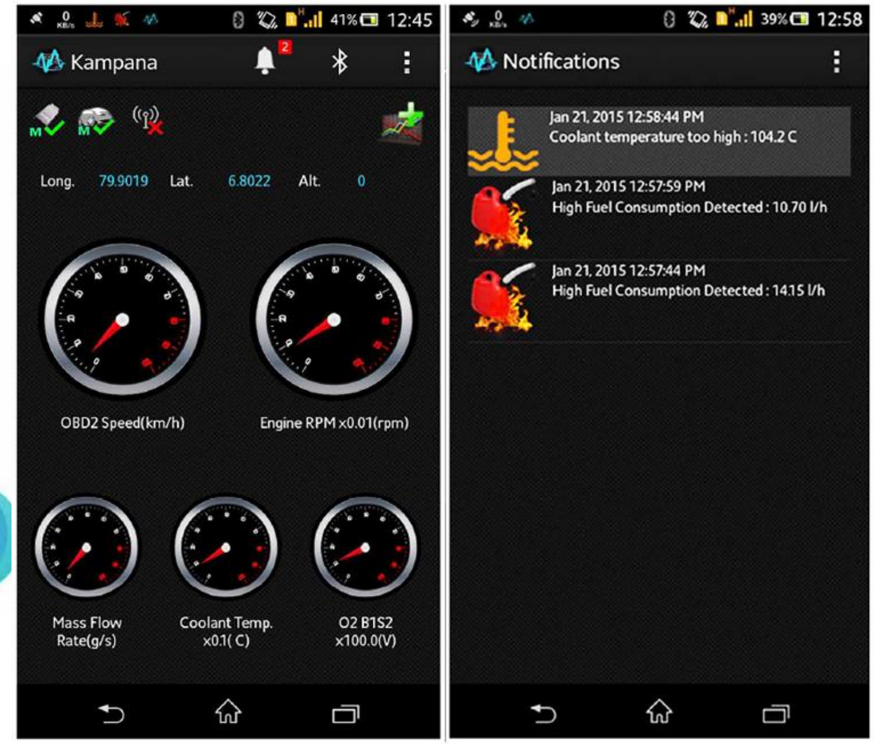
Building a stress-free traffic environment where everyone can move around as they wish.

- Utilizing big data generated from vehicles to improve traffic control and disaster-related measures.
- Implementing an ultra-micro EV sharing service integrated with public transportation.

Smart Transportation Systems (Cont.)

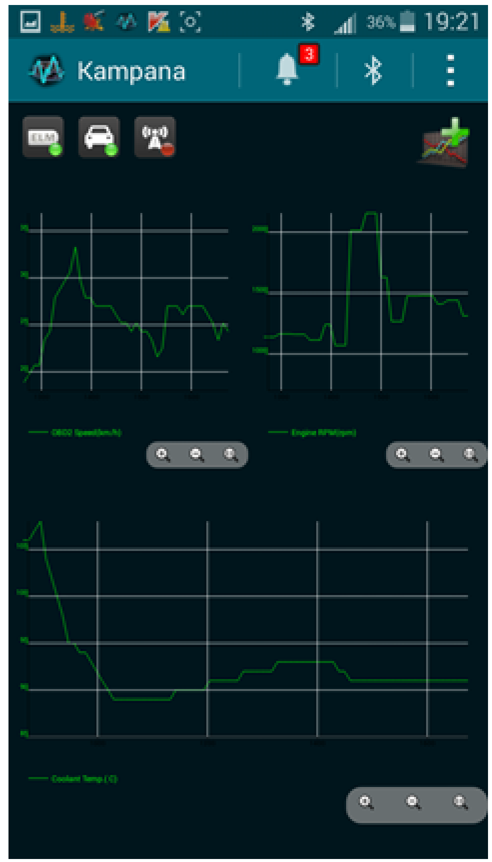


OBD2 Based Analysis

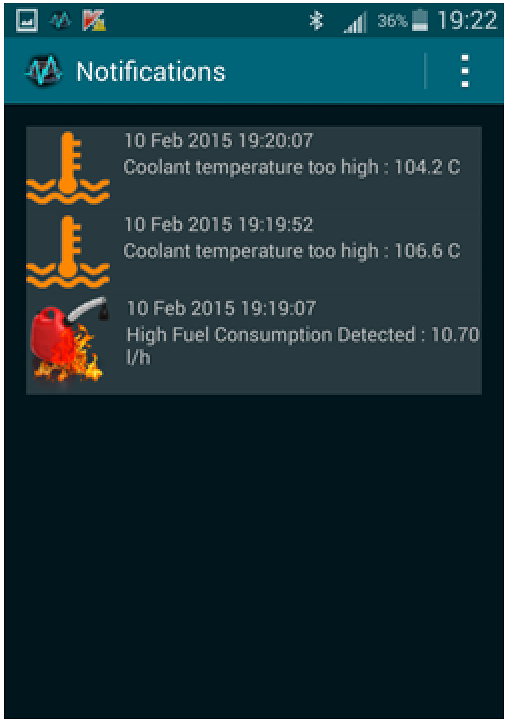


- OBD – On Board Diagnostics
  - Available in many vehicles since 1996
  - OBD2 – In most vehicles since 2005
  - Speed, RPM, Odometer, Cooleant Temperature, Padle Position, Oxygen, Mass Air Flow, etc.

App-Level Processing – Real-Time Dashboard

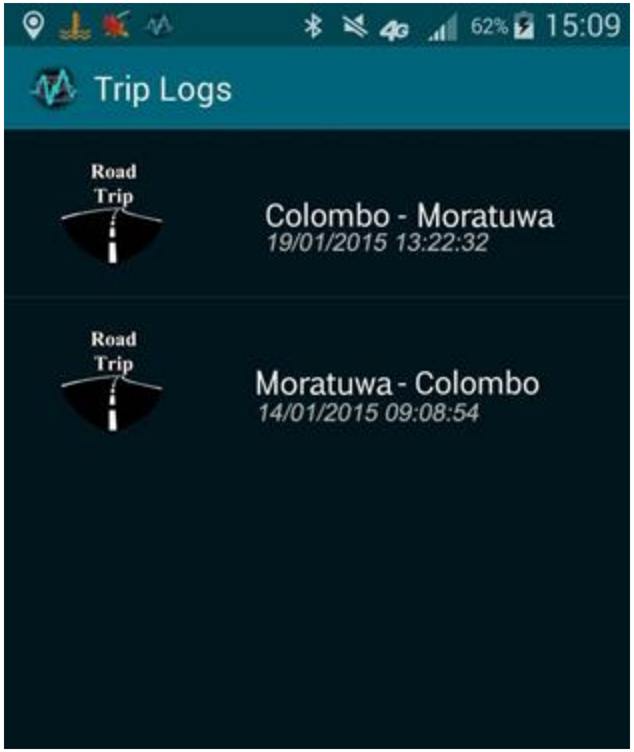


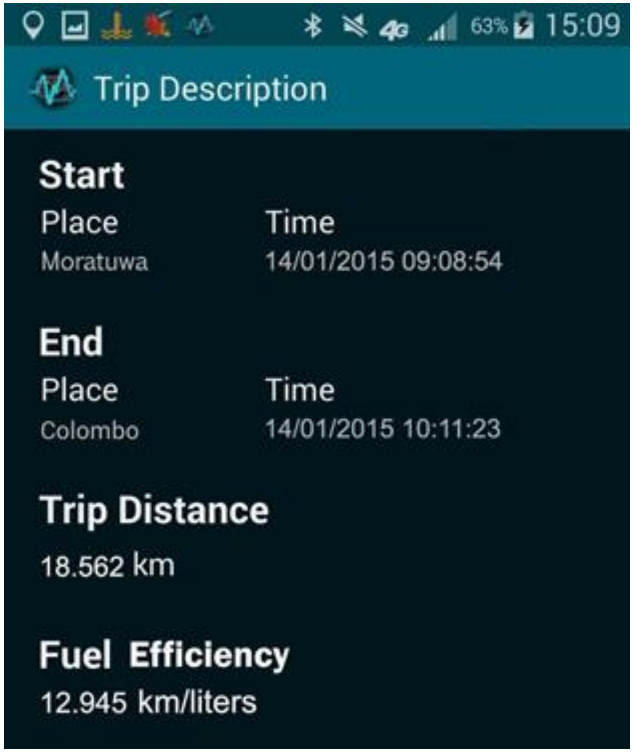
Fuel Economy & Coolant Temperature Monitoring



