Cloud-Based Driver Monitoring and Vehicle Diagnostic with OBD2 Telematics

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WSO2 Inc.
Why?

Reckless Driving

Fault Detection

Driving Anomaly Detection
Proposed Solution

Features:
- Detecting reckless driving
- Identifying driving patterns and anomalies of drivers
- Trip analysis
- Fault analysis on vehicular data
On Board Diagnostics (OBD)

- Modern vehicles consist of lots of sensors
  - Speed, RPM, Oxygen, Mass Air Flow (MAF)
- OBD2 detects stats and failures of those sensors
- Predecessors
  - ALDL 1980
  - OBD 1 1989
  - OBD 2 1994
- Most popular manufacturers have OBD2 after 2005
Data Transmission

• 2 possible approaches
  o Via smartphone as intermediator
  o Through a dedicated hardware
Data Processing

- Data should be processed both in
  - Real time
  - Long term
- Data should be processed at
  - Device / smart phone
  - Cloud
- Complex Event Processing (CEP)
  - CEP on the phone/device
  - CEP on the cloud
- Business Activity Monitoring (BAM)

<table>
<thead>
<tr>
<th>Mobile App</th>
<th>Back End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dashboard showing real time OBD2 data</td>
<td>Driver anomaly detection</td>
</tr>
<tr>
<td>Trip logs</td>
<td>Reckless driving detection</td>
</tr>
<tr>
<td>Coolant temperature monitoring</td>
<td>O2 sensor failure detection</td>
</tr>
<tr>
<td>Fuel economy monitoring</td>
<td>MAF sensor failure detection</td>
</tr>
</tbody>
</table>
Related Work

- Plainly displays data with little or no processing at edge or cloud
- A driver can’t be expected to carry a PC/laptop
- In car navigation system\cite{1} requires driver to look at navigation pane frequently
- Y. Yang et al.’s system\cite{2} performs remote monitoring, but analysis not supported
- None of them have the ability to identify impending sensor failures

\cite{1} M.J. Kim, J. W. Jang and Y. S. Yu, —A Study on In-Vehicle System using OBD-II with Navigation.
\cite{2} Y. Yang et al., —Research and Development of Hybrid Electric Vehicles CAN-Bus Data Monitor and Diagnostic System through OBD-II and Android-Based Smartphones
Solution Architecture

- Web Portal
- Event Processing & Analytics
  - Complex Event Processor
  - Business Activity Monitor
- Communication (HTTP)
- Mobile Phone
- Communication (Bluetooth)
- OBD2 Bluetooth Adapter
- Jaggery + caramel (MVC), WSO2 UES
- WSO2 BAM and CEP
- REST
- Android
- Bluetooth

Push Notifications

Identity & Authorization
Android App
Fuel Economy & Coolant Temperature Monitoring

![Notifications]

- 10 Feb 2015 19:20:07
  Coolant temperature too high: 104.2°C

- 10 Feb 2015 19:20:52
  Coolant temperature too high: 106.6°C

- 10 Feb 2015 19:19:07
  High Fuel Consumption Detected: 10.70 L/h
Trip Logs

**Start**
- **Place**: Moratuwa
- **Time**: 14/01/2015 09:08:54

**End**
- **Place**: Colombo
- **Time**: 14/01/2015 10:11:23

**Trip Distance**
- 18.562 km

**Fuel Efficiency**
- 12.945 km/liters
Monitoring Reckless Driving

- Based on hard accelerations and decelerations
- Calculate acceleration count and deceleration per time unit beyond a predefined threshold\(^1\)
- Classification of above count depend on average speed of vehicle in last \(t\) seconds
  - Implemented using Siddhi library
- Summarize periodically and store the data in a relational database
- Show an average rapid acceleration and deceleration count per hour

\(^{1}\) MA.Z. Zeeman and M.J. Booysen - Measuring recklessness using speed and acceleration.
Reckless Driving Interface

Reckless Driving Detection

Showing Reckless Driving Analysis for Vehicle - RGS23DE43234TH33

This graph shows how many rapid accelerations and decelerations are made by the driver for an hour. Using all the data received to the server an average is calculated.