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

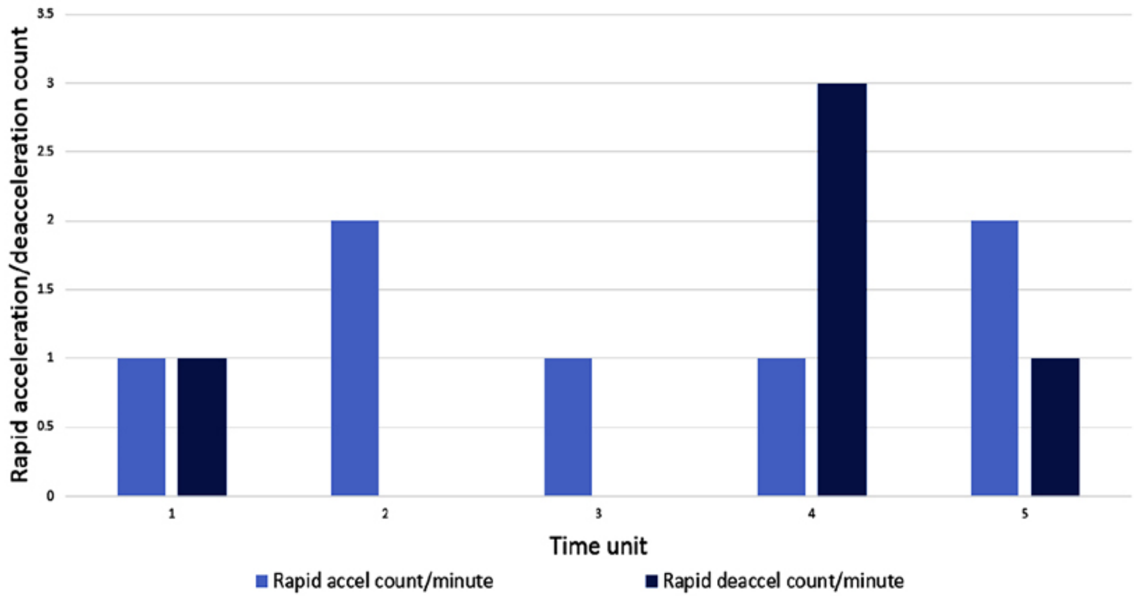
Trip Logs





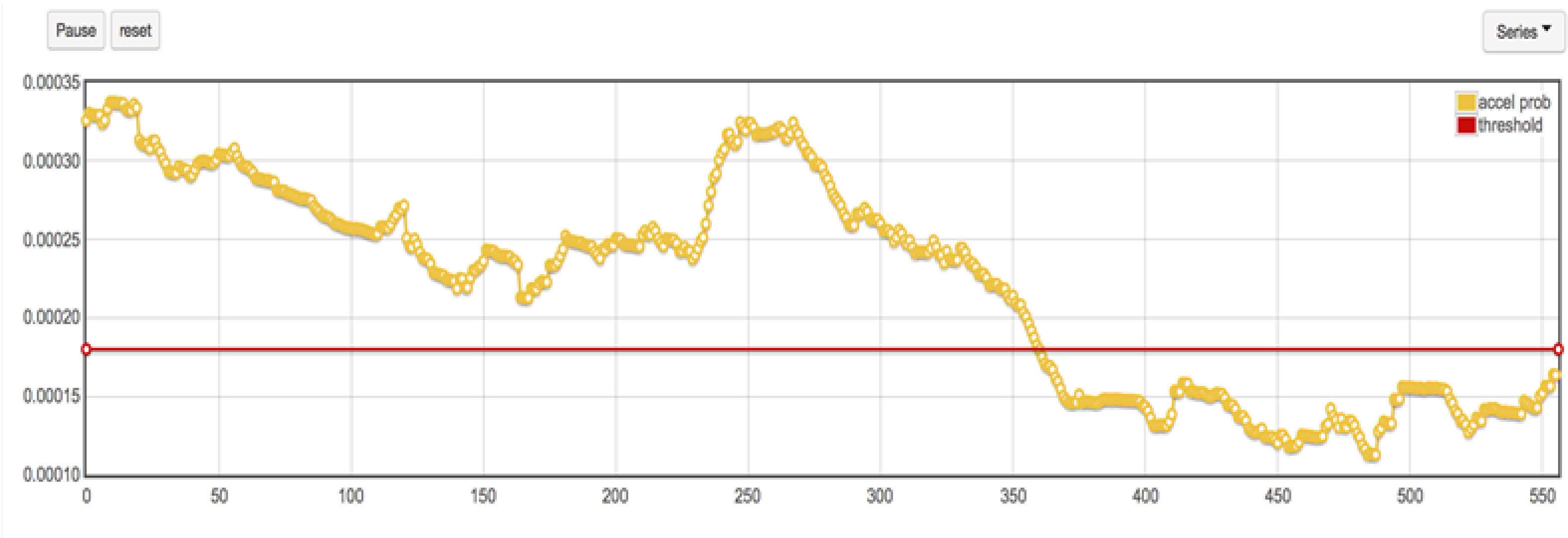
- Standard car → High-end Car

Backend Processing – Reckless Driving

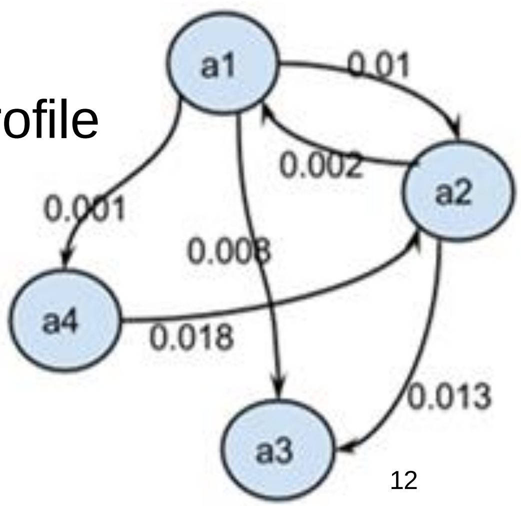


- Hard accelerations & deceleration count above a threshold
  - Per 100 Km
  - Per 1 Hour
- Count depends on average speed of vehicle in last *t* seconds
- Implemented using Siddhi CEP
- Computed values stored in RDBMS

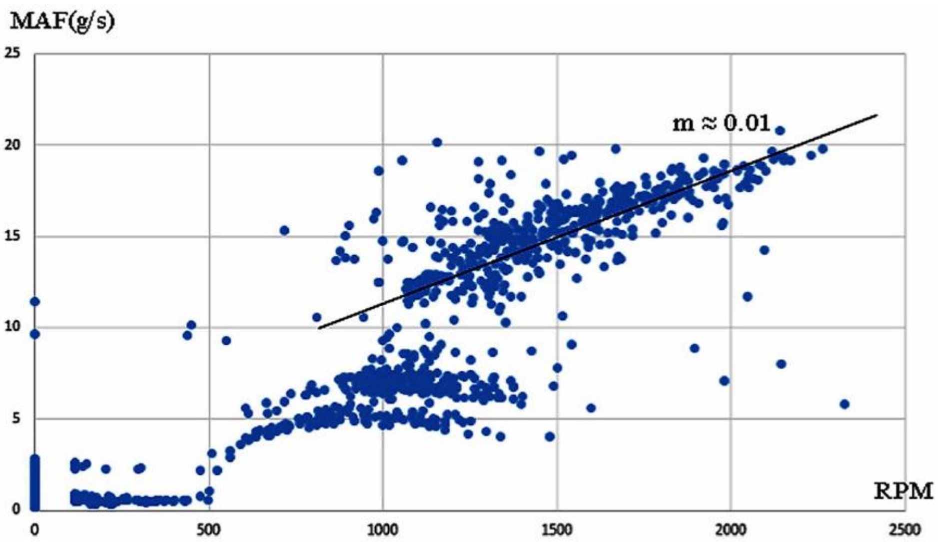
Driver Profiling

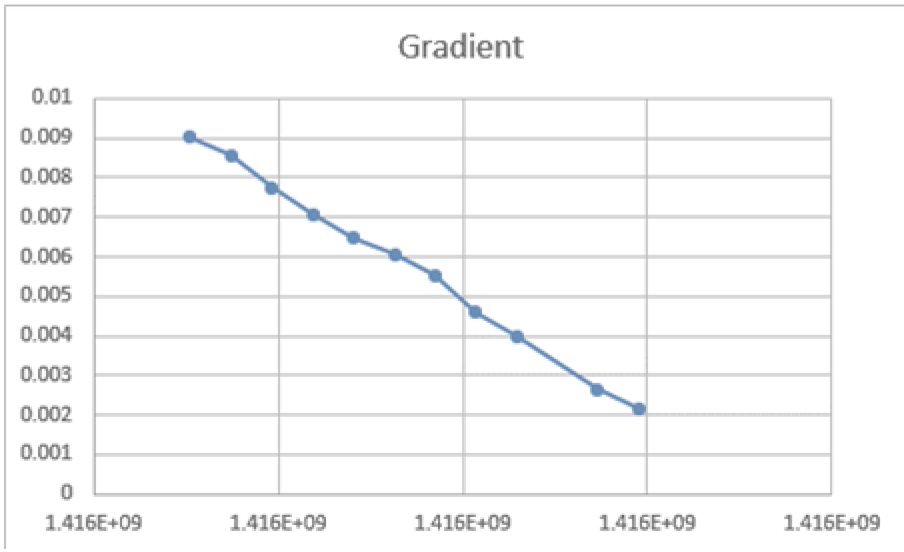


- Detection of anomalies
  - Hidden Markov Model based on acceleration profile
  - Model implemented in BAM
  - Validator implemented in CEP



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

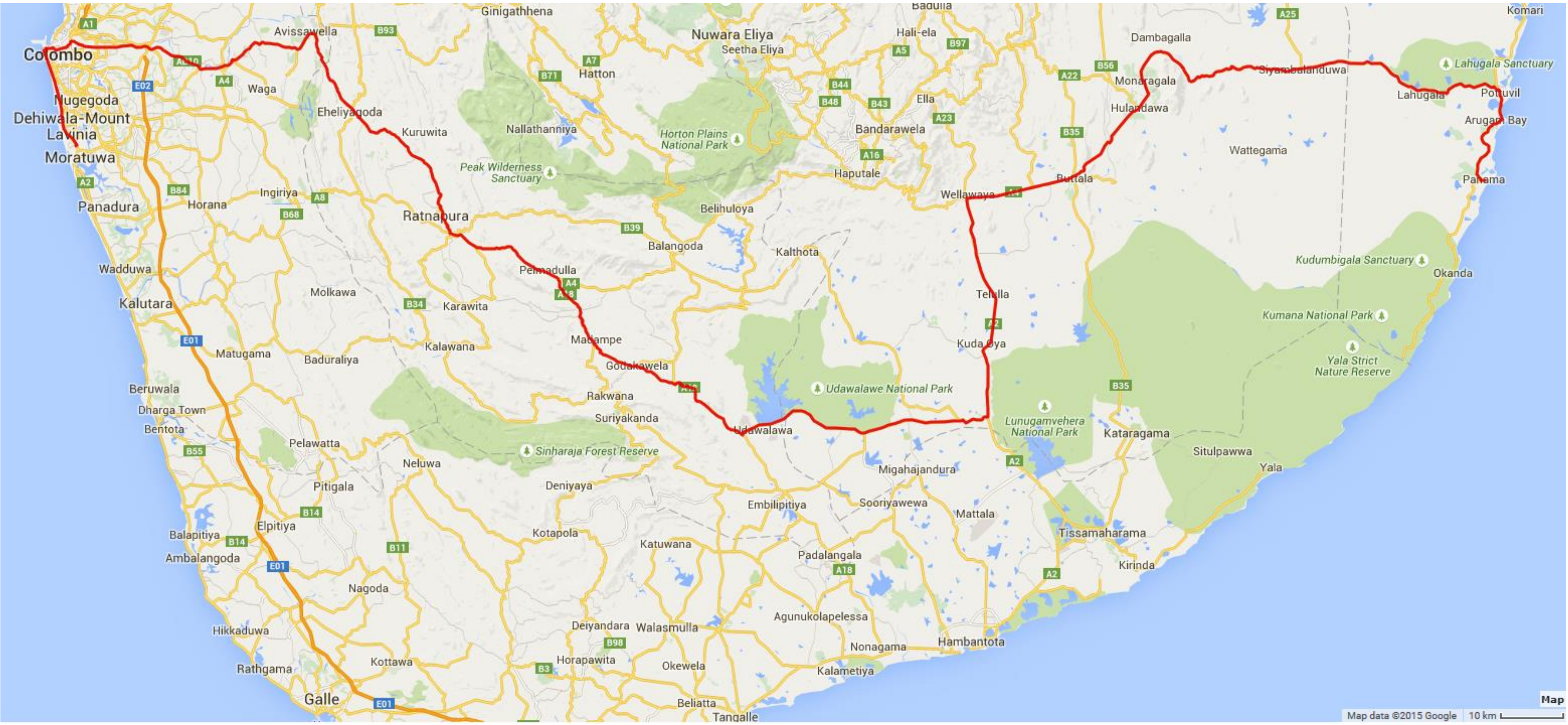
- Long-distance bus fitted with a GPS unit & high-precision fuel sensor
- Could you
  - explain variability in fuel consumption
  - predict fuel consumption of a journey
  - give tips to improve fuel consumption

?