Rapid Acceleration and Deceleration Average Table

<table>
<thead>
<tr>
<th>Class - Road Type</th>
<th>Rapid Acceleration Count per an hour</th>
<th>Rapid Deceleration Count per an hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class - A</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Class - B</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

Rapid Acceleration and Deceleration Count - class B (20 km/h - 80 km/h)

This graph shows rapid acceleration and deceleration count for class B type.
Detecting Driving Pattern Anomalies

- Detection of anomalies
  - Markov Model
  - Model implemented in BAM
  - Validator implemented in CEP
Driving Anomaly Detection detected for vehicle - RGS23DE43234TH33

This graph shows the average acceleration transition probability for a user compared against his past data. Also, it could indicate a significant change in the mental/physical status of the driver where, being drunk, is the most common reason. Therefore, driving anomaly detection is required by insurance companies to identify whether the owner of the vehicle is the person who drove the vehicle that claims for a damage.
Sensor Failures - O2 Sensor

- Good sensor should fluctuate between 0.2V and 0.8V in lean and rich conditions respectively.[1]

Impending O2 Sensor Failure Detection

Minimum observed O2 sensor voltage

Current day

A possible failure on this day
Impending O2 Sensor Failure Detection (Cont.)

O2 sensor voltage (V)

- Current day
- Possible failure
- Time (ms)
O2 Sensor Failure Detection Interface

O2 Sensor Failure Detection

O2 Sensor Analysis for Vehicle - WDE23DECT3xTH33

Following table shows the details like O2 sensor wear level and the health state of the O2 sensor. Graph shows raw data related to O2 sensor.

<table>
<thead>
<tr>
<th>Sensor Name</th>
<th>O2 Sensor Bank 1 Sensor 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last Updated</td>
<td>8 / 2 / 2015</td>
</tr>
<tr>
<td>Health Status</td>
<td>Weak</td>
</tr>
<tr>
<td>Wear Level (%)</td>
<td>90</td>
</tr>
<tr>
<td>Estimated Failure In (weeks)</td>
<td>6</td>
</tr>
</tbody>
</table>

Graph showing raw data related to O2 sensor.
MAF Sensor Failure Detection

- Mass air flow value has a linear relationship with rpm\(^1\)
- When sensor fails, gradient between MAF and RPM reduces with time

\[ m \approx 0.01 \]

\[ m \approx 0.005 \]

MAF Sensor Failure Detection (Cont.)

- Use regression analysis to detect MAF sensor failure
- Then get the gradient of each line
MAF Sensor Failure Detection Interface

MAF Sensor Failure Detection overview & stats

MAF Sensor Analysis for Vehicle - RGS23DE43234TH33

Following table show the details like maf sensor wear level and the health state of the maf sensor. Graph shows gradient between rpm and mass air flow rate.

<table>
<thead>
<tr>
<th>Last Updated</th>
<th>9 / 2 / 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Status</td>
<td>Good</td>
</tr>
<tr>
<td>Wear Level (%)</td>
<td>63</td>
</tr>
</tbody>
</table>

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Achievements

- Kampana Android app available on Google Play
- 1,000+ downloads and counting!
- In the process of commercializing

As of Aug 2015
Limitations And Future Work

- Black box hardware device that can be plugged directly to OBD2 port
  - Required for fleet vehicles
  - OBD2 + GPRS (M2M)
- Support extended PIDs
- Integration with other sensors
- ELM327 adapter doesn’t support certain vehicle models
- Comprehensive performance analysis and tuning
  - Thresholds for Reckless driving, MAF failure and Driver anomaly detection
  - Collection of large datasets
- Vehicular data analytics platform
THANK YOU !