Dataset

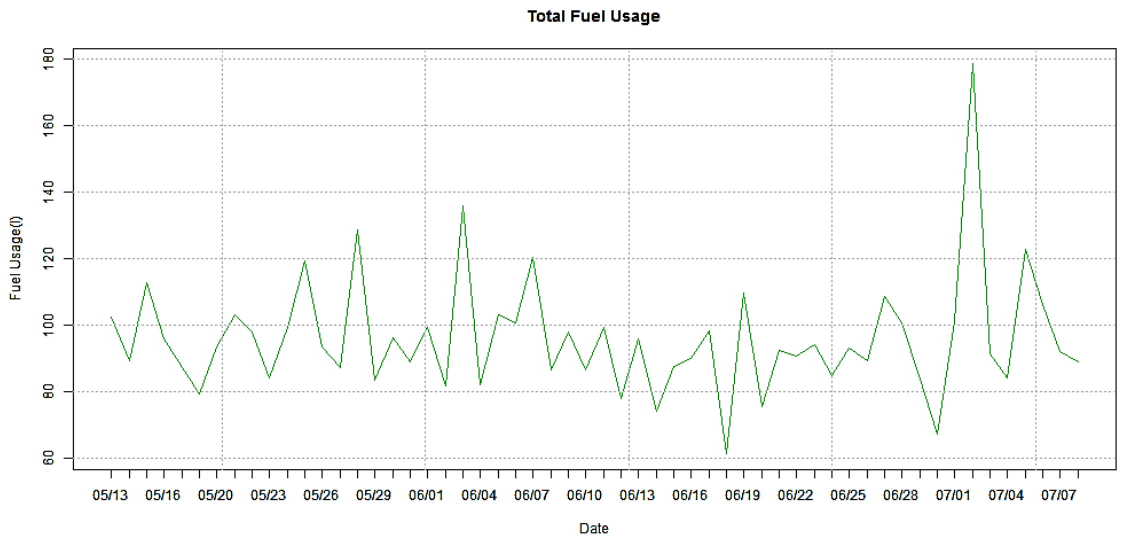
- From 13 May 2015 – 31 August 2015
- Parameters
  - Timestamp (date and time)
  - Longitude (Min: 5.918611°N, Max: 9.835556° N)
  - Latitude (Min: 79.516667° E, Max: 81.879167° E)
  - Bearing (0° to 360°)
  - Elevation (Min: 0m, Max: 2,524m)
  - Distance traveled (km) – between two samples
  - Speed (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)

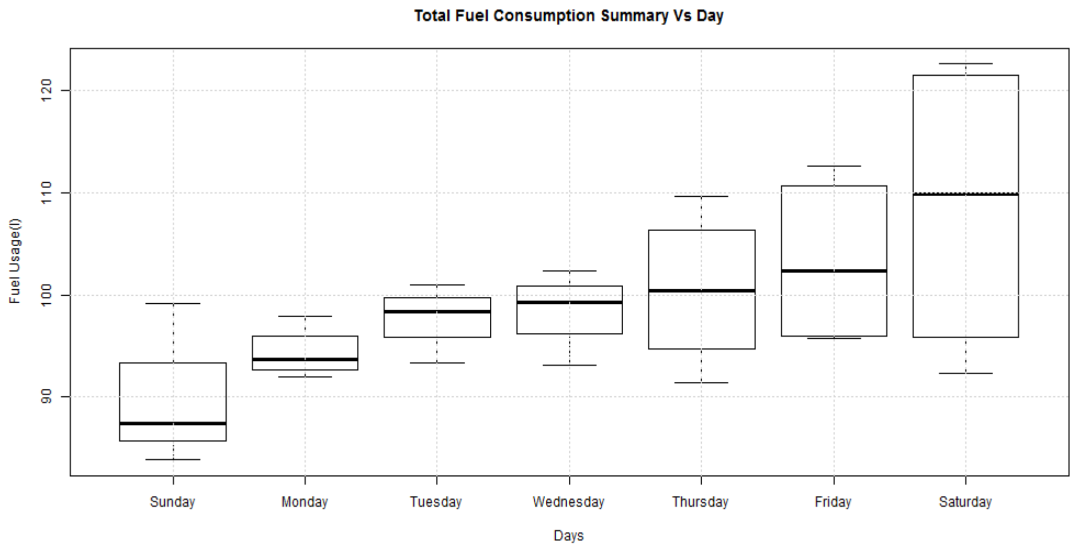
Bus Route



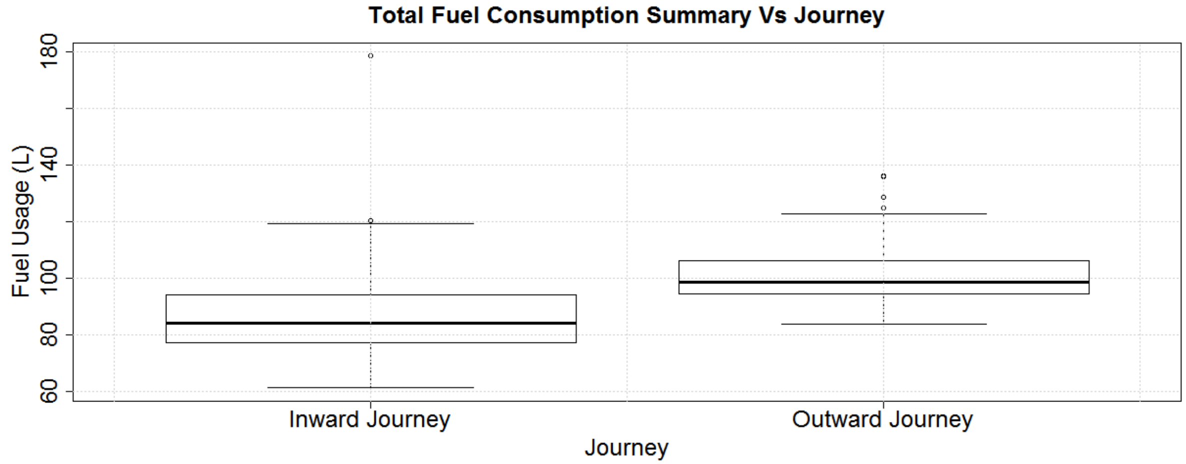
Colombo
Nugegoda
Dehiwala-Mount Lavinia
Moratuwa
Panadura
Wadduwa
Kalutara
Beruwala
Dharga Town
Bentota
Balapitiya
Ambalangoda
Hikkaduwa
Rathgama
Galle
Avissawella
Waga
Eheliyagoda
Kuruwita
Ingiriya
Horana
Ratnapura
Molkawa
Matugama
Baduraliya
Pelawatta
Pitigala
Elpitiya
Nagoda
Kottawa
Karawita
Kalawana
Neluwa
Ginigathhena
Hatton
Nallathanniya
Peak Wilderness Sanctuary
Nuwara Eliya
Seetha Eliya
Horton Plains National Park
Belihuloya
Balangoda
Pelmadulla
Madampe
Godakawela
Rakwana
Suriyakanda
Sinharaja Forest Reserve
Deniyaya
Kotapola
Katuwana
Deiyandara
Walasmulla
Horapawita
Okewela
Beliatta
Tangalle
Kalthota
Udawalawe National Park
Udawalawa
Embilipitiya
Migahajandura
Sooriyawewa
Padalangala
Agunukolapelessa
Nonagama
Kalametiya
Hambantota
Badulla
Hali-ela
Ella
Bandarawela
Haputale
Wellawaya
Telulla
Kuda Oya
Lunugamvehera National Park
Kataragama
Mattala
Tissamaharama
Kirinda
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

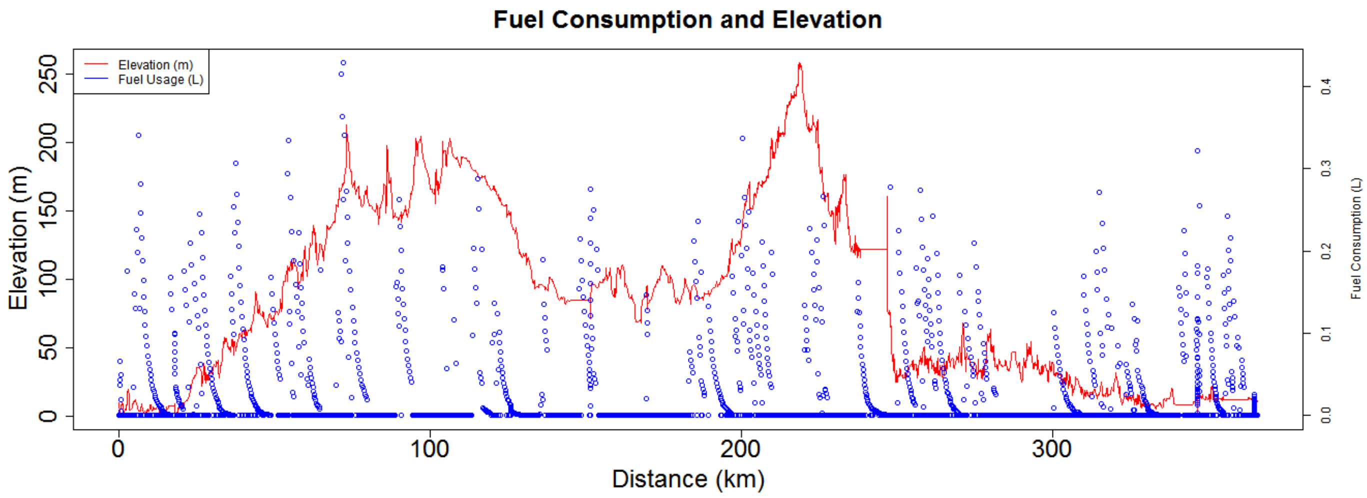
Fuel Usage


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

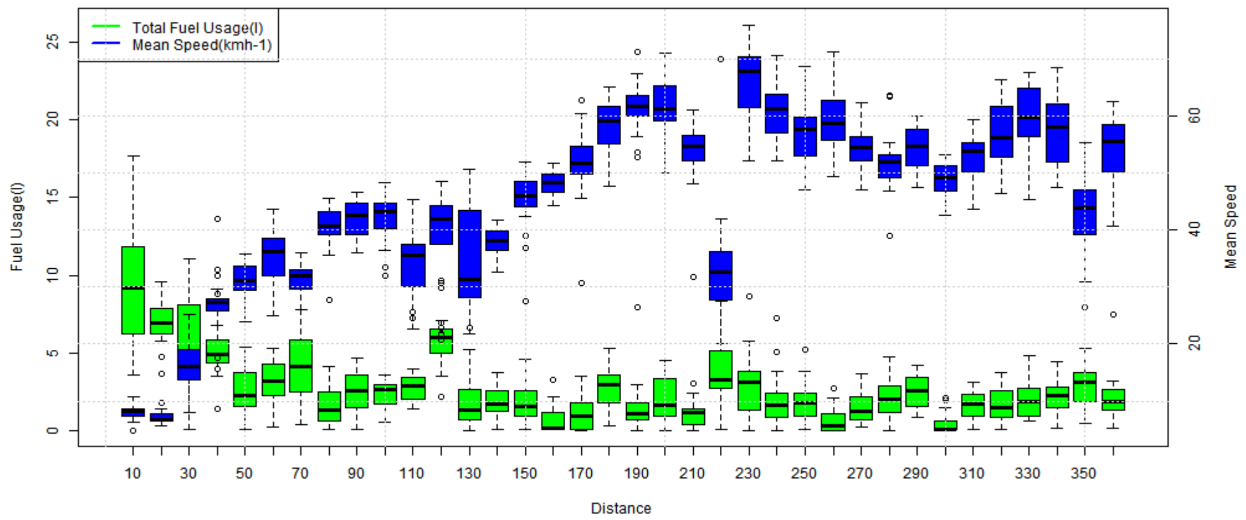

Total Fuel Consumption Summary Vs Day
Fuel Usage(l)
120
110
100
90
Sunday Monday Tuesday Wednesday Thursday Friday Saturday
Days

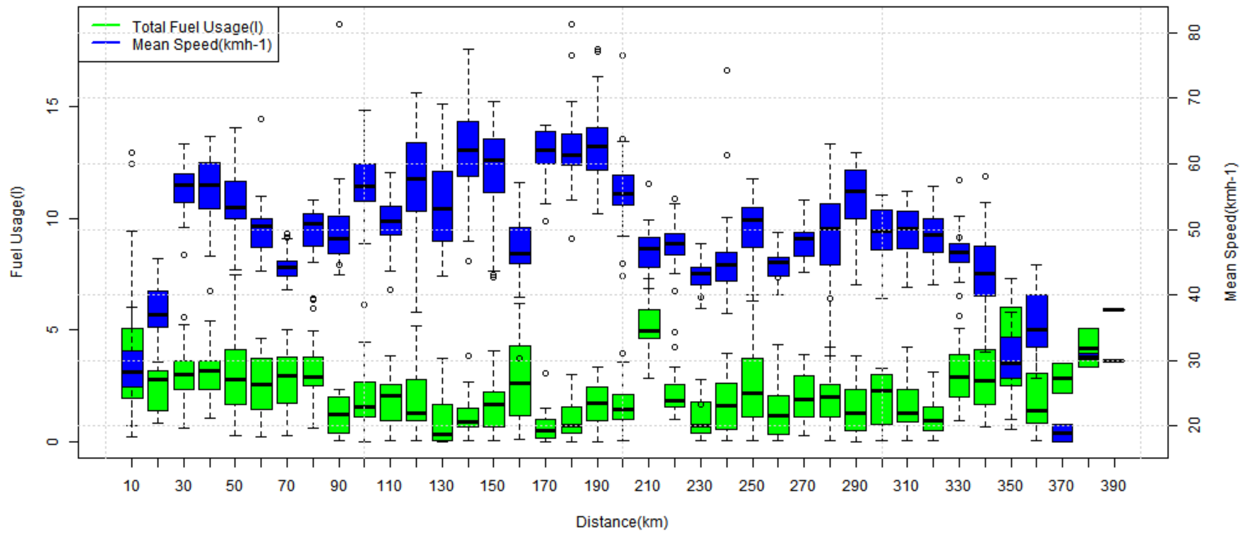
Factors Contributing to Fuel Usage



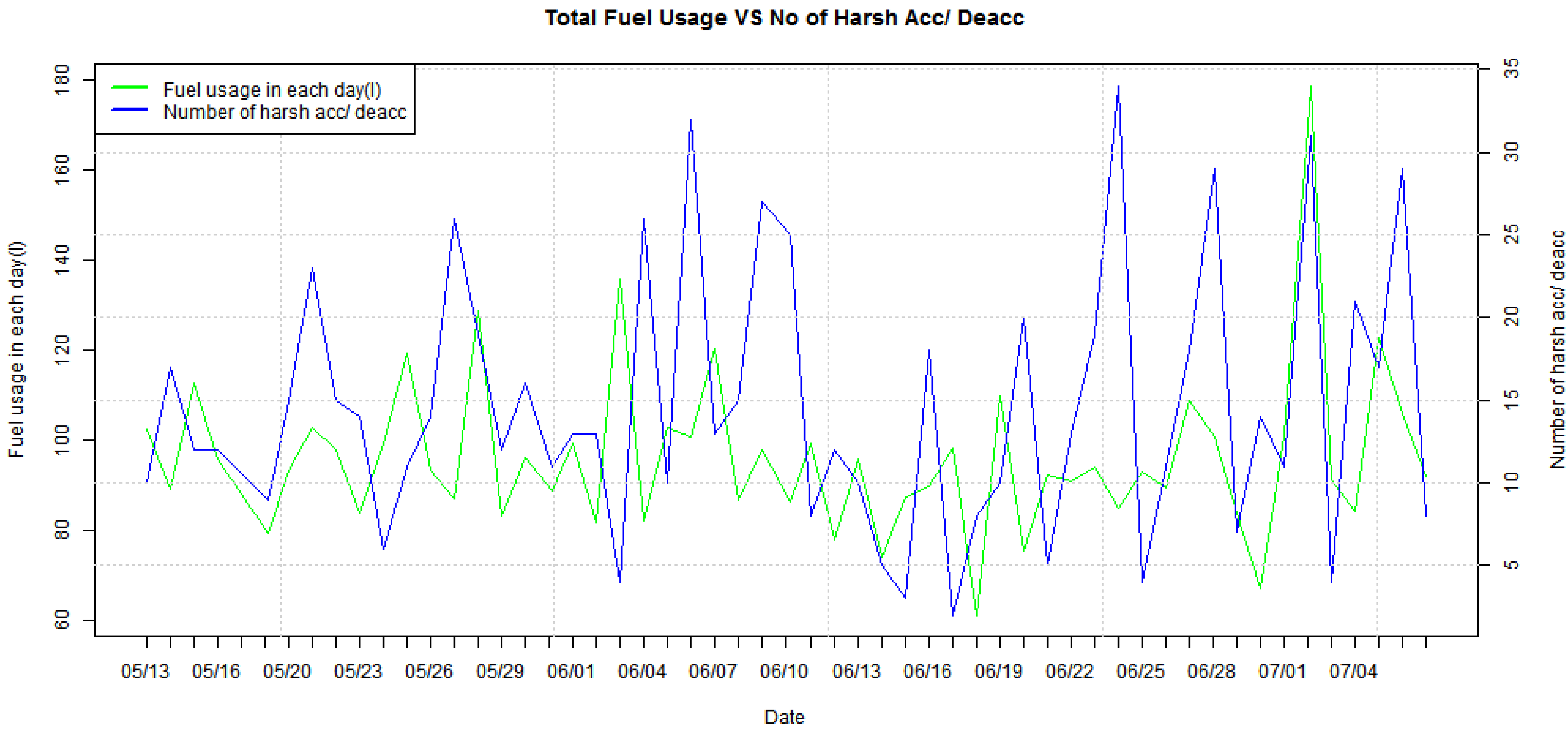


Factors Contributing to Fuel Usage (Cont.)

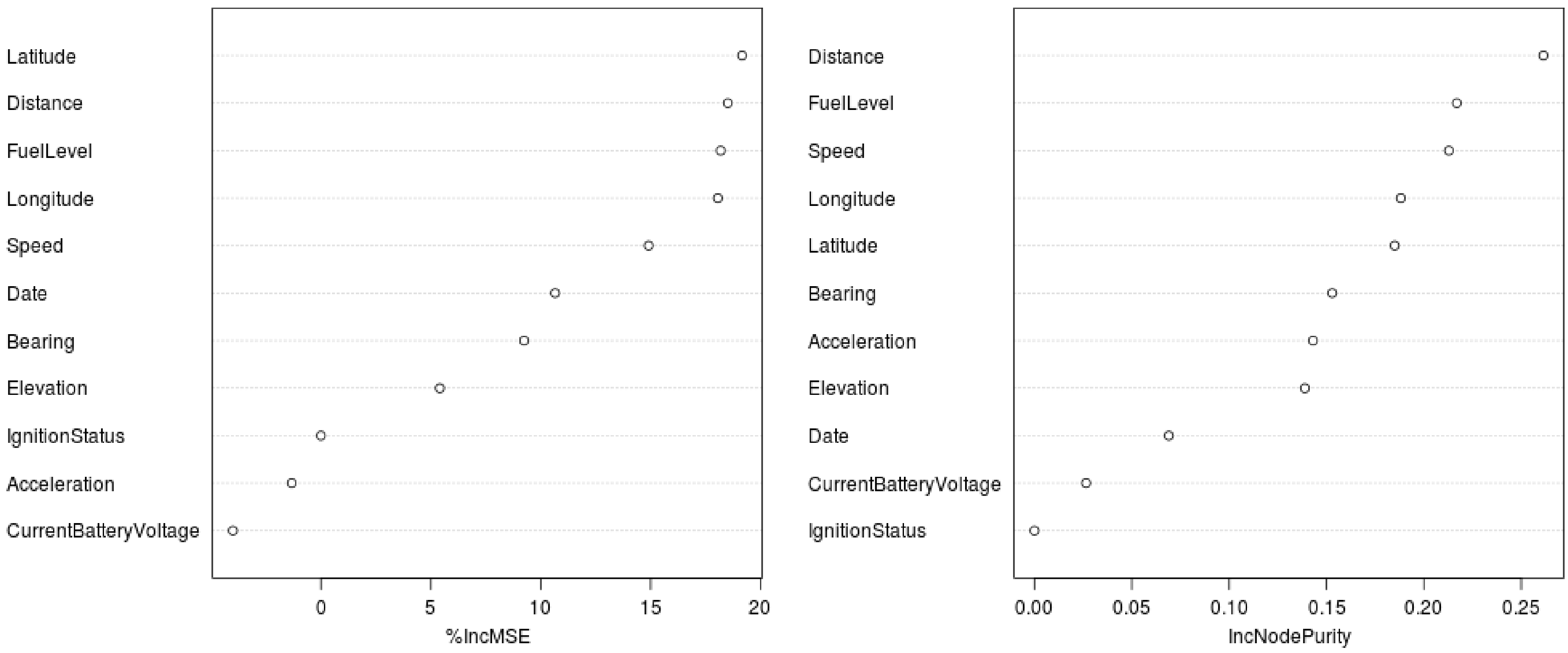




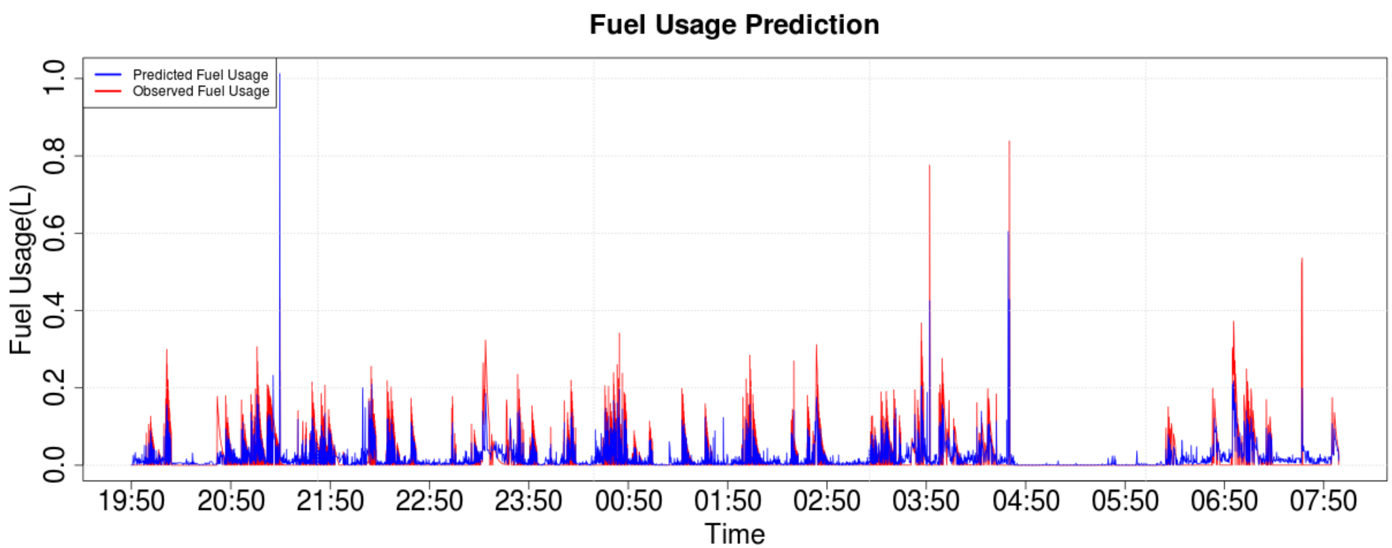
Factors Contributing to Fuel Usage (Cont.)

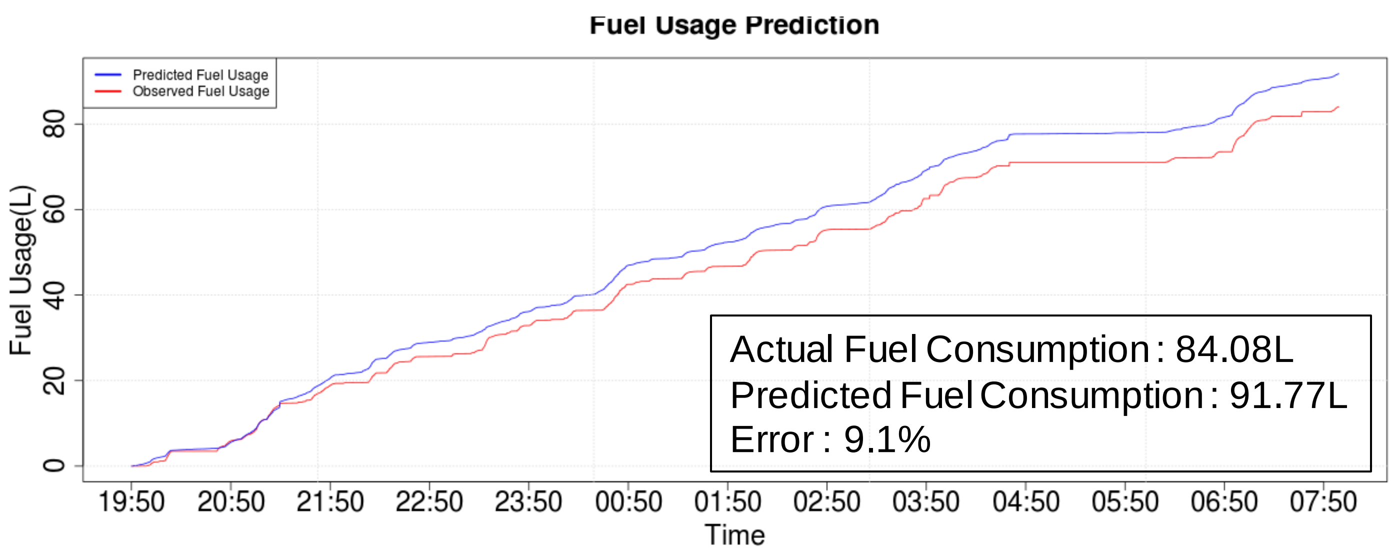


Factors Contributing to Fuel Usage (Cont.)

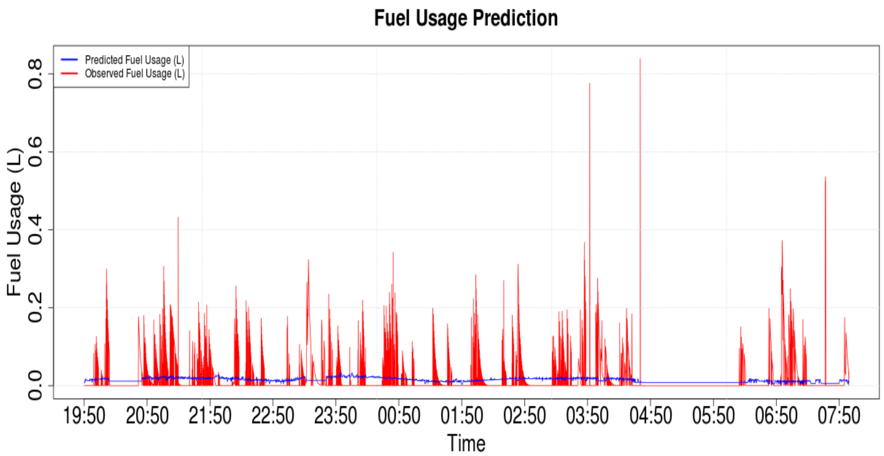


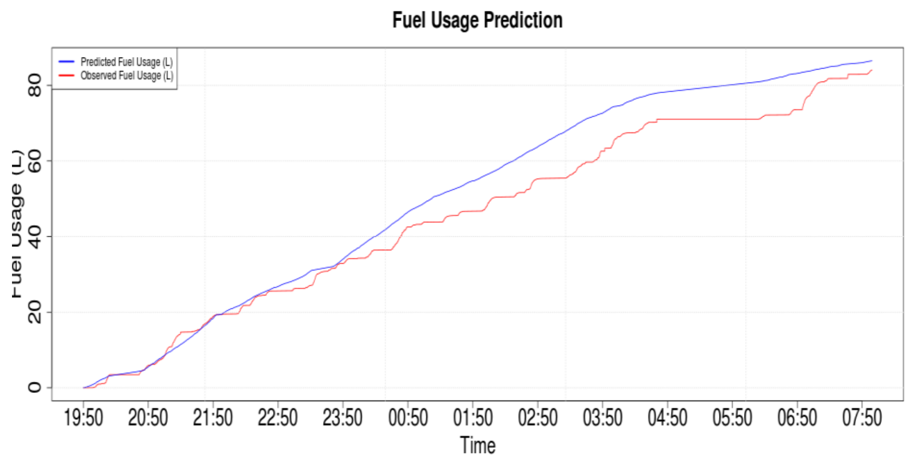
Predicting Fuel Consumption – Random Forrest

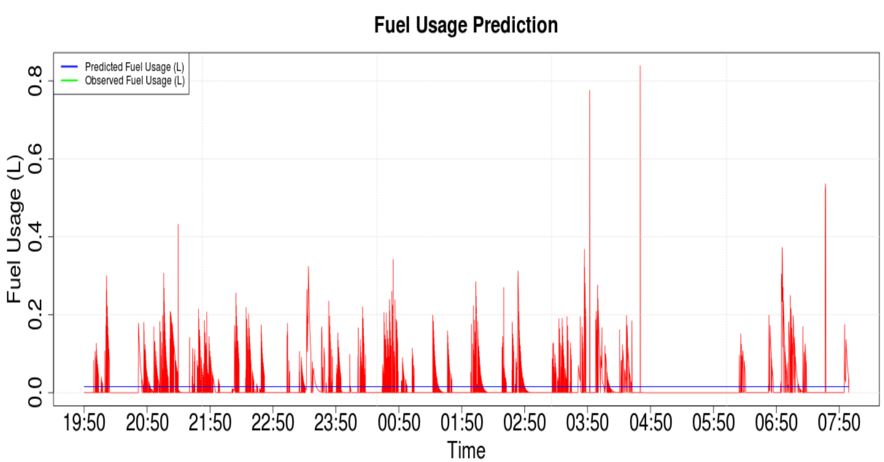


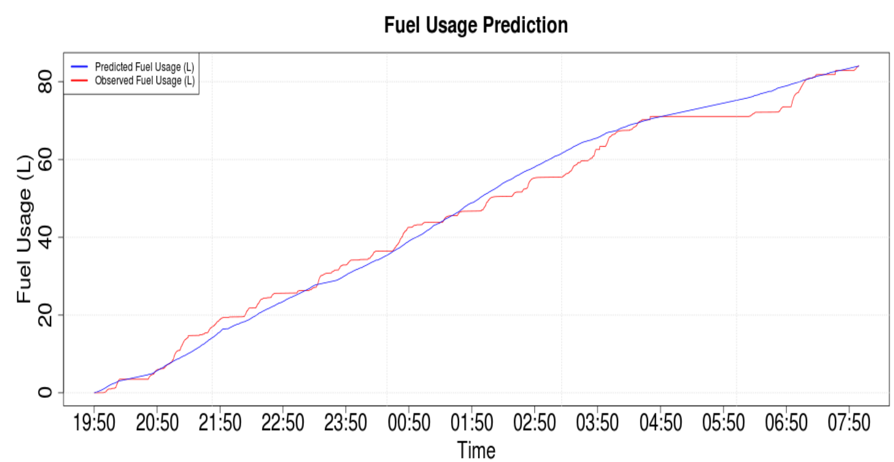


Predicting Fuel Consumption – Gradient Boosting & Neural Network

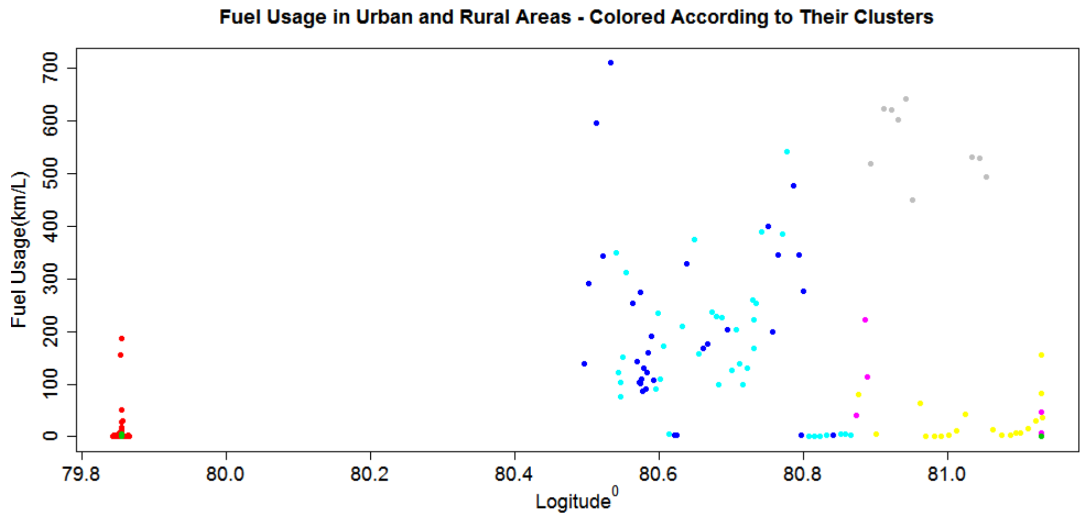








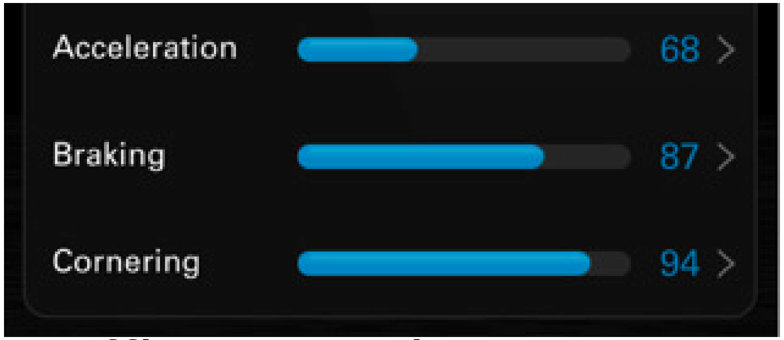
Driver Feedback to Promote Fuel Efficient Driving



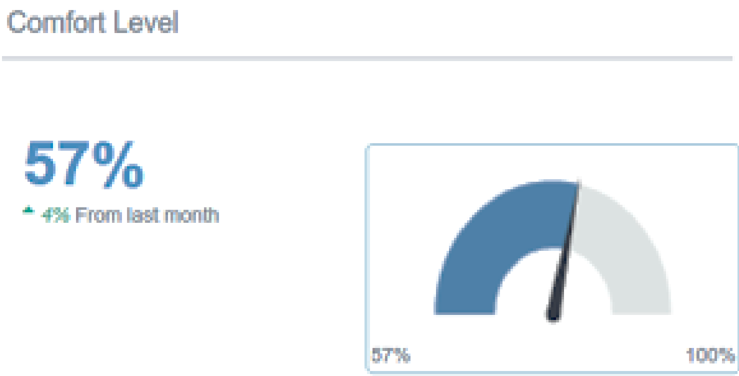
Cluster No	Mean Speed (kmh-1)	Mean Accelera-tion (kmh-2)	Mean Elevation Change (m)	Is Idling (Mode)	Hour (Mode)	Weather Condition (mode)	Mean Fuel Usage (kmL-1)	Fuel Efficiency
1	6.86	-14.56	-0.020	0	17.00	Clear	11.44	Efficient
2	0	0	0	1	00.00	Partly Cloudy	5.28	Inefficient
3	45.89	-5.53	6.360	0	23.00	Mist	214.86	Efficient
4	45.99	-109.83	-7.379	0	23.00	Mist	167.25	Efficient
5	28.35	-6,818.00	5.025	0	00.00	Mist	71.88	Efficient
6	61.12	273.00	-0.960	0	00.00	Partly Cloudy	29.57	Inefficient
7	62.77	252.54	-0.050	0	00.00	Partly Cloudy	556.30	Efficient

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



Publications

- S. Wickramanayake and H.M.N.D. Bandara, "Real-Time Monitoring and Driver Feedback to Promote Fuel Efficient Driving," Under review.
- 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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- Data
  - Nimbus Venture (Pvt) Ltd.
  - Many other drivers who help us collected data

Q&A
Demo

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